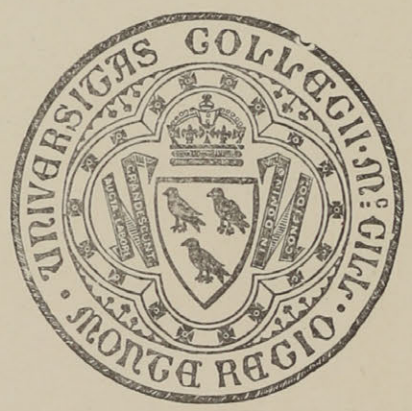
ON AN OCCURENCE OF TIN ORE AND ASSOCIATED MINERALS IN NOVA SCOTIA



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On an Occurence of Tin Ore and associated Minerals in Nova Scotia, with a comparative study of Tin Deposits in other parts of the World.

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On an occurence of Tin Ore and associated minerals in Nova Scotia, with a comparative study of Tin Deposits in other parts of the World.

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Geological Survey of Canada

ROBERT BELL, Sc. D., (Cantab), LL.D., M.D., F.R.S., I.S.O., ACTING DIRECTOR.

1906.

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MAP
OF THE PROVINCE OF
NOVA SCOTIA

to illustrate report by
E. R. FARIBAULT, B.A.Sc.
on the
"GOLD FIELDS OF NOVA SCOTIA"

Scale 12 Statute Miles to 1 Inch = 760,320

10 5 0 10 20 30

Compiled from original published and unpublished map sheets of the Geological Survey and other sources of information.

Fig 1. To illustrate Geology of South Western Nova Scotia.

C. O. Senécal, B.A.Sc., *Geographer and Chief Draughtsman.*
A. Dickison, *Draughtsman.*

Nº927.
Price 10¢

Geological Formations of the Southern part of the Province.

The oldest rock exposures in Southern Nova Scotia have been classed as Lower Cambrian. This formation extends along the Atlantic seaboard for the whole length of the province, and has, according to Mr. E.R. Faribault, a thickness of about 15,000 feet. The lower portion, comprising over two-thirds of the whole thickness is a gray quartzite called by the miners " whin", with interstratified bands of slate. The remaining part is made up of a " bluish black, sometimes graphitic or pyritiferous " slate with occasional bands of quartzite. Pressure approximately at right angles to the coast line folded this accumulation of sediment into vast anticlines and synclines with much faulting and fissuring, and developed a cleavage perpendicular to the impelling force. Smaller transverse folds formed a series of domes throughout the structure. These older sedimentary strata were, in early Devonian time, intruded by a great mass of granite which, doubtless, absorbed a portion of the older rock, and greatly altered the contact zone. Carboniferous limestone and gypsum are found underlying the glacial drift near the coast. Erosion through long lapses of time, and ice action have removed a great part of the Cambrian slates and quartzites and laid bare the granite masses in large areas throughout the entire southern portion of the province. (Fig. 1). Glacial deposits are abundant towards the south. Recent gravels,

sands, and alluvium are found in the valleys.

The excellent work done by the Geological Survey of Canada in connection with the " Gold measures" of Nova Scotia has been of great assistance to the prospector. As the gold is found to occur usually along the axis of the anticline, great pains have been taken to accurately locate these lines, as well as fissures and faults and geological boundaries. With this knowledge at his command, in searching for minerals, the prospector rarely left the slate and whin formation, and little attention was given to the granite. The recent discovery of tin-ore in the latter rock near Lake Ramsay at New Ross has brought about a change, and many areas have been taken up in that vicinity. Specimens of cassiterite had been reported previous to this from several localities in the southern part of the province, but always from drift, or decomposed material. The New Ross deposit is the first occurence in Canada of the mineral in bed-rock, and the find is of much interest, as well scientifically, as from its economic possibilities.

Location of the Deposit.

Well up towards the northern corner of Lunenburg County in the elevated upland of the interior and around the banks of the Gold River above its union with the Larder, is the New Ross settlement. The little village known locally as " The Cross" is about fifteen miles from Chester Basin on the " Halifax and South Western"

