

Constraints on the genesis of the Kibi-Gold Project deposits in the Kibi-Winneba Belt, Ghana.

By

Phoebe Kekeli Nkansa

Department of Earth and Planetary Sciences
McGill University, Montreal, QC, Canada

April 2022



A thesis submitted to the Faculty of Graduate Studies and Research in partial
fulfilments of the requirements for the degree of Master of Science

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ABSTRACT

The Kibi-Gold deposits are situated within the Apapam concession in the Kibi-Winneba volcanic belt of Ghana in West Africa. The belt comprises upper greenschist facies Birimian Paleoproterozoic metasedimentary and metavolcanic rocks, and is adjacent to the renowned Ashanti belt, which accounts for 90% of Ghana's gold production. Gold mineralization (native gold) in the Kibi-Gold deposits is hosted by quartz diorite and occurs in quartz-albite-carbonate veins and in the host rock, in close association with disseminated pyrrhotite and arsenopyrite. Introduction of the gold was contemporaneous with pervasive carbonatization, sulphidation and weak sericitization, which involved the replacement of iron-bearing silicate minerals by carbonates and pyrrhotite. Pyrite is locally present and was replaced by pyrrhotite. Oxygen isotope data for ankerite ($\delta^{18}\text{O}$ from +12.51‰ to +13.84‰, V-SMOW), suggest that the mineralizing fluid was either of magmatic or metamorphic origin. Carbon isotope data also for ankerite ($\delta^{13}\text{C}$ from -13.12‰ to -8.77‰, V-PDB), are consistent with an interpretation that the carbon was sourced from organic matter contained in argillaceous sedimentary rocks. Sulphur isotope data for pyrrhotite and arsenopyrite ($\delta^{34}\text{S}$ from -1.3 ‰ to +3.3 ‰), indicate that the sulphur had a magmatic origin or was supplied during interaction of the ore fluid with igneous rocks.

A model is proposed for the formation of the Kibi-Gold deposits involving the interaction of fluids, originating either from devolatilization reactions at the greenschist-amphibolite transition boundary or exsolution from magma, with graphitic phyllite. Based on an analysis of phase equilibria (alteration mineral assemblages) and gold solubility, the ore fluid was mildly acidic and relatively reduced (consistent with its interaction with graphitic argillites). This analysis also shows that the gold mineralization did not result from changes in pH or log $f\text{O}_2$ accompanying interaction of the ore fluids with the quartz diorite host. Instead, it is proposed that the key factor

that controlled gold deposition was a decrease in the activity of H_2S due to sulphidation of Fe-silicate minerals in the host rocks to form pyrrhotite and subordinate arsenopyrite. This destabilized the hydrosulphide complexes (AuHS^0) that were largely responsible for the transport of the gold and led to the deposition of native gold spatially associated with pyrrhotite and arsenopyrite. The occurrence of some of the gold in quartz veins may indicate that temperature was also a key factor in the mineralization; except at very low and high pH, quartz solubility is entirely temperature-dependent.

By describing orogenic gold deposits that are unusual in the nature of the mineralization (pyrrhotite rather than pyrite-associated) and providing an interpretation of their genesis, this thesis contributes new understanding of a poorly studied variant of this important class of gold deposits. It also reports the first detailed study of deposits in the relatively unexplored Kibi-Winneba greenstone belt of Ghana and thereby provides the foundation for the further exploration of this belt as well as for the exploration for similar deposits in other gold belts in Ghana and the West African Craton.

SOMMAIRE

Les gisements de Kibi-Gold sont situés dans la concession d'Apapam au sein de la ceinture volcanique de Kibi-Winneba au Ghana en Afrique de l'Ouest. La ceinture comprend des roches métasédimentaires et métavolcaniques birimiennes paléoprotérozoïques au faciès des schistes verts supérieurs, et est adjacente à la fameuse ceinture d'Ashanti, qui représente 90% de la production d'or du Ghana. La minéralisation aurifère (sous forme d'or natif) dans les gisements de Kibi-Gold est encaissée dans une diorite quartzifère et se retrouve dans des veines de quartz-albite-carbonate ainsi que dans la roche hôte, en étroite association avec la pyrrhotite et l'arsénopyrite disséminées. L'introduction de l'or est contemporaine avec une carbonatisation généralisée, une sulfuration et une faible séricitisation, ce qui implique le remplacement des minéraux silicatés ferrifères par des carbonates et de la pyrrhotite. La pyrite est localement présente et est remplacée par la pyrrhotite. Les données isotopiques de l'oxygène pour l'ankérite ($\delta^{18}\text{O}$ de +12,51‰ à +13,84‰, V-SMOW), suggèrent que le fluide minéralisateur était d'origine magmatique ou métamorphique. Les données isotopiques du carbone, également pour l'ankérite ($\delta^{13}\text{C}$ de -13,12‰ à -8,77‰, V-PDB), sont cohérentes avec une interprétation selon laquelle le carbone provenait de matières organiques contenues dans les roches sédimentaires argileuses. Les données isotopiques du soufre pour la pyrrhotite et l'arsénopyrite ($\delta^{34}\text{S}$ de -1,3 ‰ à +3,3 ‰), indiquent que le soufre provenait d'une origine magmatique ou a été fourni par l'interaction du fluide minéralisateur avec des roches ignées.

Un modèle est proposé pour la formation des gisements de Kibi-Gold impliquant l'interaction de fluides, provenant soit de réactions de dévolatilisation à la frontière de la transition schiste vert-amphibolite, soit d'exsolution du magma, avec de la phyllite graphitique. D'après une analyse des équilibres de phase des assemblages de minéraux d'altération et de la solubilité de l'or, le fluide

minéralisateur était légèrement acide et relativement réduit (conformément à son interaction avec les argilites graphitiques). Cette analyse montre également que la minéralisation aurifère n'est pas le résultat de changements de pH ou de $\log fO_2$ accompagnant l'interaction du fluide minéralisateur avec la diorite quartzifère hôte. Plutôt, il est proposé que le facteur clé qui contrôlait le dépôt d'or était une diminution de l'activité de l' H_2S . Celle-ci, due à la sulfuration des minéraux de silicate de fer dans les roches hôtes, formant une minéralisation de pyrrhotite ainsi que d'arsénopyrite. Cela a causé une déstabilisation des complexes d'hydrosulfures ($AuHS^0$) qui étaient en grande partie responsables du transport de l'or et a ainsi conduit au dépôt d'or natif spatialement associé à la pyrrhotite et à l'arsénopyrite. La présence d'or également contenue dans les veines de quartz peut indiquer que la température était également un facteur clé dans la minéralisation; excepté des conditions dont le pH est très bas ou élevé, la solubilité du quartz dépend entièrement de la température.

En décrivant des gisements d'or orogéniques inhabituels dans leurs natures de minéralisations (associée à la pyrrhotite plutôt qu'à la pyrite) et en fournissant une interprétation de leurs génèses, cette thèse contribue à la compréhension d'une variante peu étudiée de cette importante classe de gisements d'or. Elle rapporte également la première étude détaillée des gisements dans la ceinture de roches vertes relativement inexplorée de Kibi-Winneba au Ghana. Ce qui fournit la base pour une exploration plus poussée de cette ceinture ainsi que pour l'exploration de gisements similaires dans d'autres ceintures aurifères au Ghana et du craton ouest-africain.

CONTRIBUTION OF AUTHORS

This thesis has been written in manuscript format per the rules and regulations set by the Faculty of Graduate and Postdoctoral Studies, McGill University. The thesis comprises an introductory review chapter, a journal manuscript titled “Constraints on the genesis of the Kibi-Gold Project deposits in the Kibi-Winneba Belt, Ghana”, co-authored by Phoebe Kekeli Nkansa, A.E. (Willy) Williams-Jones and J.R. (Jim) Clark and a concluding chapter, completing with an appendix section.

Samples needed to conduct this research were collected during the six-weeks field season in the summer of 2019 at Kibi in Eastern Region, Ghana. Sampling and logging of drill core was conducted by Phoebe K. Nkansa under the guidance of A.E. Williams-Jones. Sample preparation, interpretation of geochemical analyses and isotope data were conducted by Phoebe K. Nkansa, with analysing of isotope data by Hao Bui, McGill University/Geotop Stable Isotope Laboratory and Evelyne Leduc, Queen’s Facility for Isotope Research (QFIR). Petrographic interpretations were carried out by Phoebe K. Nkansa with the guidance and assistance of A.E. Williams-Jones and James R. Clark.

Several drafts of the thesis prepared by Phoebe K. Nkansa were reviewed and revised by A.E. Williams-Jones and James R. Clark. The final draft of the thesis conducted by Phoebe K. Nkansa was edited by A.E. Williams-Jones.

ACKNOWLEDGEMENTS

First, all glory and honour belong to God Almighty who has been my strength, rock and support throughout this journey. He taught me patience and built my faith and trust in Him. He indeed has been faithful when He said, He that started this with me will see it to completion and He definitely kept His promise.

Utmost thanks go to A. E Williams-Jones (Willy) who accepted me and took on the challenge of being my supervisor. Indeed, it was a learning experience, but Willy was there every step of the way, encouraging and assuring me he has my back, and he kept his word. It was definitely an honour learning from his great mind and hearing his endless adventures and certainly his witty demeanour, there was never a dull moment around him.

Grateful for the endless input of J.R Clark (Jim) to make this thesis a success, with the numerous emails and bugging him and thanks to Jeanne Paquette who helped to shape the initial stages of this thesis during committee meetings. Grateful also to Lang, who walked me through the earlier stages of operating the SEM and microprobe, always ready to lend a helping hand when I got stuck and helped processed my probe data.

Who I am, is born out of the prayers of my mother, Ayorkos who was and is my sounding board no matter the time of the day and my strong backbone and support, the sternness of my father, Doe who pushes me to want more, to strive for more no matter what. Nothing can compare to Doe's support during this period of my life and words will not be enough to express my gratitude. My big brother and first playmate, Tenuvi, where honestly words cannot express and my mind cannot phantom the love, care, and consistency he has shown during these years of my study and drafting this thesis. Yehowa bless you, my people.

Special thanks to David who had constant patience helping me out to complete this thesis. Indeed, I have found an irreplaceable friend in him, and it was pure joy to watch and judge him come in with a bag of Tims in his hand. Heartfelt thanks to Jake, who no matter the time of day lent a helping hand. The genuine care and willingness to help, always left me overwhelmed and always kept room 346 lively, surely the life of the party. Deepest thanks and love to Robert who our friendship grew leading to the months of the completion of this thesis, he offered a comforting shoulder during my lowest moments and was at the center of most of my joyous experiences in Montreal. A relationship that now forms part of the core of who I am, I will surely miss our banter. We definitely brought life to the zoo. Thanks to Kira, Sarah and Kevin who made each day lovely. Finally, Kyle, who was constantly on my nerves just to rile me up, but I knew it was all love. Notwithstanding, anytime I hollered he always responded, dropped whatever he was doing and listened. That kind of selflessness is rare to find and must be protected at all cost. Everyone needs a Kyle in their lives.

Special thanks to Maxwell, Lui, Emmanuelle and Nesta, no matter the time zone, was and is my sounding board who reminded me that I still had friends who loved and cared for me back home in Accra. Also, to Priscilla who listened to my rants and assured me it will be well and the sheer foolery we displayed over the love of Gretzky, gave me sheer joy.

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CHAPTER I

Thesis Introduction

INTRODUCTION

The term “mesothermal” gold deposits was introduced to refer to hydrothermal lode gold deposits of any age hosted in metamorphic terranes of prehnite-pumpellyite to lower granulite facies (Kerrick, 1993). However, this definition was considered too broad and was subsequently replaced by the term “orogenic”, in recognition of the tectonic environment in which these deposits generally form (Bohlke, 1982; Groves et al., 1998). This class of gold deposits is now taken to comprise structurally hosted, epigenetic precious metal deposits spatially associated with accretionary metamorphic terranes (Barley & Groves, 1992; Kerrich & Wyman, 1990; Goldfarb et al., 2005).

Orogenic gold deposits vary in age from the Meso-Archean through to the Phanerozoic and occur typically in deformed, metamorphosed accretionary wedges (Goldfarb et al., 2001). They are spatially related to major crustal structures, and the gold mineralization commonly occurs in these structures as well as in second-order structures, which serve as conduits for the ore-forming fluids (Groves et al., 2003). Ore-forming hydrothermal fluids which form these deposits have low salinity (≤ 6 wt% NaCl), are H₂O-CO₂-rich and contain minor components of CH₄ and N₂ (Prokofiev & Naumov, 2020).

Although orogenic gold deposits are gold-dominated, they may include significant Ag, with Au/Ag ratios averaging ~ 5 . They also commonly contain minor proportions of As, Sb, Te, W, Mo, Bi and B, but generally show low or no enrichment of Cu, Zn and Pb (Groves & Phillips, 1987; Phillips & Hughes, 1996). The gold fineness in orogenic gold deposits of all ages ranges between 800 to 950, and averages 900 (Kerrick, 1983).

Orogenic gold deposits are currently responsible for greater than for 50% of global gold production (Phillips, 2013). Additionally, this style of gold mineralization is responsible for most of the gold produced from the West African Craton (WAC). Indeed, the Ashanti belt, which has a gold endowment in excess of 125 million ounces, is responsible for 90% of Ghana's gold production which is sourced by the Birimian Supergroup (Akabzaa et al., 2007).

Considering the large contribution that orogenic deposits make to global gold production, it is essential to understand their genesis. Their formation has been a matter of debate for many years. Although researchers are divided over whether they are metamorphogenic or magmas were involved in their genesis (Spence-Jones et al., 2018; Hazarika et al., 2021), it is now generally agreed that orogenic lode gold deposits in metamorphic and igneous rocks form at depths of ~4-30 km within the crust during active tectonism (Cox, 2016; Groves et al., 2020).

Groves (1993) proposed the crustal continuum model to explain the formation of orogenic gold deposits over a wide interval of crustal depths, and temperature-pressure conditions ranging from 180°C at < 1 kb to 700°C at 5 kb, corresponding to sub-greenschist and granulite facies, respectively. Most orogenic gold deposits, however, are interpreted to have formed at greenschist to lower amphibolite facies conditions (Groves et al., 1998; Goldfarb & Groves, 2015). Moreover, Tomkins & Grundy, (2009) noted that, transmission of hydrothermal fluids through rocks at >600-650°C would lead to partial melting (migmatization) and consumption of these fluids, suggesting that the upper temperature limit of 700 °C by Groves (1993) for the formation of orogenic gold deposits is unreasonably high.

Despite a developing consensus on the range of P-T conditions over which orogenic gold deposits form, there is still a paucity of data on the nature and origin of the ore-forming fluids due to the difficulty of acquiring reliable fluid inclusion data and relating isotopic data for the ore and

associated alteration minerals to the ore fluid. Consequently, there is no consensus on the genesis of these deposits. A majority of researchers, however, favour the hypothesis that the deposits are the products of fluids produced by metamorphic devolatilization (Ridley & Diamond, 2000; White et al., 2015; Mishra et al., 2018).

As noted above, most of the gold production in the West African Craton is from orogenic deposits and mainly from those in the Ashanti greenstone belt of Ghana, which are mainly metasediment-hosted (Berge, 2011; Křibek et al., 2015). There are several other greenstone belts in Ghana of the same age that also are potential hosts for orogenic gold deposits but are relatively unexplored. One of these is the Kibi-Winneba greenstone belt that hosts the Kibi Gold Project deposits (South Ridge, Big Bend and Double 19), which is the focus of this study. These deposits have been classified by the company exploring them (Xtra-Gold Resources Corporation) as mesozonal orogenic deposits based on their styles of mineralization and alteration. They are different, however, from other orogenic deposits, including those of the Ashanti belt, in that the host for the gold mineralization is a quartz diorite and the main sulphide mineral is pyrrhotite. In most orogenic gold deposits, pyrite is the main sulfide phase (Large et al., 2012), and this is also the case for the deposits of the Ashanti belt (Mumin et al., 1994; Salvi et al., 2016) and other orogenic gold deposits in the West African Craton (Béziat et al., 2008; Dabo et al., 2016; Le Mignot et al., 2017).

The purpose of this study is to shed light on the genesis of the Kibi Gold deposits and determine the conditions that led to pyrrhotite being the dominant sulphide and principal ore mineral. The Kibi Gold deposits also provide an opportunity to investigate the source and nature of the ore fluid responsible for their formation and the roles that pyrrhotite, arsenopyrite and ankerite crystallization played in gold deposition. By addressing the issues raised here, the study will develop a model for the formation of the Kibi deposits that will help guide exploration for other

orogenic gold deposits in the Kibi-Winneba belt and pyrrhotite-type orogenic gold mineralization in other parts of the world.

TECTONIC SETTING AND DEPTH OF EMPLACEMENT

Orogenic gold deposits are interpreted to occur in tectonic zones that form as a result of the accretion and underplating of oceanic crust and continental margins (Kerrick et al., 2000; Goldfarb et al., 2001; Groves et al., 2003). They are associated with convergent plate margins and hosted by major trans-lithospheric structures that are compressional to tranpressional-transtensional and develop at or above the brittle-ductile transition; ~6-20km (Groves et al., 1998).

Orogenic gold deposits have been subdivided into epizonal (<6km, ~150-300°C, ~0.5-1.5kb) deposits hosted by prehnite-pumpellyite to lower greenschist metamorphic facies, mesozonal (~6-12km, ~300-475°C, at ~1.5-3kb) deposits of greenschist to lower amphibolite metamorphic facies, and hypozonal (>12km, ~475-700°C, at ~3-6kb) deposits of amphibolite to lower granulite metamorphic facies (Gebre-Mariam et al., 1995). Most of these orogenic deposits, however, occur in greenschist to amphibolite settings and are commonly syn-to-post peak metamorphic (Groves, 1993).

The deposits are structurally controlled and are associated with second and higher-order splays of major lithospheric faults, with the structures commonly displaying high-angle reverse oblique or transcurrent displacement on the scale of tens to hundreds of metres (Kerrick et al., 2000).

Morphologically, these second and higher-order splays exhibit four (4) structural styles: breccias, stockworks, laminated veins in shear zones, and ductile shear zones hosting thin and discontinuous deformed veins (Hronsky et al., 1990 Groves et al., 1992). The four structural

styles are ordered to reflect increasing crustal depths and temperatures of formation, representing a succession from brittle to predominantly ductile conditions.

ORIGIN OF OROGENIC GOLD DEPOSITS

The source and evolution of the fluids responsible for forming orogenic gold deposits have been debated extensively. In large part, this is because, stable isotopic data have provided conflicting evidence for whether they are magmatic or metamorphic in origin (Goldfarb & Groves, 2015; Wyman et al., 2016). A variety of models have been proposed for the origin of orogenic gold deposits. These include, models involving metamorphic, magmatic-hydrothermal, supracrustal and meteoric-fluids (Hutchinson & Burlington, 1984; Groves et al., 1987; Nesbitt & Muehlenbachs, 1991; Mueller, 1992; Walshe et al., 2003).

Although an early syngenetic-exhalative model for the origin of these deposits was proposed (Fripp, 1976a, 1976b; Hutchinson, 1987), this model was subsequently shown to be inconsistent with the structurally controlled nature of the deposits, and their emplacement in syn- to late metamorphic settings (Goldberg, 1964; Lewis, 1965). Moreover, some deposits that appear stratiform and, thus, potentially syngenetic-exhalative, such as those hosted by banded iron formations, have been shown to have formed by the sulfidation of magnetite (Hutchinson et al., 1971; Phillips et al., 1984), and thus to be epigenetic.

Some researchers, noting a close spatial association of the gold mineralization with granitic plutons, have proposed that the deposits are the product of magmatic hydrothermal fluids (Bath et al., 2013; Kerr et al., 2018). Geochronological studies, however, have shown that the granitic

intrusions are generally not coeval with the gold mineralization (Goldfarb & Groves, 2015), and thus, are unlikely to be genetically associated.

As lamprophyres are commonly associated with orogenic gold deposits it has been suggested that they may be genetically related. Indeed, Rock et al. (1989) proposed that fluids released during crystallization of gold-rich shoshonitic lamprophyre magmas were responsible for the formation of lode gold deposits. Kerrich and Wyman (1994) rejected this hypothesis on the grounds that lamprophyres are not intrinsically gold-rich and that there is no spatial and temporal relationship between orogenic gold deposits and shoshonitic lamprophyre suites, except that both were emplaced within translithospheric structures, which defined terrain boundaries between distinct tectonostratigraphic terranes. Vielreicher et al. (2010), while acknowledging that some lamprophyres may be of similar age to the gold mineralization expressed the view that they are volumetrically too small to have provided the amount of fluid required to form the deposits.

Fyon et al. (1984) and Cameron (1988) proposed that advection of mantle CO₂ through the lower crust could generate granulite and that this CO₂-rich pseudo-metamorphic fluid might be responsible for the formation of some gold deposits. This hypothesis was considered by Kerrich (1989) to be problematic, however, due to the generally low CO₂/H₂O ratio of the hydrothermal fluids and carbon isotope data which did not support the granulitization model.

Based on stable isotope data (O and D) from bulk analyses of fluid inclusions, Nesbitt and Muehlenbachs (1991) concluded that meteoric fluids may have played a role in the genesis of some deposits. This hypothesis was challenged by Goldfarb and Groves (2015) because of the difficulty of avoiding the contribution (commonly large) of secondary fluid inclusions.

The supracrustal model has posed some difficulty in accounting for the formation of hypozonal gold deposits, for instance, deposits formed in Archean terranes (Renco, Hutti, Kolar, Nevoria) subjected to mid-to-upper-amphibolite facies metamorphism (Kolb et al., 2005a). Certain aspects of the supracrustal model argue that these deposits formed under low P-T conditions and were later metamorphosed under amphibolite conditions (Tomkins & Mavrogenes, 2002; Phillips & Powell, 2009). Kolb et al. (2015c) emphatically refutes this claim and asserts that these deposits were formed under amphibolite-facies conditions, where fluids were sourced from deeper than 15km. Browning et al. (1987) and McNaughton and Groves (1996) provided lead isotope data to support the claim of the auriferous fluids being deep-sourced.

The subduction-diamond model which was proposed by Wyman et al. (2008) and later modified by (Goldfarb & Santosh, 2014; Groves & Santosh, 2016; Groves et al., 2020), proposes for orogenic gold deposits of all ages and environments that the gold and related metals are likely to have been derived from devolatilized sedimentary rocks (rather than supracrustal mafic rocks). The model entails the subduction of the oceanic crust/slab and its overlying sediments, resulting in the upward movement of fluid along the slab-mantle boundary (**Fig. 1**).

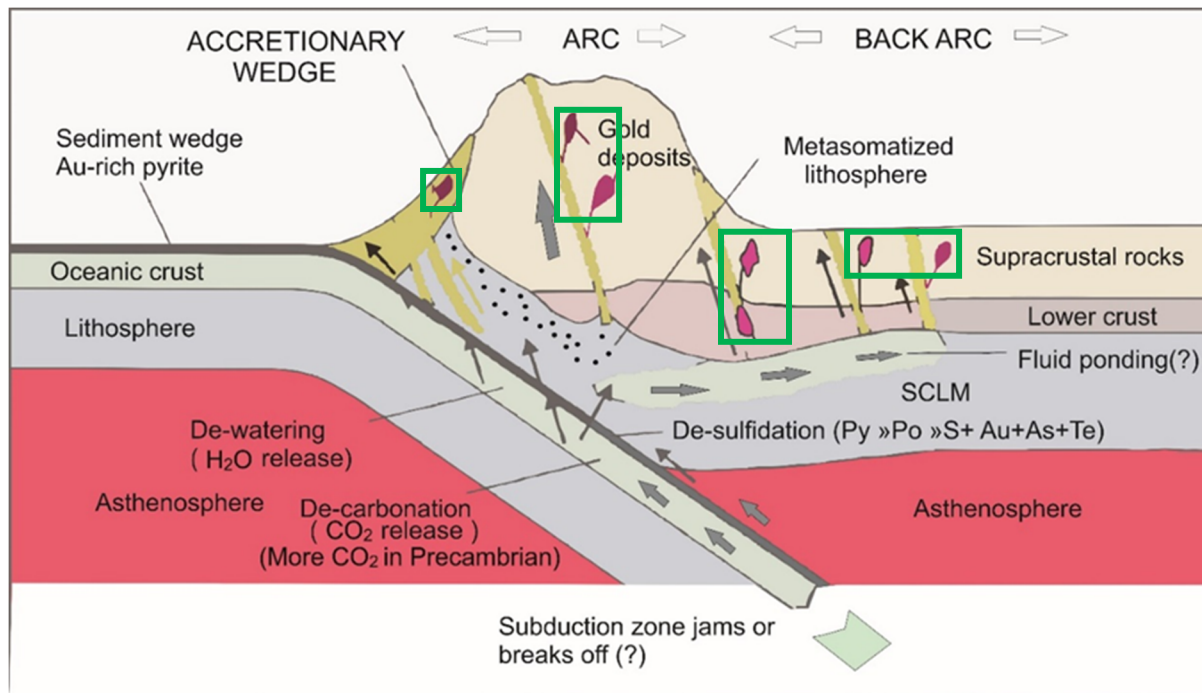


Figure 1: An illustration of the subduction model for the formation of orogenic gold deposits. Green insert boxes highlight environments (accretionary wedge, arc, and back arc) in which gold deposits are most common (modified after Groves et al., 2020).

In the subduction model, the fluid is derived from the devolatilization of the oceanic slab and its overlying pyrite-bearing oceanic sediment wedge, which rises up-dip between the slab and the mantle wedge. In this model, the presence of Au and pyrite-bearing sedimentary source rocks is a key prerequisite for the formation of orogenic gold deposits (Wyman et al., 2008). Metamorphism releases gold and related elements, including Ag, As, Bi, Sb, Te and W, to a sulphur-bearing fluid through the replacement of pyrite by pyrrhotite (Pitcairn et al., 2006; Large et al., 2009). Overpressured fluids enter deep-seated faults which serve as conduits for these fluids to move upwards and form orogenic gold deposits in back-arc or arc terranes in either second order structures, veins or in highly fractured rocks.

The formation of giant orogenic gold deposits may be related to the thickness of the subcontinental lithospheric mantle (SCLM); high heat influx would trigger and sustain crustal devolatilization

and melting, enabling fluid to ascend and deposit large deposits (Kerrick et al., 2000; Bierlien et al., 2006). Lithospheric instabilities, plume impact, delamination of the mantle lithosphere, erosion of the mantle lithosphere and subduction are all possible triggers for the onset of crustal melting by asthenosphere upwelling, causing the SCLM to be poorly established or thinned, which potentially allows for the passage of the large fluid volumes thought to be responsible for these giant deposits (Kerrick et al., 2000; Wortel & Spakman, 2000; Condie, 2004).

The subduction model, which is well-supported by argument and evidence, presents a hypothesis applicable to orogenic deposits of all ages and proposes a source for the gold (Au-bearing, sediment hosted pyrite) which is fundamental for forming these deposits, something that the supracrustal model fails to address. The formation of giant orogenic gold deposits relies heavily on the thickness of the SCLM, which depends on certain triggers to cause it to be poorly established or thinned. If these triggers are not present, these giant orogenic gold deposits will not form, which poses a challenge to this model. Overall, the subduction model serves as a viable model for the genesis of orogenic gold deposits.

Metamorphic Devolatilization

Models proposing metamorphic devolatilization have become widely accepted in recent years as has the recognition that the nature of the source rocks plays a crucial role in fluid generation (Tomkins, 2010, 2013a; White et al., 2015). These models propose that rocks undergoing greenschist to amphibolite facies metamorphism are capable of generating large fluid volumes, e.g., 2-5 wt% metamorphic fluid, during the transition from greenschist to amphibolite facies (Fyfe & Henry, 1973; Kerrich, 1977).

Elmer et al. (2006) and Wilson et al. (2013) have suggested that hydrated, carbonate-altered mafic rocks release fluids at the greenschist-amphibolite transition, mainly when chlorite is converted to amphibole. The volume of fluid produced during this transition depends on the modal proportions of the volatile-bearing minerals prior to metamorphism (Gaboury, 2019). At the transition, the mineral assemblage chlorite-carbonate is transformed to hornblende-plagioclase, causing the metamorphosed rock to lose hydrous, carbonate and sulphur species, especially when pyrite is present (Phillips & Powell, 2010).

According to thermodynamic calculations, devolatilization of mafic rocks takes place within the range of 440 to 520°C, producing H₂O-rich fluid with $X(\text{CO}_2) < 0.1$ at ~ 440-470°C and $X(\text{CO}_2)$ of ~0.2-0.3 at ~ 500-520°C (Elmer et al., 2006). The net result of the devolatilization of the mafic rocks is a H₂O-CO₂-H₂S fluid that is controlled by the metamorphic assemblage chlorite-calcite-albite-epidote-quartz (Powell et al., 1991; Philips & Powell, 2010).

Large et al., (2011), in supporting the metamorphic devolatilization model, noted that metamorphism of pyrite-rich carbonaceous sedimentary rocks can generate more fluid than mafic rocks. This is due to the fact that sedimentary rocks (especially shales and siltstones that produce pelite when metamorphosed) contain greater abundances of hydrous silicates and thus are capable of releasing more fluid (Tomkins, 2010; Zhong et al., 2015).

Progressive temperature and pressure increases during metamorphism of hydrated rocks can play a crucial role in the release of fluids (Connolly, 2010) and may involve rapid burial during the mountain- building phase, for which optimal fluid generation is at temperatures of ~550°C and a pressure range of 2-10 kbar. **(Fig. 2)**

The most common source of sulphur in volcano-sedimentary rocks is pyrite, which is concentrated in pelites due to the production of free aqueous sulphur (HS^- , S^{2-}) from organic matter (Tomkins, 2010). During metamorphism, the pyrite is converted to pyrrhotite by desulfidation reactions (Toulmin & Barton, 1964), which release sulphur allowing it to serve as a ligand for gold complexation (Williams-Jones, et al., 2009). The prevailing temperature-pressure conditions and consumption of S by Fe-silicates to form pyrrhotite, control the S available for forming gold complexes (Zhong et al., 2015).

Gaboury (2019) suggested that release of sulphur during the pyrite-pyrrhotite conversion occurs at 500-550°C, i.e., at a temperature similar to that of the greenschist-amphibolite facies transition and proposed that both the fluid and the sulphur are produced at this boundary, supporting the proposal by Tomkins (2010) that the gold in orogenic gold deposits is derived mainly from pyrite-rich sedimentary rocks.

The metamorphic devolatilization model, supported by the evidence referred to above, provides a concrete description of how and at what conditions the ore-forming fluids form. In so doing it also emphasizes the role of pyrite-rich sedimentary rocks in providing both a source for the gold and the ligand necessary to transport this gold to the environment of orogenic ore formation.

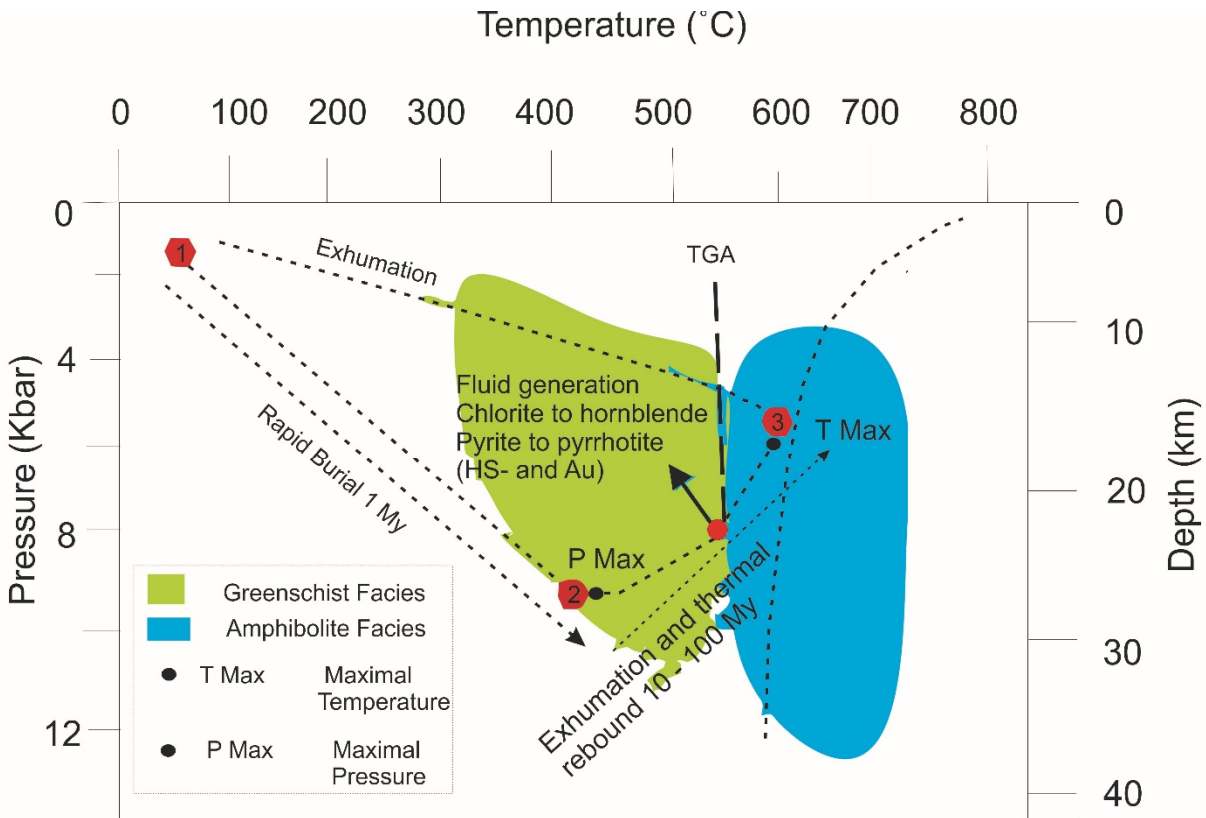


Figure 2: A pressure-temperature-time diagram illustrating possible *P-T-t* pathways for hydrated sedimentary rocks undergoing rapid burial, thermal rebound, and exhumation. Points (1-3) represent the pathway of the schematic blocks showing the thickening, rapid burial, and exhumation of the hydrated rocks. Metamorphic fluid is released mainly at the transition between greenschist and amphibolite facies (TGA) at approximately 550°C (modified after Gaboury, 2019).

The Role of Magmas

The fluid involved in the formation of some orogenic gold deposits is interpreted to have had a magmatic source (mainly felsic) based on metal association, for example, the metal assemblage, Au-As-Pb-Zn-Cu which is commonly associated with calc-alkaline intrusions (Schreiber et al., 1990; Sillitoe & Thompson, 1998). Thermodynamic modelling of the evolution of granitic magmas indicates that the salinity of the fluid released is strongly dependent on the pressure of crystallization and that at pressures greater than ~1.3 kbar, low salinity conditions predominate

(Cline & Bodnar, 1991). Eggler and Kadlik (1979) proposed that CO₂-solubility in granitic magmas is directly proportional to pressure such that exsolution of a CO₂-rich, mixed aqueous-carbonic fluid at solidus temperatures is plausible above ~3 kbar. Based on this observation, Ridley and Diamond (2000) concluded that fluid composition should not be used to rule out a magmatic source for the ore fluids, given that the formation of orogenic gold deposits typically occurs at relatively high pressure. Significantly, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses of pyrite in Paleoproterozoic orogenic deposits in the Mana district in Burkina Faso revealed an association of gold mineralization with Bi, Te, Mo, Sn and W in pyrite (Augustin & Gaboury, 2019), which is a clear signature of calc-alkaline and alkaline magmatism (Sillitoe, 1991). Thus, it is likely that deposits like these owe their origin to magmatic hydrothermal fluids (Sillitoe & Thompson, 1998; Craig & Goldfarb, 2005). Recent stable isotope studies of orogenic gold deposits thought to be intrusion-related have supported this interpretation. For example, analyses of hydrothermal biotite from the Malartic deposit in the Abitibi greenstone belt, Quebec (Helt et al., 2014; 2014b) indicate that the isotope composition of the mineralizing fluid is $\delta^{18}\text{O}_{\text{fluid}}$ of 8.2 to 9.8‰, which is consistent with a potentially magmatic source (Ridley & Diamond, 2000). The $\delta^{34}\text{S}_{\text{fluid}}$ values, which range from -4.5 to +3.3‰, are also consistent with a dominantly magmatic fluid source (Helt et al., 2014). The same conclusion has also been reached for the sulphur isotope compositions interpreted for fluids from some other Archean deposits (Bellerophon, Victory and Wallaby of the Yilgarn craton; Xue et al., 2013); this study suggested that there was also a small contribution from sedimentary and possibly metamorphic sources.

MINERALIZATION AND ALTERATION

The mineralization in orogenic gold deposits occurs mainly in quartz±carbonate veins and sulphidized wallrocks. Deposits in prehnite-pumpellyite to lower greenschist metamorphic facies are associated with brittle faults and are commonly characterized by brecciated ore textures (Hagemann et al., 1992, 1994). These deposits formed during post-peak metamorphism (Bishop, 1972). The main sulphide minerals are usually pyrite, pyrrhotite, arsenopyrite and stibnite, and the alteration minerals typically comprise sericite, chlorite, epidote, carbonate, albite, and quartz (Mueller & Groves, 1991). Examples of this style of mineralization are provided by the Wiluna and Racetrack deposits in the Yilgarn craton, Australia (Groves, 1993; Kent & Hagemann, 1996).

Syn-to-post metamorphic deposits are hosted by greenschist to lower amphibolite facies metamorphic rocks, which are also associated with faults or shear zones (Ridley, 1997; Allibone et al., 2002a). The principal sulphide minerals are pyrite, arsenopyrite and pyrrhotite, and the alteration minerals comprise sericite, carbonate, albite, chlorite, and biotite (Kishida & Kerrich, 1987). Examples of such mid-level mineralization are the Kerr-Addison and Sigma-Lamaque deposits of the Abitibi belt, Quebec, and the deposits of the Ashanti district of the West African Craton (Poulsen et al., 2000; Groves et al., 2003).

Amphibolite to lower granulite facies metamorphic rock-hosted orogenic deposits, occur in deformation corridors manifested by wide shear zones and formed pre-to-syn-peak metamorphism (Powell et al., 1999; Phillips & Powell, 2009). The main alteration minerals are biotite, K-feldspar, muscovite, quartz, barite, microcline, carbonates (calcite and siderite) and garnet, with the main sulphide minerals being arsenopyrite, pyrrhotite, chalcopyrite, loellingite, pyrite, stibnite, sphalerite, and realgar. Examples of this type of deposit are the Renco mine in the Limpopo belt,

Zimbabwe, The New Consort Gold Mine in the Barberton greenstone belt, South Africa and the Hemlo deposit, Ontario, Canada (Kisters et al., 1998; Tomkins et al., 2004; Heiligmann et al., 2008).

FLUID INCLUSION DATA

Analyses of fluid inclusions provide essential information on the composition of ore fluids and the P-T conditions of mineralization. The chemical constituents of the fluids responsible for orogenic deposits differ from those of other gold-bearing systems (Hodgson & MacGeehan, 1982), and are generally independent of deposits ages and lithological settings (McCuaig and Kerrich, 1998).

Fluid inclusions in barren and mineralized quartz from orogenic gold deposits have been classified into three main types: Type 1 $\text{CO}_2(\text{liquid}) \pm \text{N}_2 \pm \text{CH}_4$ inclusions; Type 2 $\text{H}_2\text{O}-\text{NaCl}$ inclusions; and Type 3 $\text{H}_2\text{O}-\text{CO}_2-\text{NaCl} \pm \text{N}_2 \pm \text{CH}_4$ inclusions (Mumm et al., 1997; Ridley & Diamond, 2000; Klein, 2014). Type 3 inclusions are thought to be heterogeneous mixtures of the two end members, i.e., Type 1 and Type 2 inclusions (Diamond, 1990).

In some deposits, multiphase Type 4 $\text{H}_2\text{O}-\text{CO}_2-\text{NaCl}-\text{FeCl}_2 \pm \text{N}_2 \pm \text{CH}_4$ inclusions have also been observed, including those in the Luolo mining district in Mali, the Suizao area of the Tongbai-Dabie orogenic gold belt, Central China and the Baikal-Patom and Muya areas of Siberia (Lawrence et al., 2013; Lambert-Smith et al., 2015; Niu et al., 2019; Prokofiev et al., 2019). These latter hypersaline, multiphase fluid inclusions contain numerous daughter minerals, including dominant halite, iron chlorides, Na and Mg chlorides, sylvite and Ca-bearing chlorides, with carbonate (ankerite, calcite), hematite, chalcopyrite and magnetite, as trapped solids.

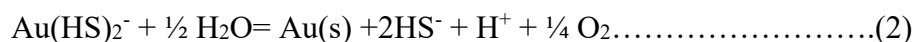
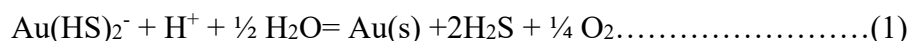
The Type 4 fluid inclusions in the deposits referred to above occur with Type 3 inclusions and have a salinity of ~40wt% NaCl, whereas the Type 3 inclusions contain ~10wt% NaCl (Lawrence et al., 2013; Lambert-Smith et al., 2015; Prokofiev et al., 2019). In some cases, Type 4 fluids are thought to have formed from the mixing of a low salinity ($\leq 10\text{wt}\%$) $\text{H}_2\text{O}-\text{CO}_2-\text{NaCl}\pm\text{N}_2\pm\text{CH}_4$ fluid and a high temperature ($>400^\circ\text{C}$), high salinity (~35-40wt% NaCl), metalliferous $\text{H}_2\text{O}-\text{CO}_2-\text{NaCl}-\text{FeCl}_2$ fluid (Lawrence et al., 2013).

Aqueous-carbonic and carbonic fluid inclusions are common in most systems (Robert & Kelly, 1987). Their $X(\text{CO}_2)$ values vary from 0.05 to 0.90, depending on the deposit (Ridley & Diamond, 2000), but mostly they are in the range 0.1 to 0.25 (Clark et al., 1989). The dominant and ubiquitous fluid inclusions, however, are low salinity ($\leq 6\text{ wt}\% \text{ NaCl}$) aqueous-carbonic inclusions; these inclusions also are thought to represent the ore fluid in most orogenic gold deposits (Yao et al., 2001; Klein, 2014). In the Ashanti deposits in Ghana, the Osprey and Fumani deposits in the Limpopo belt, South Africa and the Fazenda Maria Preta deposit of the Rio Itapicuru greenstone belt, Brazil, the fluid is dominantly carbonic (van Reenen et al., 1994; Klemd et al., 1996; Mumm et al., 1997; Xavier & Foster, 1999).

According to Lambert-Smith et al., (2015), the P-T trapping conditions of the ore fluids for the Gounkoto deposit were 1.1 to 1.7 kbar, and 315 to 356°C, respectively. These P-T conditions fall within the range that Groves (1993) stated most orogenic gold deposits form. In summary, the gold mineralization in many of the major deposits of the Birimian terrane of the WAC, and a significant proportion of orogenic deposits globally, can thus be attributed to low salinity, aqueous- CO_2 -rich fluids with minor proportions of CH_4 and N_2 (Goldfarb et al., 1989; Channer & Spooner, 1994; Mumm et al., 1997; Yao et al., 2001).

CONTROLS ON GOLD DEPOSITION

Under the physicochemical conditions of epizonal and lower temperature mesozonal deposits (near-neutral pH, and temperatures up to ~400 °C) gold is transported primarily as the thiosulphide species, $\text{Au}(\text{HS})_2^-$ (**Fig. 3 & Fig. 4**; Hayashi & Ohmoto, 1991; Gammons & Williams-Jones, 1997; Stefansson & Seward, 2004) and deposits according to the reaction:



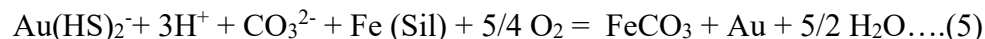
Consequently, gold deposition is promoted by decreases in oxygen fugacity and pH (Reaction 1) and particularly a decrease in the activity of HS^- , or an increase in pH (Reaction 2). Deposition can also be driven by an increase in oxygen fugacity (Ridley et al., 1996; Williams-Jones & Migdisov, 2014), if conditions are close to the predominance field of sulphate, because of the loss of H_2S due to the reaction:



Thus, gold deposition is most likely to occur because of sulphidation (Phillips & Groves, 1983; Williams-Jones et al., 2009) of the host rocks (replacement of Fe silicate minerals by pyrite or pyrrhotite), which decreases the activity of H_2S via the following reaction:

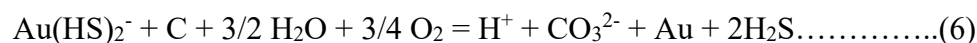


Because the ore fluids for orogenic gold deposits contain abundant CO_2 (an important acidifying component), loss of CO_2 due to carbonation of the wall rocks would also be an effective means of depositing gold (Neill & Phillips, 1987; Augustin et al., 2017).as shown by the reaction:

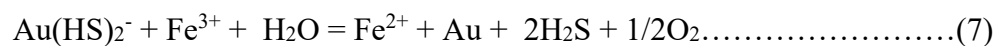


The same would be true of CO₂ effervescence, which might be promoted by pressure release during faulting, as in the fault-valve model (Sibson, 1987; Sibson et al., 1988). This would also have the added advantage of increasing oxygen fugacity due to the loss of hydrogen to the gas. Gold deposition would be localized in zones of maximum dilation at the intersection of shear zones (**Fig. 5**) where transient fluid pressure drops cause phase separation (Wilkinson & Johnson, 1996).

Reduction due to the interaction of the ore fluid with reduced carbon (e.g., organic matter) is another mechanism for depositing gold (Connolly & Cesare, 1993; Gaboury, 2013) as illustrated by the reaction:

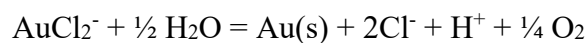


Finally, as mentioned above, by consuming H₂S, oxidation, like sulphidation is a particularly effective mechanism for depositing gold (Phillips & Gibb, 1993). This could occur either through the interaction of the fluid with host rocks containing minerals capable of buffering the fluid to high oxygen fugacity, such as hematite as shown by the reaction:



or through mixing of the fluid with meteoric water (Williams-Jones et al., 2009; Phillips & Powell, 2010).

At the higher temperature of some mesozonal deposits and all hypozonal deposits, gold chloride complexes (Stefansson & Seward, 2004)., e.g., AuCl₂⁻ takes over from Au(HS)₂⁻ as the dominant gold species in typical orogenic ore fluids (i.e., fluids containing ~ 1 m NaCl) and gold deposition will take place in response to the reaction:



Any process that increases pH and reduces oxygen fugacity, including those referred to above will lead to gold deposition. In addition to the parameters discussed above, decreasing temperature will also lead to gold deposition, because the solubility of gold is prograde in respect to temperature. Thus, rapid pressure drops, leading to rapid decreases in temperature are effective means of gold deposition (Mernagh & Bierlein, 2008; Hodkiewicz et al., 2009).

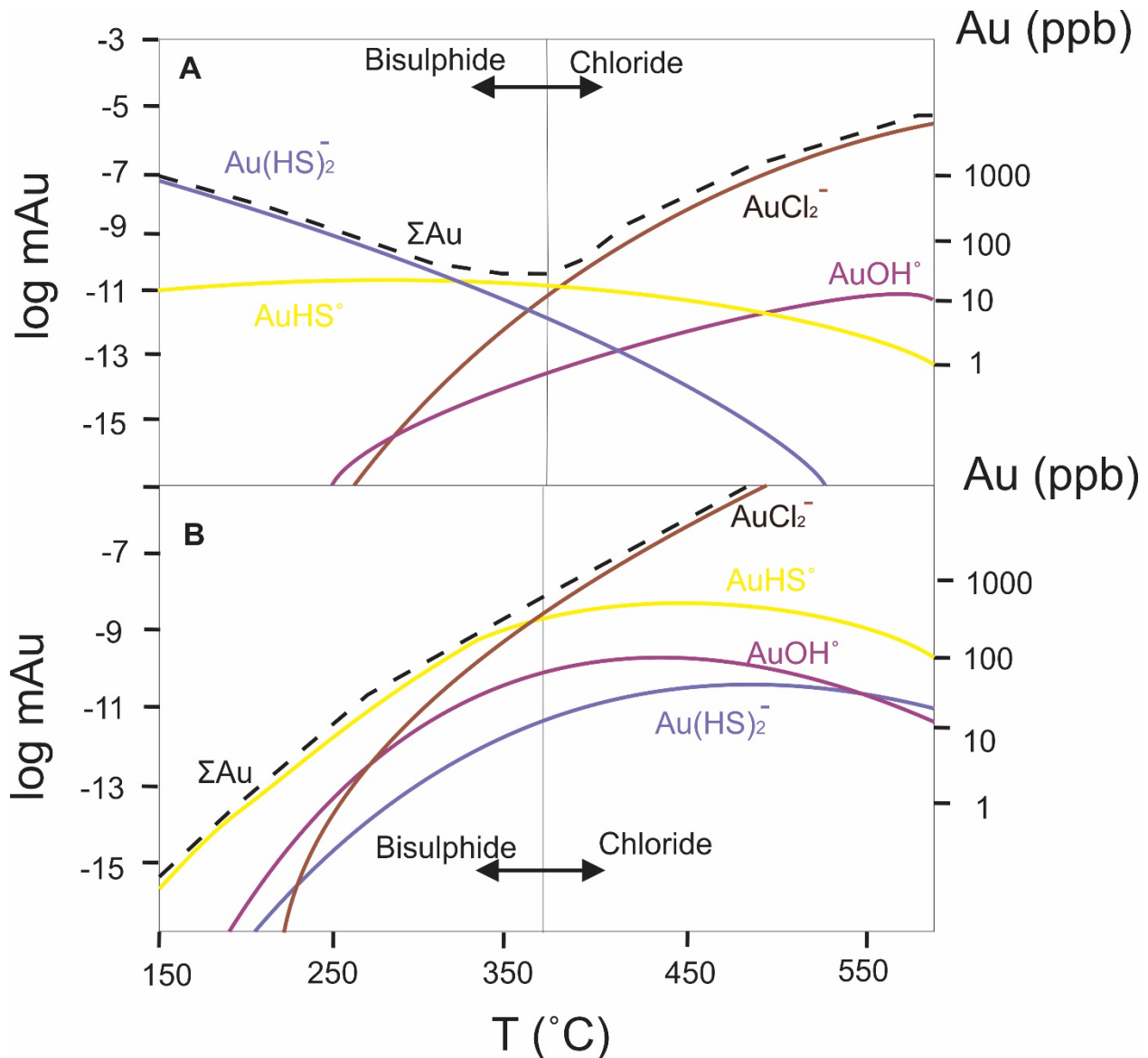


Figure 3: Plots of gold solubility expressed in molality and ppb as against temperature at a constant pressure of 1kbar in solution. (A). Au complexes indicating how a decrease in temperature can affect solubility buffered by a hematite-magnetite assemblage. (B). Au complexes at various temperatures indicating how gold solubility can be controlled buffered by a pyrite-pyrrhotite-magnetite assemblage (modified after Williams-Jones et al., 2009).

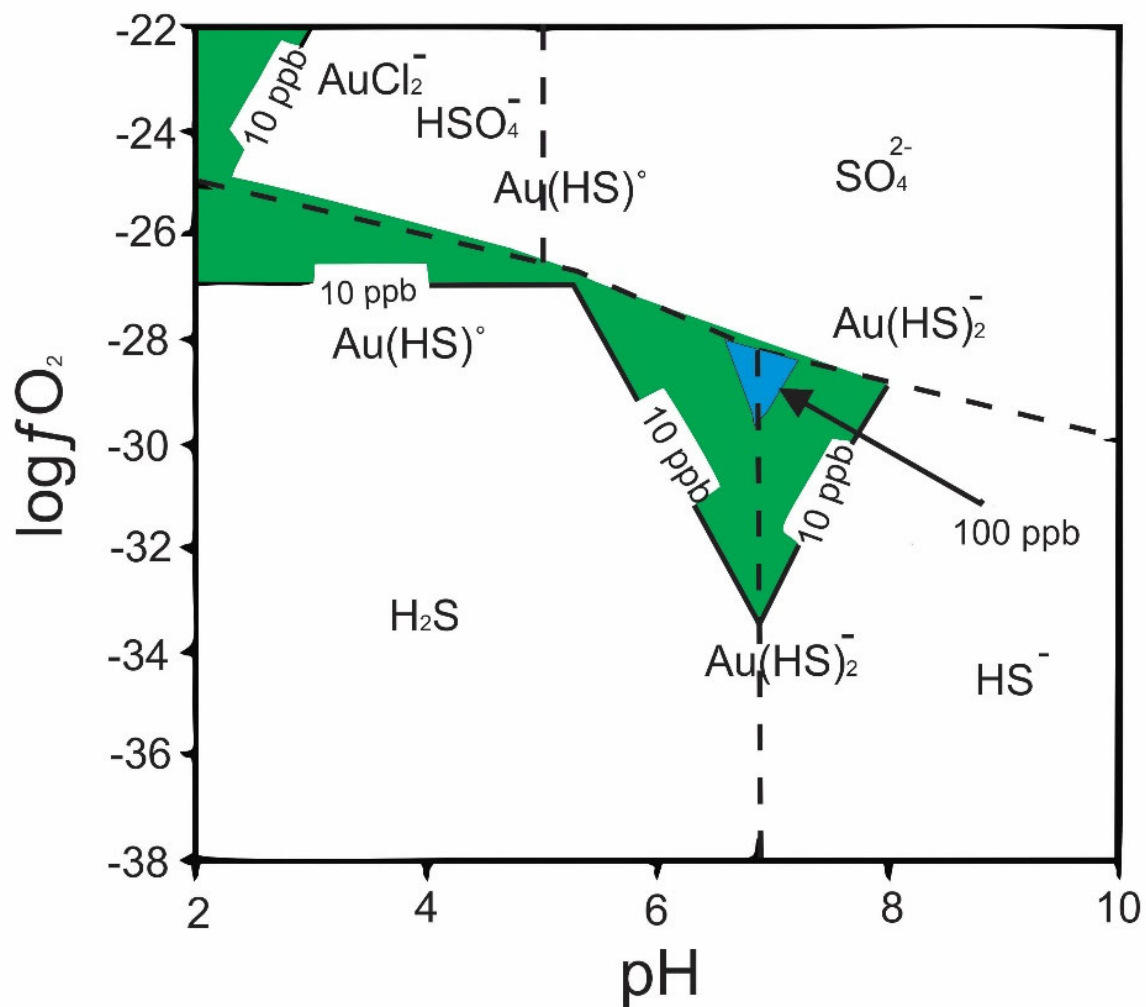


Figure 4: Gold solubility in ppb expressed as a function of log of oxygen fugacity and pH at a constant temperature and pressure of 250°C and 500 bar, respectively. The maximum concentration of $Au(HS)_2^-$ is at the point of equi-predominance of the species H_2S , HS^- , SO_4^{2-} (modified after Williams-Jones et al., 2009).

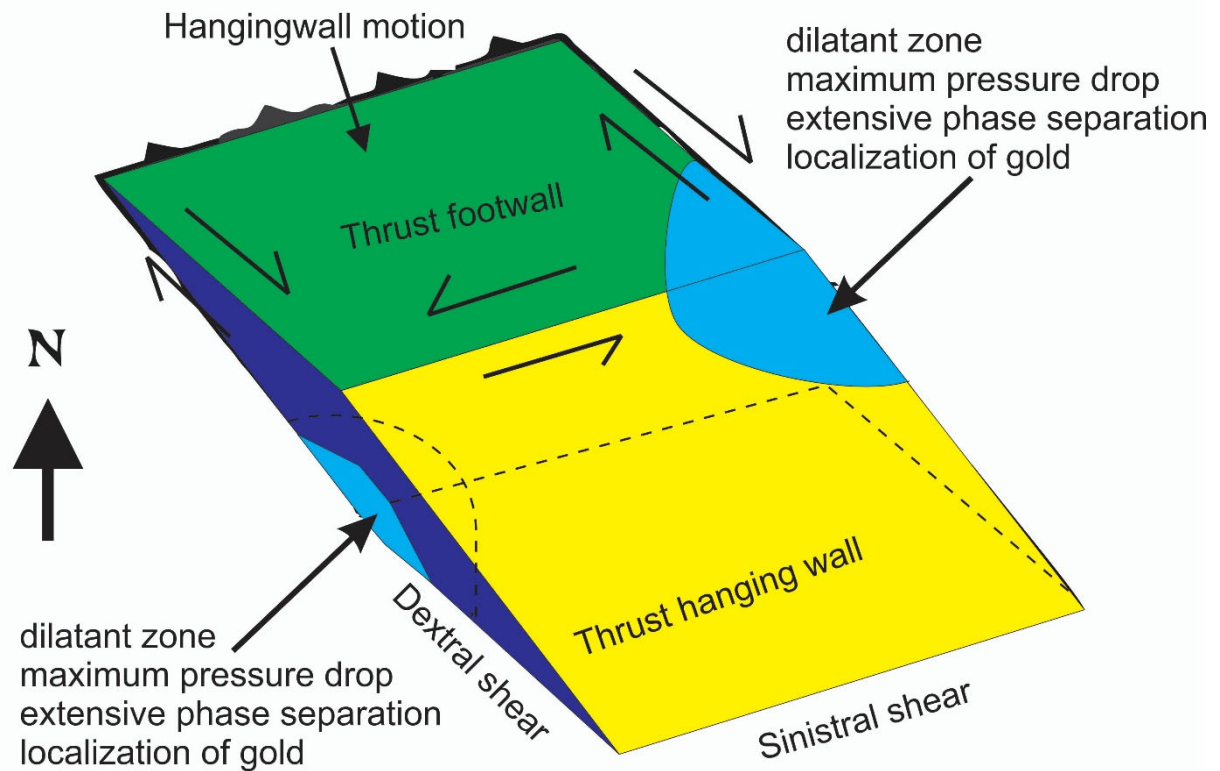


Figure 5: Schematic block diagram displaying zones of inferred maximum dilation where gold is deposited when pressure drops rapidly causing phase separation (modified after Wilkinson and Johnston, 1996).

STABLE ISOTOPE DATA

Stable isotope ratios are important in constraining the origin and evolution of mineralizing fluids in orogenic gold deposits (Huston et al., 2007; Xue et al., 2013). Most orogenic gold deposits have $\delta^{18}\text{O}_{\text{fluid}}$ values between +4 and +15‰, and their $\delta\text{D}_{\text{fluid}}$ values are between -80 and -5‰ (Ho et al., 1992; McCuaig & Kerrich, 1998; Beaudoin & Pitre, 2005; Sarangi et al., 2012). These values overlap with both the magmatic and metamorphic fields (**Fig. 6**; Ridley & Diamond, 2000) and are thus often difficult to interpret.

For example, hydrogen isotope values from orogenic gold deposits in the Ashanti belt have compositions that could be either magmatic or metamorphic, with $\delta\text{D}_{\text{fluid}}$ values ranging from -37 to -53‰ for water extracted from auriferous quartz veins (Oberthür et al., 1996); the $\delta^{18}\text{O}_{\text{fluid}}$ values calculated from the quartz range from 7.4 to 10.2‰ at 350°C, and 9.7 to 12.5‰ at 450°C. These values suggest fluids of magmatic or metamorphic origin or a combination of the two (Mumin et al., 1996; Oberthür et al., 1996); which is similar to fluid $\delta^{18}\text{O}$ values of many Archean orogenic gold deposits (6-10‰; Golding et al., 1989; de Ronde, 1991, 1992).

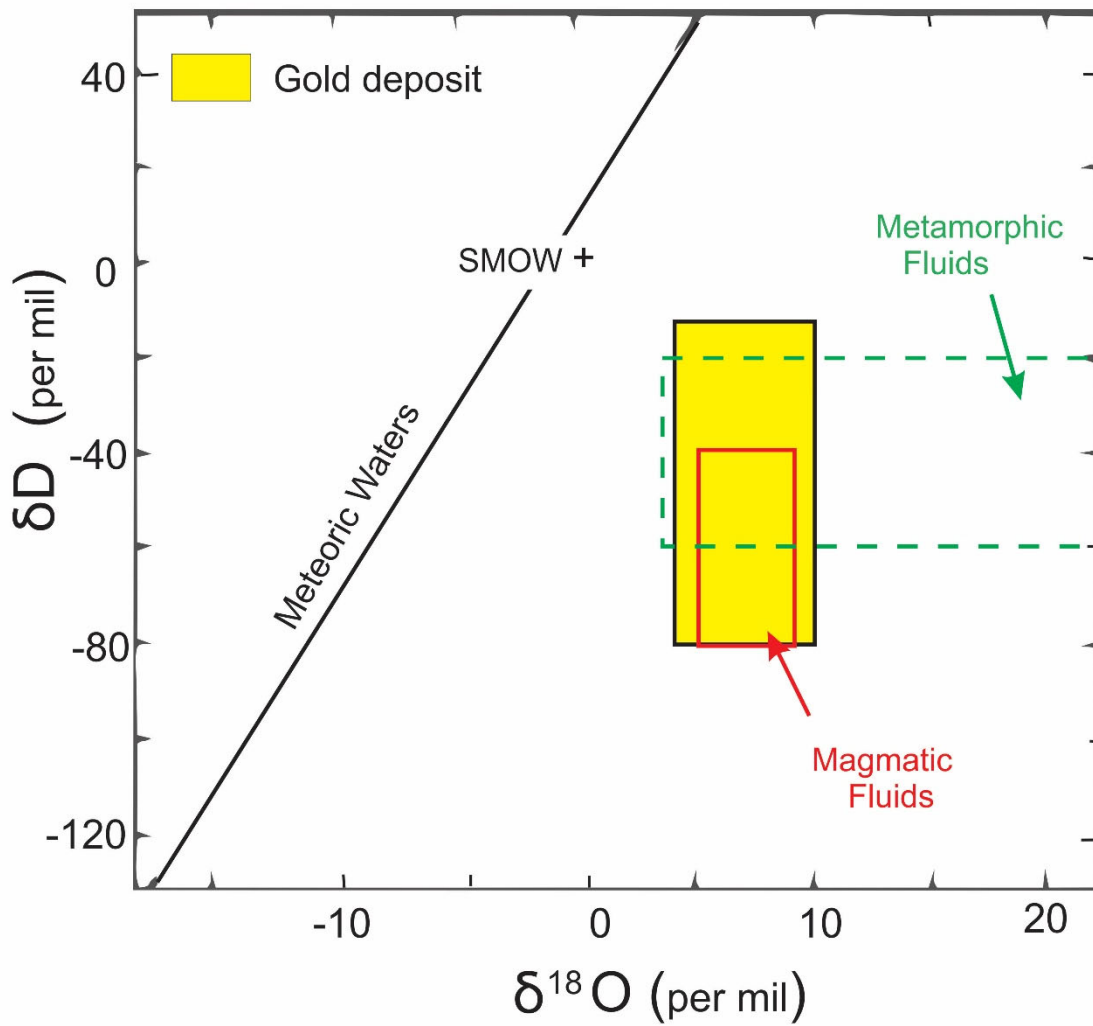


Figure 6: The $\delta^{18}O$ and δD compositions of the ore fluids of orogenic gold. Also shown are the fields for typical magmatic and metamorphic fluids (modified after Ridley & Diamond, 2000).

Carbon isotope compositions can be used to distinguish the major carbon reservoirs for orogenic gold deposits. Seawater-derived carbonate is characterized by average $\delta^{13}\text{C}$ values close to 0 per mil (Golding et al., 1989), whereas magmatic CO_2 has $\delta^{13}\text{C}$ values between -5 and -7 per mil (Pineau et al., 1976; Colvine et al., 1988), and reduced carbon in sedimentary or metamorphic rocks has a mean $\delta^{13}\text{C}$ value of about -25 per mil (Schidlowski et al., 1983; Hoefs, 1987).

Most Archean gold deposits have $\delta^{13}\text{C}_{\text{carb}}$ values in the range of -8 to -3‰, corresponding to $\delta^{13}\text{C}_{\text{fluid}}$ values of -6 to +3‰ (at 400°C), which overlap those of the mantle carbon reservoir (Burrows et al., 1986; Kerrich, 1990; Lüders et al., 2015). The $\delta^{13}\text{C}_{\text{PDB}}$ values of CO_2 extracted from fluid inclusions in quartz veins from the Ashanti belt range from -9.5 to -15.7‰ (Oberthür et al., 1996), suggesting that the hydrothermal fluids reacted with reduced carbon in Birimian metasedimentary rocks in the deeper parts of the hydrothermal system. Carbonaceous matter in Birimian metasedimentary rocks is isotopically light ($\delta^{13}\text{C} = -11.4$ to -28.8 ‰) and falls within the range of organic carbon; petrographic studies also support an organic derivation of the carbonaceous matter (Schidlowski et al., 1983; Hoefs, 1987; Koch, 1991, 1992).

Sulphur isotope data for orogenic gold deposits indicate that the sulphides in most deposits have $\delta^{34}\text{S}$ values within the range of -3 to +9‰ (Steed & Morris, 1997; Ramsay et al., 1998). The corresponding calculated $\delta^{34}\text{S}_{\text{fluid}}$ values range between -1 and +8 (at 450°C), and broadly overlap the values for magmatic rocks and crustal sulfur (Ohmoto & Rye, 1979; Lambert & Donnelly, 1990).

Sulphides associated with gold mineralization in the Ashanti belt are isotopically light with $\delta^{34}\text{S}$ values ranging from -4.6 to -11.4‰ (Osae et al., 1995; Oberthür et al., 1996). Syn-sedimentary to diagenetic sulphides in Birimian metasedimentary rocks are a potential source

for this sulfur, with $\delta^{34}\text{S}$ values ranging from -20.9 to +7.3‰ (Oberthür et al., 1996). These sulphides display a large range of $\delta^{34}\text{S}$ values but a similar median $\delta^{34}\text{S}$ value of -10‰ to that of sulphides related to gold mineralization ($\delta^{34}\text{S}$ value ~ 7 ‰).

Mantle or magma-derived sulfur has $\delta^{34}\text{S}$ values close to 0 per mil (Ohmoto & Rye, 1979). By contrast, sulfate in oceanic environments and in evaporites has $\delta^{34}\text{S}$ values of $+18 \pm 6$ per mil (Lambert & Donnelly, 1990), and sulphide in sediments has $\delta^{34}\text{S}$ values of -15 ± -12 per mil (Schidlowski, 1987; Bierlein et al., 2004).

Sulphur isotopic compositions differ among deposits. Thus, ore-related pyrites from Archean orogenic gold deposits of the Eastern Goldfields Province, Yilgarn Craton have $\delta^{34}\text{S}$ values of -4 to +4‰, and are possibly of magmatic origin (Hagemann, 1992; Hodkiewicz et al., 2009). However, $\delta^{34}\text{S}$ values of Au-bearing auriferous pyrite from the Paleoproterozoic Goukoto deposit in Mali, West Africa, range from 5.8 to 12.8‰, which supports an interpretation involving an evaporitic source for the sulphur (Lambert-Smith et al., 2015). These authors concluded that this source explains the occurrence of the Type 4 hypersaline brine ($\sim 40\text{wt}\%$ NaCl) inclusions in this deposit. In contrast, the Paleoproterozoic Fäboliden deposit in northern Sweden, contains arsenopyrite and pyrrhotite with $\delta^{34}\text{S}$ ranging from -0.9 and +3.6‰ and from -1.5 and +1.9‰, respectively (Bark et al., 2021). This is consistent for a magmatic source for the sulphur.

The large variation of $\delta^{34}\text{S}$ values (-40 to +30‰) which occurred after about 2.4 to 2.0 Ga, is representative of sulphides in sedimentary and exhalative strata (Schidlowski, 1987; Lambert & Donnelly, 1990; Hirdes and Nunoo, 1994). A plausible explanation for the evolution of the terrestrial sulphur cycle is the global transition to an oxidized hydrosphere, increasing oxygenation and resulting in an increase of sulphate reducing bacteria (Schidlowski, 1987; Lambert & Donnelly, 1990).

FLUID MIGRATION

The formation of orogenic gold deposits involves the migration of fluid from the source area to the depositional site through structural discontinuities, such as faults, shear zones and fracture zones (Phillips, 1972; Clark, 1980; Vearncombe & Zelic, 2015). Although it is clear that devolatilization reactions at the greenschist-amphibole transition are likely to generate large volumes of fluid, it is much less clear how the fluids migrate from grain boundaries to fluid conduits (Fyfe et al., 1978).

Cox (2005), noting that the low permeability under these metamorphic conditions impedes fluid flow, emphasized the need for strain to increase permeability and allow fluid movement. Furthermore, because healing and sealing hinder permeability, continuous deformation is crucial to maintain permeability.

The strain theory was suggested by Cox (2005) to explain the migration of fluid from the grain boundaries into fluid conduits, and was linked to the observations of Goldfarb et al., (1991a) of the relationship of gold mineralization in Alaska, USA, to the change in the boundary between the Pacific Plate and the North American plate from convergent to strike-slip. This change in plate motion provided the strain input to release auriferous fluid concurrently over tens of kilometres along a fault zone.

Migration of fluid into a sink depends on two factors: the presence of actively forming faults and shear zones, and a suitable conduit geometry that will lead to fluid focusing and gold deposition. According to Gaboury et al. (2001), irregular or curvilinear/helicoidal fault systems may be the most favourable for the transfer of large volumes of fluids.

Auriferous fluid may travel a vertical distance of ~3 to 10 km to deposit gold and requires channelized flow to reduce wall-rock interaction that may cause pre-mature gold deposition (Phillips & Powell, 2010). However, fluid-rock interaction is often essential for deposition in the sink area and the wallrock of these channelized conduits may also act as sites for mineralization (Robert et al., 1983; Groves & Phillips, 1987).

REGIONAL GEOLOGY

The West Africa Craton (WAC) has an areal extent of about 4.5 million km² and comprises the Reguibat and Leo-Man Shields in the northern and southern segments of the craton, respectively. These shields are separated by the Mesoproterozoic to Paleozoic Taoudeni Basin. Both shields consist of Archean and Paleoproterozoic cratonic blocks that stabilized at ~ 2 Ga (Abouchami et al., 1990; Couëffé & Vecoli, 2011), with the Archean rocks being exposed in the western section and separated from the Paleoproterozoic rocks to the east by major shear zones, namely the Sassandra Fault in the Leo-Man Shield (Ivory Coast) and the Zednes Fault in the Reguibat Shield (Mauritania) (Attoh & Ekwueme, 1997). Age dating and paleomagnetic reconstructions have been used to conclude that during the Paleoproterozoic era, the West Africa Craton and Amazonian Craton in South America were a single domain (Williams & Culver, 1988).

The Archean blocks of the Reguibat domain consists of TTG-type, migmatitic gneiss, and metavolcanic and metasedimentary belts with ultramafic rocks and amphibolite, which were intruded by charnockitic orthogneiss. The migmatitic gneisses have ages between 3.24 and 2.87 Ga based on Sm/Nd model ages, whereas the charnockitic orthogneisses have a weighted mean ²⁰⁷Pb/²⁰⁶Pb age of 2986 ± 8 Ma (Potrel et al., 1998).

The Leo-Man Shield (**Fig. 7**) comprises Archean felsic and mafic gneiss as well as some alkaline igneous complexes associated with narrow greenstone belts of greenschist-amphibolite metamorphic facies. The Paleoproterozoic units of the Leo-Man Shield formed between 2250 and 1800 Ma during the Eburnean Orogeny (Feybesse et al., 2006), and host major gold deposits. These rocks constitute the western units in Ghana known as the Birimian and Tarkwaian supergroups. Birimian rocks form a substantial part of the Leo-Man Shield (Bessoles, 1977) and occupy the southernmost portion of the WAC. Birimian rocks were folded, metamorphosed, and intruded by several generations of granitoids during the Eburnean event at ~2.1 Ga (Bonhomme, 1962). With a few minor exceptions, the Birimian and Tarkwaian supergroups, and the granitoids represent juvenile crustal material, with Sm/Nd model ages of 2.0 to 2.3 Ga (Taylor et al., 1988). Birimian rocks are exposed extensively in Ghana, Cote d'Ivoire, Mali, Niger, Burkina Faso and, to a limited extent, in Senegal, Guinea, and Mauritania. These rocks record an extensive episode of continental crust formation in the early part of the Proterozoic (Attoh & Ekwueme, 1997).

The Eburnean tectono-thermal event affected the supracrustal rocks and syn-volcanic granitoids and is interpreted to have involved a continuous crustal shortening process which took place diachronously from SE to NW (Davis et al., 1994). The geodynamic evolution of the Birimian has been the subject of much debate due to the complex mineralogical, geochemical, and structural signatures of the rocks. Although some researchers believe that the Birimian juvenile crust was produced in a subduction-related environment (e.g., Sylvester & Attoh, 1992; Vidal & Alric, 1994; Ama-Salah et al., 1996; Béziat et al., 2000; Dampare et al., 2004; Soumaila et al., 2004), others are of the opinion that it was generated from plume related magmatism (Abouchami et al., 1990; Boher, 1992) or that it may represent an intracontinental rift (Leube et al., 1990).

The Birimian terranes have been subdivided into the Lower and Upper Birimian units (Junner, 1935), both of which comprise a sequence of sedimentary and volcanoclastic assemblages separated by a series of evenly spaced volcanic belts (Leube et al., 1990). The Lower Birimian is thought to be older than the Upper Birimian as the latter overlies the former (Junner, 1935, 1940) but this interpretation is controversial, and outside Ghana, the Upper Birimian is thought to be older than the Lower Birimian (Papon, 1973; Hottin & Quedrigo, 1975). This issue, however, may have been resolved by revising the stratigraphic synthesis and suggesting that the sedimentary and volcanic units are contemporaneous and are lateral facies equivalents (Breakey & Breakey, 1977; Asiedu et al., 2004). The metavolcanic rocks of the Upper Birimian are dominated by tholeiitic basaltic and andesitic lavas, and the Lower Birimian metasedimentary rocks comprise volcanoclastic rocks, turbidite-related wackes, chert, graphitic schists, argillites and phyllites. It is noteworthy that argillites in the transition zones between the volcanic and sedimentary belts are carbonaceous (Leube et al., 1990).

The volcano-sedimentary terranes were intruded by metaluminous, hornblende-biotite-bearing tonalite-trondhjemite-granodiorite (TTG) granitoids. These intrusions postdate the Birimian volcanic rocks and are referred to as the Dixcove granitoids (Eisenlohr & Hirdes, 1992). The basinal metasedimentary rocks are intruded by peraluminous, two-mica granodiorites with minor hornblende-and-biotite-bearing granodiorites and constitute the Cape Coast granitoids (Eisenlohr & Hirdes, 1992). These granitoids (Dixcove and Cape Coast) are interpreted to have been emplaced synchronously with deformation during the Eburnean tectonothermal event (Eisenlohr & Hirdes, 1992).

The Tarkwaian Group consists of conglomerates, sandstones, quartzites, arkosic rocks and minor shale. Pebbles in the conglomerates are believed to have been derived locally from the Birimian

rocks (Perrouty et al., 2012). This indicates that the latter were uplifted and eroded during the Eburnean orogeny (Junner, 1940; Leube et al., 1990), with the Tarkwaian Group now unconformably overlying the Birimian Supergroup.

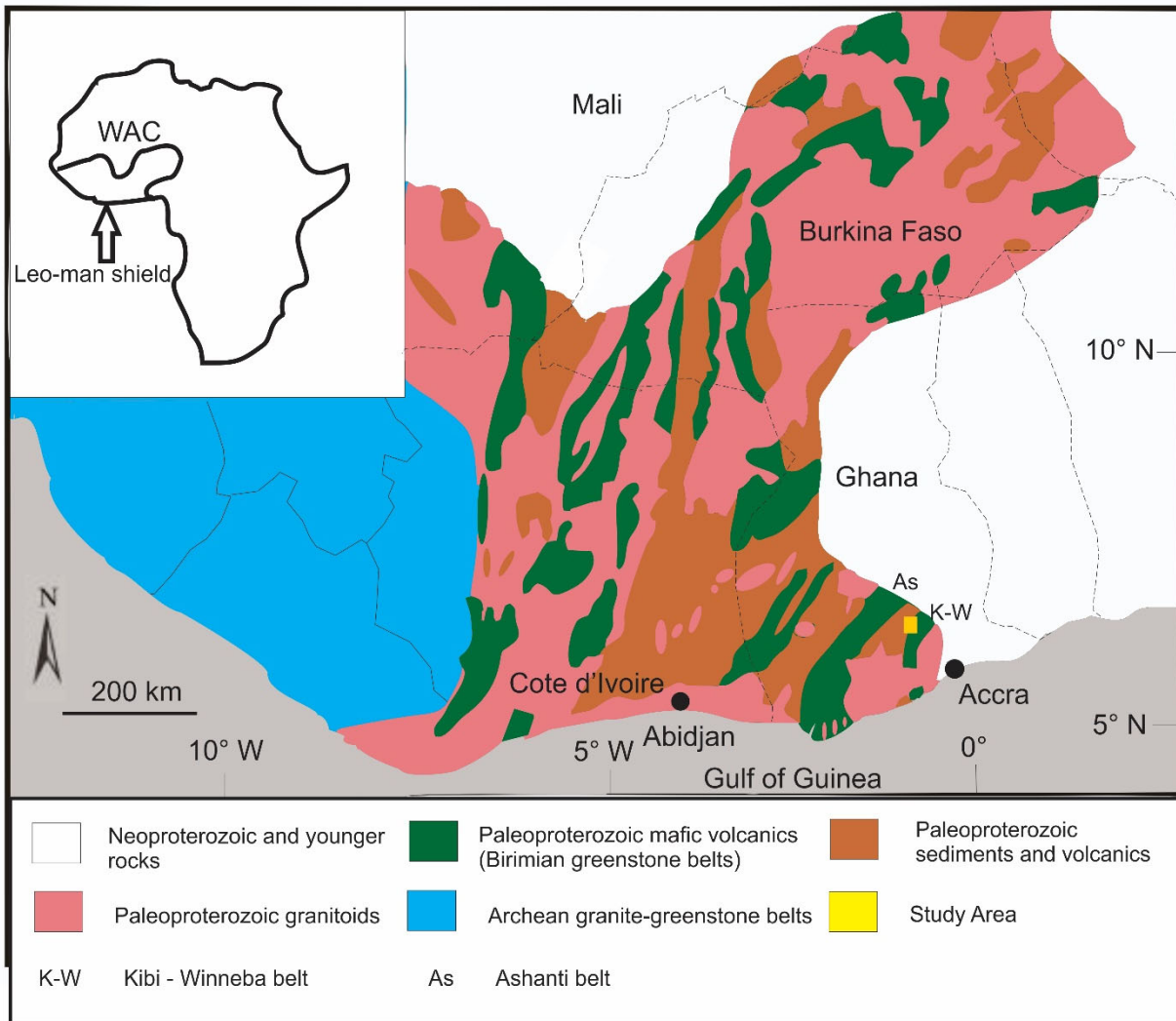


Figure 7: A Geological map of the Leo-Man Shield. The yellow block at the lower right is the study area in the Kibi-Winneba belt (modified after Atttoh et al., 2006).

THE KIBI-GOLD PROJECT

The Kibi Gold Project is located within the Apapam concession, in the Kibi-Winneba greenstone belt of Ghana, to the east of the prolific Ashanti belt, West Africa. The project comprises the Big Bend, Mushroom, South Ridge, East Dyke, Boomerang zone and Double 19 deposits but for the purpose of this study, the research has focussed on the South Ridge, Big Bend and Double 19 deposits.

The concession is dominated by the steep sided Atewa Range and includes a north-east trending, north-west dipping reverse fault, which cuts the Kibi-Winneba belt along the flanks of this range. Northeast-trending shear zones that dip steeply to the east and southeast are also present in the concession and are believed to have formed contemporaneously with the Eburnean tectonothermal event.

The gold mineralization is hosted in quartz diorite that has been altered to ankerite and proximal to the mineralization also has been sulphidized; this alteration is accompanied by weak sericitization. Chloritic alteration is weakly developed distal to the gold mineralization. The latter occurs as native gold in quartz-albite-carbonate veins and also as disseminations in the sulphidized wall rock, where the gold has a close spatial association with pyrrhotite, the dominant sulphide mineral, and also arsenopyrite, which is locally present. In addition to these two sulphide minerals there are minor proportions of chalcopyrite, sphalerite, and pyrite.

OBJECTIVES

The overarching goal of this study is to develop a genetic model for the gold mineralization of the Kibi-Winneba belt. The Kibi gold project is unusual in that the principal sulphide mineral is pyrrhotite, whereas deposits in the prolific Ashanti belt and in many other orogenic deposits elsewhere are dominated by pyrite. Thus, an important issue to address is the significance of the pyrrhotite. More generally, the objectives of the study are to determine 1) the source and nature of the ore fluid, 2) the physico-chemical conditions of ore deposition, 3) the relative importance of magmatic and metamorphic fluids in the system, and 4) the roles of wallrock alteration and arsenopyrite, pyrrhotite and ankerite precipitation in the deposition of gold. In meeting these objectives, the research will develop a model that can be used to explore other parts of the Kibi-Winneba district, and thereby help shift the focus of gold exploration onto one of the least explored Birimian belts in Ghana.

METHODOLOGY

The objectives described above were achieved using the following methods:

- Fieldwork was undertaken on the Apapam concession in Kibi, Ghana. This involved six weeks of logging the core of six representative drill holes, that intersected the South Ridge, Big Bend and Double 19 deposits; the core logging was complemented by geological mapping of trenches and road cuts.
- A total of 120 samples were obtained from the Kibi prospect, from which thirty samples were selected for study.

- Polished thin sections were analyzed petrographically by transmitted and reflective light microscopy to provide a paragenetic sequence of ore-associated minerals and to establish the relationship, between alteration and gold mineralization.
- Mineral compositions were analyzed quantitatively in the Department of Earth and Planetary Sciences at McGill University using a Cameca SX-Five FE electron microprobe on 14 carbon coated, polished thin sections. Spot analyses were carried on gold grains with wavelength dispersive spectrometers (WDS) at 20kv, a beam current of 20nA and a beam size of approximately 1µm for Au, Ag, Bi, Te, Hg and Cu. Spot analyses were carried out on pyrrhotite grains for Fe, S, Co, and Ni and arsenopyrite grains for Fe, S, Co, Ni, Cu, As, Se, Sb, Te and Pb at a voltage of 20 kV, a beam current of 20 nA and a beam size of approximately 5µm. Spot analyses were carried out on ankerite grains for Ca, Mg, Fe, Mn, on chlorite grains for K, Fe, Mg, Si, Mn, Ti and on muscovite grains for K, Al, Si, Fe, Mg. Spot analyses for ankerite, chlorite and muscovite were conducted at a voltage of 15 kV, a beam size ~5 µm and a beam current of 20 nA. The instrument was calibrated using CANMET standards for Pyrite (Fe, S), CoNiAs (Co, Ni, As), Chalcopyrite (Cu), galena (Pb), AgBiSe₂ (Se), Stibnite (sb), CdTe (cd), Pyrrhotite (Fe, S), Bi₂Te₃ (Bi, Te), Au₆₀Ag₄₀ (Au, Ag), Cinnabar (Hg), Spinel (Mg, Al), hematite (Fe), Muscovite (K, Al), Kyanite (Si), Spessartine (Mn), Rutile (Ti), Diopside (Ca, Mg) and Willimite (Mn). The data were corrected using the Pouchou and Pichoir (PAP) model and detection limits determined as described in Ancey et al., (1978).
- Sulphur isotope analyses were conducted on arsenopyrite and pyrrhotite grains in 14 samples to determine the source of the sulphur. Sulphide grains were hand-drilled to obtain 10 mg of powdered residue from the sulphides. The sulfur isotopic composition was

measured using a MAT 253 Stable Isotope Ratio Mass Spectrometer coupled to a Costech ECS 4010 Elemental Analyzer. The $\delta^{34}\text{S}$ values were calculated by normalizing the $^{34}\text{S}/^{32}\text{S}$ ratios to the Vienna Canyon Diablo Troilite (VCDT) international standard. These values are reported using the delta (δ) notation in units of per mil (‰) and are reproducible to 0.2‰. The preparation and analyses were carried out by the Queen's Facility for Isotope Research (QFIR), Queen's University, Kingston.

- Carbon and oxygen isotope analyses were carried out on ankerite grains in 24 samples to ascertain the origin of the fluid. Aliquots of 50–100 μg of powdered samples were analyzed on a Nu Instruments Perspective isotope ratio mass spectrometer equipped with a NuCarb online carbonate preparation device at the McGill University/Geotop Stable Isotope Laboratory. The resulting data were used to calculate the oxygen isotopic composition of H_2O at a temperature of 400°C (See Chapter 2), which was corrected for fractionation with water using the equations of Zheng (1999). The data was used to also calculate for the C and O isotopic composition of CO_2 at a temperature of 400°C , which was corrected using the fractionation factors of Ohmoto & Rye (1979). The data for carbon and oxygen were normalized to V-PDB (Vienna Pee Dee Belemnite) and V-SMOW (Vienna Standard Mean Ocean Water), respectively. The reproducibility of the carbon and oxygen isotope analyses were determined to be better than 0.1‰ based on regular analyses of the in-house standard (UQ6).
- Major and trace element whole rock analysis was conducted by Activation Laboratories Limited in Ancaster, Ontario. Twenty-three samples were crushed to a nominal -2 mm grain-size and then pulverized to at least 95% -105 microns. To ensure there is no Cr or Ni contamination, the mills are made of mild steel. The pulp samples were analyzed for major

elements by ICP-OES (code 4Lithoresearch) and for trace elements by ICP-MS (code 4B); gold was determined by INAA.

- Based on textural relationships and estimated fluid conditions, speciation and phase diagrams were constructed using the HCh computer software (Shvarov and Bastrakov, 1999) to constrain the conditions of formation of the minerals identified using EMPA and petrography.

Thesis Organisation

This thesis has been written in manuscript format and comprises three chapters. The first introductory chapter complements the journal manuscript by presenting an extensive review of the literature, background information pertaining to the focus area, the research objectives and the methods used to reach these objectives. The second chapter is a journal manuscript entitled “Constraints on the genesis of the Kibi-Gold Project deposits in the Kibi-Winneba Belt, Ghana”, which has been prepared for submission to *Economic Geology* and is co-authored by Phoebe Kekeli Nkansa, A.E. (Willy) Williams-Jones and J.R. (Jim) Clark. The manuscript provides a description of the geology and mineralogy of the metasedimentary rocks and quartz diorite rock suite underlying the Kibi-Gold Project area, Ghana, and reports results of whole rock geochemical, mineral major and trace element and mineral isotopic analyses. This information is used in conjunction with phase equilibrium modelling to constrain the physico-chemical conditions of gold mineralization and develop a petrogenetic model for the Kibi-Gold gold deposits. The third chapter contains a summary of the conclusions, the contributions to knowledge and recommendations for future work on the Kibi-Gold Project. The appendices contain the detection limits for the whole rock data and the results of electron microprobe analyses.

References

- Abitty, E.K., Dampare, S.B., Nude, P.M., and Asiedu, D.K. (2016). Geochemistry and petrogenesis of the K-rich 'Bongo-type' granitoids in the Paleoproterozoic Bole–Nangodi greenstone belt of Ghana, *Journal of African Earth Sciences*, Volume 122, Pages 47-62.
- Abouachami, W., Boher, M., Michard, A. and Albarede, F. (1990). A major 2.1 Ga event of mafic magmatism in West Africa: An early stage of crustal accretion. *Journal of Geophysical Research* 95, 17605-17629.
- Allibone, A. H., McCuaig, T., Campbell, H., David, E., Michael, M., Stuart, B., Amanor, D.J., and Gyapong, W. (2002a). *Structural controls on gold mineralization at the Ashanti Deposit, Obuasi, Ghana*. In: Goldfarb, Richard J., and Nielsen, Richard L., (eds.) *Integrated Methods for Discovery: global exploration in the twenty-first century*. Special Publications of the Society of Economic Geologists, 9 . Society of Economic Geologists, pp. 65-93.
- Akabzaa, T.M., Armah, T.E.K and Baneonh-Yakubo, B.K. (2007). Prediction of acid mine drainage generation potential in selected mines in the Ashanti Metallogenic Belt using static geochemical methods. *Environ Geol* 52, 957-964.
- Ama-Salah, I., Liegeois, J.-P., and A. Pouclet, A. (1996). Evolution d'un arc insulaire océanique birimien précoce au Liptako nigérien (Sirba): géologie, géochronologie et géochimie *J. Afr. Earth Sci.*, 22 (3) (1996), pp. 235-254.
- Ancey, M. Bastenaire, F. and Tixier, R. (1978). Applications des méthodes statistiques en microanalyse. In: F. Maurice, L. Meny and R. Tixier (Editors), *Microanalyse microscopie électronique à balayage*. Les Editions de Physique, Paris, pp. 323-349.
- Attoh, K. and Ekwueme, B.N. (1997). The West African Shield. In: de Wit, M. and Ashwal, L.D. (eds.) *Greenstone belts*. Oxford University Press. 517-528.
- Asiedu, D.K., Dampare, S., Asamoah-Sakyi, P., Banoeng-Yakubo, B., S. Osae, Nyarko, B.J.B and J. Manu, J. (2004). Geochemistry of Paleoproterozoic metasedimentary rocks from the Birim diamondiferous field, southern Ghana: implications for provenance and crustal evolution at the Archean-Proterozoic boundary. *Geochem. J.*, 38, pp. 215-228.
- Augustin J., and Gaboury D. (2017). Paleoproterozoic plume related basaltic rocks in the Mana gold district in Western Burkina Faso, West Africa: implications for exploration and the source of gold in orogenic deposits. *Journal Africa Earth Sci.* 129:17–30.
- Augustin, J., and Gaboury, D. (2019). Multi-stage and multi-sourced fluid and gold in the formation of orogenic gold deposits in the world-class Mana district of Burkina Faso - Revealed by LA-ICP-MS analysis of pyrites and arsenopyrites. *Ore Geol Rev.* 104:495–521.
- Augustin, J., Gaboury, D., and Crevier, M. (2017). Structural and gold mineralizing evolution of the world-class orogenic Mana District, Burkina Faso: Multiple mineralizing events during 150 million years. *Ore Geol Rev.* 91: pp. 981–1012.

Bark, G., Boyce, A.J., Fallick, A.E., and Weihed, P. (2021). Fluid and metal sources in the Fäboliden hypozonal orogenic gold deposit, Sweden. *Miner Deposita* Volume 56, pp.425–440. doi.org/10.1007/s00126-020-00977-7.

Barley, M.E., and Groves, D.I. (1992). Supercontinent cycles and the distribution of metal deposits through time. *Geology* 20, 291–294.

Bath, A.B., Walshe, J.L., Cloutier, J., Verrall, M., Cleverley, J.S., Pownceby, M.I., Macrae, C.M., Wilson, N.C., Tunjic, J., Nortje, G.S., and Robinson, P. (2013). Biotite and Apatite as Tools for Tracking Pathways of Oxidized Fluids in the Archean East Repulse Gold Deposit, Australia. *Economic Geology*, Volume 108, Issue 4, pp. 667–690.

Beaudoin, G., and Pitre, D. (2005). Stable isotope geochemistry of the Archean Val-d'Or (Canada) orogenic gold vein field. *Mineralium Deposita*, Volume 40: pp. 59–75. doi 10.1007/s00126-005-0474-z.

Berge, J. (2011). Paleoproterozoic, turbidite-hosted, gold deposits of the Ashanti gold belt (Ghana, West Africa): Comparative analysis of turbidite-hosted gold deposits and an updated genetic model, *Ore Geology Reviews*, Volume 39, Issues 1–2, p. 91-100.

Bessoles, B. (1977). *Géologie de l'Afrique*, Vol. 1, Craton de l'Ouest Africain. *Bur. Rech. Geol. Min., Mdm.*, 88, 402pp.

Béziat, D., Bourges, F., Debat, P., Lompo, M., Martin, F., Tollon, F. (2000). A Palaeoproterozoic ultramafic-mafic assemblage and associated volcanic rocks of the Boromo greenstone belt fractionates originating from island-arc volcanic activity in the West African craton. *Precambrian Res.* 101, 25–47.

Béziat, D., Dubois, M., Debat, P., Nikiéma, S., Salvi, S., and Francis Tollon, F. (2008). Gold metallogeny in the Birimian craton of Burkina Faso (West Africa), *Journal of African Earth Sciences*, Volume 50, Issues 2–4, p. 215-233.

Bierlein, F.P., Arne, D.C., and Ian Cartwright. (2004). Stable isotope (C, O, S) systematics in alteration haloes associated with orogenic gold mineralization in the Victorian gold province, SE Australia. *Geochemistry: Exploration, Environment, Analysis*, 4, 191-211.

Bierlein, F.P., Arne, D.C., Keay, S.M., and McNaughton, N.J. (2001b). Timing relationships between felsic magmatism and mineralization in the central Victorian Gold Province, SE Australia. *Aust J Earth Sci* 48:883–899.

Bierlein, F.P., Groves, D.I., Goldfarb, R.J., and Dubé, B. (2006). Lithospheric controls on the formation of giant orogenic gold deposits. *Mineral Deposita* 40:874–886.

Bishop, D.G. (1972). Progressive Metamorphism from Prehnite-Pumpellyite to Greenschist Facies in the Dansey Pass Area, Otago, New Zealand. *Geological Society of America Bulletin* 83: 3177-3198.

Boher, M., Abouchami, W., Michard, A.F., and Arndt, N.T. (1992). Crustal growth in West Africa at 2.1 Ga. *J. Geophys. Res.*, 97 (B1), pp. 345-369.

Bohlke, J.K. (1982). Orogenic metamorphic-hosted. gold-quartz veins. U.S. Geol. Surv., Open-file Rep. 795, 70–76.

Bonhomme, M. (1962). Contribution à l'étude géochronologique de la plate-forme de l'Ouest Africain, *Ann. Fac. Sci. Clermont-Ferrand*, 5, 62.

Breakey, A. and Breakey, E., 1977. The geology of 1/4 °field sheets of 0603/A3 (117) Goaso SW and 0603/A4 (118) Goaso SE. Ghana Geol. Surv. Dept., Accra, 95 pp.(unpublished).

Brown, P.E., and Lamb, W.M. (1989). P–V–T properties of fluids in the system $\text{H}_2\text{O} \pm \text{CO}_2 \pm \text{NaCl}$: new graphical presentations and implications for fluid inclusion studies. *Geochim. Cosmochim. Acta* 53, 1209–1221.

Browning, P., Groves, D.I., Blockley, J.G., and Rosman, K.J.R. (1987). Lead isotope constraints on the age and source of gold mineralization in the Archean Yilgarn Block, Western Australia. *Economic Geology*, Volume 82, Issue 4, pp. 971–986. doi: <https://doi.org/10.2113/gsecongeo.82.4.971>

Burrows, D.R., Wood, P.C.A., and Spooner, E.T.C. (1986). Carbon isotope evidence for a magmatic origin for Archean gold-quartz vein deposits: *Nature*, v. 321, p. 851-854.

Cameron, E.M. (1988). Archean gold-relation to granulite formation and redox zoning in the crust. *Geology* 16:109–112.

Channer, D.M.D. and Spooner, E.T.C. (1994). Combined gas and ion chromatographic analysis of fluid inclusions; applications to Archean granite pegmatite and gold-quartz vein fluids: *Geochimica et Cosmochimica Acta*, v. 58, p.1101-1118.

Clark, M.E. (1980). Localization of gold, Mt Charlotte, Kalgoorlie, Western Australia Unpublished BSc (Hons.) thesis, Univ. Western Australia, 128 pp.

Clark, M.E., Carmichael, D.M., Hodgson, C.J. and Fu, M. (1989). Wallrock alteration, Victory gold mine, Kambalda, Western Australia: processes and P-T- X_{CO_2} conditions of metasomatism: *Economic Geology Monograph* 6, p. 445-459.

Cline, J.S., and Bodnar, R.J. (1991). Can economic porphyry copper mineralization be generated by a typical calcalkaline melt?: *Journal of Geophysical Research*, v. 96, p.8113-8126.

Colvine, A.C., Fyon, J.A., Heather, K.B., Marmont, S., Smith, P.M., and Troop, D.G. (1988). Archean lode-gold deposits in Ontario: Ontario Geological Survey Miscellaneous Papers, no.139, 136 p.

Condie, K.C. (2004). Supercontinents and superplume events: distinguishing signals in the geologic record. *Phys Earth Planet Inter* 146:319–332.

Connolly, J.A.D. (2010). The mechanics of metamorphic fluid expulsion. *Element*. 6:165–172.

Connolly, J.A.D., and Cesare, B. (1993). C-O-H-S fluid composition and oxygen fugacity in graphitic metapelites. *Journal of Metamorphic Geology*, 11, 379–388.

Couëffé, R., and Vecoli, M. (2011). New sedimentological and biostratigraphic data in the Kwahu Group (Meso- to Neo-Proterozoic), southern margin of the Volta Basin, Ghana: Stratigraphic constraints and implications on regional lithostratigraphic correlations, *Precambrian Research*, Volume 189, Issues 1–2, pg. 155-175.

Cox, S.F. (2005). Coupling between deformation, fluid pressures, and fluid flow in ore-producing hydrothermal systems at depth in the crust. *Economic Geology*, 100th Anniversary Volume, 39–75.

Cox SF. (2016). Injection-driven swarm seismicity and permeability enhancement: implications for the dynamics of hydrothermal ore systems in high fluid-flux, overpressured faulting regimes - An invited paper. *Econ Geol.* 111:559–587.

Dabo, M., Aïfa, T., Miyouna, T., and Diallo, D.A. (2016). Gold mineralization paragenesis to tectonic structures in the Birimian of the eastern Dialé-Daléma Supergroup, Kédougou-Kéniéba Inlier, Senegal, West African Craton, *International Geology Review*, volume 58, Issue 7, p. 807-825.

Hart, Craig and Goldfarb, Richard. (2005). Distinguishing intrusion-related from orogenic gold systems. *Proceedings of Scientific Conference on Minerals*, New Zealand.

Davis, D.W., Hirdes, W., Schaltegger, U., and E.A. Nunoo, E.A. (1994). U–Pb constraints on deposition and provenance of Birimian and gold-bearing Tarkwaian sediments in Ghana, West Africa. *Precambrian Res.*, 67.pp. 89-107.

Dampare, S.B., Asiedu, D.K., Osae, S., Manu, J., Banoeng-Yakubo, B. (2004). Geochemistry of Paleoproterozoic metavolcanic rocks from the southern Ashanti volcanic belt, Ghana: Petrogenetic and tectonic setting implications. *Precambrian Research* 162 (2008) 403–423.