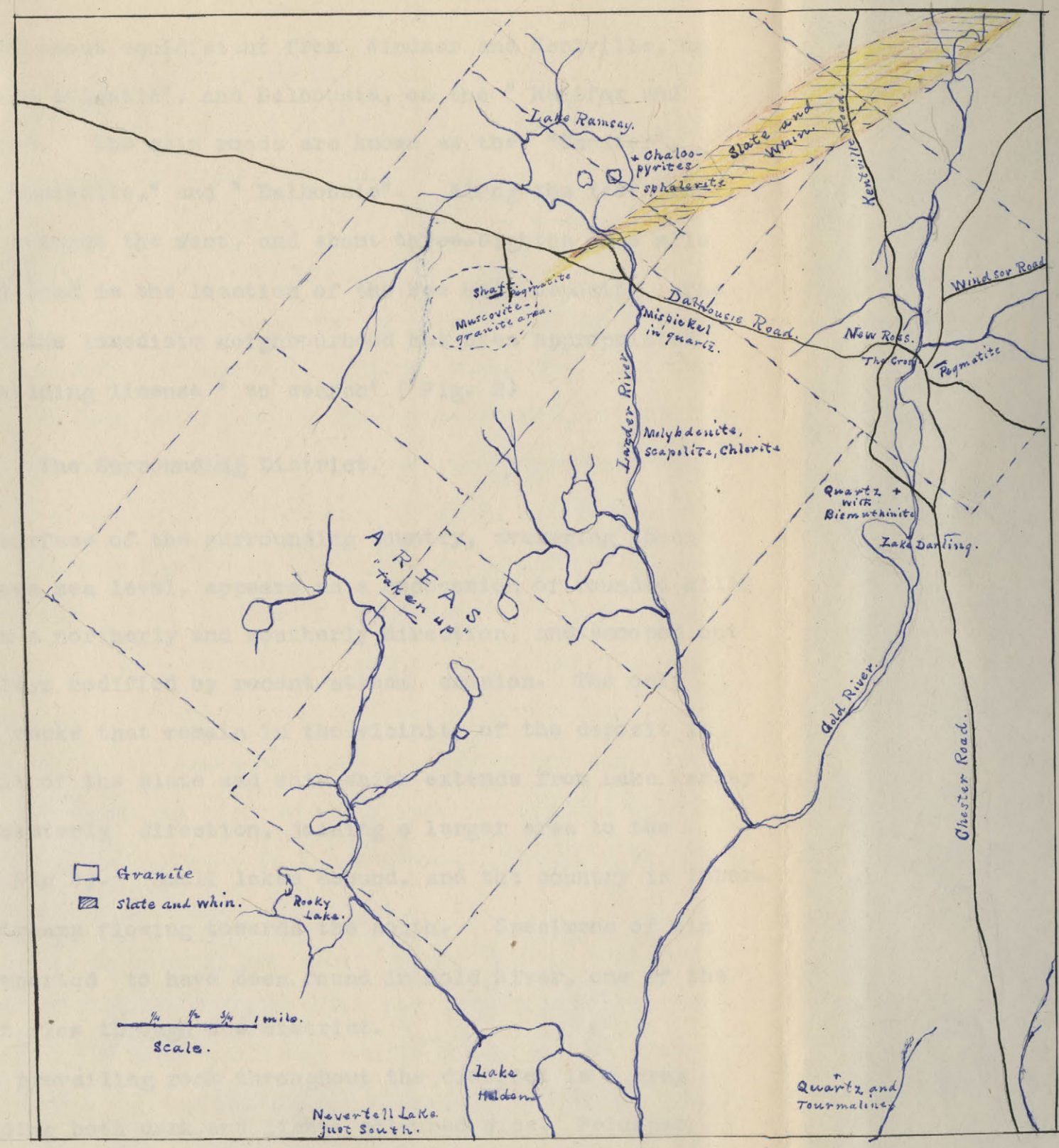


Fig. 2. Sketch Map, showing location of tin deposit, and of the minerals in the district, with the areas taken up. Muscovite-Biotite Granite Country.

railroad, and about equidistant from Windsor and Kentville, on the " Dominion Atlantic", and Dalhousie, on the " Halifax and South-Western". The main roads are known as the "Chester", " Windsor", " Kentville," and " Dalhousie". Along the last about three miles towards the west, and about three-eighths of a mile south of the road is the location of the New Ross deposit. The territory in the immediate neighbourhood has been appropriated by parties holding license " to search" (Fig. 2)

The Surrounding District.

The surface of the surrounding country, averaging about 450 feet above sea level, appears as a succession of rounded hills elongated in a northerly and southerly direction, and scooped out glacial valleys modified by recent stream erosion. The only sedimentary rocks that remain in the vicinity of the deposit is a narrow belt of the slate and whin which extends from Lake Ramsay in a north easterly direction, joining a larger area to the eastward. (Fig 2). Small lakes abound, and the country is intersected by streams flowing towards the south. Specimens of tin stone are reported to have been found in Gold River, one of the streams that flow through the district.