Diamond, L.W. (1990). Fluid inclusion evidence for P-V-T-X evolution of hydrothermal solutions in late-Alpine gold quartz veins at Brusson, Val d'Ayas, Northwest Italian Alps: *American Journal of Science*, v. 290, p. 912-958.

Eggler, D.H., and Kadik, A.A., 1979, The system NaAlSi₃O₈- H₂O-CO₂ to 20 kbar pressure: I. Compositional and thermodynamic relations of liquids and vapors coexisting with albite: *American Mineralogist*, v. 64, p. 1036-1048.

- Eisenlohr, B.N and Hirdes, W. (1992). The structural development of the early Proterozoic Birimian and Tarkwaian rocks of southwest Ghana, West Africa. *Journal of African Earth Sciences*, Vol. 14, No. 3, pp. 313-325.
- Elmer, F.L., White, R.W. and Powell, R., 2006. Devolatilization of metabasic rocks during greenschist–amphibolite facies metamorphism. *Journal of Metamorphic Geology*, 24, 497–513.
- Feybesse, J.L., Billa, M., Guerrot, C., Duguey, E., Lescuyer, J.L., Milesi, J.P., and Bouchot, V. (2006). The paleoproterozoic Ghanaian province: Geodynamic model and ore controls, including regional stress modeling, *Precambrian Research*, Volume 149, Issues 3–4, Pages 149-196. doi.org/10.1016/j.precamres.2006.06.003.
- Fripp, R. E. P. (1976a). Gold metallogeny in the Archaean of Rhodesia, in Windley, B. F., ed., *The early history of the earth*: London, Wiley, p. 455-466.
- Fripp, R. E. P. (1976b). Stratabound gold deposits in Archean banded iron-formation, Rhodesia: *ECON. GEOL.*, v. 71, p. 58-75.
- Fu, B., and Touret, J.L.R. (2014.) From granulite fluids to quartz-carbonate megashear zones—the gold rush. *Geosci Front* 5:747–758.
- Fyfe, W.S. and Henley, R.W. (1973). Some thoughts on chemical transport processes, with particular reference to gold. *Mineral Science and Engineering*, 5, 295–303.
- Fyfe, W.S., Price, N.J., and Thompson, A.B. (1978). *Fluids in the Earth's Crust*. Elsevier, Amsterdam, 383 pp.
- Fyon, J.A., Schwarcz, H.P., and Crocker, J.H. (1984). Carbonatization and gold mineralization in the Timmins area, Abitibi greenstone belt—genetic links with Archean mantle CO₂-degassing and lower crust granulitization. *Geol Assoc Can Progr with Abstracts* 9:65.
- Gaboury, D. (2013). Does gold in orogenic deposits come from pyrite in deeply buried carbon-rich sediments?: Insight from volatiles in fluid inclusions. *Geology*. 41:1207–1210.
- Gaboury, D. (2019). Parameters for the formation of orogenic gold deposits, *Applied Earth Science*, 128:3, 124-133.
- Gaboury D, Carrier A, Crevier M, Pelletier C., and Sketchley, D.A. (2001). Predictive distribution of fault-fill and extensional veins; example from the Sigma gold mine, Abitibi Subprovince, Canada. *Econ Geol*. 96:1397–1405.
- Gammons, C.H., and Williams-Jones, A.E. (1995). Hydrothermal geochemistry of electrum: Thermodynamic constraints: *Economic Geology*, v. 90, p. 420–432.
- Gammons, C.H., and Williams-Jones, A.E. (1997). Chemical mobility of gold in the porphyry-epithermal environment. *Economic Geology* 92: 45-59.

Gebre-Mariam, M., Hagemann, S.G., and Groves, D.I. (1995). A classification scheme for epigenetic Archean lode-gold deposits: *Mineralium Deposita*, v.30, p. 408–410.

Goldberg, I. (1964). Notes on the relationship between gold deposits and structure in Southern Rhodesia, in Houghton, S. H., ed., *The geology of some ore deposits in southern Africa*: Johannesburg, Geol. Soc. South Africa, v. 2, p. 9-13.

Goldfarb, R.J., Baker, T., Dube, B., Groves, D.I., Hart, C.J.R., and Gosselin, Patrice. (2005). *Distribution, character, and genesis of gold deposits in metamorphic terranes*. In: Hedenquist, J.W., Thompson, J.F.H., Goldfarb, R.G., and Richards, J.P., (eds.) *Economic geology 100th Anniversary volume*. Society of Economic Geologists, Littleton, Colorado, USA, pp. 407-450.

Goldfarb, R.J., and Groves, D.I. (2015). Orogenic gold: common or evolving fluid and metal sources through time. *Lithos* 223:2–26.

Goldfarb, R.J., Groves, D.I., and Gardoll, S. (2001). Orogenic gold and geologic time: A global synthesis: *Ore Geology Reviews*, v. 18, p. 1–75.

Goldfarb, R.J., Leach, D.L., Rose, S.C., and Landis, G.P. (1989). Fluid Inclusion Geochemistry of Gold-Bearing Quartz Veins of the Juneau Gold Belt, Southeastern Alaska: Implications for Ore Genesis: *Economic Geology Monograph no. 6*, p. 363-375.

Goldfarb, R.J., and Santosh, M. (2014). The dilemma of the Jiaodong gold deposits: are they unique? *Geosci Front* 5:139–153.

Goldfarb, R.J., Snee, L.W., Miller, L.D., and Newberry, R.J. (1991a). Rapid dewatering of the crust deduced from ages of mesothermal gold deposits. *Nature*, 354, 296–298.

Golding, S.D., McNaughton, N.J., Barley, M.E., Groves, D.I., Ho, S.E., Rock, N.M.S., and Turner, J.V. (1989). Archean carbon and oxygen reservoirs their significance for fluid sources and circulation paths for Archean mesothermal gold deposits of the Norseman-Wiluna Belt, Western Australia: *Economic Geology Monograph 6*, p. 376-388.

Groves, D.I. (1993). The crustal continuum model for late-Archaean lode-gold deposits of the Yilgarn Block, Western Australia. *Miner. Deposita* 28, 366–374.

Groves, D., Barnicoat, A. C., Barley, M., Cassidy, K. F., Fare, R. J., Hagemann, S. G., Ho, S. E., Hronsky, J. M. A., Mikucki, E. J., Mueller, A. G., Mcnaughton, N., Perring, C. S., Ridley, J. R., and Vearncombe, J. R. (1992). Sub-greenschist to granulite-hosted Archaean lode-gold deposits: a depositional continuum from deep-sourced hydrothermal fluids in crustal-scale plumbing systems, *The Archaean Terrains: Processes and Metallogeny* (eds. Glover, J.E., Ho S.E.), Perth: Vanguard Press, 325-337.

Groves, D.I., Goldfarb, R.J., Gebre-Mariam, M., Hagemann, S.G., and Robert, F. (1998). Orogenic gold deposits: A proposed classification in the context of their crustal distribution and relationship to other gold deposit types: *Ore Geology Reviews*, v. 13, p. 7–27.

Groves, D.I., Goldfarb, R.J., Robert, F., and Hart, C.J.R. (2003). Gold deposits in metamorphic belts: Overview of current understanding, outstanding problems, future research, and exploration significance. *Econ Geol.* 98:1–29.

Groves, D.I., and Phillips, G.N. (1987). The genesis and tectonic control on Archaean gold deposits of the Western Australian Shield: a metamorphic-replacement model. *Ore Geology Reviews*, volume. 2, pg. 287-322.

Groves, D.I., Phillips, G.N., Ho, S.E., Houstoun, S.M., and Standing, C.A. (1987). Craton scale distribution of Archean greenstone gold deposits—predictive capacity of the metamorphic model. *Econ Geol* 82:2045–2058

Groves, D.I., and Santosh, M. (2016). The giant Jiaodong gold province: the key to a unified model for orogenic gold deposits? *Geosc Front* 7:409–418

Groves, D.I., Santosh, M., Deng, J., Wang, Q., Yang, L., and Zhang, L. (2020). A holistic model for the origin of orogenic gold deposits and its implications for exploration. *Miner Deposita* **55**, 275–292.

Hagemann, S.G., Groves, D. I., Ridley, J.R., and Vearncombe, J.R. (1992). The Archean lode gold deposits at Wiluna, Western Australia; high-level brittle-style mineralization in a strike-slip regime. *Economic Geology*; 87 (4): 1022–1053. doi.org/10.2113/gsecongeo.87.4.1022.

Hagemann, S.G., Gebre-Mariam, M., and Groves, D.I. (1994). Surface-water influx in shallow-level Archean lode-gold deposits in Western, Australia. *Geology* 1994, Volume 22, Issue 12: pp. 1067–1070. doi.org/10.1130/0091-7613.

Hayashi, K., and Ohmoto, H. (1991). Solubility of gold in NaCl-and H₂S-bearing aqueous solutions at 250–350°C, *Geochimica et Cosmochimica Acta*, Volume 55, Issue 8, pg. 2111-2126. doi.org/10.1016/0016-7037(91)90091-I.

Hazarika, P., Upadhyay, D., Mishra, B., Borah, P., and Abhinay, K. (2021). Modelling B-release and isotopic fractionation during metamorphic dehydration of basalt and pelite: Implications for the source of mineralizing fluid in greenstone-hosted orogenic gold deposits, *Geochimica et Cosmochimica Acta*, Volume 304, p. 83-100.

Heiligmann, M., Williams-Jones, A.E., and Clark, J.R. (2008). The Role of Sulfate-Sulfide-Oxide-Silicate Equilibria in the Metamorphism of Hydrothermal Alteration at the Hemlo Gold Deposit, Ontario. *Economic Geology*; 103 (2): 335–351.

Helt, K.M ., Williams-Jones, A.E., Clark, J.R., Wing, B.A., Wares, R.B. (2013). Constraints on the Genesis of the Archean Oxidized, Intrusion-Related Canadian Malartic Gold Deposit, Quebec, Canada. *Economic Geology* 2014;109 (3): 713-735.doi.org/10.2113/econgeo.109.3.713.

Hirdes, W., and Nunoo, E.A. (1994). The Proterozoic paleoplacers at Tarkwa gold mine/SW Ghana-sedimentology, mineralogy, and precise age dating of the Main reef and West reef and bearing of the investigations on source area aspects: *Geologisches Jahrbuch*, ser, D, Volume 100, pp.317-380.

Ho, S.E., Groves, D.I., McNaughton, N.J., and Mikucki, E.J. (1992). The source of ore fluids and solutes in Archaean lode-gold deposits of Western Australia: *Journal of Volcanology and Geothermal Research*, v. 50, p. 173-196.

Hodgson, C.J. (1993). Mesothermal lode-gold deposits. In: Kirkham RV, Sinclair WD, Thorpe RI, Duke JM (eds) *Mineral deposit modelling, geological association of Canada special paper 40*, pp 635–678.

Hodgson, C.J., and MacGeehan, P.J. (1982). Geological characteristics of gold deposits in the Superior Province of the Canadian Shield, in Hodder, R.W., and Petruk, W., eds., *Geology of Canadian Gold Deposits, Proceedings of the CIM Gold Symposium: Institute of Mining and Metallurgy*, p. 211-229.

Hodkiewicz, P.F., Groves, D.I., Davidson, G.J., Weinberg, R.F., and Hagemann, S.G. (2009). Influence of structural setting on sulphur isotopes in Archean orogenic gold deposits, Eastern Goldfields Province, Yilgarn, Western Australia. *Miner Deposita* volume 44, p. 129-150 (2009).

Hoefs, J. (1987). *Stable isotope geochemistry*: Berlin, Springer-Verlag, 241 p.

Hottin, G., and Quedraogo, O. F. (1975). Notice explicative de la carte geologique and 1000 000 de la Republic de Haute Volta, 58 p. Dir. Geol. Min. de la Rep. Haute Volta, Quagadougou.

Hronsky, J.M.A., Cassidy, K.F., and Grigson, M.W. (1990). Deposit and mine scale structure, Gold Deposits of the Archaean Yilgarn Block, Western Australia: *Nature, Genesis and Exploration Guides*, Perth: Vanguard Press, 1990, 38—59.

Huston, D.L., Vandenberg, L., Wygralak, A.S., Mernagh, T.P., Leon Bagas, L., and Andrew Crispe, A., and Lambeck, A., Cross, A., Fraser, G., Williams, N., Worden, K., Meixner, T., Goleby, B., Jones, L., Lyons, P., Maidment, D. (2007). Lode-gold mineralization in the Tanami region, northern Australia. *Miner Deposita* **42**, 175–204. doi.org/10.1007/s00126-006-0106-2.

Hutchinson, R.W., and Burlington, J.L. (1984). Some broad characteristics of greenstone belt gold lodes. In: Foster RP (ed) *Gold '82—the Geology, Geochemistry and Genesis of Gold Deposits* Rotterdam Balkema, pp 339–372.

Hutchinson, R. W., Ridler, R. H., and Surfel, G. G. (1971). Metallogenic relationships in the Abitibi belt, Canada: A model for Archean metallogeny: *Canadian Inst. Mining Metall. Trans.*, v. 74, p. 106- 115.

Junner, N. R. (1935). Gold in the Gold Coast. *Gold Coast. Geol. Surv. Mem. 4*, 67 p.

Junner, N. R. (1940). Geology of the Gold Coast and Western Togoland. *Gold Coast Geol. Surv. Bull* II, 40.

Kawagucci, S., Ueno, Y., Takai, K., Toki, T., Ito, M., Inoue, K., Makabe, A., Yoshida, N., Muramatsu, Y., Takahata, N., Sano, Y., Narita, T., Teranishi, G., Obata, H., Nakagawa, S., Nunoura, T., and Toshitaka Gamo, T. (2013). Geochemical origin of hydrothermal fluid methane in sediment-associated fields and its relevance to the geographical distribution of whole hydrothermal circulation. *Chemical Geology*, Volume 339, pp. 213-225.

Kent, A.J.R & S. G. Hagemann, S.G. (1996). Constraints on the timing of lode-gold mineralization in the Wiluna greenstone belt, Yilgarn Craton, Western Australia, *Australian Journal of Earth Sciences*, Volume 43: Issue 5, pp. 573-588, doi: 10.1080/08120099608728278

Kerr, M.J., Hanley, J.J., Kontak, D.J., Morrison, G.G., Petrus, J., Fayek, M., and Zajacz, Z. (2018). Evidence of upgrading of gold tenor in an orogenic quartz-carbonate vein system by late magmatic-hydrothermal fluids at the Madrid Deposit, Hope Bay Greenstone Belt, Nunavut, Canada, *Geochimica et Cosmochimica Acta*, Volume 241, pp. 180-218.

Kerrick, R., 1977. Yellowknife mineralization: the product of metamorphic degassing. *Geological Society of America, Program with Abstracts*, 9, pp. 1048–1049.

Kerrick, R. (1983). Geochemistry of gold deposits in the Abitibi Greenstone Belt. *Canadian Instit Min Metall Spec* 27:75 p.

Kerrick, R. (1989). Archean gold–relationship to granulite formation or felsic intrusions? *Geology* 17:1011–1015.

Kerrick, R. (1990). Carbon-isotope systematics of Archean Au-Ag vein deposits in the Superior Province: *Canadian Journal of Earth Sciences*, v. 27, p. 40-56.

Kerrick, R. (1993). Perspectives on genetic models for lode-gold deposits. *Miner. Deposita* 28, 362–365.

Kerrick, R., Goldfarb, R.J., Groves, D.I., and Garwin, S. (2000). The geodynamics of world-class gold deposits: characteristics, space-time distribution, and origins. In: Hagemann SG, Brown PE (eds) *Gold in 2000*, vol 13. Society of Economic Geologists Reviews in Economic Geology, pp 501–551.

Kerrick, R., and Wyman, D.A. (1990). The geodynamic setting of mesothermal gold deposits: An association with accretionary tectonic regimes. *Geology* 18, 882–885.

Kerrick, R., and Wyman, D. (1994). The mesothermal gold–lamprophyre association: significance for an accretionary dynamic setting, supercontinental cycles, and metallogenic processes: *Mineralogy and Petrology*, v. 51, p. 147-172.

Kishida, A., and Kerrich, R. (1987). Hydrothermal alteration zoning and gold concentration at the Kerr-Addison Archean lode gold deposit, Kirkland Lake, Ontario. *Economic Geology*, Volume 82, Issue 3, pp. 649–690. doi.org/10.2113/gsecongeo.82.3.649

Kisters, A.F.M., Kolb, J., and Meyer, F.M. (1998). Gold mineralization in high-grade metamorphic shear zones of the Renco Mine, southern Zimbabwe. *Economic Geology*, Volume 93, Issue 5, pp. 587–601. doi.org/10.2113/gsecongeo.93.5.587.

Klein, E.L. (2014). Ore fluids of orogenic gold deposits of the Gurupi Belt, deposition sources, and mechanisms of Au transport and Brazil: a review of the physico-chemical properties. Geological Society, London, Special Publications, Volume 402, pp. 121-145. doi.org/10.1144/SP402.2.

Klemd, R., Huenken, U., and Olesch, M. (1996). Fluid composition and source of early Proterozoic lode gold deposits of the Birimian volcanic belt, West Africa: *International Geology Review*, v. 38, pp. 22-32.

Koch, J. (1991). Organisch-petrographische Untersuchung von Proben mit kohligter Substanz aus der Ashanti Gold Mine, Obuashi, Ghana. Internal Rep. BGR Hannover, Lab. No. K 18654-663.

Koch, J. (1992). Reflexionsmessung an organischen Einschlüssen in Arsenkies; Ashanti gold mine/ Ghana: Hannover, Bundesanstalt für Geowissenschaften und Rohstoffe, Internal Report, Laboratory K 19 289, 2p.

Kolb, J., Dziggel, A., and Bagas, L. (2015c). Hypozonal lode gold deposits: a genetic concept based on a review of the New Consort, Renco Hutti, Hira Buddini, Navachab, Nevoria and The Granites deposits. *Precambrian Res* volume 262, pp. 20–44.

Kolb, J., Rogers, A., and Meyer, F.M. (2005a). Relative timing of deformation and two-stage gold mineralization at Hutti mine, Dharwar Craton, India. *Mineral Deposita* volume 40, p. 156–174.

Kříbek, B., Sýkorová, I., Machovič, V., Knésl, I., Laufek, F., and Zachariáš, J. (2015). The origin and hydrothermal mobilization of carbonaceous matter associated with Paleoproterozoic orogenic-type gold deposits of West Africa, *Precambrian Research*, Volume 270, pp. 300-317.

LaFlamme, C., Sugiono, D., Thébaud, N., Caruso, S., Fiorentini, M., Selvaraja, V., Jeon, H., Voute, F., and Martin, L. (2018). Multiple sulfur isotopes monitor fluid evolution of an Archean orogenic gold deposit, *Geochimica et Cosmochimica Acta*, Volume 222, Pages 436-446.

Lambert, I.B., and Donnelly, T.H. (1990). The palaeoenvironmental significance of trends in sulphur isotope compositions in the Precambrian: a critical review, *in* Herbert, H.K., and Ho, S.E., eds., *Stable Isotopes and Fluid Processes in Mineralization: Geology Department and University Extension, The University of Western Australia Publication*, Volume 23, pp. 260-268.

Lambert-Smith, J.S., Lawrence, D.M., Vargas, C.A., Boyce, A.J., Treloar, P.J., and Herbert, S. (2016). The Gounkoto Au deposit, West Africa: Constraints on ore genesis and volatile sources

from petrological, fluid inclusion and stable isotope data, *Ore Geology Reviews*, Volume 78, pp. 606-622. doi.org/10.1016/j.oregeorev.2015.10.025.

Large, R., Thomas, H., Craw, D., Henne, A., and Henderson, S. (2012). Diagenetic pyrite as a source for metals in orogenic gold deposits, Otago Schist, New Zealand. *New Zealand J Geol Geophys*. Volume 55, pp. 137–149.

Large, R.R., Maslennikov, V.V., Robert, F., Danyushevsky, L.V., and Chang, Z. (2007). Multistage sedimentary and metamorphic origin of pyrite and gold in the giant Sukhoi Log deposit, Lena gold province, Russia. *Econ Geol*. Volume 102, pp. 1233–1267.

Large, R.R., Bull, S.W., and Maslennikov, V.V. (2011) A carbonaceous sedimentary source-rock model for Carlin-type and orogenic gold deposits. *Econ Geol* 106:331–358.

Large, R.R., Danyushevsky, L.V., Hollit, C., Maslennikov, V., Meffre, S., Gilbert, S., Bull, S., Scott, R., Emsbo, P., Thomas, H., and Foster, J. (2009). Gold and trace element zonation in pyrite using a laser imaging technique: implications for the timing of gold in orogenic and Carlin-style sediment-hosted deposits. *Econ Geol* Volume 104:pp. 635–668.

Lawrence, D.M., Treloar, P.J., Rankin, A.H., Boyce, A., and Harbidge, P. (2013). A fluid inclusion and stable isotope study at the Loulo mining district, Mali, West Africa: implications for multifluid sources in the generation of orogenic gold deposits. *Econ. Geol.* 108, Issue 2, pp. 229–257.

Le Mignot, E., Siebenaller, L., Béziat, D., André-Mayer, A.E., Reisberg, L., Salvi, S., Velasquez, G., Zimmermann, C., Naré, A., and Franceschi, G. (2017). The Paleoproterozoic Copper-Gold Deposits of the Gaoua District, Burkina Faso: Superposition of Orogenic Gold on a Porphyry Copper Occurrence?. *Economic Geology*. 112 (1): 99–122.

Leube, A., Hirdes, W., Mauer, R. and Kesse, G. O. (1990). The early Proterozoic Birimian Supergroup of Ghana and some aspects of its associated gold mineralization. *Precambrian Res.* 46, 139-165.

Lewis, B. R. (1965). Gold deposit of Hill 50 mine: Commonwealth Mining Metall. Cong., 8th, Australia and New Zealand, Proc., p. 98-100.

Lüders, V., Klemm, R., Oberthür, T., and Birgit Plessen, B. (2015). Different carbon reservoirs of auriferous fluids in African Archean and Proterozoic gold deposits? Constraints from stable carbon isotopic compositions of quartz-hosted CO₂-rich fluid inclusions. *Miner Deposita* volume 50: pp.449–454.

McCuaig, T.C., and Kerrich, R. (1998). P-T-t deformation fluid characteristics of lode gold deposits: evidence from alteration systematics: *Ore Geology Reviews*, v. 12, p. 381-453.

McNaughton, N.J., and Groves, D.I., 1996, A review of Pb isotope constraints on the genesis of lode-gold deposits in the Yilgarn Craton, Western Australia: *Journal of the Royal Society of Western Australia*, v. 79, p. 123-129.

Mernagh, T.P., and Bierlein, F.P. (2008). Transport and Precipitation of Gold in Phanerozoic Metamorphic Terranes from Chemical Modeling of Fluid-Rock Interaction. *Economic Geology*, volume 103, Issue 8, pp. 1613–1640.

Milesi, J.P., Ledru, P., Feybesse, J.L., Dommanget, A., and Marcoux, E. (1992). Early Proterozoic ore deposits and tectonics of the Birimian orogenic belt, West Africa. *Precam. Res.* Volume 58, pp. 305-344.

Mishra, B., Pruseth, K.L., and Hazarika, P., Chinnasamy, S.S. (2018). Nature and source of the ore-forming fluids associated with orogenic gold deposits in the Dharwar Craton, *Geoscience Frontiers*, Volume 9, Issue 3, pp. 715-726.

Mueller, A.G. (1992). Petrogenesis of amphibole-biotite-calcite-plagioclase alteration and laminated gold-silver quartz veins in four Archean shear zones of the Norseman district, Western Australia. *Can J Earth Sci*, volume 29, p. 388–417.

Mueller, A.G., and Groves, D.I. (1991). The classification of Western Australian greenstone-hosted gold deposits according to wallrock-alteration mineral assemblages, *Ore Geology Reviews*, Volume 6, Issue 4, pp. 291-331.

Mumm, A.S., Oberthur, T., Vetter, U., and T.G. Blenkinsop, T.G. (1997). High CO₂ content of fluid inclusions in gold mineralizations in the Ashanti Belt, Ghana: a new category of ore forming fluids? *Mineralium Deposita* volume 32, pp. 107–118.

Mumin, A.H., Fleet, M.E., and Chrysoulis, S.L. (1994). Gold mineralization in As-rich mesothermal gold ores of the Bogosu-Prestea mining district of the Ashanti Gold Belt, Ghana: remobilization of “invisible” gold. *Mineral. Deposita* **29**, pp. 445–460.

Mumin, A.H., Fleet, M.E., and Longstaffe, F.J. (1996). Evolution Of Hydrothermal Fluids In The Ashanti Belt, Ghana: Stable Isotope Geochemistry of Carbonates, Graphite and Quartz. *Economic Geology*, Volume 91, pp. 135-148.

Neall, F.B. and Phillips, G.N. (1987). Fluid–wallrock interaction around Archean hydrothermal gold deposits: a thermodynamic model. *Economic Geology*, 82, 1679–1694.

Nesbitt, B.E., and Muehlenbachs, K. (1991). Stable isotopic constraints on the nature of the syntectonic fluid regime of the Canadian Cordillera: *Geophysical Research Letters*, v.18, pp. 963-966.

Niu, P-P., Jiang, S-Y., Hu, Q-S., Xu, T-I., and Xiong, S-F. (2019). Fluid inclusions and H–O–C–S isotope constraints on fluid evolution and ore genesis of the Wangjiadashan Cu–Au deposit in

Suizao area of the Tongbai-Dabie orogenic belt, central China. *Geological Journal*, volume 55, Issue 2, pages 1563-1586.

Oberthur, T., Schmidt Mumm, A., Vetter. U., Simon, K., and Amanor, J.A. (1996). Gold mineralization in the Ashanti belt of Ghana: genetic constraints of the stable isotope geochemistry. *Econ. Geol.* 91,289-301.

Ohmoto, H. (1986) "Chapter 14. STABLE ISOTOPE GEOCHEMISTRY of ORE DEPOSITS". *Stable Isotopes in High Temperature Geological Processes*, edited by John W. Valley, Hugh P. Taylor and James R. O'Neil, Berlin, Boston: De Gruyter, 2018, pp. 491-560. doi.org/10.1515/9781501508936-019.

Ohmoto, H., and Rye, R.O. (1979). Isotopes of sulfur and carbon, in Barnes, H.I., ed., *Geochemistry of hydrothermal ore deposits*, 2nd Edition: New York, Wiley, pp. 509–567.

Osa, S., Kase, K., and Yamamoto, M. (1995). A geochemical study of the Ashanti gold deposit at Obuasi, Ghana. *Earth Science Reports*, Volume 2, No. 1, pp.81-90.

Otto, A., Dziggel, A., Kisters, A.F.M., and Meyer, F.M. (2007). The New Consort Gold Mine, Barberton greenstone belt, South Africa: orogenic gold mineralization in a condensed metamorphic profile. *Miner Deposita* (2007) 42:715–735

Papon, A. (1973). *Geologie et Mineralizations du Sud-Ouest de la Cote-d'Ivoire. Mem. Bur. Rech. Geol. Min.France* 80, 284.

Peacock, S.M, Christensen, N.I, Bostock, M.G, Audet, P. (2011). High pore pressures and porosity at 35 km depth in the Cascadia subduction zone. *Geology* 39:471–474.

Perrouy, S., Aillères, L., Jessell, M.W., Baratoux, L., Bourassa, Y., Crawford, B. (2012). Revised Eburnean geodynamic evolution of the gold-rich southern Ashanti Belt, Ghana, with new field and geophysical evidence of pre-Tarkwaian deformations, *Precambrian Research*, Volumes 204–205, Pages 12-39. doi.org/10.1016/j.precamres.2012.01.003.

Phillips GN. (2013). Australian and global setting for gold in 2013, in proceedings world gold 2013, Brisbane, Australia, 26–29 September 2013. *Aust Inst Min Metall.* 15–21.

Phillips, G.N., and Evans, K.A. (2004). Role of CO₂ in the formation of gold deposits. *Nature*, 429, 860–863.

Phillips, G.N., and Gibb, H.C.F. (1993). A century of gold mining at Kalgoorlie. *Contribution*, 45, 68, *Economic Geology Research Unit*, James Cook University.

Phillips, G.N., and Groves, D.I. (1983). The nature of Archaean gold-bearing fluids as deduced from gold deposits of Western Australia. *Journal Geological Society Australia*, 30, 25–39.

Phillips, G.N., Groves, D.I, and Martyn, J.E. (1984). An epigenetic origin for banded iron-formation- hosted gold deposits. *Econ Geol* 79:162–171.

Phillips, G.N., and Hughes, M.J. (1996). The geology and gold deposits of the Victorian gold province. *Ore Geol. Rev.* 11, 255–302.

Phillips, G.N., and Powell, R. (2009). Formation of gold deposits: review and evaluation of the continuum model. *Earth-Science Reviews*, 94, 1–21.

Phillips, G.N., and Powell, R. (2010). Formation of gold deposits: a metamorphic devolatilization model. *J Metam Geol.* 28:689–718.

Phillips G.N., and Powell R. (2011). Origin of Witwatersrand gold: a metamorphic devolatilization – hydrothermal replacement model. *Appl Earth Sci.* 120:112–129.

Phillips, W.J. (1972). Hydraulic fracturing and mineralization. *Geological Society of London Journal*, 128, 337–359.

Pineau, M.F., Javoy, Y., and Bottinga, Y. (1976). $^{13}\text{C}/^{12}\text{C}$ ratios of rocks and inclusions in popping rocks of the Mid-Atlantic Ridge and their bearing on the problem of isotopic composition of deep-seated carbon, *Earth and Planetary Science Letters*, Volume 29, Issue 2, pp. 413–421.

Pitcairn, I.K., Teagle, D.A.H., Craw, D., Olivo, G.R., Kerrich, R., and Brewer, T.S. (2006). Sources of metals and fluids in orogenic gold deposits: Insights from the Otago and Alpine Schists, New Zealand. *Econ Geol.* 101: pp. 1525–1546.

Potrel, A., Peucat, J.J. and Fanning, C.M. (1998). Archean crustal evolution of the West African Craton: example of the Amsaga Area (Reguibat Rise), U-Pb and Sm-Nd evidence for crustal growth and recycling. *Precambrian Research*, 90, 107–117.

Powell, R., Will, T.M., and Phillips, G.N. (1991). Metamorphism in Archaean greenstone belts; calculated fluid compositions and implications for gold mineralization. *Journal of Metamorphic Geology*, 9, 141–150.

Powell, W.G., Pattison, D.R.M., and Johnston, P. (1999). Metamorphic history of the Hemlo gold deposit from Al_2SiO_5 mineral assemblages, with implications for the timing of mineralization: *Canadian Journal of Earth Sciences*, v. 36, pp. 33–46

Poulsen, K.H., Robert, F., and Dubé, B. (2000). Geological Classification of Canadian Gold Deposits: Geological Survey of Canada Bulletin 540, 106 p.

Prokofiev, V.U., Safonov, Y.G., Lüders, V., Borovikov, A.A., Kotov, A.A., Zlobina, T.M., Murashov, K.Y., Yudovskaya, M.A., and Selektor, S.L. (2019). The sources of mineralizing fluids of orogenic gold deposits of the Baikal-Patom and Muya areas, Siberia: Constraints from the C and N stable isotope compositions of fluid inclusions. *Ore Geology Reviews*, Volume 111, 102988.

Prokofiev, V.Y., and Naumov, V.B. (2020). Physicochemical Parameters and Geochemical Features of Ore-Forming Fluids for Orogenic Gold Deposits Throughout Geological Time. *Minerals*. Volume 10, Issue 1:50.

Ramsay, W.R.H., Bierlein, F.P., Arne, D.C., and Van den Berg, A.H.M. (1998). Turbidite-hosted gold deposits of central Victoria, Australia; their regional setting, mineralising styles, and some genetic constraints: *Ore Geology Reviews*, v. 13, pp. 131-151.

Ridley, J. (1997). Syn-Metamorphic Gold deposits in Amphibolite and Granulite Facies rocks. *Mitt. Österr. Miner. Ges.* 142.

Ridley, J.R., and Diamond, L.W. (2000). Fluid chemistry of orogenic lode gold deposits and implications for genetic models. *Rev. Econ Geol.* 13:146–162.

Ridley, J., Mikucki, E.J., and Groves, D.I., (1996). Archean lode-gold deposits: fluid flow and chemical evolution in vertically extensive hydrothermal systems: *Ore Geology Reviews*, v. 10, p. 279-293.

Robert, F., Brown, A.C., and Audet, A.J. (1983). Structural control of gold mineralization at the Sigma mine, Val d'Or, Quebec. *Bulletin of the Canadian Institute of Mining and Metallurgy*, 76, 72–82.

Robert, F., and Kelly, W.C., 1987, Ore-forming fluids in Archean gold-bearing quartz veins at Sigma mine, Abitibi greenstone belt, Quebec, Canada: *Economic Geology*, v.82, pp. 1464-1482.

Rock, N.M.S., Groves, D.I., Perring, C.S. and Golding, S.D. (1989). Gold, lamprophyres, and porphyries: what does their association mean? *Economic Geology Monograph*, 6, pp. 609–625.

de Ronde, C.E.J., Spooner, E.T.C., de Wit, M.J., and Bray, C.J. (1992). Shear zone related, Au quartz vein deposits in the Barberton greenstone belt, South Africa: field and petrographic characteristics, fluid properties, and light stable isotope geochemistry. *Economic Geology*. 87 (2): 366–402. doi.org/10.2113/gsecongeo.87.2.366.

de Ronde, C.E.J., de Wit, M.J., Spooner, E.T.C., and Bray, C.J. (1991). Mafic-ultramafic hosted, shear zone related, Au-quartz vein deposits in the Barberton greenstone belt, South Africa: structural style, fluid properties and light stable isotope geochemistry. *Brazil Gold'91 Symposium*. pp 279-286.

Sakyi, P.A., Su, B.-X., Manu, J., Kwayisi, D., Anani, C.Y., Alemayehu, M., Malaviarachchi, S.P.K., Nude, P.M., and Su, B.-C. (2020). Origin and tectonic significance of the metavolcanic rocks and mafic enclaves from the Palaeoproterozoic Birimian Terrane, SE West African Craton, Ghana. *Geological Magazine*; 157 (8): 1349–1366

Santosh, M., and Omori, S. (2008). CO₂ flushing: a plate tectonic perspective. *Gondwana Res* 13:86–102.

Sarangi, S., Sarkar, A., Srinivasan, R., and Patel, S.C. (2012). Carbon isotope studies of auriferous quartz carbonate veins from two orogenic gold deposits from the Neoproterozoic Chitradurga schist belt, Dharwar craton, India: Evidence for mantle/magmatic source of auriferous fluid, *Journal of Asian Earth Sciences*, Volume 52, Pages 1-11.

Salvi, S., Velásquez, G., Miller, J.M., Béziat, D., Siebenaller, L., and Yan Bourassa, Y. (2016). The Pampe gold deposit (Ghana): Constraints on sulfide evolution during gold mineralization, *Ore Geology Reviews*, Volume 78, pp. 673-686.

Shvarov, Y.V., and Bastrakov, E.N. (1999). HCh: A software package for geochemical equilibrium modeling, user's guide: Australian Geological Survey Organisation Record 1999/25, 60 p.

Schidlowski, M. (1987). Evolution of the early sulphur cycle. In: *Geochemistry and Mineral Formation in the Earth Surface* (Eds R. Rodriguez-Clemente and Y. Tardy), pp. 29-49. Consejo Superior de Investigaciones Científicas, Madrid.

Schidlowski, M., Hayes, J.M., and Kaplan, I.R. (1983). Isotopic inferences of ancient biochemistries: carbon, sulphur, hydrogen, and nitrogen. In: Schopf, J.W. (Ed.), *Earth's earliest Biosphere: Its Origin and Evolution*. Princeton University Press, New York, pp. 149-186.

Schreiber, D.W., Fonboté, L., and Lochmann, D. (1990). Geologic setting, paragenesis, and physicochemistry of gold quartz veins hosted by plutonic rocks in the Patagón region. *Econ. Geol.*, 85, 1328-1347.

Seewald, J.S., 2001, Aqueous geochemistry of low molecular weight hydrocarbons at elevated temperatures and pressures: Constraints from mineral buffered laboratory experiments: *Geochimica et Cosmochimica Acta*, v. 65, pp. 1641-1664, doi:10.1016/S0016-7037(01)00544-0.

Senyah, G.A., Dampare, S.B., and Asiedu, D.K. (2016). Geochemistry and tectonic setting of the Paleoproterozoic metavolcanic rocks from the Chirano Gold District, Sefwi belt, Ghana, *Journal of African Earth Sciences*, Volume 122, Pages 32-46,

Seward, T.M. (1973). Thio complexes of gold and the transport of gold in hydrothermal ore solutions. *Geochimica et Cosmochimica Acta* 37: 379-399.

Sillitoe, R. H. (1991). Intrusion-related gold deposits. in *Gold Metallogeny and Exploration* (Foster, R. P., ed.), 165-209. Blackie, Glasgow & London.

Sillitoe, R.H., and Thompson, J.F.H. (1998). Intrusion-related vein gold deposits: types, tectono-magmatic settings, and difficulties of distinction from orogenic gold deposits. *Res Geol.* 48:237-250.

Spence-Jones, C.P., Jenkin, G.R.T., Boyce, A.J., Hill, N.J., and Sangster, C.J.S. (2018). Tellurium, magmatic fluids, and orogenic gold: An early magmatic fluid pulse at Cononish gold deposit, Scotland, *Ore Geology Reviews*, Volume 102, pp. 894-905.

Steadman, J.A., Large, R.R., Meffre, S., and Bull, S.W. (2013). Age, origin, and significance of nodule sulfides in 2680Ma carbonaceous black shale of the Eastern Goldfields Superterrane, Yilgarn craton, Western Australia. *Precambrian Res* 230:227–247.

Steed, G.M., and Morris, J.H. (1997). Isotopic evidence for the origin of a Caledonian gold-arsenopyrite-pyrite deposit at Clontibret, Ireland: *Institution of Mining and Metallurgy Transactions*, v. 106 Section B, pp. 109-118.

Stefánsson, A., and Seward, T.M. (2004). Gold (I) complexing in aqueous sulphide solutions to 500°C at 500 bar. *Geochimica et Cosmochimica Acta* 68: 4121-4143.

Sibson, R.H. (1987). Earthquake rupturing as a mineralizing agent in hydrothermal systems. *Geology*. 15:701–704.

Sibson, R.H. (1996). Structural permeability of fluid-driven fault-fracture meshes. *Journal of Structural Geology*, 18, 1031–1042.

Sibson, R.H. (2004). Controls on maximum fluid overpressure defining conditions for mesozonal mineralization. *J Struct Geol* 26:1127–1136.

Sibson, R.H., Robert, F. and Poulsen, K.H. (1988). High-angle reverse faults, fluid-pressure cycling, and mesothermal gold quartz deposits. *Geology*, 16, 551–555.

Soumaila, A., Henry P., Garba, Z., Rossi, M. (2004). Contexte de mise en place des roches basiques de la ceinture de roches vertes birimienne de Diagorou-Darbani (Liptako, Niger, Afrique de l'Ouest): plateau océanique ou environnement d'arc/bassin arrière-arc océanique. *C. R. Geoscience* 336 (2004) 1137–1147.

Sylvester, P.J., Attah, K., 1992. Lithostratigraphy and composition of 2.1 Ga greenstone belts of the West African Craton and their bearing on crustal evolution and the Archean-Proterozoic boundary. *J. Geol.* 100, 377–393.

Taylor, P. N., Moorbath, S., Leube, A. and Hirdes, W. (1988). Geochronology and crustal evolution of Early Proterozoic granite-greenstone terrains in Ghana/West Africa. In: *International Conference and Workshop on the Geology of Ghana with Special Emphasis on Gold, Programme and Abstracts*, Accra, Ghana, 43-45.

Tripp, G.I., and Vearncombe, J.R. (2004). Fault/fracture density and mineralization: a contouring method for targeting in gold exploration. *Journal Structural Geology* 26:1087–1108.

Tomkins, A.G. (2010). Windows of metamorphic sulfur liberation in the crust: Implications for gold deposit genesis: *Geochimica et Cosmochimica Acta*, v. 74, pp. 3246–3259, doi:10.1016/j.gca.2010.03.003.

Tomkins, A.G. (2010,). Windows of metamorphic sulfur liberation in the crust: Implications for gold deposit genesis: *Geochimica et Cosmochimica Acta*, v. 74, pp. 3246–3259, doi:10.1016/j.gca.2010.03.003.

Tomkins, A.G. (2013a). On the source of orogenic gold. *Geology*.41 (12): 55–1256.

Tomkins, A.G., and Grundy, C. (2009). Upper Temperature Limits of Orogenic Gold Deposit Formation: Constraints from the Granulite-Hosted Griffin's Find Deposit, Yilgarn Craton: *Economic Geology and the Bulletin of the Society of Economic Geologists*, v. 104, pp. 669–685, doi:10.2113/gsecongeo.104.5.669.

Tomkins, A.G., and Mavrogenes J.A. (2002). Mobilization of gold as a polymetallic melt during pelite anatexis at the Challenger deposit, South Australia-a metamorphosed Archean gold deposit. *Econ Geol* volume 97, pp. 1249–1271.

Tomkins, A.G., Pattison, D.R.M., and Eva Zaleski,E. (2004). The Hemlo Gold Deposit, Ontario: An Example of Melting and Mobilization of a Precious Metal-Sulfosalt Assemblage during Amphibolite Facies Metamorphism and Deformation. *Economic Geology*; 99 (6): 1063–1084. doi.org/10.2113/gsecongeo.99.6.1063.

Toulmin, P., and Barton, P.B. (1964). A thermodynamic study of pyrite and pyrrhotite. *Geochim et Cosmochim Acta*. 28:641–671.

van Reenen, D.D., Pretorius, A.I., and Roering, C. (1994). Characterization of fluids associated with gold mineralization and with regional high-temperature retrogression of granulites in the Limpopo belt, South Africa: *Geochimica et Cosmochimica Acta*, v. 58, pp. 1147-1159.

Vearncombe J., and Zelic, M. (2015). Structural paradigms for gold: do they help us find and mine? *Appl Earth Sci*. 124:2–19.

Vearncombe, J.R. (1998). Shear zones, fault networks, and Archean gold. *Geology* 26:855–858.

Vidal, M., Alric, G., 1994. The Palaeoproterozoic (Birimian) of Haute-Comoe' in the West African craton, Ivory Coast: a transtensional back-arc basin. *Precambr. Res.* 65, 207– 229.

Vielreicher, N.M, Groves, D.I, Snee, L.W., Fletcher, I.R., McNaughton, N.J. (2010). Broad synchronicity of three gold mineralization styles in the Kalgoorlie gold field–SHRIMP, U-Pb, and $^{40}\text{Ar}/^{39}\text{Ar}$ geochronological evidence. *Econ Geol* 105:187–227.

Walshe, J.L., Halley, S.W., Hall, G.A., and Kitto, P. (2003). Contrasting fluid systems, chemical gradients, and controls on large-tonnage, high- grade Au deposits, Eastern Goldfields Province, Yilgarn Craton, Western Australia, in *Mineral Exploration and Sustainable Development*. 7th Biennial SGA meeting Athens, pp 827–830

- White, A.J.R., Waters, D.J., and Robb, L.J. (2015). Exhumation-Driven Devolatilization as a Fluid Source for Orogenic Gold Mineralization at the Damang Deposit, Ghana. *Economic Geology* 2015;; 110 (4): 1009–1025. doi.org/10.2113/econgeo.110.4.1009
- Wilson, C.J.L., Schaubs, P.M., and Leader, L.D. (2013). Mineral precipitation in the quartz reefs of the Bendigo gold deposit, Victoria, Australia. *Econ Geol.* 108:259–278.
- Wilkinson, J.J., and Johnston, J.D. (1996). Pressure fluctuations, phase separation, and gold precipitation during seismic fracture propagation. *Geology*. 24:395–398.
- Williams-Jones, A.E., Bowtell, R.J., and Migdisov, A.A. (2009). Gold in Solution. *Elements*; 5 (5): 281–287. doi.org/10.2113/gselements.5.5.281.
- Williams-Jones, A.E., and Migdisov, A.A. (2014). Experimental Constraints on the Transport and Deposition of Metals in Ore-Forming Hydrothermal Systems. Society of Economic Geologists, Inc. Special Publication Volume 18, pp. 77–95.
- Williams, H.R., and Culver, S.J. (1988). Structural terranes and their relationships in Sierra Leone. *Journal of African Earth Sciences* 7, 473–477.
- Wyman, D.A., Cassidy, K.F., and Hollings, P. (2016). Orogenic gold and the mineral systems approach: resolving fact, fiction, and fantasy. *Ore Geol Rev* 78:322–335
- Wortel, M.J.R., and Spakman, W. (2000). Subduction and slab detachment in the Mediterranean–Carpathian region. *Science* 290:1910–1917
- Wyman, D.A., O'Neill, CO., and Ayer, J.A. (2008). Evidence for modern-style subduction to 3.1Ga: a plateau-adakite-gold (diamond) association. *Geol Soc Am Spec Pub* 440:129–148.
- Xavier, R.P., and Foster, R.P. (1999). Fluid evolution and chemical controls in the Fazenda Maria Preta (FMP) gold deposit, Rio Itapicuru greenstone belt, Bahia, Brazil: *Chemical Geology*, v. 154, pp. 133–154.
- Xue, Y., Campbell, I., Ireland, T.R., Holden, P., Armstrong, R. (2013). No mass-independent sulfur isotope fractionation in auriferous fluids supports a magmatic origin for Archean gold deposits. *Geology* 2013; 41 (7): 791–794. doi.org/10.1130/G34186.1.
- Yao, Y., Murphy, P.J., and Robb, L.J. (2001). Fluid Characteristics of Granitoid-Hosted Gold Deposits in the Birimian Terrane of Ghana: A Fluid Inclusion Microthermometric and Raman Spectroscopic Study. *Economic Geology*. Vol. 96, 2001, pp. 1611–1643.
- Zhao, H.S., Wang, Q.F, Groves, D.I., and Deng, J. (2019). A rare Phanerozoic amphibolite-hosted gold deposit at Danba, Yangtze Craton, China: significance to fluid and metal sources for orogenic gold systems. *Mineral Deposita* 54(1):133–152.
- Zheng, Y.-F. (1999) Oxygen isotope fractionation in carbonate and sulfate minerals. *Geochem J.* Volume 33, pp. 109–126.

Zhong, R., Brugger, J., Tomkins, A.G., Chen, Y., and Li, W. (2015). Fate of gold and base metals during metamorphic devolatilization of a pelite. *Geochim Cosmochim Acta*. 171:338–352.

Sibson, R.H. (1987). Earthquake rupturing as a mineralizing agent in hydrothermal systems. *Geology*. 15:701–704.

CHAPTER II : Journal Manuscript

Constraints on the genesis of the Kibi-Gold Project deposits in the Kibi- Winneba Belt, Ghana

Phoebe Kekeli Nkansa⁽¹⁾, Anthony E. Williams-Jones⁽¹⁾, James R. Clark⁽¹⁾

Earth and Planetary Sciences, McGill University
3450 University Street, Montreal, QC
Canada H3A 0E8

To be submitted to: Society of Economy Geology

ABSTRACT

The Kibi gold deposits in the Kibi-Winneba volcanic belt, Ghana, host an indicated resource containing 623,700 ounces of gold (13,893,000 tonnes grading 1.40g/t) and an inferred resource of 180,700 ounces of gold (5,694,000 tonnes grading 0.96g/t) in upper greenschist facies quartz diorites of the Birimian Supergroup. The quartz diorite host rock is characterized by variable degrees of chloritization, albitization, sericitization, carbonatization and sulphidation. The gold mineralization, which occurs as native gold in quartz-albite-ankerite veins and the adjacent in the host rock, is closely associated with sulphidation in the form of disseminated pyrrhotite and arsenopyrite as well as pervasive ankeritization, with weak white mica alteration.

The results of stable isotope analyses show that mineralising fluid that formed the Kibi-Gold deposits was either magmatic or metamorphic ($\delta^{18}\text{O}_{\text{fluid}}$ values from ankerite of +8.2 to +10.3‰, assuming a temperature of 400°C) and that it interacted with graphitic pelites ($\delta^{13}\text{C}_{\text{fluid}}$ from -11.2 to -5.7‰, also at 400°C). Sulphur isotope data for pyrrhotite and arsenopyrite (^{34}S from -1.3 to +3.3‰) suggest that the sulphur came from a magma or was supplied by leaching during fluid-rock interaction with igneous rocks.

The temperature of the ore fluid was estimated based on the calibrations of Kranidiotis and MacLean (1987) and Cathelineau (1988) chlorite geothermometers, to be between 374±11 °C and 388±15 °C, respectively. Phase equilibria considerations of the alteration assemblage and gold solubility suggest that the mineralising fluid had a weakly acidic pH between 4.5 and 5.5, at an $f\text{O}_2$ of ≤ -31.0 , assuming a temperature of 400 °C at 2 kbar. Gold mineralization in the wall rocks resulted from a drop in the fluid H_2S activity caused by sulphidation of Fe-bearing minerals to form pyrrhotite and arsenopyrite; this caused the gold-hydrosulphide complex (AuHS^0) to

destabilize and the deposition of native gold. This gold mineralization was likely not due to variations in pH or $f\text{O}_2$, as an increase in either of these parameters would have increased gold solubility for the conditions thought to be present at Kibi. A significant proportion of the gold mineralization occurs in quartz veins containing minor albite and ankerite. As both quartz and gold solubility correlate positively with temperature, it is proposed that decreasing temperature was the main cause of vein-hosted gold mineralization.

It is proposed that the Kibi-Gold deposits formed in secondary structures associated with a major shear zone from magmatic-hydrothermal fluids released at depth that had become reduced as a result of their interaction with graphitic argillite. These fluids interacted with the rocks, depositing native gold in them as a result of sulphidation and destabilisation of the hydrosulphide gold species. As fracturing related to tectonism created the pathways for the gold mineralising fluids, a large proportion of the gold also deposited in quartz-dominant veins in response to the pressure-release mediated temperature decrease that accompanied fracturing.

INTRODUCTION

Orogenic gold deposits are currently responsible for greater than 50% of global gold production (Phillips, 2013) and although they have been the subject of a large number of studies, some aspects of their genesis are not well understood. Thus, although there is a general agreement that they form during orogenesis (Groves et al., 1998), the nature of the ore-forming fluids is debated with opinions being divided over whether they are mainly the products of metamorphic reactions, meteoric fluids modified by interaction with the host rocks, or are magmatic in origin (Ridley & Diamond, 2000). In addition to the question of fluid origin, an important issue is why, in the majority of orogenic gold deposits, pyrite is the dominant sulphide mineral (Large et al., 2012) but, in some deposits, the main sulphide is pyrrhotite (Wang et al., 2020).

The subject of this paper, the Kibi-Gold Project, is an example of a series of orogenic gold deposit in which the main sulphide associated with the gold is pyrrhotite. The deposits are located in the Kibi-Winneba volcanic belt of Ghana, West Africa, which comprises of Birimian metasedimentary and metavolcanic rocks and is adjacent to the renowned Ashanti belt that hosts several world-class orogenic gold deposits. Gold from the Ashanti belt accounts for approximately 90% of Ghana's total gold production (Akabzaa et al., 2007), with the Ashanti belt having a gold endowment in excess of 125 million ounces (Volta Resources Incorporation, 2013) all sourced from the Birimian Supergroup and Tarkwaian rocks.

Deposits in the Ashanti belt are hosted by shear zones in metasedimentary rocks and the mineralization occurs in close spatial association with carbonaceous matter (Allibone et al., 2002a; Berge, 2011). The dominant sulphide mineral in Ashanti deposits is pyrite and is accompanied by small proportions of arsenopyrite and pyrrhotite (Oberthür et al., 1996; Yao & Robb, 2000). Stable

isotope data (oxygen, hydrogen, carbon and sulphur) from the Ashanti deposits indicate that the ore-forming fluids had a metamorphic source, that interacted with reduced carbon (graphitic schists), and that the sulphur had the same origin (Oberthür et al., 1996; Osae et al., 1999; Kříbek et al., 2015).

The Kibi-Gold Project area includes the Big Bend, Mushroom, South Ridge, East Dyke, Boomerang and Double 19 deposits, although this study focuses on the Double 19, South Ridge and Big Bend deposits. These deposits are unusual examples of Proterozoic orogenic systems, in which the mineralization is hosted by quartz diorite and pyrrhotite is the dominant sulphide mineral. This study of the Kibi-Gold deposits addresses the nature of the ore fluid and the reason for the dominance of the sulphide mineralization by pyrrhotite. It then goes on to develop a model that satisfactorily explains the various features of the deposits including the genesis of the gold mineralization.

REGIONAL GEOLOGY

The Kibi-Gold Project is situated within the Paleoproterozoic metamorphic terranes of the Leo-Man Shield of the West African Craton (WAC), comprising the dominant Birimian Supergroup and the Tarkwaian Group. The Birimian Supergroup covers the southwestern and northern regions of Ghana and major parts of Cote d'Ivoire, Mali, and Burkina Faso (**Fig. 1**). These rocks consist of evenly spaced belts that extend approximately 200 km along strike (NE-SW) and are dominated by metavolcanic units separated by sequences of metasedimentary-dominated units that infill basins (Cape Coast, Kumasi, Sunyani and Maluwe basins) separating these belts (**Fig. 2**). The

Birimian Supergroup formed between 2.27 and 1.96 Ga (Feybesse et al., 2006; Baratoux et al., 2011).

The metavolcanic rocks of the Birimian Supergroup consist mainly of tholeiitic basaltic and andesitic lavas and calc-alkaline volcanoclastic units (Dia et al., 1997; Diallo, 2001), and the metasedimentary units comprise of turbidite-related wackes, chert, graphitic schists, argillites and phyllites (Leube et al., 1990). A transition zone between the volcanic belts and the basinal sediments consists mainly of chemical sediments (cherts and carbonaceous schists), volcanoclastics and turbidites (Leube et al., 1990; Sylvester & Attoh, 1992; Galipp et al., 2003).

The Eburnean tectono-thermal orogenic event at approximately 2.1 Ga led to the formation of evenly spaced, NE-trending belts (from east to west, the Kibi-Winneba, Ashanti, Asankrangwa, Sefwi, Bui and Bole-Nangodi belts). This orogeny folded the Birimian volcanics and sediments, which were later intruded by granitoids causing uplift and erosion. The erosion products accumulated as sediments of the Tarkwaian Group, in syn-orogenic “molasse basins” analogous to the timiskaming basins in the Abitibi (Leube et al., 1990; Grenholm et al., 2019).

The Tarkwaian Group is composed of conglomerates, quartzites, arkosic rocks, sandstones and minor proportions of shale. Evidence supporting the interpretation that Birimian rocks were uplifted and eroded during the Eburnean event includes the presence of pebble clasts in the Tarkwaian conglomerates, which were derived from the Birimian rocks (Junner, 1940; Perrouty et al., 2012); the younger Tarkwaian Group, thus, unconformably overlies the older Birimian Supergroup. The maximum depositional age of the sediments of the Tarkwaian Group is interpreted to be 2133 ± 4 Ma based on U–Pb ages from detrital zircon crystals (Pigois et al., 2003) but Perrouty et al. (2012) counteracts this age and constrains the age of deposition to be 2107–2097 Ma.

The Birimian Supergroup was intruded by two suites of granitoids of distinctly different geochemical affinity. The older of these suites is metaluminous and dioritic to granodioritic in composition and intrudes the metavolcanic units. This suite is referred to as the Dixcove or belt-type granitoids and has been dated by U-Pb methods on zircon at 2211-2187 Ma (De Kock et al., 2011; Sakyi et al., 2014). The second suite is peraluminous and granodioritic in composition, intrudes the metasedimentary units, and is referred to as the Cape Coast or basin-type granitoids; these rocks have U/Pb age between 2165 and 2148 Ma (De Kock et al., 2011). The granitoids of the Winneba segment of the Kibi-Winneba belt, have an Archean sialic precursor (Sm-Nd model age of ~ 2.6 Ga) and are believed to be the only granitoids in Ghana to have such traits (Taylor et al., 1992).

The Tarkwaian Group in the Bole-Nangodi belt in northern Ghana was intruded by peraluminous K-rich Bongo-type granitoids (Leube et al., 1990). Based on U/Pb zircon dating, these granitoids have an age of 2097 ± 3 Ma (Oberthur et al., 1998).

With the exception of the Bongo-type granitoids, all the rock units referred to above were subjected to regional deformation and metamorphism. The deformation is interpreted to have proceeded progressively in a single event and involved compression along a NW-SE directed axis, which affected the Birimian and Tarkwaian rocks on a regional scale (Layton, 1958; Baratoux et al., 2011). This resulted in a NE strike and dips of $\sim 45^\circ$ NW or SW in the northern areas and vertically dips in the south, with isoclinal fold axes and stretching lineations that plunge steeply to the SW (Eisenlohr & Hirdes, 1992). The accompanying metamorphism was at greenschist or lower amphibolite facies.

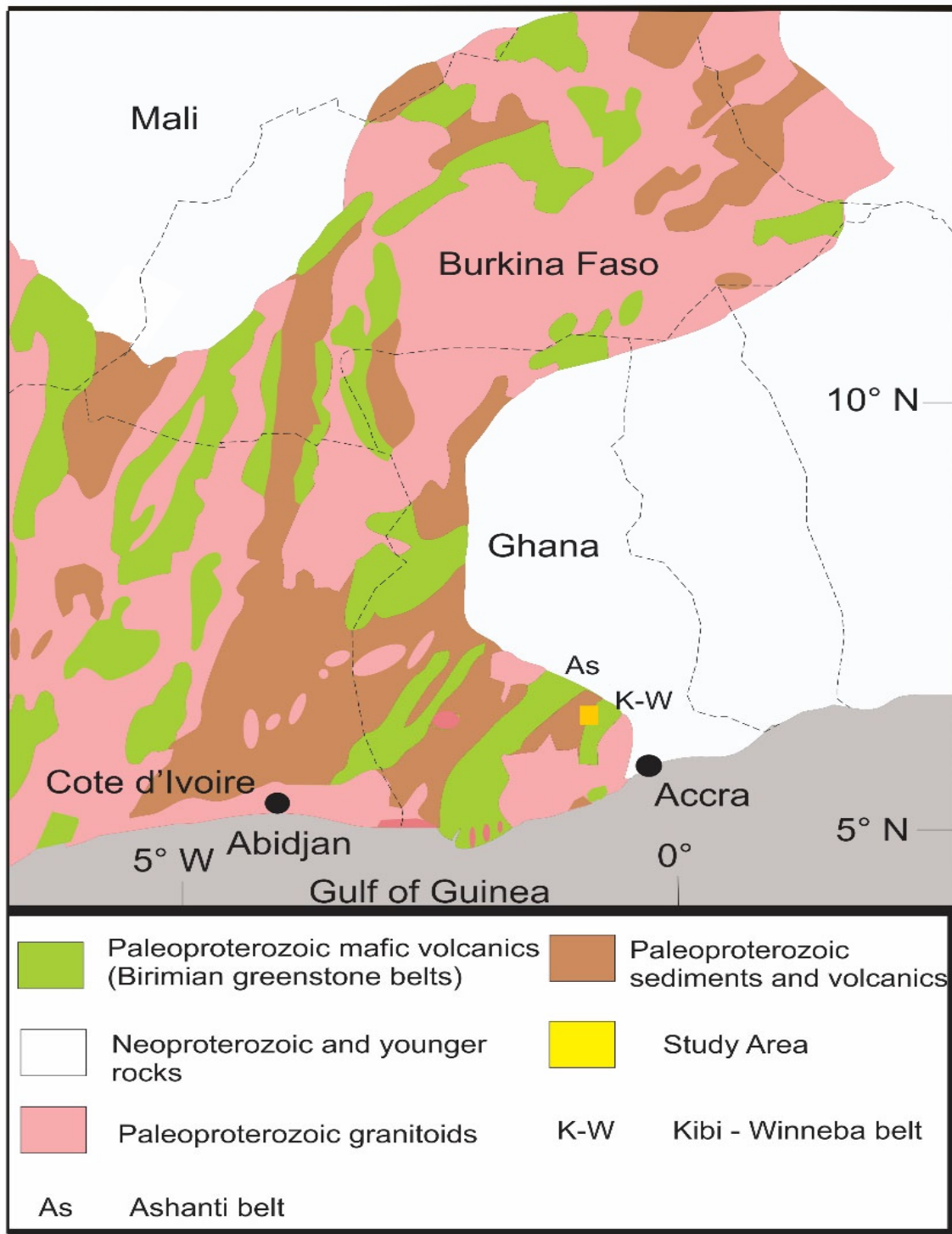


Figure 1: A Geological map of the Birimian province of the Leo-Man Shield in the West African Craton (modified after Vidal et al., 1996).

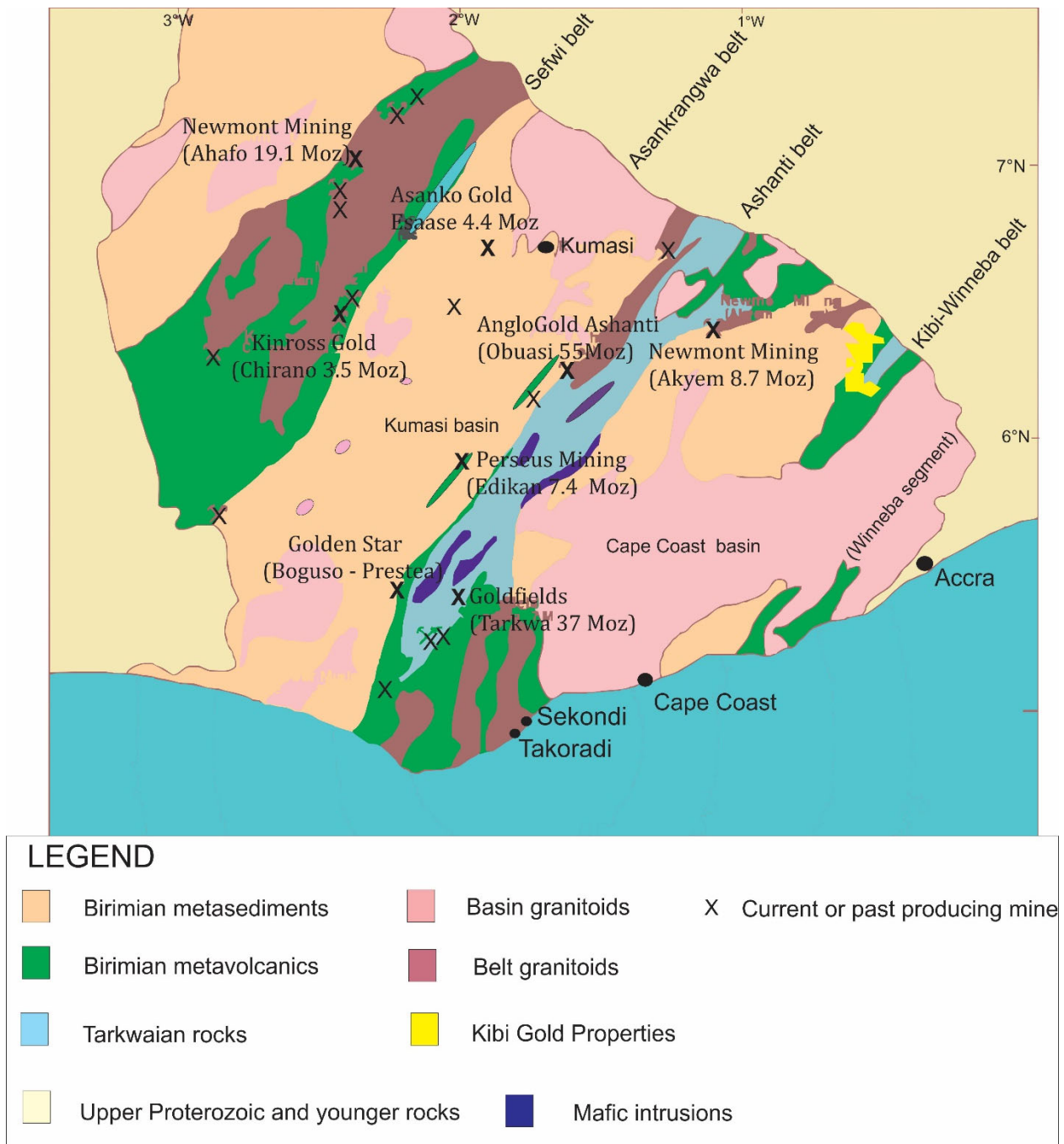


Figure 2: Geological map of southwestern Ghana showing metavolcanic belts separated by metasedimentary basins (modified after Xtra-Gold Resources Corporation, 2020. <https://xtragold.com/kibi-project/maps/>).

KIBI-WINNEBA BELT

Gold mineralization of the Kibi-Gold Project, which is located in the Apapam concession in southeastern Ghana, is hosted by rocks of the Kibi-Winneba belt in the Cape Coast basin. This belt is parallel to the Ashanti belt, which hosts most of Ghana's active gold mines.

The Kibi-Winneba belt is approximately 60 km long and is divided by the Cape Coast granitoids into northern Kibi and southern Winneba sections. It has an overall synclinal structure (Eisenlohr, 1989; Eisenlohr and Hirdes, 1992). The Kibi section of the belt is covered by younger metasedimentary rocks of the Tarkwaian Group, whereas the Winneba section is truncated by large Dixcove granitoid intrusions and is only locally overlain by Tarkwaian metasedimentary rocks (Leube et al., 1990; Hirdes et al., 1992).

The Kibi section of the Kibi-Winneba belt is composed of metamorphosed basaltic flows, amphibolites, andesitic lavas and pyroclastics, and granite-diorite plutonic suites (Yao and Robb, 1998). The Birimian metavolcanic and metasedimentary rocks (consisting of tuffaceous metagreywackes, quartzites, grey and black phyllites and schists; Anum et al., 2015) are intruded by granitoids, which include two-mica granodiorites, foliated biotite granites, hornblende-biotite granite, leucogranite pegmatoids, and gneissic biotite granites (Hirdes et al., 1992; Hirdes and Davies, 1998). Contact metamorphism locally affected metasedimentary rocks adjacent to the granitoids (Junner, 1943). There are also mafic intrusives consisting predominantly of NE-trending sills and dykes, which were affected by metamorphism, and a few later dolerite dykes which have not been metamorphosed (Griffs et al., 2002). The Winneba section of the belt consists of amphibolites, quartz-mica schists, and aplite/pegmatites which are related to the basin-type granitoids (Eisenlohr, 1989; Griffs et al., 2002; Forson et al., 2020).

Rocks in the Kibi-Winneba belt have been deformed and metamorphosed to conditions corresponding to the upper greenschist and lower amphibolite facies and are interpreted to have subsequently undergone retrograde metamorphism with which the gold mineralization is thought to have been associated (Junner, 1943; Klemd et al., 2002). Geothermobarometric studies of amphibolites and metapelites in the southern part of the Kibi-Winneba belt indicate peak metamorphic temperatures of 500 to 610°C, and pressures of 4.5-6 kbar. By contrast, hydrothermal alteration and mineralization is constrained to the temperature range of ~440-540°C, as indicated by sulphide assemblages of arsenopyrite-pyrite with loellingite inclusions and arsenopyrite-pyrrhotite (Sharp et al., 1985; Klemd et al., 2002). These peak metamorphic conditions of the southern part of the Kibi-Winneba belt are similar to those of the southern Ashanti and northwestern Sefwi belts (490-650°C at 4-6k bar; John et al., 1999). Geothermobarometric studies have not been carried out in the northern part of the Kibi-Winneba belt. The absence of key indicator minerals in the metapelites, such as staurolite and garnet and the presence of phyllites but not schists, however, suggest that the metamorphic grade was significantly lower than in the south.

LOCAL GEOLOGY

The Kibi-Gold Project is currently being explored by Xtra-Gold Resources Corporation. The area is dominated by the steep sided Atewa Range, with an elevation reaching 780 m above sea level, and overall relief of ~500 m. The Atewa Range is underlain by NE-trending Birimian greenstones, comprising metamorphosed basalt and andesite, chert, and tuff. In contrast, the valleys that surround the Atewa Range are underlain by metasedimentary rocks, namely of metagreywacke and meta-argillite.

Prior to exploration by Xtra-Gold, the geology of the northern part of the Kibi-Winneba belt was relatively unknown due to poor exposure, limited mapping by the Ghana Geological Survey, and the near-absence of previous exploration activity. Our current understanding of the geology is largely the result of the logging of drill core, mapping of exploration trenches and road-cuts, regional geological traverses, and airborne aeromagnetic and radiometric surveys. The geological map resulting from this work is shown in **Figure 3**. Based on elevated concentrations of gold in the soils, detailed geological mapping has been confined to Zones 2 and 3 (**Fig. 4**), and has been limited to trenches, saprolite exposures and drill core due to the paucity of outcrops.

The Kibi-Gold Project is underlain by NE-trending Paleoproterozoic Birimian units, including metavolcanic rocks in the north-western portion of the Apapam concession, and metasedimentary and metavolcaniclastic rocks in the central area. An ENE-trending belt-type granitoid intrusion has been inferred, from radiometric surveys, to underlie the western margin of the concession. Northeast-trending mafic dykes and sills, and small granodiorite, quartz diorite and tonalite plutons locally intrude the Birimian stratigraphy.

The Apapam concession is mainly underlain by metasedimentary rocks accompanied by minor mafic metavolcanic flows or sills and small plutons of granodiorite and quartz diorite. The mafic flows/sills are massive, medium grained units 5 to 30 m thick. These rocks are weakly foliated but contain 10 to 50 cm wide sheared intervals. They have been subjected to pervasive chloritic and patchy carbonate alteration and typically host calcite and minor quartz-ankerite veins (SEMS Exploration, 2012).

The metasedimentary rocks vary from fine-grained argillite to fine to medium-grained greywacke and exhibit weak to strong foliation and isoclinal folding. They have a dominant NNW to NE-trending, steeply east dipping axial planar foliation (S₂). These units also show strong chloritic alteration and variable degrees of carbonate alteration. Calcite veins are evident throughout, but quartz-calcite veins are restricted to intensely foliated and sheared intervals.

Granodiorite, tonalite and quartz diorite intrusions contain quartz and plagioclase as well as minor proportions of hornblende, K-feldspar, and biotite. Alteration minerals include calcite, chlorite, and sericite. Shear zones believed to have formed contemporaneously with the Eburnean event are observed in the Apapam concession. These shear zones are graphitic, ~1.5 m wide, and are NE-trending with dips steeply to the east and southeast and are postulated to have formed contemporaneously with a regional NW-SE reverse compression event (D₂). One of these zones is located at the contact of a quartz diorite body (SEMS Exploration, 2012).

The quartz diorite contains numerous cross-cutting quartz-albite-carbonate veins (0.1 to 30 cm) which locally form stockworks. The dominant vein orientations are: 1) shallow to moderate WNW-NNW dipping, 2) steep SE and NW dipping and 3) shallowly east-dipping. The veins crosscut the foliation at high angles, indicating that the emplacement of vein stockworks post-dated ductile shearing. This also suggests that gold mineralization post-dated the emplacement of

the quartz diorite, even though there is a spatial relationship between them (SRK Consulting, 2010). A regional NW-SE shortening event, which corresponds to the Eburnean tectono-thermal event, is thought to have been responsible for the development of shear zones and isoclinal folding in the metasedimentary rocks, as well as the emplacement of vein stockworks in granitoid bodies (SRK Consulting, 2010).

The north-western portion of the Apapam concession, which has been the focus of exploration, consists of an upper lateritic layer (0.25 to 2.5 m thick) of clays, underlain by a mottled clay horizon (2-5 m) which grades downward into saprolitic bedrock. The saprolite horizon has a thickness of 25 to 45 m, with a transition zone (saprock) that extends for another 0.5 to 7.0 m into fresh bedrock. The valleys are dominated by alluvium consisting of cobbles and boulders of lateritic duricrust derived from Birimian lithologies (SEMS Exploration, 2012).

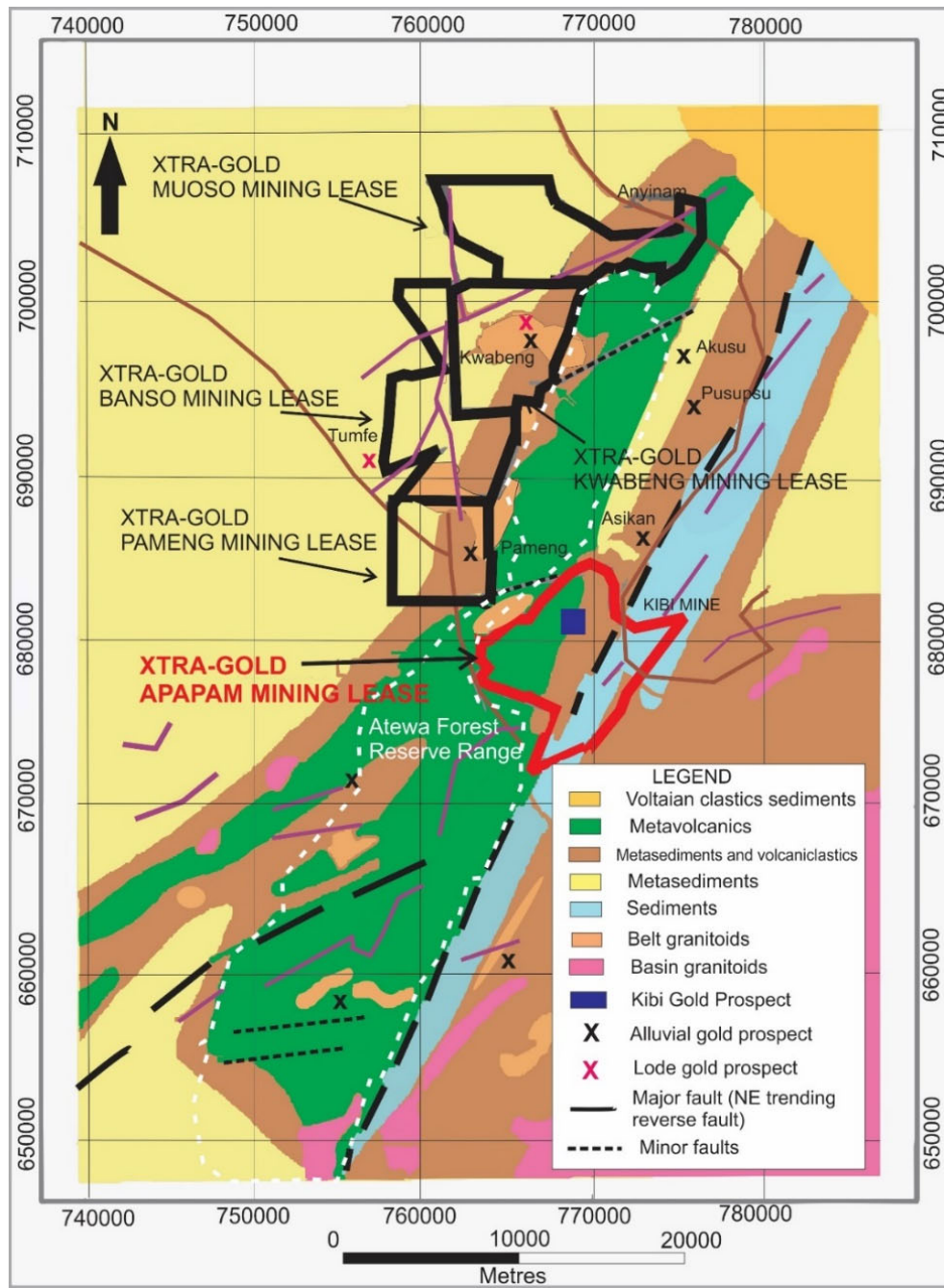


Figure 3: A geological map of the Kibi-section of the Kibi-Winneba belt, showing the Kibi Gold prospect in the Apapam concession (modified after SEMS Exploration, 2012. https://www.xtragold.com/_resources/reports/2_3_1KibiGoldProject-TechnicalReport_NI-43-101.pdf).

GOLD MINERALIZATION

The Kibi-Gold district has been mined artisanally for centuries and in recent years using excavators to dredge rivers, especially along the Offin and Birim rivers and their tributaries. Coarse nuggets of gold were first reported from this district when alluvial mining operations by Europeans were active between 1903 and 1930, with a production of ~8,600 ounces from about 298,176 m³ during the 1920s and a recovered grade in the range of 0.8 to 0.9 g/m³ (Junner, 1935).

Gold fineness in the Kibi alluvial district is high, in the range of 900 to 940 (SEMS Exploration, 2012). The gold is normally coarse, especially in the upper regions of the valleys, but decreases in grain size downstream. In the upstream sections of the Awasu and Merepong valleys, the coarsest fraction, +1 mm, makes up 30-60% of the total gold, with the fine fraction (-0.2 mm) accounting for only 4-10% of the total gold content. Downstream sections also contain coarse gold, with the -0.2 mm fraction contributing ~ 15-20% of the total gold content. The total alluvial gold production since the inception of alluvial production by Xtra-Gold in 2010 for the Kwabeng, Muoso, Banso, Pameng and Apapam concessions is 21,951 ounces (Xtra-Gold, 2020).

Four gold-bearing zones have been identified in the bedrock of the Apapam concession using soil geochemistry; Zones 2 and 3 (**Fig. 4**) are the most important and constitute the Kibi-Gold Project. The maiden resource estimate for the project, with a cut-off at 0.5 g/t was 623,700 indicated ounces of gold (13.89 million tonnes grading at 1.40 g/t) and 180,700 inferred ounces of gold (5.69 million tonnes grading at 0.96 g/t; Xtra-Gold, 2022).

Gold deposits within the Apapam concession include both mesothermal granitoid-hosted and the classic Ashanti-style sediment-hosted shear zone types; the latter is the dominant style mined in Ghana, but in terms of economic significance, granitoid-hosted mineralization predominates in the

Apapam concession (SEMS Exploration, 2012). The Ashanti-style mineralization is associated with a major NE-trending reverse fault (**Fig. 3**) along the eastern flank of the Atewa Range. Several generations of quartz veins are present, although the gold (native gold) is restricted to the latest stage. This style of mineralization is spatially associated with graphitic phyllites and manganese-rich sediments. Gold has a close spatial association with arsenopyrite, and in general with pyrite, chalcopyrite, pyrrhotite and bornite. It is accompanied by sericite and carbonate alteration (Naas, 2008).

The granitoid-hosted gold mineralization is associated with quartz-carbonate and quartz-albite-carbonate veins/stockworks developed in brittle structures in the felsic rocks, which are mostly diorite to granodiorite in composition. Much of this mineralization, however, is disseminated in the host rocks, where it is accompanied by pervasive ankerite, quartz and sulphide alteration and weak sericitization. The sulphide alteration consists mainly of fine- to medium-grained, anhedral pyrrhotite; medium to large, euhedral arsenopyrite crystals are common (**Fig. 5**). Chlorite alteration occurs distal to the mineralization. In addition to pyrrhotite and arsenopyrite, minor pyrite, chalcopyrite and sphalerite are observed. The main gangue minerals are quartz and calcite.

Native gold occurs in quartz-albite-carbonate veins associated with strong quartz-carbonate-pyrrhotite alteration (**Fig. 6**) which form local stockworks, with individual veins ranging from a few millimetres to 0.5 m in thickness. The dominant sulphide mineral in the veins ($< 0.2\text{m}$) is pyrrhotite and much less commonly, arsenopyrite. Where disseminated, the gold is mostly associated with pyrrhotite as compared to arsenopyrite.

Gold grades are controlled by a quartz-ankerite-pyrrhotite-arsenopyrite alteration assemblage which is spatially associated with quartz-albite-carbonate veins/stockwork. The intensity of hydrothermal alteration correlates with the intensity of veining. Thus, heavily veined quartz diorite

rocks display evidence of moderate to strong alteration with patchy to pervasive sulphidation, whereas weakly veined rocks display weak to no alteration with limited to no sulphide development (Fig. 7).

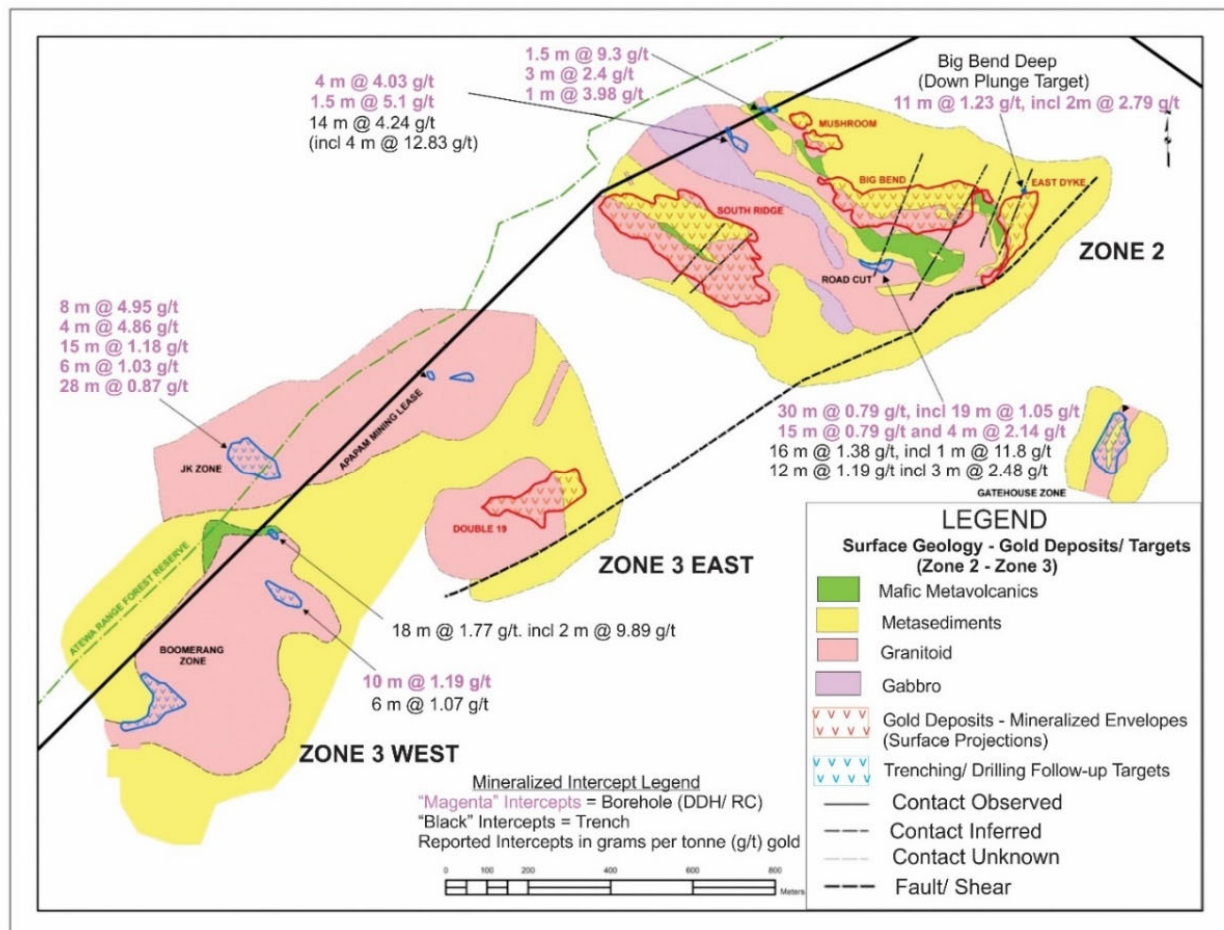


Figure 4: A geological map of part of the Apapam concession, showing Zones 2 and 3 and gold grades from drill holes and trenches (modified after Xtra-Gold Resources Corporation, 2020 <https://www.xtragold.com/kibi-project/maps/>).



Figure 5: Disseminated and vein-hosted pyrrhotite and arsenopyrite in quartz diorite accompanied by pervasive ankeritic alteration in drill core from the Kibi-Gold Project.

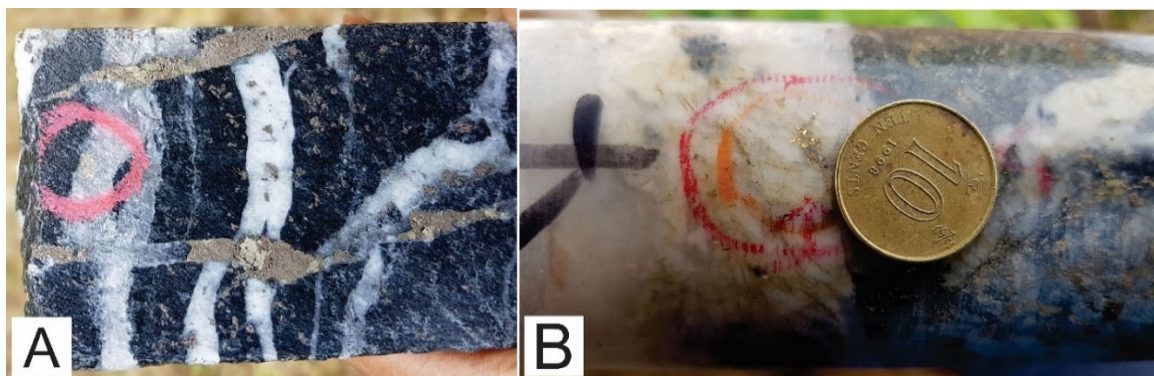


Figure 6: A. A drill core sample containing auriferous pyrrhotite-pyrite-bearing, quartz-albite-carbonate and quartz-carbonate veins in quartz diorite. There is a gold grain in the pink circle. B. Gold grains in a quartz-albite-carbonate veins in quartz diorite; the veins are surrounded by disseminated pyrrhotite and arsenopyrite and pervasive quartz and ankerite alteration. There are several gold grains in the red circle.

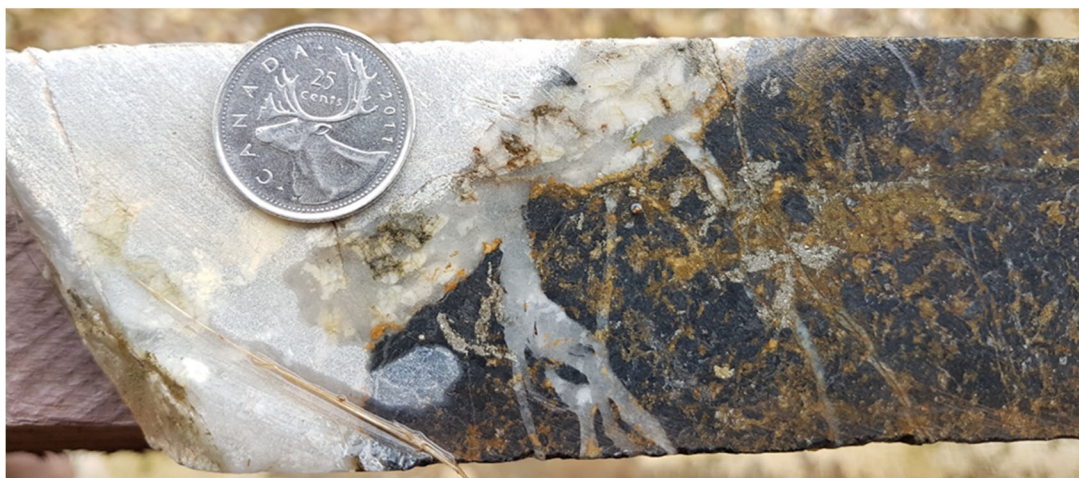


Figure 7: Quartz-albite-carbonate veins accompanied by intense ankerite alteration and disseminated pyrrhotite and arsenopyrite in quartz diorite .

PETROGRAPHY

Metasedimentary Rocks

The metasedimentary rocks in the study area consist of fine to medium-grained argillite and greywacke, with bedding dipping $\sim 45^\circ$ NW-SE. These rocks are composed primarily of quartz, biotite and plagioclase. They have been metamorphosed to greenschist facies conditions, as shown by the presence of chlorite and biotite (biotite zone) without minerals like garnet or staurolite that would be indicative of higher metamorphic grade.

Meta-argillite rocks are cut by discontinuous early quartz veins and have a weak foliation defined by carbonate and sericite (**Fig. 8a**). In addition, the meta-argillite is cut by discontinuous carbonate lenses (**Fig. 8b**).

The metagreywacke displays a strong foliation defined by laminae rich in calcite (**Fig. 8c**). Early quartz-calcite veins are common in the metagreywacke and are interpreted to be syn-metamorphic. They contain syn-metamorphic biotite, which helps define the foliation and indicates that they reached upper greenschist, biotite zone conditions. Partial replacement of the biotite by chlorite indicates that the rocks were subject to post-metamorphic alteration (**Fig. 8d**).

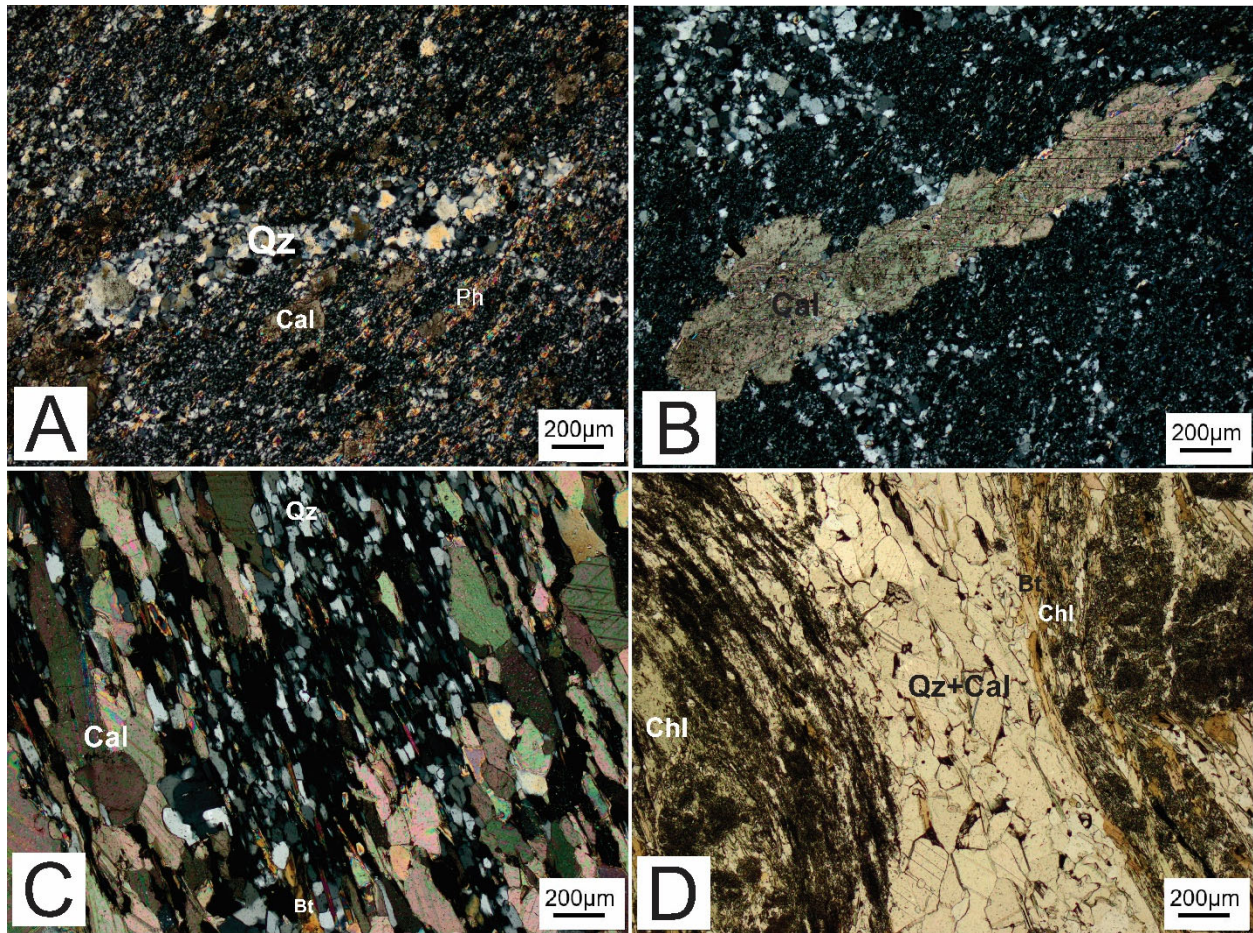


Figure 8: *A. Meta-argillite with a quartz lens in a fine-grained quartz and plagioclase-rich matrix containing calcite and white mica defined that define a weak foliation (cross-polarized light, XPL). B. A calcite lens in a fine-grained quartz and plagioclase meta-argillite (XPL). C. Quartz, biotite and calcite grains showing preferred orientations that define a foliation parallel to bedding, in metagreywacke (XPL). D. Pervasive chlorite alteration of biotite metagreywacke cut by an early quartz-calcite vein (plane-polarized light, PPL). Cal = calcite, Chl = chlorite, Qz = quartz, Ph = phengite and biotite = biotite.*

QUARTZ DIORITE

The intrusive rocks are composed mainly of quartz, biotite and plagioclase, with minor amounts of K-feldspar, clinopyroxene and hornblende. Accessory minerals include zircon, monazite, xenotime, and rare garnet, titanite and tourmaline. Based on the proportions of primary quartz (~20%) and K-feldspar (~5%), they correspond compositionally to quartz diorite using the classification scheme of Streckeisen et al. (2002).

The quartz diorite is medium-to-coarse-grained, and locally porphyritic with respect to plagioclase. The quartz crystals exhibit anhedral to sutured textures and undulose extinction. Myrmekitic intergrowths of quartz and plagioclase occur locally (**Fig.9a**), as do granophyric intergrowths of quartz and K-feldspar. Plagioclase and K-feldspar occur as euhedral to subhedral grains, with K-feldspar exhibiting Carlsbad twinning (**Fig.9b**).

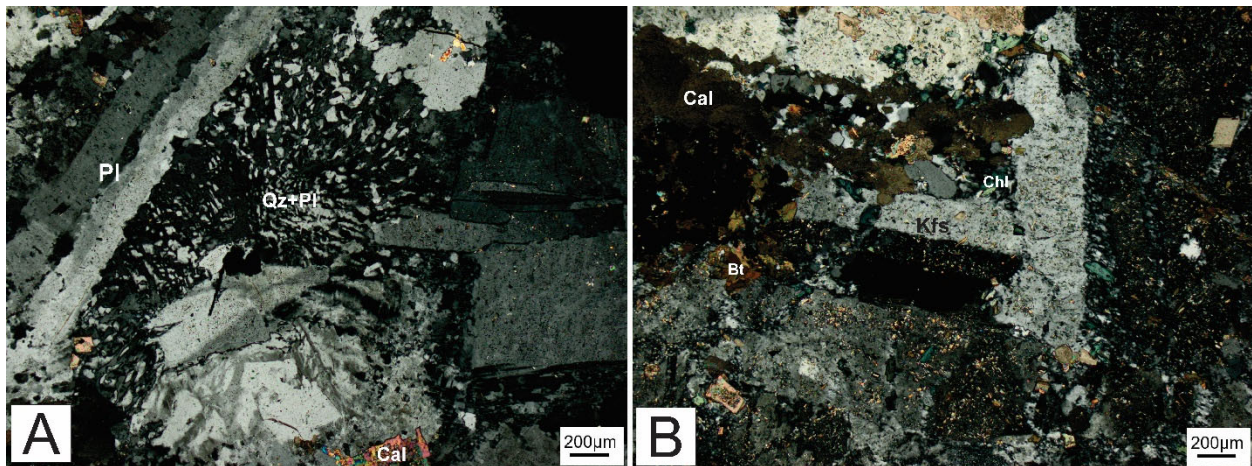


Figure 9: A. Quartz and plagioclase exhibiting a myrmekitic texture in least altered quartz diorite (XPL). B. Moderately altered quartz diorite, with chlorite altering biotite and sericite replacing plagioclase. The K-feldspar exhibits Carlsbad twinning (XPL). Pl = plagioclase, Qz = quartz, Cal = calcite, Bt = biotite, Chl = chlorite.

ALTERATION

The alteration of the quartz diorite is characterized by variable degrees of sulphidation (replacement of ferromagnesian silicate minerals by pyrrhotite and arsenopyrite), sericitization, chloritization, carbonatization and albitization. The secondary minerals consist mainly of albite (most of the primary plagioclase is altered), carbonate (ankerite and calcite), white mica and chlorite, as well as minor amounts of hematite, magnetite, rutile, ilmenite and fluorapatite.

The earliest alteration is characterized by the assemblage quartz-albite $\pm$ white mica $\pm$ calcite $\pm$ chlorite. Plagioclase and K-feldspar are variably altered to white mica (in trace amounts; **Fig. 10a**), and chlorite replaced primary biotite, garnet and hornblende (**Fig. 10 b, c & e**). Carbonate alteration involved the crystallization of secondary calcite after hornblende (**Fig. 10f**). The myrmekite may represent an even earlier alteration, i.e., the exsolution of Ca and Na from K-feldspar and its inversion to microcline and production of plagioclase and quartz (**Fig. 9a**; Collins & Collins, 2001)

Carbonatization (mainly ankerite) and sulphidation are the principal alteration types associated with gold mineralization, with weak white mica alteration (**Fig. 11a**), and trace amounts of chlorite. Evidence of ankerite replacing ferromagnesian minerals proved to be difficult to find as ankerite alteration associated with gold mineralization, is pervasive and uniformly distributed. Sulphidation was mainly the result of the replacement of ferromagnesian silicate minerals (e.g., biotite) by pyrrhotite (**Fig. 11c**); ankerite is especially common in association with pyrrhotite and arsenopyrite (**Fig. 11a**), and locally pyrrhotite replaced ankerite (**Fig. 11d**)

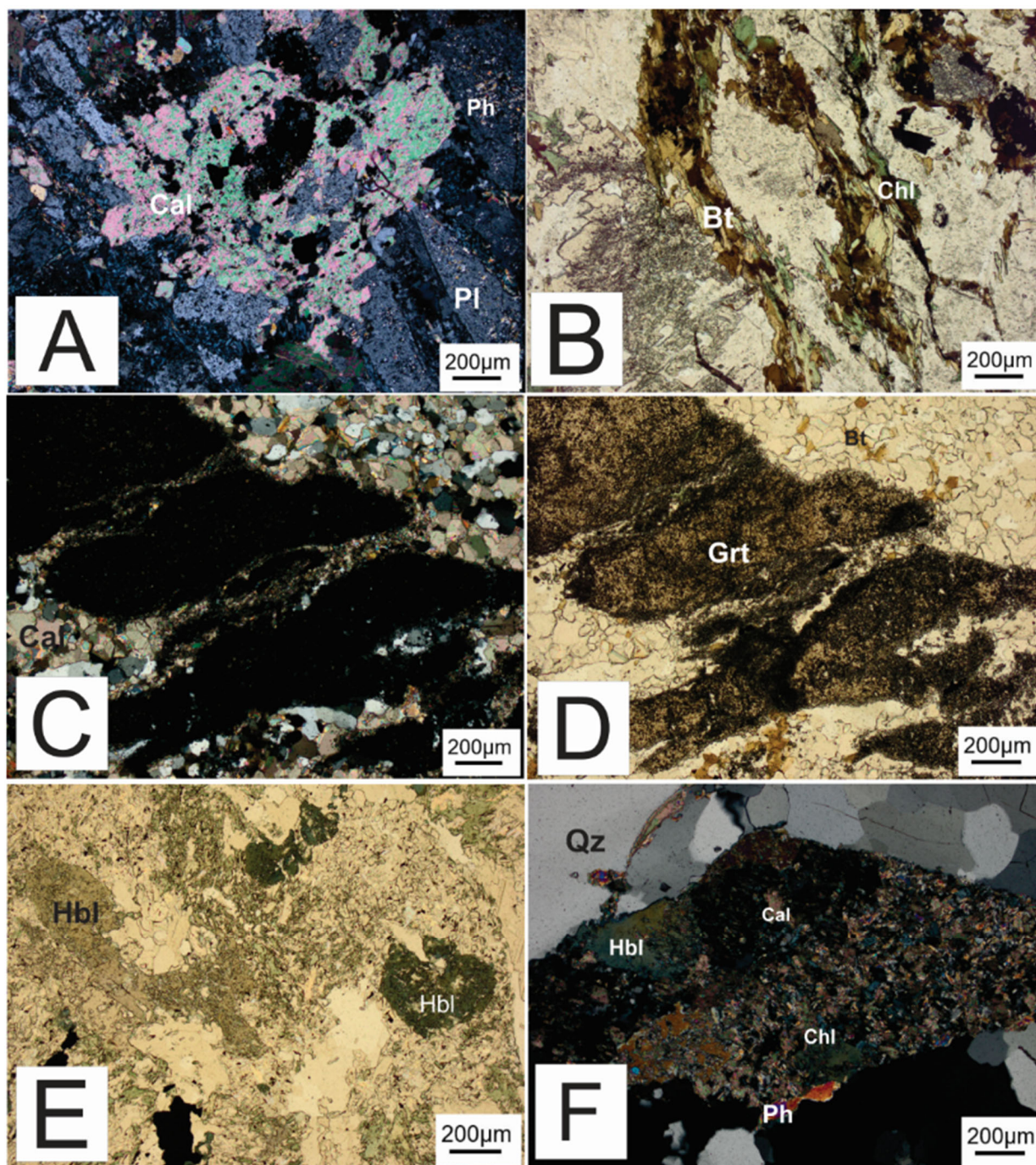


Figure 10: A. Partial replacement of plagioclase by white mica in quartz diorite(XPL). B. Biotite-chlorite-rich fractures in quartz diorite, in which chlorite partially replaced biotite (PPL). C-D. Garnet (grossular) partially altered by chlorite, in quartz diorite (XPL and PPL respectively). E. Strongly altered quartz diorite showing preferential replacement of hornblende by chlorite (PPL). F. Pervasive calcite, chlorite and white mica alteration of hornblende (XPL). Grt = garnet, Pl = plagioclase, Cal = calcite, Qz = quartz, Ph = phengite, Hbl = hornblende and Bt = biotite

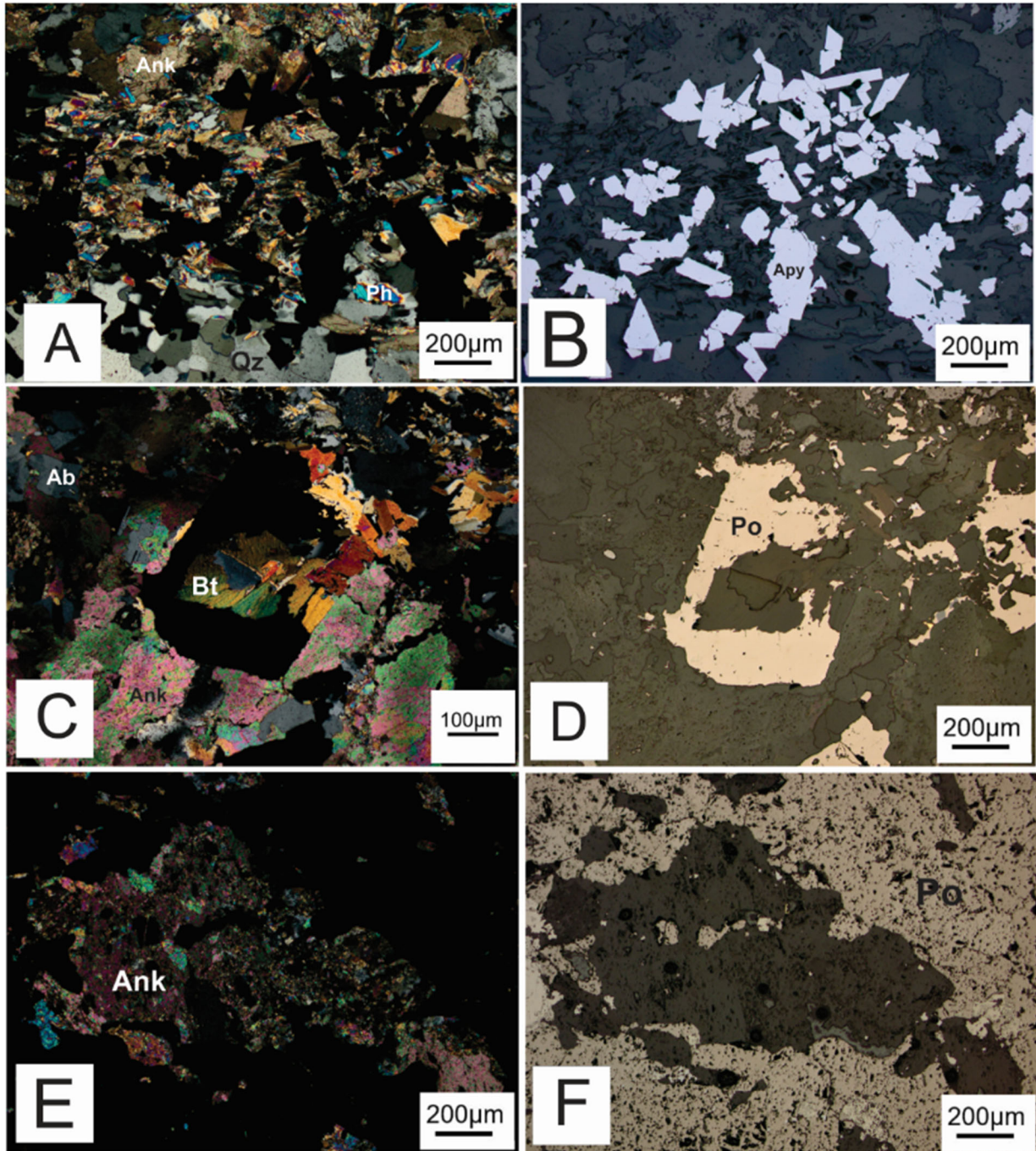


Figure 11: Disseminated arsenopyrite in association with pervasive ankerite and weak white mica alteration in quartz diorite **A.** in XPL. **B.** in reflected light. **C** and **D.** Pyrrhotite replacing biotite in XPL and reflected light, respectively. **E** and **F.** Pyrrhotite replacing ankerite in quartz diorite, XPL and reflected light, respectively. *Po* = pyrrhotite, *Bt* = biotite, *Ank* = ankerite, *Ph* = phengite, *Apy* = arsenopyrite and *Qz* = quartz.

GOLD MINERALIZATION

Gold mineralization occurs as small ($\sim 5\mu\text{m}$) to medium-sized ($\sim 35\text{--}74\ \mu\text{m}$), anhedral native gold grains, with a gold-silver weight ratio of 7:1 (based on electron microprobe WDS analyses). Native gold grains occur primarily as isolated inclusions in arsenopyrite and pyrrhotite (**Fig. 12a, b&c**). These observations suggest that native gold precipitated before the sulphides or gold and sulphides precipitated synchronously. Native gold grains also occur in quartz-albite-carbonate veins surrounded by quartz-carbonate-pyrrhotite alteration (**Fig. 6**) and is locally associated with sphalerite and pyrrhotite, and in particular with ankerite. (**Fig. 12d**).

The main sulphide minerals, pyrrhotite and arsenopyrite, occur mainly as disseminated grains in the host rocks and are particularly abundant in association with gold mineralization. Pyrrhotite, as mentioned above replaced biotite (**Fig. 11c**) and ankerite (**Fig. 11e, 12c&d**). Therefore, gold mineralization post-dates peak metamorphism.

In some parts of the deposits, quartz-albite-carbonate veins contain anhedral fluorapatite that surrounds pyrrhotite associated with native gold and arsenopyrite (**Fig. 13a**). This textural relationship indicates that in these rocks, native gold precipitation was possibly syn-arsenopyrite and was pre-pyrrhotite (**Fig. 13a**) and also pre-fluorapatite. Trace amounts of telluride minerals (altaite, hessite and bismuth-bearing tellurides) are associated with pyrrhotite and arsenopyrite but there is no obvious relationship with gold (**Fig. 13b**).

Pyrite crystallization predated pyrrhotite, and chalcopyrite deposition post-dated both minerals, (**Fig. 14a**). However, arsenopyrite appears to have predated pyrite (**Fig. 14b**).

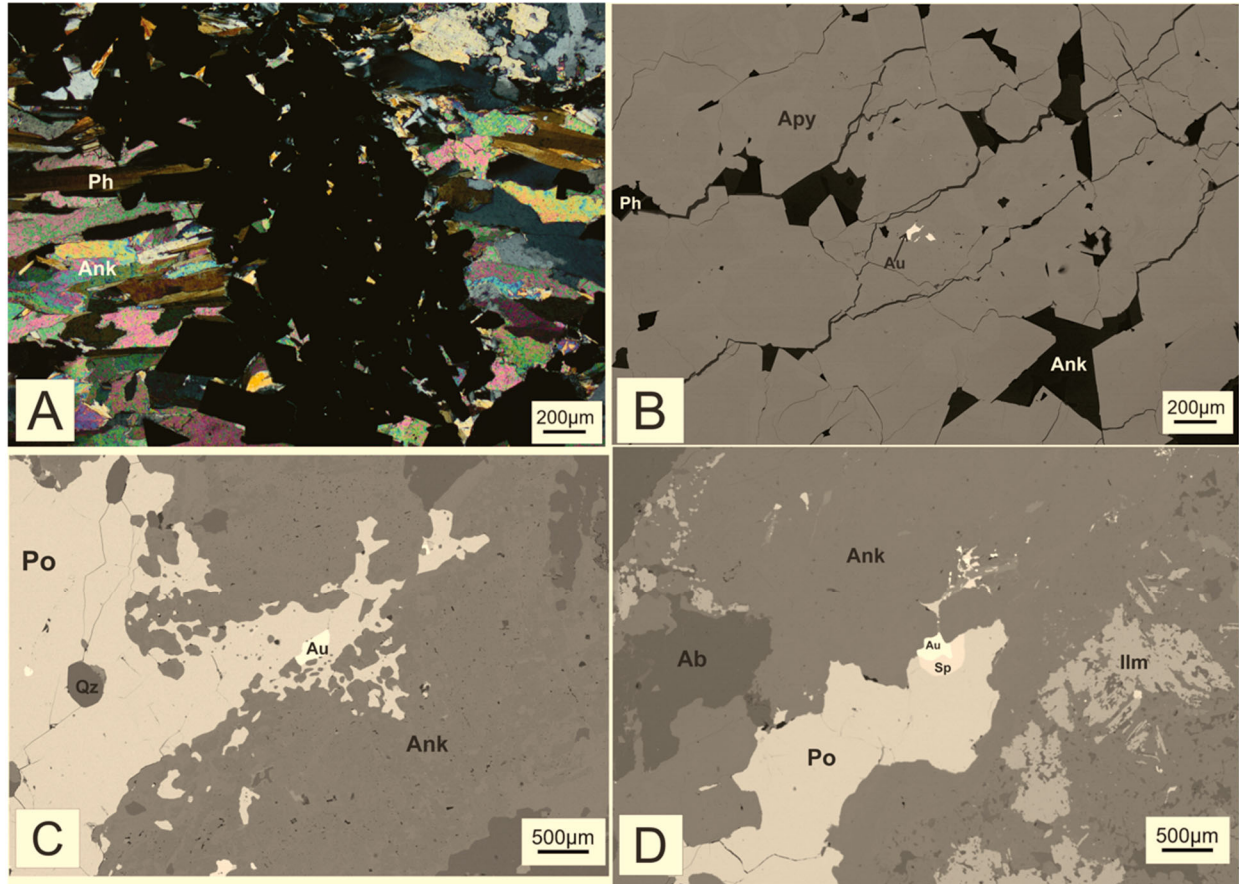


Figure 12: *A. A photomicrograph illustrating fracture-controlled arsenopyrite cutting pervasive ankerite alteration and weak white mica alteration in quartz diorite (XPL). B. A backscattered scanning electron microscope (SEM) image showing a gold inclusion (white) in arsenopyrite. C. A SEM image of a native gold inclusion in pyrrhotite surrounded by ankerite, with ankerite replacing pyrrhotite. D. A gold grain partly surrounded by sphalerite and, in turn, pyrrhotite adjacent to ankerite. Ab = albite, Ank = ankerite, Ilm = ilmenite, Po = pyrrhotite, Sp = sphalerite, Au = Gold, Qz = quartz, Ph = phengite.*

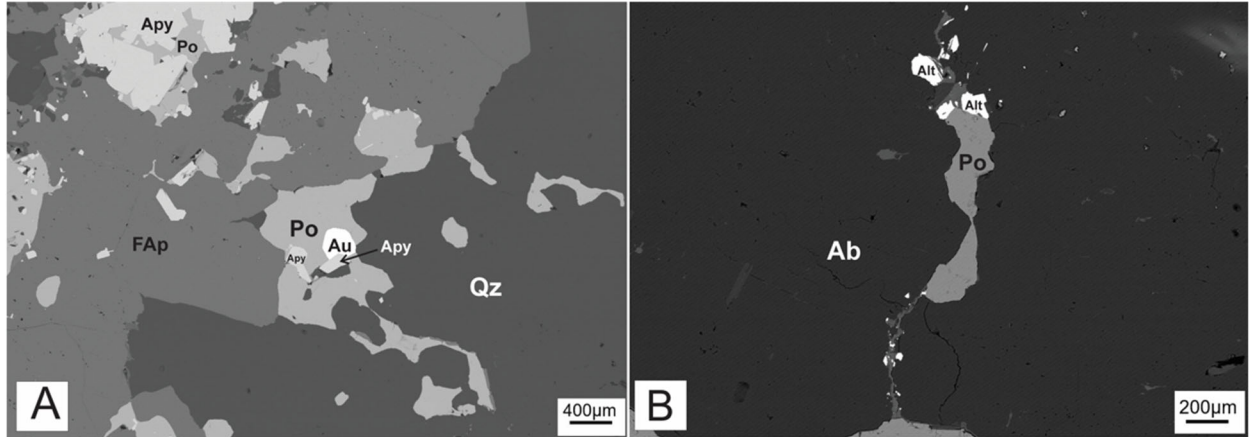


Figure 13: *A. SEM image showing a native gold grain adjacent to arsenopyrite and surrounded by pyrrhotite and, in turn, fluorapatite. B. A SEM image of an albite-hosted vein, in which altaite is closely associated with pyrrhotite. Fap = fluorapatite, Qz = quartz, Apy = arsenopyrite, Po = pyrrhotite, Ab = albite, Alt = altaite and Au = native gold.*

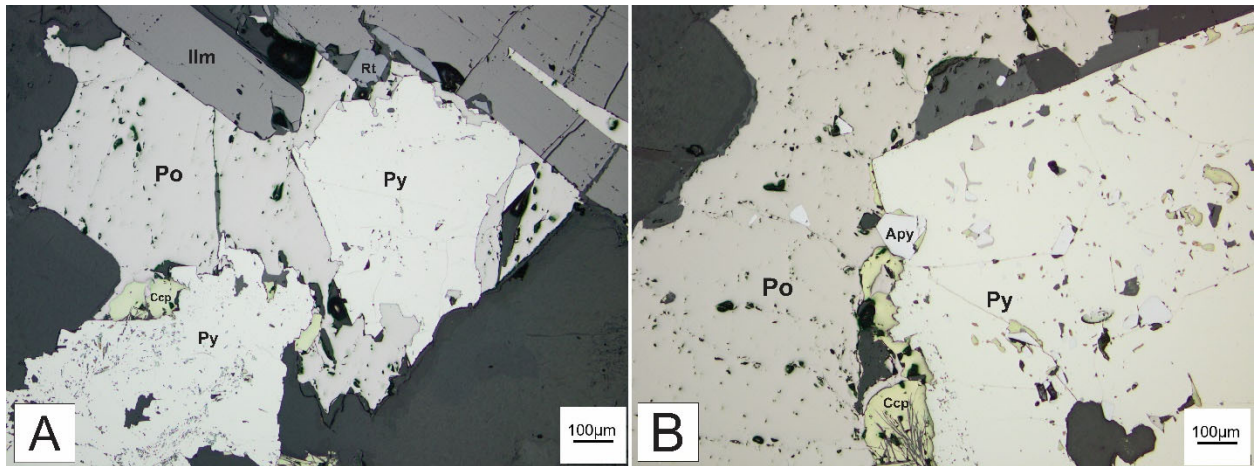


Figure 14: *A. Pyrrhotite replacing pyrite, and minor later chalcopyrite. B. A euhedral arsenopyrite crystal partly surrounded by pyrite and partly by pyrrhotite. Chalcopyrite replaced both the pyrite and the pyrrhotite. Po = pyrrhotite, Py = pyrite, Ccp = chalcopyrite, Apy = arsenopyrite, Ilm = ilmenite, Rt = rutile.*

Mineral	Primary	Early Alteration	Mineralization
Quartz			
Albite			
K-feldspar			
Biotite			
White Mica		-----	
Chlorite			-----
Hornblende		-----	
Garnet		-----	
Gold			
Ankerite			
Pyrrhotite			
Pyrite			
Arsenopyrite			
Chalcopyrite			-----
Sphalerite			-----
Fluorapatite			
Calcite			
Hematite		-----	
Magnetite		-----	
Rutile			
Ilmenite			
Tellurides			-----

Table 1: A paragenetic sequence for mineralized quartz diorite in the Kibi-Gold Project. The thick bold lines, indicate a large proportion of the minerals, the thin lines represent minor mineral proportions, and the dashed lines represent trace amounts of the minerals.

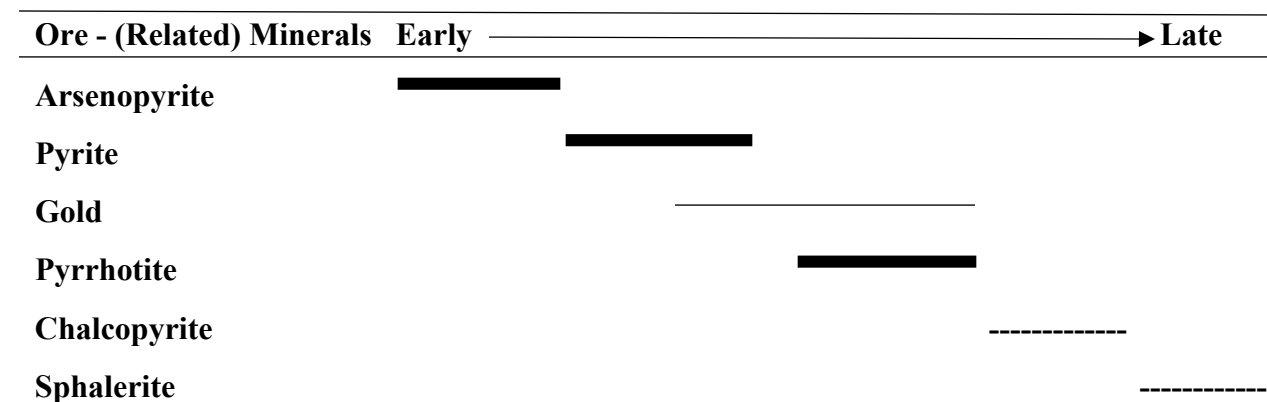


Table 2: A paragenetic sequence of gold and the early and late ore-related sulphide minerals which occurred in the mineralized quartz diorite of the Kibi-Gold Project. The thick bold lines indicate a large proportion of the minerals, the thin lines represent minor mineral proportions, and the dashed lines represent trace amounts of the minerals.

Analytical Methods

Analyses of the major and trace element contents of whole-rock samples were conducted by Activation Laboratories Limited in Ancaster, Ontario. The samples were crushed to a nominal -2 mm grain-size and then pulverized to 105 microns. The mills used in the crushing and pulverization were made of mild steel to avoid Cr or Ni contamination. The resulting pulps were analyzed for their major elements by ICP-OES (code 4Lithoresearch) and for their trace elements by ICP-MS (code 4B); gold content was determined by INAA. Both major and trace elements were analyzed after lithium tetraborate fusion.

Selected altered and mineralized rocks were analyzed for stable isotope (sulphur, carbon and oxygen) ratios. The preparation and analysis of sulphur isotopes were carried out by the Queen's Facility for Isotope Research (QFIR), Queen's University, Kingston on 10 mg of powdered sulphide separates. The isotopic compositions were measured using a MAT 253 Stable Isotope Ratio Mass Spectrometer coupled to a Costech ECS 4010 Elemental Analyzer. The data are reported in delta (δ) notation in per mil units (‰) and are reproducible to 0.2‰. Carbon and oxygen isotope analyses were carried out on aliquots of 50-100 μ g of powdered ankerite on a Nu Instruments Perspective mass spectrometer equipped with a NuCarb online preparation device at the McGill University/Geotop Stable Isotope Laboratory. The data are reported for carbon relative to V-PDB and for oxygen relative to V-SMOW. The reproducibility was better than 0.1‰ based on regular analyses of the in-house standard (UQ6).

The compositions of the alteration minerals, sulphides and ore mineral were analyzed at McGill University with a Cameca SX-Five FE electron microprobe. Analyses of gold grains were conducted with a voltage of 20 kV, a beam current of 20 nA, a counting time of 30 sec for each element and a beam diameter of approximately 1 μ m, for (Au, Ag), (Bi, Te), Hg and Fe. The

analyses are calibrated with ASTIMEX standard Au₆₀Ag₄₀, CANMET standards, Bi₂Te₃, cinnabar and pyrite, respectively.

The beam diameter was increased to ~ 5 µm for analyses of ankerite, chlorite and white mica. Analyses for these minerals were conducted at a voltage of 15 kV and beam current of 20 nA, with a counting time of 30 sec for each element. The elements analyzed in ankerite were (Mg, Ca), Fe and Mn, and were calibrated with the CANMET standards, Diopside, Hematite and Willemite, respectively. The elements analyzed in chlorite were (Mg, Al), Fe, K, Si, Mn, Ti and the standards used were the CANMET standards Spinel, Hematite, Muscovite, Kyanite, Spessartine and Rutile, respectively. The elements analyzed in white mica were Mg, Fe, (K, Al) and Si, and the standards used were the CANMET standards, Diopside, Hematite, Muscovite and Kyanite, respectively.

Analyses of arsenopyrite and pyrrhotite were conducted at a voltage of 20 kV, with a beam size of ~5 µm and a beam current of 20 nA. The counting time for each element is 30 sec except for Co, for which the time was 40 sec in arsenopyrite and 60 sec in pyrrhotite. The elements analyzed in arsenopyrite were (Fe, S), (As, Co, Ni), Cu, Pb, Se, Sb and Cd, and the standards used were the CANMET standards Pyrite, CoNiAs, Chalcopyrite, Galena, AgBiSe₂, Stibnite and CdTe, respectively. The elements analyzed in pyrrhotite were (Fe, S) and (Co, Ni) and the standards used were the CANMET standards Pyrrhotite and CoNiAs, respectively. The data were corrected using the Pouchou and Pichoir (PAP) model and the detection limits were determined as described in Ancy et al. (1978).

WHOLE-ROCK GEOCHEMISTRY

The whole-rock chemistry of sixteen representative samples of quartz diorite were used to determine the chemical affinity of this rock unit and make inferences about the tectonic setting of the study area. As the quartz diorite is highly altered, it was not possible to reliably classify the samples using major element classification diagrams (e.g., the total alkali vs silica (TAS) diagram of Middlemost, 1994, the A/CNK- A/NK diagram of Shand, 1943 and the R1-R2 diagram of De la Roche et al., 1980).

Selected immobile trace elements and their ratios were therefore used for this purpose. Zirconium and yttrium are generally immobile and, therefore, provide convenient indices of differentiation in igneous rocks (Winchester and Floyd, 1977). On a Zr-Y diagram, quartz diorite plots in the tholeiitic field and delineates a trend of fractional crystallization marked by increasing Zr and Y (**Fig. 15**). The Zr/Y values of the quartz diorite samples are displayed in **Table 3**. The Zr/TiO₂ versus SiO₂ diagram of Winchester and Floyd (1977) classifies most of the samples as trachyandesite, with some falling in the field of basanite-trachybasanite-nephelinite (**Fig. 16**). It should be cautioned, however, that this classification may be incorrect because of the mobility of silica during alteration. A more reliable classification is provided by the Nb/Y versus Zr/Ti diagram (Pearce, 1996).

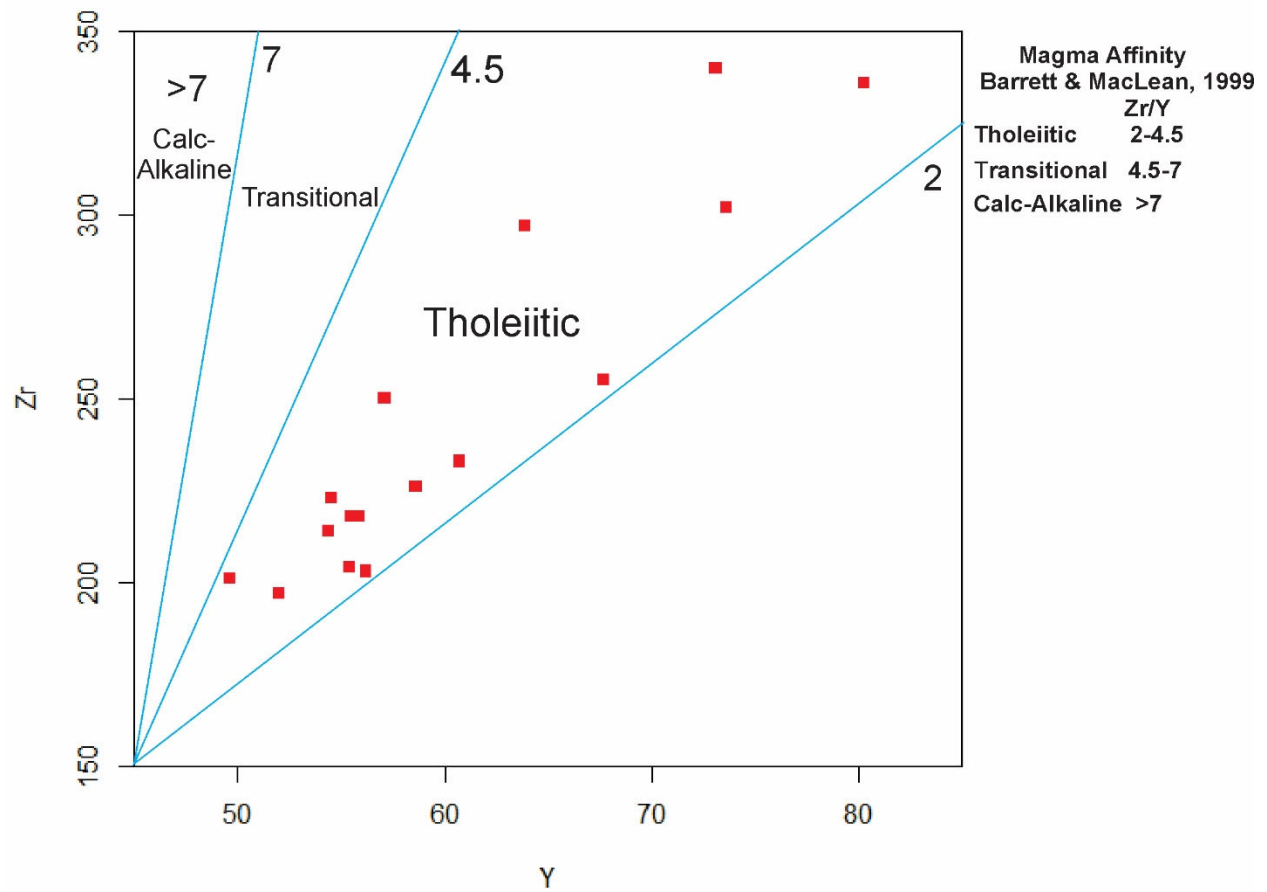


Figure 15: Magma affinity based on a Zr/Y plot (Ross and Bedard, 2009) indicating that the rocks are tholeiitic. The field boundaries were taken from Barrett and MacLean, 1999. The Zr/Y values of quartz diorite samples are listed in Table 2.

Table 3: Zr/Y values of quartz diorite samples

Sample	Zr/Y
P27804	4.37
P11301	3.86
P11302	3.93
P11303	3.84
P26301	4.65
P26303	4.65
P11101	3.93
P11103	3.79
P11104	3.90
KBDDD 11113-7	3.68
P27803	4.09
P23103	4.10
P23102	4.18
P23105	3.77
KBDD 18278-21	3.61
P10601	4.05

On a Nb/Y versus Zr/Ti diagram, most of the Kibi intrusive rocks plot within the andesite/ basaltic andesite field and a few plot in the rhyolite/dacite field. Thus, in plutonic intrusive terms, they range in composition between diorite and granodiorite (**Fig. 17**).

On a chondrite-normalized REE diagram (Boynton, 1984), the samples display moderately fractionated profiles, with a modest enrichment in the LREE, a small negative Eu anomaly and fairly flat HREE distribution (**Fig. 18**).

Their primitive mantle-normalized profiles show significant LILE enrichment and a weaker enrichment in the HFSE (**Fig. 19**). The most striking features are depletions in Nb, Ti and Sr (the Sr depletion is likely an artefact of the alteration) and enrichments in Pb and K (these enrichments may also be due to alteration). The HFSE depletion (Nb and Ti) is characteristic of a tectonic setting related to convergent plate boundaries (Gill, 1981; Kaygusuz et al., 2010).

Trace element discriminatory diagrams (e.g., Pearce et al., 1984) yield contradictory results. Whereas those involving Nb, Ta, Y and Yb (all relatively immobile elements) predict that the Kibi diorites were emplaced mainly in an ocean ridge setting (ORG; **Fig. 20**), those involving Rb predict a mainly within plate emplacement. Given the relative mobility of Rb during hydrothermal alteration, it seems more likely that the Kibi rocks were emplaced along an ocean ridge setting. This is also consistent with the conclusion that they have tholeiitic affinity (**Fig. 15**).

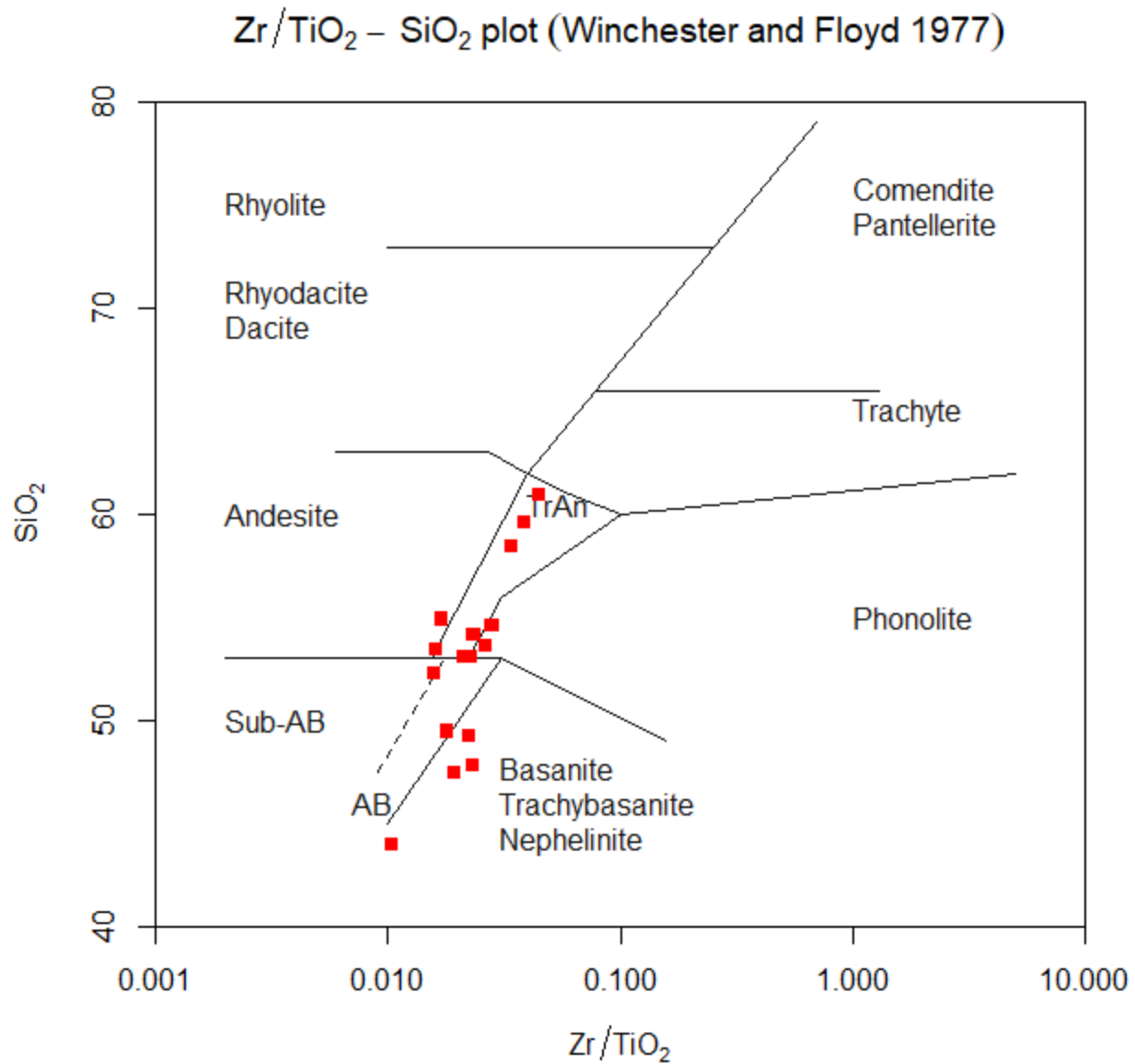


Figure 16: A Zr/TiO₂ versus SiO₂ classification diagram (Winchester and Floyd, 1977) showing that the quartz diorite plots mainly in the trachyandesite field, with some samples in the andesite basanite-trachybasanite-nephelinite, and alkali basalt fields. These classifications may be unreliable due to the mobility of silica associated with hydrothermal alteration.

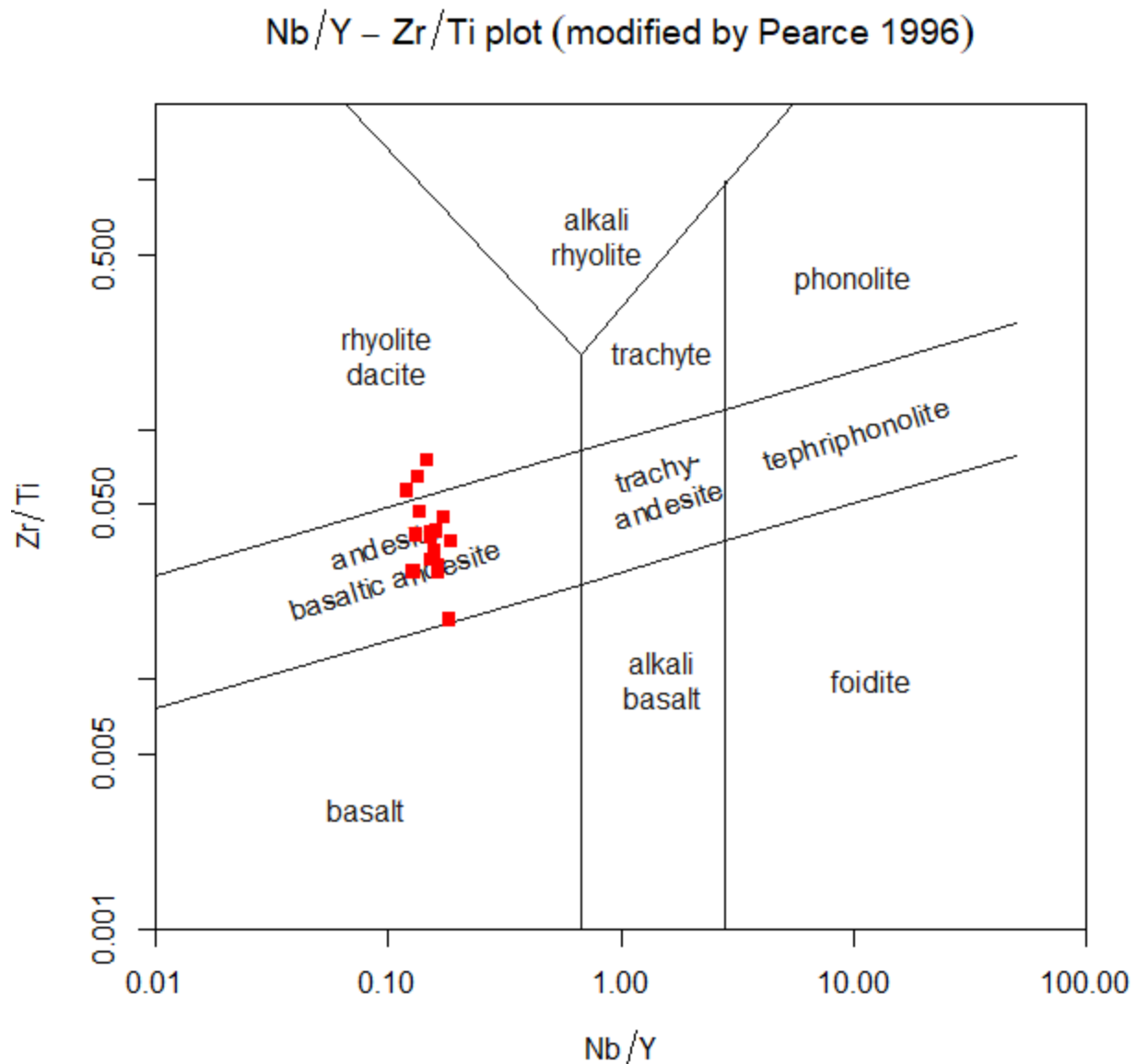


Figure 17: An igneous classification diagram of Nb/Y against Zr/Ti (Pearce, 1996) showing that most of the quartz diorite samples plot in the andesite/ basaltic andesite field, with diorite as the intrusive equivalent. This classification diagram addresses the effect of alteration on these rocks.

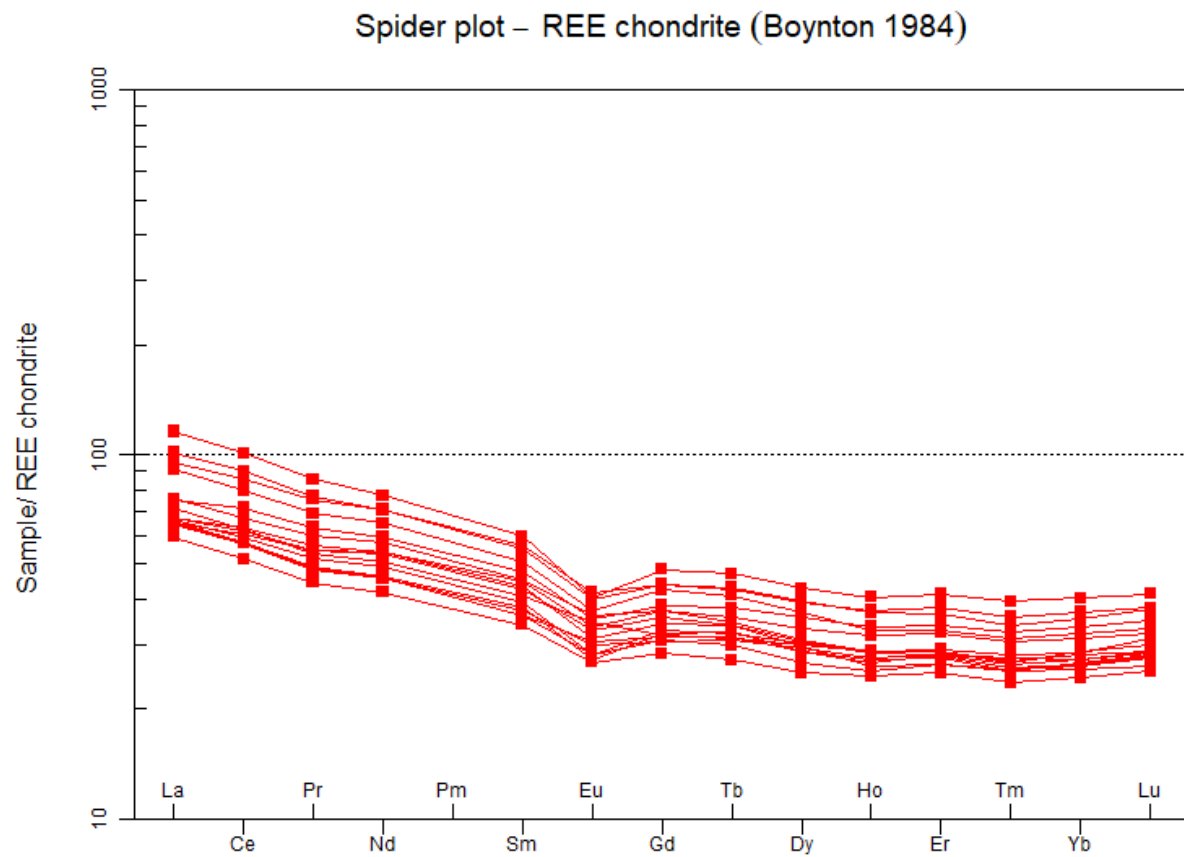


Figure 18: A chondrite-normalized REE diagram (Boynton, 1984) for Kibi quartz diorite samples, displaying a slight enrichment of LREEs, a fairly flat HREE pattern, and a minor negative Eu anomaly.

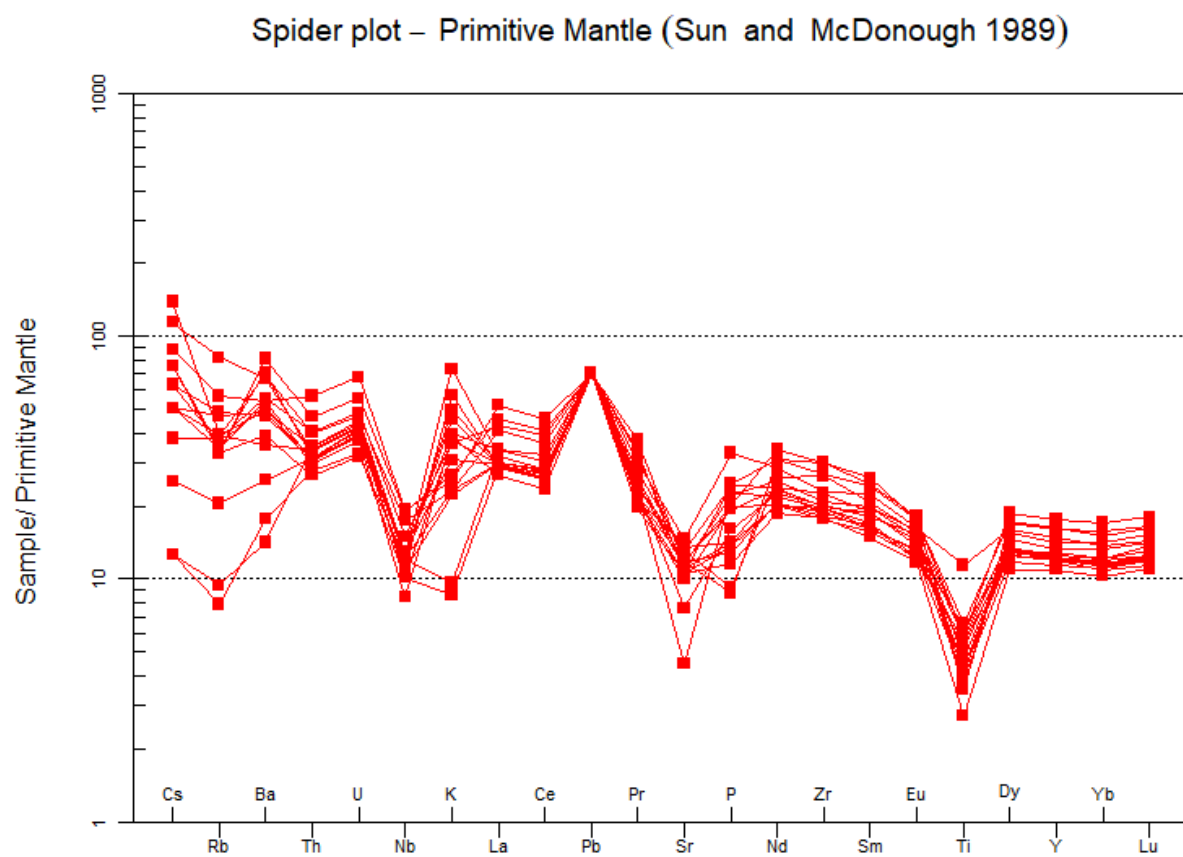


Figure 19: Primitive mantle-normalized spider plots (Sun and McDonough, 1989) for Kibi quartz diorite samples, showing a general enrichment of LILEs and depletion of the HFSEs, Nb and Ti.

Granitoid tectonic discrimination – Pearce et al. (1984)

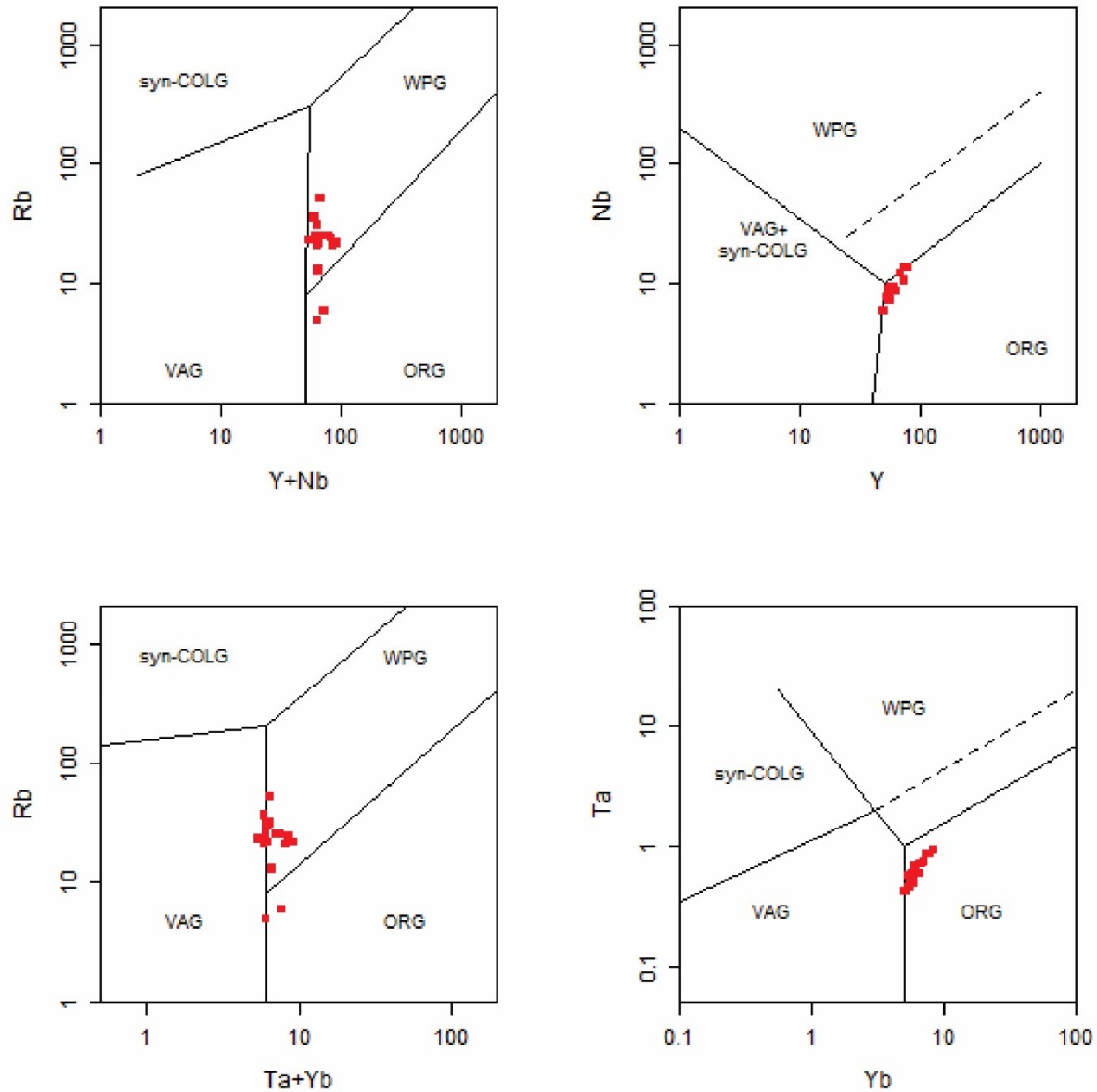


Figure 20: Tectonic discriminant diagrams (Pearce et al., 1984) showing the Kibi quartz diorites as possibly related to an ocean-ridge setting (ORG). WPG = Within-plate setting, syn-COLG = syn-collision setting, VAG = volcanic arc setting

LITHOGEOCHEMICAL CORRELATIONS WITH GOLD

From the petrographic relationships described earlier, it is evident that native gold is spatially associated with pyrrhotite, arsenopyrite, chalcopyrite and sphalerite and from its chemical composition (see the mineral chemistry section), it seems likely that Au enrichment was accompanied by enrichments in As, Cu, Zn and Ag. In order to test this hypothesis, the bulk rock contents of these elements (in ppm), were compared to those of Au for the 1m core from which these samples were selected. This was done to avoid a nugget effect for Au, which might have been introduced by the smaller bulk rock samples. Significantly, the only element for which there is an apparent correlation (positive) is Cu and even for this element there are several outliers that weaken the correlation. This correlation was unexpected as Cu is depleted relative to the unaltered/unmineralized rocks in most orogenic gold systems (Hodgson et al., 1993).

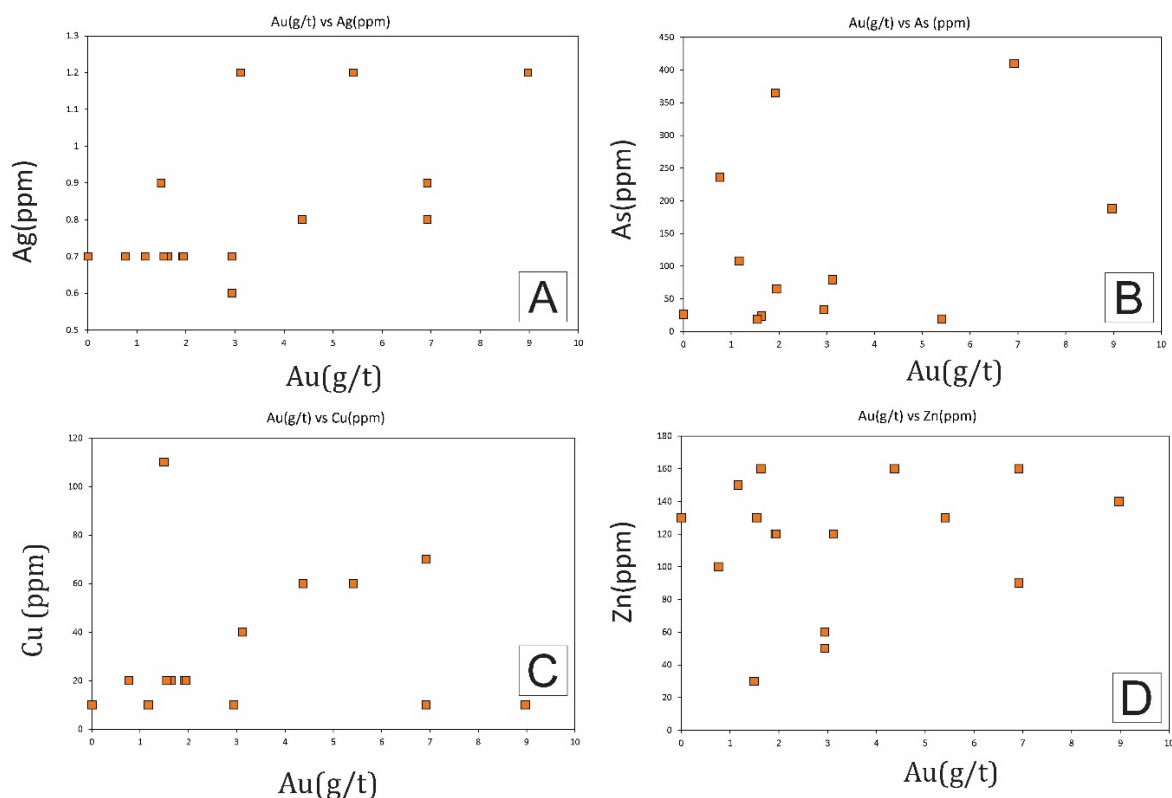


Figure 21: Binary plots showing relationships of Ag, As, Cu and Zn with Au.

STABLE ISOTOPES

Stable isotope compositions of 24 representative ankerite (C and O) and 14 representative pyrrhotite and arsenopyrite (S) samples were analysed to assess the source of the mineralizing fluid and sulphur, respectively. The carbon and oxygen isotopic compositions of ankerite in altered quartz diorite are presented in **Table 4**. The $\delta^{13}\text{C}$ values varied between -13.33 and -8.75 ‰ (V-PDB) and the $\delta^{18}\text{O}$ values between +12.51 and +14.15 ‰ (V-SMOW).

The sulphur isotope compositions of pyrrhotite and arsenopyrite from altered quartz diorite and mineralized veins are presented in **Table 5**. Both sulphides have a limited and overlapping ranges of $\delta^{34}\text{S}$, although those for disseminated pyrrhotite (+0.5 to +2.1 ‰) tend to be slightly lower than those for vein pyrrhotite (+1.3 to +3.3 ‰); the $\delta^{34}\text{S}$ values of arsenopyrite vary between +1.0 and -1.3 ‰.

The C, O, S isotopic compositions of the gold mineralizing fluid were estimated from the isotopic compositions of the minerals assuming a temperature of 400 °C, which, as discussed later, is consistent with the results of chlorite geothermometry that yielded temperatures between $374\pm 11^\circ\text{C}$ and $388\pm 15^\circ\text{C}$. The $\delta^{18}\text{O}_{(\text{fluid})}$ and $\delta^{13}\text{C}_{(\text{fluid})}$ values, which were calculated using the fractionation factors of Zheng (1999) and Ohmoto and Rye (1979), respectively, range between +8.2 and +10.3 ‰ and between -11.2 and -5.7 ‰, respectively. These values are illustrated in **Figure 22**.

Table 4: Oxygen and carbon isotope ratios for ankerite from altered Kibi quartz diorite, and the corresponding ratios for a hydrothermal fluid in equilibrium with ankerite at an estimated temperature of 400°C.

Sample	$\delta^{18}\text{O}$	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$	$\delta^{13}\text{C}$
	V-SMOW(‰)	V-PDB (‰)	fluid(400°C)	fluid(400°C)
X11103	12.57	-10.75	8.67	-8.65
X10608	12.51	-9.63	8.61	-7.53
X10606	13.09	-9.62	9.19	-7.52
X23104	13.00	-9.87	9.10	-7.77
X11309	13.84	-13.33	9.94	-11.23
X11102	12.67	-11.29	8.77	-9.19
X26310	12.73	-10.83	8.83	-8.73
X11105	12.29	-8.77	8.39	-6.67
X23109	13.12	-9.76	9.22	-7.66
X23111	14.15	-13.12	10.25	-11.02
X23106	13.13	-8.75	9.23	-6.65
X11314	12.07	-10.81	8.17	-8.71
P23604	12.34	-9.46	8.44	-7.36
X11316	12.83	-10.38	8.93	-8.28
P10605	12.85	-10.83	8.95	-8.73
P27805	13.20	-9.60	9.30	-7.50
P11304	12.72	-9.91	8.82	-7.81
P11102	12.95	-10.78	9.05	-8.68
P26302	13.01	-7.80	9.11	-5.70
P23104	13.04	-10.61	9.14	-8.51
P23101	12.89	-10.85	8.99	-8.75
P10603	13.61	-9.61	9.71	-7.51
P10604	12.68	-10.72	8.78	-8.62
X11304	12.93	-11.72	9.03	-9.62

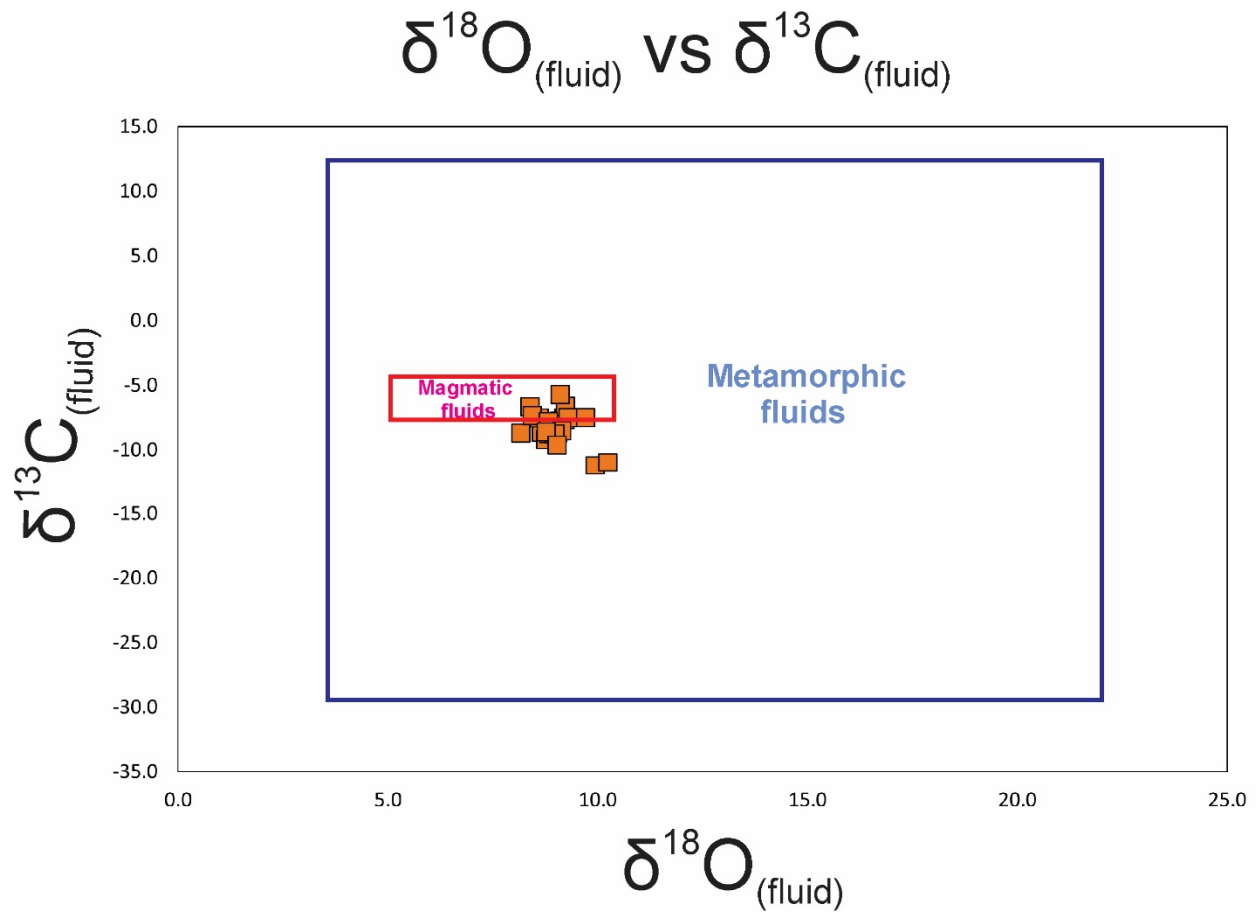


Figure 22: Carbon and oxygen isotopic compositions of the Kibi mineralizing fluid estimated for 400°C, based on the fractionation factors of Zheng (1999) and Ohmoto & Rye (1979), respectively. The magmatic and metamorphic fields are based on Ridley and Diamond, (2000) for the $\delta^{18}\text{O}_{(\text{fluid})}$ boundaries, Gavelin (1957) and Baker and Fallick (1989) for the $\delta^{13}\text{C}_{(\text{fluid})}$ boundaries.

Table 5: Sulphur isotopic compositions of pyrrhotite and arsenopyrite from altered Kibi quartz diorite and mineralized veins.

Sample	Mineral	$\delta^{34}\text{S}$ (‰)
X23105	Arsenopyrite	1.0
X11310	Arsenopyrite	0.0
X102055-1	Arsenopyrite	-1.3
X26309	Pyrrhotite	2.1
X102055	Pyrrhotite	1.0
X102073	Pyrrhotite	1.1
X102074	Pyrrhotite	0.5
X102072	Pyrrhotite	1.0
X102061	Pyrrhotite	1.5
X11313	Pyrrhotite (vein)	1.3
X102066	Pyrrhotite (vein)	1.4
X102058	Pyrrhotite (vein)	3.3
X26307	Pyrrhotite (vein)	1.8
X27816	Pyrrhotite (vein)	2.7

Mineral Chemistry

Ankerite

Ankerite is the main carbonate mineral associated with gold mineralization in the host quartz diorite and, as seen from the earlier petrographic description and the paragenesis presented in **Table 1**, it has a close spatial and temporal association with the ore-related sulphide minerals (pyrrhotite and arsenopyrite). Understanding the chemistry of ankerite, therefore, could be important in interpreting the genesis of the Kibi-Gold deposits.

The composition of ankerite was analyzed in eight representative samples (40 grains) and the carbon and oxygen contents were calculated by difference and stoichiometry. Only Ca, Fe, Mg and Mn were detected and their average proportions in apfu are 1.03, 0.62, 0.30 and 0.03, respectively. Ankerite locally exhibits variably irregular to well-defined and locally oscillatory Mg-Fe zonation, evident in backscattered electron images (**Fig. 23**). **Figure 24** illustrates the composition of the cores and rims of the zones in ankerite, showing that, whereas some ankerite has a Mg-rich core and a Fe-rich rim, in other samples, the reverse is the case. In general, the reverse zoning is restricted to more Fe-enriched ankerite. The relationships between Fe, Mg and Mn are illustrated in **Figure 25**, and except for sample X102074, the ankerite composition displays a remarkably linear distribution of compositions marked by a gradual increase in the proportion of Mn with increasing Mg. The data for sample X102074 are more scattered and the Mn content is higher than in ankerite from other samples. Significantly, this sample has the largest gold grain of any sample analysed. The average compositions of selected ankerite grains are presented in **Table 6**.

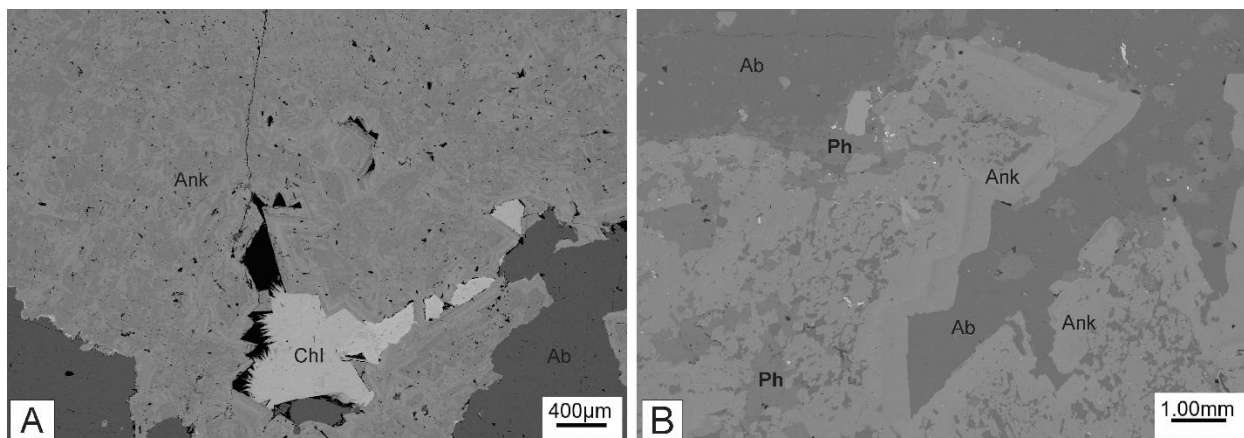


Figure 23: A. Ankerite with Mg-rich (dark) cores and Fe-rich (light) rims. Locally, ankerite displays oscillatory Mg-Fe zoning. B. Ankerite with an inner Fe-rich zone surrounded by a narrow Mg-rich zone and a rim of intermediate composition. Both images are from gold mineralized samples. Ank = ankerite, Chl = chlorite, Ab = albite, Ph = phengite.

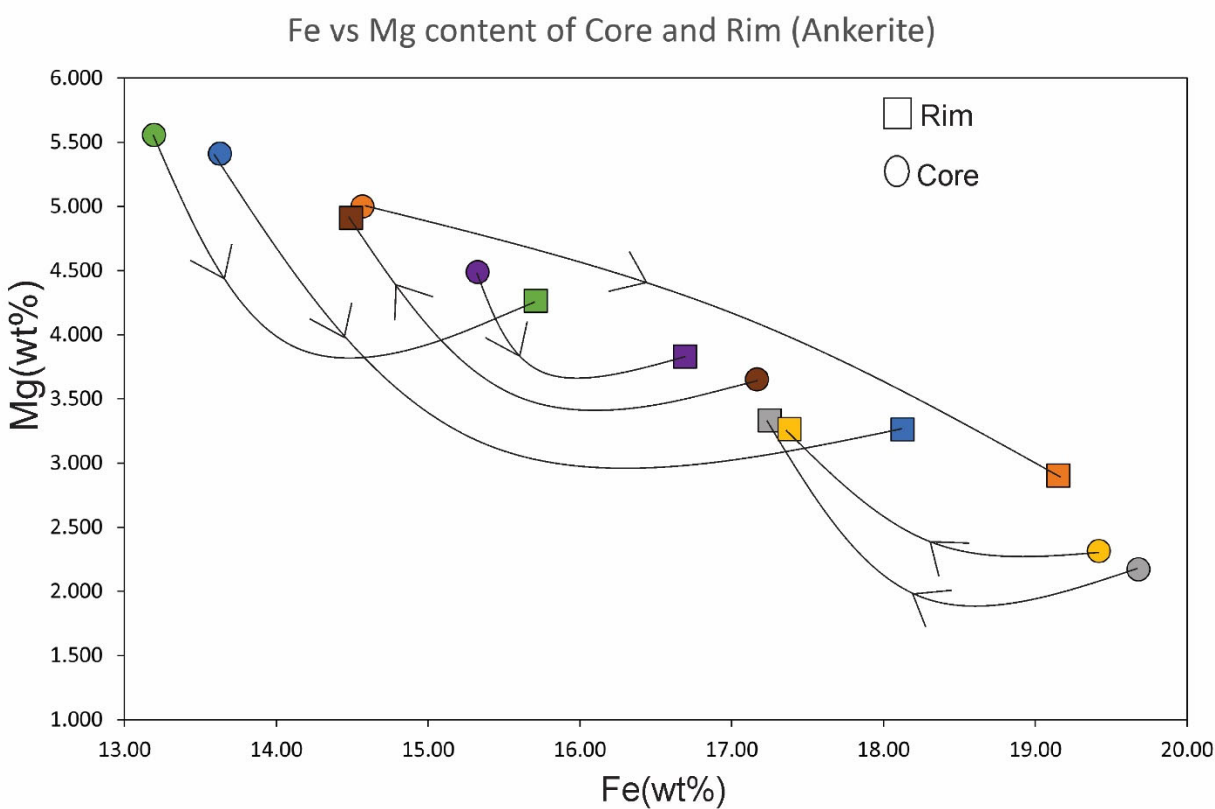


Figure 24: A binary plot of the Fe and Mg compositions of selected cores and rims of ankerite zonation showing two types of ankerite: a type with a Mg-rich core and Fe-rich rim and a type with a Mg-rich rim and Fe-rich core.

Table 6: Average composition of ankerite in mineralized Kibi quartz diorite and oxides of a set of representative suite of cores and rims of ankerite crystals

n = 854		n₁ = 6							
	wt%	Core				Rim			
CaO	28.21 ± 0.44								
MgO	5.97 ± 1.44	5.56	5.41	5.00	4.49	4.26	3.26	2.90	3.83
FeO	21.88 ± 2.18	13.19	13.63	14.57	15.33	15.71	18.13	19.15	16.69
MnO	0.99 ± 0.35								
CO₂	42.95 ± 0.73								
Total	100.00								
Cations	O = 6								
apfu									
Ca	1.03								
Mg	0.30								
Fe	0.63								
Mn	0.03								
C	2.00								

The cation proportions are based on six oxygens. apfu = atoms per formula unit.

n = number of spot analyses.

n₁ = number of representative cores and rims

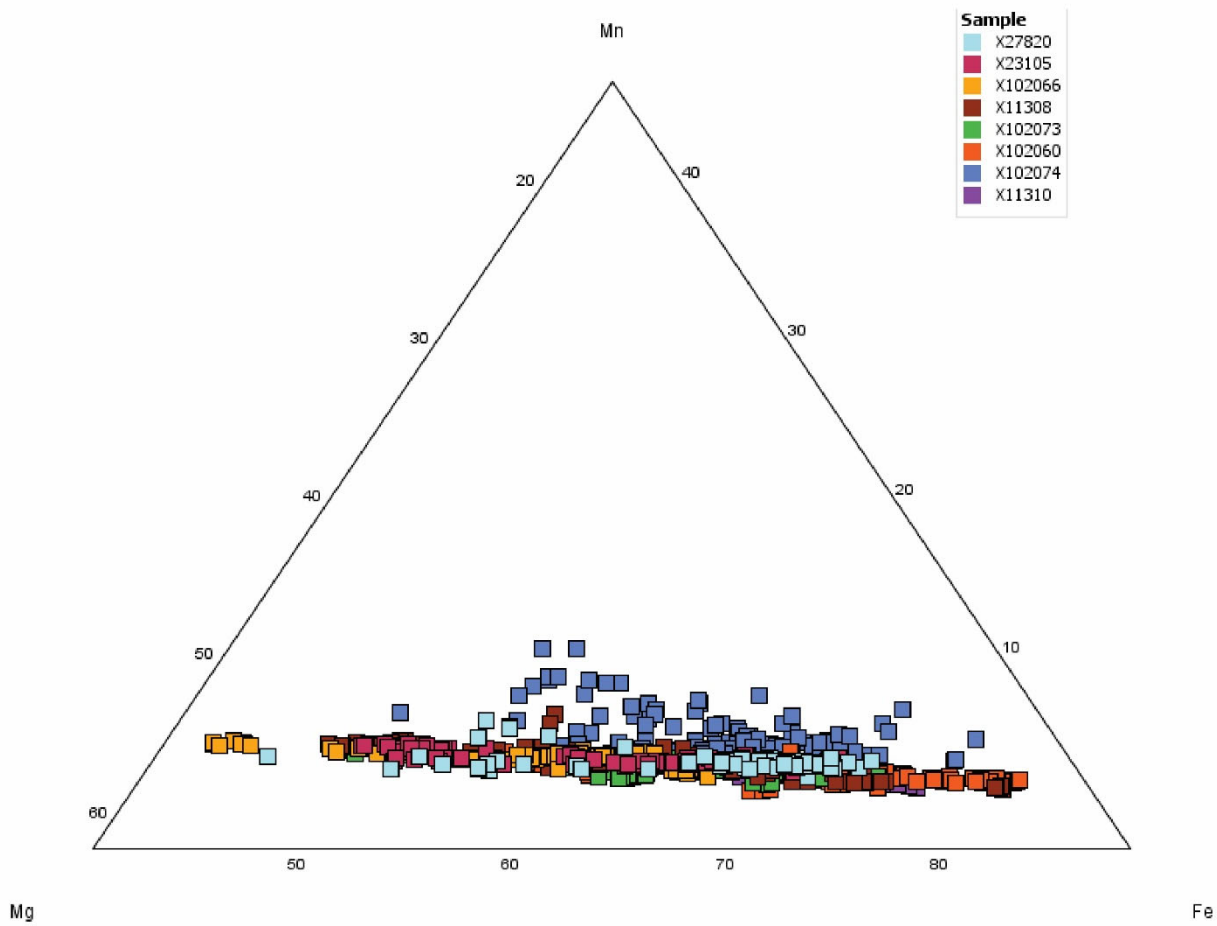


Figure 25: Selected Kibi ankerite analyses showing a variation in the proportions of Fe, Mg and Mn.

White Mica

White mica formed part of the early alteration stage in the Kibi quartz diorites and also accompanied gold mineralization (weak sericitization; **Table 1**). Therefore, the composition of this phase could provide insights into much of the evolution of the Kibi hydrothermal system.

The composition of white mica was analyzed in eight representative samples (27 grains). Based on the ternary classification diagram of Tappert et al. (2013), the white mica in mineralized rocks plots in the phengite field (**Fig. 26**), and on a plot of Al versus Si + Mg + Fe, the Al content is high (**Fig. 27**). The scheme of Park et al. (2020) classifies the Kibi white mica as a low-Mg/ high-Al Mg-phengite (**Fig. 27**). The composition of the Kibi white mica lies on a line between muscovite and aluminoceladonite compositions but is generally closer to that of muscovite. The Kibi white mica has an average Si proportion of 3.13 (apfu) that is within the parameters of phengite, which is restricted to Si values between 3.1 and 3.5 (apfu; Tappert et al. 2013). The average formula for the Kibi muscovite related to gold mineralization is $K_{0.9}Al_{1.8}(Mg_{0.1},Fe_{0.2})Si_{3.1}Al_{0.9}O_{10}(OH)_2$; the average composition is presented in **Table 7**.

Table 7: Average and representative compositions of muscovite in mineralized Kibi quartz diorite

	n = 675	n₁ = 7						
wt%								
SiO₂	45.40 ± 1.12	46.72	45.65	45.22	46.39	45.05	44.61	45.15
MgO	0.74 ± 0.35	1.54	0.67	0.60	0.92	0.54	0.45	0.53
Al₂O₃	33.35 ± 2.01	29.40	32.83	34.14	33.72	35.02	34.57	35.13
K₂O	10.18 ± 0.37	10.39	10.30	10.09	10.33	10.22	9.87	10.51
CaO	0.02 ± 0.06	0.08	0.00	0.03	0.03	0.00	0.10	0.00
FeO	2.72 ± 1.16	3.64	2.57	2.45	2.57	2.09	3.49	1.67
MnO	0.01 ± 0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Total	92.42							
Cations	O = 11							
apfu								
Si	3.13	3.26	3.17	3.11	3.14	3.10	3.08	3.08
Mg	0.08	0.16	0.09	0.06	0.09	0.06	0.05	0.05
Al(T)	2.71	2.42	2.60	2.76	2.69	2.78	2.81	2.82
Al(IV)	0.87	0.74	0.83	0.89	0.86	0.89	0.92	0.92
Al(VI)	1.84	1.69	1.77	1.87	1.83	1.88	1.90	1.90
K	0.89	0.93	0.95	0.88	0.89	0.86	0.87	0.91
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fe²⁺	0.16	0.21	0.20	0.14	0.15	0.12	0.13	0.10
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Si+Mg+Fe	3.36	3.64	3.46	3.31	3.38	3.29	3.26	3.23

The cation proportions are based on eleven oxygens. n = number of spot analyses. n₁ = number of representative samples

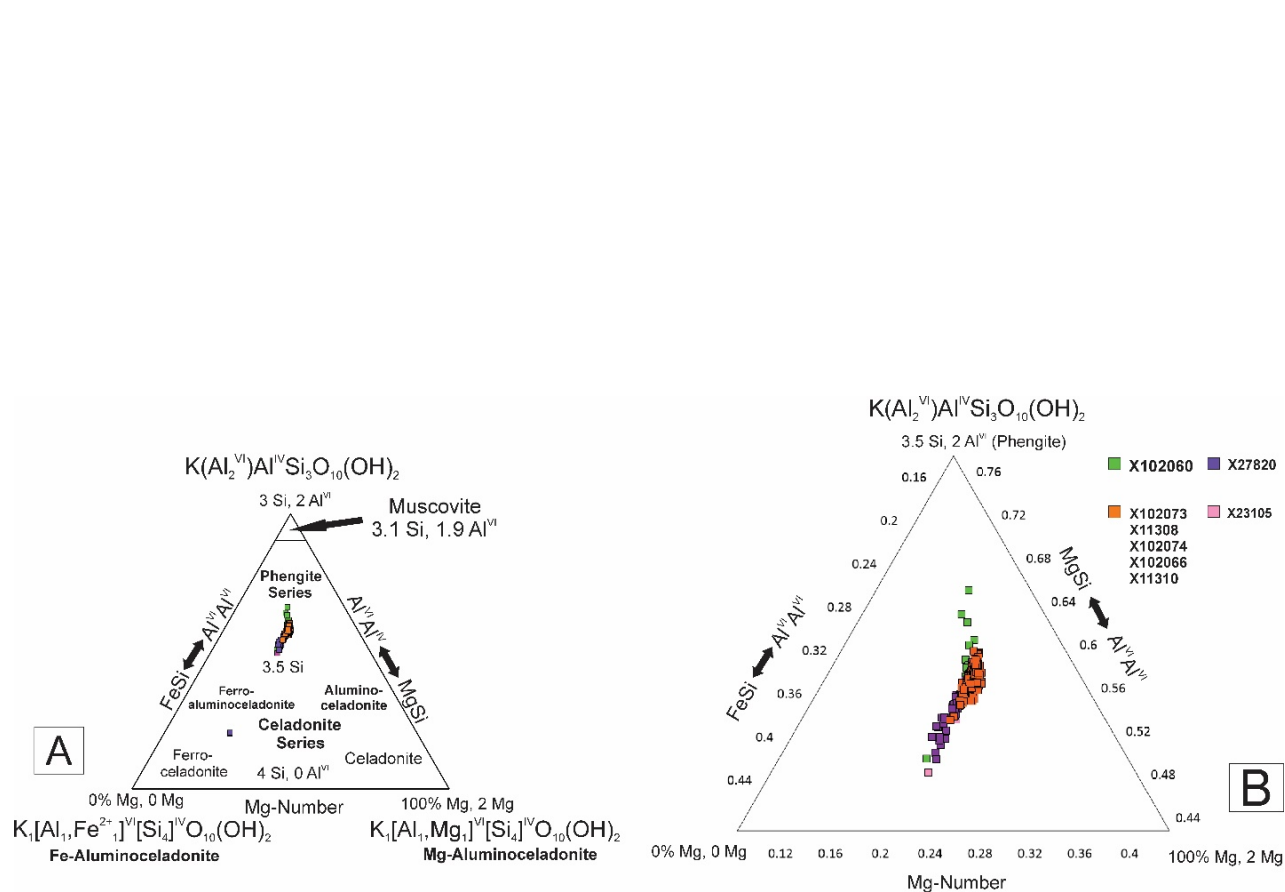


Figure 26: A. The distribution of white mica compositions on the ternary diagram of Tappert et al. (2013), classifies the Kibi white mica as phengitic. B. An enlargement of the diagram in A.

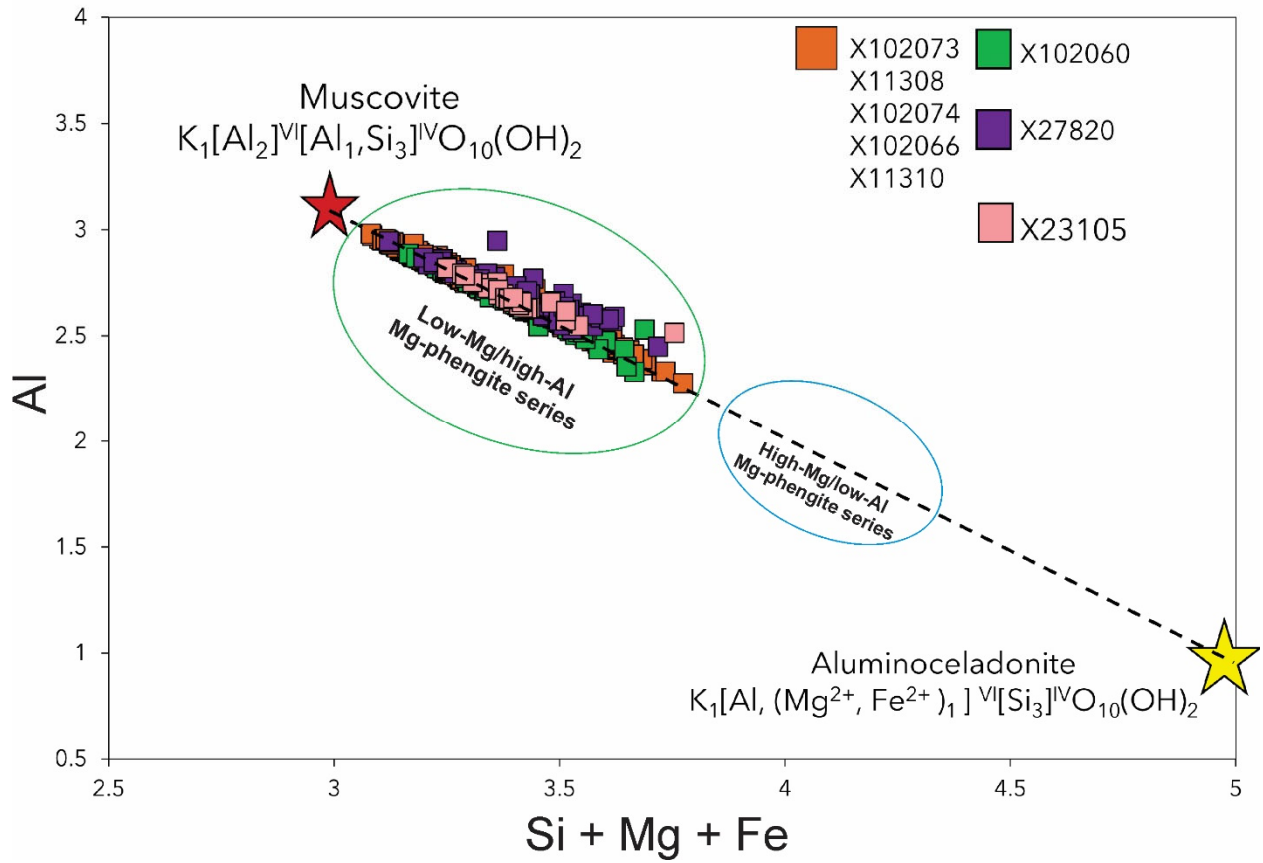


Figure 27: The composition of the Kibi white mica on a binary plot of Al versus Si + Mg + Fe in apfu (Park et al., 2020). The red and yellow stars correspond to the compositions of muscovite and aluminoceladonite, respectively, and the dashed line illustrates the substitution of $Al^{VI} Al^{IV}$ by $(Mg, Fe)^{VI} Si^{IV}$. The cation proportions are based on 11 oxygens.

Chlorite

Chloritization was a major alteration type that affected the Kibi rocks, and particularly the quartz diorites, during an early stage in the evolution of the hydrothermal system. However, it is weakly developed proximal to gold mineralization.

The composition of chlorite was analyzed in four representative samples (17 grains). The Kibi chlorite is Fe-rich (average apfu = 3.91) and plots in the Fe-chlorite (chamosite) field of the Al+□-Mg-Fe ternary classification diagram of Zane and Weiss (1998; **Fig. 28**). It also classifies as a Type I trioctahedral chlorite (**Fig. 28**). Representative and average compositions of chlorite associated with early alteration in the quartz diorites are presented in **Table 8**.

Table 8: Average and representative composition of chlorite in altered Kibi quartz diorite

	n = 549	n₁ = 4			
wt%					
SiO₂	23.93 ± 4.10	23.26	22.21	24.50	25.73
MgO	5.82 ± 1.29	6.03	4.34	3.66	2.94
Al₂O₃	18.40 ± 3.08	20.05	20.90	16.97	16.12
K₂O	0.04 ± 0.61	0.00	0.00	0.01	0.01
CaO	0.07 ± 0.08	0.03	0.00	0.21	0.17
FeO	40.39 ± 2.43	37.26	39.14	42.74	42.40
MnO	0.07 ± 0.06	0.17	0.10	0.02	0.02
TiO₂	0.04 ± 0.13	0.06	0.03	0.02	0.01
Total	88.76				
Cations	O = 14				
apfu					
Si	2.89	2.66	2.58	2.52	3.01
Mg	0.66	1.02	0.78	0.37	0.56
Al(T)	2.41	2.70	2.82	2.52	2.16
Al(IV)	1.11	1.34	1.42	1.21	0.99
Al(VI)	1.31	1.36	1.40	1.31	1.17
K	0.02	0.00	0.00	0.00	0.00
Ca	0.01	0.00	0.00	0.03	0.02
Fe²⁺	3.90	3.57	3.82	4.24	4.15
Mn	0.01	0.02	0.01	0.00	0.00
Ti	0.00	0.01	0.00	0.00	0.00

The cation proportions are based on fourteen oxygens. n = number of spot analyses.

n₁ = representative samples

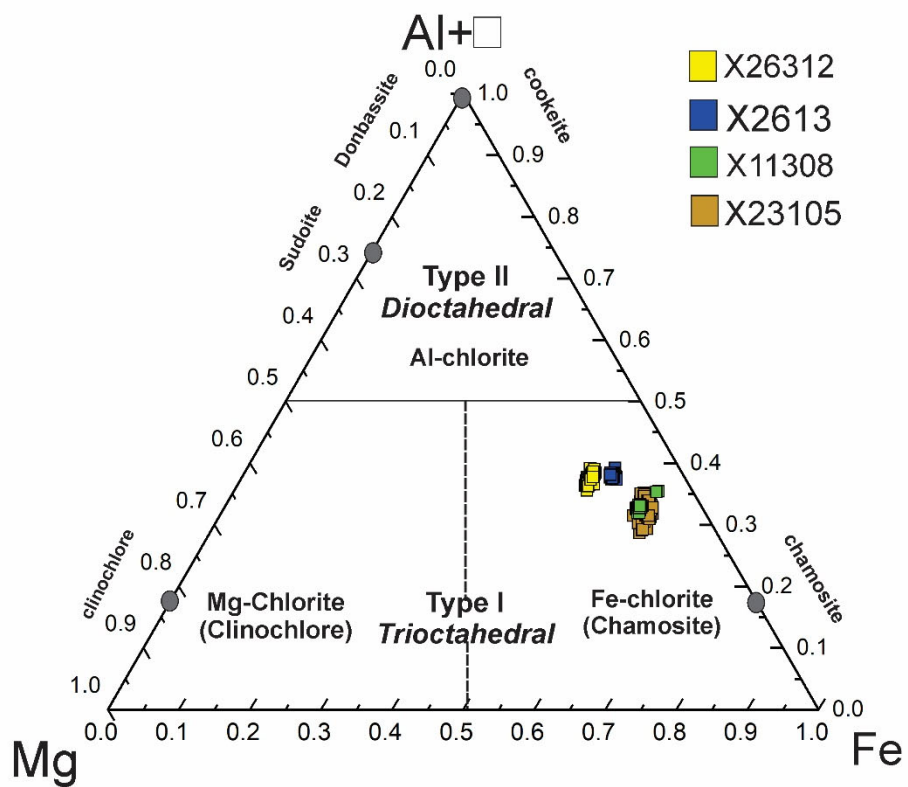


Figure 28: The Al+□- Mg-Fe ternary chlorite classification diagram of Zane and Weiss (1998) showing the distribution of Kibi chlorite compositions.

Gold and Related Sulphide Minerals

Pyrrhotite and arsenopyrite are the main sulphide minerals associated with gold mineralization in the Kibi deposits. The compositions of these minerals can provide information about the sulphur and oxygen fugacity of the ore fluid.

The composition of pyrrhotite was analyzed in nine representative samples (36 grains) and that of arsenopyrite in eight samples (27 grains). Pyrrhotite was analyzed (EPMA-WDS) for Fe, S, Co and Ni. The average composition of pyrrhotite is 59.95 wt% Fe, 39.36 wt% S, 0.07 wt% Co and 0.01 wt% Ni. The average formula is $\text{Fe}_{0.88}\text{S}$

Elements analyzed for arsenopyrite were Fe, As, S, Co, Ni, Cu, Sb, Te and Pb. The average composition of arsenopyrite is 34.48 wt% Fe, 44.58 wt% As, 20.30 wt % S, 0.36 wt% Co, 0.01 wt% Ni, 0.05 wt% Cu, 0.02 wt% Sb, 0.04 wt% Te and 0.06 wt% Pb. The average formula is $\text{Fe}_{0.99}\text{As}_{0.94}\text{S}$.

Native gold was analyzed for Au, Ag, Cu, Te, Bi and Hg. The average composition is 0.17 wt% Cu, 0.02 wt% Te, 0.08 wt% Bi, 0.11 wt% Hg, 86.64 wt% Au and 13.25 wt% Ag. The average weight ratio is $\text{Au}_{86.7}\text{Ag}_{13}$. The most notable feature of these compositional data is the enrichment of the native gold in Cu, something that is uncommon in orogenic gold deposits. Copper and Te (which also is present in the native gold) were also detected in arsenopyrite. However, no correlation was evident between Cu and Te proportions (wt%) in the native gold or the arsenopyrite (**Fig. 29**). The average elemental compositions of gold and related minerals are presented in **Table 9**.

Table 9: Average elemental compositions of ore and ore-related minerals in the Kibi-Gold deposits

Mineral	Sample	Fe	S	Co	Ni	As	Cu	Sb	Te	Pb	Ag	Bi	Hg	Au	Total
wt%															
Pyrrhotite	n = 1035	59.95	39.36	0.07	0.01										99.39
Arsenopyrite	n = 563	34.48	20.30	0.36	0.01	44.58	0.05	0.02	0.04	0.06					99.90
Gold	n = 91						0.17		0.02		13.25	0.08	0.11	86.64	100.65
apfu															
Pyrrhotite	$(\text{Fe}_{\text{totalFe,Co,Ni}}\text{S})$			$\text{Fe}_{0.88}\text{S}$											
Arsenopyrite	$(\text{Fe}_{\text{total Fe, Co, Ni}}\text{AsS})$			$\text{Fe}_{0.99}\text{As}_{0.94}\text{S}$											

n = number of spot analyses. The detection limits for pyrrhotite are 256 ppm Fe, 120 ppm S, 445 ppm Co and 279 ppm Ni. The detection limits for arsenopyrite are 253 ppm Fe, 332 ppm As, 144 ppm S, 547 ppm Co, 280 ppm Ni, 941 ppm Cu, 333 ppm Sb, 343 ppm Te and 1272 ppm Pb. The detection limits (based on personal communication with Lang Shi) for native gold are 1049 ppm Au, 500 ppm Te, 1562 ppm Bi, 2110 ppm Hg, 1867 ppm Au and 616 ppm Ag

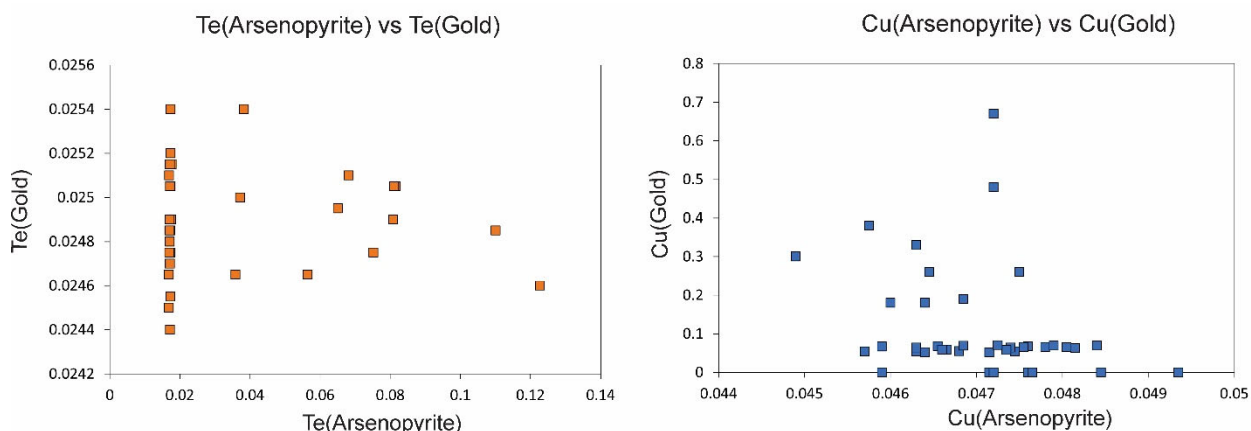


Figure 29: Binary plots of Cu and Te in arsenopyrite and native gold. No correlation between the elements is evident for either the arsenopyrite or the native gold.

DISCUSSION

The gold deposits at Kibi comprise disseminated and vein mineralization in quartz diorite intrusions hosted by meta-volcano-metasedimentary rocks of the Proterozoic Birimian Supergroup in the Kibi-Winneba greenstone belt. They differ from the well-known orogenic deposits of the greenstone Ashanti belt, which are also hosted by Birimian metasedimentary rocks, in that the gold is associated with pyrrhotite rather than arsenian pyrite, as is the case for the deposits in the Ashanti belt (Oberthür et al., 1996; Allibone et al., 2002); in both areas, some of the gold is associated with arsenopyrite.

The genesis of the Ashanti deposits has been attributed to a metamorphic fluid, which interacted with carbonaceous material (Křibek et al., 2015) and obtained its sulphur from a sedimentary source. These conclusions are based mainly on stable isotope data (Oberthür et al., 1996). Here, a genetic model is developed for the Kibi gold deposits, and an explanation provided for why they differ from those of the Ashanti belt.

Temperature-Pressure Conditions

As noted earlier, the siliciclastic sedimentary rocks are foliated and, in the case of the argillites (metapelites), this foliation is defined by fine-grained muscovite and biotite (both primary and secondary chlorite are also present), indicating peak metamorphic conditions corresponding to the biotite zone of the greenschist facies (Gillen, 1982). This contrasts with the peak metamorphic conditions in the southern Kibi-Winneba belt, which reached upper amphibolite facies corresponding to temperatures and pressures of 500-610 °C and 4.5-6 kbar, respectively (Klemd et al., 2002)

Assuming that metamorphism in the Kibi area proceeded along a Barrovian P-T trajectory, the biotite zone, (recording the reaction $\text{Chl} + \text{Kfs} = \text{Bt} + \text{Ms} + \text{H}_2\text{O}$) would correspond to a peak metamorphic temperature and pressure of $\sim 430^\circ\text{C}$ and $\sim 2\text{-}4$ kbar, respectively (Spear & Cheney, 1989; Spear 1999). As the gold mineralization post-dated peak metamorphism, this would place a maximum on the temperature of the mineralization, if the deposits were metamorphogenic. If, however, the fluids had a magmatic origin, the temperature of mineralization could have been higher (or lower).

As chlorite is an important alteration mineral in the Kibi deposits, albeit not immediately proximal to the gold, the chlorite geothermometer was used to provide a direct estimate of the likely temperature of gold mineralization. This geothermometer was first proposed by Cathelineau and Nieva (1985), and refined in numerous subsequent studies, (reviewed by Yavuz et al., 2015); the calibrations of Kranidiotis and MacLean (1987) and Cathelineau (1988) were used to estimate the temperatures of chloritization in the Kibi wall-rocks adjacent to the gold mineralization.

The calibration by Kranidiotis and MacLean (1987) assumes that the chlorite is associated with other aluminous minerals (e.g., sericite), which buffer alumina activity. This is the case at Kibi, where chlorite is associated with phengitic muscovite. The Cathelineau (1988) geothermometer assumes that the Al^{IV} tetrahedral occupancy of chlorite is a simple function of temperature.

Based on the chlorite geothermometer of Kranidiotis and MacLean (1987), the temperature of the mineralizing fluid at Kibi was $374 \pm 11^\circ\text{C}$, and based that of Cathelineau (1988) was $388 \pm 15^\circ\text{C}$. The temperature of the gold mineralising fluids at Kibi is thus estimated to have been $\sim 400^\circ\text{C}$. Mesozonal gold deposits typically form at $\sim 375\text{-}550^\circ\text{C}$ and $2\text{-}3$ kbar, under greenschist to lower amphibolite facies conditions (Groves, 1993; Gebre- Mariam et al., 1995; Hagemann and Cassidy, 2000). As the Kibi-Gold deposits appear to be mesozonal (based on the presence of biotite and

chlorite indicating conditions related to the biotite zone of the greenschist facies), the pressure of formation is estimated to have been 2 kbar.

Source of the Fluid

The oxygen isotopic composition of gold-related ankerite ranges from +12.5 to +13.8 ‰ (V-SMOW), and the calculated (using the fractionation factor of Ohmoto and Rye, 1979) oxygen isotopic composition of the fluid is +8.2 to +10.3 ‰ assuming a temperature of 400 °C (see above). This is consistent with a magmatic or metamorphic source for the fluid or the equilibration of a metamorphic fluid with igneous rocks (**Fig. 30**). In contrast, the significantly higher $\delta^{18}\text{O}$ values for the fluids of the Ashanti deposits (+8.00 to +18.30) calculated for the same temperature (this is within the range of temperatures estimated for the Ashanti gold deposits based on intersecting fluid inclusion isochores; Mumin et al. 1997) from $\delta^{18}\text{O}$ values for ankerite, strongly support a metamorphic source (**Fig. 30**; Oberthür et al., 1996; Ridley & Diamond, 2000).

Source of the Carbon

The $\delta^{13}\text{C}$ values for the Kibi ankerite range from -13.3 to -7.8 ‰, and the $\delta^{13}\text{C}$ values calculated (using the fractionation factor of Zheng, 1999) for the fluid for a temperature of 400 °C are -11.2 to -5.7 (**Fig. 30**). These values are consistent with a fluid source which interacted with reduced carbon ($\delta^{13}\text{C}$ -11.4 to -28.8) in sedimentary or metamorphic rocks (Koch, 1991, 1992; Hoefs, 1997). The $\delta^{13}\text{C}$ values Ashanti deposits calculated at the same temperature are -8.8 to -18.9. These values are strongly negative, which is consistent with the occurrence of these deposits in shear zones where they are closely associated with carbonaceous material (Schidlowski et al., 1983; Hoefs, 1997). The Kibi deposits, however, are hosted in quartz diorites. The negative $\delta^{13}\text{C}$ values,

nevertheless, suggest a strongly reduced source of the carbon, most likely graphitic argillites, although because of the poor outcrop and very limited mapping in the area, such rocks have not yet been identified.

Source of Sulphur and Metals

The range of $\delta^{34}\text{S}$ values for pyrrhotite and arsenopyrite is -1.3 to +3.3 ‰. This range suggests a magmatic source for the sulphur (Ohmoto and Rye, 1979), implying either that the sulphur was supplied by a fluid exsolved from a magma or that the fluid interacted with sulphide minerals in an igneous rock. Irrespective of which explanation is correct, it seems likely that the source of the sulphur (and perhaps the gold) was the quartz diorite, which occurs commonly in the area or a magma of similar composition.

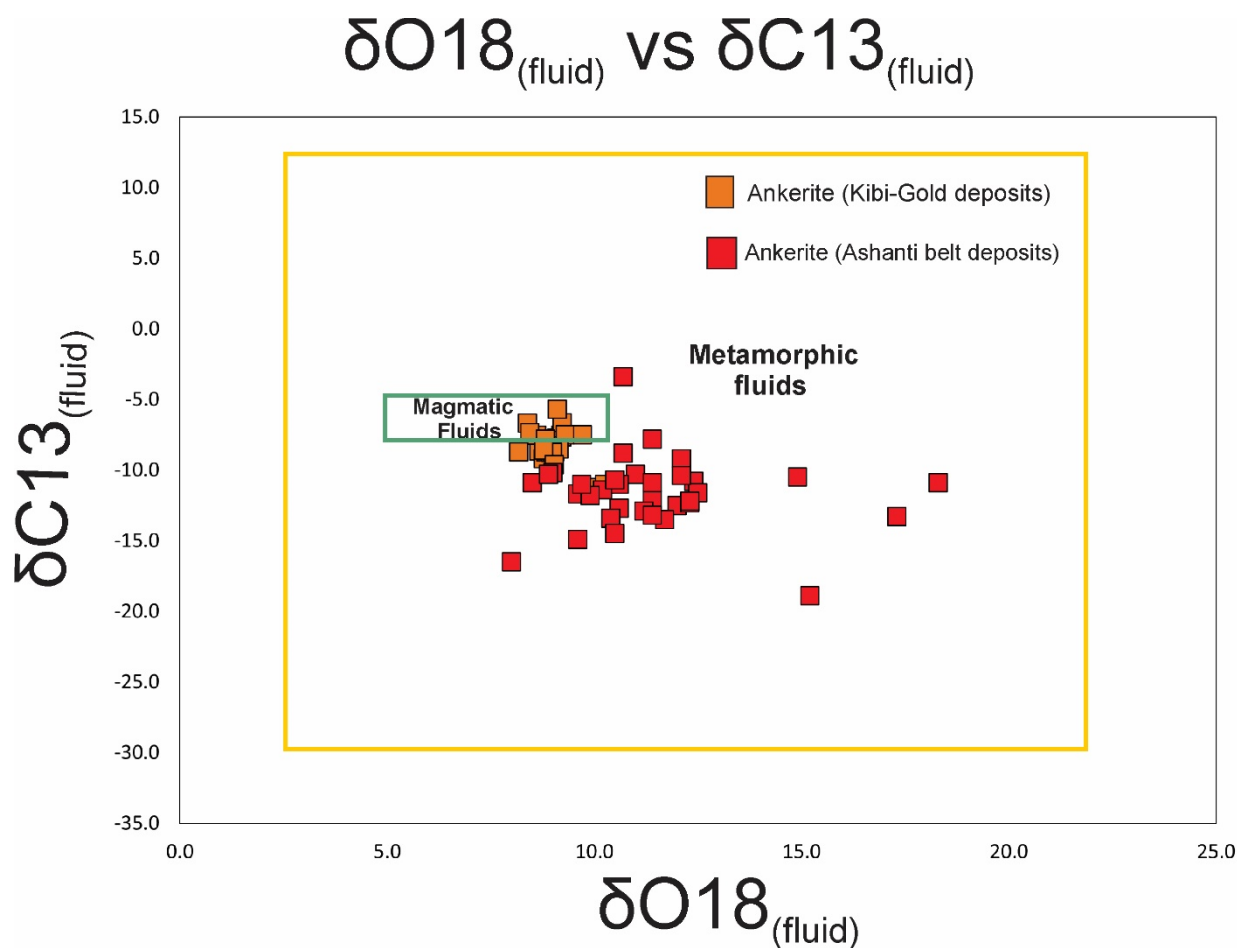


Figure 30: Carbon and oxygen isotopic compositions for Kibi and Ashanti mineralizing fluids estimated from the isotopic composition of ankerite at 400 °C based on the fractionation factors of Zheng (1999) and Ohmoto & Rye (1979), respectively. Data suggests that the source of oxygen and carbon for the Ashanti deposits was metamorphic and from reduced carbon in sedimentary rocks (Hoefs, 1997), and that for Kibi was magmatic or metamorphic for the source of oxygen and also from reduced carbon in sedimentary rocks (The magmatic and metamorphic fields are based on Ridley and Diamond, (2000) for the $\delta^{18}\text{O}_{(\text{fluid})}$ boundaries, Gavelin (1957) and Baker and Fallick (1989) for the $\delta^{13}\text{C}_{(\text{fluid})}$ boundaries).

Physico-chemical Conditions of Alteration

The principal physicochemical controls on hydrothermal alteration and gold mineralization in most orogenic gold deposits are temperature, pressure, oxygen fugacity and pH (Williams-Jones et al., 2009; Gaboury, 2019). The role of these parameters was evaluated for the Kibi deposits using a $\log f\text{O}_2$ -pH phase diagram constructed for the Fe-O-S system at a temperature of 400 °C and a pressure of 2 kbar (**Fig. 31**). This diagram shows the predominance boundaries of H_2S , HS^- , HSO_4^- and SO_4^{2-} and the stability fields of pyrite, pyrrhotite, magnetite and hematite. The activity of sulphur (ΣS) is assumed to be 0.1 m. The stability fields of paragonite, albite, muscovite and K-feldspar are also shown, as are solubility contours for the gold species AuHS^0 , AuCl_2^- and $\text{Au}(\text{HS})_2^-$ and the solubility limit of ankerite. The sodium ion concentration was assumed to be 1 m based on the salinity (~6wt% NaCl equiv.) typical of fluid inclusions from mesothermal deposits (Lawrence et al., 2013). The potassium and calcium concentrations were assumed to be 0.03 m, and the magnesium content was assumed to be 0.004 m based on the estimated compositions of orogenic ore fluids (Yardley et al., 1993; Rauchenstein-Martinek et al., 2014). The X_{CO_2} was assumed to be 0.1, which is at the lower end of the range of X_{CO_2} values reported by Tuba et al. (2021) for orogenic gold deposits.

Pyrrhotite is stable in the H_2S predominance field at $\log f\text{O}_2$ values < -31.0 within the pH range of 2 to 7.4. Further constraints are provided by the presence of ankerite (with $a_{\text{dolomite}} = 0.67$), which places the pH at ≥ 4.4 at a $\log f\text{O}_2$ value of ~ -31.0 . The absence of K-feldspar alteration, and the widespread alteration of the host rocks by phengitic muscovite implies a $\text{pH} \leq 5.5$, whereas the presence of albite in the gold-bearing veins and as an alteration mineral, and the lack of paragonite place a lower limit on the pH of ~ 4.5 . These $\log f\text{O}_2$, and pH constraints suggest that

the fluid which formed the Kibi-Gold deposits was weakly acidic (pH 4.5-5.5) and relatively reduced ($\log f\text{O}_2 \leq -31.0$, or 4 log units below the magnetite-hematite oxygen buffer).

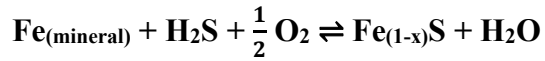
Physico-chemical Conditions of Mineralization

Chlorite geothermometry indicates that the Kibi deposit formed at a temperature of ≥ 350 °C. At such temperatures, AuCl_2^- is commonly the dominant gold species but as shown in **Figure 31**, this species is only stable at high $f\text{O}_2$, and low pH. For the reasons given above and illustrated in **Figure 31**, however, the Kibi deposits were weakly acidic and strongly reduced. At such conditions $\text{Au}(\text{HS})^0$ is the predominant species in hydrothermal fluids with the chlorinity and sulphur content of orogenic gold mineralising fluids and it is proposed that this was the case for the Kibi deposits.

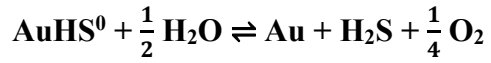
At the site of deposition, the weakly acidic and strongly reduced ore fluid interacted with its quartz diorite host and altered it, where carbonate minerals (ankerite) and sericite, buffered the pH and oxygen fugacity to higher values. From the gold solubility contours shown in **Figure 31**, it is evident that such changes to a fluid that was initially weakly acidic and strongly reduced would have served to increase gold solubility. It therefore follows that changes in pH or $f\text{O}_2$, did not lead to gold deposition.

The Role of Sulphidation

A process that has been widely invoked for the formation of gold deposits (including orogenic deposits), in which the gold is transported as complexes, is sulphidation of the wall rocks (Phillips & Groves, 1983; Olivo & Williams-Jones, 2002; Williams-Jones et al., 2009), i.e., replacement of ferromagnesian minerals by pyrite or pyrrhotite according to the reaction:



This consumes H₂S, thereby destabilizing gold complexes with HS⁻ ligands causing deposition of gold via reactions such as:



As mentioned earlier, there was extensive (and intensive) alteration of the wall rock by pyrrhotite at Kibi, which replaced ferromagnesian minerals like biotite (**Fig. 11c and d**). It is therefore probable that sulphidation of the wall-rocks played a major role in the formation of the Kibi gold deposits.

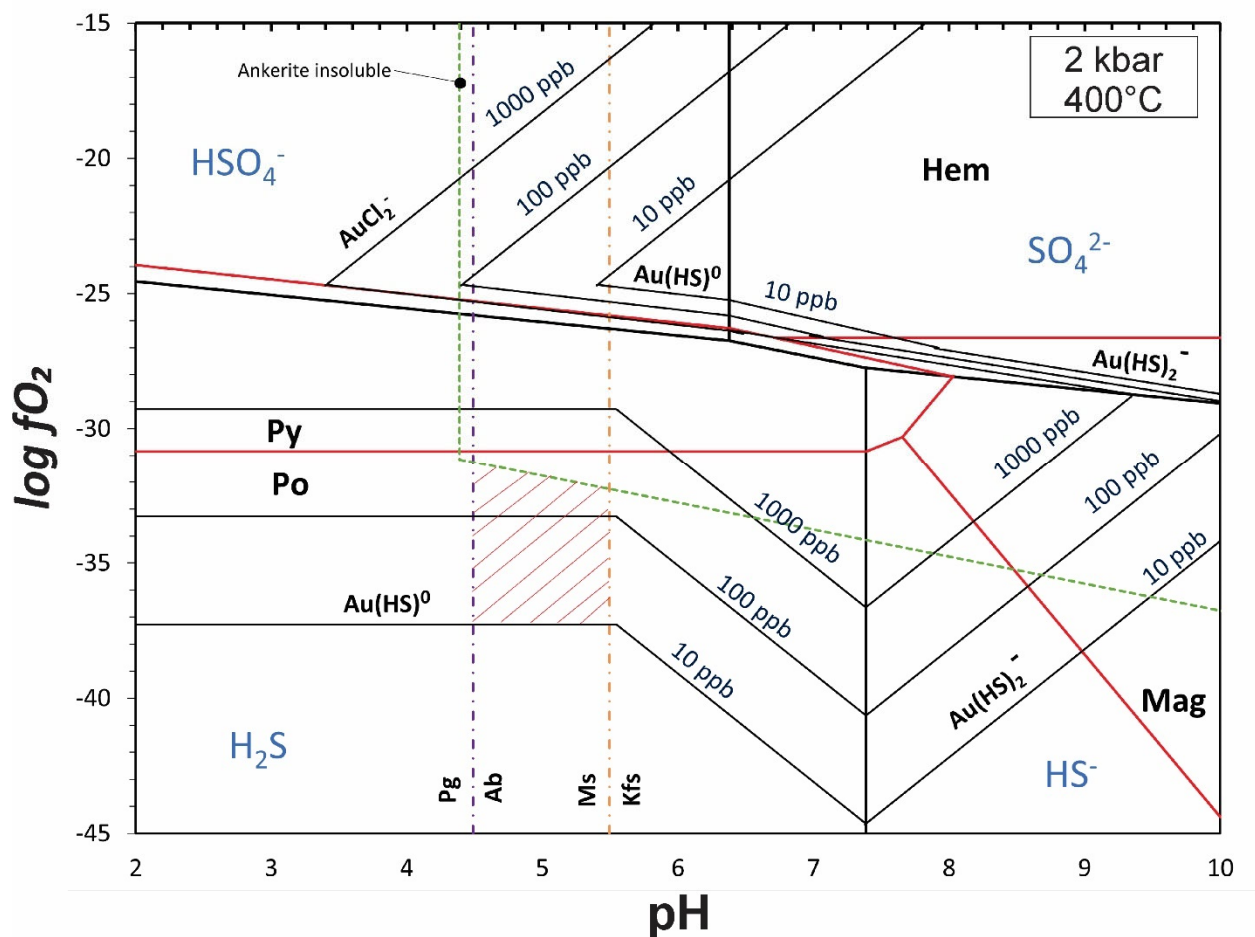


Figure 31: A phase diagram calculated for 400 °C and 2 kbar showing the stability fields of minerals in the system Fe-O-S and the predominance fields for the corresponding aqueous species. Also shown are the stability fields of alteration minerals present in the Kibi deposits and the solubility threshold of ankerite. Contours of Au solubility in ppb (thin solid lines) for bisulphide and hydrosulphide complexes are shown for higher and lower pH conditions, respectively as are contours for the species AuCl_2^- (low pH and high $\log f\text{O}_2$). The hatched area indicates the probable initial conditions for the mineralizing fluid that formed the Kibi deposits. $\Sigma S = 0.1$ m, $[\text{Ca}] = 0.03$ m, $[\text{Mg}] = 0.004$ m, $[\text{K}] = 0.03$ m, $[\text{Na}] = 1$ m, $[\text{Cl}] = 1.0$ m, $[\text{C}] = 0.1$ m. Ab = albite, Pg = paragonite, Ms = muscovite, Kfs = K-feldspar, Hem = hematite, Mag = magnetite, Py = pyrite, Po = pyrrhotite. Phase boundaries, predominance boundaries, the solubility threshold for ankerite and gold solubility contours were calculated using the program HCh (Shvarov and Bastrakov, 1999).

Genetic Model

The peak metamorphic conditions in the Kibi area correspond to the biotite zone of the greenschist facies, with peak temperature and pressure of ~ 430 °C at $\sim 2\text{--}4$ kbar, respectively. This, coupled with an estimate from chlorite geothermometry of the temperature of gold mineralization of $360\text{--}405$ °C, suggest that the Kibi gold deposits are mesozonal deposits, which typically form at temperatures of $\sim 300\text{--}475$ °C, pressures of $\sim 1.5\text{--}3$ kb and depths of $\sim 6\text{--}12$ km. Such deposits are widely regarded to form from hydrothermal fluids of metamorphic origin that are transported upwards along crustal scale faults (shear zones) and deposited in secondary shear zones (Hronsky et al., 1990; Groves et al., 1992). In some cases, however, evidence has been provided that the fluids are magmatic in origin (Sillitoe & Thompson, 1998; Helt et al., 2014; Mériaud & Jébrak, 2017).

Based on the stable isotope data discussed earlier, it is proposed that the fluids which formed the Kibi deposits are magmatic in origin and that along their path to the site of mineralization, they variably interacted with graphitic metapelites that imposed a strongly negative $\delta^{13}\text{C}$ signature on some samples and strongly reduced the oxygen fugacity of the fluid. A metamorphic origin for the ore fluid, however, is not ruled out. Gold was transported in the fluid as the species AuHS^0 and was accompanied by elevated concentrations of Cu and As, which, because of the reduced nature of the fluid, were likely transported as CuHS^0 (Williams-Jones and Migdisov, 2014) and H_3AsO_3^0 (Heinrich and Eadington, 1986), respectively. On reaching the site of deposition, these reduced fluids interacted with quartz diorite intrusions, which were altered to chlorite and particularly sericite, ankerite and pyrrhotite, arsenopyrite plus minor chalcopyrite and pyrite. This buffered the pH and oxygen fugacity of the fluid to higher values and reduced the activity of H_2S . As only the change in $a_{\text{H}_2\text{S}}$ decreased the solubility of gold, it is proposed that the reduction in $a_{\text{H}_2\text{S}}$ that

accompanied sulphidation of the wall rocks led to destabilisation of AuHS^0 , the main species transporting gold, and its deposition as native gold. This explains the close spatial association of the gold with pyrrhotite, chalcopyrite and particularly arsenopyrite in the host rocks, whereas the similar aqueous speciation of Cu and Au explains the observed positive correlation of Au with Cu in bulk rock samples (and the lack of a correlation with As) and the elevated concentration of Cu in the native gold (**Fig. 21** and **Table 8**). Although much of the gold is concentrated in the host rock, a significant proportion occurs as native gold in quartz veins containing small proportions of albite and ankerite. As temperature is the main control on quartz solubility except at very high or very low pH (Seward et al., 2014), these veins must have formed in response to a sharp drop in temperature, and likely did so in response to temperature decrease related to the pressure release that accompanied fracturing. Given that gold solubility is temperature dependent (Williams-Jones et al. 2009), it is proposed that decreasing temperature also was an important control of gold mineralization.

CONCLUSIONS

The Kibi-Gold deposits are hosted by quartz diorite intrusions and the gold mineralization is associated with pervasive ankerite and pyrrhotite alteration, and weak sericitization. There is also evidence of strong chloritization particularly in rocks distal to the mineralization. The gold occurs both in albite/ankerite-bearing quartz veins and as disseminations in the host rock, where it has a close spatial association within pyrrhotite and arsenopyrite. Application of the chlorite geothermometer yielded temperatures in the range 360 to 405 °C. Oxygen and carbon isotopic data for ankerite suggest that the hydrothermal fluid responsible for gold mineralization was magmatic but that it interacted with a reduced carbon source (mineralising fluid) prior to ore formation. A magmatic source for the fluid is also indicated by the sulphur isotope data for pyrrhotite and arsenopyrite. From the phase relationships for the silicate alteration minerals and the sulphide minerals and the solubility threshold of ankerite, the pH of the fluid is estimated to have been between 4.5 and 5.5 and the $\log f\text{O}_2$ to have been ≤ -31.0 (4 log units below the magnetite-hematite oxygen buffer), assuming a temperature of 400 °C at 2 kbar. Interaction with the host rock led to an increase in the $f\text{O}_2$ (oxidation of reduced carbon to form ankerite) of the fluid and pH (alteration of plagioclase to sericite).

It is proposed that the mineralising fluids, which formed the Kibi-Gold deposits, were introduced along secondary structures likely associated with a crustal scale shear zone and had a magmatic origin, the carbon isotope signature of which was modified by interaction with graphitic argillite. Interaction of the ore fluids with the quartz diorite intrusions hosting the mineralization increased both pH and $f\text{O}_2$ which led to an increase in gold solubility and thus changes in the values of these parameters did not lead to gold mineralization. Instead, it is proposed that the replacement of iron-bearing minerals in the quartz diorite by pyrrhotite, arsenopyrite and minor pyrite

(sulphidation) led to a decrease in the $a_{\text{H}_2\text{S}}$, destabilizing the gold-hydrosulphide complex, thereby depositing gold in the quartz diorites. Thus, sulphidation was the principal factor controlling gold mineralization in the rocks. A significant proportion of the gold, however, occurs in quartz veins containing albite and ankerite veins. This mineralization developed as a result of the sharp reduction in gold solubility that accompanied the temperature decrease caused by the fracture-induced pressure release which led to vein formation.

CHAPTER III

General Conclusions, Contributions To Knowledge and Future Work

General Conclusions

The Kibi-Gold deposits are hosted primarily by quartz diorite intrusions that crystallized from magmas with a tholeiitic affinity. The gold mineralization is associated with pervasive carbonatization (ankerite) and sulphidation of the host rocks, together with weak sericitization and the replacement of primary plagioclase by albite. Gold occurs in quartz veins and in the adjacent altered quartz diorite, in close spatial association with disseminated pyrrhotite and arsenopyrite. Biotite and chlorite which define foliation in the meta-argillites, provides evidence that the metamorphic grade corresponded to the biotite zone of the greenschist facies; assuming a Barrovian P-T gradient, this reflects a peak temperature of ~ 430 °C and a pressure of ~ 2 to 4 kbar.

The probable source of the ore fluid was assessed using oxygen, carbon and sulphur isotopic data. Oxygen isotope values for ankerite, expressed as $\delta^{18}\text{O}$, range from +12.5 to +13.8‰ (V-SMOW) and the calculated $\delta^{18}\text{O}_{\text{fluid}}$ for a temperature of 400°C ranges from +8.2 to +10.3‰. These values are consistent with a magmatic and/or possibly a metamorphic origin for the fluid. Values of $\delta^{13}\text{C}$, also for ankerite, range from -13.1 to -8.8‰ (V-PDB) and the corresponding $\delta^{13}\text{C}_{\text{fluid}}$ ranges from -11.2 to -5.7‰. These negative carbon isotope values suggest that the fluid interacted with graphitic argillites. Sulphur isotope values ($\delta^{34}\text{S}$) for pyrrhotite and arsenopyrite vary between -1.3 to +3.3‰ and suggest either a magmatic origin or fluid re-equilibration with igneous rocks.

The temperature of the ore fluid was estimated using the chlorite geothermometer. Based on the calibrations of Kranidiotis and MacLean (1987) and Cathelineau (1988), this temperature is estimated to have been between 374 ± 11 °C and 388 ± 15 °C. The temperature of ore formation was thus assumed to be ~ 400 °C.

In addition to temperature, physicochemical parameters that commonly play an important role in the formation of hydrothermal gold deposits are pH and oxygen fugacity (fO_2). These parameters were evaluated for Kibi using mineral stability relationships. Given assumptions for fluid salinity, and activities of dissolved components such as, K^+ , Ca^{2+} and Mg^{2+} , the presence of phengitic muscovite and albite as alteration phases and the absence of K-feldspar and paragonite constrain the pH to have been between ~ 4.5 and ~ 5.5 . A similar minimum pH constraint (~ 4.4) is provided by the presence of ankerite. The pervasive alteration of the host rocks to pyrrhotite, as opposed to pyrite, proximal to gold mineralization is indicative of either relatively low fS_2 or fO_2 . Assuming an activity of dissolved sulphur of 0.1m, pyrrhotite stability corresponds to a log fO_2 of < -31 . This relatively low fO_2 is consistent with the conclusion, based on carbon isotope data (see above), that the ore fluid interacted with graphitic argillites. The presence of pyrrhotite as the principal sulphide mineral associated with the gold mineralization provides strong evidence that pH was constrained to be below neutrality and fO_2 to mildly to strongly reducing conditions.

It is concluded that, for Kibi conditions, the gold was transported predominantly as the hydrosulphide complex, $AuHS^0$; the other species commonly invoked to explain the transport of gold, $Au(HS)^{2-}$ and $Au(Cl)^{2-}$, are excluded on the grounds that the pH was too low and the fO_2 too high. Fluid-rock interaction would have buffered the reduced fluid (resulting in carbonatization and sericitization), leading to an increase in pH and fO_2 . The increase in fO_2 is consistent with the presence of ankerite proximal to gold mineralization, and the increase in pH to proximal sericitization. Changes in fO_2 and/or pH did not cause gold deposition at Kibi, as increases in either of these would cause gold solubility to increase.

Pervasive replacement of ferromagnesian minerals by pyrrhotite (sulphidation) in the host quartz diorites strongly was the principal cause of gold mineralization in the host rocks at Kibi. The

formation of pyrrhotite and arsenopyrite (through the replacement of primary iron-bearing phases) led to a decrease in the activity of H_2S , which destabilized the gold-hydrosulphide complex, AuHS^0 and caused gold deposition. In the quartz veins, which host a significant proportion of the gold, the positive correlation of quartz and gold solubility suggest that decreasing temperature was the principal cause of gold mineralization.

Contributions to Knowledge and Future Work

Previous research on the Kibi-Winneba belt has been limited to investigations of the geochemistry and geochronology of the granitoids (Anum et al., 2015; Sakyi et al., 2015), mapping the gold prospectivity of the southern part of the belt (Forson et al., 2020) and determining the metamorphic grade of the rocks hosting gold-bearing quartz veins from the southern Kibi-Winneba belt (Klemd et al., 2002). There have been no published literature describing gold deposits in the Kibi-Winneba belt and interpreting their genesis prior to this thesis.

The research described in this thesis has shown that fluid forming the Kibi deposits was likely of a magmatic and/or metamorphic origin, and that it likely interacted with graphitic argillites. The sulphur was either of magmatic origin or was leached from igneous rocks. With the aid of the chlorite geothermometer, the temperature of the mineralising fluid is estimated to have been between 374 ± 11 °C and 388 ± 15 °C. The mineralising fluids responsible for forming the Kibi-Gold deposits had a weakly acidic pH between 4.5 and 5.5, and a fO_2 of ≤ -36.0 , at an estimated temperature of 400°C and a pressure of 2 kbar. Sulphidation was the principal cause of gold deposition in the host rocks because it destabilised $AuHS^0$, leading to the deposition of native gold. In the quartz veins, native gold deposition occurred in response to a decrease in temperature; the solubility of both native gold and quartz is temperature dependent.

Although, this thesis has made additions to our understanding of the geology of the Kibi-Winneba belt and the Kibi-Gold deposits, further work needs to be done to genetically model and constrain gold deposition. Future work should include: 1) oxygen isotopic studies on quartz from auriferous veins and hydrogen isotope studies on alteration-related muscovite in spatial association with gold mineralization to better constrain the origin of the fluid. The oxygen isotopic analyses in this study

were restricted to ankerite, whereas much of the gold is hosted by quartz. 2) fluid inclusion studies of gold-bearing quartz-albite-ankerite veins to better constrain the temperature and nature of the mineralising fluid that formed the deposits. The fluid temperatures estimated from the chlorite geothermometers herein should be augmented by new data derived from more proximal vein assemblages. 3) laser ablation ICP-MS analyses of sulphide minerals, especially chalcopyrite and gold grains to better establish the relationship between these two minerals. Evidence presented in this thesis show that Cu and Au were intimately associated, which stands in stark contrast with the observation that Cu is depleted in the rocks hosting most orogenic gold deposits.

References

- Adjovu, I. (2007). Exploration Summary on the Gomoa Mangose Licence. Geodita Resources Ltd.
- Akabzaa, T.M., Armah, T.E.K and Baneonh-Yakubo, B.K. (2007). Prediction of acid mine drainage generation potential in selected mines in the Ashanti Metallogenic Belt using static geochemical methods. *Environ Geol* 52, 957-964.
- Allibone, A. H., McCuaig, T., Campbell, H., David, E., Michael, M., Stuart, B., Amanor, D.J., and Gyapong, W. (2002a). *Structural controls on gold mineralization at the Ashanti Deposit, Obuasi, Ghana*. Society of Economic Geologists, Special Publication, Issue 9, pp. 65-93.
- Allibone, A., Teasdale, J., Cameron, G., Etheridge, M., Uttley, P., Soboh, A., Appiah-Kubi, J., Adanu, A., Arthur, R., Mamphey, J., Odoom, B., Zuta, J., Amegbor, T., Pataye, F., Famiyeh., and Lamb, E. (2002). Timing and structural controls on gold mineralization at the Bogoso gold mine, Ghana, West Africa. *Economic Geology*, 97(5), 949-969.
- Ancey, M., Bastenaire, F., Tixier, R., Maurice, F., and Meny, L. (1978). Applications of statistical methods in microanalysis. *Microanalysis and scanning electron microscopy (Maurice, F.; Meny, L)*, 319-343.
- Anum, S., Sakyi, P.A., Su, B-N., Nude, P.M., Nyame, F., Asiedu, D., and Kwayisi, D. (2015). Geochemistry and geochronology of granitoids in the Kibi-Asamankese area of the Kibi-Winneba volcanic belt, southern Ghana. *Journal of African Earth Sciences*, Volume 102, Pages 166-179.
- Ashanti belt. (2013, April 4th). Volta Resources Incorporation. <http://www.voltaresources.com/s/AshantiBelt.asp>
- Baker, A. J., & Fallick, A. E. (1989). Evidence from Lewisian limestones for isotopically heavy carbon in two-thousand-million-year-old sea water. *Nature*, 337(6205), 352-354.
- Baratoux, L., Metelka, V., Naba, S., Jessell, M.W., Grégoire, M., and Ganne, J. (2011). Juvenile Paleoproterozoic crust evolution during the Eburnean orogeny (2.2-2.0 Ga), western Burkina Faso Precambrian Res., 191, pp. 18-45
- Berge, J. (2011). Paleoproterozoic, turbidite-hosted, gold deposits of the Ashanti gold belt (Ghana, West Africa): Comparative analysis of turbidite-hosted gold deposits and an updated genetic model, *Ore Geology Reviews*, Volume 39, Issues 1–2, pp. 91-100.
- Boynton, W.V. (1984). Geochemistry of the rare-earth elements: meteorite studies. In: Henderson P (ed) *Rare Earth Element Geochemistry*. Elsevier, Amsterdam, pp 63–114.
- Cathelineau, M. (1988). Cation site occupancy in chlorites and illites as function of temperature. *Clay Miner.* 23, 471–485.

Cathelineau, M., Nieva, D. (1985). A chlorite solid solution geothermometer. The Los Azufres (Mexico) geothermal system. *Contrib. Mineral. Petrol.* 91, 235–244.

Connolly, J.A.D. (2010). The mechanics of metamorphic fluid expulsion. *Elements*, 6(3), 165–172.

Dai, J. X., Song, Y., Dai, C. S., & Wang, D. R. (1996). Geochemistry and accumulation of carbon dioxide gases in China. *AAPG bulletin*, 80(10), 1615-1625.

De la Roche, H. D., Leterrier, J. T., Grandclaude, P., and Marchal, M. (1980). A classification of volcanic and plutonic rocks using R1R2-diagram and major-element analyses—its relationships with current nomenclature. *Chemical geology*, 29(1-4), pp.183-210.

Dia A., Van Schmus W.R., and Kroner A. (1997). Isotopic constraints on the age and formation of a Palaeoproterozoic volcanic arc complex in the Kedougou Inliers, eastern Senegal, West Africa. *Journal Africa Earth Science*, 24 (3), pp.197-213.

Eisenlohr, B. (1989). The Structural Geology of Birimian and Tarkwaian rocks of southwest Ghana: Republic of Ghana, Federal Republic of Germany, Technical Cooperation Project no. 80.2040. 6. BGR.

Eisenlohr, B.N and Hirdes, W. (1992). The structural development of the early Proterozoic Birimian and Tarkwaian rocks of southwest Ghana, West Africa. *Journal of African Earth Sciences*, Vol. 14, No. 3, pp. 313-325.

El-Sharkawy, M.F. (2000). Talc mineralization of ultramafic affinity in the Eastern Desert of Egypt. *Mineral. Depos.* 35, 346–363.

Forson, E.D., Menyeh, A., Wemegah, D.D., Danuor, S.K., Adjovu, I., and Appiah, I. (2020). Mesothermal gold prospectivity mapping of the southern Kibi-Winneba belt of Ghana based on Fuzzy analytical hierarchy process, concentration-area (C-A) fractal model and prediction-area (P-A) plot. *Journal of Applied Geophysics*, Volume 174, 103971.

Feybesse, J-L., Billa, M., Guerrot, C., Duguey, E., Lescuyer, J-L., Milesi, J-P., and Vincent Bouchot, V. (2006). The paleoproterozoic Ghanaian province: Geodynamic model and ore controls, including regional stress modeling, *Precambrian Research*, Volume 149, Issues 3–4, pp. 149-196.

Fusswinkel, T., Wagner, T., and Sakellaris, G. (2017). Fluid evolution of the Neoarchean Pampalo orogenic gold deposit (E Finland): Constraints from LA-ICPMS fluid inclusion microanalysis, *Chemical Geology*, Volume 450, pp. 96-121.

Gillen, C. (1982). Metamorphic terrains II. In *Metamorphic Geology* (pp. 67-99). Springer, Dordrecht.

Gavelin, S. (1957). Variations in isotopic composition of carbon from metamorphic rocks in northern Sweden and their geological significance. *Geochimica et Cosmochimica Acta*, 12(4), 297-314.

Galipp, K., Klemm, R., and Hirdes, W. (2003). Metamorphism and geochemistry of the Paleoproterozoic Birimian Sefwi Volcanic Belt (Ghana, West, Africa) *Geologisches Jahrbuch Reihe*, D111 pp. 151-191.

Gebre-Mariam, M., Hagemann, S.G., and Groves, D.I. (1995). A classification scheme for epigenetic Archean lode-gold deposits: *Mineralium Deposita*, v.30, p. 408–410.

Gill, J. B. (1981). Geophysical setting of volcanism at convergent plate boundaries. In *Orogenic andesites and plate tectonics* (pp. 44-63). Springer, Berlin, Heidelberg.

Grenholm, M., Jessell, M., and Thébaud, N. (2019). A geodynamic model for the Paleoproterozoic (ca. 2.27–1.96 Ga) Birimian Orogen of the southern West African Craton – Insights into an evolving accretionary-collisional orogenic system, *Earth-Science Reviews*, Volume 192, pp. 138-193.

Griffis, J.R., Barning, K., Agezo, L.F., and Akosah, K.F. (2002). Gold deposits of Ghana. Graphic Evolution Ltd. Minerals Commission of Ghana, Ontario, Canada.

Groves, D.I. (1993). The crustal continuum model for late-Archaean lode-gold deposits of the Yilgarn Block, Western Australia. *Miner. Deposita* 28, 366–374.

Groves, D., Barnicoat, A. C., Barley, M., Cassidy, K. F., Fare, R. J., Hagemann, S. G., Ho, S.E., Hronsky, J. M. A., Mikucki, E. J., Mueller, A. G., McNaughton, N., Perring, C. S., Ridley, J. R., and Vearncombe, J. R. (1992). Sub-greenschist to granulite-hosted Archaean lode-gold deposits: a depositional continuum from deep-sourced hydrothermal fluids in crustal-scale plumbing systems. In *Sub-greenschist to granulite-hosted Archaean lode-gold deposits: a depositional continuum from deep-sourced hydrothermal fluids in crustal-scale plumbing systems* (pp. 325-338). The University of Western Australia.

Groves, D.I., Goldfarb, R.J., Gebre-Mariam, M., Hagemann, S.G., and Robert, F. (1998). Orogenic gold deposits: A proposed classification in the context of their crustal distribution and relationship to other gold deposit types: *Ore Geology Reviews*, v. 13, p. 7–27.

Groves, D.I., Santosh, M., Deng, J., Wang, Q., Yang, L., and Zhang, L. (2020). A holistic model for the origin of orogenic gold deposits and its implications for exploration. *Miner Deposita* 55, 275–292.

Hagemann, S.G., and Cassidy, K.F., 2000, Archean orogenic lode gold deposits: Reviews in *Economic Geology*, v. 13, p. 9–68.

Helt, K. M., Williams-Jones, A. E., Clark, J. R., Wing, B. A., & Wares, R. P. (2014). Constraints on the genesis of the Archean oxidized, intrusion-related Canadian Malartic gold deposit, Quebec, Canada. *Economic Geology*, 109(3), 713-735.

Hillier, S., and Velde, B. (1991). Octahedral occupancy and chemical composition of diagenetic (low-temperature) chlorites. *Clay Miner.* 26, 149–168.

Hirdes, W., and Davis, D.W. (1998). First U-Pb zircon age of extrusive volcanism in the Birimian Supergroup of Ghana/West Africa. *Journal of African Earth Sciences*, Volume 27, Issue 2, Pages 291-294.

Hirdes, W., Davis, D.W., and Eisenlohr, B.N. (1992). Reassessment of proterozoic granitoid ages in Ghana on the basis of U/Pb zircon and monazite dating. *Precambrian Research*, 56, pp. 89-96.

Hodgson, C. J., Love, D. A., and Hamilton, J. V. (1993). Giant mesothermal gold deposits: descriptive characteristics, genetic model, and exploration area selection criteria.

Hoefs, J. (1997). *Stable isotope geochemistry* (Vol. 201). Berlin: Springer.

Hronsky, J. M. A., Cassidy, K. F., Grigson, M. W., Deposit- and mine-scale structure, Gold Deposits of the Archaean Yilgarn Block, Western Australia: Nature, Genesis and Exploration Guides, Perth: Vanguard Press, 1990, 38—59.

Irvine, T.N., and Baragar, W.R.A. (1971). A guide to the chemical classification of the common volcanic rocks *Canadian Journal Earth Sci.*, 8, pp. 523-548.

John, T., Klemd, R., Hirdes, W., and Loh, G. (1999). The metamorphic evolution of the Paleoproterozoic (Birimian) gold-bearing Ashanti volcanic belt, West Africa. *Precambrian Research* 98, 11–30.

Junner, N. R. (1935). Gold in the Gold Coast. Gold Coast. *Geol. Surv. Mem.* 4, 67 p.

Junner, N. R. (1940). Geology of the Gold Coast and Western Togoland. *Gold Coast Geol. Surv. Bull* II, 40.

Junner, N.R. (1943). The Diamond Deposits of the Gold Coast with Notes on Other Diamond Deposits in West Africa. Gold Coast Geological Survey Bulletin, No. 12, 55 pp.

Jowett, E.C. (1991). Fitting iron and magnesium into the hydrothermal chlorite geothermometer. In: Proceedings of the Program with Abstracts, Geological Association of Canada – Mineralogical Association of Canada, Society of Economic Geologists, vol.16, pp.A62.

Kavalieris, I., Walshe, J.L., Halley, S., and Harrold, B.P. (1990). Dome-related gold mineralization in the Pani Volcanic Complex, North Sulawesi, Indonesia: a study of geologic relations, fluid inclusions, and chlorite compositions. *Econ. Geol.* 85, 1208–1225.

Kaygusuz, A., Siebel, W., Ilbeyli, N., Arslan, M., Satir, M., and Sen, C. (2010). Insight into magma genesis at convergent plate margins—a case study from the eastern Pontides (NE Turkey). *Neues Jahrbuch Fur Mineralogie-Abhandlungen*, 187(3), 265.

- Klemd, R., Hünken, U., and Olesch, M. (2002). Metamorphism of the country rocks hosting gold–sulfide-bearing quartz veins in the paleoproterozoic southern Kibi-Winneba belt (se-Ghana). *J. Afr. Earth Sci.* 35 (2), 199–211.
- Kranidiotis, P., and MacLean, W. (1987). Systematic of chlorite alteration the Phelps Dodge massive sulfide deposit, Matagami, Quebec. *Econ. Geol.* 82, 1898–1911.
- Kříbek, B., Sýkorová, I., Machovič, V., Knésl, I., Laufek, F., and Zachariáš, J. (2015). The origin and hydrothermal mobilization of carbonaceous matter associated with Paleoproterozoic orogenic-type gold deposits of West Africa, *Precambrian Research*, Volume 270, pp. 300–317.
- de Kock, G.S., Armstrong, R.A., Siegfried, H.P., and Thomas, E. (2011). Geochronology of the Birim Supergroup of the West African craton in the Wa-Bolé region of west-central Ghana: Implications for the stratigraphic framework, *Journal of African Earth Sciences*, Volume 59, Issue 1, pp. 1–40.
- Kříbek, B., Sýkorová, I., Machovič, V., Knésl, I., Laufek, F., and Zachariáš, J. (2015). The origin and hydrothermal mobilization of carbonaceous matter associated with Paleoproterozoic orogenic-type gold deposits of West Africa, *Precambrian Research*, Volume 270, Pages 300–317.
- Koch, J. (1991). Organisch-petrographische Untersuchung von Proben mit kohligter Substanz aus der Ashanti Gold Mine, Obuashi, Ghana. Internal Rep. BGR Hannover, Lab. No. K 18654-663.
- Koch, J. (1992). Reflexionsmessung an organischen Einschlüssen in Arsenkies; Ashanti gold mine/ Ghana: Hannover, Bundesanstalt für Geowissenschaften und Rohstoffe, Internal Report, Laboratory K 19 289, 2p.
- Layton, W. (1958). The geology of 1/4 ° field sheet 32. Ghana Geol. Surv., Bull, 24, 66 pp.
- Large, R., Thomas, H., Craw, D., Henne, A., and Henderson, S. (2012). Diagenetic pyrite as a source for metals in orogenic gold deposits, Otago Schist, New Zealand. *New Zealand J Geol Geophys.* 55:137–149.
- Leube, A., Hirdes, W., Mauer, R. and Kesse, G. O. (1990). The early Proterozoic Birimian Supergroup of Ghana and some aspects of its associated gold mineralization. *Precambrian Res.* 46, 139–165.
- Maniar, Papu., and Piccoli, P.M. (1989). Tectonic discrimination of granitoids. *GSA Bulletin*, 101 (5): pp. 635–643.
- Mériaud, N., & Jébrak, M. (2017). From intrusion-related to orogenic mineralization: the Wasamac deposit, Abitibi Greenstone Belt, Canada. *Ore Geology Reviews*, 84, 289–308.
- Middlemost, E.A.K. (1994). Naming materials in the magma/igneous rock system, *Earth-Science Reviews*, Volume 37, Issues 3–4, pp. 215–224.

- Milesi, J.P., Ledru, P., Feybesse, J.L., Dommanget, A., and Marcoux, E. (1992). Early Proterozoic ore deposits and tectonics of the Birimian orogenic belt, West Africa. *Precambrian Research* 58, 305–344.
- Mumin, A.H., Fleet, M.E., and Longstaffe, F.J. (1996). Evolution Of Hydrothermal Fluids In The Ashanti Belt, Ghana: Stable Isotope Geochemistry of Carbonates, Graphite and Quartz. *Economic Geology*, Volume 91, pp. 135-148.
- Naas, C.O. (2008). Technical Report on the Bansa and Apapam Concessions, Eastern Region, Ghana, West Africa, for Xtra-Gold Resources Corp., unpublished report by CME Consultants Inc, April 9, 2008, 2 volumes.
- Oberthür, T., Schmidt Mumm, A., Vetter, U., Simon, K., and Amanor, J.A. (1996). Gold mineralization in the Ashanti belt of Ghana: genetic constraints of the stable isotope geochemistry. *Econ. Geol.* 91, 289–301.
- Oberthür, T., Vetter, U., Davis, D.W., and Amanor, J.A. (1998). Age constraints on gold mineralization and Paleoproterozoic crustal evolution in the Ashanti belt of southern Ghana. *Precambrian Research*, 89 (1998), pp. 129-143.
- O’connor, J. T. (1965). A classification for quartz-rich igneous rocks based on feldspar ratios. *US geological survey professional paper B*, 525, pp. 79-84.
- Ohmoto, H., and Rye, R.O. (1979). Isotopes of sulfur and carbon, *in* Barnes, H.I., ed., *Geochemistry of hydrothermal ore deposits*, 2nd Edition: New York, Wiley, pp. 509–567.
- Olivo, G. R., & Williams-Jones, A. E. (2002). Genesis of the auriferous C quartz-tourmaline vein of the Siscoe mine, Val d’Or district, Abitibi subprovince, Canada: structural, mineralogical, and fluid inclusion constraints. *Economic Geology*, 97(5), 929-947.
- Osae, S., Kase, K., and Masahiro Yamamoto, M. (1999). Ore Mineralogy and Mineral Chemistry of the Ashanti Gold Deposit at Obuasi, Ghana. *Resource Geology*, Vol. 49, Issue 1, pp. 1–11.
- Park, C., Kim, N., Choi, S. J., & Song, Y. (2020). Mg-Phengite in Carbonate Rock Syngenetically Formed from Hydrothermal Fluid: Micro-Textural Evidence and Mineral Chemistry. *Minerals*, 10(8), 668.
- Pearce, J. A. (1996). A user’s guide to basalt discrimination diagrams. Trace element geochemistry of volcanic rocks: applications for massive sulphide exploration. Geological Association of Canada, Short Course Notes, 12(79), 113.
- Pearce, J. A. (2008). Geochemical fingerprinting of oceanic basalts with applications to ophiolite classification and the search for Archean oceanic crust. *Lithos*, 100 (1-4), pp. 14-48.
- Pearce, J. A., Harris, N. B., and Tindle, A. G. (1984). Trace element discrimination diagrams for the tectonic interpretation of granitic rocks. *Journal of petrology*, 25(4), pp. 956-983.

- Perrouty, S., Aillères, L., Jessell, M.W., Baratoux, L., Bourassa, Y., and Crawford, B. (2012). Revised Eburnean geodynamic evolution of the gold-rich southern Ashanti Belt, Ghana, with new field and geophysical evidence of pre-Tarkwaian deformations. *Precambrian Research*, Volumes 204–205, 2012, Pages 12–39.
- Phillips GN. (2013). Australian and global setting for gold in 2013, in proceedings world gold 2013, Brisbane, Australia, 26–29 September 2013. *Aust Inst Min Metall*. 15–21.
- Phillips, G.N. & Groves, D.I., 1983. The nature of Archaean gold-bearing fluids as deduced from gold deposits of Western Australia. *Journal Geological Society Australia*, 30, 25–39.
- Pigois, J.P. Groves, D.I., Fletcher, I.R., McNaughton, N.J., and Snee, L.W. (2003). Age constraints on Tarkwaian palaeoplacer and lode-gold formation in the Tarkwa-Damang district, SW Ghana. *Mineralium Deposita*, 38, pp. 695–714.
- Rauchenstein-Martinek, K., Wagner, T., Wälle, M., and Heinrich, C.A. (2014). Gold concentrations in metamorphic fluids: A LA-ICPMS study of fluid inclusions from the Alpine orogenic belt. *Chemical Geology*, 385, 70–83.
- Ridley, J.R., and Diamond, L.W. (2000). Fluid chemistry of orogenic lode gold deposits and implications for genetic models. *Rev. Econ Geol.* 13:146–162.
- Rieder, M., Cavazzini, G., D'yakonov, Y. S., Frank-Kamenetskii, V. A., Gottardi, G., Guggenheim, S., and Wones, D. R. (1999). Nomenclature of the micas. *Mineralogical Magazine*, 63(2), 267–279.
- Rollinson, H. (1993). *Using geochemical data: Evaluation, presentation, interpretation*: New York, Longman Scientific and Technical, 109 p.
- Ross, P. S., and Bédard, J. H. (2009). Magmatic affinity of modern and ancient subalkaline volcanic rocks determined from trace-element discriminant diagrams. *Canadian Journal of Earth Sciences*, 46(11), pp. 823–839.
- Sakyi, P.A., Su, B.-X., Anum, S., Kwayisi, D., Dampare, S.B., Anani, C.Y., and Nude, P.M. (2014). New zircon U–Pb ages for erratic emplacement of 2213–2130 Ma Paleoproterozoic calc-alkaline I-type granitoid rocks in the Lawra Volcanic Belt of Northwestern Ghana, West Africa, *Precambrian Research*, Volume 254, pp. 149–168.
- Schidlowski, M., Hayes, J. M., Kaplan, I. R. 1983. Isotopic inferences of ancient biochemistries : carbon, sulfur, hydrogen, and nitrogen. See Schopf 1983, pp. 149–86
- Shvarov, Y.V., and Bastrakov, E.N., 1999, HCh: A software package for geochemical equilibrium modeling, user's guide: Australian Geological Survey Organisation Record 1999/25, 60 p.

SEMS Exploration. (2012). Independent Technical Report of the Apapam Concession Kibi Project, Eastern Region, Ghana. https://www.xtragold.com/_resources/reports/2_3_1KibiGoldProject-TechnicalReport_NI-43-101.pdf

Sillitoe, R. H., and Thompson, J. F. (1998). Intrusion–Related Vein Gold Deposits: Types, Tectono-Magmatic Settings and Difficulties of Distinction from Orogenic Gold Deposits. *Resource Geology*, 48(4), 237-250.

Spear, F. S. (1999). Real-time AFM diagrams on your Macintosh. *Geological Materials Research*, 1(3), 1-18.

Spear, F. S., and Cheney, J. T. (1989). A petrogenetic grid for pelitic schists in the system $\text{SiO}_2\text{-Al}_2\text{O}_3\text{-FeO-MgO-K}_2\text{O-H}_2\text{O}$. *Contributions to Mineralogy and Petrology*, 101(2), 149-164.

SRK Consulting. (2010). Structural Geology Investigations of the Kibi Gold Trend Project Kibi-Winneba Greenstone Belt, Southeast Ghana.

Streckeisen, A. L., Zanettin, B. A., Le Bas, M. J., Bonin, B., Bateman, P., Bellieni, G., and Woolley, A. R. (2002). Igneous rocks; a classification and glossary of terms; recommendations of the International Union of Geological Science Subcommittee on the Systematics of Igneous Rocks. *Cambridge University Press, Cambridge*, 236.

Sun, S. S., and McDonough, W. F. (1989). Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. *Geological Society, London, Special Publications*, 42(1), pp. 313-345.

Sylvester, P.J and Attah, K. (1992). Lithostratigraphy and composition of 2.1 Ga greenstone belts of the West African Craton and their bearing on crustal evolution and the Archean–Proterozoic boundary. *Journal of Geology*, 100, pp. 377-393.

Tappert, M. C., Rivard, B., Giles, D., Tappert, R., & Mauger, A. (2013). The mineral chemistry, near-infrared, and mid-infrared reflectance spectroscopy of phengite from the Olympic Dam IOCG deposit, South Australia. *Ore Geology Reviews*, 53, 26-38.

Taylor, S. R., & McLennan, S. M. (1985). The continental crust: its composition and evolution.

Taylor, P.N., Moor bath, S., Leube, A., and Hirdes, W. (1992). Early Proterozoic crustal evolution in the Birimian of Ghana: constraints from geochronology and isotope geochemistry, *Precambrian Research*, Volume 56, Issues 1–2, Pages 97-111.

Vidal, M., Pouclet, A., Delor, C., Simeon, Y., and Alric, G. (1996). Geodynamic evolution of the West Africa between 2.2 and 2 Ga: the Archaean style of the Birimian greenstone belts and the sedimentary basins in northeastern Ivory-Coast. *Bulletin de la Societe Geologique de France*, 167(3), pp. 307-319.

- Wang, Q., Zhao, H., Groves, D.I., Deng J., Zhang Q., and Shenchao, X. (2020). The Jurassic Danba hypozonal orogenic gold deposit, western China: indirect derivation from fertile mantle lithosphere metasomatized during Neoproterozoic subduction. *Miner Deposita* **55**, 309–324.
- Wang, X. C., Li, Z. X., Li, J., Pisarevsky, S. A., & Wingate, M. T. (2014). Genesis of the 1.21 Ga Marnda Moorn large igneous province by plume–lithosphere interaction. *Precambrian Research*, *241*, pp. 85-103.
- Weiss, Z. D. E. N. E. K. (1991). Interpretation of chemical composition and X-ray diffraction patterns of chlorites. *Geol. Carpathica*, *42*(2), 93-104.
- Winchester, J. A., and Floyd, P. A. (1977). Geochemical discrimination of different magma series and their differentiation products using immobile elements. *Chemical geology*, *20*, pp. 325-343.
- Xie, X., Byerly, G. & Ferrell Jr., R. IIb trioctahedral chlorite from the Barberton greenstone belt: crystal structure and rock composition constraints with implications to geothermometry. *Contrib Mineral Petrol* **126**, 275–291 (1997). <https://doi.org/10.1007/s004100050250>
- Xtra-Gold Resources Corporation. (2020). Kibi-Gold Project. <https://xtragold.com/kibi-project/maps/>
- Yao, Y., and Robb, L.J. (2000). Gold mineralization in Palaeoproterozoic granitoids at Obuasi, Ashanti region, Ghana: Ore geology, geochemistry, and fluid characteristics. *South African Journal of Geology* 2000; 103 (3-4): 255–278. doi: <https://doi.org/10.2113/1030255>.
- Yardley, B. W. D., Banks, D. A., Bottrell, S. H., and Diamond, L. W. (1993). Post-metamorphic gold-quartz veins from NW Italy: the composition and origin of the ore fluid. *Mineralogical Magazine*, *57*(388), 407-422.
- Yavuz, F., Kumral, M., Karakaya, N., Karakaya, M. Ç., & Yıldırım, D. K. (2015). A Windows program for chlorite calculation and classification. *Computers & Geosciences*, *81*, 101-113.
- Zane, A., Sassi, R., & Guidotti, C. V. (1998). New data on metamorphic chlorite as a petrogenetic indicator mineral, with special regard to greenschist-facies rocks. *The Canadian Mineralogist*, *36*(3), 713-726.
- Zane, A., & Weiss, Z. (1998). A procedure for classifying rock-forming chlorites based on microprobe data. *Rendiconti Lincei*, *9*(1), 51-56.

APPENDICES

Appendix 1: Bulk-Rock Data Analyses

Element/Oxide	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃ (T)	MnO	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	LOI	Total	Sc	Be	V	Cr
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	ppm	ppm	ppm	ppm
Detection limit	0.01	0.01	0.01	0.001	0.01	0.01	0.01	0.01	0.001	0.01		0.01	1	1	5	20
Sample																
P27801	44.96	12.48	13.52	0.2	5.38	9	2.5	0.03	1.348	0.14	9.81	99.36	38	< 1	307	70
P27804	54.6	12.89	9.72	0.162	0.96	5.98	6.17	0.67	0.893	0.31	7.17	99.53	17	1	37	< 20
P11301	49.25	14.49	12.91	0.193	1.24	4.82	3.92	2.21	1.018	0.35	10.17	100.6	21	2	23	< 20
P11302	47.44	14.82	20.94	0.121	1.97	3.49	1.76	1.5	1.124	0.5	7.17	100.8	24	1	17	< 20
P11303	49.44	13.59	13.03	0.23	1.37	5.24	5.54	1.19	1.301	0.48	7.24	98.65	23	< 1	57	< 20
P26301	60.91	15.19	9.85	0.158	0.61	1.14	6.64	1.09	0.761	0.19	3.7	100.2	19	< 1	< 5	< 20
P26303	59.62	14	9.34	0.132	0.58	3.02	7.62	0.29	0.769	0.2	3.35	98.91	16	1	16	< 20
P26305	38.88	7.96	9.83	0.211	5.28	17.69	0.56	0.13	1.03	0.1	16.87	98.53	34	< 1	172	100
P11101	53.03	13.31	11.34	0.184	1.4	5.38	5.25	1.13	0.948	0.31	8.52	100.8	20	< 1	29	< 20
P11103	47.82	13.64	14.55	0.204	1.64	4.51	4.45	1.73	0.846	0.43	10.58	100.4	16	1	12	< 20
P11104	52.28	13.74	11.97	0.208	1.36	4.47	5.62	0.93	1.376	0.3	8.28	100.5	24	1	26	< 20
KBDD 11113-7	54.89	13.74	10.24	0.184	1.04	4.71	5.07	1.37	1.2	0.28	6.97	99.7	22	1	19	< 20
P27803	54.15	13.69	12.77	0.211	1.25	3.82	5.99	0.7	0.955	0.42	6.62	100.6	18	1	6	< 20
P23103	53.06	12.04	14.55	0.237	0.99	3.21	5.55	0.81	1.428	0.54	8.35	100.8	24	1	12	< 20
P23102	53.57	11.52	12.92	0.206	1.15	4.3	5.3	0.77	1.269	0.44	8.96	100.4	23	1	16	< 20
P23105	43.91	10.29	17.29	0.263	2.12	6.13	4.53	0.7	2.468	0.72	10.3	98.72	34	1	93	< 20
KBDD 18278-21	53.42	13.83	11.53	0.192	1.33	4.47	5.86	0.26	1.262	0.53	5.85	98.51	22	< 1	10	< 20
KBDD 18278-7	45.72	12.51	13.28	0.187	5.24	8.6	2.8	0.02	1.392	0.15	9.42	99.32	38	< 1	295	70
KBDD 18278-10	50.59	13.25	13.69	0.207	5.84	9.92	2.29	0.27	1.444	0.15	3.1	100.8	43	< 1	325	90
KBDD 11111-8	43.6	10.66	20.89	0.207	5.85	7.39	0.9	0.18	2.424	0.12	8.04	100.3	54	< 1	831	30
P10601	58.45	12.1	9.69	0.159	1.03	4.5	4.73	1.16	0.591	0.25	7.74	100.4	16	1	38	< 20
KBDD 11106-11	43.6	9.17	18.28	0.228	5.5	9.56	0.58	0.45	2.282	0.12	10.74	100.5	51	< 1	769	40
P11305	45.84	10.2	20.65	0.229	6.39	8.27	1.61	0.08	2.685	0.14	4.41	100.5	64	< 1	984	40

Element/Oxide	Co	Ni	Cu	Zn	Ga	Ge	As	Rb	Sr	Y	Zr	Nb	Mo	Ag	In	Sn
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection limit	1	20	10	30	1	0.5	5	1	2	0.5	1	0.2	2	0.5	0.1	1
Sample																
P27801	46	40	90	100	16	1.6	5	1	215	25.2	90	3.9	< 2	< 0.5	0.1	1
P27804	9	< 20	70	90	15	0.7	1340	13	233	57.1	250	7.8	< 2	0.8	0.1	1
P11301	19	< 20	20	120	25	1.3	277	52	160	58.6	226	8.9	< 2	0.7	0.1	1
P11302	13	< 20	< 10	50	23	1.3	24	31	94	55.5	218	8.8	< 2	0.7	0.1	1
P11303	21	< 20	110	< 30	17	0.6	> 2000	25	244	60.7	233	9.2	< 2	0.9	0.1	< 1
P26301	6	< 20	40	120	17	0.7	51	24	249	73.1	340	10.7	< 2	1.2	0.2	1
P26303	6	< 20	60	130	16	0.7	17	6	277	63.9	297	8.6	< 2	1.2	0.1	1
P26305	43	60	50	70	11	1.1	29	3	314	16.4	58	2.5	< 2	< 0.5	< 0.1	< 1
P11101	18	< 20	20	120	19	0.8	39	25	285	54.4	214	7.2	< 2	0.7	0.1	< 1
P11103	21	< 20	20	160	22	1.1	16	36	210	52	197	7.9	< 2	0.7	0.1	1
P11104	18	< 20	20	130	21	1.1	12	22	223	55.9	218	9.2	< 2	0.7	0.1	1
KBDD 11113-7	13	< 20	10	60	18	0.8	> 2000	30	247	55.4	204	9.1	< 2	0.6	0.1	1
P27803	15	< 20	< 10	150	23	1.3	99	21	251	54.5	223	8.7	< 2	0.7	0.1	1
P23103	15	< 20	10	160	18	1.2	371	21	224	73.6	302	13.6	< 2	0.9	0.1	1
P23102	18	< 20	< 10	140	20	1.2	163	22	247	80.3	336	13.8	< 2	1.2	0.2	1
P23105	34	< 20	60	160	13	1	> 2000	25	308	67.7	255	12.4	2	0.8	0.1	1
KBDD 18278-21	16	< 20	< 10	130	20	1.2	19	5	277	56.2	203	7.2	< 2	0.7	0.1	1
KBDD 18278-7	43	40	90	100	16	1.3	12	< 1	195	25	92	3.7	< 2	< 0.5	0.1	< 1
KBDD 18278-10	56	50	30	100	20	2.2	29	7	236	29.2	98	4.3	< 2	< 0.5	0.1	< 1
KBDD 11111-8	73	40	80	130	19	2	28	7	130	25.8	79	3.2	< 2	< 0.5	0.1	< 1
P10601	11	< 20	20	100	18	0.8	159	23	223	49.6	201	6	< 2	0.7	0.1	< 1
KBDD 11106-11	61	40	140	130	15	1.4	35	24	194	26.3	83	3.4	< 2	< 0.5	0.1	< 1
P11305	80	40	110	130	17	1.7	33	2	78	31.1	101	3.8	< 2	< 0.5	0.1	1

Element/Oxide	Sb	Cs	Ba	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Detection limit	0.2	0.1	2	0.05	0.05	0.01	0.05	0.01	0.005	0.01	0.01	0.01	0.01	0.01	0.005	0.01
Sample																
P27801	0.4	0.1	11	8.1	19.4	2.66	12.9	3.53	1.2	3.89	0.77	4.44	0.91	2.65	0.396	2.49
P27804	0.7	0.2	179	20.8	50.6	6.88	32.4	8.43	2.3	8.86	1.61	9.87	2.05	6.04	0.87	6.02
P11301	0.2	0.9	469	22.1	50.4	6.49	30.5	7.98	2.55	8.23	1.48	9.68	2.07	6.13	0.912	5.97
P11302	0.3	0.5	330	20.5	47.7	6.3	29.6	7.6	2.06	8.53	1.53	9.78	2.07	6.05	0.876	5.91
P11303	0.9	0.4	347	23.4	54.2	7.26	34.3	8.78	2.65	9.6	1.7	10.7	2.29	6.78	0.99	6.52
P26301	0.3	0.3	389	29.5	69.3	9.18	42.3	10.9	3.06	11.4	2.02	12.6	2.67	7.98	1.16	7.71
P26303	0.3	0.1	99	23.3	57.5	7.68	35.5	9.25	2.59	9.94	1.79	11.5	2.42	7.15	1.05	6.98
P26305	0.6	0.1	36	3.39	8.17	1.12	5.46	1.55	0.452	2	0.39	2.54	0.55	1.68	0.244	1.55
P11101	< 0.2	0.4	250	20.4	46.5	6	27.3	7.06	2.24	8.19	1.5	9.22	1.97	5.8	0.825	5.6
P11103	0.3	0.7	376	19.8	46	5.87	27.5	7.04	2.08	8.02	1.42	8.6	1.82	5.55	0.834	5.46
P11104	< 0.2	0.4	498	20.3	46.1	5.91	27.5	7.25	2.2	7.93	1.46	9.43	1.99	5.92	0.857	5.72
KBDD 11113-7	0.8	0.4	338	20.1	46.3	5.98	27.8	7.41	2.01	8.35	1.54	9.23	1.93	5.94	0.894	5.68
P27803	0.2	0.6	272	20.8	49.9	6.66	32.1	8.27	2.42	9.29	1.6	9.58	1.88	5.58	0.821	5.39
P23103	0.6	0.6	566	31.3	72.5	9.35	42.1	10.7	2.93	11.4	2.04	12.8	2.64	7.68	1.1	7.41
P23102	< 0.2	0.6	379	35.8	81.2	10.4	46.2	11.6	2.96	12.5	2.23	13.8	2.91	8.66	1.28	8.4
P23105	2.3	1.1	482	28.1	64.3	8.4	38.8	9.91	2.74	11	1.94	11.8	2.36	6.92	1.01	6.71
KBDD 18278-21	< 0.2	0.1	123	20.2	48.6	6.67	32.2	8.76	2.47	9.66	1.64	9.97	2.06	5.84	0.838	5.52
KBDD 18278-7	0.4	0.1	11	8	19.2	2.59	12.4	3.52	1.19	3.94	0.73	4.32	0.91	2.6	0.39	2.44
KBDD 18278-10	2.3	0.5	89	10.4	24.3	3.22	16.1	4.31	1.53	4.82	0.87	5.15	1.09	3.17	0.456	2.94
KBDD 11111-8	1	5.7	153	6.54	15.8	2.21	10.8	3.1	1.12	3.71	0.68	4.37	0.95	2.87	0.401	2.65
P10601	< 0.2	0.5	363	18.4	41.6	5.42	25.1	6.62	1.97	7.34	1.29	8.08	1.77	5.28	0.765	5.07
KBDD 11106-11	0.4	13.3	287	7.28	17	2.27	10.9	3.07	1.01	3.87	0.7	4.48	0.96	2.84	0.408	2.67
P11305	2.5	0.9	42	8.71	20.9	2.81	13.8	3.61	1.28	4.48	0.83	5.38	1.17	3.47	0.504	3.27

Element/Oxide	Lu	Hf	Ta	W	Tl	Pb	Bi	Th	U	As	Br	Cr	Ir	Sc	Se	Sb	Au
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppb
Detection limit	0.002	0.1	0.01	0.5	0.05	5	0.1	0.05	0.01	0.5	0.5	5	5	0.1	3	0.2	2
Sample																	
P27801	0.387	2.2	0.25	0.9	< 0.05	< 5	< 0.1	0.88	0.26	6.1	< 0.5	60	< 5	34.8	< 3	< 0.2	< 2
P27804	0.964	5.9	0.69	7.2	0.05	< 5	< 0.1	2.68	0.81	1890	< 0.5	< 5	< 5	15.1	< 3	< 0.2	11500
P11301	1.01	5.3	0.55	3.8	0.2	< 5	< 0.1	2.85	0.89	365	< 0.5	< 5	< 5	18.5	< 3	0.6	< 2
P11302	0.925	5	0.49	24.1	0.16	< 5	< 0.1	2.65	0.84	33.5	< 0.5	5	< 5	20.6	< 3	0.4	70
P11303	1.04	5.5	0.6	6.7	0.1	< 5	< 0.1	3.01	0.95	5290	< 0.5	< 5	< 5	20.9	< 3	< 0.2	9210
P26301	1.22	7.7	0.86	3	0.06	< 5	< 0.1	3.45	1.02	79.2	< 0.5	< 5	< 5	16.2	< 3	0.4	141
P26303	1.13	7.1	0.74	2.7	< 0.05	< 5	< 0.1	3.01	0.92	19.3	< 0.5	< 5	< 5	14.2	< 3	< 0.2	2640
P26305	0.238	1.4	0.15	3.1	< 0.05	< 5	< 0.1	0.59	0.16	42.9	< 0.5	98	< 5	31.2	< 3	0.4	92
P11101	0.908	4.8	0.48	5.1	0.08	< 5	< 0.1	2.88	0.9	65	< 0.5	< 5	< 5	18.5	< 3	< 0.2	485
P11103	0.888	4.8	0.46	1.6	0.14	< 5	< 0.1	2.59	0.82	23.6	< 0.5	< 5	< 5	15.4	< 3	< 0.2	108
P11104	0.913	5	0.58	2.8	0.09	< 5	< 0.1	2.7	0.86	18.7	< 0.5	< 5	< 5	21.6	< 3	< 0.2	509
KBDD 11113-7	0.924	4.7	0.5	4.9	0.1	< 5	< 0.1	2.69	0.87	8870	< 0.5	< 5	< 5	20.6	< 3	< 0.2	1040
P27803	0.842	5.3	0.57	1.4	0.09	< 5	< 0.1	2.27	0.67	108	< 0.5	< 5	< 5	15.9	< 3	< 0.2	7
P23103	1.21	6.7	0.87	3.6	0.08	< 5	< 0.1	3.97	1.17	410	< 0.5	< 5	< 5	20.9	< 3	1	47
P23102	1.33	8.3	0.93	3.6	0.09	< 5	< 0.1	4.82	1.43	188	< 0.5	< 5	< 5	20.2	< 3	0.3	37
P23105	1.07	6.1	0.72	8.6	0.12	< 5	< 0.1	3.39	0.99	7740	< 0.5	< 5	< 5	30.3	< 3	< 0.2	1800
KBDD 18278-21	0.894	4.8	0.53	1.2	< 0.05	< 5	< 0.1	2.37	0.69	26.2	< 0.5	< 5	< 5	20.2	< 3	< 0.2	2
KBDD 18278-7	0.391	2.4	0.22	< 0.5	< 0.05	< 5	< 0.1	0.91	0.26	20.9	< 0.5	60	< 5	33.3	< 3	0.4	7
KBDD 18278-10	0.478	2.8	0.29	1.2	< 0.05	< 5	< 0.1	1.02	0.29	26.5	< 0.5	69	< 5	36.6	< 3	1.9	< 2
KBDD 11111-8	0.437	2	0.2	2.2	< 0.05	< 5	< 0.1	0.88	0.29	49.4	< 0.5	34	< 5	49.6	< 3	1.4	< 2
P10601	0.817	4.7	0.42	1.4	0.08	< 5	< 0.1	2.54	0.78	236	< 0.5	< 5	< 5	15	< 3	0.4	211
KBDD 11106-11	0.419	2	0.21	0.7	0.14	< 5	< 0.1	0.97	0.31	51.3	< 0.5	38	< 5	45.9	< 3	0.6	13
P11305	0.512	2.5	0.24	0.6	< 0.05	< 5	< 0.1	1.19	0.37	52.3	< 0.5	44	< 5	57.5	< 3	2.8	4

Appendix 2: Detection limits, counting times and standards used for Electron Microprobe analyses

Standard	Element/Oxide	Detection limit (ppm)	Count time (sec)
CANMET_chalcopyrite	Cu(gold)	1049	30
CANMET_Au ₆₀ Ag ₄₀	Ag	616	30
CANMET_Bi ₂ Te ₃	Bi	1562	30
CANMET_Bi ₂ Te ₃	Te	497	30
CANMET_Au ₆₀ Ag ₄₀	Au	1867	30
CANMET_cinnabar	Hg	2110	30
CANMET_pyrite	Fe	299	30
CANMET_pyrrhotite	Fe	255	30
CANMET_pyrrhotite	S	120	30
CANMET_CoNiAs	Ni(pyrrhotite)	279	30
CANMET_CoNiAs	Co(pyrrhotite)	445	60
CANMET_CoNiAs	Co(arsenopyrite)	547	40
CANMET_CoNiAs	Ni(arsenopyrite)	279	30
CANMET_chalcopyrite	Cu(arsenopyrite)	941	30
CANMET_CoNiAs	As	332	30
CANMET_stibnite	Sb	333	30
CANMET_Bi ₂ Te ₃	Te	343	30
CANMET_galena	Pb	1271	30
CANMET_pyrite	Fe	253	30
CANMET_pyrite	S	144	30
CANMET_diopside	Mg	109	30
CANMET_diopside	Ca	126	30
CANMET_hematite	Fe	356	30
CANMET_willimite	Mn	320	30
CANMET_muscovite	Si	83	30
CANMET_muscovite	Mg	87	30
CANMET_muscovite	Al	149	30
CANMET_muscovite	K	117	30
CANMET_diopside	Ca	118	30
CANMET_hematite	Fe	321	30
CANMET_spessartine	Mn	287	30
CANMET_kyanite	Si	94	30
CANMET_spinel	Mg	113	30
CANMET_spinel	Al	172	30
CANMET_muscovite	K	134	30
CANMET_diopside	Ca	119	30
CANMET_hematite	Fe	377	30
CANMET_spessartine	Mn	311	30
CANMET_rutile	Ti	142	30

Appendix 3: Results of chlorite geothermometers

	Kranidiotis and MacLean (1987)	Cathelineau 1988
Unit	°C	°C
Sample		
X26312 site10 chl p.1	359	369
X26312 site10 chl p.2	366	378
X26312 site10 chl p.3	367	380
X26312 site10 chl p.4	361	372
X26312 site10 chl p.5	363	374
X26312 site10 chl p.6	360	369
X26312 site10 chl p.7	363	374
X26312 site10 chl p.8	364	375
X26312 site10 chl p.9	358	367
X26312 site10 chl p.10	368	381
X26312 site10 chl p.11	359	369
X26312 site10 chl p.12	352	358
X26312 site10 chl p.13	359	368
X26312 site10 chl p.14	364	376
X26312 site10 chl p.15	359	369
X26312 site10 chl p.16	362	372
X26312 site10 chl p.17	366	378
X26312 site10 chl p.18	362	372
X26312 site10 chl p.19	365	377
X26312 site10 chl p.20	366	379
X26312 site10 chl p.21	382	402
X26312 site10 chl p.22	360	370
X26312 site10 chl p.23	362	373
X26312 site10 chl p.24	372	386
X26312 site10 chl p.25	362	373
X26312 site10 chl p.26	356	364
X26312 site10 chl p.27	364	375
X26312 site10 chl p.28	362	372
X26312 site10 chl p.29	364	375
X26312 site10 chl p.30	366	378
X26312 site10 chl p.31	359	369
X26312 site11 chl p.1	364	376
X26312 site11 chl p.2	356	364
X26312 site11 chl p.3	362	372
X26312 site11 chl p.4	356	364
X26312 site11 chl p.5	364	376
X26312 site11 chl p.6	370	384
X26312 site11 chl p.7	362	373
X26312 site11 chl p.8	365	376
X26312 site11 chl p.9	353	360
X26312 site11 chl p.10	356	364
X26312 site11 chl p.11	357	365
X26312 site11 chl p.12	366	378
X26312 site11 chl p.13	362	373
X26312 site11 chl p.14	364	375
X26312 site11 chl p.15	363	374
X26312 site11 chl p.16	364	375

Unit	Kranidiotis and MacLean (1987) °C	Cathelineau 1988 °C
Sample		
X26312 site11 chl p.17	360	369
X26312 site11 chl p.18	366	378
X26312 site11 chl p.19	360	370
X26312 site11 chl p.20	356	364
X26312 site11 chl p.21	364	376
X26312 site11 chl p.22	364	375
X26312 site11 chl p.23	366	378
X26312 site11 chl p.24	370	385
X26312 site11 chl p.25	363	374
X26312 site11 chl p.26	365	378
X26312 site11 chl p.27	380	397
X26312 site11 chl p.28	382	401
X26312 site11 chl p.29	361	372
X26312 site11 chl p.30	365	378
X26312 site12 chl p.1	359	368
X26312 site12 chl p.2	383	402
X26312 site12 chl p.3	392	415
X26312 site12 chl p.4	362	373
X26312 site12 chl p.5	374	390
X26312 site12 chl p.6	370	384
X26312 site12 chl p.7	383	402
X26312 site12 chl p.8	378	395
X26312 site12 chl p.9	378	395
X26312 site12 chl p.10	371	385
X26312 site12 chl p.11	368	382
X26312 site12 chl p.12	375	390
X26312 site12 chl p.13	381	399
X26312 site12 chl p.14	378	395
X26312 site12 chl p.15	371	385
X26312 site12 chl p.16	375	391
X26312 site12 chl p.17	377	394
X26312 site12 chl p.18	370	384
X26312 site12 chl p.19	375	391
X26312 site12 chl p.20	371	385
X26312 site12 chl p.21	367	378
X26312 site12 chl p.22	370	384
X26312 site12 chl p.23	363	374
X26312 site12 chl p.24	370	383
X26312 site12 chl p.25	360	369
X26312 site12 chl p.26	360	370
X26312 site12 chl p.27	365	376
X26312 site12 chl p.28	385	406
X26312 site12 chl p.29	369	383
X26312 site12 chl p.30	370	383
X26312 site12 chl p.31	377	393
X26312 site12 chl p.32	380	398
X26312 site12 chl p.33	366	378
X26312 site12 chl p.34	366	379
X26312 site12 chl p.35	376	392
X26312 site12 chl p.36	365	376
X26312 site12 chl p.37	372	387
X26312 site12 chl p.38	373	388

Unit	Kranidiotis and MacLean (1987) °C	Cathelineau 1988 °C
Sample		
X26312 site12 chl p.39	372	387
X26312 site12 chl p.40	365	376
X26312 site13 chl p.1	376	392
X26312 site13 chl p.2	367	380
X26312 site13 chl p.3	369	382
X26312 site13 chl p.4	369	383
X26312 site13 chl p.5	371	385
X26312 site13 chl p.6	378	395
X26312 site13 chl p.7	360	370
X26312 site13 chl p.8	369	382
X26312 site13 chl p.9	350	355
X26312 site13 chl p.10	382	400
X26312 site13 chl p.11	369	382
X26312 site13 chl p.12	371	386
X26312 site13 chl p.13	364	376
X26312 site13 chl p.14	373	388
X26312 site13 chl p.15	377	394
X26312 site13 chl p.16	378	395
X26312 site13 chl p.17	368	382
X26312 site13 chl p.18	378	394
X26312 site13 chl p.19	374	389
X26312 site13 chl p.20	346	350
X26312 site13 chl p.21	360	369
X26312 site13 chl p.22	376	393
X26312 site13 chl p.23	373	389
X26312 site13 chl p.24	370	384
X26312 site13 chl p.25	382	401
X26312 site13 chl p.26	363	374
X26312 site13 chl p.27	360	369
X26312 site13 chl p.28	356	364
X26312 site13 chl p.29	366	378
X26312 site13 chl p.30	375	391
X26313 site3 chl p.1	384	399
X26313 site3 chl p.2	381	396
X26313 site3 chl p.3	379	392
X26313 site3 chl p.4	383	397
X26313 site3 chl p.5	386	402
X26313 site3 chl p.6	382	397
X26313 site3 chl p.7	388	406
X26313 site3 chl p.8	384	399
X26313 site3 chl p.9	382	395
X26313 site3 chl p.10	385	401
X26313 site3 chl p.11	386	402
X26313 site3 chl p.12	376	388
X26313 site3 chl p.13	381	396
X26313 site3 chl p.14	390	408
X26313 site3 chl p.15	381	394
X26313 site3 chl p.16	385	402
X26313 site3 chl p.17	383	397
X26313 site3 chl p.18	384	400
X26313 site3 chl p.19	384	400
X26313 site3 chl p.20	382	396

Unit	Kranidiotis and MacLean (1987) °C	Cathelineau 1988 °C
Sample		
X26313 site3 chl p.21	381	395
X26313 site3 chl p.22	385	400
X26313 site3 chl p.23	382	395
X26313 site3 chl p.24	383	398
X26313 site3 chl p.25	388	405
X26313 site3 chl p.26	382	397
X26313 site3 chl p.27	387	403
X26313 site3 chl p.28	377	389
X26313 site3 chl p.29	386	402
X26313 site3 chl p.30	381	394
X26313 site4 chl p.1	378	391
X26313 site4 chl p.2	383	398
X26313 site4 chl p.3	387	403
X26313 site4 chl p.4	388	406
X26313 site4 chl p.5	384	399
X26313 site4 chl p.6	387	403
X26313 site4 chl p.7	385	400
X26313 site4 chl p.8	290	256
X26313 site4 chl p.9	391	409
X26313 site4 chl p.10	391	410
X26313 site4 chl p.11	385	401
X26313 site4 chl p.12	387	403
X26313 site4 chl p.13	386	402
X26313 site4 chl p.14	385	400
X26313 site4 chl p.15	384	400
X26313 site4 chl p.16	385	400
X26313 site4 chl p.17	386	403
X26313 site4 chl p.18	380	394
X26313 site4 chl p.19	379	392
X26313 site4 chl p.20	383	398
X26313 site4 chl p.21	381	395
X26313 site4 chl p.22	379	392
X26313 site4 chl p.23	365	370
X26313 site4 chl p.25	383	398
X26313 site4 chl p.26	384	400
X26313 site4 chl p.27	379	391
X26313 site4 chl p.28	378	390
X26313 site4 chl p.29	385	400
X26313 site4 chl p.30	382	397
X26313 site 9 chl p.1	384	399
X26313 site 9 chl p.2	381	396
X26313 site 9 chl p.3	383	398
X26313 site 9 chl p.4	383	399
X26313 site 9 chl p.5	380	394
X26313 site 9 chl p.6	382	396
X26313 site 9 chl p.7	384	400
X26313 site 9 chl p.8	377	390
X26313 site 9 chl p.9	377	389
X26313 site 9 chl p.10	383	398
X26313 site 9 chl p.11	381	395
X26313 site 9 chl p.12	383	399
X26313 site 9 chl p.13	382	397

Unit	Kranidiotis and MacLean (1987) °C	Cathelineau 1988 °C
Sample		
X26313 site 9 chl p.14	382	396
X26313 site 9 chl p.15	381	395
X26313 site 9 chl p.16	380	394
X26313 site 9 chl p.17	382	396
X26313 site 9 chl p.18	381	395
X26313 site 9 chl p.19	379	393
X26313 site 9 chl p.20	383	398
X26313 site 9 chl p.21	379	393
X26313 site 9 chl p.22	379	393
X26313 site 9 chl p.24	381	395
X26313 site 9 chl p.25	382	397
X26313 site 9 chl p.26	378	390
X26313 site 9 chl p.27	383	398
X26313 site 9 chl p.28	384	400
X26313 site 9 chl p.29	379	393
X26313 site 9 chl p.30	381	396
X11308-site 6 chl p.1	381	396
X11308-site 6 chl p.2	381	396
X11308-site 6 chl p.3	381	396
X11308-site 6 chl p.4	381	396
X11308-site 6 chl p.5	381	396
X11308-site 6 chl p.6	381	396
X11308-site 6 chl p.7	381	396
X11308-site 6 chl p.8	381	396
X11308-site 6 chl p.9	381	396
X11308-site 6 chl p.10	381	396
X11308-site 6 chl p.11	381	396
X11308-site 6 chl p.12	381	396
X11308-site 6 chl p.13	381	396
X11308-site 6 chl p.14	381	396
X11308-site 6 chl p.15	381	396
X11308-site 6 chl p.16	381	396
X11308-site 6 chl p.17	381	396
X11308-site 6 chl p.18	381	396
X11308-site 6 chl p.19	381	396
X11308-site 10 chl p.1	381	396
X11308-site 10 chl p.2	381	396
X11308-site 10 chl p.3	381	396
X11308-site 10 chl p.4	381	396
X11308-site 10 chl p.5	381	396
X11308-site 10 chl p.6	381	396
X11308-site 10 chl p.7	381	396
X11308-site 10 chl p.8	381	396
X11308-site 10 chl p.9	381	396
X11308-site 10 chl p.10	381	396
X11308-site 10 chl p.11	381	396
X11308-site 10 chl p.12	381	396
X11308-site 10 chl p.13	381	396
X11308-site 10 chl p.14	381	396
X11308-site 10 chl p.15	381	396
X11308-site 11 chl p.1	381	396
X11308-site 11 chl p.2	381	396
X11308-site 11 chl p.3	381	396
X11308-site 11 chl p.4	381	396
X23105-site 5 chl p.1	381	396

Appendix 4:Electron microprobe analyses of ankerite

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102073 site 10 ank p.1	6.841	28.51	21.57	0.750	42.33	100.00
X102073 site 10 ank p.2	6.741	28.71	21.45	0.606	42.50	100.00
X102073 site 10 ank p.3	6.632	28.91	21.54	0.664	42.25	100.00
X102073 site 10 ank p.4	6.319	29.54	21.22	0.693	42.23	100.00
X102073 site 10 ank p.5	6.586	28.88	21.43	0.659	42.44	100.00
X102073 site 10 ank p.6	6.642	29.43	20.87	0.737	42.32	100.00
X102073 site 10 ank p.7	6.749	28.74	21.52	0.657	42.33	100.00
X102073 site 10 ank p.8	6.636	29.02	21.33	0.742	42.27	100.00
X102073 site 10 ank p.9	6.544	28.96	21.46	0.682	42.35	100.00
X102073 site 10 ank p.10	7.060	29.27	20.27	0.847	42.55	100.00
X102073 site 10 ank p.11	6.575	28.97	21.45	0.650	42.35	100.00
X102073 site 10 ank p.12	6.674	28.78	21.60	0.681	42.27	100.00
X102073 site 10 ank p.13	6.482	29.04	21.64	0.670	42.16	100.00
X102073 site 10 ank p.14	6.737	28.68	21.48	0.663	42.44	100.00
X102073 site 10 ank p.15	6.361	28.50	21.71	0.937	42.49	100.00
X102073 site 10 ank p.16	6.523	28.51	21.65	0.901	42.43	100.00
X102073 site 10 ank p.17	6.818	28.75	21.55	0.624	42.26	100.00
X102073 site 10 ank p.18	6.182	28.87	21.84	1.045	42.07	100.00
X102073 site 10 ank p.19	5.480	28.23	23.29	0.729	42.27	100.00
X102073 site 10 ank p.20	6.459	28.84	21.64	0.688	42.37	100.00
X102073 site 14 ank p.1	5.570	28.07	23.24	0.873	42.25	100.00
X102073 site 14 ank p.2	5.353	28.11	23.64	0.879	42.02	100.00
X102073 site 14 ank p.3	5.905	28.29	22.75	0.864	42.20	100.00
X102073 site 14 ank p.4	5.924	28.06	22.97	0.882	42.17	100.00
X102073 site 14 ank p.5	5.827	28.11	23.20	0.896	41.96	100.00
X102073 site 14 ank p.6	5.776	27.88	22.96	0.861	42.53	100.00
X102073 site 14 ank p.7	6.240	28.23	22.38	0.890	42.26	100.00
X102073 site 14 ank p.8	5.955	28.02	22.82	0.892	42.31	100.00
X102073 site 14 ank p.9	5.977	28.62	22.32	0.975	42.10	100.00
X102073 site 14 ank p.10	5.303	28.08	23.74	0.950	41.93	100.00
X102073 site 14 ank p.11	9.268	28.94	16.93	1.227	43.63	100.00
X102073 site 14 ank p.15	5.745	28.26	23.12	0.860	42.03	100.00
X102073 site 14 ank p.16	5.790	28.22	23.09	0.962	41.94	100.00
X102073 site 14 ank p.17	6.067	28.77	21.98	0.949	42.23	100.00
X102073 site 14 ank p.18	6.986	28.84	21.19	0.644	42.34	100.00
X102073 site 14 ank p.19	5.781	28.14	23.17	0.911	42.00	100.00
X102073 site 14 ank p.20	5.754	28.15	22.87	0.883	42.34	100.00
X102073 site 14 ank p.21	5.564	28.11	23.16	0.880	42.29	100.00
X102073 site 14 ank p.22	5.607	28.00	23.23	0.890	42.27	100.00
X102073 site 14 ank p.23	5.961	28.05	22.84	0.823	42.33	100.00
X102060-site 3 ank p.1	4.780	28.06	23.77	0.600	42.79	100.00
X102060-site 3 ank p.2	4.660	27.52	22.53	0.650	44.63	100.00
X102060-site 3 ank p.3	4.770	28.39	23.48	0.650	42.72	100.00
X102060-site 3 ank p.4	4.980	27.12	21.66	0.430	45.81	100.00
X102060-site 3 ank p.5	4.710	28.50	23.46	0.620	42.70	100.00
X102060-site 3 ank p.6	4.790	28.43	23.53	0.640	42.61	100.00
X102060-site 3 ank p.7	4.860	28.38	23.47	0.610	42.68	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102060-site 3 ank p.8	4.650	28.09	23.88	0.730	42.66	100.00
X102060-site 3 ank p.9	4.810	28.66	23.34	0.600	42.58	100.00
X102060-site 3 ank p.10	5.140	28.10	23.20	0.690	42.88	100.00
X102060-site 3 ank p.11	4.770	28.17	23.90	0.610	42.56	100.00
X102060-site 3 ank p.12	5.400	28.64	22.79	0.510	42.66	100.00
X102060-site 3 ank p.13	4.600	28.28	23.70	0.660	42.76	100.00
X102060-site 3 ank p.14	4.790	28.34	23.90	0.610	42.36	100.00
X102060-site 3 ank p.15	4.420	28.49	24.10	0.650	42.34	100.00
X102060-site 3 ank p.16	5.090	28.60	22.79	0.730	42.78	100.00
X102060-site 3 ank p.17	5.180	28.65	22.80	0.500	42.87	100.00
X102060-site 3 ank p.18	4.970	28.73	23.06	0.620	42.61	100.00
X102060-site 3 ank p.19	4.270	28.17	24.57	0.610	42.38	100.00
X102060-site 3 ank p.20	5.150	28.45	22.93	0.870	42.59	100.00
X102060-site 3 ank p.21	5.080	28.29	23.27	0.920	42.44	100.00
X102060-site 3 ank p.22	5.230	28.58	22.81	0.940	42.44	100.00
X102060-site 3 ank p.26	8.330	28.58	18.45	1.170	43.47	100.00
X102060-site 3 ank p.27	6.580	28.19	21.40	0.890	42.94	100.00
X102060-site 3 ank p.28	4.720	28.11	24.30	0.630	42.25	100.00
X102060-site 3 ank p.29	3.790	28.08	25.46	0.580	42.09	100.00
X102060-site 3 ank p.30	3.430	28.06	25.86	0.600	42.05	100.00
X102060-site 3 ank p.31	3.370	28.08	26.01	0.500	42.03	100.00
X102060-site 3 ank p.32	4.300	28.04	24.85	0.640	42.16	100.00
X102060-site 3 ank p.33	5.180	27.28	22.30	0.760	44.48	100.00
X102060-site 3 ank p.34	5.730	28.12	22.75	0.810	42.59	100.00
X102060-site 3 ank p.35	5.220	28.27	23.02	0.830	42.67	100.00
X102060-site 3 ank p.36	5.030	28.32	23.11	0.900	42.64	100.00
X102060-site 3 ank p.37	5.030	28.27	23.18	0.900	42.62	100.00
X102060-site 3 ank p.38	5.040	28.43	23.25	0.910	42.37	100.00
X102060-site 3 ank p.39	5.150	28.31	23.27	0.940	42.34	100.00
X102060-site 3 ank p.40	5.190	28.30	23.18	0.890	42.44	100.00
X102060-site 4 ank p.1	5.030	27.94	23.61	0.700	42.72	100.00
X102060-site 4 ank p.2	5.660	27.91	22.88	0.730	42.83	100.00
X102060-site 4 ank p.3	4.880	27.95	23.89	0.670	42.62	100.00
X102060-site 4 ank p.4	4.920	28.25	23.38	0.890	42.55	100.00
X102060-site 4 ank p.5	5.270	28.26	22.84	0.860	42.78	100.00
X102060-site 4 ank p.6	5.160	28.31	22.94	0.870	42.72	100.00
X102060-site 4 ank p.7	5.420	28.29	22.59	0.870	42.83	100.00
X102060-site 4 ank p.8	5.360	28.04	22.74	0.880	42.99	100.00
X102060-site 4 ank p.9	5.240	28.12	22.91	0.880	42.85	100.00
X102060-site 4 ank p.10	3.740	27.80	25.60	0.540	42.33	100.00
X102060-site 4 ank p.11	4.770	27.82	23.90	0.690	42.82	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102060-site 4 ank p.12	3.190	27.84	26.27	0.540	42.16	100.00
X102060-site 4 ank p.13	4.840	27.85	24.06	0.680	42.57	100.00
X102060-site 4 ank p.14	4.790	27.93	24.16	0.650	42.47	100.00
X102060-site 4 ank p.15	4.090	27.88	25.22	0.650	42.17	100.00
X102060-site 4 ank p.16	5.680	28.11	22.73	0.820	42.66	100.00
X102060-site 4 ank p.20	4.700	28.38	23.82	0.650	42.45	100.00
X102060-site 4 ank p.21	4.610	27.81	24.35	0.740	42.49	100.00
X102060-site 4 ank p.22	3.390	27.78	26.08	0.580	42.17	100.00
X102060-site 4 ank p.23	3.650	28.04	25.63	0.610	42.07	100.00
X102060-site 10 ank p.1	7.570	27.86	19.44	1.040	44.09	100.00
X102060-site 10 ank p.2	7.880	27.98	19.16	1.070	43.91	100.00
X102060-site 10 ank p.3	5.610	27.92	22.27	0.760	43.44	100.00
X102060-site 10 ank p.4	7.660	27.94	19.43	1.030	43.95	100.00
X102060-site 10 ank p.5	5.790	27.93	22.06	0.760	43.45	100.00
X102060-site 10 ank p.6	5.210	28.06	22.41	0.790	43.52	100.00
X102060-site 10 ank p.7	5.340	27.97	22.40	0.830	43.46	100.00
X102060-site 10 ank p.8	5.190	28.01	22.64	0.810	43.35	100.00
X102060-site 10 ank p.9	5.080	27.93	22.80	0.860	43.32	100.00
X102060-site 10 ank p.10	4.920	27.99	22.90	0.850	43.34	100.00
X102060-site 10 ank p.11	4.960	28.06	22.82	0.840	43.31	100.00
X102060-site 10 ank p.12	4.880	28.03	22.97	0.860	43.26	100.00
X102060-site 10 ank p.13	4.980	28.01	22.83	0.850	43.33	100.00
X102060-site 10 ank p.14	5.160	27.93	22.79	0.810	43.30	100.00
X102060-site 10 ank p.15	4.990	27.88	22.91	0.880	43.34	100.00
X102060-site 10 ank p.16	4.930	27.87	22.89	0.850	43.47	100.00
X102060-site 10 ank p.17	4.900	27.86	22.83	0.850	43.55	100.00
X102060-site 10 ank p.18	5.000	28.10	22.81	0.850	43.25	100.00
X102060-site 10 ank p.19	4.920	27.77	23.22	0.850	43.24	100.00
X102060-site 10 ank p.20	3.080	27.75	26.14	0.500	42.53	100.00
X102060-site 10 ank p.21	3.380	27.43	25.52	0.500	43.16	100.00
X102060-site 10 ank p.22	3.030	27.73	26.14	0.520	42.58	100.00
X102060-site 10 ank p.23	3.000	27.82	26.11	0.540	42.53	100.00
X102060-site 10 ank p.24	4.780	28.20	23.37	0.540	43.12	100.00
X102060-site 10 ank p.25	4.600	28.26	23.31	0.520	43.32	100.00
X102060-site 10 ank p.26	4.150	27.58	24.49	0.720	43.05	100.00
X102060-site 10 ank p.27	3.270	27.74	25.69	0.520	42.78	100.00
X102060-site 10 ank p.31	3.620	27.76	25.39	0.560	42.66	100.00
X102060-site 10 ank p.32	3.300	27.54	26.02	0.520	42.62	100.00
X102060-site 10 ank p.33	3.270	27.64	25.96	0.500	42.62	100.00
X102060-site 10 ank p.34	3.310	27.56	25.41	0.490	43.23	100.00
X102060-site 10 ank p.35	3.610	27.60	25.58	0.500	42.70	100.00
X102060-site 10 ank p.36	4.000	27.60	24.90	0.630	42.88	100.00
X102060-site 13 ank p.1	4.620	28.39	23.69	0.660	42.63	100.00
X102060-site 13 ank p.2	4.320	28.03	24.49	0.510	42.64	100.00

Element/Oxide Unit	MgO wt%	CaO wt%	FeO wt%	MnO wt%	CO2 wt%	Total wt%
Sample						
X102060-site 13 ank p.3	4.400	27.63	24.23	0.540	43.21	100.00
X102060-site 13 ank p.4	4.300	27.76	24.93	0.690	42.32	100.00
X102060-site 13 ank p.5	4.980	27.49	21.73	0.370	45.43	100.00
X102060-site 13 ank p.6	3.770	27.38	25.03	0.570	43.25	100.00
X102060-site 13 ank p.7	3.200	27.91	25.92	0.530	42.44	100.00
X102060-site 13 ank p.8	3.240	27.88	26.02	0.600	42.26	100.00
X102060-site 13 ank p.9	3.230	27.97	26.06	0.570	42.16	100.00
X102060-site 13 ank p.10	3.270	27.75	25.79	0.530	42.65	100.00
X102060-site 13 ank p.11	3.330	27.84	25.57	0.560	42.70	100.00
X102060-site 13 ank p.12	5.480	28.46	22.88	0.330	42.85	100.00
X102060-site 13 ank p.13	5.240	28.71	22.49	0.340	43.22	100.00
X102060-site 13 ank p.14	5.220	28.42	22.42	0.330	43.61	100.00
X102060-site 13 ank p.15	6.860	28.14	20.56	1.030	43.41	100.00
X102060-site 13 ank p.16	6.370	28.21	21.28	1.020	43.11	100.00
X102060-site 13 ank p.17	6.910	28.19	20.36	1.070	43.47	100.00
X102060-site 13 ank p.18	5.710	28.17	22.15	0.860	43.11	100.00
X102060-site 13 ank p.19	5.800	28.13	21.97	0.900	43.20	100.00
X102060-site 13 ank p.20	6.820	28.33	20.55	1.090	43.20	100.00
X102060-site 13 ank p.21	3.800	27.65	25.35	0.560	42.64	100.00
X102060-site 13 ank p.22	3.440	27.83	25.97	0.540	42.22	100.00
X102060-site 13 ank p.23	4.630	28.18	24.06	0.450	42.68	100.00
X102060-site 13 ank p.24	4.610	28.13	24.01	0.550	42.71	100.00
X102060-site 13 ank p.25	5.040	27.62	22.03	0.350	44.95	100.00
X102060-site 10 ank p.31	3.620	27.76	25.39	0.560	42.66	100.00
X102060-site 10 ank p.32	3.300	27.54	26.02	0.520	42.62	100.00
X102060-site 10 ank p.33	3.270	27.64	25.96	0.500	42.62	100.00
X102060-site 10 ank p.34	3.310	27.56	25.41	0.490	43.23	100.00
X102060-site 10 ank p.35	3.610	27.60	25.58	0.500	42.70	100.00
X102060-site 10 ank p.36	4.000	27.60	24.90	0.630	42.88	100.00
X102060-site 13 ank p.1	4.620	28.39	23.69	0.660	42.63	100.00
X102060-site 13 ank p.2	4.320	28.03	24.49	0.510	42.64	100.00
X102060-site 13 ank p.3	4.400	27.63	24.23	0.540	43.21	100.00
X102060-site 13 ank p.4	4.300	27.76	24.93	0.690	42.32	100.00
X102060-site 13 ank p.5	4.980	27.49	21.73	0.370	45.43	100.00
X102060-site 13 ank p.6	3.770	27.38	25.03	0.570	43.25	100.00
X102060-site 13 ank p.7	3.200	27.91	25.92	0.530	42.44	100.00
X102060-site 13 ank p.8	3.240	27.88	26.02	0.600	42.26	100.00
X102060-site 13 ank p.9	3.230	27.97	26.06	0.570	42.16	100.00
X102060-site 13 ank p.10	3.270	27.75	25.79	0.530	42.65	100.00
X102060-site 13 ank p.11	3.330	27.84	25.57	0.560	42.70	100.00
X102060-site 13 ank p.12	5.480	28.46	22.88	0.330	42.85	100.00
X102060-site 13 ank p.13	5.240	28.71	22.49	0.340	43.22	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102060-site 13 ank p.14	5.220	28.42	22.42	0.330	43.61	100.00
X102060-site 13 ank p.15	6.860	28.14	20.56	1.030	43.41	100.00
X102060-site 13 ank p.16	6.370	28.21	21.28	1.020	43.11	100.00
X102060-site 13 ank p.17	6.910	28.19	20.36	1.070	43.47	100.00
X102060-site 13 ank p.18	5.710	28.17	22.15	0.860	43.11	100.00
X102060-site 13 ank p.19	5.800	28.13	21.97	0.900	43.20	100.00
X102060-site 13 ank p.20	6.820	28.33	20.55	1.090	43.20	100.00
X102060-site 13 ank p.21	3.800	27.65	25.35	0.560	42.64	100.00
X102060-site 13 ank p.22	3.440	27.83	25.97	0.540	42.22	100.00
X102060-site 13 ank p.23	4.630	28.18	24.06	0.450	42.68	100.00
X102060-site 13 ank p.24	4.610	28.13	24.01	0.550	42.71	100.00
X102060-site 13 ank p.25	5.040	27.62	22.03	0.350	44.95	100.00
X102060-site 13 ank p.29	4.560	28.42	23.47	0.840	42.71	100.00
X102060-site 13 ank p.30	4.490	28.38	23.44	0.870	42.82	100.00
X102060-site 15 ank p.1	4.600	28.08	23.90	0.670	42.74	100.00
X102060-site 15 ank p.2	4.980	28.47	23.08	0.730	42.75	100.00
X102060-site 15 ank p.3	4.510	27.91	24.35	0.740	42.49	100.00
X102060-site 15 ank p.4	4.710	27.96	24.23	0.740	42.35	100.00
X102060-site 15 ank p.5	4.520	28.37	23.89	0.670	42.55	100.00
X102060-site 15 ank p.6	5.040	27.49	22.62	0.640	44.22	100.00
X102060-site 15 ank p.7	4.890	28.25	23.67	0.700	42.49	100.00
X102060-site 15 ank p.8	4.820	28.12	24.15	0.660	42.25	100.00
X102060-site 15 ank p.9	5.170	29.54	21.52	0.800	42.97	100.00
X102060-site 15 ank p.10	4.290	28.48	24.45	0.400	42.38	100.00
X102060-site 15 ank p.11	5.340	28.96	22.35	0.800	42.54	100.00
X102060-site 15 ank p.12	4.890	28.46	23.28	0.510	42.87	100.00
X102060-site 15 ank p.13	4.570	28.36	23.20	0.440	43.43	100.00
X102060-site 15 ank p.14	3.730	27.73	23.75	0.490	44.30	100.00
X102060-site 15 ank p.15	4.570	27.91	24.50	0.720	42.30	100.00
X102060-site 15 ank p.16	4.510	27.78	24.63	0.750	42.32	100.00
X102060-site 15 ank p.17	4.690	27.69	24.59	0.740	42.29	100.00
X102060-site 15 ank p.18	5.290	27.17	21.82	0.860	44.86	100.00
X102060-site 15 ank p.19	5.190	26.93	22.32	0.840	44.71	100.00
X102060-site 15 ank p.20	4.400	27.76	24.75	0.730	42.36	100.00
X102060-site 15 ank p.21	4.420	27.83	21.28	0.540	45.92	100.00
X102060-site 15 ank p.22	4.830	28.35	22.97	0.740	43.11	100.00
X102060-site 15 ank p.23	3.660	22.14	18.77	0.740	54.69	100.00
X102073-site 2 ank p.1	7.260	28.50	20.73	0.870	42.64	100.00
X102073-site 2 ank p.2	7.530	28.53	20.30	0.920	42.72	100.00
X102073-site 2 ank p.3	7.420	28.68	20.22	0.920	42.76	100.00
X102073-site 2 ank p.4	7.070	28.50	21.11	0.700	42.62	100.00
X102073-site 2 ank p.5	8.070	28.96	18.91	1.040	43.02	100.00
X102073-site 2 ank p.6	7.030	28.23	20.91	0.740	43.09	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102073-site 2 ank p.10	7.320	28.35	20.50	0.860	42.98	100.00
X102073-site 2 ank p.11	8.020	28.71	19.50	1.070	42.70	100.00
X102073-site 2 ank p.12	8.300	28.93	18.84	1.020	42.91	100.00
X102073-site 2 ms p.13	6.770	28.34	21.79	0.610	42.47	100.00
X102073-site 2 ank p.14	5.310	28.10	23.65	0.660	42.29	100.00
X102073-site 2 ank p.15	6.820	28.55	21.54	0.940	42.15	100.00
X102073-site 2 ank p.16	6.710	28.20	21.33	0.840	42.93	100.00
X102073-site 2 ank p.17	8.820	29.44	17.39	1.270	43.08	100.00
X102073-site 2 ank p.18	6.480	28.23	22.10	0.940	42.25	100.00
X102073-site 2 ank p.19	6.680	28.85	21.17	0.980	42.33	100.00
X102073-site 2 ank p.20	8.600	27.90	18.41	1.360	43.73	100.00
X11310-site 11 ank p.1	4.790	28.11	23.13	0.640	43.33	100.00
X11310-site 11 ank p.2	4.030	28.31	24.68	0.470	42.52	100.00
X11310-site 11 ank p.3	4.560	28.10	24.01	0.550	42.78	100.00
X11310-site 11 ank p.4	5.440	28.00	22.76	0.870	42.93	100.00
X11310-site 11 ank p.5	4.340	28.46	24.13	0.550	42.52	100.00
X11310-site 11 ank p.6	5.310	27.83	22.83	1.080	42.95	100.00
X11310-site 11 ank p.7	3.950	28.50	24.33	0.670	42.55	100.00
X11310-site 11 ank p.8	4.800	29.21	22.51	0.810	42.67	100.00
X11310-site 11 ank p.9	5.470	27.72	23.25	0.890	42.67	100.00
X11310-site 11 ank p.10	4.450	28.61	23.81	0.730	42.41	100.00
X11310-site 11 ank p.11	5.570	27.67	23.21	0.900	42.65	100.00
X11310-site 11 ank p.12	5.350	28.53	22.35	0.950	42.81	100.00
X11310-site 11 ank p.13	5.490	28.00	22.42	0.940	43.15	100.00
X11310-site 11 ank p.14	5.410	27.85	22.88	0.900	42.96	100.00
X11310-site 11 ank p.15	5.260	28.03	22.81	0.990	42.90	100.00
X11310-site 11 ank p.16	5.360	27.81	23.24	0.940	42.65	100.00
X11310-site 11 ank p.17	5.320	27.90	23.03	0.940	42.81	100.00
X11310-site 11 ank p.18	5.400	28.06	22.92	0.970	42.64	100.00
X11310-site 11 ank p.19	5.540	27.70	22.67	0.920	43.16	100.00
X11310-site 11 ank p.20	5.320	27.90	22.99	1.020	42.78	100.00
X11310-site 11 ank p.24	5.500	27.77	22.78	0.980	42.97	100.00
X11310-site 11 ank p.25	5.180	27.86	23.29	1.040	42.62	100.00
X11310-site 11 ank p.26	5.530	28.61	22.03	0.940	42.89	100.00
X11310-site 11 ank p.27	5.200	27.76	23.07	0.970	43.01	100.00
X11310-site 11 ank p.28	5.270	28.31	22.60	0.980	42.85	100.00
X11310-site 11 ank p.29	5.220	27.95	23.11	0.990	42.72	100.00
X11310-site 11 ank p.30	5.340	27.98	22.95	0.930	42.79	100.00
X11310-site 11 ank p.31	5.620	27.90	22.72	0.970	42.78	100.00
X11310-site 11 ank p.32	5.380	28.26	22.67	0.930	42.75	100.00
X11310-site 11 ank p.33	5.290	28.04	23.06	0.950	42.66	100.00
X11310-site 11 ank p.34	5.310	28.04	23.25	0.950	42.45	100.00
X11310-site 11 ank p.35	5.500	27.84	22.98	0.910	42.77	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X11310-site 11 ank p.36	5.230	28.15	22.85	1.010	42.76	100.00
X11310-site 11 ank p.37	5.180	28.32	22.89	0.970	42.64	100.00
X11310-site 11 ank p.38	5.070	28.17	23.33	1.040	42.40	100.00
X11310-site 11 ank p.39	5.260	28.25	23.06	0.950	42.48	100.00
X11310-site 11 ank p.40	4.960	28.24	23.37	0.940	42.49	100.00
X11310-site 11 ank p.41	5.220	27.87	23.26	0.950	42.69	100.00
X11310-site 11 ank p.42	5.280	28.22	23.07	0.960	42.48	100.00
X11310-site 11 ank p.43	5.500	28.18	22.35	0.910	43.07	100.00
X11310-site 11 ank p.44	5.380	28.33	22.81	0.930	42.55	100.00
X11310-site 11 ank p.45	4.330	28.84	24.08	0.530	42.22	100.00
X11310-site 11 ank p.46	4.090	28.34	24.61	0.460	42.50	100.00
X11310-site 11 ank p.47	4.270	28.23	24.60	0.490	42.41	100.00
X11310-site 11 ank p.48	3.970	28.13	25.08	0.400	42.42	100.00
X11310-site 11 ank p.49	5.360	29.20	22.06	0.610	42.78	100.00
X11310-site 11 ank p.50	4.260	28.20	24.72	0.490	42.34	100.00
X11310-site 11 ank p.51	5.070	28.35	22.92	0.770	42.90	100.00
X11310-site 11 ank p.52	5.140	27.95	23.05	0.790	43.07	100.00
X11310-site 11 ank p.53	4.430	28.35	24.29	0.540	42.39	100.00
X11310-site 11 ank p.54	4.200	28.61	24.30	0.470	42.42	100.00
X11310-site 11 ank p.58	4.380	28.90	23.76	0.530	42.42	100.00
X11310-site 12 ank p.1	5.810	27.57	22.12	0.990	43.51	100.00
X11310-site 12 ank p.2	5.990	28.12	21.36	0.970	43.56	100.00
X11310-site 12 ank p.3	6.630	27.80	21.32	1.020	43.23	100.00
X11310-site 12 ank p.4	5.380	27.42	23.05	1.010	43.14	100.00
X11310-site 12 ank p.5	5.560	27.94	22.61	0.960	42.93	100.00
X11310-site 12 ank p.6	5.140	28.48	22.64	0.980	42.77	100.00
X11310-site 12 ank p.7	5.290	28.07	22.98	0.930	42.74	100.00
X11310-site 12 ank p.8	5.790	28.07	22.07	0.920	43.15	100.00
X11310-site 12 ank p.9	5.590	28.35	22.07	0.960	43.04	100.00
X11310-site 12 ank p.10	5.680	27.73	22.30	0.950	43.33	100.00
X11310-site 12 ank p.11	5.800	28.36	22.07	0.960	42.81	100.00
X11310-site 12 ank p.12	5.810	28.32	22.30	0.920	42.65	100.00
X11310-site 12 ank p.13	4.180	28.62	24.55	0.450	42.19	100.00
X11310-site 12 ank p.14	4.480	28.73	23.55	0.620	42.62	100.00
X11310-site 12 ank p.15	5.670	28.48	22.32	0.960	42.58	100.00
X11310-site 12 ank p.16	4.410	28.53	24.02	0.580	42.46	100.00
X11310-site 12 ank p.17	4.130	28.26	24.88	0.480	42.25	100.00
X11310-site 12 ank p.18	4.090	28.74	24.62	0.450	42.10	100.00
X11310-site 12 ank p.19	5.550	28.14	22.68	1.010	42.61	100.00
X11310-site 12 ank p.20	5.440	28.22	22.93	0.910	42.50	100.00
X11310-site 12 ank p.21	5.200	29.00	22.14	0.910	42.74	100.00
X11310-site 12 ank p.22	5.320	29.18	21.72	0.960	42.83	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X11310-site 12 ank p.23	5.600	27.93	22.87	0.950	42.65	100.00
X11310-site 12 ank p.24	5.720	27.81	22.94	0.940	42.59	100.00
X11310-site 12 ank p.25	5.860	27.67	22.72	0.880	42.88	100.00
X11310-site 12 ank p.26	5.700	27.76	22.75	0.920	42.86	100.00
X11310-site 12 ank p.27	5.400	27.85	23.28	1.010	42.46	100.00
X11310-site 12 ank p.28	5.260	28.09	23.03	0.950	42.67	100.00
X11310-site 12 ank p.29	5.060	28.90	22.67	0.990	42.38	100.00
X11310-site 12 ank p.30	5.040	29.47	22.02	0.950	42.52	100.00
X11310-site 14 ank p.4	6.590	28.15	21.37	1.000	42.88	100.00
X11310-site 14 ank p.5	6.060	28.01	22.24	1.000	42.68	100.00
X11310-site 14 ank p.6	6.320	28.04	21.71	0.970	42.96	100.00
X11310-site 14 ank p.7	6.060	28.07	22.18	1.000	42.69	100.00
X11310-site 14 ank p.8	5.920	27.71	22.32	0.930	43.12	100.00
X11310-site 14 ank p.9	6.900	27.85	21.10	0.900	43.25	100.00
X11310-site 14 ank p.10	6.520	27.91	21.61	1.000	42.96	100.00
X11310-site 14 ank p.11	5.860	28.07	22.58	0.980	42.51	100.00
X11310-site 14 ank p.12	6.860	27.90	21.19	0.880	43.18	100.00
X11310-site 14 ank p.13	6.010	28.06	22.08	1.020	42.84	100.00
X11310-site 14 ank p.14	5.680	29.11	21.79	0.840	42.58	100.00
X11310-site 14 ank p.15	5.800	27.68	22.64	0.990	42.89	100.00
X11310-site 14 ank p.16	6.710	27.84	21.26	0.960	43.23	100.00
X11310-site 14 ank p.17	6.430	28.24	21.46	0.930	42.94	100.00
X11310-site 14 ank p.18	5.900	27.99	22.41	0.870	42.82	100.00
X11310-site 14 ank p.19	5.460	28.06	23.08	0.830	42.59	100.00
X11310-site 14 ank p.20	7.040	28.19	20.35	1.050	43.39	100.00
X11310-site 14 ank p.21	4.630	27.81	24.53	0.680	42.35	100.00
X11310-site 14 ank p.22	4.880	27.95	24.26	0.750	42.15	100.00
X11310-site 14 ank p.23	6.600	28.28	20.94	0.980	43.20	100.00
X11310-site 14 ank p.24	5.500	28.13	22.60	0.860	42.91	100.00
X11310-site 14 ank p.25	5.990	28.23	22.19	0.940	42.64	100.00
X11310-site 14 ank p.26	5.920	27.74	22.79	0.890	42.66	100.00
X11310-site 14 ank p.27	5.300	28.04	23.49	0.870	42.29	100.00
X11310-site 14 ank p.28	5.570	28.06	23.03	0.990	42.35	100.00
X11310-site 14 ank p.29	5.880	27.93	22.53	0.970	42.69	100.00
X11310-site 14 ank p.30	6.700	28.07	21.10	0.960	43.17	100.00
X11310-site 18 ank p.1	5.680	27.78	22.90	0.890	42.76	100.00
X11310-site 18 ank p.2	5.430	27.93	23.07	0.990	42.58	100.00
X11310-site 18 ank p.3	5.070	28.74	22.68	0.990	42.53	100.00
X11310-site 18 ank p.4	5.460	28.03	22.97	0.930	42.61	100.00
X11310-site 18 ank p.8	5.250	28.13	22.92	0.980	42.72	100.00
X11310-site 18 ank p.9	4.530	28.84	23.57	0.730	42.33	100.00
X11310-site 18 ank p.10	4.610	28.65	23.84	0.740	42.16	100.00
X11310-site 18 ank p.11	4.540	28.72	23.42	0.720	42.61	100.00
X11310-site 18 ank p.12	4.520	28.78	23.37	0.700	42.63	100.00
X11310-site 18 ank p.13	4.640	28.75	23.52	0.640	42.45	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X11310-site 18 ank p.14	4.500	28.74	23.37	0.720	42.67	100.00
X11310-site 18 ank p.15	4.490	28.08	24.62	0.660	42.16	100.00
X11310-site 18 ank p.16	5.670	27.76	23.00	0.940	42.63	100.00
X11310-site 18 ank p.17	5.780	27.69	22.86	0.970	42.70	100.00
X11310-site 18 ank p.18	5.970	27.71	22.69	0.880	42.74	100.00
X11310-site 18 ank p.19	5.230	29.00	22.47	0.900	42.41	100.00
X11310-site 18 ank p.20	5.040	28.79	22.38	1.000	42.78	100.00
X11310-site 18 ank p.21	5.840	27.59	23.05	0.950	42.58	100.00
X11310-site 18 ank p.22	5.270	28.04	23.38	1.030	42.29	100.00
X11310-site 18 ank p.23	5.550	28.11	23.14	0.950	42.25	100.00
X11310-site 18 ank p.24	5.480	29.29	21.53	0.910	42.79	100.00
X11310-site 18 ank p.25	5.150	28.25	22.54	0.980	43.08	100.00
X11310-site 18 ank p.26	5.140	28.49	22.79	1.050	42.53	100.00
X11310-site 18 ank p.27	5.940	28.63	21.70	0.900	42.83	100.00
X11310-site 18 ank p.28	5.760	28.60	22.02	0.960	42.66	100.00
X11308-site 3 ank p.1	4.720	28.63	24.18	0.690	41.79	100.00
X11308-site 3 ank p.2	5.240	27.90	24.21	0.540	42.11	100.00
X11308-site 3 ank p.3	6.960	28.16	21.32	0.920	42.64	100.00
X11308-site 3 ank p.4	5.430	28.50	23.11	0.770	42.19	100.00
X11308-site 3 ank p.5	5.630	28.52	22.82	0.770	42.26	100.00
X11308-site 3 ank p.6	5.510	28.30	23.18	0.760	42.25	100.00
X11308-site 3 ank p.7	5.270	28.66	23.10	0.800	42.17	100.00
X11308-site 3 ank p.8	5.390	28.67	23.18	0.810	41.95	100.00
X11308-site 3 ank p.9	6.530	28.16	22.05	0.860	42.40	100.00
X11308-site 3 ank p.10	5.340	28.55	23.38	0.710	42.01	100.00
X11308-site 3 ank p.14	4.730	28.16	24.31	0.540	42.25	100.00
X11308-site 3 ank p.15	7.020	28.32	20.58	1.210	42.87	100.00
X11308-site 3 ank p.16	8.760	28.80	18.16	1.370	42.91	100.00
X11308-site 3 ank p.17	9.070	28.89	17.50	1.350	43.18	100.00
X11308-site 3 ank p.18	9.230	28.77	17.23	1.350	43.42	100.00
X11308-site 3 ank p.19	8.910	28.76	18.03	1.340	42.96	100.00
X11308-site 3 ank p.20	8.430	28.83	18.18	1.380	43.18	100.00
X11308-site 3 ank p.21	9.220	28.82	17.22	1.340	43.41	100.00
X11308-site 3 ank p.22	8.970	28.80	17.59	1.350	43.28	100.00
X11308-site 3 ank p.23	8.800	28.77	18.00	1.320	43.11	100.00
X11308-site 3 ank p.24	9.040	28.63	17.36	1.330	43.64	100.00
X11308-site 3 ank p.25	9.330	28.61	16.76	1.370	43.93	100.00
X11308-site 3 ank p.26	9.140	28.47	16.99	1.340	44.07	100.00
X11308-site 3 ank p.27	8.660	28.75	17.83	1.280	43.48	100.00
X11308-site 3 ank p.28	8.600	28.57	17.91	1.450	43.47	100.00
X11308-site 3 ank p.29	9.050	28.75	17.14	1.390	43.67	100.00
X11308-site 3 ank p.30	9.240	28.87	17.03	1.360	43.49	100.00
X11308-site 3 ank p.31	9.040	28.82	17.53	1.270	43.34	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X11308-site 4 ank p.1	6.050	28.38	22.63	0.800	42.13	100.00
X11308-site 4 ank p.2	6.090	29.01	21.51	1.280	42.11	100.00
X11308-site 4 ank p.3	6.710	28.50	21.62	0.900	42.28	100.00
X11308-site 4 ank p.4	5.260	28.74	23.31	0.850	41.84	100.00
X11308-site 4 ank p.5	6.360	28.36	22.08	0.980	42.23	100.00
X11308-site 4 ank p.6	7.570	28.65	20.22	1.030	42.53	100.00
X11308-site 4 ank p.7	6.790	29.37	19.27	1.950	42.62	100.00
X11308-site 4 ank p.8	5.850	28.04	22.83	0.930	42.34	100.00
X11308-site 4 ank p.9	5.900	28.49	22.30	0.980	42.34	100.00
X11308-site 4 ank p.10	5.880	28.81	21.89	1.110	42.31	100.00
X11308-site 4 ank p.11	5.960	28.91	21.91	1.230	41.99	100.00
X11308-site 4 ank p.12	5.810	28.86	22.24	0.950	42.14	100.00
X11308-site 4 ank p.13	6.940	28.93	19.41	1.740	42.98	100.00
X11308-site 4 ank p.17	7.510	28.48	20.32	1.040	42.65	100.00
X11308-site 4 ank p.18	8.680	29.03	17.91	1.430	42.95	100.00
X11308-site 4 ank p.19	8.720	28.83	17.66	1.390	43.40	100.00
X11308-site 4 ank p.20	8.070	28.59	19.10	1.200	43.03	100.00
X11308-site 4 ank p.21	8.550	28.80	17.92	1.370	43.36	100.00
X11308-site 4 ank p.22	8.920	28.79	17.74	1.360	43.19	100.00
X11308-site 4 ank p.23	8.920	28.82	17.97	1.270	43.01	100.00
X11308-site 5 ank p.1	6.430	28.32	22.28	0.910	42.05	100.00
X11308-site 5 ank p.2	8.760	29.04	18.05	1.350	42.80	100.00
X11308-site 5 ank p.3	8.670	28.91	18.42	1.260	42.75	100.00
X11308-site 5 ank p.4	5.060	28.36	24.27	0.530	41.78	100.00
X11308-site 5 ank p.5	9.080	29.10	17.43	1.350	43.03	100.00
X11308-site 5 ank p.6	7.590	28.51	20.06	1.310	42.53	100.00
X11308-site 5 ank p.7	5.820	28.21	23.45	0.930	41.59	100.00
X11308-site 5 ank p.8	8.820	29.13	17.63	1.350	43.07	100.00
X11308-site 5 ank p.9	8.790	28.84	17.79	1.340	43.24	100.00
X11308-site 5 ank p.10	6.520	28.35	22.07	0.870	42.18	100.00
X11308-site 5 ank p.11	5.770	28.06	23.05	0.880	42.24	100.00
X11308-site 5 ank p.12	5.380	28.05	23.87	0.790	41.92	100.00
X11308-site 5 ank p.13	8.780	28.73	17.72	1.350	43.42	100.00
X11308-site 5 ank p.14	8.850	28.66	17.47	1.330	43.68	100.00
X11308-site 5 ank p.15	8.910	28.58	17.40	1.290	43.82	100.00
X11308-site 5 ank p.16	7.770	28.14	19.36	1.220	43.51	100.00
X11308-site 5 ank p.17	9.130	28.61	17.32	1.300	43.64	100.00
X11308-site 5 ank p.18	7.390	28.22	20.35	0.860	43.18	100.00
X11308-site 5 ank p.19	8.970	29.00	17.77	1.310	42.94	100.00
X11308-site 5 ank p.20	8.000	28.63	19.78	1.080	42.51	100.00
X11308-site 7 ank p.1	6.080	28.17	22.42	0.940	42.40	100.00
X11308-site 7 ank p.2	4.510	28.33	24.93	0.510	41.72	100.00
X11308-site 7 ank p.3	3.340	28.18	27.12	0.370	40.99	100.00
X11308-site 7 ank p.4	4.500	28.28	24.86	0.550	41.83	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X11308-site 7 ank p.8	9.020	28.85	17.69	1.360	43.08	100.00
X11308-site 7 ank p.9	4.650	28.52	24.84	0.540	41.44	100.00
X11308-site 7 ank p.10	8.690	28.86	18.04	1.300	43.11	100.00
X11308-site 7 ank p.11	6.380	28.10	21.90	0.880	42.74	100.00
X11308-site 7 ank p.12	8.970	28.63	17.43	1.370	43.61	100.00
X11308-site 7 ank p.13	4.330	28.13	25.04	0.550	41.95	100.00
X11308-site 7 ank p.14	8.940	29.13	17.89	1.380	42.67	100.00
X11308-site 7 ank p.15	5.960	29.13	22.27	0.790	41.85	100.00
X11308-site 7 ank p.16	6.090	28.33	22.96	0.910	41.70	100.00
X11308-site 7 ank p.17	3.390	27.80	27.54	0.440	40.84	100.00
X11308-site 7 ank p.18	7.260	29.37	19.85	1.290	42.24	100.00
X11308-site 7 ank p.19	3.380	27.87	27.03	0.420	41.29	100.00
X11308-site 7 ank p.20	6.540	28.40	22.18	0.870	42.01	100.00
X11308-site 7 ank p.21	8.850	28.70	17.62	1.340	43.49	100.00
X11308-site 7 ank p.22	4.620	28.16	24.89	0.510	41.82	100.00
X11308-site 7 ank p.23	7.650	28.39	20.19	0.970	42.80	100.00
X11308-site 7 ank p.24	6.910	28.19	21.18	0.960	42.76	100.00
X11308-site 7 ank p.25	3.370	27.71	26.79	0.420	41.70	100.00
X23105-site 9 ank p.1	8.680	28.32	17.63	1.260	44.11	100.00
X23105-site 9 ank p.2	8.620	28.21	17.84	1.180	44.14	100.00
X23105-site 9 ank p.3	8.930	28.50	17.07	1.330	44.16	100.00
X23105-site 9 ank p.4	8.160	28.35	18.53	1.260	43.69	100.00
X23105-site 9 ank p.5	8.700	28.26	17.42	1.360	44.27	100.00
X23105-site 9 ank p.6	8.250	28.20	18.54	1.260	43.75	100.00
X23105-site 9 ank p.7	6.330	28.37	21.24	0.970	43.09	100.00
X23105-site 9 ank p.8	8.230	28.35	18.35	1.230	43.84	100.00
X23105-site 9 ank p.9	6.170	28.37	21.54	0.980	42.94	100.00
X23105-site 9 ank p.10	9.040	28.41	17.37	1.350	43.84	100.00
X23105-site 9 ank p.11	8.500	28.16	18.25	1.150	43.94	100.00
X23105-site 9 ank p.12	6.390	28.08	21.20	0.900	43.43	100.00
X23105-site 9 ank p.13	6.550	28.35	20.63	0.930	43.53	100.00
X23105-site 9 ank p.17	8.730	28.34	17.60	1.290	44.04	100.00
X23105-site 9 ank p.18	8.380	28.19	18.24	1.330	43.86	100.00
X23105-site 9 ank p.19	8.470	28.31	18.22	1.260	43.74	100.00
X23105-site 9 ank p.20	8.140	28.26	18.89	1.040	43.67	100.00
X23105-site 10 ank p.1	5.260	28.22	22.30	1.060	43.16	100.00
X23105-site 10 ank p.2	8.280	28.29	18.60	1.050	43.78	100.00
X23105-site 10 ank p.3	6.960	28.24	20.13	1.100	43.56	100.00
X23105-site 10 ank p.4	8.500	28.39	17.83	1.370	43.91	100.00
X23105-site 10 ank p.5	8.580	28.25	18.09	1.260	43.82	100.00
X23105-site 10 ank p.6	8.810	28.30	17.94	1.010	43.94	100.00
X23105-site 10 ank p.7	8.750	28.62	17.87	1.070	43.69	100.00
X23105-site 10 ank p.8	8.150	28.33	18.90	1.070	43.56	100.00
X23105-site 10 ank p.9	8.460	28.40	18.81	1.010	43.32	100.00
X23105-site 10 ank p.10	8.530	28.05	18.07	1.030	44.33	100.00
X23105-site 10 ank p.11	7.070	28.28	20.51	0.920	43.21	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X23105-site 10 ank p.12	7.850	28.50	19.20	1.260	43.20	100.00
X23105-site 10 ank p.13	7.790	28.25	19.63	0.910	43.42	100.00
X23105-site 10 ank p.14	5.070	28.09	23.65	0.740	42.45	100.00
X23105-site 10 ank p.15	8.400	28.48	18.57	1.070	43.48	100.00
X23105-site 18 ank p.1	5.330	28.28	22.66	1.050	42.68	100.00
X23105-site 18 ank p.2	5.440	28.09	22.68	1.000	42.78	100.00
X23105-site 18 ank p.3	5.250	27.98	23.19	0.960	42.61	100.00
X23105-site 18 ank p.4	5.360	28.15	23.26	0.980	42.26	100.00
X23105-site 18 ank p.5	5.940	27.90	21.97	1.000	43.20	100.00
X23105-site 18 ank p.6	6.210	27.61	22.18	0.950	43.05	100.00
X23105-site 18 ank p.7	6.000	27.78	22.22	0.990	43.01	100.00
X23105-site 18 ank p.8	5.630	27.96	22.53	1.000	42.87	100.00
X23105-site 18 ank p.9	5.550	28.00	23.01	1.020	42.42	100.00
X23105-site 18 ank p.10	5.340	28.09	23.20	1.020	42.36	100.00
X23105-site 18 ank p.11	5.360	28.05	23.29	1.000	42.31	100.00
X23105-site 18 ank p.12	4.620	27.73	24.45	1.050	42.15	100.00
X23105-site 18 ank p.16	5.240	27.64	23.26	0.920	42.94	100.00
X23105-site 18 ank p.17	5.660	27.89	22.12	0.990	43.33	100.00
X23105-site 18 ank p.18	5.890	27.69	22.44	0.930	43.05	100.00
X23105-site 18 ank p.19	5.800	28.20	22.41	1.000	42.59	100.00
X23105-site 18 ank p.20	5.070	27.77	23.69	0.960	42.51	100.00
X23105-site 18 ank p.21	5.980	27.98	22.07	1.040	42.93	100.00
X23105-site 18 ank p.22	5.900	28.01	22.25	0.970	42.86	100.00
X23105-site 1 ank p.1	6.110	27.93	22.46	0.980	42.53	100.00
X23105-site 1 ank p.2	5.690	27.98	22.76	0.930	42.64	100.00
X23105-site 1 ank p.3	6.430	28.12	21.93	0.960	42.56	100.00
X23105-site 1 ank p.4	6.490	27.99	22.04	0.980	42.50	100.00
X23105-site 1 ank p.5	6.980	28.10	21.10	1.020	42.80	100.00
X23105-site 1 ank p.6	5.880	27.95	22.57	0.950	42.65	100.00
X23105-site 1 ank p.7	6.360	27.99	21.94	0.950	42.77	100.00
X23105-site 1 ank p.8	6.400	28.05	21.87	0.980	42.69	100.00
X23105-site 1 ank p.9	6.110	27.96	22.52	0.920	42.49	100.00
X23105-site 1 ank p.10	5.520	28.15	23.04	1.030	42.26	100.00
X23105-site 1 ank p.11	7.050	28.35	20.67	1.040	42.90	100.00
X23105-site 1 ank p.12	5.830	28.16	22.60	1.040	42.37	100.00
X23105-site 1 ank p.13	6.520	28.03	21.76	1.000	42.70	100.00
X23105-site 1 ank p.14	6.460	28.07	21.91	0.930	42.63	100.00
X23105-site 1 ank p.15	6.660	27.89	21.59	0.910	42.95	100.00
X23105-site 1 ank p.16	6.030	27.93	22.37	0.930	42.74	100.00
X23105-site 1 ank p.17	5.510	27.55	23.15	0.930	42.86	100.00
X23105-site 1 ank p.18	5.250	27.76	23.27	0.930	42.79	100.00
X23105-site 1 ank p.19	5.350	27.98	23.42	0.920	42.33	100.00
X23105-site 1 ank p.20	5.760	28.28	22.49	0.970	42.49	100.00
X27820-site 2 ank p.1	7.810	28.68	19.08	0.760	43.66	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X27820-site 2 ank p.2	5.690	28.44	21.90	1.050	42.92	100.00
X27820-site 2 ank p.3	6.380	28.74	20.70	1.240	42.94	100.00
X27820-site 2 ank p.4	7.570	29.04	18.85	0.960	43.58	100.00
X27820-site 2 ank p.8	4.950	28.20	23.79	0.620	42.45	100.00
X27820-site 2 ank p.9	5.390	28.32	22.59	0.900	42.79	100.00
X27820-site 2 ank p.10	5.050	28.37	22.77	0.960	42.84	100.00
X27820-site 2 ank p.11	4.940	28.15	22.97	0.930	43.01	100.00
X27820-site 2 ank p.12	4.530	27.79	23.84	0.900	42.94	100.00
X27820-site 2 ank p.13	5.160	28.71	22.60	0.980	42.55	100.00
X27820-site 2 ank p.14	5.060	28.50	22.97	0.950	42.53	100.00
X27820-site 2 ank p.15	5.480	28.55	22.13	0.980	42.85	100.00
X27820-site 2 ank p.16	7.790	28.30	19.00	0.920	43.99	100.00
X27820-site 2 ank p.17	7.870	28.76	18.83	0.820	43.72	100.00
X27820-site 2 ank p.18	5.380	28.66	22.25	0.930	42.78	100.00
X27820-site 2 ank p.19	5.200	28.39	22.85	0.940	42.61	100.00
X27820-site 2 ank p.20	8.640	29.20	17.46	0.820	43.89	100.00
X27820-site 2 ank p.21	6.970	28.61	20.30	0.880	43.24	100.00
X27820-site 2 ank p.22	9.800	28.82	15.64	1.090	44.64	100.00
X27820-site 2 ank p.23	8.380	28.64	17.93	1.090	43.97	100.00
X27820-site 16 ank p.1	4.770	27.82	23.71	0.890	42.80	100.00
X27820-site 16 ank p.2	5.040	28.64	22.34	0.950	43.03	100.00
X27820-site 16 ank p.3	5.470	28.25	22.06	0.940	43.27	100.00
X27820-site 16 ank p.4	4.830	28.12	23.34	0.890	42.82	100.00
X27820-site 16 ank p.5	5.010	28.02	22.94	0.870	43.16	100.00
X27820-site 16 ank p.6	4.590	28.10	23.45	0.840	43.02	100.00
X27820-site 16 ank p.7	5.400	27.81	22.57	0.820	43.41	100.00
X27820-site 16 ank p.8	6.690	29.15	19.67	0.770	43.72	100.00
X27820-site 16 ank p.9	7.450	28.87	18.29	1.820	43.57	100.00
X27820-site 16 ank p.10	7.190	28.93	18.48	1.650	43.76	100.00
X27820-site 16 ank p.11	7.830	28.74	18.78	0.850	43.79	100.00
X27820-site 16 ank p.12	6.980	28.51	19.41	1.470	43.63	100.00
X27820-site 16 ank p.13	7.610	29.00	18.33	1.450	43.61	100.00
X27820-site 16 ank p.14	7.240	28.88	18.64	1.650	43.60	100.00
X27820-site 16 ank p.15	4.390	28.09	24.20	0.820	42.50	100.00
X27820-site 19 ank p.4	5.670	28.33	22.43	0.880	42.70	100.00
X27820-site 19 ank p.5	4.460	28.31	24.05	0.930	42.25	100.00
X27820-site 19 ank p.6	5.200	28.49	22.55	0.940	42.82	100.00
X27820-site 19 ank p.7	5.110	28.32	22.98	0.960	42.63	100.00
X27820-site 19 ank p.8	4.560	28.09	23.63	0.820	42.91	100.00
X27820-site 19 ank p.9	5.240	28.66	22.12	0.770	43.21	100.00
X27820-site 19 ank p.10	4.710	28.01	23.53	0.850	42.90	100.00
X27820-site 19 ank p.11	4.880	28.53	23.01	0.800	42.78	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X27820-site 19 ank p.12	4.890	28.08	23.04	0.940	43.05	100.00
X27820-site 19 ank p.13	5.160	27.61	22.64	0.860	43.72	100.00
X27820-site 19 ank p.14	5.150	27.92	23.24	0.830	42.86	100.00
X27820-site 19 ank p.15	4.950	27.78	23.80	0.860	42.61	100.00
X27820-site 19 ank p.16	4.980	27.83	22.97	0.910	43.30	100.00
X27820-site 19 ank p.17	5.490	27.88	22.42	0.880	43.33	100.00
X27820-site 19 ank p.18	4.990	28.00	23.00	0.850	43.16	100.00
X27820-site 19 ank p.19	4.700	28.49	22.99	0.910	42.91	100.00
X27820-site 19 ank p.20	4.630	28.44	23.31	0.900	42.72	100.00
X27820-site 19 ank p.21	5.880	28.48	21.77	0.930	42.93	100.00
X27820-site 19 ank p.22	4.900	28.10	23.00	0.870	43.13	100.00
X27820-site 19 ank p.23	4.890	28.16	22.68	0.900	43.38	100.00
X27820-site 19 ank p.24	4.980	27.95	23.11	0.850	43.11	100.00
X27820-site 19 ank p.25	5.000	28.12	23.24	0.860	42.78	100.00
X27820-site 19 ank p.26	4.280	27.95	24.52	0.940	42.31	100.00
X27820-site 19 ank p.27	4.930	28.06	23.21	0.850	42.94	100.00
X27820-site 19 ank p.28	4.730	28.24	23.68	0.880	42.48	100.00
X27820-site 19 ank p.29	4.640	28.06	24.00	0.800	42.50	100.00
X27820-site 19 ank p.30	4.640	28.26	23.85	0.810	42.45	100.00
X27820-site 19 ank p.31	4.580	28.26	23.69	1.020	42.45	100.00
X27820-site 19 ank p.32	5.110	28.05	23.49	0.890	42.45	100.00
X27820-site 19 ank p.33	5.610	28.52	22.31	0.930	42.63	100.00
X102074-site 3 ank p.1	5.340	27.76	22.48	1.650	42.77	100.00
X102074-site 3 ank p.5	6.410	28.37	18.08	3.250	43.89	100.00
X102074-site 3 ank p.6	6.100	28.11	20.52	1.910	43.37	100.00
X102074-site 3 ank p.7	6.640	28.39	18.81	2.660	43.51	100.00
X102074-site 3 ank p.8	7.260	27.89	19.92	1.300	43.63	100.00
X102074-site 3 ank p.9	5.710	28.05	22.39	1.020	42.82	100.00
X102074-site 3 ank p.10	6.070	28.43	20.32	2.090	43.09	100.00
X102074-site 3 ank p.11	6.010	28.15	19.84	2.570	43.44	100.00
X102074-site 3 ank p.12	6.800	28.31	18.56	2.510	43.81	100.00
X102074-site 3 ank p.13	6.110	28.54	19.55	2.580	43.23	100.00
X102074-site 3 ank p.14	6.590	28.34	18.66	2.700	43.71	100.00
X102074-site 3 ank p.15	5.670	27.70	21.80	1.040	43.79	100.00
X102074-site 3 ank p.16	5.600	27.74	22.21	1.320	43.13	100.00
X102074-site 3 ank p.17	5.800	27.84	21.84	1.160	43.37	100.00
X102074-site 3 ank p.18	5.650	27.95	21.87	1.000	43.53	100.00
X102074-site 3 ank p.19	6.170	27.89	20.90	1.140	43.90	100.00
X102074-site 3 ank p.20	6.550	28.10	19.87	1.520	43.96	100.00
X102074-site 3 ank p.21	7.000	27.98	18.51	2.340	44.16	100.00
X102074-site 3 ank p.22	6.530	28.47	18.85	2.720	43.43	100.00
X102074-site 3 ank p.23	6.280	28.37	19.40	2.630	43.32	100.00
X102074-site 3 ank p.24	5.880	27.72	22.21	0.920	43.27	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102074-site 3 ank p.25	4.900	27.95	23.44	0.930	42.78	100.00
X102074-site 3 ank p.26	5.260	28.21	22.16	1.560	42.82	100.00
X102074-site 3 ank p.27	6.200	28.13	21.50	1.130	43.04	100.00
X102074-site 3 ank p.28	6.130	28.14	21.37	1.040	43.33	100.00
X102074-site 3 ank p.29	5.710	27.52	22.01	1.230	43.53	100.00
X102074-site 3 ank p.30	6.110	28.01	21.57	1.120	43.18	100.00
X102074-site 2 ank p.1	4.720	27.78	23.22	1.330	42.95	100.00
X102074-site 2 ank p.2	4.490	28.07	23.40	1.370	42.67	100.00
X102074-site 2 ank p.3	4.710	27.96	23.07	1.340	42.93	100.00
X102074-site 2 ank p.4	4.700	27.69	23.46	1.280	42.87	100.00
X102074-site 2 ank p.5	5.030	28.21	22.64	1.300	42.82	100.00
X102074-site 2 ank p.9	4.350	27.83	23.93	1.420	42.46	100.00
X102074-site 2 ank p.10	5.650	28.38	21.80	1.210	42.96	100.00
X102074-site 2 ank p.11	4.340	27.59	24.62	1.090	42.35	100.00
X102074-site 2 ank p.12	4.360	28.03	23.63	1.350	42.62	100.00
X102074-site 2 ank p.13	4.980	27.99	22.73	1.280	43.02	100.00
X102074-site 2 ank p.14	4.670	27.93	23.62	1.110	42.67	100.00
X102074-site 2 ank p.15	3.170	27.76	25.31	1.380	42.39	100.00
X102074-site 2 ank p.16	4.800	28.15	22.85	1.300	42.89	100.00
X102074-site 2 ank p.17	3.500	27.70	25.38	0.950	42.47	100.00
X102074-site 2 ank p.18	4.640	27.79	24.03	1.130	42.40	100.00
X102074-site 2 ank p.19	5.040	27.72	22.93	1.130	43.19	100.00
X102074-site 2 ank p.20	4.610	27.85	23.48	1.340	42.72	100.00
X102074-site 2 ank p.21	4.480	27.72	23.66	1.320	42.81	100.00
X102074-site 2 ank p.22	5.720	28.36	21.72	1.390	42.81	100.00
X102074-site 2 ank p.23	5.040	27.69	23.51	1.250	42.51	100.00
X102074-site 2 ank p.24	3.930	27.93	24.10	1.710	42.34	100.00
X102074-site 2 ank p.25	3.930	27.89	24.32	1.560	42.30	100.00
X102074-site 2 ank p.26	3.460	27.74	25.27	0.980	42.55	100.00
X102074-site 2 ank p.27	5.370	28.07	22.52	1.260	42.78	100.00
X102074-site 2 ank p.28	5.130	27.82	22.88	1.200	42.97	100.00
X102074-site 2 ank p.29	4.160	28.01	24.51	1.080	42.24	100.00
X102074-site 2 ank p.30	4.370	27.91	24.15	1.130	42.44	100.00
X102074-site 2 ank p.31	4.460	27.96	23.81	1.170	42.60	100.00
X102074-site 2 ank p.32	4.350	28.12	23.49	1.500	42.54	100.00
X102074-site 2 ank p.33	4.250	28.21	23.53	1.430	42.58	100.00
X102074-site 2 ank p.34	5.570	28.61	21.63	1.180	43.01	100.00
X102074-site 2 ank p.35	4.760	27.89	23.69	0.920	42.74	100.00
X102074-site 2 ank p.36	5.750	28.26	21.99	0.940	43.06	100.00
X102074-site 7 ank p.1	6.770	28.24	19.96	1.600	43.43	100.00
X102074-site 7 ank p.2	5.660	28.03	22.49	1.070	42.76	100.00
X102074-site 7 ank p.3	5.450	28.49	21.57	1.630	42.86	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102074-site 7 ank p.7	4.700	27.85	23.82	0.920	42.71	100.00
X102074-site 7 ank p.8	5.240	28.03	22.51	1.200	43.02	100.00
X102074-site 7 ank p.9	6.650	28.17	20.92	1.130	43.13	100.00
X102074-site 7 ank p.10	5.780	28.33	21.70	1.070	43.12	100.00
X102074-site 7 ank p.11	5.490	27.68	22.48	1.360	42.99	100.00
X102074-site 7 ank p.12	4.830	27.50	23.15	1.560	42.96	100.00
X102074-site 7 ank p.13	5.260	27.84	22.70	1.490	42.71	100.00
X102074-site 7 ank p.14	5.270	27.72	22.57	1.480	42.96	100.00
X102074-site 7 ank p.15	5.320	28.18	22.19	1.300	43.00	100.00
X102074-site 7 ank p.16	5.630	28.24	22.01	1.070	43.04	100.00
X102074-site 7 ank p.17	5.750	28.22	22.13	1.090	42.82	100.00
X102074-site 7 ank p.18	4.920	27.90	23.47	0.970	42.75	100.00
X102074-site 7 ank p.19	4.990	27.95	23.15	1.250	42.67	100.00
X102074-site 7 ank p.20	4.770	28.58	22.51	1.700	42.43	100.00
X102074-site 7 ank p.21	5.200	27.66	22.78	1.420	42.94	100.00
X102074-site 7 ank p.22	5.800	28.39	21.74	1.220	42.85	100.00
X102074-site 7 ank p.23	6.000	28.40	21.68	1.180	42.73	100.00
X102074-site 7 ank p.24	5.400	27.75	22.92	1.400	42.53	100.00
X102074-site 8 ank p.1	5.390	28.28	21.14	2.120	43.07	100.00
X102074-site 8 ank p.2	5.530	28.11	21.37	1.980	43.01	100.00
X102074-site 8 ank p.3	8.450	28.34	17.49	2.050	43.66	100.00
X102074-site 8 ank p.4	5.890	28.06	22.07	1.090	42.90	100.00
X102074-site 8 ank p.5	5.370	28.54	21.03	2.210	42.86	100.00
X102074-site 8 ank p.6	5.830	28.70	20.30	2.140	43.03	100.00
X102074-site 8 ank p.7	4.800	28.57	21.77	2.280	42.59	100.00
X102074-site 8 ank p.8	5.830	28.47	20.65	2.020	43.02	100.00
X102074-site 8 ank p.9	6.410	28.46	20.59	1.340	43.19	100.00
X102074-site 8 ank p.10	7.360	28.22	19.29	1.840	43.29	100.00
X102074-site 8 ank p.11	6.460	28.15	20.11	1.900	43.38	100.00
X102074-site 8 ank p.12	5.780	27.91	21.83	1.250	43.24	100.00
X102074-site 8 ank p.13	3.650	28.07	24.13	1.990	42.17	100.00
X102074-site 15 ank p.2	5.740	28.46	20.92	1.650	43.24	100.00
X102074-site 15 ank p.3	5.560	27.62	22.61	1.220	42.98	100.00
X102074-site 15 ank p.4	5.350	28.00	21.47	1.670	43.51	100.00
X102074-site 15 ank p.5	6.200	28.31	21.08	1.390	43.02	100.00
X102074-site 15 ank p.6	4.820	27.74	24.12	0.670	42.64	100.00
X102074-site 15 ank p.7	4.850	27.81	23.68	0.890	42.77	100.00
X102074-site 15 ank p.8	5.790	27.87	22.23	1.200	42.90	100.00
X102074-site 15 ank p.9	6.050	27.79	21.95	1.190	43.03	100.00
X102074-site 15 ank p.10	5.850	27.85	22.73	0.780	42.79	100.00
X102074-site 15 ank p.11	6.050	27.79	22.48	0.740	42.94	100.00
X102074-site 15 ank p.12	4.990	27.83	24.14	0.600	42.45	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102074-site 15 ank p.13	4.730	27.94	24.29	0.660	42.38	100.00
X102074-site 15 ank p.14	5.630	27.85	22.95	0.810	42.76	100.00
X102074-site 15 ank p.15	4.730	27.86	23.99	0.620	42.79	100.00
X102074-site 15 ank p.16	5.210	27.71	23.51	0.900	42.66	100.00
X102074-site 15 ank p.17	6.280	28.06	21.13	1.230	43.31	100.00
X102074-site 15 ank p.18	4.460	27.81	24.51	0.580	42.63	100.00
X102074-site 15 ank p.19	5.700	27.95	22.28	1.120	42.95	100.00
X102074-site 15 ank p.20	6.000	28.92	20.52	1.680	42.87	100.00
X102074-site 15 ank p.21	4.630	28.35	22.50	1.860	42.66	100.00
X102074-site 15 ank p.22	6.010	28.04	22.20	0.930	42.83	100.00
X102074-site 15 ank p.23	5.570	27.98	22.45	1.120	42.87	100.00
X102074-site 15 ank p.24	5.780	27.97	22.08	1.140	43.02	100.00
X102074-site 15 ank p.25	4.800	28.10	23.25	1.440	42.40	100.00
X102074-site 15 ank p.26	5.030	27.72	23.46	0.800	42.98	100.00
X102074-site 15 ank p.27	5.760	28.03	22.26	1.080	42.87	100.00
X102074-site 15 ank p.28	5.310	27.71	22.93	1.280	42.77	100.00
X102074-site 15 ank p.29	5.660	28.03	22.47	1.220	42.62	100.00
X102074-site 15 ank p.30	6.860	28.01	20.25	1.340	43.55	100.00
X102066-site 11 ank p.1	6.690	27.82	21.23	1.100	43.16	100.00
X102066-site 11 ank p.2	6.670	27.94	20.83	1.070	43.49	100.00
X102066-site 11 ank p.6	6.670	27.90	21.04	1.110	43.28	100.00
X102066-site 11 ank p.7	6.870	28.03	20.70	1.110	43.29	100.00
X102066-site 11 ank p.8	6.590	27.87	21.16	1.090	43.29	100.00
X102066-site 11 ank p.9	7.340	27.97	20.12	1.130	43.45	100.00
X102066-site 11 ank p.10	6.570	27.95	21.05	1.080	43.35	100.00
X102066-site 11 ank p.11	6.590	28.05	20.91	1.110	43.33	100.00
X102066-site 11 ank p.12	6.660	27.92	21.13	1.060	43.23	100.00
X102066-site 11 ank p.13	6.430	27.69	20.95	1.090	43.83	100.00
X102066-site 11 ank p.14	6.720	27.74	20.89	1.050	43.61	100.00
X102066-site 11 ank p.15	6.570	27.66	20.87	1.040	43.85	100.00
X102066-site 11 ank p.16	6.440	27.97	21.43	1.190	42.97	100.00
X102066-site 11 ank p.17	6.520	28.03	21.20	1.140	43.12	100.00
X102066-site 11 ank p.18	6.340	28.07	21.39	1.170	43.04	100.00
X102066-site 11 ank p.19	6.690	27.96	20.49	1.040	43.82	100.00
X102066-site 11 ank p.20	6.710	27.87	20.84	1.070	43.51	100.00
X102066-site 11 ank p.21	6.390	28.07	21.19	1.150	43.20	100.00
X102066-site 11 ank p.22	6.940	28.15	20.20	1.130	43.58	100.00
X102066-site 11 ank p.23	6.220	27.91	21.46	1.140	43.27	100.00
X102066-site 11 ank p.24	6.590	27.99	21.20	1.070	43.14	100.00
X102066-site 11 ank p.25	6.470	28.02	20.94	1.120	43.45	100.00
X102066-site 11 ank p.26	6.560	27.97	21.13	1.090	43.25	100.00
X102066-site 15 ank p.1	7.460	28.29	19.72	1.080	43.45	100.00

Element/Oxide	MgO	CaO	FeO	MnO	CO2	Total
Unit	wt%	wt%	wt%	wt%	wt%	wt%
Sample						
X102066-site 15 ank p.2	7.380	28.32	19.83	1.120	43.35	100.00
X102066-site 15 ank p.3	7.500	28.29	19.86	1.110	43.23	100.00
X102066-site 15 ank p.4	7.410	28.30	19.77	1.100	43.42	100.00
X102066-site 15 ank p.5	7.460	28.32	19.66	1.090	43.47	100.00
X102066-site 15 ank p.6	7.320	28.27	19.89	1.080	43.44	100.00
X102066-site 15 ank p.7	7.320	28.41	19.69	1.080	43.50	100.00
X102066-site 15 ank p.8	7.420	28.29	19.75	1.080	43.47	100.00
X102066-site 15 ank p.9	7.290	28.25	20.05	1.080	43.33	100.00
X102066-site 15 ank p.10	7.370	28.38	19.86	1.040	43.34	100.00
X102066-site 15 ank p.14	7.550	28.16	19.74	1.030	43.52	100.00
X102066-site 15 ank p.15	7.460	28.11	19.82	1.060	43.55	100.00
X102066-site 15 ank p.16	7.350	28.26	19.83	1.090	43.48	100.00
X102066-site 15 ank p.17	7.430	28.27	19.71	1.060	43.53	100.00
X102066-site 15 ank p.18	7.240	28.29	19.86	1.070	43.54	100.00
X102066-site 16 ank p.1	10.16	28.30	15.40	1.420	44.73	100.00
X102066-site 16 ank p.2	8.390	28.08	18.18	1.090	44.25	100.00
X102066-site 16 ank p.3	8.620	28.30	17.85	1.180	44.06	100.00
X102066-site 16 ank p.4	7.890	28.19	18.96	1.000	43.96	100.00
X102066-site 16 ank p.5	10.50	28.40	15.03	1.380	44.69	100.00
X102066-site 16 ank p.6	9.280	28.27	16.69	1.270	44.49	100.00
X102066-site 16 ank p.7	7.940	28.22	18.93	1.060	43.84	100.00
X102066-site 16 ank p.8	8.470	28.03	18.22	1.140	44.14	100.00
X102066-site 16 ank p.9	8.000	28.18	18.90	1.030	43.89	100.00
X102066-site 16 ank p.10	8.700	28.18	17.99	1.140	43.99	100.00
X102066-site 16 ank p.11	10.11	28.45	15.37	1.370	44.71	100.00
X102066-site 16 ank p.12	10.22	28.56	15.22	1.450	44.55	100.00
X102066-site 16 ank p.13	7.240	28.12	19.94	1.030	43.67	100.00
X102066-site 16 ank p.14	7.330	28.32	19.68	1.120	43.55	100.00
X102066-site 16 ank p.15	7.270	28.18	19.86	1.090	43.60	100.00
X102066-site 16 ank p.16	6.890	28.09	20.52	1.070	43.43	100.00
X102066-site 16 ank p.17	7.770	28.19	19.34	1.020	43.69	100.00
X102066-site 16 ank p.18	10.45	28.58	14.95	1.410	44.61	100.00
X102066-site 16 ank p.19	10.47	28.42	15.16	1.350	44.60	100.00
X102066-site 16 ank p.20	10.22	28.53	15.44	1.370	44.43	100.00
X102066-site 16 ank p.21	10.08	28.57	15.51	1.340	44.51	100.00
X102066-site 16 ank p.22	9.320	28.25	16.96	1.210	44.26	100.00
X102066-site 16 ank p.23	8.800	28.29	17.81	1.150	43.95	100.00
X102066-site 16 ank p.24	8.300	28.14	18.65	1.090	43.83	100.00
X102066-site 16 ank p.25	8.810	28.29	17.72	1.250	43.93	100.00
X102066-site 16 ank p.26	8.910	28.35	17.56	1.160	44.01	100.00
X102066-site 16 ank p.30	6.990	28.08	20.46	1.070	43.40	100.00
X102066-site 16 ank p.31	6.130	28.14	22.04	0.730	42.96	100.00
X102066-site 17 ank p.1	7.220	28.29	20.27	0.800	43.40	100.00

Element/Oxide Unit	MgO wt%	CaO wt%	FeO wt%	MnO wt%	CO2 wt%	Total wt%
Sample						
X102066-site 17 ank p.2	8.400	28.41	18.13	1.220	43.85	100.00
X102066-site 17 ank p.3	8.440	28.31	18.30	1.190	43.77	100.00
X102066-site 17 ank p.4	9.050	28.48	17.22	1.280	43.96	100.00
X102066-site 17 ank p.5	8.350	28.30	18.45	1.230	43.67	100.00
X102066-site 17 ank p.6	8.260	28.21	18.37	1.200	43.96	100.00
X102066-site 17 ank p.7	5.850	28.38	21.67	0.890	43.22	100.00
X102066-site 17 ank p.8	6.070	27.97	22.29	0.770	42.89	100.00
X102066-site 17 ank p.9	6.040	28.01	22.25	0.730	42.96	100.00
X102066-site 17 ank p.10	6.180	28.16	21.98	0.780	42.91	100.00
X102066-site 17 ank p.11	6.000	27.99	22.17	0.790	43.06	100.00
X102066-site 17 ank p.12	6.090	28.17	22.13	0.800	42.80	100.00
X102066-site 17 ank p.13	6.030	28.02	22.14	0.800	43.02	100.00
X102066-site 17 ank p.14	6.130	28.05	22.02	0.770	43.03	100.00
X102066-site 17 ank p.15	7.280	28.28	19.76	1.070	43.60	100.00
X102066-site 18 ank p.1	7.440	28.32	19.54	1.090	43.62	100.00
X102066-site 18 ank p.2	7.400	28.17	19.69	1.110	43.63	100.00
X102066-site 18 ank p.3	7.450	28.20	19.67	1.070	43.61	100.00
X102066-site 18 ank p.4	7.320	28.58	19.99	1.080	43.03	100.00
X102066-site 18 ank p.5	7.420	28.31	19.69	1.080	43.50	100.00
X102066-site 18 ank p.6	7.660	28.03	19.68	1.030	43.60	100.00
X102066-site 18 ank p.7	7.540	28.05	19.76	1.090	43.56	100.00
X102066-site 18 ank p.8	7.400	28.17	19.90	1.020	43.50	100.00
X102066-site 18 ank p.9	7.380	28.28	19.67	1.050	43.62	100.00
X102066-site 18 ank p.10	7.310	28.15	19.79	1.080	43.67	100.00
X102066-site 18 ank p.11	7.440	28.18	19.67	1.080	43.63	100.00
X102066-site 18 ank p.12	7.520	28.17	19.56	1.020	43.73	100.00
X102066-site 18 ank p.13	7.400	28.17	19.81	1.080	43.54	100.00
X102066-site 18 ank p.14	7.400	28.11	19.77	1.060	43.67	100.00
X102066-site 18 ank p.18	5.850	28.12	22.37	0.650	43.02	100.00
X102066-site 18 ank p.19	6.010	28.19	21.97	0.780	43.05	100.00
X102066-site 18 ank p.20	7.150	28.02	20.15	1.140	43.55	100.00
X102066-site 18 ank p.21	6.750	27.96	20.86	1.070	43.36	100.00

Electron microprobe analyses of muscovite

Element/Oxide	SiO2	MgO	Al2O3	K2O	CaO	FeO	MnO	Total
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
Sample								
X102073 site 6 ms p.2	47.16979	1.621794	29.60032	10.55355	0.008325	3.980389	0	92.93417
X102073 site 6 ms p.3	47.24253	1.474207	30.81714	10.64028	0.008465	3.122302	0	93.30492
X102073 site 6 ms p.4	46.86601	1.392952	30.42035	10.51621	0	3.521113	0	92.71663
X102073 site 6 ms p.5	47.50352	1.462599	30.93806	10.62944	0	2.865005	0	93.39863
X102073 site 6 ms p.6	46.95586	1.450991	30.73967	10.6439	0.008395	3.351297	0	93.15011
X102073 site 6 ms p.7	46.85531	1.512348	30.30887	10.68967	0	3.674205	0.019175	93.05958
X102073 site 6 ms p.8	47.98487	1.558779	30.33532	10.2271	0.008185	3.377027	0.019175	93.51046
X102073 site 6 ms p.9	48.3892	1.497423	31.08544	10.17892	0.008465	2.655308	0.018787	93.83354
X102073 site 6 ms p.10	47.46074	1.499081	29.67212	10.57524	0	3.087567	0	92.29474
X102073 site 6 ms p.11	48.24159	1.648326	30.29753	10.05364	0.008395	3.082421	0.018465	93.35037
X102073 site 6 ms p.12	45.98675	0.553864	35.11188	10.50898	0	1.45373	0.019175	93.63438
X102073 site 6 ms p.13	47.7089	1.509031	30.17283	10.53789	0	3.25481	0.018981	93.20244
X102073 site 6 ms p.14	47.69178	1.441042	30.44869	10.54994	0	3.063124	0.0184	93.21298
X102073 site 6 ms p.15	47.5784	1.563754	30.22384	10.41502	0	3.104292	0.018529	92.90384
X102073 site 6 ms p.16	45.05829	0.252058	36.33059	10.54271	0.008465	1.35853	0	93.55064
X102073 site 6 ms p.17	48.05119	1.666567	30.70944	10.37888	0	2.906173	0.018916	93.73117
X102073 site 6 ms p.18	47.10347	1.606869	30.31265	10.25963	0	3.779697	0	93.06232
X102073 site 6 ms p.19	47.49925	1.455966	30.69432	10.36202	0	3.108151	0.018723	93.13843
X102073 site 6 ms p.20	48.15388	1.732898	29.24321	10.1994	0.008325	3.61374	0.018594	92.97005
X102073 site 6 ms p.21	46.528	0.641753	34.93616	10.14037	0	1.693016	0.018206	93.95751
X102073 site 7 ms p.1	45.92685	0.72135	33.77981	9.965705	0.008325	2.226908	0	92.62895
X102073 site 7 ms p.2	45.94824	0.527332	34.54694	10.28252	0.008185	1.806227	0.018723	93.13816
X102073 site 7 ms p.3	47.38158	1.49079	30.58851	10.58608	0.008325	3.324281	0	93.37957
X102073 site 7 ms p.4	46.96442	1.530589	29.94987	10.54512	0	3.684497	0.019046	92.69354
X102073 site 7 ms p.5	47.26178	1.518981	30.00845	10.48128	0	3.406616	0.0184	92.6955
X102073 site 7 ms p.6	46.19854	1.001599	32.46097	10.57524	0.008185	2.738929	0.018206	93.00166
X102073 site 7 ms p.7	47.12914	1.40456	31.15724	10.35961	0.008255	3.145459	0	93.20427
X102073 site 7 ms p.8	46.04665	0.563814	33.87995	9.895838	0.008045	1.915578	0.017754	92.32763
X102073 site 7 ms p.9	47.61477	1.505714	30.24841	10.07171	0.008185	3.172475	0.018271	92.63953
X102073 site 7 ms p.10	47.20616	1.389635	30.76801	10.28131	0.008185	3.441351	0.018787	93.11344
X102073 site 7 ms p.12	46.86173	1.49079	30.39201	10.21144	0.008395	3.684497	0.018916	92.66778
X102073 site 7 ms p.13	45.33212	0.437785	35.42742	10.25481	0.008325	1.573373	0.018981	93.05282
X102073 site 7 ms p.14	47.40298	1.555463	29.63244	10.47646	0.008395	3.56614	0.018529	92.6604
X102073 site 7 ms p.15	45.32784	0.235475	36.49875	10.11869	0.008255	1.102519	0.0184	93.30993
X102073 site 7 ms p.16	46.70556	1.381344	30.67921	10.1223	0	3.658767	0.018335	92.56551
X102073 site 7 ms p.17	46.91307	1.376369	30.84359	10.53428	0	3.166043	0.018723	92.85208
X102073 site 8 ms p.1	47.04571	1.303405	31.36697	10.60535	0.008395	2.908746	0	93.23858
X102073 site 8 ms p.2	47.04999	1.507373	30.15393	10.5138	0.008605	3.775837	0.018658	93.0282
X102073 site 8 ms p.3	46.90452	1.449333	30.42602	10.47525	0.008045	3.413048	0.018852	92.69506
X102073 site 8 ms p.4	47.24039	1.366419	31.32351	10.462	0.008185	2.944767	0.017883	93.36316
X102073 site 8 ms p.5	47.13984	1.640035	30.12559	10.45357	0	3.793848	0	93.15289
X102073 site 8 ms p.6	46.8275	1.543855	30.33154	10.56198	0	3.747535	0.018787	93.03121
X102073 site 8 ms p.7	48.21378	1.814154	29.28667	10.06207	0.008255	3.44907	0	92.834
X102073 site 8 ms p.8	48.27154	1.877168	28.71983	10.15362	0.008185	3.629178	0.018206	92.67773
X102073 site 8 ms p.9	46.81466	1.621794	30.56773	10.32468	0.008045	3.939221	0.018142	93.29427

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X102073 site 8 ms p.10	47.83298	1.852294	28.60458	10.39575	0.008325	4.107751	0.019562	92.82124
X102073 site 8 ms p.11	47.43721	1.727923	29.16575	10.51139	0.008465	4.011264	0.019175	92.88117
X102073 site 8 ms p.12	47.7581	1.790938	29.26589	10.3054	0	3.567427	0.018787	92.70655
X102073 site 8 ms p.13	47.90144	1.600236	29.61355	10.47164	0	3.35001	0.018594	92.95547
X102073 site 8 ms p.14	46.73337	1.691441	29.68346	10.54151	0.008465	3.82987	0.019691	92.5078
X102073 site 8 ms p.15	47.59124	1.465916	30.68676	10.5656	0	2.912605	0.018594	93.24071
X102073 site 8 ms p.16	46.65208	0.989991	32.42507	10.58728	0.008605	2.318248	0	92.98127
X102073 site 8 ms p.17	47.61905	1.303405	31.24793	10.31384	0.008325	2.745362	0.018077	93.25599
X102073 site 8 ms p.18	47.13556	1.344862	30.59985	10.57403	0.008815	3.535265	0	93.19838
X102073 site 8 ms p.19	47.58482	1.454308	30.40334	10.26806	0.008535	3.332	0	93.05107
X102073 site 8 ms p.20	49.05025	2.013147	28.16433	10.18976	0.008465	3.57	0	92.99595
X102073 site 8 ms p.21	47.83512	1.38466	31.46333	10.24999	0.008185	2.674605	0.01769	93.63358
X102073 site 8 ms p.22	48.35711	1.761089	29.25455	10.34756	0.008325	3.476086	0.018465	93.22319
X102073 site 8 ms p.23	47.47571	1.527272	30.49782	10.63426	0	3.051546	0.018658	93.20527
X102073 site 8 ms p.24	47.0778	1.703049	29.22432	10.51139	0	4.182367	0	92.69893
X102073 site 8 ms p.25	47.61263	1.495765	30.61496	10.39816	0.008045	3.135167	0.018594	93.28332
X102073 site 8 ms p.26	47.7089	1.318329	31.48601	9.881382	0.008535	2.70934	0.019368	93.13186
X102073 site 8 ms p.27	48.08328	1.469232	31.82989	7.697432	0.008185	3.936648	0.018594	93.04326
X102060-site 12 ms p.1	45.95252	0.912052	31.91302	10.60053	0.008255	3.550702	0.018335	92.95542
X102060-site 12 ms p.2	46.3162	0.945217	31.91302	10.70895	0.013992	3.550702	0.0184	93.46649
X102060-site 12 ms p.3	45.6958	0.77939	32.72549	10.62462	0.027984	3.229081	0	93.08237
X102060-site 12 ms p.4	45.78137	0.77939	32.80107	10.63667	0.027984	3.319135	0	93.34562
X102060-site 12 ms p.5	44.34803	0.563814	34.87948	10.15483	1.133341	2.778811	0.038737	93.89704
X102060-site 12 ms p.6	45.46048	0.696476	32.81997	10.70895	0.013992	3.074702	0.017754	92.79231
X102060-site 12 ms p.7	44.455	0.646728	33.61354	10.74508	0.013992	3.100432	0	92.57478
X102060-site 12 ms p.8	45.26794	0.795972	31.79966	10.41984	0.055967	3.717946	0	92.05732
X102060-site 12 ms p.9	46.10227	0.696476	32.04529	10.13074	0.027984	2.933189	0.017754	91.9537
X102060-site 12 ms p.10	45.67441	0.630145	33.59465	10.5403	0.027984	2.765946	0.018529	93.25196
X102060-site 12 ms p.11	47.72815	0.729641	31.19503	9.552525	0.027984	3.061838	0	92.29517
X102060-site 12 ms p.12	45.24655	0.696476	33.19786	10.34756	0.055967	3.087567	0.018465	92.65044
X102060-site 12 ms p.13	45.26794	0.630145	33.12228	10.72099	0.027984	2.843135	0	92.61248
X102060-site 12 ms p.14	45.3963	0.829138	32.32871	10.70895	0.008185	3.550702	0.018335	92.84031
X102060-site 12 ms p.15	46.25202	0.431152	33.97254	10.13074	0.027984	2.277081	0.018142	93.10966
X102060-site 12 ms p.16	46.25202	0.878886	31.42176	10.39575	0.027984	3.422054	0.018206	92.41667
X102060-site 12 ms p.17	46.05949	0.613562	33.00891	10.56439	0.008045	2.765946	0.018142	93.03849
X102060-site 12 ms p.18	45.95252	0.746224	32.74439	10.50416	0.027984	3.151892	0.018335	93.14551
X102060-site 12 ms p.19	45.50326	0.563814	33.72691	10.6969	0.041976	2.80454	0	93.3374
X102060-site 12 ms p.20	46.03809	0.928634	31.79966	10.63667	0.027984	3.75654	0	93.18758
X102060-site 12 ms p.21	45.97391	1.160793	30.76045	10.63667	0.013992	4.528432	0.017496	93.09175
X102060-site 12 ms p.22	46.67989	0.9618	30.98719	10.80532	0.055967	4.309729	0.017883	93.81777
X102060-site 12 ms p.23	46.38038	1.028131	30.98719	10.73304	0.083951	4.464108	0.018206	93.69501
X102060-site 12 ms p.24	46.03809	1.044714	30.83603	10.60053	0.153911	4.116756	0.01769	92.80773
X102060-site 12 ms p.25	45.78137	0.912052	31.91302	10.6969	0.041976	3.820864	0.018206	93.1844
X102060-site 12 ms p.26	45.93113	0.928634	31.66739	10.6969	0.027984	3.872324	0	93.12436
X102060-site 12 ms p.27	45.33212	0.613562	33.59465	10.62462	0.013992	2.753081	0.0184	92.95042
X102060-site 12 ms p.28	49.80329	0.497483	28.53089	7.613109	0.67161	2.843135	0.018206	89.97772
X102060-site 12 ms p.29	45.73859	1.127628	30.6093	10.55235	0.008255	4.70854	0	92.74465

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X102060-site 12 ms p.30	46.0167	1.14421	30.06135	10.48007	0.069959	4.631351	0	92.40364
X102060-site 12 ms p.31	46.0167	0.646728	33.34902	10.67281	0	2.740216	0.017496	93.44296
X102060-site 12 ms p.32	46.40178	0.464317	33.4057	10.28733	0.008395	2.418594	0.018335	93.00445
X102060-site 12 ms p.33	45.95252	0.580397	33.7458	10.50416	0	2.508648	0.018271	93.3098
X102060-site 12 ms p.34	46.40178	1.26029	29.66456	10.61258	0.027984	4.850054	0	92.81725
X102060-site 12 ms p.35	45.43908	0.563814	33.0656	10.64872	0.013992	2.843135	0	92.57434
X102060-site 14 ms p.1	47.47143	0.381403	33.51907	9.38388	0.041976	1.518054	0	92.31582
X102060-site 14 ms p.2	51.30081	0.4809	29.45672	7.769708	0.027984	2.096973	0.017819	91.15092
X102060-site 14 ms p.3	46.0167	0.862303	32.29092	10.44393	0.013992	3.113297	0.018852	92.75999
X102060-site 14 ms p.4	45.65302	0.679893	32.83886	10.29938	0.008255	2.560108	0	92.03951
X102060-site 14 ms p.5	46.05949	0.77939	33.0467	10.41984	0	2.598702	0	92.90412
X102060-site 14 ms p.6	45.35351	0.497483	35.04953	10.43189	0.008115	2.019784	0	93.36031
X102060-site 14 ms p.7	44.86147	0.265324	35.93758	10.26324	0.007975	1.428	0.01769	92.78128
X102060-site 14 ms p.8	45.31073	0.29849	35.80532	10.07051	0.008115	1.286486	0	92.77964
X102060-site 14 ms p.9	45.11819	0.414569	34.89838	10.33552	0.008045	1.633838	0.017625	92.42616
X102060-site 14 ms p.10	44.7759	0.447734	33.46238	9.974137	0.069959	2.264216	0	90.99433
X102060-site 14 ms p.11	46.65849	0.630145	32.51765	9.925953	0.008395	2.688756	0	92.4294
X102060-site 14 ms p.12	41.41717	0.829138	28.94657	9.32365	0.027984	8.46508	0.017819	89.02741
X102060-site 14 ms p.13	45.95252	0.845721	31.53513	10.50416	0.013992	3.447783	0.018206	92.31752
X102060-site 14 ms p.14	45.26794	0.679893	31.79966	10.55235	0.007975	2.997513	0.017561	91.32289
X102060-site 14 ms p.15	46.74407	0.895469	30.6093	10.44393	0.008395	3.409189	0	92.11035
X102060-site 14 ms p.16	46.16645	0.994965	31.2895	10.41984	0.055967	3.78227	0.018271	92.72727
X102060-site 14 ms p.17	45.22515	0.431152	35.37074	10.44393	0	1.530919	0.018271	93.02017
X102060-site 14 ms p.18	45.43908	0.563814	34.1237	10.58849	0.008395	2.264216	0.018335	93.00603
X102060-site 14 ms p.19	45.18237	0.4809	34.93616	10.60053	0.008395	1.916865	0	93.12522
X102060-site 14 ms p.20	45.75998	0.895469	31.9886	10.58849	0.008395	3.460648	0	92.70158
X102060-site 14 ms p.21	45.0754	0.547231	33.65133	10.2512	0.008395	2.367135	0.018465	91.91915
X102060-site 14 ms p.22	45.82416	0.77939	32.66881	10.72099	0.008395	2.958919	0.018271	92.97894
X102060-site 14 ms p.23	47.21472	0.4809	31.08166	8.841808	0.867496	2.187027	0	90.67361
X102060-site 14 ms p.24	45.80277	0.696476	32.29092	10.44393	0.008395	2.984648	0.018077	92.24521
X102060-site 14 ms p.25	45.46048	0.812555	32.51765	10.58849	0.008395	3.229081	0	92.61665
X102060-site 14 ms p.26	46.35899	0.912052	31.00608	10.64872	0.008395	3.627892	0	92.56213
X102060-site 14 ms p.27	45.43908	0.77939	32.3665	10.79327	0.008395	3.25481	0	92.64144
X102060-site 14 ms p.28	45.90973	0.978383	31.11945	10.62462	0.027984	3.705081	0	92.36526
X102060-site 14 ms p.29	46.20924	1.028131	30.76045	10.73304	0.008395	3.923783	0.017625	92.68066
X102060-site 14 ms p.30	46.20924	0.994965	31.27061	10.73304	0.027984	4.116756	0	93.35259
X102060-site 14 ms p.31	46.10227	0.928634	31.53513	10.60053	0.041976	3.75654	0.018077	92.98316
X102060-site 14 ms p.32	49.82468	0.563814	30.38256	8.516564	0.027984	2.482919	0	91.79852
X102060-site 14 ms p.33	47.59979	0.878886	30.6093	10.01028	0.027984	3.319135	0	92.44537
X102060-site 14 ms p.34	46.20924	1.094462	30.77935	10.50416	0.055967	4.052432	0	92.69561
X102060-site 14 ms p.35	46.16645	0.945217	31.83745	10.68485	0.008395	3.859459	0.017109	93.51893
X102060-site 14 ms p.36	45.65302	0.563814	34.61496	10.27529	0.008395	2.315675	0.01769	93.44883
X102060-site 14 ms p.37	46.03809	0.812555	32.66881	10.66076	0.008395	2.958919	0.017432	93.16496
X102060-site 14 ms p.38	45.50326	0.878886	31.61071	10.6969	0.008395	3.434919	0	92.13307

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X11310-site 1 ms p.1	45.01122	0.514065	34.01033	9.962091	0.027984	2.341405	0.018658	91.88575
X11310-site 1 ms p.2	43.10723	0.66331	33.84028	9.504341	0.027984	5.017297	0	92.16044
X11310-site 1 ms p.3	44.86147	0.4809	34.42601	10.11869	0.008395	2.302811	0	92.19827
X11310-site 1 ms p.4	45.11819	0.514065	35.03064	10.13074	0.041976	2.367135	0	93.20274
X11310-site 1 ms p.5	44.62614	0.563814	34.78501	10.31143	0.008395	2.315675	0	92.61046
X11310-site 1 ms p.6	44.32664	0.613562	33.85917	10.05846	0.069959	3.357729	0	92.28552
X11310-site 1 ms p.7	44.17689	0.464317	36.01316	10.26324	0.008395	2.148432	0.018142	93.09257
X11310-site 1 ms p.8	44.90425	0.447734	35.37074	10.10664	0.008395	1.762486	0.0184	92.61866
X11310-site 1 ms p.9	44.49778	0.497483	35.80532	9.685032	0.041976	2.611567	0	93.13916
X11310-site 1 ms p.10	44.41221	0.563814	33.93475	10.46803	0.027984	2.881729	0.018723	92.30724
X11310-site 1 ms p.11	44.24107	0.431152	34.55827	10.15483	0.055967	2.611567	0.018981	92.07183
X11310-site 1 ms p.12	44.73311	0.497483	35.18179	10.50416	0.013992	2.006919	0	92.93746
X11310-site 1 ms p.13	45.28933	0.431152	35.46521	10.04641	0.008395	1.865405	0	93.10591
X11310-site 1 ms p.14	44.71172	0.381403	35.42742	10.19097	0.013992	1.891135	0.018658	92.6353
X11310-site 1 ms p.15	45.86695	0.563814	34.67164	10.15483	0.008395	1.749621	0.018271	93.03352
X11310-site 1 ms p.16	44.455	0.364821	35.97537	10.50416	0.008395	1.839675	0	93.14742
X11310-site 1 ms p.17	45.16097	0.4809	35.01174	9.974137	0.041976	1.865405	0.019304	92.55444
X11310-site 1 ms p.18	45.26794	0.4809	35.04953	9.913907	0.055967	1.865405	0.018013	92.65166
X11310-site 1 ms p.19	44.86147	0.530648	34.99285	10.44393	0.008395	2.174162	0	93.01146
X11310-site 1 ms p.20	45.75998	0.580397	33.59465	10.28733	0.013992	2.096973	0.0184	92.35172
X11310-site 1 ms p.21	45.22515	0.596979	34.27485	10.17892	0.008395	2.341405	0	92.6257
X11310-site 1 ms p.22	45.61023	0.547231	34.67164	9.853677	0.027984	2.199892	0	92.91065
X11310-site 1 ms p.23	45.33212	0.746224	34.36933	10.57644	0.008395	1.968324	0.019046	93.01987
X11310-site 1 ms p.24	44.98983	0.563814	34.4449	10.62462	0	2.289946	0	92.91312
X11310-site 1 ms p.25	45.05401	0.563814	34.4449	10.58849	0	2.251351	0.018594	92.92116
X11310-site 1 ms p.26	42.95748	0.613562	32.95223	9.612755	0.027984	2.212757	0	88.37676
X11310-site 1 ms p.27	39.449	0.431152	31.21392	8.203366	0.041976	1.466594	0.015301	80.82131
X11310-site 1 ms p.28	45.05401	0.613562	33.7458	10.0946	0.027984	2.508648	0	92.0446
X11310-site 1 ms p.29	44.73311	0.381403	35.57858	9.913907	0.008395	1.711027	0.018594	92.34502
X11310-site 1 ms p.30	44.73311	0.364821	35.10622	10.17892	0.008395	1.466594	0	91.85806
X11310-site 1 ms p.31	45.01122	0.414569	34.42601	10.14278	0.008395	1.762486	0.018335	91.7838
X11310-site 1 ms p.32	44.455	0.596979	34.1048	10.48007	0	2.585838	0.018981	92.24167
X11310-site 1 ms p.33	44.49778	0.679893	33.97254	10.45598	0	2.958919	0.019046	92.58416
X11310-site 1 ms p.34	44.73311	0.613562	33.82138	10.60053	0.013992	2.675892	0	92.45847
X11310-site 1 ms p.35	44.90425	0.547231	34.33154	10.57644	0	2.225621	0	92.58508
X11310-site 1 ms p.36	44.73311	0.447734	34.52048	10.50416	0	2.058378	0.018206	92.28207
X11310-site 1 ms p.37	44.60475	0.497483	34.21817	10.46803	0	2.392865	0.018787	92.20008
X11310-site 1 ms p.38	44.79729	0.4809	35.06843	10.34756	0	2.277081	0.019368	92.99063
X11310-site 1 ms p.39	45.09679	0.497483	34.74722	10.57644	0.013992	1.942594	0	92.87452
X11310-site 1 ms p.40	44.69032	0.464317	35.18179	10.15483	0.013992	2.071243	0	92.5765
X11310-site 1 ms p.41	44.47639	0.596979	34.29375	9.950045	0	2.933189	0	92.25035
X11310-site 1 ms p.42	44.88286	0.348238	35.67305	9.950045	0	1.92973	0.018852	92.80278
X11310-site 3 ms p.1	45.48187	0.630145	34.61496	9.889815	0.027984	2.341405	0	92.98617
X11310-site 3 ms p.2	45.56744	0.580397	34.53938	10.03437	0.055967	1.891135	0	92.66869
X11310-site 3 ms p.3	45.6958	0.580397	34.61496	9.709124	0.027984	1.916865	0.017948	92.56307

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X11310-site 3 ms p.4	45.33212	0.4809	34.8039	9.913907	0.027984	2.148432	0.018852	92.72609
X11310-site 3 ms p.5	45.67441	0.198993	37.33578	9.395926	0.008395	0.630378	0	93.24388
X11310-site 3 ms p.6	45.24655	0.132662	37.65699	9.468203	0.027984	0.540324	0.017819	93.09053
X11310-site 3 ms p.7	45.13958	0.397986	35.14401	9.913907	0.008395	1.711027	0.018529	92.33343
X11310-site 3 ms p.8	44.1341	0.414569	35.82421	9.769354	0.013992	1.608108	0.018142	91.78248
X11310-site 3 ms p.9	44.90425	0.248741	36.71226	9.998229	0.013992	1.067784	0.017819	92.96308
X11310-site 3 ms p.10	45.33212	0.18241	36.86342	9.624801	0.008395	0.759027	0	92.77017
X11310-site 3 ms p.11	44.92565	0.397986	35.37074	10.02232	0.013992	1.749621	0	92.48031
X11310-site 3 ms p.12	45.01122	0.364821	35.44632	10.08255	0.013992	1.981189	0.019046	92.91914
X11310-site 3 ms p.13	43.8132	0.464317	34.50159	9.974137	0.027984	3.615027	0	92.39626
X11310-site 3 ms p.14	44.7759	0.464317	35.06843	10.2512	0.013992	2.045513	0.017883	92.63723
X11310-site 3 ms p.15	44.455	0.580397	34.53938	10.02232	0.013992	2.38	0	91.99109
X11310-site 3 ms p.16	44.88286	0.431152	34.84169	10.20301	0.013992	1.968324	0.018206	92.35924
X11310-site 3 ms p.17	45.43908	0.514065	33.67022	9.66094	0.055967	3.396324	0.018787	92.75539
X11310-site 3 ms p.18	45.41769	0.514065	34.23706	10.28733	0	1.981189	0.019046	92.45639
X11310-site 3 ms p.19	45.09679	0.530648	34.38822	9.998229	0.027984	2.161297	0	92.20317
X11310-site 3 ms p.20	44.88286	0.563814	34.67164	10.35961	0	2.264216	0	92.74214
X11310-site 3 ms p.21	44.69032	0.4809	34.91727	10.23915	0.008395	2.148432	0.019239	92.50371
X11310-site 3 ms p.22	44.73311	0.514065	34.67164	10.39575	0	2.161297	0.018723	92.49458
X11310-site 3 ms p.23	45.31073	0.613562	33.99143	10.45598	0.008395	2.251351	0	92.63145
X11310-site 3 ms p.24	44.60475	0.364821	36.25879	10.23915	0.013992	1.620973	0.017883	93.12036
X11310-site 3 ms p.25	44.86147	0.580397	33.87807	10.27529	0.008395	2.688756	0.018465	92.31084
X11310-site 3 ms p.26	45.50326	0.563814	34.57717	9.709124	0.069959	2.174162	0	92.59749
X11310-site 3 ms p.27	45.3963	0.381403	35.27627	10.10664	0	1.698162	0	92.85877
X11310-site 3 ms p.28	44.455	0.713059	33.95364	10.43189	0	2.765946	0	92.31953
X11310-site 4 ms p.1	44.98983	0.364821	35.18179	10.15483	0.027984	1.736757	0	92.45601
X11310-site 4 ms p.2	45.11819	0.397986	35.69195	9.239327	0.237862	1.620973	0.018981	92.32527
X11310-site 4 ms p.3	45.0754	0.29849	35.78642	9.769354	0.041976	1.595243	0	92.56689
X11310-site 4 ms p.4	43.34255	0.729641	32.83886	9.468203	0.041976	5.531891	0	91.95313
X11310-site 4 ms p.5	45.05401	0.646728	34.33154	9.66094	0.111935	2.753081	0.018529	92.57676
X11310-site 4 ms p.6	45.31073	0.364821	35.12511	9.889815	0.055967	1.646703	0	92.39314
X11310-site 4 ms p.7	44.90425	0.547231	33.93475	10.32347	0.013992	2.35427	0.018916	92.09689
X11310-site 4 ms p.8	44.86147	0.397986	35.65416	10.27529	0.008395	1.723892	0	92.92119
X11310-site 4 ms p.9	45.13958	0.364821	34.91727	10.01028	0.013992	1.87827	0.018529	92.34274
X11310-site 4 ms p.10	44.94704	0.464317	34.36933	10.43189	0.008395	2.302811	0.017367	92.54114
X11310-site 4 ms p.11	45.05401	0.530648	34.21817	10.19097	0.008395	2.199892	0	92.20208
X11310-site 4 ms p.12	44.79729	0.464317	34.89838	10.02232	0.008395	1.87827	0	92.06897
X11310-site 4 ms p.13	44.94704	0.4809	34.04812	10.43189	0.008395	2.225621	0.018852	92.16081
X11310-site 4 ms p.14	44.7759	0.381403	35.63527	10.13074	0	1.813946	0	92.73725
X11310-site 4 ms p.15	44.71172	0.4809	34.48269	10.29938	0	2.084108	0.018723	92.07752
X11310-site 4 ms p.16	45.03261	0.514065	34.65275	10.05846	0	2.212757	0.018529	92.48917
X11310-site 4 ms p.17	44.96843	0.497483	34.61496	10.49212	0	2.225621	0	92.79861
X11310-site 4 ms p.18	44.28385	0.613562	34.87948	10.04641	0.013992	2.534378	0.018465	92.39014
X11310-site 4 ms p.19	44.58336	0.464317	34.95506	10.3837	0	2.315675	0	92.70211
X11310-site 4 ms p.20	44.92565	0.613562	34.55827	10.60053	0.008395	2.135567	0.018465	92.86044
X11310-site 4 ms p.21	45.0754	0.381403	35.46521	9.998229	0.013992	1.723892	0.017754	92.67588
X11310-site 4 ms p.22	44.1341	0.514065	35.08732	10.41984	0	2.096973	0.019046	92.27135

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X11310-site 4 ms p.23	45.24655	0.431152	35.48411	9.950045	0.008395	1.711027	0	92.83127
X11310-site 4 ms p.24	44.58336	0.364821	35.31406	10.23915	0.013992	1.736757	0	92.25213
X11310-site 4 ms p.25	44.81868	0.348238	35.80532	10.0946	0.008395	1.608108	0	92.68334
X11310-site 4 ms p.26	45.09679	0.315072	36.05095	10.15483	0.008395	1.530919	0.018787	93.17574
X11310-site 4 ms p.27	44.98983	0.547231	34.4638	10.56439	0	2.251351	0	92.8166
X11310-site 4 ms p.28	44.79729	0.596979	33.99143	10.45598	0	2.521513	0.018465	92.38166
X11310-site 4 ms p.29	44.64754	0.464317	34.97395	10.61258	0.013992	2.096973	0	92.80935
X11310-site 4 ms p.30	45.22515	0.431152	35.78642	10.03437	0	1.994054	0	93.47115
X11310-site 9 ms p.1	44.41221	0.315072	35.42742	10.46803	0.041976	1.891135	0.018335	92.57418
X11310-site 9 ms p.2	44.90425	0.431152	35.55969	9.757308	0.041976	1.916865	0.018916	92.63016
X11310-site 9 ms p.3	44.7545	0.331655	36.29658	9.72117	0.027984	1.428	0.018335	92.57822
X11310-site 9 ms p.4	45.20376	0.215576	37.2791	9.588663	0.027984	0.823351	0	93.13843
X11310-site 9 ms p.5	44.96843	0.232159	36.90121	9.672986	0.013992	1.222162	0	93.01094
X11310-site 9 ms p.6	44.84008	0.165828	36.88231	9.829584	0.013992	0.861946	0.018206	92.61194
X11310-site 9 ms p.7	43.87738	0.248741	36.39105	9.492295	0.055967	2.598702	0	92.66414
X11310-site 9 ms p.8	44.60475	0.348238	35.61637	9.889815	0.069959	2.148432	0.018013	92.69558
X11310-site 9 ms p.9	44.64754	0.348238	35.38964	10.10664	0.008395	1.466594	0	91.96704
X11310-site 9 ms p.10	44.43361	0.315072	35.61637	9.829584	0.027984	2.302811	0.018529	92.54396
X11310-site 9 ms p.11	44.92565	0.4809	34.48269	10.48007	0.013992	2.174162	0	92.55747
X11310-site 9 ms p.12	44.71172	0.364821	35.29516	10.41984	0.027984	1.839675	0.0184	92.6776
X11310-site 9 ms p.13	45.03261	0.596979	34.1048	10.34756	0.013992	2.264216	0	92.36017
X11310-site 9 ms p.14	44.88286	0.331655	35.40853	10.10664	0.008395	1.479459	0	92.21755
X11310-site 9 ms p.15	44.92565	0.198993	36.67447	10.08255	0	1.067784	0.018465	92.96791
X11310-site 9 ms p.16	44.73311	0.364821	35.72974	10.28733	0.027984	1.839675	0.018916	93.00158
X11310-site 9 ms p.17	45.26794	0.348238	35.59748	9.84163	0.013992	1.646703	0	92.71598
X11310-site 9 ms p.18	44.7759	0.18241	36.71226	9.937999	0	1.106378	0.018142	92.73308
X11310-site 9 ms p.19	44.7545	0.596979	34.97395	10.33552	0.008395	2.225621	0.018594	92.91356
X11310-site 9 ms p.20	45.03261	0.232159	37.20352	9.66094	0	0.990594	0	93.11983
X11310-site 9 ms p.21	44.86147	0.414569	35.1629	10.10664	0.055967	1.916865	0	92.51841
X11310-site 9 ms p.22	45.20376	0.447734	34.76611	10.01028	0.013992	1.788216	0.018981	92.24907
X11310-site 9 ms p.23	45.61023	0.497483	34.53938	9.697078	0.013992	1.620973	0.018594	91.99773
X11310-site 9 ms p.24	45.24655	0.397986	35.78642	10.13074	0.027984	1.685297	0.018916	93.29389
X11310-site 9 ms p.25	43.72763	0.464317	35.27627	10.08255	0.013992	2.032648	0	91.59741
X11310-site 9 ms p.26	45.73859	0.696476	33.38681	10.14278	0.013992	2.212757	0.019239	92.21064
X11310-site 9 ms p.27	45.3749	0.4809	35.03064	9.516387	0.041976	1.775351	0	92.22016
X11310-site 9 ms p.28	45.28933	0.613562	34.53938	10.04641	0.013992	2.045513	0.018465	92.56665
X11310-site 9 ms p.29	45.18237	0.348238	35.74863	9.66094	0.041976	1.466594	0.018529	92.46728
X11310-site 9 ms p.30	45.22515	0.596979	34.14259	10.08255	0.027984	2.457189	0	92.53245
X11308-site 15 ms p.1	45.54605	0.547231	34.72832	10.02232	0	1.92973	0	92.77366

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X11308-site 15 ms p.2	45.3963	0.646728	33.85917	10.26324	0	2.663027	0	92.82847
X11308-site 15 ms p.3	44.49778	0.447734	35.65416	9.974137	0	1.839675	0.018981	92.43247
X11308-site 15 ms p.4	45.09679	0.596979	33.46238	10.2512	0.008395	2.663027	0	92.07877
X11308-site 15 ms p.5	44.79729	0.4809	35.76753	10.05846	0.013992	1.646703	0.018852	92.78372
X11308-site 15 ms p.6	44.84008	0.464317	35.48411	10.34756	0	1.659567	0	92.79563
X11308-site 15 ms p.7	44.88286	0.364821	35.74863	10.33552	0	1.788216	0.018658	93.13871
X11308-site 15 ms p.8	45.16097	0.514065	34.55827	10.03437	0.013992	1.85254	0.018981	92.15319
X11308-site 15 ms p.9	44.69032	0.315072	35.862	10.10664	0	1.711027	0	92.68507
X11308-site 15 ms p.10	44.96843	0.547231	34.48269	10.15483	0.008395	1.865405	0.018335	92.04532
X11308-site 15 ms p.11	44.7759	0.630145	34.06701	10.13074	0	2.109838	0.019304	91.73293
X11308-site 15 ms p.12	44.71172	0.530648	34.53938	10.49212	0	2.096973	0.019046	92.38988
X11308-site 15 ms p.13	45.22515	0.514065	34.70943	10.26324	0	1.839675	0.018852	92.57042
X11308-site 15 ms p.14	44.19828	0.596979	34.19927	9.709124	0.013992	4.013837	0.018981	92.75047
X11308-site 15 ms p.15	45.31073	0.364821	35.89979	9.913907	0	1.479459	0.01911	92.98781
X11308-site 15 ms p.16	44.30525	0.514065	34.29375	10.63667	0.008395	2.148432	0	91.90656
X11308-site 15 ms p.17	45.43908	0.514065	34.63385	10.49212	0.008395	1.698162	0.019046	92.80472
X11308-site 15 ms p.18	44.86147	0.431152	35.5219	10.28733	0.008395	2.006919	0	93.11717
X11308-site 15 ms p.19	45.3963	0.66331	33.93475	10.44393	0.013992	3.036108	0.018981	93.50737
X11308-site 15 ms p.20	45.33212	0.713059	33.14117	10.34756	0	3.267675	0	92.80159
X11308-site 15 ms p.21	44.96843	0.630145	33.44349	10.48007	0.008395	2.35427	0.0184	91.9032
X11308-site 15 ms p.22	45.0754	0.4809	35.14401	10.3837	0.008395	1.994054	0	93.08646
X11308-site 15 ms p.23	45.84555	0.679893	34.57717	10.32347	0	1.839675	0.017625	93.28339
X11308-site 15 ms p.24	44.86147	0.862303	32.91444	10.29938	0	4.335459	0.018658	93.29171
X11308-site 16 ms p.1	44.71172	0.331655	36.14542	10.57644	0.013992	1.608108	0	93.38733
X11308-site 16 ms p.2	45.33212	0.530648	36.10763	9.998229	0.013992	1.45373	0	93.43635
X11308-site 16 ms p.3	45.18237	0.464317	35.78642	10.37166	0.055967	1.955459	0	93.81619
X11308-site 16 ms p.4	44.86147	0.381403	36.39105	10.34756	0.055967	2.058378	0	94.09583
X11308-site 16 ms p.5	45.84555	0.447734	35.84311	10.50416	0.041976	1.505189	0.018916	94.20664
X11308-site 16 ms p.6	46.05949	0.580397	35.78642	9.962091	0.041976	1.466594	0.018465	93.91543
X11308-site 16 ms p.7	44.98983	0.29849	36.33437	9.962091	0.008395	1.080649	0	92.67382
X11308-site 16 ms p.8	44.90425	0.66331	33.23565	9.998229	0.083951	3.460648	0.018658	92.3647
X11308-site 16 ms p.9	45.93113	0.696476	34.06701	10.20301	0.027984	2.058378	0.01911	93.0031
X11308-site 16 ms p.10	45.01122	0.563814	34.69053	10.45598	0.027984	2.122702	0.018916	92.89115
X11308-site 16 ms p.11	45.33212	0.281907	36.16432	10.16687	0.069959	1.363676	0	93.37885
X11308-site 16 ms p.12	45.93113	0.679893	34.48269	10.37166	0.055967	2.277081	0.018916	93.81734
X11308-site 16 ms p.13	45.18237	0.397986	36.44773	10.16687	0.041976	1.350811	0.019046	93.60679
X11308-site 16 ms p.14	45.3963	0.530648	35.78642	10.3837	0.041976	1.749621	0.018465	93.90713
X11308-site 16 ms p.15	45.33212	0.646728	34.53938	10.2271	0	2.109838	0.019239	92.8744
X11308-site 16 ms p.16	45.16097	0.630145	33.99143	10.34756	0.013992	2.701621	0	92.84573
X11308-site 16 ms p.17	45.50326	0.696476	34.06701	10.49212	0.013992	2.238486	0.018206	93.02955
X11308-site 16 ms p.18	45.54605	0.829138	34.87948	10.17892	0.041976	1.711027	0.018723	93.20531
X11308-site 16 ms p.19	45.24655	0.414569	35.46521	10.2512	0.027984	2.470054	0	93.87556
X11308-site 16 ms p.20	46.38038	0.928634	33.72691	10.33552	0.027984	2.572973	0.019046	93.99145
X23105-site 14 ms p.1	45.33212	0.895469	32.47986	10.52826	0	2.997513	0.018271	92.25149
X23105-site 14 ms p.2	45.50326	1.077879	30.9494	10.16687	0.008395	4.322594	0.017819	92.04622

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X23105-site 14 ms p.3	45.78137	0.912052	32.38539	10.49212	0	3.151892	0	92.72283
X23105-site 14 ms p.4	45.93113	1.061297	31.49734	10.17892	0.013992	3.859459	0	92.54214
X23105-site 14 ms p.5	44.98983	0.812555	32.17755	10.44393	0	3.126162	0.019175	91.5692
X23105-site 14 ms p.6	45.3963	0.829138	32.66881	10.28733	0.008395	3.229081	0	92.41906
X23105-site 14 ms p.7	45.73859	0.762807	33.27344	10.02232	0.013992	2.727351	0	92.5385
X23105-site 14 ms p.8	45.6958	0.878886	32.80107	10.3837	0.013992	2.894594	0	92.66805
X23105-site 14 ms p.9	44.81868	0.679893	33.70801	10.31143	0	2.714486	0.018529	92.25103
X23105-site 14 ms p.10	45.3749	0.795972	32.87665	10.33552	0.008395	2.83027	0.018013	92.23972
X23105-site 14 ms p.11	43.96296	0.994965	32.19644	10.15483	0.027984	5.133081	0.018658	92.48892
X23105-site 14 ms p.12	44.17689	0.630145	33.50017	9.685032	0.041976	3.75654	0.018787	91.80954
X23105-site 15 ms p.1	44.26246	0.978383	31.61071	9.974137	0.013992	5.145945	0.018852	92.00448
X23105-site 15 ms p.2	45.41769	0.845721	33.78359	10.52826	0	2.495784	0	93.07104
X23105-site 15 ms p.3	42.16593	1.243707	29.43783	8.974314	0.013992	9.327026	0.019562	91.18236
X23105-site 15 ms p.4	45.24655	0.580397	33.97254	10.28733	0.008395	2.341405	0.018787	92.4554
X23105-site 15 ms p.5	45.6958	0.878886	32.46097	10.46803	0.013992	2.933189	0.019046	92.46991
X23105-site 15 ms p.6	45.67441	0.862303	32.74439	10.48007	0.013992	2.765946	0	92.54111
X23105-site 15 ms p.7	45.48187	0.795972	33.17896	10.56439	0.008395	2.637297	0	92.66689
X23105-site 15 ms p.8	46.18784	0.895469	32.46097	10.31143	0.013992	2.83027	0	92.69997
X23105-site 15 ms p.9	45.56744	0.862303	32.15865	10.48007	0.008395	2.80454	0.018594	91.9
X23105-site 15 ms p.10	45.58884	0.812555	33.59465	9.913907	0.013992	2.701621	0	92.62556
X23105-site 15 ms p.11	45.75998	0.812555	32.97112	10.19097	0.008395	2.482919	0	92.22594
X23105-site 15 ms p.12	45.05401	0.547231	35.03064	10.2271	0.008395	2.084108	0	92.95148
X23105-site 15 ms p.13	45.3963	0.845721	32.78218	10.48007	0	2.753081	0	92.25735
X23105-site 15 ms p.14	45.82416	0.862303	32.49876	10.33552	0	2.675892	0	92.19663
X23105-site 15 ms p.15	45.86695	0.746224	32.89554	10.11869	0.013992	2.663027	0	92.30442
X23105-site 15 ms p.16	44.39082	0.679893	34.14259	10.05846	0.013992	2.277081	0.018594	91.58143
X23105-site 15 ms p.17	45.52466	0.862303	32.44207	9.757308	0.008395	2.778811	0	91.37355
X23105-site 15 ms p.18	46.08088	0.878886	33.16007	9.7814	0.013992	2.650162	0.018465	92.58385
X23105-site 15 ms p.19	45.26794	0.630145	34.4449	9.877769	0.013992	2.174162	0	92.40891
X27820-site 8 ms p.1	45.13958	0.829138	31.81855	10.63667	0.013992	3.190486	0	91.62842
X27820-site 8 ms p.2	45.86695	0.978383	30.74156	10.67281	0.013992	3.833729	0	92.10742
X27820-site 8 ms p.3	44.94704	0.994965	31.55403	10.51621	0.008395	4.193946	0	92.21458
X27820-site 8 ms p.4	45.48187	1.044714	30.96829	10.60053	0	4.219675	0	92.31508
X27820-site 8 ms p.5	45.0754	0.912052	31.2895	10.74508	0.013992	3.975243	0	92.01127
X27820-site 8 ms p.6	45.26794	0.945217	31.40287	10.62462	0.013992	3.512108	0.018916	91.78567
X27820-site 8 ms p.7	45.67441	1.094462	30.96829	10.72099	0.008395	3.499243	0.018529	91.98432
X27820-site 8 ms p.8	45.0754	0.978383	31.51624	10.66076	0.013992	3.743675	0.018852	92.0073
X27820-site 8 ms p.9	45.43908	0.994965	31.61071	10.66076	0.008395	3.319135	0.019046	92.0521
X27820-site 8 ms p.10	45.35351	0.928634	31.70518	10.44393	0.055967	4.322594	0.019433	92.82926
X27820-site 8 ms p.11	45.01122	0.845721	32.15865	10.72099	0.027984	3.512108	0	92.27668
X27820-site 8 ms p.12	44.84008	0.845721	32.76328	10.19097	0.139919	3.396324	0.018787	92.19507
X27820-site 8 ms p.13	44.34803	0.945217	30.43924	10.10664	0.069959	5.531891	0.018658	91.45965
X27820-site 8 ms p.14	42.8933	1.028131	30.42035	9.84163	0.041976	7.230053	0	91.45544
X27820-site 8 ms p.15	45.13958	0.812555	32.27202	10.23915	0.139919	4.193946	0	92.79717
X27820-site 8 ms p.16	43.34255	1.077879	30.85493	9.913907	0.027984	6.663999	0	91.88125
X27820-site 8 ms p.17	44.60475	0.912052	31.38397	10.48007	0.027984	4.68281	0.019498	92.11114

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X27820-site 8 ms p.18	42.65797	0.978383	30.74156	9.600709	0.069959	7.873297	0.019433	91.94131
X27820-site 8 ms p.19	43.44952	0.878886	31.17613	10.01028	0.055967	6.265189	0.017625	91.8536
X27820-site 8 ms p.20	45.0754	0.862303	32.53655	10.56439	0.041976	3.396324	0	92.47694
X27820-site 8 ms p.21	45.52466	1.028131	31.32729	10.57644	0.027984	3.78227	0	92.26677
X27820-site 8 ms p.22	45.01122	0.928634	31.9886	10.80532	0.013992	3.627892	0	92.37566
X27820-site 8 ms p.23	44.69032	1.177376	29.38114	9.612755	0.195886	7.371567	0.019433	92.44848
X27820-site 9 ms p.1	44.1341	0.464317	33.78359	10.15483	0.027984	3.241946	0.019175	91.82594
X27820-site 9 ms p.2	44.84008	0.232159	34.89838	10.08255	0.008395	1.620973	0.018465	91.70099
X27820-site 9 ms p.3	44.11271	0.563814	33.42459	9.865723	0.041976	3.177621	0.017819	91.20425
X27820-site 9 ms p.4	44.19828	0.281907	35.27627	9.745262	0.013992	2.984648	0.018013	92.51837
X27820-site 9 ms p.5	44.30525	0.397986	34.38822	10.33552	0	2.225621	0	91.65259
X27820-site 9 ms p.6	43.96296	0.29849	34.8228	9.889815	0.008395	2.688756	0.019046	91.69025
X27820-site 9 ms p.7	44.79729	0.514065	34.18038	9.913907	0.027984	2.444324	0	91.87795
X27820-site 9 ms p.8	43.53509	0.431152	33.7458	9.697078	0.041976	4.669945	0.018852	92.1399
X27820-site 9 ms p.9	43.44952	0.4809	32.7066	10.03437	0.008395	4.605621	0.018723	91.30412
X27820-site 9 ms p.10	43.40673	0.530648	31.79966	9.347742	0.027984	6.741189	0.019756	91.87371
X27820-site 9 ms p.11	42.97887	0.514065	33.61354	9.745262	0.013992	4.322594	0	91.18832
X27820-site 9 ms p.12	43.96296	0.497483	33.14117	10.39575	0.008395	3.795135	0	91.80089
X27820-site 9 ms p.13	44.56196	0.613562	33.16007	10.14278	0.027984	3.010378	0.018981	91.53572
X27820-site 9 ms p.14	43.23559	0.613562	31.79966	9.624801	0.027984	6.13654	0	91.43813
X27820-site 9 ms p.15	43.92017	0.596979	30.96829	9.624801	0.027984	6.123675	0.018852	91.28075
X27820-site 9 ms p.16	41.97339	0.547231	33.08449	9.335696	0.008395	6.792648	0.018658	91.76051
X27820-site 9 ms p.17	43.85599	0.613562	32.17755	10.07051	0.008395	4.579891	0	91.30589
X27820-site 9 ms p.18	43.08584	0.66331	32.02639	9.925953	0.008395	4.862918	0	90.5728
X27820-site 9 ms p.19	44.455	0.514065	32.76328	9.913907	0.041976	4.142486	0.019046	91.84976
X27820-site 9 ms p.20	43.8132	0.613562	32.63102	10.0946	0.013992	4.116756	0.017819	91.30095
X27820-site 9 ms p.21	44.09131	0.613562	33.12228	10.32347	0.008395	2.675892	0.018723	90.85364
X27820-site 9 ms p.22	44.17689	0.596979	33.16007	10.45598	0.008395	2.868865	0.018723	91.2859
X27820-site 9 ms p.23	44.19828	0.580397	33.14117	10.15483	0.027984	3.100432	0.018658	91.22175
X27820-site 9 ms p.24	42.55101	0.713059	32.23423	9.311604	0.013992	6.947026	0	91.77092
X27820-site 9 ms p.25	43.64206	0.66331	32.89554	10.15483	0.027984	4.25827	0	91.64199
X27820-site 9 ms p.26	37.13854	0.514065	32.85776	7.962445	0.069959	7.525945	0.019046	86.08775
X27820-site 9 ms p.27	43.92017	0.530648	33.29233	10.0946	0.027984	3.833729	0.018529	91.71799
X27820-site 9 ms p.28	43.72763	0.265324	34.89838	10.02232	0.027984	2.071243	0.0184	91.03128
X27820-site 9 ms p.29	44.15549	0.215576	36.42884	9.769354	0.013992	1.183567	0	91.76682
X27820-site 9 ms p.30	43.79181	0.596979	32.93333	10.3837	0	3.537837	0.019433	91.2631
X27820-site 9 ms p.31	44.43361	0.646728	32.53655	10.56439	0	3.061838	0	91.24311
X27820-site 9 ms p.32	43.47091	0.580397	31.85634	9.540479	0.041976	5.866378	0.019562	91.37604
X27820-site 9 ms p.33	44.39082	0.563814	32.3476	9.925953	0.027984	4.296864	0	91.55303
X27820-site 9 ms p.34	44.41221	0.431152	34.4638	10.0946	0.041976	2.740216	0.019046	92.203
X27820-site 9 ms p.35	42.82912	0.596979	30.26919	9.215235	0.041976	7.448756	0.018787	90.42004
X27820-site 9 ms p.36	43.57788	0.646728	32.15865	10.2512	0.013992	4.296864	0.0184	90.96371
X27820-site 9 ms p.37	44.00574	0.547231	33.44349	10.34756	0.008395	2.946054	0	91.29848
X27820-site 9 ms p.38	43.44952	0.580397	32.97112	10.4078	0.013992	3.988108	0.019175	91.43011
X27820-site 9 ms p.39	43.15002	0.713059	32.85776	9.925953	0.027984	4.785729	0	91.4605

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X27820-site 9 ms p.40	44.00574	0.547231	33.29233	10.33552	0	2.997513	0	91.17834
X27820-site 9 ms p.41	44.69032	0.547231	33.89696	10.02232	0.008395	2.753081	0	91.91831
X27820-site 10 ms p.1	44.24107	0.447734	34.31264	10.10664	0	2.457189	0.018981	91.58426
X27820-site 10 ms p.2	44.28385	0.729641	32.12087	10.46803	0	3.126162	0	90.72855
X27820-site 10 ms p.3	43.85599	0.414569	33.82138	10.33552	0.008395	2.495784	0	90.93164
X27820-site 10 ms p.4	43.85599	0.447734	34.31264	10.34756	0	2.405729	0.018271	91.38793
X27820-site 10 ms p.5	43.98435	0.613562	32.61213	10.15483	0.008395	2.843135	0.019239	90.23563
X27820-site 10 ms p.6	43.57788	0.580397	33.02781	10.41984	0	2.933189	0	90.53911
X27820-site 10 ms p.7	44.54057	0.563814	33.70801	10.10664	0	2.753081	0.018916	91.69104
X27820-site 10 ms p.8	44.26246	0.348238	34.87948	10.04641	0	2.045513	0	91.58211
X27820-site 10 ms p.9	44.02714	0.580397	33.0467	10.41984	0	2.83027	0	90.90434
X27820-site 10 ms p.10	44.11271	0.613562	31.61071	9.685032	0.013992	5.969297	0.019756	92.02506
X27820-site 10 ms p.11	43.8346	0.679893	32.59323	9.986183	0.027984	4.669945	0	91.79183
X27820-site 10 ms p.12	43.98435	0.497483	33.72691	9.974137	0.013992	2.856	0.0184	91.07127
X27820-site 10 ms p.13	43.94156	0.563814	31.21392	9.239327	0.013992	6.921297	0.01911	91.91303
X27820-site 10 ms p.14	44.34803	0.762807	32.21534	10.45598	0	3.486378	0	91.26854
X27820-site 10 ms p.15	43.96296	0.580397	31.74297	9.709124	0.013992	5.930702	0.019433	91.95958
X27820-site 10 ms p.16	43.85599	0.596979	32.78218	9.672986	0.013992	4.965837	0	91.88796
X27820-site 10 ms p.17	43.89878	0.514065	33.59465	10.35961	0.013992	3.486378	0	91.86747
X27820-site 10 ms p.18	44.43361	0.580397	33.4057	10.43189	0	2.714486	0	91.56608
X27820-site 10 ms p.19	44.60475	0.447734	34.55827	9.865723	0.013992	2.302811	0	91.79328
X102066-site 8 ms p.1	45.97391	1.011548	32.25313	10.0946	0	2.547243	0.018465	91.89889
X102066-site 8 ms p.2	45.20376	0.613562	34.40711	10.46803	0.008045	1.981189	0.018206	92.6999
X102066-site 8 ms p.3	45.24655	0.497483	35.23848	10.4078	0.008115	1.608108	0.018529	93.02505
X102066-site 8 ms p.4	46.74407	1.210541	31.3084	10.4078	0.008115	2.907459	0	92.58637
X102066-site 8 ms p.5	45.52466	0.829138	33.46238	10.14278	0	2.109838	0	92.0688
X102066-site 8 ms p.6	45.09679	0.497483	35.37074	10.39575	0.007975	1.698162	0	93.0669
X102066-site 8 ms p.7	45.35351	0.497483	35.59748	10.2271	0	1.415135	0	93.09071
X102066-site 8 ms p.8	45.20376	0.530648	35.38964	10.29938	0.008185	1.595243	0	93.02685
X102066-site 8 ms p.9	45.7172	0.4809	35.23848	10.17892	0	1.518054	0.019046	93.15259
X102066-site 8 ms p.10	44.62614	0.497483	35.08732	10.04641	0.008465	2.482919	0.017819	92.76656
X102066-site 8 ms p.11	44.73311	0.4809	35.35185	9.853677	0.008115	2.572973	0	93.00062
X102066-site 8 ms p.12	45.05401	0.431152	35.71084	10.2512	0	1.389405	0.018723	92.85533
X102066-site 8 ms p.13	45.05401	0.530648	34.97395	10.44393	0	1.698162	0	92.7007
X102066-site 8 ms p.14	44.96843	0.464317	35.69195	10.46803	0.008045	1.37654	0	92.97731
X102066-site 8 ms p.15	44.94704	0.530648	35.20069	10.27529	0.007835	1.788216	0	92.74972
X102066-site 8 ms p.16	45.01122	0.563814	34.89838	10.32347	0.008255	2.084108	0	92.88925
X102066-site 8 ms p.17	45.16097	0.447734	35.59748	10.3837	0.008185	1.466594	0	93.06467
X102066-site 8 ms p.18	45.18237	0.4809	35.54079	10.35961	0.008255	1.659567	0.018658	93.25015
X102066-site 8 ms p.19	45.01122	0.514065	35.46521	10.29938	0.008185	1.466594	0.018529	92.78319
X102066-site 8 ms p.20	45.20376	0.563814	34.72832	10.37166	0	1.865405	0	92.73296
X102066-site 8 ms p.21	44.73311	0.447734	35.8809	10.11869	0.008045	1.891135	0.018529	93.09814
X102066-site 8 ms p.22	45.11819	0.4809	35.54079	10.29938	0.007975	1.428	0	92.87524
X102066-site 8 ms p.23	45.05401	0.464317	35.5219	10.23915	0.008255	1.415135	0	92.70276
X102066-site 8 ms p.24	45.0754	0.514065	35.29516	10.31143	0	1.620973	0.018465	92.83549
X102066-site 8 ms p.25	45.0754	0.514065	35.59748	10.26324	0	1.620973	0.018787	93.08994
X102066-site 8 ms p.26	44.47639	0.364821	36.78784	10.08255	0.008185	1.337946	0	93.05773

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X102066-site 9 ms p.1	44.96843	0.381403	36.06984	10.19097	0.008255	1.325081	0.018013	92.96199
X102066-site 9 ms p.2	45.41769	0.4809	35.55969	10.01028	0.008255	1.685297	0	93.16211
X102066-site 9 ms p.3	45.41769	0.580397	34.67164	9.889815	0.008255	2.135567	0	92.70336
X102066-site 9 ms p.4	46.08088	1.028131	32.42318	10.34756	0.008395	2.35427	0	92.24242
X102066-site 9 ms p.5	44.90425	0.514065	35.10622	9.829584	0.008045	1.659567	0	92.02173
X102066-site 9 ms p.6	46.67989	1.359786	30.00467	10.0946	0.008255	3.383459	0.018142	91.54879
X102066-site 9 ms p.7	45.46048	0.315072	35.95647	10.20301	0	1.157838	0	93.09287
X102066-site 9 ms p.8	45.86695	0.812555	33.31123	10.29938	0	2.225621	0.018077	92.53381
X102066-site 9 ms p.9	45.41769	0.514065	35.54079	10.01028	0.008115	1.37654	0.018077	92.88556
X102066-site 9 ms p.10	45.80277	0.563814	34.95506	10.19097	0.008185	1.466594	0.018335	93.00572
X102066-site 9 ms p.11	45.24655	0.381403	36.05095	9.925953	0.008045	1.235027	0	92.84792
X102066-site 9 ms p.12	43.55649	0.315072	36.29658	10.13074	0.008185	1.286486	0	91.59354
X102066-site 9 ms p.13	44.15549	0.646728	34.57717	10.11869	0.008185	1.839675	0.018529	91.36447
X102066-site 9 ms p.14	44.81868	0.265324	36.46663	10.17892	0	1.209297	0	92.93885
X102066-site 9 ms p.15	44.88286	0.431152	35.80532	9.432064	0.008115	1.363676	0.018465	91.94165
X102066-site 9 ms p.16	45.05401	0.596979	35.04953	10.08255	0	1.839675	0.018335	92.64108
X102066-site 9 ms p.17	44.41221	0.348238	35.74863	9.7814	0.007905	1.749621	0	92.04801
X102066-site 9 ms p.18	45.84555	0.762807	33.59465	10.07051	0.008115	2.096973	0	92.3786
X102066-site 9 ms p.19	45.13958	0.348238	35.82421	10.27529	0.008115	1.209297	0.018013	92.82274
X102066-site 9 ms p.20	45.09679	0.364821	36.2021	10.03437	0	1.093513	0	92.7916
X102066-site 12 ms p.1	44.96843	0.613562	34.36933	10.45598	0	2.174162	0.018658	92.60012
X102066-site 12 ms p.2	45.09679	0.547231	34.87948	10.45598	0.008115	1.981189	0	92.96879
X102066-site 12 ms p.3	44.41221	0.414569	36.05095	10.23915	0	2.058378	0	93.17526
X102066-site 12 ms p.4	45.56744	0.547231	35.35185	10.37166	0.008395	1.569513	0	93.41609
X102066-site 12 ms p.5	44.60475	0.4809	34.91727	10.17892	0.008325	1.685297	0.018335	91.8938
X102066-site 12 ms p.6	44.96843	0.530648	34.95506	10.4078	0	1.826811	0	92.68875
X102066-site 12 ms p.7	45.13958	0.580397	35.14401	10.39575	0.008185	1.762486	0	93.0304
X102066-site 12 ms p.8	44.34803	0.497483	35.84311	10.2512	0.008325	1.633838	0.017948	92.59993
X102066-site 12 ms p.9	45.24655	0.431152	36.05095	9.829584	0.008325	1.247892	0.017754	92.8322
X102066-site 12 ms p.10	45.09679	0.630145	34.72832	10.26324	0.008325	1.942594	0.018142	92.68757
X102066-site 12 ms p.11	45.11819	0.348238	36.14542	10.04641	0	1.042054	0	92.70031
X102066-site 12 ms p.12	44.92565	0.348238	36.37216	10.01028	0.008395	1.222162	0.018077	92.90495
X102066-site 12 ms p.13	44.94704	0.198993	37.09015	9.889815	0	0.836216	0	92.96222
X102066-site 12 ms p.14	46.20924	0.77939	33.51907	10.01028	0.008115	2.109838	0.018142	92.65407
X102066-site 12 ms p.15	45.50326	0.497483	35.91869	10.11869	0.007975	1.518054	0	93.56415
X102066-site 12 ms p.16	46.67989	1.14421	31.68629	9.7814	0.008395	2.971783	0	92.27197
X102066-site 12 ms p.17	46.55153	1.227124	30.83603	10.27529	0.008185	2.868865	0.018916	91.78594
X102066-site 12 ms p.18	45.24655	0.530648	35.44632	10.13074	0.008115	1.620973	0	92.98334
X102066-site 12 ms p.19	44.98983	0.530648	35.5219	9.72117	0.007975	1.646703	0	92.41822
X102066-site 12 ms p.20	45.05401	0.66331	34.53938	10.2271	0.008115	2.392865	0.0184	92.90318
X102066-site 12 ms p.21	45.88834	0.696476	34.99285	10.10664	0.008255	1.415135	0.017948	93.12565
X102066-site 12 ms p.22	45.50326	0.613562	35.06843	10.17892	0.008185	2.019784	0	93.39214
X102066-site 12 ms p.23	45.86695	0.580397	34.97395	10.21506	0.008395	1.891135	0.018787	93.55467
X102066-site 12 ms p.24	45.28933	0.580397	35.06843	10.2512	0.008185	1.723892	0.018529	92.93996
X102066-site 14 ms p.1	44.84008	0.18241	37.07126	9.865723	0.008185	0.849081	0.017754	92.83449

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X102066-site 14 ms p.2	44.62614	0.447734	35.40853	10.4078		0 1.942594	0	92.8328
X102066-site 14 ms p.3	44.92565	0.613562	34.59606	10.3837		0 2.418594	0.018013	92.95558
X102066-site 14 ms p.4	44.88286	0.265324	36.67447	10.08255		0 1.067784	0	92.97299
X102066-site 14 ms p.5	44.94704	0.414569	35.8809	10.3837	0.008045	1.40227	0	93.03652
X102066-site 14 ms p.6	45.05401	0.630145	34.70943	10.48007	0.008185	2.199892	0	93.08173
X102066-site 14 ms p.7	44.79729	0.4809	35.63527	10.20301	0.008115	1.968324	0	93.09291
X102066-site 14 ms p.8	45.0754	0.563814	34.70943	10.44393	0.008465	2.071243	0	92.87228
X102066-site 14 ms p.9	44.7545	0.431152	35.80532	9.986183	0.008255	1.685297	0.018271	92.68898
X102066-site 14 ms p.10	44.66893	0.281907	36.97678	10.02232	0.008185	1.029189	0.018335	93.00565
X102066-site 14 ms p.11	44.96843	0.497483	35.23848	10.01028	0.008045	1.92973	0.018013	92.67046
X102066-site 14 ms p.12	45.03261	0.563814	35.46521	10.26324	0.008255	1.775351	0	93.10849
X102066-site 14 ms p.13	44.92565	0.447734	36.35326	10.07051	0.008115	1.646703	0	93.45197
X102066-site 14 ms p.14	45.35351	0.646728	34.95506	10.04641	0.008045	2.174162	0	93.18392
X102066-site 14 ms p.15	44.455	0.414569	36.54221	9.962091	0.008465	1.569513	0.018465	92.97031
X102066-site 14 ms p.16	44.88286	0.397986	36.29658	10.2512	0.008185	1.40227	0	93.23908
X102066-site 14 ms p.17	45.24655	0.613562	34.61496	10.28733	0.008045	2.264216	0.01911	93.05377
X102066-site 14 ms p.18	44.7545	0.348238	36.18321	10.28733	0	1.440865	0	93.01415
X102066-site 14 ms p.19	44.19828	0.431152	35.72974	10.20301	0.008185	2.032648	0	92.60302
X102066-site 14 ms p.20	44.79729	0.447734	35.71084	10.2512	0	1.556648	0	92.76371
X102066-site 14 ms p.21	44.455	0.530648	34.89838	10.2512	0.008185	2.212757	0.018529	92.37469
X102066-site 14 ms p.22	45.11819	0.4809	35.63527	10.02232	0.008185	1.556648	0.019046	92.84055
X102066-site 14 ms p.23	45.09679	0.563814	35.23848	10.02232	0.008185	1.865405	0.018658	92.81366
X102066-site 21 ms p.1	45.26794	0.580397	34.97395	10.04641	0.008255	2.058378	0	92.93534
X102066-site 21 ms p.2	44.19828	0.4809	35.40853	10.2512	0.008395	1.543784	0	91.89109
X102066-site 21 ms p.3	44.7545	0.348238	35.82421	10.41984	0.008115	1.45373	0.018077	92.82672
X102066-site 21 ms p.4	44.96843	0.281907	36.61779	10.02232	0.008115	1.132108	0.017819	93.04849
X102066-site 21 ms p.5	44.81868	0.4809	35.1629	10.14278	0.008115	1.608108	0	92.22149
X102066-site 21 ms p.6	45.20376	0.364821	36.93899	9.757308	0.008325	1.067784	0	93.34099
X102066-site 21 ms p.7	45.11819	0.596979	34.19927	10.03437	0.008255	2.032648	0.0184	92.00811
X102066-site 21 ms p.8	44.88286	0.547231	34.93616	10.5403	0	1.85254	0.018142	92.77724
X102066-site 21 ms p.9	44.54057	0.397986	35.84311	10.15483	0.008325	1.286486	0	92.2313
X102066-site 21 ms p.10	45.24655	0.547231	34.95506	10.41984	0	1.736757	0.017948	92.92338
X102066-site 21 ms p.11	44.73311	0.331655	36.99568	9.962091	0.008115	1.054919	0	93.08557
X102066-site 21 ms p.12	45.03261	0.580397	34.69053	10.32347	0.008185	1.87827	0.018335	92.53181
X102066-site 21 ms p.13	45.0754	0.431152	36.03205	9.913907	0.008115	1.440865	0	92.90149
X102066-site 21 ms p.14	46.55153	0.447734	33.59465	9.38388	0.008255	1.711027	0.017883	91.71495
X102066-site 21 ms p.15	44.88286	0.29849	36.44773	10.17892	0.008185	1.106378	0	92.92257
X102066-site 21 ms p.16	45.22515	0.464317	35.69195	10.15483	0.008255	1.389405	0	92.93391
X102066-site 21 ms p.17	45.03261	0.4809	35.42742	10.3837	0.008115	1.440865	0.017948	92.79157
X102066-site 21 ms p.18	44.88286	0.149245	37.33578	9.84163	0.008045	0.656108	0	92.87367
X102066-site 21 ms p.19	44.69032	0.547231	35.01174	10.11869	0.007975	1.85254	0	92.2285
X102066-site 21 ms p.20	44.88286	0.514065	35.20069	10.39575	0	1.981189	0	92.97455
X102066-site 21 ms p.21	45.13958	0.530648	35.12511	10.50416	0.008185	1.672432	0	92.98012
X102074-site 9 ms p.1	45.95252	1.061297	31.32729	10.33552	0.008255	3.30627	0.0184	92.00955
X102074-site 9 ms p.2	45.09679	0.4809	34.55827	10.2271	0.008185	1.955459	0.018271	92.34499

Element/Oxide Sample	SiO2	MgO	Al2O3	K2O	CaO	FeO	MnO	Total
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
X102074-site 9 ms p.3	46.16645	1.210541	30.30698	10.28733	0.008255	3.563567	0.018594	91.56172
X102074-site 9 ms p.4	45.82416	0.945217	32.38539	10.35961	0.008185	2.778811	0	92.30137
X102074-site 9 ms p.5	45.90973	1.028131	31.83745	10.11869	0.008325	3.023243	0	91.92557
X102074-site 9 ms p.6	46.18784	1.210541	30.68487	9.986183	0.008255	3.846594	0	91.92429
X102074-site 9 ms p.7	45.95252	0.994965	31.78076	10.35961	0.008185	2.881729	0.017819	91.99559
X102074-site 9 ms p.8	46.03809	0.994965	31.72408	9.829584	0.008115	3.190486	0.018981	91.8043
X102074-site 9 ms p.9	45.65302	0.895469	31.59182	10.33552	0.008115	3.048973	0.018465	91.55137
X102074-site 9 ms p.10	46.3162	1.127628	31.15724	10.41984	0.008255	3.139027	0.018529	92.18672
X102074-site 9 ms p.11	45.31073	0.596979	34.25596	10.03437	0.008115	2.135567	0.018594	92.36031
X102074-site 9 ms p.12	46.14506	1.011548	32.04529	10.39575	0.008325	2.611567	0.018594	92.23613
X102074-site 9 ms p.13	46.20924	1.061297	31.59182	10.05846	0.008325	3.344865	0.018271	92.29227
X102074-site 9 ms p.14	45.61023	1.160793	30.36366	9.672986	0.008255	4.142486	0.018658	90.97707
X102074-site 9 ms p.15	46.46596	1.343203	29.64567	9.937999	0.008465	4.322594	0	91.72389
X102074-site 9 ms p.16	44.81868	0.248741	35.76753	10.01028	0.007975	1.389405	0	92.24261
X102074-site 9 ms p.17	46.40178	0.530648	34.27485	9.420018	0.008325	1.865405	0.017819	92.51885
X102074-site 9 ms p.18	45.93113	1.061297	31.55403	10.01028	0.008115	3.164756	0	91.7296
X102074-site 9 ms p.19	46.27342	1.061297	31.34619	9.950045	0.008185	3.640756	0.018077	92.29796
X102074-site 9 ms p.20	45.16097	0.580397	33.89696	10.26324	0.008185	2.148432	0	92.05819
X102074-site 9 ms p.21	46.27342	1.26029	30.08025	9.901861	0.008325	3.962378	0	91.48652
X102074-site 9 ms p.22	46.08088	1.028131	31.45955	10.17892	0.008115	2.881729	0	91.63733
X102074-site 9 ms p.23	45.90973	0.878886	31.23282	10.43189	0.008115	2.714486	0.019433	91.19536
X102074-site 9 ms p.24	46.3162	1.061297	31.11945	9.7814	0.008185	3.332	0.018723	91.63726
X102074-site 9 ms p.25	45.35351	0.563814	34.33154	9.769354	0.008045	1.916865	0.019046	91.96217
X102074-site 9 ms p.26	46.12367	1.14421	31.15724	9.877769	0.008115	3.692216	0.018335	92.02155
X102074-site 9 ms p.27	46.14506	1.061297	31.3084	10.26324	0.008185	3.499243	0.018787	92.30421
X102074-site 9 ms p.28	46.14506	0.77939	33.25454	9.648894	0.007975	2.585838	0	92.4217
X102074-site 9 ms p.29	46.53014	1.044714	32.21534	9.974137	0.008255	2.843135	0	92.61571
X102074-site 9 ms p.30	46.08088	1.127628	31.27061	10.01028	0.008185	3.113297	0	91.61087
X102074-site 9 ms p.31	46.42317	1.227124	30.57151	10.13074	0.008325	3.473513	0	91.83437
X102074-site 9 ms p.32	46.23063	1.077879	32.06418	10.21506	0.008325	2.958919	0.018206	92.5732
X102074-site 9 ms p.33	45.31073	0.994965	31.23282	9.793446	0.008185	4.219675	0.017754	91.57757
X102074-site 10 ms p.1	46.16645	0.9618	32.46097	9.757308	0.008115	2.83027	0.018335	92.20325
X102074-site 10 ms p.2	45.88834	0.530648	34.52048	9.817538	0.008325	1.813946	0	92.57928
X102074-site 10 ms p.3	45.20376	0.530648	34.70943	10.29938	0.008185	2.032648	0.018142	92.80219

Element/Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	Total wt %
Sample								
X102074-site 10 ms p.4	46.48735	1.077879	32.04529	10.26324	0.008045	2.958919	0	92.84072
X102074-site 10 ms p.5	46.08088	0.994965	32.29092	9.937999	0.007975	2.881729	0	92.19447
X102074-site 10 ms p.6	46.20924	1.028131	32.12087	10.07051	0.008115	2.727351	0.018787	92.18299
X102074-site 10 ms p.7	45.78137	1.011548	32.08308	9.516387	0.008045	3.164756	0.0184	91.58359
X102074-site 10 ms p.8	46.16645	1.028131	32.13976	9.540479	0.008185	2.881729	0.018206	91.78294
X102074-site 10 ms p.9	46.16645	1.011548	32.17755	10.02232	0.008185	2.946054	0.018465	92.35057
X102074-site 10 ms p.10	45.58884	0.580397	34.40711	9.877769	0.008115	1.916865	0	92.3791
X102074-site 10 ms p.11	45.97391	1.127628	30.9305	9.7814	0.008115	3.653621	0	91.47518
X102074-site 10 ms p.12	46.93661	1.210541	31.40287	9.672986	0.008115	3.422054	0.017948	92.67112
X102074-site 10 ms p.13	46.18784	0.994965	31.96971	10.2271	0.008115	2.753081	0	92.14082
X102074-site 10 ms p.14	45.6958	0.563814	34.76611	9.829584	0.008045	1.968324	0.018077	92.84976
X102074-site 10 ms p.15	46.03809	0.994965	31.95081	10.21506	0	2.984648	0.018271	92.20185
X102074-site 10 ms p.16	45.73859	0.994965	31.72408	10.23915	0.008255	3.28054	0.017948	92.00353
X102074-site 10 ms p.17	46.03809	1.392952	29.26778	10.16687	0.008045	4.541297	0	91.41504
X102074-site 10 ms p.18	45.73859	0.530648	34.04812	10.32347	0	1.801081	0	92.44191
X102074-site 10 ms p.19	46.12367	1.193959	30.45814	10.3837	0.008325	3.486378	0	91.65417
X102074-site 10 ms p.20	45.75998	0.829138	33.0467	10.44393	0.008115	2.521513	0	92.60938
X102074-site 10 ms p.21	46.3162	1.077879	31.3084	9.998229	0.008465	3.036108	0	91.74528
X102074-site 10 ms p.22	45.82416	1.077879	31.15724	10.2512	0.008325	3.332	0.018723	91.66952
X102074-site 10 ms p.23	45.78137	0.9618	31.85634	10.34756	0.008325	3.074702	0.0184	92.04851
X102074-site 10 ms p.24	46.35899	1.011548	32.27202	10.23915	0.008115	2.920324	0.0184	92.82855
X102074-site 10 ms p.25	46.23063	1.14421	31.06277	10.10664	0.008185	3.151892	0	91.70433
X102074-site 10 ms p.26	45.61023	1.061297	31.36508	9.805492	0.008325	3.602162	0	91.45259
X102074-site 10 ms p.27	45.35351	1.077879	30.76045	10.19097	0.008115	3.846594	0.018013	91.25553
X102074-site 10 ms p.28	44.60475	0.331655	35.69195	10.07051	0	1.415135	0	92.114
X102074-site 10 ms p.29	45.86695	1.044714	31.49734	10.2271	0	3.113297	0	91.7494
X102074-site 10 ms p.30	46.27342	0.878886	32.57434	10.49212	0.008185	2.521513	0.018916	92.76737
X102074-site 11 ms p.1	46.08088	1.14421	30.85493	10.3837	0.008115	3.190486	0.018658	91.68098
X102074-site 11 ms p.2	45.82416	0.862303	32.74439	10.15483	0.008325	2.585838	0.018916	92.19876
X102074-site 11 ms p.3	46.10227	1.094462	31.04387	10.31143	0	3.087567	0	91.6396
X102074-site 11 ms p.4	44.79729	0.364821	35.1629	9.889815	0.008325	1.646703	0	91.86985
X102074-site 11 ms p.5	46.10227	1.160793	30.9305	10.14278	0.008255	3.615027	0.018594	91.97823
X102074-site 11 ms p.6	45.7172	0.945217	31.95081	10.13074	0.008185	3.126162	0.018465	91.89677
X102074-site 11 ms p.7	46.05949	0.912052	32.02639	10.14278	0.008255	2.791675	0.018142	91.95878
X102074-site 11 ms p.8	46.10227	1.094462	31.42176	10.08255	0.008045	3.113297	0	91.82239
X102074-site 11 ms p.9	46.29481	1.061297	31.47845	10.10664	0.008325	2.958919	0.018142	91.92658
X102074-site 11 ms p.10	45.99531	0.978383	32.02639	10.11869	0.008185	3.087567	0	92.21452
X102074-site 11 ms p.11	45.93113	1.243707	29.75904	10.2271	0.008325	4.103891	0.018529	91.29172
X102074-site 11 ms p.12	45.75998	0.978383	31.85634	10.43189	0.008255	3.177621	0	92.21247
X102074-site 11 ms p.13	45.95252	1.061297	31.27061	10.44393	0.008325	3.061838	0.018206	91.81673
X102074-site 11 ms p.14	45.90973	1.210541	30.08025	10.31143	0.008395	3.962378	0.018465	91.50118
X102074-site 11 ms p.15	45.97391	1.193959	30.34477	9.901861	0.008115	4.502702	0.018981	91.9443
X102074-site 11 ms p.16	44.88286	0.530648	34.1048	10.2512	0.008255	2.019784	0.018465	91.81601
X102074-site 11 ms p.17	46.05949	0.514065	34.40711	9.974137	0.008045	1.556648	0.017819	92.53732
X102074-site 11 ms p.18	45.26794	0.978383	31.45955	10.19097	0.008115	4.039567	0	91.94452

Element/Oxide	SiO2	MgO	Al2O3	K2O	CaO	FeO	MnO	Total
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
Sample								
X102074-site 11 ms p.19	45.24655	0.829138	32.21534	10.50416	0.008395	2.611567	0	91.41515
X102074-site 11 ms p.20	46.18784	1.310038	29.94798	10.28733	0.008045	3.898054	0	91.6393
X102074-site 12 ms p.1	45.33212	0.66331	33.82138	10.31143	0.008045	2.289946	0.018529	92.44476
X102074-site 12 ms p.2	45.88834	1.011548	32.0075	10.4078	0.008185	3.126162	0.018787	92.46832
X102074-site 12 ms p.3	44.7759	0.812555	31.93192	9.733216	0	2.238486	0.017044	89.50912
X102074-site 12 ms p.4	46.05949	1.077879	31.49734	10.31143	0.008185	3.512108	0	92.46643
X102074-site 12 ms p.5	45.88834	0.945217	32.38539	10.21506	0.008255	2.727351	0.0184	92.18801
X102074-site 12 ms p.6	45.95252	1.077879	30.38256	10.31143	0.008115	4.193946	0.019175	91.94562
X102074-site 12 ms p.7	46.08088	0.994965	31.78076	10.34756	0.008605	2.907459	0	92.12024
X102074-site 12 ms p.8	45.88834	1.028131	31.40287	10.17892	0.008185	3.216216	0.018787	91.74145
X102074-site 12 ms p.9	45.63162	0.912052	32.21534	10.23915	0.008325	2.946054	0	91.95254
X102074-site 12 ms p.10	46.6371	0.945217	31.70518	10.34756	0.008325	2.560108	0	92.2035
X102074-site 12 ms p.11	45.56744	0.563814	34.23706	10.11869	0.008185	1.87827	0	92.37347
X102074-site 12 ms p.12	46.08088	0.978383	31.72408	10.44393	0.008395	2.663027	0	91.8987
X102074-site 12 ms p.13	45.73859	0.928634	32.23423	10.44393	0.008395	3.023243	0	92.37703
X102074-site 12 ms p.14	45.90973	0.994965	31.32729	10.15483	0.008255	3.550702	0	91.94578
X102074-site 12 ms p.15	45.90973	1.011548	31.45955	10.29938	0.008255	3.126162	0.017883	91.83252
X102074-site 12 ms p.16	45.73859	0.994965	31.78076	10.34756	0.008115	3.383459	0.018529	92.27198
X102074-site 12 ms p.17	46.40178	1.111045	30.9305	9.950045	0.008255	3.627892	0	92.02952
X102074-site 12 ms p.18	45.61023	0.862303	32.25313	10.29938	0.008185	3.190486	0	92.22371
X102074-site 12 ms p.19	45.97391	1.011548	31.79966	10.29938	0.008325	2.868865	0.018206	91.97989
X102074-site 12 ms p.20	46.20924	1.376369	28.96546	10.11869	0.008255	4.374054	0.018852	91.07092
X102074-site 12 ms p.21	45.99531	0.912052	30.72266	10.15483	0.008325	3.975243	0.018981	91.7874
X102074-site 12 ms p.22	46.53014	1.094462	31.11945	10.14278	0.008325	3.409189	0	92.30434
X102074-site 12 ms p.23	45.99531	1.177376	30.00467	9.84163	0.008465	4.013837	0.018335	91.05962
X102074-site 12 ms p.24	46.05949	1.011548	31.72408	9.564571	0.008325	3.074702	0.018465	91.46118
X102074-site 13 ms p.1	45.88834	1.011548	31.59182	10.07051	0.008255	3.319135	0.018465	91.90806
X102074-site 13 ms p.2	46.20924	1.127628	30.9494	10.17892	0.008115	3.75654	0	92.22984
X102074-site 13 ms p.3	45.35351	0.630145	34.06701	10.55235	0.008465	1.955459	0.018594	92.58553
X102074-site 13 ms p.4	46.14506	1.210541	30.55261	10.05846	0.008465	3.640756	0.01769	91.63358
X102074-site 13 ms p.5	45.86695	1.044714	31.44066	10.07051	0.008115	3.409189	0.018852	91.85898
X102074-site 13 ms p.6	45.54605	0.994965	31.11945	10.32347	0.008465	3.975243	0.018013	91.98566
X102074-site 13 ms p.7	46.12367	0.994965	32.06418	10.43189	0.008115	3.023243	0	92.64606
X102074-site 13 ms p.8	46.08088	0.9618	31.72408	10.5403	0.008255	2.778811	0.018335	92.11246
X102074-site 13 ms p.9	46.18784	1.044714	31.13834	10.26324	0.008185	3.550702	0	92.19303
X102074-site 13 ms p.10	45.75998	0.9618	31.91302	10.37166	0.008325	3.357729	0.017432	92.38995
X102074-site 13 ms p.11	46.08088	0.978383	32.3665	10.23915	0.008255	2.881729	0.018077	92.57297
X102074-site 13 ms p.12	45.56744	0.9618	31.61071	10.2271	0.008535	3.627892	0	92.00348
X102074-site 13 ms p.13	46.87243	0.994965	31.23282	10.19097	0.008465	2.971783	0.018142	92.28957
X102074-site 13 ms p.14	45.3749	0.713059	33.36791	10.2512	0.008045	2.405729	0.018271	92.13912
X102074-site 13 ms p.15	46.25202	0.9618	32.46097	10.11869	0.008395	2.701621	0.019304	92.5228
X102074-site 13 ms p.16	45.6958	0.729641	33.57575	10.28733	0.008045	2.392865	0	92.68944
X102074-site 13 ms p.17	46.14506	1.094462	31.61071	10.19097	0.008395	3.319135	0.019175	92.3879
X102074-site 13 ms p.18	46.0167	0.994965	31.72408	10.20301	0.008395	3.048973	0.018529	92.01465
X102074-site 13 ms p.19	46.57292	1.028131	31.83745	10.17892	0.008255	2.778811	0	92.40448
X102074-site 13 ms p.20	45.54605	1.028131	31.76187	10.33552	0.008325	2.868865	0	91.54876
X102074-site 13 ms p.21	44.62614	0.66331	33.48128	10.3837	0.008325	2.225621	0	91.38838
X102074-site 13 ms p.22	45.78137	0.862303	32.49876	10.50416	0.008185	2.675892	0	92.33068
X102074-site 13 ms p.23	44.28385	0.630145	33.72691	10.21506	0.008325	2.199892	0	91.06418
X102074-site 13 ms p.24	46.08088	0.895469	32.25313	10.45598	0.008115	2.740216	0	92.43379
X102074-site 13 ms p.25	45.84555	0.812555	32.64991	10.26324	0.008395	2.740216	0.018529	92.33841
X102074-site 13 ms p.26	45.13958	0.729641	32.6877	10.2512	0.008185	3.190486	0.018465	92.02526
X102074-site 13 ms p.27	45.99531	0.912052	32.3476	10.04641	0.008045	2.688756	0.0184	92.01657
X102074-site 13 ms p.28	45.50326	0.862303	32.23423	10.05846	0.008255	2.611567	0.018916	91.297

Appendix6: Electron microprobe analyses of chlorite

Element/ C	SiO2	MgO	Al2O3	K2O	CaO	FeO	MnO	TiO2	Total
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
Sample									
X26312 site	23.25865	6.027833	20.04531	0	0.030782	37.26308	0.170442	0.058381	86.85447
X26312 site	22.71098	5.644771	20.10577	0	0.054568	37.2232	0.171733	0.035029	85.94605
X26312 site	22.85004	5.785724	20.32873	0	0.043375	37.24249	0.183354	0.051709	86.48543
X26312 site	22.98268	5.911753	19.91872	0	0.041976	37.04695	0.185937	0.055045	86.14305
X26312 site	22.90994	5.858688	19.97729	0	0.043375	37.26694	0.135579	0.041701	86.23351
X26312 site	23.10462	5.89517	19.91683	0	0.082552	37.13572	0.149782	0.056713	86.34138
X26312 site	23.03402	6.01125	20.04531	0	0.041976	37.20647	0.176898	0.058381	86.57431
X26312 site	23.02974	5.941602	20.0642	0	0.039177	37.48178	0.184646	0.046705	86.78786
X26312 site	23.19875	6.057681	19.81857	0	0.03498	37.07268	0.174316	0.061717	86.41869
X26312 site	22.75805	5.749242	20.23803	0	0.03358	37.3467	0.166568	0.045037	86.33721
X26312 site	23.1795	5.974768	19.94139	0	0.029383	37.21419	0.169151	0.060049	86.56843
X26312 site	23.48114	6.233459	19.51815	0	0.030782	36.98906	0.166568	0.046705	86.46586
X26312 site	23.25865	5.95321	19.97729	0	0.030782	37.38915	0.175607	0.053377	86.83807
X26312 site	23.06397	5.873613	20.21536	0	0.026585	37.60271	0.163986	0.053377	86.9996
X26312 site	23.23084	6.037782	19.94139	0	0.039177	37.30425	0.160112	0.045037	86.75858
X26312 site	23.07253	5.825523	20.1549	0	0.044774	37.15373	0.178189	0.055045	86.48468
X26312 site	22.87785	5.820548	20.28716	0	0.048972	37.14215	0.163986	0.043369	86.38403
X26312 site	23.15168	5.81889	20.14923	0	0.03498	37.54482	0.170442	0.053377	86.92342
X26312 site	22.95273	5.787383	20.34007	0	0.023786	37.29009	0.173024	0.056713	86.62379
X26312 site	22.85646	5.845422	20.34573	0	0.03498	37.13314	0.149782	0.050041	86.41556
X26312 site	22.21252	5.384421	21.30558	0	0.041976	37.1846	0.192393	0.048373	86.36987
X26312 site	23.14313	5.986376	19.99807	0	0.053169	37.05981	0.198849	0.071725	86.51113
X26312 site	22.99551	5.830498	20.23803	0	0.036379	36.75749	0.178189	0.050041	86.08614
X26312 site	22.5869	5.641454	20.48744	0	0.043375	37.28366	0.1472	0.065053	86.25509
X26312 site	22.96556	5.807282	20.10955	0	0.046173	37.06753	0.1472	0.050041	86.19334
X26312 site	23.30144	5.973109	19.93572	0	0.037778	36.87199	0.153656	0.053377	86.32706
X26312 site	22.89069	5.865321	19.99051	0	0.039177	37.2605	0.15753	0.046705	86.25044
X26312 site	22.98482	5.833814	20.05854	0	0.022387	37.00192	0.165277	0.046705	86.11346
X26312 site	22.82651	5.716077	20.10199	0	0.03498	37.07911	0.163986	0.048373	85.97103
X26312 site	22.93561	5.883563	20.24748	0	0.022387	37.43675	0.151074	0.035029	86.7119
X26312 site	23.07681	5.893512	19.88848	0	0.032181	37.08297	0.173024	0.048373	86.19535

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X26312 site11 chl p.4	23.28646	6.080897	19.64096	0	0.018189	37.22963	0.196267	0.046705	86.49911
X26312 site11 chl p.5	22.95273	5.858688	20.13222	0	0.022387	37.41102	0.134288	0.033361	86.5447
X26312 site11 chl p.6	22.63397	5.583415	20.47989	0	0.040576	37.23863	0.166568	0.033361	86.17641
X26312 site11 chl p.7	23.09392	5.925019	20.23803	0	0.019589	37.05338	0.165277	0.058381	86.5536
X26312 site11 chl p.8	22.94417	5.880246	20.12089	0	0.036379	37.37114	0.160112	0.056713	86.56965
X26312 site11 chl p.9	23.50253	6.211901	19.61451	0	0.025185	37.21548	0.138161	0.061717	86.76949
X26312 site11 chl p.10	23.31855	5.961501	19.82991	0	0.023786	37.19361	0.169151	0.043369	86.53988
X26312 site11 chl p.11	23.31213	6.090847	19.71276	0	0.029383	37.35185	0.144617	0.061717	86.70331
X26312 site11 chl p.12	22.90566	5.901804	20.25504	0	0.030782	37.25793	0.151074	0.051709	86.554
X26312 site11 chl p.13	23.14313	5.813915	20.19647	0	0.030782	37.52552	0.156239	0.045037	86.91109
X26312 site11 chl p.14	23.05114	5.862005	20.13411	0	0.037778	37.60014	0.185937	0.048373	86.91948
X26312 site11 chl p.15	22.97626	5.860347	19.94706	0	0.039177	37.46377	0.153656	0.041701	86.48197
X26312 site11 chl p.16	22.92064	5.837131	20.08499	0	0.030782	37.21033	0.163986	0.045037	86.29289
X26312 site11 chl p.17	23.19019	5.926678	20.01319	0	0.025185	37.30167	0.154947	0.055045	86.66691
X26312 site11 chl p.18	22.97198	5.825523	20.22481	0	0.050371	37.68762	0.153656	0.045037	86.95899
X26312 site11 chl p.19	23.25009	6.077581	19.88093	0	0.03358	37.55382	0.187228	0.068389	87.05162
X26312 site11 chl p.20	23.21158	5.956527	19.75811	0	0.046173	36.93888	0.152365	0.040033	86.10368
X26312 site11 chl p.21	22.86288	5.951552	20.08688	0	0.025185	37.04695	0.16786	0.040033	86.18133
X26312 site11 chl p.22	22.89497	5.870296	20.14167	0	0.023786	37.01479	0.16786	0.036697	86.15006
X26312 site11 chl p.23	22.91422	5.689544	20.37597	0	0.037778	37.44447	0.148491	0.028357	86.63883
X26312 site11 chl p.24	22.7281	5.794016	20.51012	0	0.022387	37.31196	0.163986	0.046705	86.57727
X26312 site11 chl p.25	22.92278	5.871955	20.04909	0	0.027984	37.00192	0.169151	0.043369	86.08624
X26312 site11 chl p.26	22.96984	5.880246	20.31361	0	0.03498	37.32997	0.16786	0.033361	86.72988
X26312 site11 chl p.27	22.2767	5.283267	21.05239	0	0.032181	37.4226	0.158821	0.023352	86.24932
X26312 site11 chl p.28	22.25103	5.415929	21.33959	0	0.039177	37.0804	0.176898	0.026689	86.32971
X26312 site11 chl p.29	23.07039	5.971451	20.02641	0	0.01679	37.17431	0.161403	0.033361	86.45412
X26312 site11 chl p.30	22.94203	5.926678	20.16812	0	0.020988	37.43547	0.169151	0.038365	86.7008
X26312 site12 chl p.1	23.39343	6.006275	19.95839	0	0.006996	37.83299	0.183354	0.065053	87.44649
X26312 site12 chl p.2	22.21038	5.464019	20.92769	0	0.01679	37.86901	0.127832	0.046705	86.66243
X26312 site12 chl p.3	21.79964	5.225227	21.37549	0	0.008325	37.77253	0.173024	0.053377	86.40761
X26312 site12 chl p.4	23.10248	5.925019	19.96217	0	0.008325	37.62329	0.180772	0.080066	86.88213

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X26312 site12 chl p.5	22.55268	5.465677	20.70662	0	0.008535	37.60271	0.161403	0.053377	86.551
X26312 site12 chl p.6	22.69601	5.767483	20.1908	0	0.008465	37.71721	0.185937	0.068389	86.63429
X26312 site12 chl p.7	22.22536	5.316432	21.05806	0	0.020988	37.94492	0.173024	0.055045	86.79383
X26312 site12 chl p.8	22.43501	5.508792	20.87667	0	0.008395	37.60657	0.187228	0.048373	86.67104
X26312 site12 chl p.9	22.44357	5.449094	20.85967	0	0.008675	37.89603	0.152365	0.048373	86.85777
X26312 site12 chl p.10	22.70457	5.694519	20.38919	0	0.008605	37.7751	0.148491	0.048373	86.76885
X26312 site12 chl p.11	22.80939	5.749242	20.2626	0	0.008605	37.65417	0.176898	0.070057	86.73096
X26312 site12 chl p.12	22.5484	5.570148	20.57625	0	0.008815	37.8034	0.171733	0.046705	86.72545
X26312 site12 chl p.13	22.32591	5.444119	20.81243	0	0.01679	38.01696	0.170442	0.060049	86.8467
X26312 site12 chl p.14	22.38795	5.467335	20.79732	0	0.008325	37.64002	0.187228	0.053377	86.54155
X26312 site12 chl p.15	22.4885	5.669645	20.22103	0	0.013992	37.28237	0.175607	0.053377	85.90452
X26312 site12 chl p.16	22.52914	5.464019	20.68773	0	0.008325	37.75966	0.160112	0.053377	86.66236
X26312 site12 chl p.17	22.58477	5.573465	20.84266	0	0.008535	38.05169	0.138161	0.040033	87.23932
X26312 site12 chl p.18	22.83079	5.677936	20.4232	0	0.008815	37.95135	0.15753	0.046705	87.09632
X26312 site12 chl p.19	22.54412	5.604972	20.51579	0	0.013992	37.84071	0.165277	0.051709	86.73656
X26312 site12 chl p.20	22.55909	5.613264	20.18324	0	0.013992	37.65288	0.170442	0.043369	86.23628
X26312 site12 chl p.21	22.61899	5.591706	19.71843	0	0.008535	37.75966	0.152365	0.043369	85.89306
X26312 site12 chl p.22	22.79228	5.653062	20.43454	0	0.008465	37.82656	0.151074	0.060049	86.92603
X26312 site12 chl p.23	22.89069	5.729343	20.03397	0	0.008535	37.19361	0.153656	0.046705	86.05651
X26312 site12 chl p.24	22.7174	5.522058	20.37974	0	0.019589	37.77639	0.148491	0.050041	86.61371
X26312 site12 chl p.25	23.13885	5.800649	19.76189	0	0.008535	37.8986	0.142035	0.050041	86.8006
X26312 site12 chl p.26	23.07895	6.057681	19.70332	0	0.013992	37.32097	0.182063	0.065053	86.42202
X26312 site12 chl p.27	23.00621	5.785724	20.14734	0	0.008395	37.69534	0.156239	0.056713	86.85596
X26312 site12 chl p.28	22.0478	5.245126	20.98626	0	0.008605	38.01439	0.149782	0.043369	86.49533
X26312 site12 chl p.29	22.8479	5.79899	20.43265	0	0.015391	37.68504	0.163986	0.055045	86.99901
X26312 site12 chl p.30	22.95915	5.701152	20.63104	0	0.008535	37.88188	0.143326	0.071725	87.3968
X26312 site12 chl p.31	22.56123	5.465677	20.90313	0	0.008465	37.8986	0.15753	0.056713	87.05134
X26312 site12 chl p.32	22.3473	5.457386	20.82755	0	0.008745	37.8986	0.138161	0.055045	86.73279
X26312 site12 chl p.33	22.84576	5.699494	20.11333	0	0.019589	37.58727	0.148491	0.038365	86.4523
X26312 site12 chl p.34	22.88641	5.759192	20.15301	0	0.01679	37.72235	0.160112	0.056713	86.75458
X26312 site12 chl p.35	22.60402	5.595023	20.77275	0	0.008605	37.94234	0.154947	0.040033	87.11772
X26312 site12 chl p.36	22.9784	5.709444	20.30228	0	0.015391	37.4702	0.149782	0.058381	86.68388
X26312 site12 chl p.37	22.68317	5.550249	20.58192	0	0.008675	37.83042	0.154947	0.053377	86.86276
X26312 site12 chl p.38	22.53984	5.538641	20.62726	0	0.008605	37.39559	0.160112	0.051709	86.32176

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X26312 site12 chl p.39	22.7388	5.545274	20.69528	0	0.008535	37.78796	0.144617	0.048373	86.96884
X26312 site12 chl p.40	23.19233	5.794016	20.41564	0	0.008255	37.83556	0.143326	0.056713	87.44585
X26312 site13 chl p.1	22.57835	5.497184	20.77275	0	0.013992	37.94234	0.163986	0.061717	87.03032
X26312 site13 chl p.2	23.05541	5.911753	20.26071	0	0.053169	38.05169	0.197558	0.065053	87.59535
X26312 site13 chl p.3	22.74735	5.79899	20.20213	0	0.041976	37.55125	0.166568	0.060049	86.56832
X26312 site13 chl p.4	22.69601	5.658037	20.31361	0	0.008535	37.55564	0.171733	0.055045	86.45937
X26312 site13 chl p.5	22.77516	5.62653	20.61971	0	0.008395	37.64259	0.169151	0.055045	86.89658
X26312 site13 chl p.6	22.42004	5.444119	20.92391	0	0.018189	37.50751	0.16786	0.053377	86.535
X26312 site13 chl p.7	23.13457	6.004617	19.70898	0	0.008255	37.7082	0.156239	0.066721	86.78759
X26312 site13 chl p.8	22.86074	5.669645	20.4062	0	0.008465	37.89474	0.175607	0.050041	87.06543
X26312 site13 chl p.9	23.63945	6.13562	19.46335	0	0.015391	37.39044	0.161403	0.070057	86.87571
X26312 site13 chl p.10	22.30665	5.31809	21.11097	0	0.008325	37.93076	0.15753	0.041701	86.87403
X26312 site13 chl p.11	22.76447	5.598339	20.37408	0	0.013992	37.61686	0.144617	0.045037	86.55739
X26312 site13 chl p.12	22.81795	5.709444	20.5139	0	0.008395	37.95006	0.15753	0.055045	87.21232
X26312 site13 chl p.13	22.90994	5.772458	19.97162	0.001205	0.025185	37.60914	0.187228	0.065053	86.54183
X26312 site13 chl p.14	22.58904	5.48226	20.58003	0	0.019589	37.7275	0.15753	0.043369	86.59932
X26312 site13 chl p.15	22.33019	5.333015	20.66694	0	0.008535	37.71849	0.187228	0.048373	86.29277
X26312 site13 chl p.16	22.28312	5.281608	20.78409	0	0.019589	37.55897	0.15753	0.068389	86.1533
X26312 site13 chl p.17	22.71526	5.679595	20.27771	0	0.023786	37.37886	0.179481	0.050041	86.30474
X26312 site13 chl p.18	22.43715	5.389396	20.871	0	0.008395	37.76223	0.174316	0.048373	86.69087
X26312 site13 chl p.19	22.56551	5.470652	20.68017	0	0.008395	37.70563	0.144617	0.051709	86.62668
X26312 site13 chl p.20	23.57955	6.228484	18.92297	0	0.011193	37.22834	0.170442	0.066721	86.2077
X26312 site13 chl p.21	23.1795	5.996325	19.72599	0	0.015391	37.69019	0.156239	0.061717	86.82535
X26312 site13 chl p.22	22.50989	5.477285	20.84266	0	0.008255	37.70177	0.156239	0.043369	86.73947
X26312 site13 chl p.23	22.5976	5.580098	20.60081	0	0.008325	37.65803	0.165277	0.048373	86.65851
X26312 site13 chl p.24	22.89069	5.76085	20.51579	0	0.008325	37.90503	0.166568	0.056713	87.30396
X26312 site13 chl p.25	22.25745	5.347939	21.11663	0	0.011193	37.70177	0.153656	0.048373	86.63702
X26312 site13 chl p.26	22.94845	5.923361	19.78645	0	0	37.55382	0.193684	0.065053	86.47082
X26312 site13 chl p.27	23.20089	5.704469	19.75433	0	0.013992	38.16876	0.160112	0.050041	87.0526
X26312 site13 chl p.28	23.33994	6.094164	19.54838	0	0.008395	37.61557	0.174316	0.060049	86.84082
X26312 site13 chl p.29	22.89497	5.740951	20.22292	0	0.009794	37.604	0.163986	0.053377	86.68999
X26312 site13 chl p.30	22.40934	5.518742	20.45343	0	0.026585	37.73522	0.151074	0.053377	86.34777
X26313 site3 chl p.1	22.08416	4.261769	20.56869	0	0	39.74214	0.098133	0.041701	86.7966
X26313 site3 chl p.2	22.24034	4.37619	20.478	0	0.008395	39.75629	0.08393	0.046705	86.98984

Element/ Oxide	SiO2	MgO	Al2O3	K2O	CaO	FeO	MnO
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %
Sample							
X26313 site4 chl p.7	22.0863	4.187146	20.5498	0	0.009794	40.00715	0.085221
X26313 site4 chl p.8	27.27415	3.659815	18.36558	4.020975	0.018189	35.5855	0.0736
X26313 site4 chl p.9	21.90018	4.109207	20.94469	0	0	40.08692	0.077474
X26313 site4 chl p.10	21.84884	4.160614	20.89935	0	0.008325	39.94669	0.100716
X26313 site4 chl p.11	22.12053	4.31815	20.478	0	0.008465	40.08434	0.09426
X26313 site4 chl p.12	22.0478	4.17388	20.69717	0	0.008395	40.02002	0.072309
X26313 site4 chl p.13	22.12695	4.255136	20.7992	0	0.008535	39.86307	0.105881
X26313 site4 chl p.14	22.03068	4.187146	20.43076	0	0	39.94412	0.08393
X26313 site4 chl p.15	22.05635	4.23192	20.79543	0	0	39.46554	0.089095
X26313 site4 chl p.16	22.09486	4.230262	20.46855	0	0.009794	40.09077	0.072309
X26313 site4 chl p.17	22.07133	4.308201	20.8899	0	0.025185	39.5556	0.100716
X26313 site4 chl p.18	22.1676	4.324783	20.23992	0.020478	0.008255	39.66237	0.087803
X26313 site4 chl p.19	22.23392	4.304884	20.38541	0	0	39.55302	0.099425
X26313 site4 chl p.20	22.13123	4.258452	20.478	0	0.006996	39.92996	0.077474
X26313 site4 chl p.21	22.20397	4.331416	20.32684	0	0	39.82576	0.090386
X26313 site4 chl p.22	22.32591	4.341366	20.36085	0	0.009794	39.76658	0.086512
X26313 site4 chl p.23	22.99979	4.095941	19.82424	0.632418	0.008395	39.57747	0.076182
X26313 site4 chl p.25	22.10984	4.253477	20.495	0.018069	0.020988	39.74857	0.086512
X26313 site4 chl p.26	22.13979	4.281668	20.75953	0	0.008325	39.71126	0.087803
X26313 site4 chl p.27	22.36442	4.158956	20.50823	0.232489	0.008465	39.58647	0.081347
X26313 site4 chl p.28	22.38367	4.359607	20.3703	0	0.009794	39.72413	0.118793
X26313 site4 chl p.29	22.04352	4.265085	20.58192	0	0.015391	39.68553	0.092968
X26313 site4 chl p.30	22.16332	4.253477	20.42509	0	0.012593	39.92096	0.065853
X26313 site 9 chl p.1	22.1077	4.379506	20.52334	0	0.008465	39.62507	0.103298
X26313 site 9 chl p.2	22.18899	4.36624	20.5309	0	0.008465	39.47969	0.103298
X26313 site 9 chl p.3	22.19755	4.334733	20.60459	0	0	39.86564	0.065853
X26313 site 9 chl p.4	22.10128	4.41433	20.63671	0	0.008465	39.41666	0.09426
X26313 site 9 chl p.5	22.17188	4.404381	20.48178	0	0.008395	39.29701	0.09426
X26313 site 9 chl p.6	22.07989	4.298251	20.50067	0	0.008675	39.34461	0.102007
X26313 site 9 chl p.7	21.91302	4.261769	20.63671	0	0.008395	39.1645	0.105881
X26313 site 9 chl p.8	22.21894	4.3281	20.19647	0	0.008395	39.41923	0.08393
X26313 site 9 chl p.9	22.31307	4.407697	20.10388	0	0.008465	39.66366	0.095551
X26313 site 9 chl p.10	21.99004	4.303226	20.57814	0.001205	0.008325	39.15679	0.086512
X26313 site 9 chl p.11	22.16332	4.343024	20.46477	0	0.008465	39.50285	0.081347

TiO2 wt %	Total wt %
0.065053	86.99047
1.276046	90.27385
0.051709	87.17018
0.050041	87.01457
0.043369	87.14712
0.051709	87.07128
0.056713	87.21549
0.066721	86.74335
0.041701	86.68004
0.045037	87.01159
0.058381	87.00931
0.068389	86.57961
0.048373	86.62503
0.043369	86.92548
0.053377	86.83174
0.061717	86.95273
0.273558	87.488
0.063385	86.79584
0.036697	87.02507
0.145119	87.08549
0.065053	87.03134
0.041701	86.72611
0.045037	86.88633
0.050041	86.79742
0.038365	86.71595
0.036697	87.10506
0.033361	86.70506
0.026689	86.48439
0.041701	86.3758
0.021684	86.11196
0.046705	86.30177
0.041701	86.63403
0.053377	86.1776
0.033361	86.59714

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X26313 site 9 chl p.12	22.09272	4.407697	20.52145		0 0.008465	39.52343	0.090386	0.030025	86.67418
X26313 site 9 chl p.13	22.1676	4.36624	20.6386		0 0.008395	39.44367	0.095551	0.036697	86.75675
X26313 site 9 chl p.14	22.07347	4.178855	20.41375		0 0.015391	39.67138	0.067144	0.050041	86.47003
X26313 site 9 chl p.15	22.25531	4.503877	20.40998		0 0.008535	39.59548	0.103298	0.035029	86.9115
X26313 site 9 chl p.16	22.16118	4.396089	20.32117		0 0	39.45911	0.077474	0.043369	86.45839
X26313 site 9 chl p.17	22.16332	4.251819	20.51201		0 0.008395	39.64951	0.100716	0.045037	86.7308
X26313 site 9 chl p.18	22.24034	4.216995	20.64238	0.163826	0 0.008535	39.54016	0.072309	0.105086	86.98962
X26313 site 9 chl p.19	22.1569	4.333075	20.19647		0 0.008465	39.57747	0.080056	0.035029	86.38746
X26313 site 9 chl p.20	22.15048	4.314834	20.64805		0 0.008325	39.56589	0.076182	0.045037	86.8088
X26313 site 9 chl p.21	22.34302	4.409355	20.36274		0 0.008395	39.82962	0.103298	0.043369	87.0998
X26313 site 9 chl p.22	22.19113	4.359607	20.42131		0 0.015391	39.33689	0.086512	0.036697	86.44754
X26313 site 9 chl p.24	22.12695	4.326442	20.51012		0 0.009794	39.38964	0.08393	0.030025	86.4769
X26313 site 9 chl p.25	22.26173	4.391114	20.74063		0 0.008255	39.58519	0.096842	0.046705	87.13046
X26313 site 9 chl p.26	22.38795	4.338049	20.34384		0 0.008675	39.76787	0.108463	0.038365	86.99321
X26313 site 9 chl p.27	22.19755	4.401064	20.67261		0 0	39.52601	0.107172	0.050041	86.95444
X26313 site 9 chl p.28	22.15048	4.333075	20.89746		0 0	39.41666	0.113628	0.038365	86.94966
X26313 site 9 chl p.29	22.21466	4.338049	20.58381		0 0.008325	39.14392	0.103298	0.026689	86.41875
X26313 site 9 chl p.30	22.16118	4.374532	20.57814		0 0.008395	39.32274	0.087803	0.046705	86.5795
X11308-site 6 chl p.1	24.32403	3.830617	16.77843		0 0.041976	43.12302	0.020079	0.011843	88.12999
X11308-site 6 chl p.2	24.38821	3.797452	17.00516		0 0.027984	43.32886	0.020143	0.011676	88.57949
X11308-site 6 chl p.3	24.1101	3.681372	17.26969		0 0.111935	43.03297	0.020918	0.011843	88.23882
X11308-site 6 chl p.4	24.36682	3.697955	16.8918		0 0.083951	43.09729	0.019433	0.011843	88.16909
X11308-site 6 chl p.5	24.1101	3.797452	17.02406		0 0.008185	43.32886	0.020208	0.01176	88.30062
X11308-site 6 chl p.6	24.53796	3.913531	17.11853		0 0.041976	43.20021	0.020014	0.012093	88.84432
X11308-site 6 chl p.7	24.51657	3.498962	17.26969		0 0.041976	43.14875	0.020079	0.011843	88.50787
X11308-site 6 chl p.8	24.32403	3.498962	17.55311		0 0.041976	43.22594	0.020208	0.011676	88.6759
X11308-site 6 chl p.9	24.47378	3.664789	17.213		0 0.008395	43.22594	0.019691	0.011593	88.6172
X11308-site 6 chl p.10	24.4096	3.880365	17.08074		0 0.008185	43.11016	0.01982	0.01176	88.52063
X11308-site 6 chl p.11	24.04592	3.764286	17.19411		0 0.027984	43.23881	0.020079	0.012093	88.30328
X11308-site 6 chl p.12	24.28124	3.896948	17.11853		0 0.027984	42.86573	0.02066	0.011843	88.22293
X11308-site 6 chl p.13	24.28124	3.880365	16.98627		0 0.008115	42.76281	0.019627	0.01201	87.95044
X11308-site 6 chl p.14	24.60214	3.8472	17.19411		0 0.027984	42.90432	0.020079	0.01176	88.60759
X11308-site 6 chl p.15	24.66632	3.8472	16.77843		0 0.041976	43.08443	0.01982	0.01176	88.44993
X11308-site 6 chl p.16	24.30264	3.631624	17.06185		0 0.069959	43.16162	0.019691	0.011593	88.25897

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X11308-site 6 chl p.17	23.89617	3.581876	17.40195	0	0.008255	43.21308	0.019691	0.011843	88.13286
X11308-site 6 chl p.18	24.28124	3.764286	17.30748	0	0.027984	43.21308	0.019756	0.012093	88.62592
X11308-site 6 chl p.19	24.32403	3.780869	17.213	0	0.008395	43.00724	0.020337	0.011843	88.36572
X11308-site 10 chl p.1	24.60214	3.714538	17.17522	0	0.055967	43.21308	0.020466	0.01176	88.79316
X11308-site 10 chl p.2	24.23846	3.416048	17.32637	0	0.153911	43.35459	0.020014	0.01201	88.5214
X11308-site 10 chl p.3	24.66632	3.747703	17.19411	0	0.041976	43.22594	0.020401	0.011843	88.9083
X11308-site 10 chl p.4	23.96035	3.54871	17.45863	0	0.097943	43.22594	0.020208	0.011676	88.32346
X11308-site 10 chl p.5	24.79468	3.930114	16.57059	0	0.027984	42.86573	0.020014	0.033361	88.24246
X11308-site 10 chl p.6	24.38821	3.565293	17.26969	0	0.069959	43.0587	0.019949	0.01201	88.38381
X11308-site 10 chl p.7	24.21706	3.681372	17.08074	0	0.041976	42.93005	0.020079	0.01201	87.98329
X11308-site 10 chl p.8	24.13149	3.648207	17.2319	0	0.041976	43.03297	0.019627	0.01201	88.11818
X11308-site 10 chl p.9	24.28124	3.631624	17.19411	0	0.041976	43.11016	0.020208	0.012177	88.2915
X11308-site 10 chl p.10	24.58075	3.697955	16.98627	0	0.055967	43.17448	0.020401	0.033361	88.54918
X11308-site 10 chl p.11	24.34542	3.498962	17.06185	0.008131	0.069959	42.98151	0.01982	0.01176	87.99741
X11308-site 10 chl p.12	24.04592	3.631624	17.47753	0	0.055967	43.0201	0.020982	0.01176	88.26389
X11308-site 10 chl p.13	24.68771	3.814034	16.58948	0	0.083951	43.00724	0.020272	0.033361	88.23605
X11308-site 10 chl p.14	24.28124	3.648207	17.30748	0	0.069959	43.11016	0.020208	0.012093	88.44935
X11308-site 10 chl p.15	24.04592	3.498962	17.38306	0	0.097943	43.20021	0.019885	0.01176	88.25774
X11308-site 11 chl p.1	24.49517	3.664789	16.96737	0.008131	0.209878	42.73708	0.020014	0.011926	88.11437
X11308-site 11 chl p.2	24.47378	3.482379	16.96737	0.036138	0.37778	42.19675	0.020337	0.011843	87.56639
X11308-site 11 chl p.3	24.21706	1.989931	18.44116	0	0.209878	43.84346	0.020208	0.011843	88.73353
X11308-site 11 chl p.4	24.00313	2.139176	18.36558	0	0.22387	43.61189	0.021176	0.011926	88.37674
X23105-site 5 chl p.1	24.70911	2.802486	16.41943	0.024092	0.111935	42.56983	0.020079	0.011593	86.66856
X23105-site 5 chl p.2	24.77329	2.868817	17.572	0.00789	0.069959	41.92659	0.020595	0.011843	87.25098
X23105-site 5 chl p.3	24.88025	2.868817	17.70427	0.012046	0.041976	41.74648	0.020208	0.011843	87.28589
X23105-site 5 chl p.4	24.81607	2.669824	17.28858	0.008131	0.041976	41.90086	0.020401	0	86.74585
X23105-site 5 chl p.5	24.85886	2.802486	17.13743	0.008191	0.027984	42.05524	0.020337	0.01176	86.92228
X23105-site 5 chl p.6	24.79468	2.785903	17.25079	0.008131	0.041976	41.77221	0.019175	0.01201	86.68488
X23105-site 5 chl p.7	25.43647	2.769321	17.11853	0.240921	0.041976	41.32194	0.020272	0	86.94944
X23105-site 5 chl p.8	24.90164	3.117558	16.92959	0.072276	0.055967	41.96519	0	0	87.04222
X23105-site 5 chl p.9	25.00861	3.299969	17.15632	0.024092	0.111935	41.51491	0.019433	0	87.13528
X23105-site 5 chl p.10	25.45787	3.06781	15.90928	0.072276	0.139919	42.18389	0	0.011926	86.84296
X23105-site 5 chl p.11	25.17976	2.901983	16.26827	0.024092	0.097943	42.31254	0.019949	0.01176	86.81629
X23105-site 5 chl p.12	24.55935	2.819069	17.15632	0.008432	0.083951	41.90086	0.019691	0.01176	86.55944

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X23105-site 5 chl p.13	24.58075	2.852234	17.91211	0	0.055967	41.57924	0.020143	0.012177	87.01261
X23105-site 5 chl p.14	26.78424	2.736155	16.81622	0.674579	0.041976	39.86821	0.020595	0.011926	86.9539
X23105-site 5 chl p.15	25.30812	2.901983	16.36275	0.024092	0.139919	42.20962	0.020079	0.012177	86.97873
X23105-site 5 chl p.16	25.11558	2.901983	17.17522	0	0.125927	41.79794	0.020337	0.01176	87.14874
X23105-site 5 chl p.17	24.88025	2.819069	17.51532	0	0.055967	41.92659	0.020208	0.01176	87.22916
X23105-site 5 chl p.18	25.00861	2.852234	17.13743	0	0.083951	42.18389	0.019627	0.011509	87.29725
X23105-site 5 chl p.19	25.88573	3.084393	16.32496	0.06023	0.181894	41.33481	0.019949	0.011843	86.9038
X23105-site 5 chl p.20	25.20115	2.852234	16.70285	0.072276	0.083951	42.26108	0.02066	0	87.1942
X23105-site 5 chl p.21	25.86434	3.06781	16.13601	0.433658	0.139919	41.47632	0.020466	0.011593	87.15011
X23105-site 5 chl p.22	26.05688	3.134141	15.8148	0.301151	0.125927	41.77221	0.02066	0.01176	87.23753
X23105-site 5 chl p.23	25.15836	2.918565	17.32637	0.024092	0.055967	41.96519	0.020466	0.011843	87.48085
X23105-site 5 chl p.24	25.03	2.852234	17.47753	0	0.069959	41.72075	0.019949	0.01176	87.18219
X23105-site 5 chl p.25	24.75189	2.819069	17.08074	0	0.083951	42.18389	0.020337	0	86.93988
X23105-site 5 chl p.26	24.70911	2.901983	17.02406	0	0.083951	41.68216	0.019562	0.011676	86.4325
X23105-site 5 chl p.27	26.16384	3.714538	15.32354	0.008131	0.251854	41.52778	0.01982	0.011926	87.02143
X23105-site 5 chl p.28	25.15836	2.901983	16.57059	0.008131	0.153911	42.24821	0	0	87.04119
X23105-site 5 chl p.29	24.38821	2.819069	17.74205	0	0.041976	41.43773	0.019885	0.01176	86.46068
X23105-site 5 chl p.30	24.7305	2.918565	17.76095	0	0.041976	41.69502	0.019949	0	87.16696
X23105-site 5 chl p.31	25.09418	2.802486	16.81622	0	0.055967	42.45405	0	0.011926	87.23483
X23105-site 5 chl p.32	25.26533	2.819069	16.83511	0.008071	0.097943	42.14529	0.020079	0.011843	87.20274
X23105-site 5 chl p.33	24.92304	2.819069	16.55169	0.008071	0.111935	42.26108	0.019756	0	86.69464
X23105-site 5 chl p.34	25.13697	2.8854	16.21159	0	0.125927	42.31254	0.019885	0.011843	86.70415
X23105-site 6 chl p.1	25.13697	2.868817	16.60838	0.008011	0.139919	42.95578	0.01982	0.011926	87.74962
X23105-site 6 chl p.2	25.07279	2.769321	17.00516	0	0.097943	42.42832	0.019627	0.011926	87.40509
X23105-site 6 chl p.3	25.15836	2.868817	16.72174	0.036138	0.167902	42.44119	0.020208	0.01176	87.42612
X23105-site 6 chl p.4	25.0514	2.951731	17.213	0	0.083951	42.17102	0.020466	0.011676	87.50325
X23105-site 6 chl p.5	24.98722	2.868817	16.91069	0	0.097943	42.28681	0.019304	0	87.17078
X23105-site 6 chl p.6	26.09966	3.697955	14.92675	0.024092	0.293829	41.65643	0.020079	0.01201	86.73081
X23105-site 6 chl p.7	26.07827	3.681372	14.39771	0.008131	0.349797	42.35113	0.02066	0.012093	86.89916
X23105-site 6 chl p.8	26.9126	4.228603	14.11429	0.024092	0.293829	41.91373	0.020014	0.011676	87.51883
X23105-site 6 chl p.9	25.22254	3.250221	16.15491	0.008071	0.237862	41.70789	0.020079	0.01176	86.61333
X23105-site 6 chl p.10	25.39369	3.316552	15.70143	0.008252	0.181894	42.364	0.020208	0.011843	86.99787
X23105-site 6 chl p.11	25.39369	3.266803	15.55028	0.008191	0.195886	42.42832	0.020272	0.011926	86.87537
X23105-site 6 chl p.12	25.20115	2.951731	16.70285	0.008071	0.167902	41.99091	0.02066	0.011926	87.0552

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X23105-site 6 chl p.13	25.13697	2.951731	17.15632	0.008131	0.083951	41.83654	0.020789	0.011926	87.20636
X23105-site 6 chl p.14	24.88025	2.868817	17.36416	0	0.097943	41.86227	0.020401	0	87.09384
X23105-site 6 chl p.15	24.77329	2.852234	17.76095	0	0.069959	41.46346	0.020337	0	86.94022
X23105-site 6 chl p.16	25.00861	2.835652	17.06185	0.008071	0.055967	42.18389	0.020272	0.011593	87.1859
X23105-site 6 chl p.17	24.92304	2.935148	17.11853	0	0.055967	41.68216	0.019239	0	86.73408
X23105-site 6 chl p.18	25.03	3.001479	17.51532	0	0.055967	41.56637	0.019368	0.011593	87.2001
X23105-site 6 chl p.19	25.26533	3.283386	15.79591	0.008131	0.195886	42.20962	0.019562	0.011926	86.78975
X23105-site 6 chl p.20	25.41508	3.3663	15.90928	0.008191	0.153911	42.49264	0.020079	0.01176	87.37724
X23105-site 6 chl p.21	24.94443	3.018062	16.11712	0.008372	0.22387	42.35113	0.019304	0.011676	86.69396
X23105-site 6 chl p.22	24.53796	2.918565	17.9499	0	0.125927	41.6307	0.020466	0.011926	87.19544
X23105-site 6 chl p.23	24.90164	2.852234	17.42085	0	0.111935	41.97805	0.020337	0.01201	87.29706
X23105-site 6 chl p.24	26.33499	3.963279	14.15208	0.024092	0.335805	41.55351	0	0.012093	86.37584
X23105-site 6 chl p.25	25.41508	3.06781	16.00375	0.008312	0.195886	42.35113	0.02066	0.011843	87.07447
X23105-site 6 chl p.26	24.88025	2.935148	16.38164	0.012046	0.139919	42.35113	0.020079	0.012093	86.73231
X23105-site 6 chl p.27	24.77329	2.819069	17.32637	0	0.055967	41.91373	0	0.01176	86.90018
X23105-site 6 chl p.28	25.13697	2.935148	16.40054	0	0.111935	42.49264	0.020079	0	87.09731
X23105-site 6 chl p.29	24.7305	2.868817	17.09964	0	0.097943	42.20962	0.020789	0.012093	87.0394
X23105-site 6 chl p.30	25.15836	2.8854	16.62727	0.012046	0.153911	42.44119	0.020466	0.011843	87.31048
X23105-site 12 chl p.1	26.12106	3.615041	16.04154	0.012046	0.181894	41.5921	0.020079	0.01226	87.59602
X23105-site 12 chl p.2	25.50065	3.316552	16.24938	0.00783	0.111935	41.54064	0.020208	0	86.7472
X23105-site 12 chl p.3	25.24394	3.150724	16.34385	0.012046	0.139919	41.97805	0.020079	0.012343	86.90095
X23105-site 12 chl p.4	25.26533	3.117558	16.68396	0.00795	0.097943	42.05524	0.020853	0.01176	87.26059
X23105-site 12 chl p.5	24.79468	2.901983	17.213	0	0.083951	42.26108	0	0.011926	87.26662
X23105-site 12 chl p.6	25.13697	2.935148	17.00516	0	0.069959	41.8494	0.020208	0	87.01685
X23105-site 12 chl p.7	24.66632	2.769321	17.36416	0	0.069959	42.49264	0.02066	0	87.38307
X23105-site 12 chl p.8	25.11558	3.3663	15.92817	0.024092	0.251854	41.55351	0.019885	0.012093	86.27148
X23105-site 12 chl p.9	26.31359	4.062776	15.64475	0.008191	0.335805	40.82021	0.020208	0.011843	87.21738
X23105-site 12 chl p.10	24.79468	2.852234	16.92959	0	0.097943	42.17102	0.020595	0	86.86606
X23105-site 12 chl p.11	25.28672	3.084393	16.19269	0.008071	0.181894	42.71135	0.020143	0.011843	87.49711
X23105-site 12 chl p.12	24.85886	2.769321	16.70285	0.00777	0.125927	42.51837	0.020079	0.01176	87.01494
X23105-site 12 chl p.13	24.7305	2.835652	17.40195	0	0.055967	41.83654	0.020272	0.011426	86.8923
X23105-site 12 chl p.14	25.0514	2.852234	16.92959	0	0.097943	42.0681	0.019368	0.011676	87.03031
X23105-site 12 chl p.15	26.03548	3.416048	15.70143	0.008011	0.111935	42.00378	0.019368	0.011676	87.30774
X23105-site 12 chl p.16	24.96582	2.852234	17.04295	0	0.041976	41.56637	0.019239	0.011509	86.50011

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X23105-site 12 chl p.17	24.92304	2.802486	16.81622	0	0.055967	41.75935	0.019949	0.011676	86.38868
X23105-site 12 chl p.18	24.79468	2.984896	17.04295	0.008011	0.125927	41.56637	0.019949	0.011843	86.55463
X23105-site 12 chl p.19	25.03	3.382883	16.06043	0.012046	0.783544	41.1547	0.020272	0.011676	86.45556
X23105-site 12 chl p.20	24.98722	3.051227	17.2319	0.008071	0.139919	41.24475	0.020079	0.011593	86.69476
X23105-site 12 chl p.21	26.03548	3.54871	14.90786	0.024092	0.307821	41.50205	0.020014	0.011509	86.35754
X23105-site 12 chl p.22	26.84842	3.996445	14.88897	0.012046	0.251854	41.19329	0.019885	0.01176	87.22267
X23105-site 12 chl p.23	25.52205	3.233638	16.43833	0.008011	0.167902	41.78508	0.020595	0.01176	87.18735
X23105-site 13 chl p.1	24.75189	3.018062	16.5139	0.012046	0.055967	41.70789	0.020014	0.50041	86.58018
X23105-site 13 chl p.2	24.92304	2.868817	17.28858	0.012046	0.083951	41.83654	0.019756	0.011676	87.0444
X23105-site 13 chl p.3	25.0514	3.001479	17.04295	0.008011	0.083951	42.05524	0.020272	0.011843	87.27515
X23105-site 13 chl p.4	25.20115	2.901983	17.06185	0	0.055967	42.01664	0.019949	0.01176	87.2693
X23105-site 13 chl p.5	24.81607	2.802486	16.55169	0	0.097943	42.84	0.020208	0.01176	87.14016
X23105-site 13 chl p.6	25.13697	2.785903	16.75953	0	0.069959	42.44119	0.020208	0.01176	87.22552
X23105-site 13 chl p.7	24.94443	2.935148	17.11853	0	0.069959	42.04237	0.020595	0.011926	87.14297
X23105-site 13 chl p.8	24.85886	2.951731	16.30606	0.024092	0.125927	42.46691	0.019433	0.011593	86.76461
X23105-site 13 chl p.9	25.60762	3.382883	15.64475	0.012046	0.167902	42.59556	0.020143	0.011926	87.44283
X23105-site 13 chl p.10	25.62901	3.100976	16.02264	0.008011	0.139919	42.99437	0.020079	0.011926	87.92694
X23105-site 13 chl p.11	25.03	2.785903	16.47611	0.008252	0.139919	42.45405	0.020272	0.011676	86.92619
X23105-site 13 chl p.12	25.82155	3.498962	15.32354	0.024092	0.251854	41.92659	0.019885	0.011843	86.87832
X23105-site 13 chl p.13	25.20115	3.266803	15.4747	0.00795	0.167902	42.3254	0.020208	0.011676	86.47579
X23105-site 13 chl p.14	24.62353	2.669824	17.36416	0	0.041976	42.27394	0.019949	0.011343	87.00473
X23105-site 13 chl p.15	25.17976	2.984896	16.06043	0.012046	0.139919	42.65989	0.020208	0.011676	87.06882
X23105-site 13 chl p.16	25.13697	2.852234	16.47611	0	0.097943	42.82713	0.020208	0.011509	87.42211
X23105-site 13 chl p.17	25.50065	3.18389	15.68254	0.008252	0.167902	42.67275	0.020531	0.01176	87.24828
X23105-site 13 chl p.18	25.28672	2.8854	16.85401	0	0.097943	42.09383	0.020079	0.01176	87.24974
X23105-site 13 chl p.19	24.92304	2.868817	17.26969	0	0.069959	41.81081	0	0.011593	86.9539
X23105-site 13 chl p.20	25.52205	3.06781	16.28717	0.012046	0.167902	42.05524	0.019949	0.01176	87.14392
X23105-site 13 chl p.21	24.77329	2.935148	17.53421	0	0.041976	41.68216	0	0.011676	86.97846
X23105-site 13 chl p.22	28.70963	3.416048	14.94565	1.096191	0.237862	38.9934	0.019949	0.01176	87.43049
X23105-site 13 chl p.23	24.90164	2.968314	17.02406	0.012046	0.111935	42.05524	0.020272	0.011426	87.10494
X23105-site 13 chl p.24	24.90164	2.901983	17.64758	0.00783	0.041976	41.82367	0.021047	0.011509	87.35724
X23105-site 13 chl p.25	25.09418	3.06781	15.90928	0.012046	0.139919	42.5827	0.019304	0.011676	86.83691
X23105-site 13 chl p.26	25.28672	3.18389	16.75953	0.008131	0.097943	41.86227	0.019433	0.01201	87.22993
X23105-site 13 chl p.27	25.11558	3.200472	16.85401	0.096368	0.083951	41.69502	0.019885	0.011843	87.07713

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X23105-site 13 chl p.28	26.14245	3.814034	14.64334	0.072276	0.279837	41.33481	0	0.011593	86.29833
X23105-site 13 chl p.29	25.15836	3.266803	16.79732	0.012046	0.097943	42.08097	0.01982	0.01201	87.44528
X23105-site 13 chl p.30	25.09418	3.167307	16.72174	0.012046	0.097943	42.14529	0.020079	0.011676	87.27027
X23105-site 13 chl p.31	25.26533	2.951731	16.24938	0.012046	0.111935	42.68562	0.020401	0.011593	87.30803
X23105-site 13 chl p.32	24.96582	2.835652	17.11853	0.036138	0.055967	42.23535	0.01982	0.011593	87.27887
X23105-site 15 chl p.1	25.94991	3.233638	16.30606	0.024092	0.153911	41.64356	0.01982	0.01201	87.34301
X23105-site 15 chl p.2	25.20115	2.835652	16.70285	0	0.097943	42.20962	0.019498	0.033361	87.10007
X23105-site 15 chl p.3	25.32951	2.852234	16.94848	0.008011	0.069959	41.8494	0.019175	0.01176	87.08853
X23105-site 15 chl p.4	24.96582	2.819069	17.19411	0	0.041976	41.79794	0.019885	0.011593	86.8504
X23105-site 15 chl p.5	25.30812	2.901983	17.00516	0.012046	0.083951	41.5921	0	0.011843	86.91521
X23105-site 15 chl p.6	25.69319	3.299969	16.09822	0.012046	0.209878	41.5921	0	0.011593	86.917
X23105-site 15 chl p.7	24.94443	2.968314	17.68537	0.00789	0.055967	41.18043	0.018658	0.011593	86.87265
X23105-site 15 chl p.8	24.68771	2.868817	17.08074	0	0.069959	42.26108	0.019627	0	86.98794
X23105-site 15 chl p.9	24.79468	2.835652	17.32637	0	0.041976	41.87513	0.020401	0.011926	86.90614
X23105-site 15 chl p.10	24.81607	2.769321	17.2319	0	0.083951	42.20962	0.020724	0.011676	87.14326
X23105-site 15 chl p.11	25.03	3.233638	16.21159	0.008252	0.153911	42.00378	0.019691	0.011926	86.67279
X23105-site 15 chl p.12	24.85886	2.901983	17.572	0	0.055967	41.888	0.020014	0.011926	87.30875
X23105-site 15 chl p.13	24.53796	2.8854	17.53421	0	0.055967	41.75935	0.020143	0.011843	86.80488
X23105-site 15 chl p.14	24.77329	2.802486	17.28858	0	0.069959	42.24821	0.020337	0.01176	87.21462
X23105-site 15 chl p.15	24.88025	2.868817	17.36416	0	0.041976	41.68216	0.020272	0.011843	86.86948
X23105-site 15 chl p.16	24.88025	2.852234	17.68537	0	0.055967	41.65643	0.020789	0.011676	87.16272
X23105-site 15 chl p.17	24.77329	2.802486	17.36416	0.008252	0.097943	42.09383	0.020918	0.011843	87.17272
X23105-site 15 chl p.18	25.11558	2.968314	16.47611	0.008011	0.125927	41.91373	0.020401	0.011843	86.63991
X23105-site 15 chl p.19	25.26533	2.918565	17.00516	0	0.069959	41.91373	0.020724	0.011843	87.20531
X23105-site 15 chl p.20	25.3509	3.150724	16.64617	0	0.167902	41.74648	0.020079	0.01201	87.09426
X23105-site 15 chl p.21	24.81607	3.001479	17.79874	0.008071	0.055967	41.07751	0	0.01176	86.7696
X23105-site 15 chl p.22	25.00861	3.084393	15.90928	0.008372	0.139919	42.02951	0.019627	0.011843	86.21155
X23105-site 15 chl p.23	24.90164	2.901983	17.5909	0	0.069959	41.60497	0.020337	0.011926	87.10172
X23105-site 15 chl p.24	25.17976	2.8854	17.11853	0.012046	0.097943	41.81081	0.020208	0.01176	87.13645
X23105-site 15 chl p.25	24.96582	2.868817	17.38306	0.012046	0.069959	41.51491	0.020272	0.011926	86.84682
X23105-site 15 chl p.26	24.83747	2.769321	17.17522	0.012046	0.111935	41.97805	0.020595	0.011926	86.91655
X23105-site 15 chl p.27	25.47926	3.018062	16.13601	0.036138	0.167902	42.27394	0.019756	0	87.13107
X23105-site 15 chl p.28	24.85886	2.868817	17.19411	0.012046	0.069959	41.86227	0.019949	0.01176	86.89777
X23105-site 15 chl p.29	25.3509	3.167307	15.8148	0.012046	0.181894	42.51837	0.021047	0.012093	87.07847

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X23105-site 15 chl p.30	25.24394	3.001479	16.19269	0.012046	0.153911	42.60843	0.020724	0.011676	87.2449
X23105-site 15 chl p.31	24.70911	2.868817	17.83653	0	0.055967	41.8494	0.02066	0.011843	87.35232
X23105-site 15 chl p.32	24.88025	2.802486	16.68396	0	0.069959	42.3254	0.019046	0.011593	86.79269
X23105-site 15 chl p.33	25.09418	2.835652	16.64617	0.012046	0.111935	42.45405	0.020337	0.011843	87.18621
X23105-site 15 chl p.34	24.70911	2.802486	17.62869	0	0.069959	41.83654	0.019627	0	87.0664
X23105-site 15 chl p.35	24.66632	2.819069	17.2319	0.008131	0.055967	41.97805	0	0.011843	86.77128
X23105-site 15 chl p.36	25.24394	2.968314	15.90928	0.012046	0.125927	42.90432	0.020079	0.011676	87.19557
X23105-site 15 chl p.37	24.92304	2.819069	16.55169	0.024092	0.139919	42.81427	0.020143	0.011926	87.30415
X23105-site 15 chl p.38	25.13697	2.935148	16.77843	0.012046	0.139919	42.20962	0.019949	0.011676	87.24375
X23105-site 15 chl p.39	24.81607	2.8854	17.26969	0.008071	0.055967	41.75935	0.020337	0.01201	86.82689
X23105-site 15 chl p.40	25.03	2.802486	17.17522	0.012046	0.097943	41.82367	0.019949	0	86.96132
X23105-site 15 chl p.41	25.30812	3.134141	15.85259	0.012046	0.167902	42.22248	0.020143	0.011843	86.72927
X23105-site 15 chl p.42	25.09418	2.8854	16.38164	0	0.125927	42.5827	0	0.011843	87.08169
X23105-site 15 chl p.43	24.88025	3.051227	16.96737	0	0.097943	41.93946	0.02066	0.011926	86.96884
X23105-site 15 chl p.44	25.37229	2.868817	16.55169	0.008191	0.139919	41.65643	0.020337	0.011843	86.62952
X23105-site 15 chl p.45	26.03548	3.283386	15.92817	0.024092	0.209878	41.46346	0.051649	0.011843	87.00796
X23105-site 15 chl p.46	25.09418	2.819069	16.70285	0.012046	0.139919	42.01664	0.020595	0.01226	86.81757
X23105-site 15 chl p.47	24.90164	2.901983	17.32637	0	0.055967	41.412	0.020466	0.011676	86.63011
X23105-site 16 chl p.1	25.58623	3.217055	15.77701	0.008191	0.167902	42.18389	0.020143	0.011926	86.97235
X23105-site 16 chl p.2	25.03	2.984896	16.11712	0.012046	0.139919	42.5441	0.020272	0.011676	86.86003
X23105-site 16 chl p.3	25.45787	3.134141	16.09822	0	0.125927	42.42832	0.020143	0.011843	87.27646
X23105-site 16 chl p.4	25.45787	3.117558	15.92817	0.012046	0.153911	42.69848	0.020143	0.011843	87.40002
X23105-site 16 chl p.5	25.45787	3.283386	15.4747	0.008131	0.139919	42.63416	0.020531	0.011926	87.03062
X23105-site 16 chl p.6	25.50065	3.382883	15.72033	0.008131	0.125927	42.19675	0.020143	0.01201	86.96683
X23105-site 16 chl p.7	24.94443	3.217055	16.74064	0	0.153911	41.73362	0.020466	0.012093	86.82221
X23105-site 16 chl p.8	24.92304	3.200472	16.02264	0.012046	0.181894	42.05524	0.020079	0.011926	86.42734
X23105-site 16 chl p.9	25.45787	3.648207	15.96596	0.008312	0.167902	41.888	0	0.01201	87.14825
X23105-site 16 chl p.10	24.98722	2.935148	16.77843	0	0.083951	42.11956	0.01982	0.011593	86.93572
X23105-site 16 chl p.11	24.77329	2.868817	17.2319	0	0.083951	41.95232	0.020853	0.011676	86.9428
X23105-site 16 chl p.12	25.09418	3.283386	15.96596	0.012046	0.237862	42.0681	0.020466	0.011676	86.69368
X23105-site 16 chl p.13	24.88025	2.819069	16.79732	0	0.083951	41.69502	0.019885	0	86.2955
X23105-site 16 chl p.14	25.52205	3.233638	15.79591	0.024092	0.22387	41.96519	0.019175	0.01201	86.79592
X23105-site 16 chl p.15	24.79468	2.901983	17.53421	0	0.069959	41.48919	0.020272	0.011593	86.82188
X23105-site 16 chl p.16	26.48474	3.930114	14.34102	0.024092	0.335805	41.99091	0.019562	0.01201	87.13826

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X23105-site 16 chl p.17	24.77329	2.8854	17.11853	0	0.069959	42.24821	0.020595	0.011259	87.12724
X23105-site 16 chl p.18	25.26533	3.001479	16.47611	0.012046	0.153911	42.01664	0.01982	0.011843	86.95719
X23105-site 16 chl p.19	24.85886	2.736155	16.66506	0.012046	0.097943	42.27394	0.019627	0.011676	86.67531
X23105-site 16 chl p.20	24.88025	2.852234	17.02406	0	0.055967	42.29967	0.019691	0.01201	87.14388
X23105-site 16 chl p.21	25.54344	3.134141	16.21159	0.012046	0.195886	42.42832	0.020079	0.01201	87.55751
X23105-site 16 chl p.22	24.58075	2.868817	17.64758	0	0.055967	41.74648	0.020272	0.01201	86.93188
X23105-site 16 chl p.23	25.07279	3.167307	16.21159	0.012046	0.181894	41.78508	0	0.01201	86.44271
X23105-site 16 chl p.24	25.90712	3.349717	15.79591	0.012046	0.22387	41.96519	0.020014	0.011676	87.28554
X23105-site 16 chl p.25	24.92304	2.8854	17.38306	0.008071	0.069959	41.54064	0.020595	0.011593	86.84236
X23105-site 16 chl p.26	25.15836	3.200472	16.62727	0.008312	0.181894	41.50205	0.020531	0.011926	86.71082
X23105-site 16 chl p.27	25.30812	3.498962	16.15491	0.012046	0.153911	42.0681	0.020079	0.033361	87.24948
X23105-site 16 chl p.28	24.68771	2.785903	17.04295	0.012046	0.083951	42.14529	0.021176	0.011843	86.79088
X23105-site 16 chl p.29	24.98722	2.852234	17.04295	0	0.055967	42.08097	0.020079	0.011926	87.05135
X23105-site 16 chl p.30	24.94443	2.901983	17.5909	0	0.041976	41.55351	0.020466	0.011676	87.06494
X23105-site 16 chl p.31	24.90164	2.802486	16.8729	0	0.069959	42.19675	0.020014	0.011426	86.87518
X23105-site 16 chl p.32	24.85886	2.802486	17.19411	0	0.055967	42.29967	0.020014	0.01176	87.24287
X23105-site 16 chl p.33	25.0514	2.8854	16.94848	0	0.055967	42.0681	0.02066	0.01201	87.04202
X23105-site 16 chl p.34	25.26533	2.8854	16.5328	0	0.097943	42.65989	0.020853	0.011676	87.47389
X23105-site 16 chl p.35	24.62353	2.835652	16.75953	0	0.041976	41.82367	0	0.011676	86.09604
X23105-site 16 chl p.36	24.92304	2.935148	17.25079	0	0.069959	41.75935	0.020789	0.01201	86.97109
X23105-site 16 chl p.37	24.77329	2.901983	17.572	0	0.055967	41.56637	0.020337	0.011676	86.90163
X23105-site 16 chl p.38	25.26533	2.8854	17.00516	0	0.069959	42.22248	0.019949	0.011926	87.48021
X23105-site 16 chl p.39	25.13697	3.283386	16.66506	0.012046	0.125927	41.95232	0.020014	0.011926	87.20765
X23105-site 16 chl p.40	25.00861	2.852234	17.17522	0	0.027984	42.09383	0.019304	0.011843	87.18903
X23105-site 16 chl p.41	25.58623	3.167307	15.60696	0.012046	0.111935	42.67275	0.019562	0.011843	87.18863
X23105-site 16 chl p.42	24.83747	3.051227	16.72174	0.012046	0.195886	41.99091	0.020272	0.012093	86.84165
X23105-site 16 chl p.43	25.80016	3.316552	15.49359	0.012046	0.209878	42.19675	0.020401	0.011926	87.06131
X23105-site 16 chl p.44	24.75189	2.852234	17.04295	0	0.083951	42.08097	0.020789	0.011926	86.84472
X23105-site 16 chl p.45	24.68771	2.785903	17.17522	0	0.055967	42.31254	0.020724	0.01201	87.05007
X23105-site 16 chl p.46	25.45787	3.06781	15.73922	0.012046	0.167902	42.46691	0.020208	0.012177	86.94415
X23105-site 16 chl p.47	25.50065	3.233638	15.17239	0.012046	0.251854	41.96519	0.021112	0.01201	86.16888
X23105-site 16 chl p.48	25.24394	2.935148	16.11712	0.012046	0.167902	42.40259	0.020401	0.012093	86.91123
X23105-site 16 chl p.49	25.24394	2.752738	16.40054	0	0.111935	42.5441	0.019239	0.011593	87.08408
X23105-site 16 chl p.50	25.73598	3.233638	15.68254	0.024092	0.195886	42.38973	0.020531	0.011926	87.29432

Element/ Oxide Unit	SiO2 wt %	MgO wt %	Al2O3 wt %	K2O wt %	CaO wt %	FeO wt %	MnO wt %	TiO2 wt %	Total wt %
Sample									
X27820-site 11 chl p.4	42.70076	1.459283	6.858749	1.975554	0.181894	35.53275	0.038737	0.011926	88.75966
X27820-site 11 chl p.5	28.19619	2.354752	16.34385	1.060053	0.041976	38.67178	0.019949	0.01201	86.70056
X27820-site 11 chl p.6	42.20872	1.426117	6.594225	1.9876	0.195886	35.39124	0.051649	0.01201	87.86744
X27820-site 11 chl p.7	42.5724	1.459283	6.367489	1.770771	0.125927	35.50702	0.038737	0.012177	87.85381
X27820-site 11 chl p.8	42.48683	1.475865	7.123274	1.782817	0.139919	35.224	0.064561	0.01226	88.30952
X27820-site 11 chl p.9	39.04253	1.343203	6.480857	1.927369	0.111935	32.71535	0.038737	0.011676	81.67165
X27820-site 11 chl p.10	44.17689	1.525614	6.273016	1.782817	0.153911	36.15027	0.077474	0.012343	90.15233
X27820-site 11 chl p.11	43.12862	1.509031	6.310805	1.662356	0.153911	35.76432	0.064561	0.012093	88.6057
X27820-site 11 chl p.12	43.06444	1.459283	7.463377	1.686448	0.139919	35.57135	0.051649	0.012594	89.44906
X27820-site 11 chl p.13	43.08584	1.426117	6.839855	2.312843	0.195886	34.64508	0.051649	0.012093	88.56936
X27820-site 11 chl p.14	36.71067	1.558779	6.518646	1.300974	0.37778	34.00183	0.038737	0.011509	80.51893
X27820-site 11 chl p.15	37.05296	1.326621	7.501167	2.156245	0.125927	31.17156	0.038737	0.01176	79.38498
X27820-site 11 chl p.16	41.952	1.4427	7.444483	1.698494	0.153911	35.04389	0.051649	0.01226	87.79938
X27820-site 11 chl p.17	41.11766	1.426117	6.065175	1.59008	0.153911	34.18194	0.038737	0.012093	84.58572
X27820-site 11 chl p.18	41.37438	1.426117	6.159648	1.782817	0.153911	35.24973	0.020466	0.01201	86.17908
X27820-site 11 chl p.19	42.35847	1.459283	6.461962	1.734633	0.153911	35.28832	0.038737	0.01226	87.50757
X27820-site 11 chl p.20	38.8072	1.359786	6.159648	1.541896	0.22387	32.85686	0.051649	0.033361	81.03427
X27820-site 11 chl p.21	41.43856	1.4427	6.102964	1.686448	0.153911	35.32692	0.064561	0.01201	86.22807
X27820-site 11 chl p.22	45.78137	1.094462	9.8441	5.444819	0.251854	27.29924	0.020272	0	89.73612
X27820-site 11 chl p.23	42.70076	1.459283	7.444483	1.457573	0.139919	34.85092	0.020595	0.012093	88.08562
X27820-site 11 chl p.24	37.26689	1.824103	9.655154	1.180514	0.195886	37.88702	0.020982	0.012093	88.04265
X27820-site 11 chl p.25	35.53405	1.591945	8.937158	1.13233	0.181894	35.75146	0.020724	0.012343	83.1619
X27820-site 11 chl p.26	31.76885	2.271838	13.16955	0.566165	0.069959	39.80389	0.020143	0.01176	87.68216
X27820-site 11 chl p.27	24.51657	2.984896	16.75953	0.012046	0.008325	41.95232	0.020401	0.011843	86.26593
X27820-site 11 chl p.28	24.36682	2.736155	19.02689	0	0.041976	39.84248	0.020143	0	86.03446
X27820-site 11 chl p.29	32.21811	2.072845	12.26261	0.602303	0.293829	38.96767	0.02066	0.011926	86.44996
X27820-site 11 chl p.30	34.37882	2.205507	11.2423	0.722764	0.097943	39.16064	0.020337	0.01201	87.84033
X27820-site 11 chl p.31	36.09027	1.873852	10.16531	1.023915	0.097943	37.93848	0.020853	0.011926	87.22255
X27820-site 12 chl p.1	24.60214	2.719572	16.15491	0.024092	0.041976	42.24821	0.020272	0.012093	85.82326
X27820-site 12 chl p.2	28.02505	2.387917	16.66506	0.927547	0.027984	39.07059	0.019691	0	87.12384
X27820-site 12 chl p.3	24.55935	2.686407	16.28717	0.048184	0.041976	42.38973	0	0.012093	86.02491

Appendix7: Electron microprobe analyses of pyrrhotite

Element	S	Fe	Co	Ni	Total
Unit	wt%	wt%	wt%	wt%	wt%
Sample					
x102074 sit	39.5564	59.7026	0.0808	0.01395	99.3447
x102074 sit	39.5924	59.7856	0.0735	0.0138	99.4659
x102074 sit	39.6268	59.5751	0.0965	0.01405	99.2915
x102074 sit	39.7205	59.5939	0.0749	0.01415	99.3662
x102074 sit	39.5691	59.8043	0.0723	0.0141	99.4403
x102074 sit	39.5902	59.7253	0.0968	0.014	99.409
x102074 sit	39.5939	59.6582	0.0778	0.0139	99.3319
x102074 sit	39.549	59.8104	0.0839	0.01405	99.4461
x102074 sit	39.5755	59.7366	0.0872	0.0139	99.3967
x102074 sit	39.605	59.7501	0.0852	0.01375	99.4506
x102074 sit	39.4866	59.6528	0.0711	0.0138	99.2244
x102074 sit	39.5384	59.751	0.0777	0.0141	99.3475
x102074 sit	39.6443	59.8034	0.0635	0.01425	99.4989
x102074 sit	39.7182	59.6366	0.0859	0.01395	99.4332
x102074 sit	39.4828	59.8016	0.0814	0.01435	99.3471
x102074 sit	39.5499	59.8415	0.091	0.0139	99.4856
x102074 sit	39.4686	59.6409	0.1023	0.01405	99.2044
x102074 sit	39.5206	59.6736	0.07	0.014	99.2688
x102074 sit	39.5249	59.6221	0.0892	0.01405	99.2233
x102074 sit	39.4682	59.7899	0.0895	0.01375	99.3544
x102074 sit	39.5871	59.8888	0.0825	0.014	99.5511
x102074 sit	39.3175	59.7904	0.0601	0.01405	99.1705
x102074 sit	39.4275	59.791	0.0713	0.0139	99.2875
x102074 sit	39.3831	59.9532	0.0897	0.014	99.4187
x102074 sit	39.4231	59.8768	0.0586	0.01405	99.3518
x102074 sit	39.6345	59.8131	0.0695	0.01375	99.526
x102074 sit	39.5426	59.9704	0.059	0.0139	99.5711
x102074 sit	39.4001	59.7489	0.076	0.01385	99.2243
x102074 sit	39.4824	59.6463	0.0623	0.01395	99.1801
x102074 sit	39.4095	59.8208	0.0802	0.014	99.3151
x102074 sit	39.415	59.6911	0.0705	0.0138	99.1784
x102074 sit	39.5075	59.7365	0.0759	0.0139	99.3241
x102074 sit	38.9147	60.5308	0.0636	0.01405	99.5014
x102074 sit	38.8971	60.2482	0.0646	0.01385	99.2136
x102074 sit	38.9457	60.2928	0.0905	0.014	99.3355
x102074 sit	39.1335	60.1629	0.0617	0.01405	99.3543
x102074 sit	39.6098	59.8354	0.0633	0.01395	99.5051
x102074 sit	39.4841	59.7722	0.0612	0.0138	99.3221
x102074 sit	39.5798	59.8513	0.0908	0.01405	99.5099
x102074 sit	39.2881	60.0517	0.0872	0.0142	99.4048
x102074 sit	39.518	59.7913	0.068	0.01395	99.3763
x102074 sit	38.89	60.5396	0.0695	0.01405	99.4942
x102074 sit	39.5055	59.7899	0.0575	0.01395	99.3499
x102074 sit	39.4012	59.757	0.0561	0.01415	99.2081

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102074 site 3 po p.24	39.5776	59.9612	0.0825	0.01405	99.6219
x102074 site 3 po p.25	39.5041	60.0537	0.0885	0.01385	99.6506
x102074 site 3 po p.26	39.4778	59.6916	0.0763	0.0139	99.2453
x102074 site 3 po p.27	39.5833	59.7359	0.0827	0.0141	99.3996
x102074 site 3 po p.28	39.4929	59.8058	0.1014	0.01425	99.3853
x102074 site 3 po p.29	39.3597	59.9206	0.0856	0.01365	99.3729
x102074 site 3 po p.30	39.5715	59.6462	0.0593	0.01405	99.271
x102074 site 3 po p.31	39.2635	59.8689	0.0834	0.01435	99.2056
x102074 site 3 po p.32	38.8601	60.4579	0.0503	0.0139	99.3689
x102074 site 3 po p.33	38.8789	60.2423	0.0674	0.01395	99.1828
x102074 site 3 po p.34	38.8096	60.2595	0.0697	0.01395	99.1427
x102074 site 3 po p.35	39.4462	59.9253	0.0767	0.01375	99.4606
x102074 site 4 po p.1	39.4399	59.8986	0.0509	0.014	99.3906
x102074 site 4 po p.2	39.5837	59.9809	0.0706	0.0138	99.6448
x102074 site 4 po p.3	39.2043	59.8048	0.0894	0.0141	99.1002
x102074 site 4 po p.4	39.5282	59.8268	0.0715	0.0141	99.4255
x102074 site 4 po p.5	39.6934	59.9334	0.0653	0.0137	99.6995
x102074 site 4 po p.6	39.6175	59.9823	0.0829	0.0142	99.6727
x102074 site 4 po p.7	39.5231	59.8524	0.0694	0.01385	99.4406
x102074 site 4 po p.8	39.5372	59.9687	0.0854	0.0139	99.5913
x102074 site 4 po p.9	39.6291	60.1077	0.0655	0.01385	99.8116
x102074 site 4 po p.10	39.5803	59.9914	0.0708	0.01385	99.6429
x102074 site 4 po p.11	39.6842	60.3951	0.0982	0.01415	100.1774
x102074 site 4 po p.12	39.7595	60.1883	0.0745	0.01415	100.0138
x102074 site 4 po p.13	39.4569	59.7827	0.0564	0.0139	99.3059
x102074 site 4 po p.14	39.4638	59.9706	0.0578	0.0138	99.4986
x102074 site 4 po p.15	39.4707	59.8294	0.0791	0.0142	99.3816
x102074 site 4 po p.16	39.5144	59.9407	0.0853	0.0138	99.5469
x102074 site 4 po p.17	39.622	59.9302	0.0751	0.01365	99.6344
x102074 site 4 po p.18	39.6508	59.8992	0.079	0.01405	99.6222
x102074 site 4 po p.19	39.4036	59.9021	0.062	0.0141	99.3633
x102074 site 4 po p.20	39.5369	59.7453	0.104	0.014	99.3788
x102074 site 4 po p.21	39.458	59.7144	0.0648	0.0141	99.2302
x102074 site 4 po p.22	39.4438	59.8634	0.0738	0.01415	99.3725
x102074 site 4 po p.23	39.5226	59.862	0.0598	0.014	99.4497
x102074 site 4 po p.24	39.4386	59.7556	0.0833	0.0138	99.2789
x102074 site 4 po p.25	39.4203	59.7864	0.0729	0.0139	99.2765
x102074 site 4 po p.26	39.4012	59.7129	0.0641	0.014	99.1738
x102074 site 4 po p.27	39.6241	60.0008	0.0633	0.014	99.6865
x102074 site 4 po p.28	39.5578	59.8821	0.0571	0.01395	99.4882
x102074 site 4 po p.29	39.5916	59.7933	0.0767	0.01395	99.4542
x102074 site 4 po p.30	39.5836	60.249	0.0828	0.0141	99.9107
x102074 site 9 po p.1	39.5965	59.7434	0.075	0.0139	99.4001
x102074 site 9 po p.2	39.4772	59.7929	0.0683	0.01415	99.3247
x102074 site 9 po p.3	39.4831	59.9303	0.0564	0.01405	99.4667
x102074 site 9 po p.4	39.6444	59.7749	0.0599	0.014	99.4654
x102074 site 9 po p.5	39.5068	59.7621	0.0887	0.01365	99.3777

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102074 site 9 po p.6	39.4998	59.8484	0.0797	0.014	99.431
x102074 site 9 po p.7	39.5145	59.7582	0.0755	0.014	99.348
x102074 site 9 po p.8	39.5952	59.815	0.0594	0.01395	99.4647
x102074 site 9 po p.9	39.4394	59.8345	0.0663	0.014	99.3336
x102074 site 9 po p.10	39.6607	59.9648	0.0627	0.014	99.6908
x102074 site 9 po p.11	39.4883	59.9149	0.0664	0.0135	99.4876
x102074 site 9 po p.12	39.4949	59.7145	0.0578	0.0139	99.2678
x102074 site 9 po p.13	39.4027	59.7066	0.1008	0.0139	99.2172
x102074 site 9 po p.14	39.5243	59.7468	0.0617	0.0142	99.3312
x102074 site 9 po p.15	39.6329	59.905	0.0573	0.01405	99.5839
x102074 site 9 po p.16	39.4788	59.8652	0.0769	0.0142	99.428
x102074 site 9 po p.17	39.4659	59.9683	0.0685	0.0141	99.4952
x102074 site 9 po p.18	39.5025	59.5882	0.0607	0.01385	99.1561
x102074 site 9 po p.19	39.3918	59.7872	0.0551	0.0139	99.2404
x102074 site 9 po p.20	39.5207	59.7292	0.0642	0.01395	99.3132
x102074 site 9 po p.21	39.5677	59.8459	0.0908	0.014	99.4958
x102074 site 9 po p.22	39.5006	59.7298	0.0607	0.01395	99.2873
x102074 site 9 po p.23	39.5572	59.9015	0.0505	0.0141	99.4898
x102074 site 9 po p.24	39.5968	59.8619	0.0686	0.01405	99.5343
x102074 site 9 po p.25	39.5282	59.8026	0.0631	0.014	99.3867
x102074 site 9 po p.26	39.6562	59.7908	0.0231	0.0138	99.4901
x102074 site 9 po p.27	39.5242	59.6518	0.0694	0.0141	99.2356
x102074 site 10 po p.1	39.4403	59.5439	0.0969	0.0142	99.0723
x102074 site 10 po p.2	39.5675	59.6315	0.0809	0.01415	99.2728
x102074 site 10 po p.3	39.4347	59.6817	0.0794	0.01395	99.1927
x102074 site 10 po p.4	39.4789	59.6664	0.0836	0.0141	99.2226
x102074 site 10 po p.5	39.5175	59.6351	0.0691	0.01395	99.2215
x102074 site 10 po p.6	39.5241	59.5504	0.0861	0.0139	99.1567
x102074 site 10 po p.7	39.6006	59.8293	0.0952	0.01375	99.5367
x102074 site 10 po p.8	39.6603	59.7665	0.0791	0.0138	99.5074
x102074 site 10 po p.9	39.6103	59.7587	0.0701	0.01405	99.4408
x102074 site 10 po p.10	39.5584	59.7731	0.0563	0.0138	99.3999
x102074 site 10 po p.11	39.482	59.6518	0.02245	0.01385	99.1855
x102074 site 10 po p.12	39.6744	59.5339	0.0775	0.01385	99.2942
x102074 site 10 po p.13	39.562	59.6182	0.0893	0.01385	99.2771
x102074 site 10 po p.14	39.4081	59.6215	0.0881	0.01385	99.1269
x102074 site 10 po p.15	39.4036	59.6366	0.0977	0.01395	99.1409
x102074 site 10 po p.16	39.4175	59.4844	0.0909	0.0138	98.9901
x102074 site 10 po p.17	39.4213	59.6237	0.0966	0.01395	99.145
x102074 site 10 po p.18	39.4485	59.4622	0.0944	0.014	98.9896
x102074 site 10 po p.19	39.3518	59.5164	0.067	0.0137	98.9342
x102074 site 10 po p.20	39.3644	59.5957	0.111	0.014	99.0631
x102074 site 10 po p.21	39.4135	59.5313	0.0823	0.0137	99.0393
x102074 site 10 po p.22	39.3965	59.7356	0.0896	0.01375	99.2295
x102074 site 10 po p.23	39.4016	59.5759	0.0804	0.0139	99.0525
x102074 site 10 po p.24	39.441	59.6496	0.0978	0.01405	99.1824
x102074 site 10 po p.25	39.6583	59.4782	0.0701	0.01415	99.1992

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102074 site 10 po p.26	39.4596	59.5559	0.095	0.01395	99.0962
x102074 site 10 po p.27	39.266	59.4366	0.0964	0.01375	98.7986
x102074 site 10 po p.28	39.4251	59.5466	0.0994	0.01405	99.0739
x102074 site 10 po p.29	39.4015	59.7766	0.0831	0.01395	99.2519
x102074 site 10 po p.30	39.3581	59.6902	0.0745	0.01425	99.1116
x102074 site 10 po p.31	39.5918	59.7937	0.0646	0.01395	99.4456
x102074 site 5 po p.1 near gold grain	39.6326	59.7571	0.0698	0.014	99.4521
x102074 site 5 po p.2 near gold grain	39.6239	59.9999	0.0775	0.01395	99.699
x102074 site 5 po p.3 near gold grain	39.4354	59.6692	0.071	0.01395	99.1773
x102074 site 5 po p.4 near gold grain	39.5649	59.8252	0.0611	0.01385	99.4556
x102074 site 5 po p.5 near gold grain	39.4626	59.6711	0.0652	0.01405	99.2051
x102074 site 5 po p.6 near gold grain	39.3487	59.7334	0.058	0.0139	99.1406
x102074 site 5 po p.7 near gold grain	39.4733	59.3356	0.0515	0.0141	98.8614
x102074 site 5 po p.8 near gold grain	39.6147	59.7607	0.0852	0.01425	99.446
x102074 site 5 po p.9 near gold grain	39.5912	59.7423	0.0573	0.014	99.3875
x102074 site 5 po p.10 near gold grain	39.6111	59.7094	0.0743	0.01375	99.3941
x102074 site 5 po p.11 near gold grain	39.6415	59.7612	0.0622	0.0138	99.4732
x102074 site 5 po p.12 near gold grain	39.5733	59.723	0.0857	0.01405	99.3762
x102066 site 3 po p.1	39.2318	59.8113	0.0661	0.0138	99.1136
x102066 site 3 po p.2	39.2543	59.805	0.072	0.01375	99.1319
x102066 site 3 po p.3	39.2823	59.6354	0.0791	0.01405	99.0001
x102066 site 3 po p.4	39.3259	59.7926	0.02265	0.0139	99.1751
x102066 site 3 po p.5	39.2092	59.7334	0.0597	0.01395	99.0015
x102066 site 3 po p.6	39.2877	59.757	0.0882	0.01405	99.1238
x102066 site 3 po p.7	39.2472	59.7018	0.0536	0.014	98.9965
x102066 site 3 po p.8	39.3721	59.88	0.076	0.0136	99.3304
x102066 site 3 po p.9	39.3719	59.7429	0.0587	0.01385	99.1839
x102066 site 3 po p.10	39.4601	60.02	0.0721	0.0138	99.5505
x102066 site 3 po p.11	39.3964	59.8133	0.0735	0.01415	99.2682
x102066 site 3 po p.12	39.2761	59.7951	0.0649	0.01405	99.1324
x102066 site 3 po p.13	39.4708	59.7828	0.0569	0.01385	99.3118
x102066 site 3 po p.14	39.436	59.8895	0.0646	0.0141	99.3749
x102066 site 3 po p.15	39.4134	59.7543	0.0716	0.0139	99.2392
x102066 site 3 po p.16	39.4891	59.7643	0.0732	0.01375	99.3338
x102066 site 3 po p.17	39.355	59.3939	0.0976	0.01405	98.8431
x102066 site 3 po p.18	39.4697	59.6172	0.0733	0.01375	99.1595
x102066 site 3 po p.19	39.4645	59.6978	0.0923	0.01375	99.2581
x102066 site 3 po p.20	39.4461	59.6677	0.0517	0.0139	99.1593
x102066 site 3 po p.21	39.3572	59.5885	0.0782	0.01385	99.0261
x102066 site 3 po p.22	39.3369	59.5173	0.0553	0.01395	98.9087
x102066 site 3 po p.23	39.3135	59.8151	0.08	0.014	99.1983
x102066 site 3 po p.24	39.3924	59.8336	0.0706	0.0141	99.2776
x102066 site 3 po p.25	39.4193	59.8059	0.0831	0.01405	99.3048
x102066 site 3 po p.26	39.4829	59.9994	0.0772	0.0139	99.562
x102066 site 3 po p.27	39.3496	59.8795	0.06	0.01385	99.2949
x102066 site 3 po p.28	39.3571	59.6713	0.0779	0.01395	99.0992
x102066 site 3 po p.29	39.3898	59.7001	0.0525	0.01425	99.1251

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102066 site 3 po p.30	39.4891	59.614	0.0744	0.014	99.1642
x102066 site 8 po p.1	39.5188	59.2092	0.0911	0.01415	98.8077
x102066 site 8 po p.2	39.3469	59.4438	0.0864	0.01415	98.8565
x102066 site 8 po p.3	39.3855	59.5064	0.0711	0.01395	98.9661
x102066 site 8 po p.4	39.4017	59.4256	0.0781	0.0141	98.9033
x102066 site 8 po p.5	39.3841	59.6346	0.101	0.0138	99.1177
x102066 site 8 po p.6	39.2886	59.2835	0.0705	0.014	98.6353
x102066 site 8 po p.7	39.3535	59.4421	0.101	0.01395	98.8901
x102066 site 8 po p.8	39.3129	59.4644	0.0892	0.0139	98.8709
x102066 site 8 po p.9	39.3137	59.4077	0.0641	0.0138	98.7792
x102066 site 8 po p.10	39.5123	59.5032	0.067	0.01395	99.0732
x102066 site 8 po p.11	39.3383	59.3349	0.0724	0.01395	98.7418
x102066 site 8 po p.12	39.5448	59.4775	0.0678	0.0138	99.093
x102066 site 8 po p.13	39.3615	59.4932	0.0642	0.01395	98.916
x102066 site 8 po p.14	39.4307	59.5752	0.023	0.014	99.0487
x102066 site 8 po p.15	39.3874	59.3315	0.0858	0.01375	98.811
x102066 site 8 po p.16	39.3759	59.3774	0.0582	0.0139	98.8215
x102066 site 8 po p.17	39.3448	59.4455	0.082	0.0138	98.8796
x102066 site 8 po p.18	39.3915	59.4568	0.0781	0.01415	98.9149
x102066 site 8 po p.19	39.3325	59.3259	0.0837	0.01405	98.739
x102066 site 8 po p.20	39.3134	59.3908	0.0739	0.01375	98.784
x102066 site 8 po p.21	39.3588	59.3656	0.0226	0.01405	98.776
x102066 site 8 po p.22	39.5136	59.4037	0.079	0.01405	98.9739
x102066 site 8 po p.23	39.2808	59.4897	0.0814	0.01375	98.8614
x102066 site 8 po p.24	39.352	59.4586	0.0565	0.0139	98.8614
x102066 site 8 po p.25	39.4645	59.3517	0.0641	0.0139	98.8778
x102066 site 8 po p.26	39.3489	59.4506	0.0714	0.0138	98.8776
x102066 site 8 po p.27	39.2983	59.3372	0.076	0.0136	98.7276
x102066 site 8 po p.28	39.2619	59.2526	0.0721	0.01395	98.5819
x102066 site 8 po p.29	39.334	59.4879	0.0831	0.0141	98.9006
x102066 site 8 po p.30	39.5401	59.6785	0.0639	0.01385	99.2891
x102066 site 8 po p.31	39.3376	59.3753	0.06	0.0139	98.7685
x102066 site 8 po p.32	39.4728	59.5211	0.0917	0.01405	99.0789
x102066 site 8 po p.33	39.4327	59.397	0.051	0.0139	98.8737
x102066 site 8 po p.34	39.3438	59.3611	0.067	0.0142	98.7535
x102066 site 8 po p.35	39.4845	59.8061	0.0735	0.0138	99.3704
x102066 site 8 po p.36	39.3104	59.5546	0.0564	0.01415	98.9098
x102066 site 8 po p.37	39.4293	59.3627	0.0682	0.01405	98.8607
x102066 site 8 po p.38	39.3562	59.5794	0.0792	0.01385	99.0224
x11308 site 1 po p.1	39.1293	59.521	0.0723	0.0138	98.7209
x11308 site 1 po p.2	39.1535	59.7138	0.0994	0.01385	98.97
x11308 site 1 po p.3	39.184	59.6539	0.0817	0.01385	98.9238
x11308 site 1 po p.4	39.4339	59.4497	0.0701	0.014	98.9519
x11308 site 1 po p.5	39.2622	59.4162	0.0831	0.01385	98.7555
x11308 site 1 po p.6	39.317	59.5578	0.0581	0.0139	98.9289
x11308 site 1 po p.7	39.4455	59.5393	0.0794	0.0138	99.0644
x11308 site 1 po p.8	39.3214	59.3617	0.0626	0.01385	98.7504

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x11308 site 1 po p.9	39.4868	59.592	0.0877	0.014	99.1731
x11308 site 1 po p.10	39.2398	59.4666	0.0807	0.01425	98.7753
x11308 site 1 po p.11	39.2077	59.7384	0.0579	0.01395	99.0045
x11308 site 1 po p.12	39.3271	59.7142	0.0738	0.0142	99.1042
x11308 site 1 po p.13	39.3521	59.6031	0.079	0.0139	99.041
x11308 site 1 po p.14	39.2857	59.5381	0.1019	0.01385	98.9192
x11308 site 1 po p.15	39.3164	59.5941	0.1041	0.0138	99.018
x11308 site 1 po p.16	39.236	59.6824	0.0978	0.01395	99.0204
x11308 site 1 po p.17	39.4282	59.5338	0.063	0.01395	99.0266
x11308 site 1 po p.18	39.3098	59.6952	0.0827	0.0141	99.0863
x11308 site 1 po p.19	39.2543	59.5125	0.0708	0.01385	98.841
x11308 site 1 po p.20	39.2584	59.692	0.0786	0.01405	99.029
x11308 site 1 po p.21	39.2931	59.5688	0.0787	0.01395	98.937
x11308 site 1 po p.22	39.2265	59.4876	0.072	0.0139	98.7839
x11308 site 1 po p.23	39.2862	59.4935	0.0817	0.01415	98.8618
x11308 site 1 po p.24	39.3077	59.6256	0.0825	0.01395	99.0161
x11308 site 1 po p.25	39.2053	59.6511	0.0784	0.0139	98.9305
x11308 site 1 po p.26	39.3024	59.6357	0.0856	0.0138	99.0357
x11308 site 4 po p.1	39.1844	59.5597	0.0785	0.014	98.8189
x11308 site 4 po p.2	39.326	59.7562	0.0912	0.01415	99.1596
x11308 site 4 po p.3	39.3476	59.9216	0.0682	0.01375	99.3418
x11308 site 4 po p.4	39.2886	59.8269	0.1046	0.014	99.2187
x11308 site 4 po p.5	39.224	59.5706	0.0645	0.01415	98.8517
x11308 site 4 po p.6	39.4184	59.7374	0.0781	0.014	99.2272
x11308 site 4 po p.7	39.4385	59.6935	0.0831	0.0139	99.2178
x11308 site 4 po p.8	39.3871	59.58	0.072	0.0138	99.0414
x11308 site 4 po p.9	39.3738	59.9056	0.0662	0.014	99.3412
x11308 site 4 po p.10	39.3687	59.7728	0.0648	0.01405	99.2027
x11308 site 4 po p.11	39.4686	59.7466	0.0692	0.01385	99.2841
x11308 site 4 po p.12	39.4107	59.5579	0.0737	0.01395	99.0466
x11308 site 4 po p.13	39.4193	59.6103	0.0746	0.01425	99.0845
x11308 site 4 po p.14	39.4001	59.7327	0.0961	0.0139	99.2335
x11308 site 4 po p.15	39.3826	59.8283	0.0789	0.014	99.2966
x11308 site 4 po p.16	39.3873	59.6806	0.0751	0.01405	99.1467
x11308 site 4 po p.17	39.2994	59.7838	0.1103	0.01395	99.1865
x11308 site 4 po p.18	39.3732	59.7698	0.0799	0.01405	99.2238
x11308 site 4 po p.19	39.372	59.5271	0.0683	0.01385	98.9667
x11308 site 4 po p.20	39.4545	59.6705	0.0848	0.014	99.2069
x11308 site 4 po p.21	39.3196	59.5993	0.0992	0.0135	99.0352
x11308 site 4 po p.22	39.3636	59.6609	0.0839	0.0142	99.1055
x11308 site 4 po p.23	39.4314	59.7009	0.068	0.0141	99.1943
x11308 site 4 po p.24	39.3205	59.5517	0.0914	0.0137	98.9726
x11308 site 4 po p.25	39.3309	59.762	0.0604	0.014	99.1603
x11308 site 4 po p.26	39.3175	59.5785	0.0902	0.01395	98.9865
x11308 site 4 po p.27	39.3051	59.6293	0.0758	0.01405	99.0089
x11308 site 6 po p.1	39.3388	59.2764	0.0822	0.0138	98.7078
x11308 site 6 po p.2	39.3505	59.5684	0.071	0.0141	98.9973

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x11308 site 6 po p.3	39.3494	59.5417	0.0917	0.014	98.9833
x11308 site 6 po p.4	39.3659	59.6697	0.0905	0.014	99.125
x11308 site 6 po p.5	39.4881	59.6101	0.0865	0.0138	99.1872
x11308 site 6 po p.6	39.5003	59.5142	0.091	0.01395	99.1008
x11308 site 6 po p.7	39.3305	59.6736	0.1155	0.0138	99.1284
x11308 site 6 po p.8	39.3739	59.5504	0.076	0.014	98.9972
x11308 site 6 po p.9	39.4547	59.5308	0.0955	0.0139	99.0922
x11308 site 6 po p.10	39.4607	59.3287	0.0831	0.01395	98.87
x11308 site 6 po p.11	40.1409	59.4311	0.1128	0.014	99.6781
x11308 site 6 po p.12	39.7152	59.6588	0.0972	0.0141	99.4615
x11308 site 6 po p.13	39.9589	59.2243	0.1007	0.01405	99.2816
x102060 site 2 po p.1	39.6187	59.6118	0.0764	0.0141	99.2988
x102060 site 2 po p.2	39.2512	60.3758	0.0931	0.0141	99.7151
x102060 site 2 po p.3	39.6309	59.7554	0.0547	0.01405	99.4376
x102060 site 2 po p.4	39.6278	59.7974	0.0539	0.014	99.4846
x102060 site 2 po p.5	39.6813	59.7686	0.0858	0.0143	99.5283
x102060 site 2 po p.6	39.6074	59.6731	0.0969	0.01405	99.3782
x102060 site 2 po p.7	39.7568	59.7353	0.1083	0.01375	99.6121
x102060 site 2 po p.8	39.6464	59.7774	0.0853	0.01385	99.506
x102060 site 2 po p.9	39.6728	59.738	0.076	0.014	99.48
x102060 site 2 po p.10	39.628	59.5814	0.0785	0.01385	99.296
x102060 site 2 po p.11	39.6219	59.8452	0.0852	0.0139	99.559
x102060 site 2 po p.12	39.6925	59.5749	0.0859	0.01405	99.3478
x102060 site 2 po p.13	39.6539	59.6793	0.0624	0.01405	99.3847
x102060 site 2 po p.14	39.6972	59.8079	0.0486	0.01385	99.5524
x102060 site 2 po p.15	39.8419	59.5973	0.0798	0.014	99.5263
x102060 site 2 po p.16	39.7465	59.5036	0.0815	0.0142	99.3285
x102060 site 2 po p.17	39.768	59.9639	0.02345	0.0141	99.7551
x102060 site 2 po p.18	39.726	59.9275	0.0958	0.0139	99.7388
x102060 site 2 po p.19	39.7688	59.9841	0.0507	0.0141	99.7941
x102060 site 2 po p.20	39.695	60.0306	0.0603	0.01415	99.7706
x102060 site 2 po p.21	39.0099	60.4463	0.0857	0.01385	99.5554
x102060 site 2 po p.22	39.0186	60.4757	0.0675	0.01395	99.5712
x102060 site 2 po p.23	39.6866	59.8765	0.0803	0.01395	99.6432
x102060 site 2 po p.24	39.6759	59.8432	0.0928	0.014	99.6047
x102060 site 2 po p.25	39.6267	59.8913	0.0624	0.0139	99.5864
x102060 site 2 po p.26	39.5719	59.7917	0.0542	0.01385	99.4313
x102060 site 2 po p.27	39.7304	59.6168	0.1005	0.01405	99.4469
x102060 site 2 po p.28	39.6236	59.6875	0.02295	0.0139	99.3581
x102060 site 2 po p.29	39.6199	59.7172	0.0988	0.01395	99.4349
x102060 site 2 po p.30	39.6699	59.7473	0.0585	0.0137	99.4864
x102060 site 2 po p.31	39.6841	59.8468	0.0595	0.0139	99.5898
x102060 site 2 po p.32	39.7483	59.708	0.1086	0.01395	99.568
x102060 site 2 po p.33	39.5556	59.6455	0.0774	0.0142	99.28
x102060 site 2 po p.34	39.6619	59.6355	0.0758	0.01395	99.3668
x102060 site 2 po p.35	39.6427	59.71	0.0714	0.0138	99.4213
x102060 site 2 po p.36	39.4654	59.7717	0.0514	0.01405	99.2883

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102060 site 2 po p.37	39.7439	59.7456	0.0739	0.01415	99.5491
x102060 site 2 po p.38	39.758	59.8009	0.0755	0.0138	99.6426
x102060 site 2 po p.39	39.593	59.7379	0.0734	0.014	99.4068
x102060 site 2 po p.40	39.5608	59.8481	0.0507	0.01365	99.4635
x102060 site 2 po p.41	39.6772	59.5497	0.0783	0.014	99.3105
x102060 site 2 po p.42	39.5941	59.6954	0.077	0.0142	99.3555
x102060 site 2 po p.43	39.6073	59.736	0.0735	0.0141	99.4228
x102060 site 2 po p.44	39.6781	59.7172	0.0605	0.01395	99.4614
x102060 site 2 po p.45	39.6564	59.935	0.0607	0.014	99.6538
x102060 site 2 po p.46	39.7129	59.7192	0.0954	0.014	99.5258
x102060 site 2 po p.47	39.5525	60.0152	0.0559	0.014	99.6206
x102060 site 2 po p.48	39.1702	60.5541	0.0487	0.01385	99.7783
x102060 site 2 po p.49	39.6053	59.8073	0.0827	0.0138	99.4893
x102060 site 2 po p.50	39.1885	60.2296	0.083	0.014	99.5115
x102060 site 2 po p.51	39.6886	59.8535	0.0928	0.01405	99.6296
x102060 site 2 po p.52	39.4252	60.0882	0.0733	0.0139	99.5895
x102060 site 2 po p.53	39.6432	59.8102	0.0513	0.01395	99.5043
x102060 site 2 po p.54	38.966	60.3186	0.0643	0.01405	99.3426
x102060 site 2 po p.55	39.6221	59.9075	0.0728	0.0139	99.6086
x102060 site 2 po p.56	39.6447	59.9323	0.0811	0.014	99.6578
x102060 site 5 po p.1	39.6502	59.7753	0.0787	0.01405	99.5042
x102060 site 5 po p.2	39.6724	59.6738	0.0572	0.0141	99.4032
x102060 site 5 po p.3	39.5659	60.0105	0.0719	0.014	99.6514
x102060 site 5 po p.4	39.6826	59.8456	0.0663	0.014	99.5826
x102060 site 5 po p.5	39.6395	59.9132	0.0993	0.0139	99.6564
x102060 site 5 po p.6	39.4843	59.7604	0.0816	0.0138	99.3269
x102060 site 5 po p.7	39.6405	59.8631	0.0661	0.01385	99.5714
x102060 site 5 po p.8	39.5403	59.9733	0.0231	0.01395	99.5624
x102060 site 5 po p.9	39.5765	59.8567	0.0731	0.0141	99.4869
x102060 site 5 po p.10	39.6353	59.9101	0.0642	0.01395	99.6067
x102060 site 5 po p.11	39.5286	59.8102	0.0793	0.0137	99.4237
x102060 site 5 po p.12	39.5698	59.8814	0.0804	0.01395	99.5316
x102060 site 5 po p.13	39.4649	59.7651	0.0838	0.0136	99.3213
x102060 site 5 po p.14	39.5356	59.9917	0.069	0.0141	99.5976
x102060 site 5 po p.15	39.5484	59.7767	0.0868	0.0142	99.4078
x102060 site 5 po p.16	39.4901	59.7414	0.0726	0.01395	99.308
x102060 site 5 po p.17	39.5961	59.8518	0.0686	0.01395	99.5144
x102060 site 5 po p.18	39.5339	59.8776	0.0918	0.01405	99.5115
x102060 site 5 po p.19	39.5134	59.8639	0.0643	0.01395	99.438
x102060 site 5 po p.20	39.6476	60.0511	0.0824	0.0141	99.7741
x102060 site 5 po p.21	39.5404	59.9912	0.0731	0.01395	99.6049
x102060 site 5 po p.22	39.5682	59.9398	0.0842	0.01385	99.5939
x102060 site 5 po p.23	39.4729	59.8367	0.057	0.0141	99.3623
x102060 site 5 po p.24	39.5901	59.8605	0.0942	0.01375	99.5486
x102060 site 5 po p.25	39.6446	60.059	0.0638	0.014	99.7629
x102060 site 5 po p.26	39.6303	59.9943	0.0614	0.01395	99.6806
x102060 site 5 po p.27	39.6194	59.9107	0.0556	0.0139	99.5898

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102060 site 5 po p.28	39.6084	59.7772	0.0732	0.014	99.4544
x102060 site 5 po p.29	39.0257	60.6581	0.0689	0.0141	99.7564
x102060 site 5 po p.30	38.9349	60.4439	0.077	0.01385	99.4621
x102060 site 5 po p.31	39.6055	59.929	0.0699	0.014	99.6023
x102060 site 5 po p.32	39.3861	60.2343	0.0834	0.0137	99.7089
x102060 site 5 po p.33	39.4571	59.9845	0.0619	0.014	99.5101
x102060 site 5 po p.34	39.5508	59.7215	0.056	0.0139	99.3381
x102060 site 5 po p.35	38.9466	60.4315	0.0713	0.0141	99.4514
x102060 site 5 po p.36	39.2475	60.541	0.083	0.0142	99.8538
x102060 site 5 po p.37	39.6026	59.7738	0.073	0.01415	99.4434
x102060 site 5 po p.38	39.5761	59.957	0.0225	0.0139	99.5787
x102060 site 5 po p.39	39.4503	60.0493	0.0517	0.0137	99.5587
x102060 site 5 po p.40	39.5068	60.0455	0.0668	0.01395	99.6264
x102060 site 5 po p.41	39.5458	59.9846	0.0886	0.01385	99.6222
x102060 site 5 po p.42	39.6753	59.6884	0.0705	0.0138	99.4346
x102060 site 5 po p.43	39.4865	59.6415	0.0564	0.01385	99.1819
x102060 site 5 po p.44	39.5206	59.717	0.066	0.01405	99.2971
x102060 site 5 po p.45	39.6578	59.7965	0.0626	0.014	99.5173
x102060 site 5 po p.46	39.6046	59.5838	0.02265	0.01385	99.2279
x102060 site 5 po p.47	39.5375	59.9309	0.1048	0.01405	99.5601
x102060 site 5 po p.48	38.979	60.6045	0.0565	0.01415	99.6291
x102060 site 5 po p.49	39.1485	60.3967	0.0559	0.014	99.6045
x102060 site 5 po p.50	38.9723	60.4347	0.0727	0.014	99.474
x102060 site 5 po p.51	39.6736	59.9373	0.0811	0.01385	99.6959
x102060 site 5 po p.52	39.6387	59.9502	0.0227	0.0138	99.64
x102060 site 5 po p.53	39.5408	59.9084	0.0767	0.01395	99.5294
x102060 site 5 po p.54	39.4352	59.941	0.0565	0.0139	99.4297
x102060 site 5 po p.55	39.0556	60.3699	0.074	0.0141	99.4965
x102060 site 5 po p.56	38.9215	60.7693	0.0901	0.01405	99.7775
x102060 site 5 po p.57	39.0555	60.4072	0.076	0.01395	99.5324
x102060 site 5 po p.58	39.4873	60.1889	0.0539	0.0142	99.727
x102060 site 5 po p.59	38.8244	60.3708	0.0767	0.01385	99.2741
x102060 site 5 po p.60	39.4644	59.9646	0.0683	0.01395	99.5049
x102060 site 5 po p.61	39.7771	60.0655	0.0654	0.0138	99.9067
x102060 site 5 po p.62	39.7532	59.9702	0.053	0.01355	99.7938
x102060 site 5 po p.63	39.5378	59.9056	0.0685	0.01385	99.5178
x102060 site 5 po p.64	39.6124	59.9609	0.0591	0.01395	99.622
x102060 site 5 po p.65	39.7589	59.8852	0.058	0.014	99.6951
x102060 site 5 po p.66	39.0742	60.6424	0.0777	0.01405	99.7885
x102060 site 7 po p.1	39.475	59.9577	0.0813	0.01415	99.5047
x102060 site 7 po p.2	39.1899	60.5111	0.0979	0.01405	99.7948
x102060 site 7 po p.3	39.0614	60.293	0.0587	0.01385	99.4273
x102060 site 7 po p.4	39.5012	60.0848	0.0593	0.01395	99.6433
x102060 site 7 po p.5	39.4469	59.9402	0.0675	0.01395	99.4514
x102060 site 7 po p.6	39.4515	60.0055	0.1079	0.01405	99.5613
x102060 site 7 po p.7	39.5185	59.9245	0.0912	0.0141	99.5265
x102060 site 7 po p.8	39.5028	59.9685	0.0847	0.01405	99.5497

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102060 site 7 po p.9	39.5766	60.0233	0.0641	0.0139	99.6629
x102060 site 7 po p.10	39.4916	60.0305	0.0764	0.01415	99.581
x102060 site 7 po p.11	39.5637	60.1491	0.063	0.01385	99.7804
x102060 site 7 po p.12	38.821	60.7071	0.0662	0.01395	99.5978
x102060 site 7 po p.13	39.5408	60.0857	0.0662	0.01395	99.695
x102060 site 7 po p.14	38.8852	60.6516	0.0757	0.014	99.6053
x102060 site 7 po p.15	38.9014	60.5955	0.0647	0.0138	99.5688
x102060 site 7 po p.16	39.3894	60.0306	0.0729	0.0142	99.4854
x102060 site 7 po p.17	38.9132	60.6067	0.0601	0.0141	99.5727
x102060 site 7 po p.18	38.7959	60.5913	0.0681	0.01375	99.466
x102060 site 7 po p.19	38.8074	60.5584	0.069	0.0136	99.4518
x102060 site 7 po p.20	38.8122	60.5363	0.0871	0.01405	99.437
x102060 site 7 po p.21	39.5261	59.995	0.0741	0.0139	99.5941
x102060 site 7 po p.22	38.7617	60.521	0.059	0.01405	99.3425
x102060 site 7 po p.23	38.9437	60.6037	0.0549	0.014	99.6102
x102060 site 7 po p.24	38.8022	60.4395	0.0752	0.0143	99.3049
x102060 site 7 po p.25	39.3645	59.8223	0.0491	0.01415	99.2307
x102060 site 7 po p.26	39.19	60.3097	0.0771	0.01385	99.5864
x102060 site 7 po p.27	38.8721	60.5187	0.0566	0.01375	99.4623
x102060 site 7 po p.28	39.5101	60.0007	0.0605	0.01395	99.5723
x102060 site 7 po p.29	39.3252	60.0756	0.0701	0.01385	99.4731
x102060 site 7 po p.30	38.7844	60.4295	0.0737	0.01385	99.2904
x102060 site 7 po p.31	38.8739	60.5245	0.0751	0.014	99.4651
x102060 site 7 po p.32	38.9074	60.4594	0.0693	0.0139	99.4445
x102060 site 7 po p.33	38.8143	60.5225	0.0828	0.01415	99.4154
x102060 site 7 po p.34	38.7971	60.6871	0.066	0.01385	99.5375
x102060 site 7 po p.35	38.8961	60.5074	0.088	0.0138	99.4928
x102060 site 7 po p.36	38.8958	60.4208	0.0818	0.01415	99.4005
x102060 site 7 po p.37	38.9403	60.5483	0.0878	0.01405	99.5649
x102060 site 7 po p.38	38.9117	60.5216	0.0897	0.0142	99.5242
x102060 site 7 po p.39	38.6758	60.6131	0.0713	0.01405	99.355
x102060 site 7 po p.40	38.8355	60.5419	0.0935	0.01365	99.4702
x102060 site 7 po p.41	38.7933	60.2636	0.064	0.0143	99.1108
x102060 site 7 po p.42	39.3054	60.0676	0.02315	0.01405	99.4098
x102060 site 7 po p.43	38.8235	60.5893	0.0813	0.0142	99.4779
x102060 site 7 po p.44	38.7963	60.4941	0.0637	0.01405	99.3564
x102060 site 7 po p.45	38.6978	60.4376	0.0724	0.0138	99.2214
x102060 site 7 po p.46	38.8317	60.503	0.0777	0.01385	99.4106
x102060 site 7 po p.47	39.3355	59.8518	0.0748	0.01405	99.2529
x102060 site 7 po p.48	39.3815	59.9455	0.0838	0.01385	99.4085
x102060 site 7 po p.49	39.3685	59.6851	0.0815	0.014	99.1328
x102060 site 7 po p.50	39.0517	60.2749	0.02295	0.0142	99.3599
x102060 site 7 po p.51	39.1593	60.1678	0.0769	0.01395	99.4077
x102060 site 7 po p.52	38.9252	60.5206	0.0636	0.01435	99.4876
x102060 site 7 po p.53	39.2246	60.2149	0.0733	0.01395	99.5144
x102060 site 7 po p.54	39.4506	59.8373	0.0931	0.01405	99.3692
x102060 site 7 po p.55	38.8775	60.551	0.0876	0.0139	99.5204

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102060 site 7 po p.56	39.4604	59.8407	0.0724	0.01395	99.3681
x102060 site 7 po p.57	38.8834	60.3624	0.072	0.01405	99.3122
x102060 site 7 po p.58	38.9965	60.3141	0.068	0.01385	99.3812
x102060 site 7 po p.59	38.8409	60.3603	0.0508	0.01385	99.2498
x102060 site 7 po p.60	38.9254	60.5194	0.0608	0.0143	99.4865
x102060 site 8 po p.1	39.6108	59.9921	0.076	0.01385	99.686
x102060 site 8 po p.2	39.5854	59.9163	0.0581	0.01385	99.5583
x102060 site 8 po p.3	39.4964	59.7833	0.0619	0.0142	99.3418
x102060 site 8 po p.4	39.5177	59.8196	0.0767	0.01425	99.3974
x102060 site 8 po p.5	39.5928	59.8136	0.0615	0.0143	99.4539
x102060 site 8 po p.6	39.4659	59.9589	0.0479	0.01395	99.4703
x102060 site 8 po p.7	39.3831	59.9786	0.0707	0.0141	99.4295
x102060 site 8 po p.8	39.5129	59.8773	0.0693	0.0142	99.4582
x102060 site 8 po p.9	39.5605	59.7388	0.0855	0.01395	99.3887
x102060 site 8 po p.10	39.5505	59.8947	0.0731	0.0142	99.5131
x102060 site 8 po p.11	39.4695	59.7554	0.0786	0.01415	99.2969
x102060 site 8 po p.12	39.447	59.9579	0.0627	0.0141	99.4762
x102060 site 8 po p.13	39.4588	59.8874	0.0675	0.01375	99.4342
x102060 site 8 po p.14	39.5466	60.058	0.0667	0.01395	99.6741
x102060 site 8 po p.15	39.4964	59.6842	0.0788	0.01395	99.2685
x102060 site 8 po p.16	38.9186	60.4418	0.0537	0.0141	99.4056
x102060 site 8 po p.17	39.1022	60.3869	0.0788	0.0141	99.5676
x102060 site 8 po p.18	38.9665	60.4276	0.0719	0.0141	99.4652
x102060 site 8 po p.19	39.3175	60.0759	0.0684	0.01395	99.4476
x102060 site 8 po p.20	39.2613	60.2775	0.0227	0.01355	99.6063
x102060 site 8 po p.21	39.1953	60.1213	0.0621	0.01375	99.3923
x102060 site 8 po p.22	38.945	60.6014	0.0498	0.01405	99.5914
x102060 site 8 po p.23	39.26	60.1453	0.0685	0.014	99.4739
x102060 site 8 po p.24	38.9011	60.2675	0.0863	0.01395	99.26
x102060 site 8 po p.25	39.3103	59.9393	0.077	0.01405	99.3254
x102060 site 8 po p.26	39.4324	59.6766	0.0595	0.014	99.1647
x102060 site 8 po p.27	38.9461	60.5896	0.0716	0.01415	99.5976
x102060 site 8 po p.28	38.7954	60.5744	0.0591	0.01405	99.421
x102060 site 8 po p.29	38.8094	60.4324	0.0832	0.014	99.3241
x102060 site 8 po p.30	38.8668	60.5265	0.0531	0.01395	99.4472
x102060 site 8 po p.31	38.8837	60.5093	0.0716	0.014	99.4556
x102060 site 8 po p.32	39.4085	59.9576	0.0622	0.01395	99.432
x102060 site 8 po p.33	39.0261	60.3456	0.0809	0.01405	99.4492
x102060 site 8 po p.34	39.5157	59.8558	0.0632	0.014	99.4309
x102060 site 8 po p.35	39.4512	59.8176	0.0879	0.0141	99.3453
x102060 site 8 po p.36	39.471	59.7292	0.0709	0.0139	99.2761
x102060 site 8 po p.37	39.3214	59.6174	0.1025	0.01385	99.0523
x102060 site 8 po p.38	39.56	60.1291	0.0672	0.01415	99.7346
x102060 site 8 po p.39	39.4566	59.828	0.0737	0.01415	99.359
x102060 site 8 po p.40	39.5203	59.9157	0.0621	0.01415	99.4893
x102060 site 8 po p.41	39.0981	60.3804	0.0608	0.01385	99.5396
x102060 site 8 po p.42	39.447	59.8984	0.096	0.0137	99.4499

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102060 site 8 po p.43	39.4845	59.9729	0.0891	0.01425	99.5277
x102060 site 8 po p.44	39.3706	60.0063	0.0499	0.0138	99.4353
x102060 site 8 po p.45	39.4685	60.0148	0.0786	0.014	99.5569
x102060 site 8 po p.46	39.4689	59.9875	0.0491	0.01365	99.521
x102060 site 8 po p.47	39.4987	59.8707	0.0703	0.01395	99.447
x102060 site 8 po p.48	39.4689	59.9227	0.0891	0.01375	99.4799
x102060 site 8 po p.49	39.5673	59.8745	0.0711	0.01395	99.5142
x102060 site 8 po p.50	39.3823	59.8982	0.0688	0.01395	99.3503
x102060 site 8 po p.51	39.4981	59.835	0.0642	0.0139	99.3925
x102060 site 8 po p.52	39.5075	59.8418	0.0221	0.014	99.3964
x102060 site 8 po p.53	39.3665	59.7879	0.0228	0.01385	99.199
x102060 site 8 po p.54	39.4243	59.9604	0.0571	0.01415	99.4267
x102060 site 8 po p.55	39.3387	59.8811	0.0644	0.0141	99.2763
x102060 site 8 po p.56	39.5036	59.9151	0.0625	0.01395	99.4873
x102060 site 8 po p.57	39.4145	59.8851	0.0711	0.0137	99.3852
x102060 site 8 po p.58	39.0022	60.4657	0.0861	0.0139	99.5575
x102060 site 8 po p.59	38.9591	60.339	0.0796	0.0141	99.3727
x102060 site 8 po p.60	38.7922	60.4052	0.066	0.014	99.2703
x102060 site 8 po p.61	38.8641	60.6037	0.0729	0.01395	99.5404
x102060 site 8 po p.62	39.3881	59.869	0.0581	0.01415	99.3042
x102060 site 8 po p.63	39.506	59.8025	0.0641	0.01365	99.3831
x102060 site 8 po p.64	39.4964	59.9624	0.0826	0.01425	99.5287
x102060 site 8 po p.65	39.5485	59.8029	0.0812	0.01395	99.4351
x102060 site 8 po p.66	39.5943	59.7897	0.066	0.01385	99.4436
x102060 site 8 po p.67	39.5575	59.8662	0.0978	0.0142	99.512
x102060 site 9 po p.1	39.4895	59.874	0.0667	0.0141	99.4172
x102060 site 9 po p.2	38.87	60.2926	0.074	0.01415	99.2255
x102060 site 9 po p.3	39.4006	59.98	0.0898	0.01395	99.4691
x102060 site 9 po p.4	39.2746	59.9384	0.0756	0.0139	99.2825
x102060 site 9 po p.5	39.3581	59.7125	0.0641	0.0139	99.1303
x102060 site 9 po p.6	38.8993	60.4091	0.0741	0.014	99.3804
x102060 site 9 po p.7	38.9557	60.3412	0.0644	0.0139	99.3674
x102060 site 9 po p.8	39.0161	60.246	0.0227	0.01395	99.3186
x102060 site 9 po p.9	39.3621	59.6287	0.0794	0.0138	99.0688
x102060 site 9 po p.10	39.0941	60.136	0.0693	0.0138	99.3083
x102060 site 9 po p.11	39.3207	60.124	0.0652	0.014	99.5114
x102060 site 9 po p.12	38.9924	60.3908	0.0665	0.01405	99.4412
x102060 site 9 po p.13	39.0127	60.417	0.0674	0.0141	99.4925
x102060 site 9 po p.14	39.3928	59.732	0.0737	0.01395	99.1946
x102060 site 9 po p.15	39.1111	60.4639	0.0812	0.0138	99.6568
x102060 site 9 po p.16	39.4444	59.9682	0.0605	0.01395	99.4743
x102060 site 9 po p.17	39.4531	59.8025	0.0919	0.0141	99.3448
x102060 site 9 po p.18	39.5351	59.8793	0.0665	0.014	99.4785
x102060 site 9 po p.19	39.4946	59.6479	0.0791	0.0139	99.2168
x102060 site 9 po p.20	39.6113	59.815	0.0617	0.01375	99.5018
x102060 site 9 po p.21	39.5074	59.7356	0.061	0.0139	99.3062
x102060 site 9 po p.22	39.4719	59.742	0.0894	0.01395	99.3089

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102060 site 9 po p.23	39.6767	59.8789	0.0748	0.01405	99.6179
x102060 site 9 po p.24	39.1071	60.4053	0.0547	0.0142	99.5671
x102060 site 9 po p.25	39.1218	60.2713	0.0624	0.01425	99.4493
x102060 site 9 po p.26	39.0683	60.3883	0.0832	0.0139	99.5486
x102060 site 9 po p.27	39.5709	59.9506	0.0776	0.01395	99.6007
x102060 site 9 po p.28	39.0137	60.4477	0.0625	0.014	99.5253
x102060 site 9 po p.29	38.9668	60.3563	0.0676	0.0139	99.3847
x102060 site 9 po p.30	38.898	60.3873	0.0845	0.01385	99.3753
x102060 site 9 po p.31	39.033	60.4504	0.0687	0.01385	99.5581
x102060 site 9 po p.32	39.054	60.5601	0.0615	0.01405	99.6746
x102060 site 9 po p.33	39.126	60.4235	0.078	0.0141	99.6289
x102060 site 9 po p.34	39.6352	59.9723	0.071	0.0139	99.6693
x102060 site 9 po p.35	39.6224	59.8847	0.0871	0.01395	99.589
x102060 site 9 po p.36	39.3018	60.192	0.081	0.014	99.5705
x102060 site 9 po p.37	39.5472	59.953	0.0821	0.0141	99.5876
x102060 site 11 po p.1	39.6063	59.7617	0.0601	0.01385	99.4264
x102060 site 11 po p.2	39.7261	59.7131	0.089	0.0141	99.5155
x102060 site 11 po p.3	39.5064	59.8682	0.0603	0.01365	99.4507
x102060 site 11 po p.4	39.1623	60.3208	0.0699	0.01365	99.5694
x102060 site 11 po p.5	39.3718	59.8886	0.0902	0.014	99.3509
x102060 site 11 po p.6	39.4527	59.6739	0.0927	0.0141	99.2138
x102060 site 11 po p.7	39.6163	59.6686	0.0927	0.01395	99.3744
x102060 site 11 po p.8	39.5371	59.8055	0.0694	0.01405	99.4106
x102060 site 11 po p.9	39.6462	59.8539	0.0997	0.014	99.5935
x102060 site 11 po p.10	39.555	59.9551	0.0753	0.0142	99.5804
x102060 site 11 po p.11	39.4838	59.8212	0.0625	0.01385	99.3686
x102060 site 11 po p.12	39.4048	59.7979	0.0542	0.0138	99.2604
x102060 site 11 po p.13	38.9059	60.5724	0.0674	0.01365	99.56
x102060 site 11 po p.14	39.2089	60.0585	0.0682	0.01385	99.3446
x102060 site 11 po p.15	39.4721	59.7725	0.0658	0.01425	99.2989
x102060 site 11 po p.16	39.4245	59.8533	0.0845	0.01415	99.353
x102060 site 11 po p.17	39.4161	59.6683	0.0825	0.0142	99.1549
x102060 site 11 po p.18	39.5789	59.8531	0.0531	0.0141	99.4865
x102060 site 11 po p.19	39.4521	59.8532	0.0595	0.01395	99.364
x102060 site 11 po p.20	39.4445	59.9006	0.061	0.0138	99.4145
x102060 site 11 po p.21	39.5252	59.8323	0.0805	0.0139	99.4436
x102060 site 11 po p.22	39.5977	59.7705	0.0602	0.0139	99.4243
x102060 site 11 po p.23	39.587	59.9228	0.0614	0.01405	99.5745
x102060 site 11 po p.24	39.5412	59.8497	0.0593	0.01385	99.4611
x102060 site 11 po p.25	39.5303	59.9864	0.087	0.01385	99.6091
x102060 site 11 po p.26	39.6044	60.0109	0.0789	0.0139	99.6944
x102060 site 11 po p.27	39.6598	60.1089	0.0694	0.01385	99.8453
x102060 site 11 po p.28	39.4819	59.9042	0.0707	0.014	99.4569
x102060 site 11 po p.29	39.7924	60.0007	0.0829	0.01385	99.888
x102060 site 11 po p.30	39.3991	60.1477	0.0665	0.014	99.5995
x102060 site 11 po p.31	39.6155	59.694	0.081	0.0139	99.3946
x102060 site 11 po p.32	39.6119	59.9821	0.0841	0.01395	99.6786

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102060 site 11 po p.33	39.7347	60.0168	0.0847	0.014	99.8371
x102060 site 11 po p.34	39.6341	59.9751	0.0745	0.0141	99.67
x102060 site 11 po p.35	39.3395	60.0889	0.0752	0.01365	99.5177
x102060 site 11 po p.36	39.6045	59.8681	0.0713	0.0141	99.5425
x102073 site 1 po p.1	39.7678	59.9815	0.0631	0.0141	99.7989
x102073 site 1 po p.2	39.6477	60.0862	0.0704	0.014	99.8087
x102073 site 1 po p.3	39.7322	60.0152	0.0601	0.01385	99.8155
x102073 site 1 po p.4	39.6745	59.9519	0.0625	0.01385	99.694
x102073 site 1 po p.5	39.675	60.0826	0.0574	0.01405	99.8117
x102073 site 1 po p.6	39.6317	59.8928	0.0848	0.01405	99.6061
x102073 site 1 po p.7	39.5463	60.0425	0.0589	0.0138	99.6638
x102073 site 1 po p.8	39.8451	59.9294	0.0749	0.0137	99.8528
x102073 site 1 po p.9	39.5935	59.8172	0.0235	0.0139	99.4487
x102073 site 1 po p.10	39.6625	60.0067	0.0712	0.014	99.7417
x102073 site 1 po p.11	39.6039	59.9922	0.0645	0.014	99.6544
x102073 site 1 po p.12	39.7454	59.8367	0.0772	0.014	99.6635
x102073 site 1 po p.13	39.8044	59.8953	0.0595	0.0141	99.7578
x102073 site 1 po p.14	39.6796	60.0638	0.0574	0.01375	99.8079
x102073 site 1 po p.15	39.6258	59.8891	0.0524	0.01405	99.5698
x102073 site 1 po p.16	39.7168	59.9121	0.0854	0.01395	99.7261
x102073 site 1 po p.17	39.6683	59.8132	0.02275	0.0139	99.529
x102073 site 1 po p.18	39.7791	59.9357	0.0768	0.0138	99.8004
x102073 site 1 po p.19	39.623	59.835	0.0712	0.0138	99.5323
x102073 site 1 po p.20	39.6273	60.0658	0.0668	0.014	99.7572
x102073 site 1 po p.21	39.5832	60.2586	0.02245	0.0138	99.8958
x102073 site 1 po p.22	39.6108	60.1061	0.0764	0.01405	99.7918
x102073 site 1 po p.23	39.6162	60.1883	0.0684	0.014	99.8681
x102073 site 1 po p.24	39.6165	60.0421	0.0956	0.014	99.7525
x102073 site 1 po p.25	39.6441	60.1386	0.0795	0.0137	99.8706
x102073 site 1 po p.26	39.5981	59.9882	0.048	0.0141	99.6193
x102073 site 1 po p.27	39.655	59.9796	0.0492	0.0139	99.6829
x102073 site 1 po p.28	39.7052	60.0415	0.0637	0.01405	99.8094
x102073 site 1 po p.29	39.653	59.9393	0.0782	0.01395	99.674
x102073 site 1 po p.30	39.7456	59.8518	0.082	0.0139	99.6821
x102073 site 1 po p.31	39.6511	59.9875	0.0516	0.0138	99.6949
x102073 site 1 po p.32	39.7071	59.9772	0.0605	0.01415	99.7385
x102073 site 1 po p.33	39.6734	59.9244	0.0596	0.014	99.6475
x102073 site 1 po p.34	39.6089	59.955	0.0802	0.01385	99.6376
x102073 site 1 po p.35	39.8055	60.1515	0.0711	0.01415	100.0316
x102073 site 1 po p.36	39.6965	60.064	0.0745	0.0139	99.8531
x102073 site 1 po p.37	39.6125	60.0834	0.0626	0.0141	99.7455
x102073 site 1 po p.38	39.6663	60.0602	0.0965	0.0142	99.817
x102073 site 1 po p.39	39.6014	59.923	0.0729	0.014	99.6031
x102073 site 1 po p.40	39.5173	60.0389	0.0632	0.01385	99.621
x102073 site 1 po p.41	39.5331	60.0639	0.0692	0.01375	99.6815
x102073 site 1 po p.42	39.7074	60.0132	0.0733	0.01395	99.8048
x102073 site 1 po p.43	39.6267	59.8685	0.0942	0.0137	99.6018

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102073 site 1 po p.44	39.6661	60.021	0.0671	0.014	99.7477
x102073 site 1 po p.45	39.7131	59.71	0.0821	0.01395	99.5064
x102073 site 1 po p.46	39.6609	60.0893	0.0706	0.01395	99.8235
x102073 site 1 po p.47	39.609	60.0928	0.0708	0.01385	99.7788
x102073 site 1 po p.48	39.6957	60.0161	0.067	0.01395	99.7763
x102073 site 1 po p.49	39.6459	59.8575	0.0632	0.0141	99.5495
x102073 site 1 po p.50	39.578	59.9458	0.0629	0.01415	99.5787
x102073 site 1 po p.51	39.5716	60.0278	0.0537	0.0143	99.6352
x102073 site 1 po p.52	39.7068	60.0486	0.0806	0.0138	99.8276
x102073 site 1 po p.53	39.6479	59.929	0.0606	0.0139	99.6404
x102073 site 2 po p.1	39.6495	59.8923	0.0635	0.0139	99.6144
x102073 site 2 po p.2	39.6356	59.9194	0.0757	0.0137	99.6545
x102073 site 2 po p.3	39.3883	60.1948	0.0525	0.0141	99.6258
x102073 site 2 po p.4	39.6858	60.02	0.069	0.0139	99.7717
x102073 site 2 po p.5	39.6109	60.1278	0.0696	0.01395	99.8158
x102073 site 2 po p.6	39.5809	60.0312	0.0688	0.01395	99.6789
x102073 site 2 po p.7	39.5615	59.9296	0.0632	0.01395	99.5539
x102073 site 2 po p.8	39.5854	59.9214	0.0602	0.0139	99.5723
x102073 site 2 po p.9	39.6849	59.9054	0.0913	0.01365	99.6887
x102073 site 2 po p.10	39.3373	59.8155	0.0567	0.014	99.2072
x102073 site 2 po p.11	39.5171	60.1914	0.061	0.01375	99.7759
x102073 site 2 po p.12	39.4984	59.9685	0.077	0.01385	99.5516
x102073 site 2 po p.13	39.6052	59.9429	0.05	0.01395	99.6045
x102073 site 2 po p.14	39.6398	59.9362	0.0791	0.01395	99.6525
x102073 site 2 po p.15	39.5395	60.0019	0.0503	0.01395	99.5842
x102073 site 2 po p.16	39.5004	59.9412	0.0666	0.01405	99.5127
x102073 site 2 po p.17	39.6256	59.9978	0.0626	0.01375	99.6897
x102073 site 2 po p.18	39.621	59.9005	0.0557	0.01375	99.5871
x102073 site 2 po p.19	39.6282	59.8785	0.0651	0.014	99.5642
x102073 site 2 po p.20	39.5649	59.8594	0.0642	0.014	99.4864
x102073 site 2 po p.21	39.5316	59.9763	0.0747	0.0139	99.5808
x102073 site 2 po p.22	39.545	59.867	0.0528	0.01405	99.4648
x102073 site 2 po p.23	39.5294	59.9	0.081	0.0138	99.5223
x102073 site 2 po p.24	39.6366	59.9339	0.0701	0.0138	99.6425
x102073 site 2 po p.25	39.5669	59.9724	0.0978	0.01415	99.6324
x102073 site 2 po p.26	39.4985	59.8043	0.0705	0.014	99.3682
x102073 site 2 po p.27	39.5899	59.9937	0.0228	0.0141	99.6237
x102073 site 2 po p.28	39.6544	59.9692	0.0732	0.01385	99.6996
x102073 site 2 po p.29	39.5948	60.0601	0.0685	0.01395	99.7075
x102073 site 2 po p.30	39.6003	59.9597	0.0779	0.0138	99.6485
x102073 site 2 po p.31	39.7809	60.0722	0.0677	0.01405	99.9214
x102073 site 2 po p.32	39.698	60.0353	0.0548	0.01405	99.7859
x102073 site 2 po p.33	39.6356	59.9592	0.0487	0.01415	99.6368
x102073 site 2 po p.34	39.4902	60.2054	0.0793	0.01395	99.7855
x102073 site 2 po p.35	39.6186	60.103	0.0585	0.01405	99.7798
x102073 site 2 po p.36	39.6864	59.9765	0.0806	0.01405	99.7325
x102073 site 2 po p.37	39.5782	59.9407	0.0876	0.014	99.6086

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102073 site 2 po p.38	39.6154	59.8719	0.0895	0.0138	99.5827
x102073 site 2 po p.39	39.5139	59.8385	0.0223	0.0139	99.4012
x102073 site 2 po p.40	39.6003	60.0259	0.0697	0.01375	99.7044
x102073 site 2 po p.41	39.5717	59.9607	0.0652	0.01385	99.5988
x102073 site 2 po p.42	39.6269	59.9685	0.0812	0.01395	99.6739
x102073 site 2 po p.43	39.4892	59.9468	0.059	0.01395	99.4962
x102073 site 2 po p.44	39.6235	59.9079	0.0912	0.0137	99.6367
x102073 site 2 po p.45	39.6783	59.8556	0.0551	0.01405	99.5869
x102073 site 2 po p.46	39.511	59.857	0.0766	0.0139	99.446
x102073 site 2 po p.47	39.7514	60.1165	0.0511	0.01405	99.9117
x102073 site 2 po p.48	39.5639	59.9667	0.0554	0.014	99.5921
x102073 site 2 po p.49	39.6575	59.9492	0.0743	0.01405	99.6847
x102073 site 3 po p.1	39.6237	59.8757	0.087	0.01385	99.5897
x102073 site 3 po p.2	39.4894	60.0472	0.0907	0.01415	99.6073
x102073 site 3 po p.3	39.7432	59.9409	0.0618	0.01395	99.7364
x102073 site 3 po p.4	39.5652	60.1676	0.0719	0.0138	99.808
x102073 site 3 po p.5	39.561	60.0236	0.1006	0.0138	99.6871
x102073 site 3 po p.6	39.5109	59.7947	0.0858	0.01375	99.3967
x102073 site 3 po p.7	39.4692	59.9002	0.0811	0.01385	99.4535
x102073 site 3 po p.8	39.4828	59.8735	0.0957	0.01385	99.4557
x102073 site 3 po p.9	39.4859	59.8364	0.0676	0.01395	99.3858
x102073 site 3 po p.10	39.5103	59.8399	0.0665	0.01385	99.4175
x102073 site 3 po p.11	39.6909	59.7986	0.0884	0.014	99.5841
x102073 site 3 po p.12	39.4444	59.9601	0.0587	0.0137	99.4815
x102073 site 3 po p.13	39.5787	59.902	0.0684	0.01405	99.5556
x102073 site 3 po p.14	39.5419	59.7693	0.0892	0.0139	99.3974
x102073 site 3 po p.15	39.6606	59.8443	0.0932	0.0141	99.5958
x102073 site 3 po p.16	39.4842	59.8573	0.0808	0.014	99.426
x102073 site 3 po p.17	39.4768	59.6534	0.0817	0.0139	99.22
x102073 site 3 po p.18	39.5602	59.9708	0.0816	0.0138	99.6275
x102073 site 3 po p.19	39.5612	59.8142	0.0617	0.0139	99.4409
x102073 site 3 po p.20	39.4423	59.7795	0.0685	0.01385	99.2781
x102073 site 3 po p.21	39.7257	60.0164	0.0834	0.01395	99.8208
x102073 site 3 po p.22	39.6034	59.9113	0.0864	0.0138	99.6003
x102073 site 3 po p.23	39.7482	59.8825	0.0793	0.0141	99.7003
x102073 site 3 po p.24	39.5867	59.6382	0.0687	0.01415	99.2807
x102073 site 3 po p.25	39.5969	59.9399	0.084	0.01395	99.6102
x102073 site 3 po p.26	39.6954	60.0949	0.0645	0.014	99.8558
x102073 site 3 po p.27	39.5854	60.1175	0.0483	0.01385	99.7504
x102073 site 3 po p.28	39.6582	59.9342	0.073	0.014	99.6675
x102073 site 3 po p.29	39.6639	59.9565	0.0926	0.01425	99.6897
x102073 site 3 po p.30	39.6197	59.9472	0.0732	0.01365	99.6475
x102073 site 3 po p.31	39.6262	60.0423	0.0848	0.0139	99.7618
x102073 site 3 po p.32	39.5545	59.8844	0.0861	0.01405	99.514
x102073 site 3 po p.33	39.5946	59.9727	0.0797	0.01415	99.6352
x102073 site 3 po p.34	39.5491	60.0553	0.0933	0.01375	99.6978
x102073 site 3 po p.35	39.6896	59.9553	0.09	0.01385	99.7424

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102073 site 3 po p.36	39.6037	59.8809	0.0566	0.014	99.5431
x102073 site 3 po p.37	39.7432	60.1031	0.0652	0.0138	99.9174
x102073 site 3 po p.38	39.6573	59.8082	0.0592	0.01405	99.512
x102073 site 3 po p.39	39.5817	59.9065	0.082	0.014	99.5722
x102073 site 3 po p.40	39.6193	59.9068	0.0738	0.01365	99.6086
x102073 site 3 po p.41	39.5529	59.7326	0.081	0.0139	99.3693
x102073 site 3 po p.42	39.5804	59.7837	0.0679	0.01395	99.4305
x102073 site 3 po p.43	39.605	59.8525	0.0929	0.0138	99.5632
x102073 site 3 po p.44	39.6853	59.9508	0.0607	0.01395	99.6923
x102073 site 3 po p.45	39.5274	59.8034	0.0912	0.0139	99.4148
x102073 site 3 po p.46	39.6146	59.9866	0.0761	0.01405	99.673
x102073 site 3 po p.47	39.502	59.7608	0.0578	0.01385	99.3278
x102073 site 3 po p.48	39.5987	60.082	0.0792	0.01415	99.7623
x102073 site 3 po p.49	39.6079	59.978	0.0653	0.01385	99.6583
x102073 site 3 po p.50	39.5515	59.9658	0.0556	0.01395	99.5734
x102073 site 5 po p.1	39.5713	60.044	0.0502	0.01405	99.6581
x102073 site 5 po p.2	39.6522	59.9903	0.0498	0.0139	99.6942
x102073 site 5 po p.3	39.6731	60.0848	0.0681	0.01405	99.8294
x102073 site 5 po p.4	39.5917	59.9954	0.0744	0.01415	99.6512
x102073 site 5 po p.5	39.609	59.9016	0.0613	0.014	99.5729
x102073 site 5 po p.6	39.4675	59.8147	0.0783	0.014	99.3604
x102073 site 5 po p.7	39.5424	59.8858	0.0604	0.01415	99.4795
x102073 site 5 po p.8	39.5864	59.9711	0.0688	0.0139	99.6278
x102073 site 5 po p.9	39.6243	59.9464	0.0636	0.01405	99.6275
x102073 site 5 po p.10	39.6636	60.0458	0.0227	0.0139	99.7431
x102073 site 5 po p.11	39.6281	60.1247	0.02325	0.01395	99.7786
x102073 site 5 po p.12	39.7336	60.068	0.0579	0.0139	99.8692
x102073 site 5 po p.13	39.6989	60.1029	0.02225	0.0139	99.8415
x102073 site 5 po p.14	39.7524	60.1942	0.0669	0.014	100.0172
x102073 site 5 po p.15	39.7307	60.1094	0.0549	0.01375	99.8997
x102073 site 5 po p.16	39.6244	60.1336	0.0707	0.014	99.8266
x102073 site 5 po p.17	39.4867	60.0277	0.075	0.01375	99.6058
x102073 site 5 po p.18	39.641	59.9348	0.0651	0.014	99.6307
x102073 site 5 po p.19	39.5334	60.053	0.0771	0.01415	99.6587
x102073 site 5 po p.20	39.6593	60.0691	0.063	0.014	99.7852
x102073 site 5 po p.21	39.65	60.1198	0.0621	0.01415	99.8188
x102073 site 5 po p.22	39.6958	60.0423	0.0705	0.0137	99.8258
x102073 site 5 po p.23	39.7043	59.938	0.0585	0.01385	99.7023
x102073 site 5 po p.24	39.766	59.9947	0.0532	0.014	99.8184
x102073 site 5 po p.25	39.5736	60.0395	0.0608	0.0143	99.6631
x102073 site 5 po p.26	39.6629	59.8588	0.0652	0.0138	99.5896
x102073 site 5 po p.27	39.5444	59.9666	0.0835	0.01415	99.5801
x102073 site 5 po p.28	39.5047	59.9709	0.0723	0.01425	99.5409
x102073 site 5 po p.29	39.6078	59.8404	0.0724	0.01395	99.5237
x102073 site 5 po p.30	39.6135	60.1496	0.0783	0.014	99.837
x102073 site 5 po p.31	39.604	59.8727	0.0596	0.01405	99.5353
x102073 site 5 po p.32	39.6207	60.042	0.0517	0.0139	99.7136

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x102073 site 9 po p.1	39.5537	59.9071	0.0746	0.01395	99.5381
x102073 site 9 po p.2	39.5955	59.8446	0.0808	0.0136	99.5433
x102073 site 9 po p.3	39.6609	59.8964	0.0643	0.01365	99.6341
x102073 site 9 po p.4	39.676	59.6715	0.0897	0.0141	99.432
x102073 site 9 po p.5	39.7051	59.9095	0.0567	0.01385	99.6671
x102073 site 9 po p.6	39.719	59.7728	0.0616	0.014	99.5578
x102073 site 9 po p.7	39.615	59.6984	0.0775	0.01415	99.3714
x102073 site 9 po p.8	39.7397	59.8993	0.0668	0.01405	99.6917
x102073 site 9 po p.9	39.7172	59.843	0.0575	0.0139	99.6227
x102073 site 9 po p.10	39.631	59.7425	0.0946	0.0138	99.4777
x102073 site 9 po p.11	39.7061	59.7768	0.0682	0.01385	99.5569
x102073 site 9 po p.12	39.7245	59.7891	0.0821	0.0138	99.6121
x102073 site 9 po p.13	39.7688	59.9005	0.0732	0.0138	99.7523
x102073 site 9 po p.14	39.5968	59.7747	0.0612	0.014	99.4328
x102073 site 9 po p.15	39.7204	59.8334	0.0656	0.01395	99.6072
x102073 site 9 po p.16	39.5713	59.928	0.0593	0.01385	99.5595
x102073 site 9 po p.17	39.7886	60.2256	0.054	0.01405	100.0664
x102073 site 9 po p.18	39.6546	60.1129	0.0689	0.0139	99.8319
x102073 site 9 po p.19	39.6266	59.9769	0.0767	0.014	99.6835
x102073 site 9 po p.20	39.704	59.8446	0.066	0.01415	99.6055
x102073 site 9 po p.21	39.8261	59.9264	0.0942	0.01435	99.8336
x102073 site 9 po p.22	39.7248	59.971	0.02315	0.014	99.7376
x102073 site 9 po p.23	39.7715	59.9781	0.069	0.01405	99.812
x102073 site 9 po p.24	39.6047	60.0451	0.0667	0.0141	99.7134
x102073 site 9 po p.25	39.669	59.9561	0.0689	0.01405	99.6935
x102073 site 9 po p.26	39.6348	60.0894	0.0756	0.014	99.7917
x102073 site 9 po p.27	39.5611	59.9131	0.0722	0.0139	99.5452
x102073 site 9 po p.28	39.506	59.9462	0.0604	0.01375	99.521
x102073 site 9 po p.29	39.7278	59.8599	0.0568	0.01385	99.6548
x102073 site 9 po p.30	39.6663	59.9803	0.0892	0.01415	99.7349
x102073 site 9 po p.31	39.6793	60.0004	0.0727	0.014	99.7511
x102073 site 9 po p.32	39.6536	59.9295	0.0896	0.0138	99.6722
x102073 site 9 po p.33	39.7475	60.1706	0.0659	0.0138	99.9904
x102073 site 9 po p.34	39.7217	59.9912	0.0534	0.0137	99.7778
x102073 site 9 po p.35	39.6503	60.0907	0.0826	0.014	99.8263
x102073 site 9 po p.36	39.5678	59.9127	0.02295	0.0141	99.5219
x26309 site 1 po p.1	38.5924	60.2127	0.0601	0.0141	98.8445
x26309 site 1 po p.2	38.7573	60.2061	0.0635	0.0139	99.0347
x26309 site 1 po p.3	38.578	60.2571	0.0701	0.01405	98.9171
x26309 site 1 po p.4	38.7754	60.0362	0.0797	0.01395	98.8966
x26309 site 1 po p.5	38.7836	60.1025	0.0616	0.01425	98.9325
x26309 site 1 po p.6	38.8573	60.1629	0.0828	0.0138	99.1131
x26309 site 1 po p.7	38.9547	59.9979	0.0791	0.014	99.024
x26309 site 1 po p.8	39.1814	59.8824	0.0692	0.01395	99.1353
x26309 site 1 po p.9	38.8041	60.262	0.0907	0.01395	99.157
x26309 site 1 po p.10	39.1175	60.0775	0.0496	0.01415	99.2413
x26309 site 1 po p.11	38.9205	60.0394	0.0888	0.014	99.0372

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x26309 site 1 po p.12	38.9067	59.9322	0.0662	0.0138	98.9134
x26309 site 1 po p.13	39.3816	59.7538	0.0591	0.0139	99.2036
x26309 site 1 po p.14	38.726	60.1008	0.0598	0.01405	98.8714
x26309 site 1 po p.15	38.7165	60.1713	0.077	0.01425	98.9531
x26309 site 1 po p.16	38.8528	60.2184	0.0553	0.01395	99.1356
x26309 site 1 po p.17	38.9401	60.1265	0.0637	0.01405	99.1245
x26309 site 1 po p.18	39.1773	59.7674	0.0635	0.01385	99.0168
x26309 site 1 po p.19	38.7335	59.9862	0.0738	0.014	98.7958
x26309 site 1 po p.20	38.6924	60.1561	0.0794	0.0138	98.9345
x26309 site 1 po p.21	38.8218	60.0988	0.0504	0.01375	98.98
x26309 site 7 po p.1	39.2388	59.076	0.0875	0.01395	98.3921
x26309 site 7 po p.2	39.2774	59.5992	0.0626	0.0138	98.9479
x26309 site 7 po p.3	39.2675	59.4377	0.0615	0.01405	98.7687
x26309 site 7 po p.4	38.814	59.8858	0.0803	0.01405	98.7834
x26309 site 7 po p.5	38.8465	59.863	0.0731	0.0142	98.7723
x26309 site 7 po p.6	38.639	60.0549	0.0655	0.0141	98.7616
x26309 site 7 po p.7	38.6553	60.1771	0.0844	0.01385	98.9141
x26309 site 7 po p.8	38.6555	60.0341	0.05	0.0139	98.7512
x26309 site 7 po p.9	38.6227	59.8537	0.0567	0.014	98.5296
x26309 site 7 po p.10	38.7	60.2118	0.0603	0.01365	98.9783
x26309 site 7 po p.11	38.8077	60.4549	0.0816	0.01395	99.333
x26309 site 7 po p.12	39.109	59.5189	0.0885	0.0141	98.701
x26309 site 7 po p.13	38.9046	59.7849	0.074	0.0142	98.7523
x26309 site 7 po p.14	38.7326	60.0336	0.081	0.0139	98.8531
x26309 site 7 po p.15	38.5975	60.2594	0.0948	0.0139	98.9523
x26309 site 7 po p.16	38.7371	60.3019	0.0726	0.01405	99.1034
x26309 site 7 po p.17	38.6693	60.2272	0.0832	0.0139	98.986
x26309 site 7 po p.18	38.6748	60.1164	0.0679	0.01405	98.8645
x26309 site 7 po p.19	38.688	60.2513	0.0534	0.01375	98.9977
x26309 site 7 po p.20	38.7223	60.1197	0.0597	0.01425	98.8846
x26309 site 7 po p.21	38.955	59.9185	0.0547	0.014	98.9332
x26309N site 2 p.1	38.67	60.3	0.07	0.0141	99.04
x26309N site 2 p.2	38.71	60.63	0.08	0.0137	99.43
x26309N site 2 p.3	38.8	60.35	0.07	0.0137	99.22
x26309N site 2 p.4	38.85	60.3	0.05	0.01405	99.2
x26309N site 2 p.5	38.71	60.34	0.05	0.01405	99.09
x26309N site 2 p.6	38.82	60.38	0.08	0.01365	99.29
x26309N site 2 p.7	38.78	60.37	0.08	0.014	99.23
x26309N site 2 p.8	38.81	60.52	0.06	0.01395	99.38
x26309N site 2 p.9	39.32	59.72	0.08	0.01395	99.12
x26309N site 2 p.10	39.02	60.23	0.05	0.01395	99.31
x26309N site 2 p.11	39.1	59.97	0.07	0.01375	99.15
x26309N site 2 p.12	39.31	59.77	0.07	0.01405	99.14
x26309N site 2 p.13	39.36	59.54	0.07	0.0138	98.98
x26309N site 2 p.14	39.42	59.83	0.06	0.01385	99.32
x26309N site 2 p.15	39.26	60	0.08	0.0141	99.33
x26309N site 2 p.16	38.82	60.41	0.02345	0.01405	99.27

Element	S	Fe	Co	Ni	Total
Unit	wt%	wt%	wt%	wt%	wt%
Sample					
x26309N site 2 p.20	38.67	60.32	0.07	0.014	99.06
x26309N site 2 p.21	38.85	60.48	0.06	0.01405	99.39
x26309N site 2 p.22	39.32	59.83	0.06	0.01355	99.22
x26309N site 2 p.23	38.63	60.48	0.08	0.01395	99.19
x26309N site 2 p.24	38.73	60.34	0.05	0.0138	99.12
x26309N site 2 p.25	39.49	59.75	0.07	0.01395	99.32
x26309N site 2 p.26	39.42	59.65	0.07	0.01375	99.14
x26309N site 2 p.27	38.89	60.34	0.09	0.0141	99.31
x26309N site 2 p.28	38.89	60.27	0.06	0.014	99.22
x26309N site 2 p.29	38.72	60.42	0.08	0.01395	99.22
x26309N site 2 p.30	38.87	60.53	0.07	0.01365	99.48
x26309N site 2 p.31	38.82	60.35	0.09	0.01405	99.25
x26309N site 2 p.32	38.95	60.32	0.1	0.0138	99.37
x26309N site 2 p.33	38.93	60.37	0.07	0.01405	99.36
x26309N site 2 p.34	38.79	60.42	0.07	0.01385	99.29
x26309N site 2 p.35	38.76	60.38	0.07	0.01395	99.21
x26309N site 2 p.36	38.87	60.45	0.07	0.01395	99.39
x26309N site 2 p.37	38.74	60.44	0.06	0.0141	99.23
x26309N site 2 p.38	38.86	60.5	0.02295	0.0138	99.39
x26309N site 2 p.39	38.8	60.3	0.06	0.0135	99.17
x26309N site 2 p.40	38.88	60.42	0.07	0.01405	99.38
x26309N site 2 p.41	38.95	60.39	0.08	0.01415	99.42
x26309N site 2 p.42	38.8	60.46	0.06	0.014	99.31
x26309N site 2 p.43	38.94	60.44	0.06	0.0141	99.43
x26309N site 2 p.44	39.04	60.32	0.06	0.014	99.42
x26309N site 2 p.45	38.86	60.3	0.08	0.01365	99.25
x26309N site 2 p.46	38.87	60.4	0.07	0.01405	99.34
x26309N site 2 p.47	39.22	60.01	0.07	0.0141	99.28
x26309N site 2 p.48	38.76	60.47	0.06	0.0139	99.3
x26309N site 2 p.49	38.74	60.25	0.06	0.0142	99.04
x26309N site 2 p.50	39.17	59.56	0.07	0.0139	98.78
x26309N site 2 p.51	39.13	59.96	0.06	0.01395	99.15
x26309N site 2 p.52	39.19	59.74	0.1	0.0139	99.02
x26309N site 2 p.53	39.27	59.83	0.02305	0.0139	99.14
x26309N site 2 p.54	38.8	60.52	0.07	0.01385	99.39
x26309N site 3 p.1	38.7	60.56	0.07	0.0136	99.36
x26309N site 3 p.2	38.7	60.45	0.08	0.0137	99.25
x26309N site 3 p.3	38.81	60.13	0.07	0.01385	99.01
x26309N site 3 p.4	39.44	59.83	0.09	0.01375	99.37
x26309N site 3 p.5	38.91	60.06	0.06	0.01395	99.04
x26309N site 3 p.6	38.74	60.33	0.06	0.014	99.13
x26309N site 3 p.7	39.4	59.77	0.07	0.014	99.23
x26309N site 3 p.8	39.33	59.8	0.06	0.0141	99.18
x26309N site 3 p.9	39.3	59.92	0.05	0.01395	99.26

Element Unit	S wt%	Fe wt%	Co wt%	Ni wt%	Total wt%
Sample					
x26309N site 3 p.10	39.33	59.83	0.07	0.0138	99.23
x26309N site 3 p.11	39.19	59.85	0.07	0.01365	99.13
x26309N site 3 p.12	39.31	59.8	0.05	0.01385	99.15
x26309N site 3 p.13	39.28	59.95	0.06	0.01395	99.3
x26309N site 3 p.14	39.22	59.88	0.05	0.01385	99.16
x26309N site 3 p.15	38.79	60.53	0.08	0.01405	99.4
x26309N site 3 p.16	39.01	60.26	0.02315	0.01395	99.31
x26309N site 3 p.17	38.86	60.24	0.07	0.01405	99.16
x26309N site 3 p.18	38.73	60.34	0.08	0.014	99.13
x26309N site 3 p.19	38.75	60.54	0.07	0.01415	99.34
x26309N site 3 p.20	38.84	60.43	0.06	0.01395	99.32
x26309N site 3 p.21	38.7	60.35	0.02365	0.01395	99.08
x26309N site 3 p.22	38.79	60.58	0.08	0.0138	99.46
x26309N site 3 p.23	38.83	60.6	0.1	0.0138	99.54
x26309N site 3 p.24	38.73	60.6	0.06	0.01395	99.39
x26309N site 3 p.25	38.84	60.38	0.05	0.014	99.28
x26309N site 3 p.26	39.34	59.93	0.05	0.014	99.32
x26309N site 3 p.27	38.66	60.42	0.07	0.0138	99.15
x26309N site 3 p.28	38.89	60.61	0.05	0.01395	99.55
x26309N site 3 p.29	38.67	60.24	0.07	0.0135	98.99
x26309N site 3 p.30	39.38	59.89	0.09	0.0141	99.36
x26309N site 3 p.31	39.28	59.72	0.08	0.01375	99.07
x26309N site 3 p.32	38.94	60.44	0.07	0.01415	99.44
x26309N site 3 p.33	38.77	60.38	0.09	0.0139	99.24
x26309N site 3 p.34	38.87	60.29	0.07	0.0141	99.23
x26309N site 3 p.35	38.75	60.64	0.06	0.014	99.44
x26309N site 3 p.36	39.19	60.1	0.09	0.01385	99.39
x26309N site 3 p.37	39.27	59.81	0.06	0.01395	99.14
x26309N site 8 p.1	39.34	59.6	0.07	0.01375	99.01
x26309N site 8 p.2	39.12	59.75	0.07	0.01405	98.94
x26309N site 8 p.3	38.86	59.76	0.06	0.0141	98.68
x26309N site 8 p.4	39.1	59.81	0.07	0.0138	98.98
x26309N site 8 p.5	39.21	59.89	0.08	0.014	99.17
x26309N site 8 p.6	38.69	60.44	0.07	0.0138	99.21
x26309N site 8 p.7	38.75	60.37	0.08	0.0141	99.21
x26309N site 8 p.8	38.73	60.46	0.07	0.0138	99.26
x26309N site 8 p.9	38.68	60.29	0.09	0.01405	99.06
x26309N site 8 p.10	38.69	60.33	0.07	0.01395	99.09
x26309N site 8 p.11	38.76	60.44	0.1	0.01385	99.31
x26309N site 8 p.12	38.74	60.58	0.09	0.01405	99.4
x26309N site 8 p.13	38.75	60.16	0.07	0.0139	98.98
x26309N site 8 p.14	39.25	59.87	0.06	0.0137	99.19
x26309N site 8 p.15	39.23	60.03	0.08	0.01415	99.32
x26309N site 8 p.16	38.9	60.06	0.07	0.01415	99.04
x26309N site 8 p.17	38.69	60.42	0.06	0.0138	99.17
x26309N site 8 p.18	38.75	60.29	0.07	0.01395	99.12
x26309N site 8 p.19	38.68	60.56	0.07	0.0139	99.32

Element	S	Fe	Co	Ni	Total
Unit	wt%	wt%	wt%	wt%	wt%
Sample					
x26309N site 8 p.20	38.57	60.4	0.06	0.0138	99.04
x26309N site 8 p.21	38.96	60.15	0.07	0.01385	99.18
x26309N site 8 p.22	39.1	59.82	0.06	0.0141	98.98
x26309N site 8 p.23	39.33	59.9	0.06	0.01405	99.28
x26309N site 8 p.24	39.35	59.84	0.08	0.01395	99.26
x26309N site 8 p.25	38.67	60.29	0.07	0.01375	99.04
x26309N site 8 p.26	38.94	60.28	0.07	0.014	99.29
x26309N site 8 p.27	39.17	59.96	0.08	0.0139	99.22
x26309N site 8 p.28	39.18	59.73	0.08	0.01395	99
x26309N site 8 p.29	38.83	60.36	0.05	0.01385	99.23
x26309N site 8 p.30	38.79	60.25	0.06	0.0141	99.09
x26309N site 8 p.31	38.62	60.47	0.07	0.014	99.16
x26309N site 8 p.32	38.78	60.53	0.07	0.01385	99.39
x26309N site 8 p.33	38.75	60.54	0.06	0.0138	99.34
x26309N site 8 p.34	39.33	59.93	0.09	0.0139	99.35
x26309N site 8 p.35	38.79	60.3	0.07	0.01385	99.16
x26309N site 8 p.36	38.73	60.33	0.06	0.01395	99.13
x26309N site 9 p.1	38.96	60.2	0.08	0.0139	99.25
x26309N site 9 p.2	38.87	60.35	0.07	0.014	99.28
x26309N site 9 p.3	39.22	59.63	0.08	0.01395	98.93
x26309N site 9 p.4	38.77	60.21	0.07	0.0138	99.05
x26309N site 9 p.5	38.8	60.44	0.08	0.0138	99.32
x26309N site 9 p.6	39.15	60.08	0.07	0.01375	99.3
x26309N site 9 p.7	38.72	60.32	0.07	0.01405	99.1
x26309N site 9 p.8	38.98	60.33	0.06	0.01395	99.38
x26309N site 9 p.9	39.23	59.9	0.07	0.0142	99.19
x26309N site 9 p.10	38.86	60.36	0.06	0.01395	99.28
x26309N site 9 p.11	38.87	60.27	0.08	0.01365	99.24
x26309N site 9 p.12	38.91	60.25	0.09	0.0139	99.25
x26309N site 9 p.13	38.73	60.65	0.06	0.0141	99.42
x26309N site 9 p.14	38.79	60.48	0.02335	0.014	99.32
x26309N site 9 p.15	38.84	60.25	0.07	0.0137	99.18
x26309N site 9 p.16	38.95	60.29	0.05	0.0136	99.28
x26309N site 9 p.17	38.87	60.36	0.07	0.01395	99.31
x26309N site 9 p.18	39.29	59.79	0.08	0.0144	99.15
x26309N site 11 near gold grain p.1	39.26	59.49	0.05	0.0141	98.79
x26309N site 11 near gold grain p.2	39.49	59.7	0.06	0.01405	99.24
x26309N site 11 near gold grain p.3	39.48	59.55	0.06	0.014	99.08
x26309N site 11 near gold grain p.4	39.34	59.16	0.07	0.014	98.56
x26309N site 11 near gold grain p.5	39.21	59.11	0.07	0.0139	98.39
x26309N site 11 near gold grain p.6	39.01	59.09	0.08	0.0137	98.2
x26309N site 11 near gold grain p.7	38.83	59.11	0.1	0.0139	98.03
x102058 site 9 p.1	38.78	60.59	0.06	0.0139	99.44
x102058 site 9 p.2	38.74	60.43	0.08	0.0138	99.26
x102058 site 9 p.3	38.6	60.6	0.06	0.01375	99.26
x102058 site 9 p.4	38.71	60.45	0.07	0.01385	99.22
x102058 site 9 p.5	38.74	60.44	0.07	0.0139	99.25
x102058 site 9 p.6	38.8	60.42	0.07	0.0138	99.29
x102058 site 9 p.7	38.8	60.71	0.06	0.01395	99.56
x102058 site 9 p.8	38.72	60.33	0.0235	0.01405	99.09
x102058 site 9 p.9	38.7	60.47	0.08	0.0138	99.25

Appendix 8: Electron microprobe analyses of arsenopyrite

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x102074 site 5 apy p.1 near gold grain	19.6507	34.1505	0.5159	0.014	0.04745	45.4176	0.01625	0.0175	0.0621	99.6172
x102074 site 5 apy p.2 near gold grain	19.6845	34.3297	0.4044	0.014	0.0463	45.4138	0.0166	0.01705	0.0623	99.7845
x102074 site 5 apy p.3 near gold grain	19.6128	34.134	0.4684	0.01405	0.04935	45.3198	0.0167	0.01705	0.06555	99.3023
x102074 site 5 apy p.4 near gold grain	20.7456	33.0269	2.0082	0.01395	0.0464	43.8068	0.0167	0.0815	0.0636	99.5369
x102074 site 5 apy p.5 near gold grain	19.6662	33.0809	1.2805	0.0138	0.0463	44.9966	0.01665	0.0173	0.06235	98.8848
x102074 site 5 apy p.6 near gold grain	19.7613	33.6353	0.5443	0.01395	0.04715	44.8957	0.01685	0.0177	0.0631	98.6967
x102074 site 5 apy p.7 near gold grain	19.9159	33.9962	0.209	0.014	0.0459	44.8214	0.01695	0.01695	0.0632	98.8979
x102074 site 6 apy p.1	19.5721	33.9509	0.3923	0.014	0.04575	45.615	0.0163	0.0172	0.0638	99.4473
x102074 site 6 apy p.2	19.7296	34.2009	0.3744	0.01405	0.04735	45.4676	0.0343	0.01675	0.0625	99.7189
x102074 site 6 apy p.3	19.659	34.1164	0.459	0.0142	0.0468	45.5811	0.01645	0.0371	0.0629	99.7964
x102074 site 6 apy p.4	19.4632	34.2875	0.3522	0.0142	0.04695	45.6745	0.0166	0.01725	0.0621	99.6718
x102074 site 6 apy p.5	19.6683	33.8381	0.9326	0.0141	0.04645	45.3777	0.01655	0.0171	0.0645	99.7353
x102074 site 6 apy p.6	19.4544	33.8538	0.668	0.014	0.04485	45.6305	0.01635	0.01715	0.0622	99.5573
x102074 site 6 apy p.7	19.605	34.1813	0.3505	0.01405	0.0463	45.3786	0.0164	0.01715	0.0642	99.4141
x102074 site 6 apy p.8	19.3706	33.0557	1.7003	0.01375	0.046	45.5783	0.0199	0.017	0.0612	99.7227
x102074 site 6 apy p.9	19.6892	34.4669	0.4447	0.01395	0.04635	45.3856	0.01645	0.01775	0.06415	99.8615
x102074 site 6 apy p.10	19.5412	34.0326	0.3438	0.01415	0.0486	45.628	0.01655	0.017	0.0631	99.4224
x102074 site 6 apy p.11	19.7264	34.1852	0.4464	0.01375	0.0483	45.318	0.0165	0.0171	0.06305	99.6218
x102074 site 6 apy p.12	19.5677	34.0626	0.4084	0.01395	0.0475	45.553	0.0163	0.01725	0.06535	99.4923
x102074 site 6 apy p.13	19.636	33.627	1.1216	0.0142	0.04875	45.4468	0.01635	0.01715	0.06235	99.7558
x102074 site 6 apy p.14	19.6822	32.5813	2.0789	0.0141	0.0458	45.2782	0.01665	0.01725	0.0643	99.5842
x102074 site 6 apy p.15	19.8284	33.2987	1.5101	0.014	0.0474	44.9427	0.01635	0.0173	0.06275	99.5693
x102074 site 6 apy p.16	19.497	33.7989	0.8677	0.0141	0.0465	45.4281	0.01675	0.0174	0.06595	99.4851
x102074 site 6 apy p.17	19.5592	33.3885	1.2534	0.01395	0.04515	45.5367	0.01695	0.01715	0.06485	99.6713
x102074 site 6 apy p.18	19.6036	34.2778	0.375	0.01395	0.0477	45.3079	0.0167	0.01755	0.0634	99.4948
x102074 site 6 apy p.19	19.5209	33.6805	1.0304	0.01365	0.0485	45.5155	0.01665	0.01745	0.06285	99.6047
x102074 site 6 apy p.20	19.5079	33.1334	1.4636	0.01405	0.04955	45.3228	0.0163	0.0172	0.06325	99.2302
x102074 site 6 apy p.21	19.7447	33.1625	1.4742	0.0141	0.0464	45.033	0.01695	0.041	0.0625	99.2848
x102074 site 6 apy p.22	19.6122	32.7371	1.9384	0.014	0.04665	45.3819	0.0168	0.017	0.06275	99.5956
x102074 site 6 apy p.23	19.5154	33.4936	1.0913	0.0141	0.0463	45.4069	0.01645	0.0174	0.0635	99.4335
x102074 site 6 apy p.24	19.8922	34.4285	0.2368	0.0137	0.0486	44.8724	0.0166	0.05	0.0645	99.2449
x102074 site 6 apy p.25	19.793	34.5982	0.154	0.01385	0.0467	45.0671	0.0167	0.0358	0.06265	99.5434
x102074 site 7 apy p.1	19.6622	34.0898	0.6607	0.0139	0.0493	45.3108	0.01655	0.0537	0.0641	99.5571
x102074 site 7 apy p.2	19.5306	32.9671	1.5669	0.0138	0.04655	45.4552	0.01645	0.0171	0.0653	99.3913
x102074 site 7 apy p.3	19.3952	32.9067	1.7201	0.014	0.0484	45.5886	0.01675	0.0173	0.0649	99.4225
x102074 site 7 apy p.4	19.8849	31.7797	3.011	0.0138	0.047	44.968	0.01635	0.0173	0.0634	99.5751
x102074 site 7 apy p.5	19.5357	32.5045	1.9985	0.01385	0.04785	45.6077	0.0168	0.0171	0.0626	99.5889
x102074 site 7 apy p.6	19.6551	33.6998	0.8672	0.01385	0.04685	45.337	0.0167	0.01735	0.06475	99.4205
x102074 site 7 apy p.7	19.71	34.4625	0.2639	0.014	0.0476	45.1343	0.0169	0.0173	0.06155	99.4936
x102074 site 7 apy p.8	19.6221	34.2481	0.368	0.01415	0.04635	45.3002	0.0164	0.01675	0.0633	99.4655
x102074 site 7 apy p.9	19.6647	34.0807	0.4655	0.0139	0.04715	45.205	0.0167	0.0705	0.0645	99.389
x102074 site 7 apy p.10	19.3439	34.4011	0.2786	0.01425	0.04915	45.6712	0.0168	0.0409	0.06275	99.5624
x102074 site 7 apy p.11	19.4603	33.4519	1.31	0.0145	0.04715	45.5044	0.0164	0.0397	0.0617	99.6655
x102074 site 7 apy p.12	19.6736	34.512	0.1282	0.0136	0.0453	45.4345	0.01685	0.01725	0.0619	99.6721
x102074 site 7 apy p.13	19.6178	34.6846	0.1906	0.01405	0.0478	45.3793	0.01705	0.017	0.06455	99.7
x102074 site 7 apy p.14	19.5489	33.1276	1.4896	0.0139	0.04535	45.5943	0.0167	0.01725	0.0638	99.6775

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x102074 site 7 apy p.15	19.437	33.8139	0.814	0.01405	0.04625	45.6456	0.01665	0.01745	0.06545	99.5041
x102074 site 7 apy p.16	19.5876	34.1699	0.3897	0.0138	0.04655	45.5168	0.01645	0.01715	0.06375	99.5681
x102074 site 7 apy p.17	19.4173	34.0843	0.5225	0.01425	0.0468	45.5288	0.01665	0.01725	0.064	99.4256
x102074 site 7 apy p.18	19.3745	34.2307	0.4077	0.0139	0.04465	45.6332	0.01625	0.01745	0.06305	99.5454
x102074 site 7 apy p.19	19.5144	34.1729	0.5246	0.0141	0.04685	45.5225	0.01655	0.0174	0.06365	99.5525
x102074 site 7 apy p.20	20.2332	33.0874	1.8796	0.0139	0.04645	44.7016	0.01685	0.0173	0.06505	99.7392
x102074 site 7 apy p.21	19.6529	34.3049	0.36	0.01415	0.04715	45.4512	0.0168	0.0173	0.0629	99.5881
x102074 site 7 apy p.22	19.537	33.9003	0.8306	0.014	0.04545	45.4378	0.01665	0.01725	0.06235	99.6844
x102074 site 7 apy p.23	19.479	34.4296	0.2281	0.01385	0.0477	45.4425	0.01645	0.017	0.06395	99.476
x102074 site 7 apy p.24	19.3864	34.1555	0.5199	0.0141	0.0459	45.5323	0.01665	0.0171	0.06305	99.5239
x102074 site 7 apy p.25	19.4655	34.4546	0.1829	0.014	0.04655	45.2793	0.0165	0.017	0.0633	99.2626
x102074 site 7 apy p.26	19.6605	34.4545	0.3179	0.014	0.04655	45.2174	0.01675	0.0355	0.0661	99.5364
x102074 site 7 apy p.27	19.6254	34.2489	0.4335	0.0141	0.04935	45.0946	0.0165	0.0394	0.0633	99.3172
x102074 site 7 apy p.28	19.4887	34.0734	0.3963	0.01405	0.0467	45.3923	0.01665	0.01755	0.06365	99.2031
x102074 site 8 apy p.1	19.5082	34.2747	0.1281	0.01395	0.04545	45.5866	0.0165	0.0171	0.05965	99.5131
x102074 site 8 apy p.2	19.5857	34.3892	0.1136	0.01405	0.04695	45.4131	0.0165	0.01685	0.063	99.3992
x102074 site 8 apy p.3	19.6116	34.4121	0.1241	0.0142	0.0456	45.4742	0.01635	0.0389	0.0662	99.5336
x102074 site 8 apy p.4	19.6146	34.0725	0.5755	0.014	0.04745	45.2918	0.017	0.0541	0.06425	99.3991
x102074 site 8 apy p.5	19.4878	34.0454	0.6037	0.0141	0.04525	45.5112	0.0168	0.0174	0.065	99.4918
x102074 site 8 apy p.6	19.6319	34.3514	0.1348	0.01405	0.04735	45.4707	0.0162	0.01705	0.0648	99.4505
x102074 site 8 apy p.7	19.6076	34.1098	0.1672	0.01395	0.04615	45.537	0.01695	0.01725	0.06505	99.3473
x102074 site 8 apy p.8	19.4576	34.306	0.0794	0.01415	0.04855	45.5247	0.0164	0.0172	0.06125	99.219
x102074 site 8 apy p.9	19.9178	34.3587	0.1368	0.01395	0.0464	45.0581	0.0168	0.0475	0.0627	99.4421
x102074 site 8 apy p.10	19.7236	34.4013	0.159	0.01395	0.0485	45.3267	0.0166	0.0359	0.0617	99.5964
x102074 site 8 apy p.11	19.8001	34.5779	0.1217	0.01395	0.0485	45.3356	0.01685	0.0171	0.06385	99.729
x102074 site 8 apy p.12	19.5724	34.3281	0.2178	0.01405	0.0481	45.401	0.0167	0.0169	0.06165	99.4286
x102074 site 8 apy p.13	19.7583	34.1762	0.4747	0.014	0.04805	45.2355	0.0168	0.0997	0.06215	99.6811
x102074 site 8 apy p.14	19.7336	34.0065	0.441	0.0139	0.04665	45.4097	0.0168	0.0545	0.06435	99.5071
x102074 site 8 apy p.15	19.6215	34.1841	0.1787	0.01415	0.0456	45.4762	0.01675	0.01715	0.0647	99.4093
x102074 site 8 apy p.16	19.7503	34.2434	0.2824	0.01385	0.04745	45.0936	0.01685	0.1547	0.06445	99.4166
x102074 site 8 apy p.17	19.4153	33.8463	0.6352	0.01405	0.0482	45.6334	0.0168	0.01695	0.0631	99.4428
x102074 site 8 apy p.18	19.4574	34.2514	0.3635	0.01395	0.04645	45.6106	0.0167	0.01695	0.0638	99.5458
x102074 site 8 apy p.19	19.6578	33.1865	1.3698	0.01385	0.0468	45.2254	0.0166	0.01725	0.06435	99.3279
x102074 site 8 apy p.20	19.9415	32.9074	1.8182	0.0139	0.0464	45.0724	0.01665	0.0173	0.06525	99.6269
x102074 site 8 apy p.21	19.5344	34.3811	0.1711	0.01385	0.04755	45.431	0.017	0.01705	0.06255	99.5043
x102074 site 8 apy p.22	19.4981	33.8429	0.7764	0.01415	0.0412	45.3893	0.01665	0.01745	0.0623	99.4032
x102074 site 8 apy p.23	19.6654	34.2371	0.3092	0.0141	0.04685	45.0007	0.0167	0.01725	0.06445	99.041
x102074 site 8 apy p.24	19.3806	33.4306	1.0896	0.0138	0.0448	45.7049	0.01655	0.0414	0.06495	99.5287
x11310 site 2 apy p.1	22.2289	35.6668	0.0281	0.014	0.0472	42.3448	0.0163	0.01725	0.0644	100.1794
x11310 site 2 apy p.3	19.6417	34.7191	0.0758	0.014	0.0469	45.7114	0.01695	0.01695	0.06415	100.0123
x11310 site 2 apy p.4	22.6016	35.7461	0.02655	0.0139	0.0477	41.635	0.01665	0.0172	0.06415	99.9434
x11310 site 2 apy p.5	19.6463	34.677	0.0634	0.014	0.04655	45.9023	0.0164	0.0171	0.0624	100.2623
x11310 site 2 apy p.6	21.0075	35.2501	0.0593	0.0141	0.04865	43.9629	0.0169	0.0172	0.06385	100.1224
x11310 site 2 apy p.7	22.6693	35.7747	0.0282	0.01435	0.0448	41.3933	0.01665	0.017	0.06495	99.7456
x11310 site 2 apy p.8	21.5741	35.2634	0.0831	0.014	0.045	43.543	0.01665	0.0173	0.0641	100.3929
x11310 site 2 apy p.9	21.9903	35.4838	0.0271	0.01385	0.0469	42.618	0.0165	0.0173	0.06405	100.1
x11310 site 2 apy p.10	21.3329	35.1411	0.0633	0.0138	0.04705	43.4967	0.01655	0.0419	0.06235	100.0018
x11310 site 2 apy p.11	21.9826	35.5209	0.0272	0.0139	0.04565	42.5336	0.01675	0.01705	0.06555	99.9408
x11310 site 2 apy p.12	22.2181	35.6598	0.0275	0.01405	0.04655	42.1403	0.0163	0.0174	0.06665	99.9287

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x11310 site 2 apy p.13	19.8478	34.6202	0.0269	0.0139	0.0497	45.4789	0.0171	0.0172	0.0621	99.8662
x11310 site 2 apy p.14	20.3926	35.1098	0.02765	0.0141	0.0463	44.6565	0.01675	0.01715	0.06245	100.0926
x11310 site 2 apy p.15	22.7996	35.8643	0.02735	0.0141	0.04765	41.3072	0.0166	0.0412	0.0646	99.8674
x11310 site 2 apy p.16	22.3858	35.6623	0.061	0.014	0.0466	41.9905	0.01715	0.017	0.0644	99.9923
x11310 site 2 apy p.17	22.1355	35.6383	0.02755	0.01415	0.0486	42.3303	0.01645	0.01715	0.0628	99.9988
x11310 site 2 apy p.18	21.2165	35.2281	0.02755	0.01405	0.0475	43.9353	0.0167	0.01705	0.0636	100.3297
x11310 site 2 apy p.19	20.8776	35.0648	0.02735	0.014	0.0478	44.0202	0.01625	0.01755	0.06545	99.7846
x11310 site 4 apy p.1	22.5143	35.6181	0.02735	0.014	0.04725	41.9294	0.01655	0.0171	0.0643	99.9441
x11310 site 4 apy p.2	22.6093	35.7325	0.0699	0.01395	0.04845	41.6898	0.01675	0.0172	0.06445	100.0489
x11310 site 4 apy p.3	21.2469	35.1974	0.0279	0.0139	0.0463	43.6324	0.0167	0.0172	0.0652	100.0067
x11310 site 4 apy p.4	19.7589	34.7868	0.0545	0.01395	0.04685	45.706	0.0167	0.01695	0.066	100.1186
x11310 site 4 apy p.5	21.3263	35.4606	0.02675	0.0137	0.0481	43.373	0.01655	0.0171	0.06405	100.0594
x11310 site 4 apy p.6	22.2208	35.66	0.0278	0.01395	0.04665	42.0807	0.0167	0.01715	0.0654	99.8064
x11310 site 4 apy p.7	22.3512	35.7143	0.0278	0.0142	0.04545	42.0028	0.0164	0.01715	0.06495	100.0209
x11310 site 4 apy p.8	22.4231	35.8477	0.0601	0.0137	0.0463	41.9174	0.0168	0.0171	0.06275	100.1896
x11310 site 4 apy p.9	19.662	34.6845	0.0708	0.014	0.0466	45.7372	0.0164	0.01705	0.06455	100.0187
x11310 site 4 apy p.10	21.6023	35.3817	0.076	0.014	0.0485	43.2104	0.01655	0.0172	0.0625	100.1559
x11310 site 4 apy p.11	22.5203	35.6325	0.02705	0.01395	0.0489	41.7146	0.0165	0.01715	0.0636	99.8326
x11310 site 4 apy p.12	19.7136	34.7826	0.02675	0.01385	0.04785	45.644	0.01655	0.01705	0.0634	100.0827
x11310 site 4 apy p.13	22.1224	35.5765	0.0708	0.0141	0.0475	42.3487	0.01665	0.0379	0.06355	100.105
x11310 site 4 apy p.14	22.0317	35.5296	0.02805	0.014	0.04535	42.3999	0.0167	0.01695	0.06635	99.8829
x11310 site 6 apy p.1	22.144	35.7224	0.0271	0.01365	0.0465	42.3324	0.01625	0.017	0.06565	100.176
x11310 site 6 apy p.2	22.402	35.7249	0.0272	0.0139	0.04655	41.9624	0.01665	0.0516	0.06305	100.1121
x11310 site 6 apy p.3	22.7271	35.9198	0.027	0.01385	0.0481	41.4534	0.0165	0.01715	0.0632	100.0449
x11310 site 6 apy p.4	21.2998	35.3581	0.0272	0.014	0.0463	43.4881	0.0168	0.01715	0.06415	100.0533
x11310 site 6 apy p.5	22.9591	36.089	0.02775	0.014	0.04745	41.1695	0.0169	0.01725	0.06295	100.1091
x11310 site 6 apy p.6	22.2598	35.715	0.0277	0.01365	0.0486	42.2397	0.01665	0.01705	0.06585	100.1254
x11310 site 6 apy p.7	21.7833	35.6057	0.02765	0.01395	0.0478	42.9499	0.01685	0.01745	0.06425	100.1896
x11310 site 6 apy p.8	23.69	36.1872	0.0278	0.0142	0.04495	40.2022	0.01645	0.017	0.0627	100.1168
x11310 site 6 apy p.9	22.9674	35.9629	0.02655	0.0142	0.0463	41.3538	0.01655	0.01735	0.06375	100.2341
x11310 site 6 apy p.10	22.2226	35.6783	0.0277	0.0137	0.04725	42.3247	0.0165	0.01705	0.06275	100.2483
x11310 site 6 apy p.11	20.7266	35.2816	0.0682	0.01395	0.04775	44.1063	0.0166	0.01725	0.06405	100.0279
x11310 site 6 apy p.12	22.0607	35.6108	0.0275	0.014	0.04425	42.3738	0.0165	0.0634	0.0658	100.0478
x11310 site 6 apy p.13	21.8332	35.7576	0.0549	0.0139	0.0466	42.5878	0.0166	0.0172	0.06345	100.2077
x11310 site 6 apy p.14	22.355	35.9306	0.02685	0.01425	0.04965	42.0023	0.0167	0.0172	0.06465	100.1382
x11310 site 6 apy p.15	22.1734	35.6224	0.027	0.0137	0.0472	42.2826	0.01695	0.1377	0.06405	100.1834
x11310 site 6 apy p.16	20.7246	35.3212	0.02815	0.01395	0.04795	44.0385	0.0166	0.1474	0.06465	100.1143
x11310 site 6 apy p.17	21.9301	35.6393	0.02745	0.014	0.0468	42.7688	0.01665	0.0172	0.0632	100.2969
x11310 site 6 apy p.18	21.2702	35.4946	0.0881	0.0141	0.04665	43.6396	0.01655	0.01725	0.06105	100.4548
x11310 site 6 apy p.19	21.4475	35.5277	0.055	0.01405	0.04835	43.4824	0.01665	0.01725	0.06355	100.371
x11310 site 6 apy p.20	22.687	35.9268	0.0733	0.01415	0.04755	41.6875	0.0163	0.01725	0.0638	100.2704
x11310 site 6 apy p.21	21.4272	35.5716	0.02665	0.014	0.048	43.5907	0.01665	0.01705	0.06305	100.5112
x11310 site 6 apy p.22	21.1534	35.286	0.0271	0.01395	0.04695	43.7275	0.0168	0.01735	0.0632	100.1415
x11310 site 9 apy p.1	22.3525	35.4543	0.0553	0.0139	0.0473	42.1255	0.0167	0.01695	0.06445	99.8521
x11310 site 9 apy p.2	22.0557	35.2744	0.0798	0.01395	0.0474	42.4675	0.0165	0.0364	0.0664	99.7099
x11310 site 9 apy p.3	22.3447	35.717	0.0273	0.0141	0.0471	41.9736	0.0164	0.0601	0.0649	100.0465
x11310 site 9 apy p.4	21.5973	35.427	0.0283	0.01385	0.04665	43.0509	0.01695	0.0171	0.0636	100.0472
x11310 site 9 apy p.5	21.92	35.5251	0.02715	0.0141	0.0472	42.2159	0.01685	0.5289	0.0645	100.1283
x11310 site 9 apy p.6	22.3889	35.5642	0.02725	0.01395	0.04655	41.6465	0.01675	0.01695	0.06355	99.5292

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x11310 site 9 apy p.10	20.7436	35.3608	0.074	0.01375	0.0469	43.8021	0.01655	0.01715	0.0642	99.9147
x11310 site 9 apy p.11	21.9034	35.5631	0.0272	0.01395	0.04845	42.751	0.01655	0.01725	0.06385	100.1526
x11310 site 9 apy p.12	22.999	35.9362	0.0606	0.01385	0.04795	41.0445	0.0537	0.0171	0.0642	100.0177
x11310 site 9 apy p.13	22.9314	35.892	0.0552	0.014	0.04615	41.343	0.0347	0.0463	0.06345	100.2327
x11310 site 9 apy p.14	20.7277	35.0733	0.02835	0.01405	0.0471	43.6567	0.01635	0.4773	0.06345	99.9223
x11310 site 9 apy p.15	23.0317	35.9453	0.02795	0.0141	0.0479	40.6626	0.01655	0.2816	0.06365	99.9227
x11310 site 9 apy p.16	23.1287	36.132	0.02825	0.0143	0.04695	40.768	0.0167	0.01745	0.06515	99.9059
x11310 site 9 apy p.17	22.2094	35.7049	0.0271	0.0138	0.04765	41.9124	0.01675	0.0699	0.0657	99.799
x11310 site 9 apy p.18	22.5451	35.9205	0.02705	0.0141	0.047	41.7519	0.0404	0.01695	0.06285	100.2441
x11310 site 9 apy p.19	22.3481	35.6284	0.02745	0.01395	0.04775	42.1531	0.01625	0.0445	0.06465	100.1136
x11310 site 9 apy p.20	22.2099	35.6457	0.02825	0.01425	0.04785	41.8373	0.0166	0.01705	0.06495	99.6669
x11310 site 9 apy p.21	22.4678	35.6657	0.02645	0.01425	0.049	41.9775	0.01665	0.0173	0.06415	99.948
x11310 site 9 apy p.22	20.1584	34.6797	0.0943	0.01415	0.0462	45.1458	0.01695	0.01695	0.06495	99.9248
x11310 site 9 apy p.23	21.2658	35.3141	0.087	0.0142	0.0513	43.6648	0.0167	0.0439	0.0637	100.2201
x11310 site 9 apy p.24	22.3369	35.7178	0.02825	0.0141	0.0464	42.3051	0.01685	0.0168	0.0645	100.2941
x11310 site 9 apy p.25	22.0118	35.5508	0.028	0.01405	0.0479	42.6723	0.0164	0.0169	0.06395	100.1996
x11310 site 9 apy p.26	21.6637	35.396	0.02695	0.014	0.047	42.9077	0.01675	0.0709	0.06195	100.0372
x11310 site 9 apy p.27	21.7194	35.4859	0.0276	0.01415	0.04945	42.5847	0.0165	0.017	0.06295	99.6909
x11310 site 9 apy p.28	21.4125	35.4327	0.059	0.014	0.04675	43.2289	0.0168	0.01705	0.0648	100.0648
x11310 site 9 apy p.29	21.4623	35.4354	0.0586	0.014	0.04815	43.2251	0.0168	0.0519	0.0636	100.1431
x11310 site 9 apy p.30	22.3345	35.5767	0.0274	0.01395	0.04695	41.7685	0.0166	0.0171	0.06375	99.6245
x11310 site 9 apy p.31	22.4551	35.7624	0.0271	0.01405	0.04615	41.516	0.0168	0.01715	0.06455	99.7042
x102066 site 1 apy p.1	19.534	33.9953	0.3791	0.01405	0.04805	45.6411	0.01665	0.01695	0.06385	99.4166
x102066 site 1 apy p.2	19.9245	33.9702	0.6905	0.01395	0.04695	45.1438	0.0163	0.0171	0.06455	99.6636
x102066 site 1 apy p.3	21.9327	34.4918	0.825	0.014	0.0472	42.1004	0.01685	0.0165	0.06535	99.2502
x102066 site 1 apy p.4	21.554	34.9947	0.2921	0.0142	0.046	42.6466	0.01675	0.0362	0.0635	99.4344
x102066 site 1 apy p.5	21.4041	34.7974	0.1464	0.0138	0.0471	42.7694	0.01635	0.01715	0.0649	99.0081
x102066 site 1 apy p.6	21.3489	34.903	0.1344	0.01395	0.0469	42.925	0.0164	0.01715	0.0626	99.249
x102066 site 1 apy p.7	21.6836	34.9908	0.2588	0.0139	0.04705	42.6114	0.01635	0.01685	0.0642	99.4914
x102066 site 1 apy p.8	21.5902	34.7848	0.4447	0.0142	0.04805	42.6328	0.0162	0.01715	0.06395	99.3505
x102066 site 1 apy p.9	19.8304	33.6708	0.8078	0.0137	0.04585	44.9678	0.0169	0.0172	0.06475	99.1997
x102066 site 1 apy p.10	21.0043	34.3591	0.6653	0.0139	0.0466	43.545	0.0167	0.1497	0.06465	99.6166
x102066 site 1 apy p.11	21.52	34.2325	0.9044	0.01385	0.04625	42.7497	0.0167	0.01695	0.0661	99.2596
x102066 site 1 apy p.12	19.5288	34.4102	0.1509	0.01395	0.04635	45.708	0.01685	0.0171	0.0623	99.7368
x102066 site 1 apy p.13	20.8825	34.8469	0.1163	0.01385	0.04735	43.5511	0.01655	0.0171	0.0625	99.2911
x102066 site 1 apy p.14	19.7802	34.5028	0.1089	0.0138	0.0477	45.2211	0.01685	0.056	0.06435	99.5927
x102066 site 1 apy p.15	21.2679	34.7989	0.0649	0.01405	0.0459	42.9091	0.0167	0.0416	0.06495	98.9988
x102066 site 1 apy p.16	21.3142	34.7485	0.4777	0.0138	0.04825	43.1062	0.01665	0.01695	0.0651	99.5156
x102066 site 1 apy p.17	19.7348	33.6905	0.7017	0.0142	0.04735	45.2366	0.0167	0.0172	0.06165	99.2905
x102066 site 1 apy p.18	21.2788	34.9691	0.316	0.0139	0.04775	43.1186	0.0165	0.0172	0.0635	99.5304
x102066 site 1 apy p.19	19.5268	33.2886	1.0503	0.01385	0.04635	45.4182	0.01705	0.01695	0.06335	99.2021
x102066 site 1 apy p.20	19.5	33.9952	0.5353	0.0141	0.0468	45.4657	0.0166	0.01705	0.0629	99.389
x102066 site 1 apy p.21	19.4673	33.9782	0.5753	0.01385	0.04695	45.6421	0.0169	0.0173	0.0629	99.6315
x102066 site 1 apy p.22	19.5505	34.3479	0.2523	0.0139	0.0488	45.5929	0.01665	0.01715	0.063	99.6005
x102066 site 1 apy p.23	20.9021	34.8725	0.0916	0.01395	0.0464	43.657	0.0166	0.0357	0.0657	99.3247
x102066 site 1 apy p.24	19.5832	33.8092	0.765	0.0138	0.0475	45.4898	0.0169	0.0173	0.06245	99.5771

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x102066 site 1 apy p.25	19.6944	33.6346	1.0022	0.01375	0.04925	45.2792	0.01655	0.0479	0.06305	99.4996
x102066 site 1 apy p.26	19.6729	33.4674	1.102	0.01405	0.04885	45.3561	0.01635	0.01705	0.0654	99.4588
x102066 site 1 apy p.27	19.5315	34.2426	0.8653	0.0141	0.04745	46.195	0.0164	0.0173	0.0625	100.7584
x102066 site 1 apy p.28	19.4396	33.5768	0.8289	0.0138	0.04615	45.5299	0.0165	0.01705	0.0623	99.3211
x102066 site 1 apy p.29	19.5845	33.8059	0.8297	0.014	0.0472	45.6262	0.0168	0.017	0.06255	99.708
x102066 site 1 apy p.30	19.8825	34.1111	0.522	0.014	0.0462	45.2443	0.01685	0.01715	0.0613	99.6855
x102066 site 6 apy p.1	21.0962	34.5264	0.4435	0.014	0.04585	43.4362	0.0166	0.0171	0.06505	99.3855
x102066 site 6 apy p.2	21.4269	34.9528	0.288	0.01365	0.04825	43.0722	0.0165	0.0173	0.0635	99.6289
x102066 site 6 apy p.3	21.0624	34.6582	0.2939	0.0141	0.0473	43.2603	0.0168	0.0377	0.06205	99.2198
x102066 site 6 apy p.4	21.1429	34.8311	0.2008	0.01415	0.0475	43.3692	0.0167	0.01715	0.06355	99.4063
x102066 site 6 apy p.5	22.5127	35.5119	0.02725	0.014	0.04765	41.6287	0.01645	0.01755	0.0652	99.4682
x102066 site 6 apy p.6	21.3253	35.1372	0.0967	0.01395	0.0493	43.1195	0.0161	0.01715	0.06565	99.5658
x102066 site 6 apy p.7	21.1958	34.928	0.1045	0.014	0.048	43.3251	0.0168	0.1646	0.06405	99.5553
x102066 site 6 apy p.8	21.8744	34.8575	0.5067	0.01405	0.0462	42.4678	0.0167	0.0375	0.06485	99.5914
x102066 site 6 apy p.9	21.3792	34.7918	0.3576	0.01375	0.0478	43.135	0.0329	0.01685	0.0608	99.6799
x102066 site 6 apy p.10	19.7447	33.9815	0.582	0.0138	0.04655	45.1761	0.0169	0.01735	0.0633	99.4468
x102066 site 6 apy p.11	19.7235	34.0362	0.5676	0.0141	0.04795	45.4534	0.0169	0.01745	0.0652	99.6129
x102066 site 6 apy p.12	21.0552	33.7181	1.4407	0.01385	0.0459	43.2795	0.01615	0.108	0.06425	99.5438
x102066 site 6 apy p.13	21.6761	35.0859	0.2404	0.01425	0.0459	42.6656	0.01695	0.01745	0.06375	99.5818
x102066 site 6 apy p.14	21.772	35.1031	0.2868	0.01415	0.04765	42.5879	0.0167	0.0168	0.0633	99.6552
x102066 site 6 apy p.15	21.1241	35.0747	0.2658	0.01395	0.04735	43.34	0.017	0.01695	0.06425	99.6581
x102066 site 6 apy p.16	21.6609	35.1578	0.2584	0.01395	0.0471	42.6171	0.0165	0.0172	0.06205	99.6092
x102066 site 6 apy p.17	20.9832	33.9309	1.3438	0.01385	0.04885	43.459	0.01685	0.01745	0.06385	99.6568
x102066 site 6 apy p.18	21.511	35.0496	0.2246	0.0139	0.0451	42.7456	0.0166	0.01715	0.06345	99.5352
x102066 site 6 apy p.19	21.0885	34.8262	0.1479	0.01385	0.04875	43.3739	0.01635	0.01725	0.0639	99.3969
x102066 site 6 apy p.20	20.9546	34.8354	0.1028	0.01405	0.04685	43.489	0.01665	0.0174	0.0628	99.3827
x102066 site 6 apy p.21	21.853	34.8413	0.4507	0.0138	0.0469	42.2681	0.01695	0.01685	0.0631	99.355
x102066 site 6 apy p.22	21.197	35.021	0.0976	0.01415	0.0459	43.2281	0.0165	0.01675	0.0644	99.5096
x102066 site 6 apy p.23	21.633	34.6304	0.5055	0.014	0.04875	42.6557	0.0166	0.01725	0.0649	99.3283
x102066 site 6 apy p.24	21.3471	34.1894	0.9245	0.01385	0.0453	43.1968	0.01675	0.01735	0.065	99.5736
x102066 site 6 apy p.25	21.3125	34.7775	0.2044	0.01405	0.0477	43.0984	0.0168	0.0173	0.065	99.277
x102066 site 6 apy p.26	21.6613	35.109	0.1765	0.0139	0.0466	42.6003	0.0165	0.01715	0.06285	99.526
x11308 site 1 apy p.1	20.1277	32.4767	2.1722	0.01385	0.048	44.474	0.01665	0.01695	0.06415	99.1025
x11308 site 1 apy p.2	21.804	35.2113	0.0735	0.01415	0.04675	42.3113	0.01655	0.01735	0.0627	99.3304
x11308 site 1 apy p.3	20.8091	33.2467	1.6653	0.01405	0.04765	43.6694	0.0168	0.01735	0.06285	99.2887
x11308 site 1 apy p.4	20.0011	31.6736	2.9316	0.0139	0.0462	44.5483	0.01645	0.01715	0.063	99.053
x11308 site 1 apy p.5	19.9875	32.1897	2.7024	0.01405	0.04605	44.6633	0.01645	0.0171	0.06385	99.4221
x11308 site 1 apy p.6	20.0058	31.9853	2.7391	0.0141	0.0449	44.6779	0.01695	0.0169	0.0625	99.4082
x11308 site 1 apy p.7	19.8893	32.1254	2.623	0.01375	0.04785	44.7604	0.0168	0.0172	0.0646	99.2542
x11308 site 1 apy p.8	20.9485	35.0162	0.02865	0.01405	0.04605	43.0663	0.01645	0.0171	0.0635	98.9833
x11308 site 1 apy p.9	21.0351	35.0346	0.0277	0.01405	0.04605	43.0955	0.0168	0.01715	0.06225	99.102
x11308 site 1 apy p.10	20.8623	34.9944	0.027	0.01405	0.0464	43.2643	0.01665	0.017	0.06315	99.0744
x11308 site 1 apy small p.1	19.8196	33.7541	0.9765	0.01405	0.04625	45.0881	0.01675	0.0362	0.0638	99.6261
x11308 site 1 apy small p.2	20.2822	30.9343	3.6413	0.01375	0.0471	44.1579	0.01665	0.0172	0.0636	98.8898
x11308 site 1 apy small p.3	20.0345	33.2426	1.7309	0.01385	0.04655	44.8217	0.01665	0.0172	0.0639	99.7359
x11308 site 1 apy small p.4	19.7979	33.139	1.6619	0.01385	0.0483	44.9601	0.0164	0.0172	0.0619	99.4814
x11308 site 1 apy small p.5	26.9206	41.974	0.5292	0.014	0.04945	32.4695	0.0166	0.01675	0.0647	101.8086
x11308 site 3 apy grain1 p.1	19.9423	33.4218	1.1199	0.0138	0.04715	44.938	0.01675	0.01685	0.06465	99.4365
x11308 site 3 apy grain1 p.2	20.203	31.9025	2.7668	0.0139	0.04635	44.3962	0.0167	0.01715	0.0637	99.1626

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x11308 site 3 apy grain1 p.3	20.0337	31.7238	2.9347	0.014	0.0452	44.7473	0.017	0.01675	0.0631	99.3799
x11308 site 3 apy grain1 p.4	19.6864	32.9263	1.6432	0.01395	0.04815	45.2069	0.016	0.01725	0.063	99.3569
x11308 site 3 apy grain1 p.5	19.8484	32.7837	1.7995	0.0138	0.04775	45.0225	0.01715	0.01695	0.06395	99.2847
x11308 site 3 apy grain1 p.6	19.9519	32.6212	2.0353	0.0141	0.048	44.868	0.0166	0.01715	0.0612	99.4177
x11308 site 3 apy grain1 p.7	19.8691	32.1593	2.404	0.0139	0.04675	44.9488	0.0164	0.0173	0.06425	99.2998
x11308 site 3 apy grain1 p.8	20.6955	34.7763	0.0637	0.01375	0.04695	43.9149	0.01655	0.01725	0.06315	99.3297
x11308 site 3 apy grain1 p.9	21.4384	34.9226	0.0595	0.0139	0.04675	42.986	0.01695	0.0171	0.06175	99.3386
x11308 site 3 apy grain1 p.10	21.2915	35.0077	0.02705	0.01395	0.04815	43.1971	0.0167	0.01715	0.0645	99.4282
x11308 site 3 apy grain1 p.11	21.2566	35.0192	0.0724	0.0138	0.0475	43.2371	0.0165	0.0169	0.0636	99.4359
x11308 site 3 apy grain1 p.12	21.1913	34.8915	0.02765	0.01385	0.0467	43.5065	0.01685	0.01725	0.06315	99.4627
x11308 site 3 apy grain1 p.13	20.382	34.6755	0.0685	0.01385	0.0474	44.4454	0.0167	0.01725	0.0635	99.4526
x11308 site 3 apy grain2 p.1	19.9963	31.7624	2.7327	0.0141	0.0484	44.7629	0.01665	0.0173	0.06395	99.0979
x11308 site 3 apy grain2 p.2	20.145	32.734	1.8991	0.0139	0.0453	44.584	0.0167	0.0491	0.0627	99.3836
x11308 site 3 apy grain2 p.3	19.7541	33.3341	1.0998	0.01395	0.0452	45.1541	0.0167	0.0171	0.0623	99.3386
x11308 site 3 apy grain2 p.4	19.959	31.8913	2.8676	0.01415	0.0479	44.7592	0.0168	0.01705	0.06595	99.2481
x11308 site 3 apy grain2 p.5	19.6972	32.511	2.0535	0.01395	0.04725	45.1259	0.0169	0.0171	0.0623	99.307
x11308 site 3 apy grain2 p.6	19.7247	32.1455	2.4626	0.01375	0.0459	45.3202	0.01645	0.01745	0.06425	99.6069
x11308 site 3 apy grain2 p.7	20.3627	30.9896	3.8577	0.014	0.0467	44.392	0.0167	0.01735	0.06215	99.5573
x11308 site 3 apy grain2 p.8	21.0706	35.0851	0.02785	0.0141	0.04725	43.4476	0.01655	0.0171	0.06345	99.5055
x11308 site 3 apy grain2 p.9	20.5549	31.2706	3.5396	0.0139	0.04825	43.9403	0.01695	0.01715	0.06315	99.1753
x11308 site 3 apy grain3 p.1	19.9657	33.059	1.5785	0.01405	0.04585	44.7342	0.01665	0.0174	0.0642	99.1612
x11308 site 3 apy grain3 p.2	20.551	35.0036	0.0745	0.0142	0.04735	44.0322	0.01655	0.01725	0.0614	99.6306
x11308 site 3 apy grain3 p.3	20.5469	34.8317	0.0277	0.01405	0.0471	44.126	0.01645	0.017	0.0628	99.4504
x11308 site 3 apy grain3 p.4	21.18	35.1987	0.0567	0.0139	0.0476	43.2918	0.01645	0.01715	0.064	99.6279
x11308 site 3 apy grain3 p.5	21.3776	35.0986	0.027	0.0141	0.046	42.6825	0.01645	0.01705	0.06435	99.1114
x11308 site 3 apy grain3 p.6	21.0356	35.1485	0.0266	0.01385	0.0457	43.2799	0.0167	0.01725	0.06155	99.5267
x11308 site 3 apy grain3 p.7	21.3516	35.1034	0.02815	0.01395	0.0485	42.9527	0.0165	0.0169	0.06395	99.2891
x11308 site 3 apy grain3 p.8	21.2425	35.0347	0.0275	0.014	0.04595	43.0049	0.01665	0.0171	0.06655	99.1427
x11308 site 3 apy grain3 p.9	21.161	35.1777	0.02775	0.01405	0.047	43.1146	0.0166	0.01715	0.06335	99.4154
x11308 site 3 apy grain3 p.10	21.1145	35.0329	0.0279	0.0139	0.04745	43.4918	0.01685	0.0169	0.0643	99.6411
x102073 site 8 apy p.1	19.9576	34.8332	0.0781	0.01395	0.0472	45.2239	0.01655	0.0171	0.06355	99.9816
x102073 site 8 apy p.2	19.7062	34.6015	0.1979	0.0139	0.0479	45.5003	0.0169	0.0422	0.0627	99.9311
x102073 site 8 apy p.3	19.9299	34.2614	0.4593	0.0138	0.0473	45.2493	0.0165	0.0172	0.06285	99.7939
x102073 site 8 apy p.4	19.7533	34.3525	0.4025	0.014	0.04725	45.4397	0.01675	0.01715	0.06385	99.9003
x102073 site 8 apy p.5	19.767	34.141	0.7121	0.0141	0.0464	45.482	0.0165	0.0173	0.06185	100.0635
x102073 site 8 apy p.6	19.7664	34.2268	0.5669	0.014	0.04625	45.4649	0.01665	0.0172	0.0634	99.9235
x102073 site 8 apy p.7	19.6884	34.4983	0.231	0.0141	0.0452	45.4319	0.01655	0.017	0.06285	99.7593
x102073 site 8 apy p.8	19.6556	34.6405	0.1589	0.014	0.0486	45.2252	0.0166	0.039	0.0649	99.5262
x102073 site 8 apy p.9	19.8035	34.6938	0.02735	0.01375	0.0485	45.5983	0.01695	0.0173	0.0619	99.9943
x102073 site 8 apy p.10	19.6897	34.5812	0.2637	0.014	0.0473	45.4134	0.0165	0.01725	0.065	99.8343
x102073 site 8 apy p.11	20.9542	34.0068	1.2757	0.014	0.04805	43.7387	0.01645	0.01725	0.06355	99.8723
x102073 site 8 apy p.12	19.5917	34.0582	0.6979	0.01415	0.0469	45.5387	0.0166	0.017	0.0624	99.792
x102073 site 8 apy p.13	19.8226	34.5897	0.1932	0.014	0.0479	45.3402	0.0171	0.01735	0.0631	99.8115
x102073 site 8 apy p.14	19.8357	34.611	0.1472	0.0139	0.04675	45.3595	0.01665	0.01715	0.0636	99.8031
x102073 site 8 apy p.15	19.7455	34.668	0.0601	0.0139	0.04655	45.2809	0.01665	0.01725	0.06225	99.603
x102073 site 8 apy p.16	19.8123	34.7114	0.0549	0.01395	0.0468	45.3162	0.0165	0.0409	0.0635	99.8259
x102073 site 8 apy p.17	19.8335	34.6719	0.0924	0.0138	0.04385	45.2424	0.0167	0.0381	0.06405	99.7613
x102073 site 8 apy p.18	19.9822	34.8493	0.1116	0.0141	0.0468	45.2717	0.01655	0.01695	0.06475	100.088
x102073 site 8 apy p.19	20.078	34.326	0.6369	0.0142	0.0473	44.9514	0.01635	0.01735	0.06385	99.8933

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x102073 site 8 apy p.20	19.8271	34.4361	0.3694	0.01405	0.04555	45.317	0.0166	0.0169	0.065	99.8645
x102073 site 8 apy p.21	19.6448	34.7353	0.11	0.01365	0.04725	45.4151	0.01655	0.01725	0.0639	99.7484
x102073 site 8 apy p.22	19.5948	34.7574	0.0809	0.01375	0.04755	45.5855	0.01665	0.01705	0.0618	99.9797
x102073 site 8 apy p.23	19.9074	34.8507	0.0685	0.01415	0.04695	45.1641	0.01705	0.0173	0.06335	99.8855
x102073 site 8 apy p.24	19.8409	34.6684	0.069	0.01395	0.047	45.3271	0.0167	0.01715	0.06335	99.776
x102073 site 8 apy p.25	19.831	34.7869	0.0279	0.01385	0.0473	45.3688	0.0165	0.01725	0.06285	99.9214
x102073 site 8 apy p.26	20.8714	33.3397	1.8434	0.01385	0.047	43.808	0.01675	0.01725	0.06455	99.717
x102073 site 8 apy p.27	19.8827	34.3244	0.4198	0.01405	0.04565	45.1438	0.0168	0.01705	0.0637	99.6465
x102073 site 8 apy p.28	19.9732	34.7529	0.1147	0.01405	0.04565	45.2205	0.01665	0.01725	0.06425	99.9331
x102073 site 8 apy p.29	19.6983	34.6229	0.1962	0.01395	0.04785	45.5865	0.0167	0.0173	0.0648	99.9796
x102073 site 8 apy p.30	19.8394	34.7089	0.02935	0.01405	0.0477	45.3389	0.01635	0.0385	0.0639	99.825
x102073 site 8 apy p.31	19.7271	34.3357	0.1848	0.01405	0.0463	45.4363	0.017	0.0172	0.0619	99.6166
x102073 site 8 apy p.32	19.5928	34.5415	0.1753	0.0142	0.0456	45.5924	0.01655	0.01725	0.06245	99.8503
x102073 site 8 apy p.33	19.6882	34.6069	0.1705	0.01405	0.04665	45.4773	0.01665	0.017	0.0621	99.8797
x102073 site 8 apy p.34	19.7296	34.5579	0.1323	0.0139	0.04655	45.5157	0.01705	0.01705	0.0644	99.8838
x102073 site 8 apy p.35	19.8766	34.6366	0.1564	0.01405	0.0477	45.25	0.01665	0.0646	0.06285	99.8955
x102073 site 8 apy p.36	19.8335	34.6313	0.02855	0.01405	0.04455	45.4788	0.0169	0.0374	0.06285	99.9002
x102073 site 8 apy p.37	19.9395	34.8103	0.0943	0.0138	0.04775	45.3305	0.01645	0.0172	0.06475	100.0892
x102073 site 10 apy p.1	19.8012	34.8446	0.0964	0.014	0.04745	45.3991	0.01675	0.01705	0.0624	100.0212
x102073 site 10 apy p.2	19.8103	34.6323	0.1357	0.0137	0.0464	45.2773	0.0164	0.01715	0.0633	99.7556
x102073 site 10 apy p.3	19.6881	34.722	0.1311	0.0141	0.0475	45.4423	0.01645	0.01685	0.0631	99.9338
x102073 site 10 apy p.4	19.7533	34.6925	0.1145	0.0138	0.04515	45.3605	0.0167	0.0175	0.06465	99.7689
x102073 site 10 apy p.5	19.8868	34.4565	0.3035	0.01405	0.048	45.1101	0.01675	0.0171	0.0636	99.6084
x102073 site 10 apy p.6	19.7374	34.502	0.3376	0.01375	0.04755	45.5119	0.01665	0.0175	0.062	99.9751
x102073 site 10 apy p.7	19.7339	34.5139	0.3405	0.01415	0.04585	45.2034	0.017	0.0173	0.06215	99.7124
x102073 site 10 apy p.8	19.7554	34.6612	0.1061	0.014	0.04685	45.2415	0.01685	0.0172	0.06345	99.7141
x102073 site 10 apy p.9	19.7621	34.6432	0.0769	0.0141	0.048	45.4029	0.0168	0.0175	0.06315	99.7083
x102073 site 10 apy p.10	19.7232	34.3409	0.343	0.0141	0.0477	45.5534	0.0169	0.01685	0.0643	99.8392
x102073 site 10 apy p.11	19.6646	34.3762	0.1148	0.0142	0.04765	45.6421	0.01665	0.0173	0.06495	99.6183
x102073 site 10 apy p.12	19.6704	34.169	0.3961	0.0142	0.0479	45.3627	0.01685	0.017	0.0641	99.4591
x102073 site 10 apy p.13	20.0596	34.1166	0.6921	0.0137	0.0474	44.8323	0.0167	0.0171	0.06325	99.6502
x102073 site 10 apy p.14	21.3662	34.5734	0.5811	0.0142	0.04815	43.0685	0.01635	0.0974	0.06485	99.4661
x102073 site 10 apy p.15	21.0067	35.0899	0.02785	0.0141	0.04845	43.6235	0.01665	0.0573	0.06345	99.6426
x102073 site 10 apy p.16	19.9111	34.0696	0.6435	0.014	0.04775	45.2516	0.01665	0.01715	0.06385	99.7571
x102073 site 10 apy p.17	19.7336	33.834	0.7816	0.01405	0.04745	45.3361	0.0169	0.01735	0.0637	99.5998
x102073 site 10 apy p.18	19.8137	34.3577	0.3977	0.01405	0.046	45.1633	0.0168	0.01715	0.06595	99.555
x102073 site 10 apy p.19	19.657	34.2659	0.4134	0.01415	0.04765	45.7229	0.0163	0.01695	0.06335	99.9227
x102073 site 10 apy p.20	19.6808	34.5199	0.2097	0.0141	0.0481	45.5658	0.0167	0.01725	0.06295	99.8857
x102073 site 10 apy p.21	19.7944	34.7222	0.1205	0.0141	0.0463	45.2589	0.01645	0.0173	0.0619	99.8625
x102073 site 10 apy p.22	19.6582	34.2183	0.3386	0.014	0.0476	45.5483	0.0163	0.017	0.06275	99.6628
x102073 site 10 apy p.23	19.7462	34.2546	0.3613	0.014	0.04595	45.3643	0.01665	0.0443	0.0626	99.6748
x102073 site 10 apy p.24	19.7245	34.1641	0.5885	0.0139	0.0471	45.3572	0.0165	0.01695	0.0642	99.7234
x102073 site 10 apy p.25	19.6635	34.0758	0.6648	0.0141	0.04785	45.3896	0.0169	0.01715	0.0644	99.6362
x102073 site 10 apy p.26	19.6897	34.3552	0.4102	0.01415	0.0458	45.2763	0.01625	0.0173	0.06285	99.6495
x102073 site 10 apy p.27	20.139	33.8973	0.956	0.0141	0.04625	44.9874	0.01655	0.0175	0.0646	99.9013
x102073 site 10 apy p.28	19.778	34.3958	0.432	0.0138	0.0477	45.3229	0.01685	0.01715	0.06615	99.7768
x102073 site 10 apy p.29	19.7763	34.3481	0.3947	0.01425	0.04595	45.3299	0.01665	0.01755	0.06145	99.7883
x102073 site 10 apy p.30	19.8255	34.8135	0.0642	0.0139	0.0472	45.2742	0.01655	0.0651	0.0642	99.8978
x102073 site 10 apy p.31	19.6921	34.2351	0.5624	0.0139	0.04935	45.4771	0.01675	0.01705	0.06305	99.8891

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x102073 site 10 apy p.32	19.7903	34.1213	0.5788	0.01405	0.0475	45.2526	0.01655	0.01725	0.06365	99.5777
x102073 site 10 apy p.33	19.8211	34.1634	0.5213	0.014	0.048	45.1266	0.0169	0.0173	0.0646	99.447
x102073 site 10 apy p.34	21.1949	34.0682	1.0455	0.01375	0.0481	43.397	0.0166	0.0399	0.06415	99.6294
x102073 site 10 apy p.35	21.3414	34.3686	0.7845	0.01405	0.0455	43.0709	0.0166	0.0543	0.06375	99.5414
x102073 site 10 apy p.36	19.7743	34.64	0.0861	0.01395	0.048	45.366	0.017	0.01705	0.063	99.721
x102073 site 10 apy p.37	19.863	34.0703	0.6612	0.014	0.048	45.2288	0.01665	0.01725	0.0633	99.7227
x102073 site 10 apy p.38	21.0779	34.0042	1.1627	0.0139	0.0465	43.6514	0.01635	0.0171	0.06505	99.797
x102073 site 10 apy p.39	21.0676	33.8029	1.493	0.0139	0.04865	43.5704	0.0168	0.0171	0.0656	99.7968
x102073 site 10 apy p.40	19.9475	33.998	0.8801	0.014	0.04805	44.9336	0.01655	0.01725	0.065	99.617
x102073 site 10 apy p.41	19.8248	34.2912	0.4315	0.0142	0.04755	45.2419	0.0165	0.0172	0.063	99.7068
x102073 site 10 apy p.42	19.6957	34.4404	0.0272	0.01385	0.04495	45.3746	0.01645	0.01715	0.06215	99.5548
x102073 site 10 apy p.43	19.9605	34.5522	0.2401	0.0141	0.0462	45.1827	0.01645	0.01735	0.06225	99.8777
x102073 site 10 apy p.44	19.9367	34.5531	0.1795	0.0141	0.04865	45.0684	0.0167	0.0168	0.0648	99.6186
x23105 site 2 apy p.1	19.8272	34.6473	0.02725	0.01395	0.0475	45.3985	0.01665	0.0372	0.0644	99.7581
x23105 site 2 apy p.2	19.9339	34.681	0.0745	0.014	0.04645	45.1984	0.0165	0.0359	0.06425	99.7724
x23105 site 2 apy p.3	19.6801	34.6335	0.0571	0.01375	0.0468	45.3596	0.0165	0.0565	0.0617	99.6585
x23105 site 2 apy p.4	19.711	34.5365	0.02745	0.01415	0.0476	45.4031	0.01685	0.0169	0.0633	99.5193
x23105 site 2 apy p.5	19.9602	34.6713	0.0674	0.014	0.0484	45.0707	0.01665	0.01685	0.06325	99.6535
x23105 site 2 apy p.6	19.8804	34.6152	0.02735	0.014	0.0478	45.3498	0.01645	0.01735	0.06325	99.7582
x23105 site 2 apy p.7	19.7263	34.7065	0.0278	0.01385	0.04815	45.2989	0.0169	0.0811	0.06295	99.7281
x23105 site 2 apy p.8	19.6933	34.6821	0.0596	0.01415	0.0479	45.4009	0.0165	0.01735	0.06455	99.6737
x23105 site 2 apy p.9	19.6821	34.7535	0.0634	0.01395	0.04665	45.3787	0.0166	0.0383	0.06135	99.8473
x23105 site 2 apy p.10	19.7035	34.4808	0.02715	0.0143	0.0472	45.6689	0.01675	0.01725	0.0645	99.7502
x23105 site 2 apy p.11	19.8215	34.6473	0.02725	0.01415	0.04755	45.4836	0.01695	0.01705	0.06325	99.8575
x23105 site 2 apy p.12	19.8387	34.6931	0	0.0139	0.04935	45.3893	0.01645	0.0651	0.06365	99.7579
x23105 site 2 apy p.13	19.6306	34.7516	0.0568	0.0139	0.04685	45.7178	0.01675	0.01685	0.0638	100.052
x23105 site 2 apy p.14	19.8146	34.7499	0.02755	0.014	0.0449	45.2896	0.01665	0.1101	0.06375	99.8924
x23105 site 2 apy p.15	19.7229	34.5413	0.0701	0.01385	0.0459	45.6126	0.01665	0.01735	0.06255	99.9149
x23105 site 2 apy p.16	19.555	34.6117	0.02765	0.01395	0.0474	45.7702	0.0169	0.01715	0.0651	99.8324
x23105 site 2 apy p.17	19.6272	34.5676	0.0737	0.0138	0.046	45.7623	0.0166	0.017	0.0642	99.9806
x23105 site 2 apy p.18	19.6877	34.6358	0.02725	0.0142	0.0476	45.6015	0.0167	0.0171	0.06545	99.7381
x23105 site 2 apy p.19	19.8782	34.5617	0.0817	0.01405	0.04655	45.2706	0.0169	0.0173	0.06155	99.6946
x23105 site 2 apy p.20	19.8912	34.6351	0.02655	0.01405	0.04735	45.1536	0.01675	0.0682	0.06265	99.7048
x23105 site 2 apy p.21	19.7928	34.6355	0.0292	0.01395	0.0472	45.4617	0.01685	0.01715	0.0634	99.715
x23105 site 2 apy p.22	19.7337	34.5931	0.02805	0.0141	0.0466	45.2428	0.01685	0.1227	0.06505	99.5452
x23105 site 2 apy p.23	19.6387	34.631	0.02735	0.014	0.0472	45.6196	0.0165	0.01735	0.06335	99.7948
x23105 site 2 apy p.24	19.6987	34.6252	0.02705	0.0143	0.04575	45.5299	0.0169	0.0172	0.06485	99.7405
x23105 site 2 apy p.25	20.5153	34.7687	0.174	0.01405	0.0464	44.346	0.01635	0.0808	0.0647	99.7743
x23105 site 2 apy p.26	19.6944	34.6315	0.0274	0.01385	0.04765	45.5018	0.0167	0.0172	0.0629	99.8379
x23105 site 2 apy p.27	19.5985	34.6039	0.0285	0.0141	0.04685	45.5029	0.01685	0.0171	0.06295	99.5536
x23105 site 2 apy p.28	19.6886	34.729	0.0586	0.0139	0.0457	45.5893	0.0169	0.0171	0.06345	100.0089
x23105 site 2 apy p.29	19.7101	34.699	0.06	0.0136	0.04715	45.552	0.017	0.0171	0.06365	99.9948
x23105 site 2 apy p.30	20.7803	34.1736	0.8004	0.0142	0.04805	43.9602	0.01685	0.0752	0.06325	99.6151
x23105 site 3 apy p.1	19.9283	34.736	0.0763	0.0139	0.0459	45.1239	0.0164	0.0582	0.0629	99.8459
x23105 site 3 apy p.2	19.7517	34.6254	0.02815	0.01395	0.0482	45.3735	0.0167	0.0751	0.06325	99.7192
x23105 site 3 apy p.3	19.7616	34.6468	0.0281	0.0139	0.0463	45.3717	0.0166	0.0173	0.0641	99.6976
x23105 site 3 apy p.4	20.0269	34.6608	0.0688	0.01415	0.0468	44.9003	0.0166	0.069	0.06475	99.5824
x23105 site 3 apy p.5	20.3515	34.8499	0.0283	0.01395	0.0476	44.513	0.0164	0.0618	0.06145	99.8033
x23105 site 3 apy p.6	19.9351	34.7207	0.0277	0.01395	0.0478	45.0327	0.01685	0.1311	0.06295	99.7158

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x23105 site 3 apy p.7	19.9031	34.6562	0.0274	0.0141	0.0464	45.2181	0.01685	0.0173	0.06425	99.7157
x23105 site 3 apy p.8	19.8584	34.5816	0.076	0.0141	0.0483	45.3432	0.0166	0.0175	0.0641	99.7156
x23105 site 3 apy p.9	19.7943	34.4843	0.0657	0.0137	0.0468	45.3696	0.0168	0.041	0.06445	99.5941
x23105 site 3 apy p.10	19.7924	34.5234	0.0565	0.01415	0.0446	45.0877	0.01655	0.2102	0.064	99.578
x23105 site 3 apy p.11	20.0796	34.765	0.0586	0.0139	0.04675	44.9249	0.0166	0.0177	0.06515	99.6406
x23105 site 3 apy p.12	19.8638	34.5488	0.02735	0.01405	0.04705	45.2075	0.01635	0.0173	0.06035	99.6682
x23105 site 3 apy p.13	19.7676	34.6638	0.0281	0.01405	0.04725	45.2318	0.0167	0.0363	0.06445	99.5559
x23105 site 3 apy p.14	20.1606	34.6914	0.0599	0.01405	0.0483	44.7099	0.0167	0.01735	0.06295	99.4911
x23105 site 3 apy p.15	20.1573	34.8064	0.0279	0.01425	0.0466	44.8165	0.0164	0.0172	0.06255	99.6731
x23105 site 3 apy p.16	20.2664	34.7805	0.0275	0.0142	0.04735	44.7394	0.01675	0.0539	0.0636	99.7617
x23105 site 3 apy p.17	19.6361	34.5822	0.0277	0.014	0.0469	45.5331	0.0165	0.01745	0.06075	99.7461
x23105 site 3 apy p.18	19.8798	34.5878	0.0279	0.01415	0.04765	45.112	0.0168	0.01715	0.06485	99.4186
x23105 site 3 apy p.19	20.3681	34.8151	0.0752	0.01385	0.04745	44.508	0.01685	0.093	0.06235	99.7447
x23105 site 3 apy p.20	19.6408	34.5974	0.0277	0.014	0.04765	45.53	0.01635	0.0929	0.06515	99.7281
x23105 site 3 apy p.21	19.8616	34.6421	0.02715	0.0139	0.0487	45.0702	0.01665	0.091	0.06375	99.6082
x23105 site 3 apy p.22	19.6669	34.5693	0.065	0.01395	0.04695	45.4453	0.01665	0.0714	0.0644	99.658
x23105 site 3 apy p.23	19.4719	34.5384	0.0571	0.0141	0.04775	45.6133	0.01655	0.01725	0.06485	99.4866
x23105 site 3 apy p.24	19.7109	34.7181	0.02725	0.0141	0.0451	45.4317	0.01665	0.0381	0.0637	99.808
x23105 site 3 apy p.25	19.9544	34.7754	0.0277	0.01385	0.0469	44.9682	0.01685	0.0644	0.06515	99.6179
x23105 site 3 apy p.26	19.837	34.6388	0.0666	0.0141	0.0473	45.0996	0.01665	0.1667	0.0616	99.7072
x23105 site 3 apy p.27	19.6331	34.5457	0.0272	0.01395	0.04615	45.3931	0.0168	0.0172	0.06375	99.4722
x23105 site 3 apy p.28	19.5304	34.5315	0.0574	0.0138	0.0462	45.4901	0.01695	0.0175	0.0619	99.4994
x23105 site 3 apy p.29	19.7582	34.4958	0.0266	0.01385	0.04695	45.2819	0.01675	0.0952	0.0633	99.5681
x23105 site 3 apy p.30	19.8577	34.6937	0.02745	0.0139	0.048	45.0725	0.0168	0.107	0.06405	99.6253
x23105 site 3 apy p.31	19.7313	34.6261	0.0268	0.01375	0.04545	45.3088	0.01695	0.053	0.06435	99.622
x23105 site 3 apy p.32	19.4583	34.6898	0.0668	0.014	0.04845	45.7541	0.0167	0.0174	0.0619	99.8927
x23105 site 3 apy p.33	19.5686	34.5533	0.02775	0.0141	0.04815	45.5095	0.017	0.0171	0.06195	99.5033
x23105 site 7 apy p.1	19.665	34.507	0.02675	0.01395	0.04855	45.3158	0.0165	0.01715	0.06365	99.4153
x23105 site 7 apy p.2	20.1054	34.7927	0.0268	0.0137	0.04625	44.6424	0.0167	0.01755	0.0636	99.542
x23105 site 7 apy p.3	19.647	34.4304	0.02635	0.014	0.04565	45.4558	0.0164	0.0671	0.06345	99.5229
x23105 site 7 apy p.4	19.5714	34.3753	0.02815	0.01395	0.0455	45.6271	0.01655	0.017	0.0628	99.5501
x23105 site 7 apy p.5	19.8902	34.4996	0.0275	0.0137	0.0492	45.0631	0.0163	0.0698	0.0621	99.4611
x23105 site 7 apy p.6	19.595	34.4501	0.0279	0.0138	0.04765	45.4647	0.01655	0.0419	0.06365	99.454
x23105 site 7 apy p.7	19.74	34.5186	0.0268	0.0138	0.04835	45.4194	0.0165	0.058	0.06365	99.5856
x23105 site 7 apy p.8	19.8907	34.6488	0.0273	0.0139	0.04485	45.2094	0.01655	0.0694	0.06445	99.766
x23105 site 7 apy p.9	19.7969	34.5962	0.02765	0.0141	0.0473	45.2035	0.01685	0.0709	0.06315	99.5584
x23105 site 7 apy p.10	19.5392	34.4579	0.02775	0.01385	0.0475	45.6014	0.01655	0.01745	0.06505	99.458
x23105 site 7 apy p.11	19.6885	34.5756	0.0696	0.01395	0.0456	45.4797	0.017	0.0169	0.06325	99.7522
x23105 site 7 apy p.12	19.6586	34.4763	0.02805	0.0138	0.0453	45.5151	0.0168	0.01715	0.0636	99.52
x23105 site 7 apy p.13	19.433	34.4532	0.0275	0.0138	0.04465	45.5532	0.01645	0.01725	0.06405	99.4087
x23105 site 7 apy p.14	19.82	34.5752	0.0269	0.0143	0.04715	45.206	0.0167	0.0394	0.0637	99.5004
x23105 site 7 apy p.15	19.546	34.5542	0.0679	0.01375	0.0479	45.4765	0.01655	0.01735	0.0614	99.5075
x23105 site 7 apy p.16	19.8942	34.6431	0.0277	0.01415	0.0468	45.0459	0.01655	0.0175	0.0614	99.5401
x23105 site 7 apy p.17	19.8861	34.701	0.02705	0.01375	0.0453	44.8614	0.01665	0.0874	0.063	99.5812
x23105 site 7 apy p.18	19.785	34.7297	0.0696	0.01405	0.0454	45.3445	0.01645	0.01715	0.0612	99.8915
x23105 site 7 apy p.19	19.6703	34.6685	0.02725	0.014	0.04555	45.5382	0.0166	0.046	0.06305	99.824
x23105 site 7 apy p.20	19.6453	34.6356	0.0631	0.014	0.04445	45.6624	0.0166	0.0172	0.0645	99.9011
x23105 site 7 apy p.21	19.6132	34.6587	0.0789	0.01405	0.0458	45.5064	0.01685	0.0626	0.0616	99.829
x23105 site 7 apy p.22	19.8697	34.624	0.0271	0.0138	0.04575	45.3351	0.01635	0.041	0.06295	99.8457

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x23105 site 7 apy p.23	19.7437	34.5343	0.0684	0.0139	0.04535	45.3301	0.0168	0.038	0.06305	99.6371
x23105 site 7 apy p.24	19.4548	34.4375	0.0767	0.0139	0.04565	45.6997	0.0165	0.0168	0.06315	99.5709
x23105 site 7 apy p.25	19.6454	34.6556	0.02665	0.0139	0.04515	45.5498	0.01705	0.0457	0.0627	99.8432
x23105 site 7 apy p.26	19.6961	34.6389	0.0682	0.0139	0.04745	45.4791	0.0163	0.01705	0.063	99.7688
x23105 site 7 apy p.27	19.5286	34.5782	0.0555	0.0138	0.0467	45.6289	0.0168	0.0171	0.0645	99.6444
x23105 site 7 apy p.28	19.7641	34.6958	0.0604	0.014	0.04715	44.7188	0.01625	0.1261	0.0636	99.2257
x23105 site 7 apy p.29	19.5153	34.3883	0.02775	0.0139	0.04575	45.2063	0.0168	0.0457	0.06285	99.0408
x23105 site 7 apy p.30	19.7223	34.7922	0.0269	0.01385	0.0465	45.2774	0.0168	0.054	0.0641	99.7152
x23105 site 7 apy p.31	19.6	34.656	0.0614	0.01405	0.04545	45.613	0.0165	0.0172	0.06255	99.831
x23105 site 7 apy p.32	19.6522	34.7094	0.0644	0.0141	0.0461	45.3563	0.01675	0.01705	0.06425	99.6647
x23105 site 7 apy p.33	20.0152	34.6697	0.02745	0.0138	0.04565	44.8522	0.01635	0.0805	0.0646	99.5127
x23105 site 7 apy p.34	19.669	34.4849	0.0799	0.01395	0.0475	45.3047	0.01655	0.0173	0.06315	99.4463
x23105 site 7 apy p.35	19.588	34.444	0.0785	0.01385	0.04775	45.1974	0.01645	0.0171	0.06365	99.1723
x23105 site 7 apy p.36	20.0067	34.6737	0.02755	0.01385	0.0483	44.6476	0.0171	0.0875	0.0635	99.3201
x23105 site 7 apy p.37	19.5997	34.5385	0.0271	0.01395	0.0473	45.5144	0.0169	0.0173	0.06335	99.5382
x23105 site 7 apy p.38	19.588	34.5806	0.02695	0.01395	0.0482	45.6411	0.0166	0.01735	0.06315	99.7041
x23105 site 7 apy p.39	19.4587	34.5848	0.0267	0.014	0.0469	45.7476	0.01675	0.0177	0.06515	99.6483
x23105 site 9G apy p.1	19.8265	34.7308	0.0274	0.01405	0.0464	44.758	0.0167	0.1791	0.0638	99.3796
x23105 site 9G apy p.2	19.6303	34.7019	0.02735	0.01405	0.0461	45.3869	0.01685	0.01745	0.06375	99.6113
x23105 site 9G apy p.3	19.9145	34.6509	0.0786	0.014	0.0479	44.6932	0.0167	0.1915	0.06205	99.3975
x23105 site 9G apy p.4	19.4628	34.5041	0.0273	0.014	0.04725	45.7237	0.01685	0.01725	0.0637	99.5592
x23105 site 9G apy p.5	19.6077	34.5652	0.0274	0.0138	0.04705	45.4451	0.01625	0.01705	0.06355	99.6029
x23105 site 9G apy p.6	19.8262	34.8262	0.0275	0.0141	0.0475	44.9812	0.0169	0.0899	0.0636	99.558
x23105 site 9G apy p.7	19.8306	34.7716	0.0546	0.0138	0.0472	45.1933	0.0169	0.0614	0.06455	99.7868
x23105 site 9G apy p.8	19.6302	34.5789	0.02655	0.01385	0.0477	45.4846	0.0165	0.0736	0.06215	99.7531
x23105 site 9G apy p.9	19.8093	34.66	0.0275	0.014	0.045	45.2285	0.0165	0.0537	0.06395	99.6939
x23105 site 9G apy p.10	19.3698	34.4093	0.02775	0.0137	0.04835	45.7109	0.01685	0.0173	0.0628	99.4365
x23105 site 9G apy p.11	19.7041	34.6479	0.0655	0.0141	0.0474	45.4331	0.01705	0.0171	0.06425	99.6558
x23105 site 9G apy p.12	19.6386	34.5395	0.02755	0.0137	0.04615	45.5006	0.01705	0.0169	0.0647	99.578
x23105 site 9G apy p.13	19.5567	34.427	0.075	0.0139	0.04705	45.643	0.01655	0.01725	0.0637	99.6284
x23105 site 9G apy p.14	19.3839	34.4871	0.027	0.01395	0.04625	45.6667	0.01655	0.01705	0.06345	99.4989
x23105 site 9G apy p.15	19.8323	34.6475	0.0272	0.01435	0.047	45.1568	0.01665	0.01705	0.063	99.5748
x23105 site 9G apy p.16	19.9343	34.7949	0.02715	0.01415	0.04795	45.1371	0.01665	0.0554	0.06585	99.7973
x23105 site 9G apy p.17	20.0453	34.7967	0.0784	0.01425	0.04595	45.0491	0.017	0.094	0.06355	99.9082
x23105 site 9G apy p.18	19.6723	34.6434	0.0273	0.01395	0.0467	45.4623	0.0164	0.0755	0.06325	99.7031
x23105 site 9G apy p.19	20.0754	34.5873	0.02665	0.01415	0.04775	44.8409	0.0165	0.0797	0.0619	99.5058
x23105 site 9G apy p.20	19.6582	34.602	0.0275	0.014	0.04695	45.0958	0.0168	0.0627	0.06235	99.3281
x23105 site 9G apy p.21	19.6962	34.5928	0.02735	0.0139	0.0475	45.3729	0.0167	0.0816	0.06295	99.6835
x23105 site 9G apy p.22	19.8585	34.4427	0.02805	0.01385	0.04625	45.3055	0.0169	0.0891	0.06375	99.616
x23105 site 9G apy p.23	19.7737	34.3397	0.0272	0.01395	0.0477	45.5109	0.01635	0.0713	0.06515	99.5583
x23105 site 9G apy p.24	19.9519	34.3935	0.0572	0.0138	0.0485	45.5891	0.0168	0.0648	0.0608	100.0052
x23105 site 9G apy p.25	19.5	34.531	0.0905	0.01415	0.04805	45.6797	0.0169	0.01735	0.06325	99.6167
x23105 site 9G apy p.26	19.994	34.3869	0.0535	0.01405	0.04735	45.178	0.0166	0.0423	0.06365	99.5341
x23105 site 9G apy p.27	19.9002	34.4941	0.0279	0.01395	0.0462	45.0598	0.0162	0.0652	0.064	99.4642
x23105 site 9G apy p.28	19.7302	34.5066	0.0278	0.01385	0.04755	45.2567	0.01665	0.0788	0.06465	99.4445
x23105 site 9G apy p.29	19.6147	34.5313	0.02705	0.01405	0.0486	45.4353	0.017	0.052	0.0634	99.4578
x23105 site 9G apy p.30	19.6814	34.6652	0.02755	0.01405	0.04745	45.2661	0.0167	0.0605	0.06405	99.4987
x23105 site 9G apy p.31	19.7044	34.5939	0.0577	0.01415	0.0468	45.2819	0.01665	0.0409	0.0633	99.5931
x23105 site 9G apy p.32	19.5724	34.464	0.0606	0.0141	0.0473	45.3824	0.017	0.0173	0.06385	99.2689

Element Unit	S wt %	Fe wt %	Co wt %	Ni wt %	Cu wt %	As wt %	Sb wt %	Te wt %	Pb wt %	Total wt %
Sample										
x23105 site 9G apy p.33	19.426	34.4027	0.02745	0.01395	0.0466	45.747	0.01675	0.0366	0.06235	99.5695
x23105 site 11 apy p.1	19.9583	34.8374	0.02725	0.01395	0.04735	45.0626	0.01645	0.0692	0.06185	99.9206
x23105 site 11 apy p.2	20.148	34.7459	0.0924	0.0141	0.04545	44.9581	0.0168	0.0529	0.06405	99.8897
x23105 site 11 apy p.3	20.2827	34.7247	0.02625	0.014	0.047	44.6973	0.0165	0.017	0.0664	99.602
x23105 site 11 apy p.4	19.9905	34.6243	0.0557	0.01415	0.047	45.0281	0.0165	0.01695	0.06345	99.6324
x23105 site 11 apy p.5	19.7681	34.6697	0.028	0.01385	0.04595	45.3221	0.017	0.0573	0.0619	99.7232
x23105 site 11 apy p.6	19.437	34.5653	0.0274	0.01395	0.04735	45.7416	0.0163	0.0172	0.0625	99.6672
x23105 site 11 apy p.7	19.7344	34.7042	0.02665	0.0139	0.0482	45.4222	0.0167	0.01715	0.06405	99.7799
x23105 site 11 apy p.8	19.9448	34.6445	0.0268	0.014	0.0465	44.9771	0.01665	0.0177	0.0602	99.5317
x23105 site 11 apy p.9	19.7343	34.6022	0.0649	0.01395	0.04725	45.4087	0.01655	0.01695	0.06335	99.736
x23105 site 11 apy p.10	19.7149	34.6574	0.0267	0.01405	0.0481	45.1842	0.0168	0.109	0.0641	99.546
x23105 site 11 apy p.11	19.887	34.619	0.0551	0.0139	0.04475	45.1948	0.01665	0.0171	0.06415	99.6631
x23105 site 11 apy p.12	19.7882	34.7597	0.02705	0.01405	0.04735	45.3893	0.0165	0.059	0.0628	99.9235
x23105 site 11 apy p.13	19.8684	34.556	0.02695	0.0139	0.0472	45.2344	0.01655	0.0525	0.06435	99.6156
x23105 site 11 apy p.14	20.071	34.6821	0.0744	0.01415	0.04885	44.9799	0.01635	0.0481	0.06375	99.757
x23105 site 11 apy p.15	19.6775	34.4233	0.0716	0.0137	0.0464	45.4786	0.0164	0.017	0.06505	99.5497
x23105 site 11 apy p.16	19.5708	34.5028	0.02775	0.01395	0.0443	45.5475	0.01665	0.0173	0.062	99.6195
x23105 site 11 apy p.17	19.5447	34.7503	0.02755	0.0139	0.045	45.4733	0.01675	0.0175	0.0613	99.7346
x23105 site 11 apy p.18	19.9725	34.6015	0.02775	0.01405	0.04755	44.8891	0.0166	0.147	0.06225	99.6352
x23105 site 11 apy p.19	19.7319	34.4079	0.02735	0.0139	0.04685	45.3567	0.0164	0.01755	0.0615	99.5188
x23105 site 11 apy p.20	19.7977	34.5882	0.0271	0.01405	0.0471	45.4712	0.01655	0.0168	0.06375	99.7913
x23105 site 11 apy p.21	19.8676	34.6233	0.057	0.0139	0.0476	45.1342	0.0168	0.1021	0.0638	99.5924
x23105 site 11 apy p.22	19.9616	34.59	0.02695	0.01395	0.04515	45.0246	0.0165	0.0709	0.0647	99.4975
x23105 site 11 apy p.23	19.9216	34.5655	0.02715	0.01405	0.0494	45.238	0.01675	0.01715	0.06385	99.5929
x23105 site 11 apy p.24	19.7111	34.4817	0.0276	0.0139	0.04695	45.2358	0.0163	0.01715	0.06195	99.3451
x23105 site 11 apy p.25	19.614	34.5966	0.02675	0.01395	0.04765	45.3906	0.0167	0.01725	0.0625	99.5073
x23105 site 11 apy p.26	19.9846	34.7208	0.0709	0.01395	0.0478	45.0799	0.01675	0.01705	0.064	99.6376
x23105 site 11 apy p.27	19.7828	34.5003	0.02825	0.01375	0.04655	45.2652	0.0165	0.0172	0.0625	99.5567
x23105 site 11 apy p.28	19.7431	34.3658	0.0555	0.01395	0.04845	45.3696	0.01685	0.0717	0.06305	99.4468
x23105 site 11 apy p.29	19.6187	34.4675	0.02855	0.014	0.0465	45.4917	0.01665	0.01745	0.06365	99.5353
x23105 site 11 apy p.30	19.6296	34.563	0.0715	0.01415	0.04875	45.5573	0.0166	0.01725	0.0631	99.6033
x23105 site 11 apy p.31	19.8016	34.5586	0.0272	0.01365	0.0467	45.1178	0.0168	0.0931	0.06415	99.4284
x27820 site 3 apy p.1	20.16	34.14	0.02835	0.01415	0.0467	45.11	0.01655	0.04	0.06345	99.7
x27820 site 3 p.2	19.62	34.02	0.09	0.01385	0.0481	45.63	0.01705	0.0171	0.06285	99.62
x27820 site 3 p.3	19.67	33.95	0.08	0.01405	0.04475	45.66	0.0169	0.0168	0.0629	99.69
x27820 site 3 p.4	19.63	33.96	0.08	0.01385	0.04855	45.73	0.01675	0.0171	0.06315	99.67
x27820 site 3 p.5	19.65	33.95	0.08	0.01395	0.04675	45.7	0.01675	0.04	0.06175	99.66
x27820 site 3 p.6	20.45	34.27	0.08	0.01395	0.0476	44.46	0.01645	0.08	0.06145	99.65
x27820 site 3 p.7	20.79	34.35	0.13	0.0139	0.0472	44.19	0.0166	0.01675	0.06305	99.76
x27820 site 3 p.8	20.82	34.33	0.08	0.0139	0.0485	44.13	0.0164	0.13	0.06325	99.7
x27820 site 3 p.9	19.75	34.03	0.1	0.01395	0.04605	45.78	0.0167	0.0169	0.063	99.96
x27820 site 3 p.10	20.18	34.2	0.08	0.01415	0.0473	45.04	0.01665	0.017	0.0647	99.67
x27820 site 3 p.11	20.29	34.15	0.08	0.0138	0.0482	44.83	0.0168	0.017	0.06155	99.66
x27820 site 3 p.12	20.16	34.17	0.02805	0.0138	0.0488	45.06	0.01685	0.0172	0.0652	99.55
x27820 site 3 p.13	19.95	34.26	0.08	0.0139	0.04755	45.46	0.0165	0.0171	0.0649	99.98
x27820 site 3 p.14	19.79	33.97	0.09	0.01405	0.04645	45.57	0.01655	0.0175	0.06375	99.62
x27820 site 3 p.15	20.3	34.22	0.07	0.01375	0.0491	45.03	0.0169	0.01705	0.06445	99.87
x27820 site 3 p.16	19.98	34.19	0.09	0.0138	0.04825	45.42	0.0163	0.0173	0.06345	99.94
x27820 site 3 p.17	20.64	34.3	0.1	0.0139	0.04795	44.38	0.01625	0.0171	0.06545	99.66

Element	S	Fe	Co	Ni	Cu	As	Sb	Te	Pb	Total
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
Sample										
x27820 site 3 p.18	19.73	34.04	0.11	0.014	0.0487	45.63	0.01665	0.01715	0.06445	99.74
x27820 site 3 p.19	20.66	33.22	1.22	0.01385	0.04715	44.2	0.0166	0.22	0.0644	99.79
x27820 site 3 p.20	20.19	34.28	0.06	0.01425	0.04685	45.16	0.0163	0.01715	0.0634	99.96
x27820 site 3 p.21	20.04	34.31	0.06	0.0139	0.0482	45.21	0.0165	0.01705	0.0638	99.83
x27820 site 3 p.22	20.33	34.32	0.07	0.0138	0.0492	44.91	0.0169	0.0172	0.0642	99.79
x27820 site 3 p.23	20.31	34.42	0.07	0.014	0.0482	44.9	0.0168	0.01715	0.06295	99.89
x27820 site 3 p.24	20.86	34.32	0.15	0.01395	0.04675	43.86	0.01685	0.16	0.06355	99.6
x27820 site 3 p.25	20.8	34.03	0.62	0.0139	0.04755	43.97	0.0168	0.22	0.0646	99.98
x27820 site 3 p.26	19.95	34.15	0.02835	0.0138	0.04905	45.26	0.01615	0.01715	0.0627	99.7
x27820 site 3 p.27	20.46	34.36	0.07	0.0139	0.0486	44.56	0.01655	0.05	0.0627	99.73
x27820 site 3 p.28	20.79	34.18	0.4	0.014	0.0481	44.29	0.01675	0.0169	0.064	99.98
x27820 site 3 p.29	20.34	34.33	0.11	0.0141	0.048	44.88	0.0166	0.0172	0.0632	99.88
x27820 site 3 p.30	20.03	34.07	0.0282	0.0138	0.04775	45.37	0.0168	0.04	0.06285	99.77
x27820 site 5 apy p.1	20.21	34.26	0.06	0.0139	0.048	44.95	0.01665	0.0173	0.06245	99.68
x27820 site 5 p.2	20.75	33.74	0.77	0.014	0.04705	43.99	0.0165	0.0173	0.0639	99.59
x27820 site 5 p.3	20.96	32.99	1.61	0.01395	0.0481	43.84	0.01655	0.11	0.0633	99.73
x27820 site 5 p.4	19.82	34.1	0.1	0.0139	0.0476	45.59	0.01665	0.0172	0.064	99.87
x27820 site 5 p.5	20.83	33.38	1.24	0.03	0.0465	43.83	0.01655	0.22	0.0645	99.81
x27820 site 5 p.6	21.12	32.98	1.58	0.01395	0.0479	43.37	0.04	0.25	0.06395	99.59
x27820 site 5 p.7	21.08	32.67	2.02	0.014	0.0459	43.43	0.0166	0.23	0.0639	99.73
x27820 site 5 p.8	20.61	33.75	0.72	0.01385	0.0471	44.23	0.0167	0.04	0.06165	99.64
x27820 site 5 p.9	20.64	33.37	0.98	0.03	0.04745	44.01	0.01725	0.2	0.0645	99.49
x27820 site 5 p.10	19.86	34.1	0.09	0.0139	0.0449	45.66	0.01665	0.01685	0.06235	100.08
x27820 site 5 p.11	19.84	34.11	0.1	0.01395	0.04705	45.51	0.0169	0.01715	0.0638	99.84
x27820 site 5 p.12	20.03	34.17	0.02795	0.0141	0.04765	45.05	0.0164	0.0174	0.06265	99.53
x27820 site 5 p.13	20.72	33.87	0.56	0.0138	0.04805	44.11	0.01675	0.23	0.0635	99.79

Appendix 9: Electron microprobe analyses of gold

Element	Cu	Ag	Bi	Te	Au	Hg	Fe	Total
Unit	wt %	wt %	wt %	wt %	wt %	wt %	wt %	wt %
Sample								
X102060 gold grain site 1 p.1	0.29	14.21	0.0807	0.02465	84.74	0.1052	0.22	99.42
X102060 gold grain site 1 p.2	0.05985	14.22	0.0791	0.0248	85.34	0.1063	0.1	99.53
X102060 gold grain site 1 p.3	0.38	14.24	0.0763	0.0246	85.84	0.10555	0.08	100.58
X102060 gold grain site 1 p.4	0.06265	14.22	0.07765	0.0247	85.14	0.1039	0.1	99.60
X102060 gold grain site 1 p.5	0.06175	14.17	0.07795	0.025	86.42	0.1049	0.08	100.72
X102060 gold grain site 1 p.6	0	14.18	0.07725	0.025	85.98	0.1061	0.19	100.32
X102060 gold grain site 1 p.7	0	14.05	0.0786	0.02485	86.34	0.10545	0.04	100.40
X102060 gold grain site 1 p.8	0.0642	14.06	0.07545	0.02455	86.05	0.22	0.06	100.20
X102060 gold grain site 1 p.9	0.0563	14.24	0.0795	0.0246	85.9	0.10515	0.08	100.35
X102060 gold grain site 1 p.10	0.05645	13.92	0.0782	0.02445	85.9	0.1047	0.04	99.88
X102060 gold grain site 1 p.11	0.0696	14.08	0.0783	0.0248	86.38	0.10505	0.03	100.28
X102060 gold grain site 1 p.12	0.0625	13.97	0.07825	0.02495	85.73	0.1047	0.13	99.73
X102060 gold grain site 1 p.13	0.19	14.05	0.0796	0.0251	86.17	0.10595	0.15	100.59
X102060 gold grain site 1 p.14	0.07115	14.11	0.07705	0.02445	86.4	0.10575	0.08	100.34
X102060 gold grain site 1 p.15	0.68	14.06	0.0796	0.0247	86.19	0.1058	0.09	101.03
X102060 gold grain site 1 p.16	0.51	13.81	0.0768	0.0247	85.64	0.10505	0.08	100.04
X102060 gold grain site 1 p.17	0.24	14.2	0.07935	0.0249	86.1	0.10575	0.13	100.67
X102060 gold grain site 1 p.18	0.28	14.26	0.07865	0.02505	86.42	0.10565	0.09	101.03
X102060 gold grain site 1 p.19	0	14.16	0.0761	0.025	86.14	0.1049	0.27	100.73
X102060 gold grain site 4 p.1	0.23	15.18	0.07785	0.02495	84.81	0.10615	0.17	100.22
X102060 gold grain site 4 p.2	0.0666	15.39	0.0777	0.02505	85.56	0.10555	0.05	100.68
X102060 gold grain site 4 p.3	0.0615	15.32	0.0769	0.02485	85.23	0.10485	0.04	100.63
X102060 gold grain site 4 p.4	0.36	15.13	0.0774	0.0247	85.36	0.1051	0.04	100.96
X102060 gold grain site 4 p.5	0.2	15.31	0.0779	0.02465	85.41	0.1053	0.05	101.03
X102060 gold grain site 4 p.6	0.36	15.01	0.0741	0.02445	85.68	0.10505	0.03	101.25
X102060 gold grain site 4 p.7	0.36	15.29	0.0781	0.0248	85.53	0.10485	0.04	101.28
X102060 gold grain site 4 p.8	0.0619	15.24	0.0756	0.0248	85.27	0.10385	0.05	100.60
X102060 gold grain site 4 p.9	0.0578	15.32	0.0762	0.0248	85.19	0.23	0.1	100.78
X102060 gold grain site 4 p.10	0.23	15.31	0.0773	0.0251	85.18	0.10525	0.11	100.91
X102060 gold grain site 4 p.11	0.73	15.31	0.0761	0.02455	85.07	0.1052	0.09	101.36
X102060 gold grain site 4 p.12	0.16	15.37	0.0767	0.02475	84.56	0.1044	0.15	100.34
X102060 gold grain site 4 p.13	0.33	15.47	0.0764	0.0248	85.08	0.10585	0.28	101.14
X102060 gold grain site 6 p.1	0.06655	15.73	0.077	0.02485	83.39	0.10435	0.33	99.35
X102060 gold grain site 6 p.2	0.63	15.61	0.07815	0.0245	85.08	0.10445	0.22	101.76
X102060 gold grain site 6 p.3	0.79	15.57	0.0775	0.0247	84.9	0.10585	0.24	101.56
X102060 gold grain site 6 p.4	0.23	15.7	0.07565	0.02465	84.7	0.10425	0.16	101.04
X102060 gold grain site 6 p.5	0.25	15.71	0.0755	0.02455	84.18	0.10445	0.14	100.39
X102060 gold grain site 6 p.6	0	15.76	0.08015	0.02485	84.26	0.1055	0.19	100.12
X102060 gold grain site 6 p.7	0.0662	15.82	0.0757	0.0246	84.71	0.1063	0.17	100.47
X102060 gold grain site 6 p.8	0.0653	16.01	0.07655	0.02465	84.24	0.1048	0.28	100.36
X102060 gold grain site 6 p.9	0.23	16	0.07745	0.02475	83.95	0.1047	0.29	100.63
X102060 gold grain site 6 p.10	0.069	15.76	0.07895	0.02475	83.74	0.10515	0.34	99.61
X102060 gold grain site 6 p.11	0.19	14.97	0.07625	0.02485	84.45	0.1053	0.68	100.35
X102060 gold grain site 6 p.12	0.49	14.89	0.0759	0.02465	84.66	0.105	0.67	100.82
X102074 gold grain site 5 p.1	0.0546	9.29	0.0766	0.0249	90.9	0.1044	0.09	100.49
X102074 gold grain site 5 p.2	0.0544	9.25	0.0794	0.02475	90.58	0.1055	0.06	100.03
X102074 gold grain site 5 p.3	0	9.32	0.08135	0.02515	90.68	0.1055	0.07	100.00

Element Unit	Cu wt %	Ag wt %	Bi wt %	Te wt %	Au wt %	Hg wt %	Fe wt %	Total wt %
Sample								
X102074 gold grain site 5 p.4	0.18	9.23	0.0783	0.02505	91.05	0.10575	0.11	100.70
X102074 gold grain site 5 p.5	0.0644	9.29	0.08125	0.02515	91.45	0.1052	0.11	100.71
X102074 gold grain site 5 p.6	0	9.29	0.07935	0.02515	90.78	0.105	0.07	100.29
X102074 gold grain site 5 p.7	0.06675	9.29	0.08065	0.02485	91.12	0.1059	0.13	100.26
X102074 gold grain site 5 p.8	0.26	9.31	0.0818	0.025	90.95	0.1054	0.08	100.59
X102074 gold grain site 5 p.9	0.26	9.39	0.07935	0.02465	90.81	0.10535	0.04	100.59
X102074 gold grain site 5 p.10	0.0551	9.36	0.08005	0.02465	90.58	0.1057	0.03	100.07
X102074 gold grain site 5 p.11	0.0676	9.23	0.0781	0.0251	90.78	0.10575	0.07	99.79
X102074 gold grain site 5 p.12	0.06945	9.45	0.0821	0.02465	90.76	0.10545	0.04	99.85
X102074 gold grain site 5 p.13	0.0656	9.48	0.07855	0.0254	90.57	0.1056	0.07	99.99
X102074 gold grain site 5 p.14	0.06265	9.53	0.08215	0.02505	91.03	0.1054	0.07	100.47
X102074 gold grain site 5 p.15	0.0693	9.43	0.07995	0.0252	90.93	0.10575	0.06	100.07
X102074 gold grain site 5 p.16	0.05865	9.6	0.08035	0.0254	90.53	0.23	0.14	100.36
X11310 gold grain site 3 p.1	0.46	13.27	0.0778	0.02545	83.07	0.1063	3.03	99.80
X11310 gold grain site 4 p.1	0	12.13	0.0772	0.0244	87.29	0.10675	0.86	100.27
X11310 gold grain site 4 p.2	0.069	12.46	0.0765	0.0249	87.68	0.10705	0.86	100.68
X11310 gold grain site 4 p.3	0.0547	12.36	0.0794	0.0248	87.49	0.1067	0.84	100.66
X11310 gold grain site 4 p.4	0.05135	12.46	0.0782	0.0248	87.8	0.1066	0.76	101.11
X11310 gold grain site 4 p.5	0.0652	12.54	0.078	0.02475	87.85	0.10605	0.74	100.97
X11310 gold grain site 4 p.6	0.0705	12.48	0.07955	0.02515	87.67	0.106	0.87	100.56
X11310 gold grain site 4 p.7	0	12.44	0.07655	0.02515	87.17	0.10685	1.17	100.85
X11310 gold grain site 4 p.9	0.33	12.67	0.0791	0.0247	87.25	0.10625	0.96	101.12
X11310 gold grain site 4 p.12	0.05415	12.23	0.07605	0.02495	86.34	0.10535	1.19	100.11
X11310 gold grain site 4 p.13	0.06015	12.15	0.0761	0.02455	85.54	0.10675	1.26	98.87
X11310 gold grain site 4 p.14	0.06325	12.47	0.07905	0.02475	85.94	0.10755	1.37	99.74
X11310 gold grain site 4 p.15	0.0586	12.39	0.07865	0.0249	84.49	0.1066	1.23	98.09
X23105 gold grain site 2 p.1	0.67	12.98	0.077	0.02485	86.75	0.10565	0.65	101.14
X23105 gold grain site 2 p.2	0.06565	12.91	0.07955	0.0247	87.32	0.10455	0.4	100.45
X23105 gold grain site 2 p.3	0	12.77	0.07775	0.02495	87.09	0.1062	0.54	100.46
X23105 gold grain site 2 p.4	0.19	12.73	0.0761	0.0245	86.75	0.1055	0.53	100.27
X23105 gold grain site 2 p.5	0.3	12.91	0.0781	0.02485	86.92	0.1065	0.69	100.80
X23105 gold grain site 2 p.6	0	12.77	0.0804	0.02475	86.18	0.10585	0.93	99.91
X23105 gold grain site 2 p.7	0.06445	12.82	0.07735	0.02475	86.31	0.1056	0.69	99.72
X23105 gold grain site 2 p.8	0.18	12.74	0.0793	0.02475	86.77	0.1054	0.52	100.21
X23105 gold grain site 2 p.9	0	12.81	0.0772	0.02485	85.76	0.10595	1.17	99.76
X23105 gold grain site 2 p.12	0.0677	13.09	0.0793	0.02455	86.65	0.10615	0.53	99.93
X23105 gold grain site 2 p.13	0.05805	12.95	0.07865	0.0251	87	0.1061	0.42	100.31
X23105 gold grain site 2 p.14	0	13.12	0.07825	0.0248	87.22	0.1059	0.36	100.66
X23105 gold grain site 2 p.15	0.0587	13.03	0.0777	0.0246	86.97	0.10565	0.38	100.38
X23105 gold grain site 2 p.17	0.48	12.92	0.07775	0.02505	86.48	0.1063	0.79	100.71
X23105 gold grain site 2 p.18	0.38	13.04	0.0775	0.02505	87.18	0.1057	0.4	100.97
X23105 gold grain site 2 p.19	0.0517	13.17	0.07895	0.0249	87.24	0.10625	0.45	101.05
X23105 gold grain site 9 p.12	0.61	10.92	0.0785	0.0248	87.07	0.106	0.89	99.50
X26309 gold grain site 11 p.1	0	21.91	0.07665	0.02525	76.77	0.10465	0.46	99.10