The prevailing rock throughout the district is a gray granite holding both dark and light- coloured mica. Feldspar phenocrysts varying from a fraction of an inch to three inches

or more in length are abundant in the granite. There are numerous large patches of a darker colour than the main mass through the rock. These patches hold the same constituents as the enclosing granite, with the exception of muscovite, and are probably a more basic recrystallisation of slate absorbed in the molten magma. In thin section, under the microscope, the quartz of the granite shows strain shadows, and numerous minute inclusions; the orthoclase is more or less decomposed to muscovite and kaolin, and holds portions differently orientated within the larger grains; the plagioclase is plentiful, and occasionally shows zonary banding with decomposition of the inner more basic material, and is chiefly andesine-oligoclase and albite; primary muscovite is present in some quantity; a deep brown colour charecterises the biotite, which is abundant, and which holds inclusions surrounded by a zone of decomposition; small crystals of apatite are seen, and larger portions which are also probably apatite; zircons and fragments of biotite are numerous in the feldspars; chlorite is present as a decomposition product.

A separation of the constituents of this rock was made by means of Thoulet's solution. The crushed material that passed through a 72- mesh sieve was considered of a sufficient degree of fineness for the process. A small quantity of pulverised material was removed by washing. From the dried grains, a trace

of iron was taken by the magnet. This iron was, probably, the small particles broken from the pestle during the crushing, as no iron-ore was found when examining the rock in thin section. When placed in the full strength solutions, a separation of the rock fragments took place, the zircon, apatite and composite grains made up of these heavier minerals and fragments of their hosts sank, while the lighter floated. The precipitated part run out, a dilution of the liquid to a specific gravity, just less than 2.86, caused the biotite to settle, and allowed of its removal. At just above 2.65, composite grains of quartz and biotite, and feldspar and biotite were in like manner obtained. The quartz was found to be lighter than quartz ordinarily is, doubtless owing to internal cavities in the grains, so that it could not be separated by the heavy liquid from the feldspar nearest it in specific gravity. The microscope, however, showed the grains of bright quartz, and of turbid feldspar, that sank at 2.623 to be in about equal proportions. This feldspar, from its specific gravity 2.623 - 2.644, and its extinction angle, 16° measured in thin section, is an ologoclase-andesine. In the solution at 2.620, albite was obtained. Composite grains of plagioclase and orthoclase sank at 2.57, and the remainder of the material, orthoclase, at a slightly lower specific gravity. A measurement of the separation results, and conversion into proportions by weight, and into percentages gave the following approxim te analysis:-

Quartz	20.5%
Orthoclase	9.
Oligoclase - Andesine	20.5
Albite	19.
Biotite	20.
Apatite, Zircon, and composite grains of Apatite or Zircon with quartz and feldspar	.5
Composite grains of Orthoclase and Plagioclase	4.5
" " Quartz, Feldspar and Biotite	6.
	100.

Along the Dalhousie road, east of the Larder river, is a small area of a coarse-grained pinkish granite, succeeded by a fine-grained one of the same colour, both muscovite-biotite granite. The quartz in these hold many inclusions, among which are mobile bubbles in cavities containing a fluid. On the west side of Lake Ramsay, at Red Rock Point, is a dark - red mass of rock with what seems to be a dyke running through it. In thin section, it is difficult to determine whether the dyke-like rock is a quartz porphyry that has suffered shearing or an arkose that has been subjected to strain. On the east side of the lake is seen further evidence of dynamic action in a granite whose feldspar and biotite are much strained. Parts of the rock have a botryoidal shape at the surface, and are coated with fluorite. The fluor was, probably, deposited by pneumatolytic vapours. Another outcrop of interest occurs about a mile east of The Cross,

appearing at first sight to be a quartz porphyry dyke. It is, however, a quartz breccia, the cement of which is ferruginous and siliceous. It would seem to be a quartz mass or vein that has undergone crushing. When polished, it is said to be quite ornamental.

Mineral Distribution.

Although nothing of economic value has yet been done in the way of mining in the district, there is, nevertheless, a great variety of minerals found. Sphalerite occurs on an island in Lake Ramsay, and a few hundred yards east of it is a six-inch vein of chalcopyrite and pyrites. A hundred yards or so south of where the Dalhousie road crosses the Larder river, and on the left bank is an outcrop of quartz showing mispickel, while about a mile further south along the river on the right bank is an inch vein of molybdenite, with scapolite and chlorite. South east of New Ross village, about half a mile, a mass of white brittle quartz bearing bismuthinite is associated with a course pegmatite which holds wolframite, scheelite and metals of the rare earths. In this pegmatite there are large intergrowths of quartz and muscovite witn a beautiful plumose structure. In the bed of the stream that flows by this outcrop is a great variety of different coloured granites and pegmatites. Another outcrop of white brittle quartz bearing bismuthinite in small blebs disseminated through it, is found west of the road about a half mile north of Lake Darling. Black smoky quartz with white quartz carrying long slender needles of tourmaline

occurs about five miles south of this locality, and away to the West several miles at Nevertell Lake is an outcrop of quartz, white, and smoky, which contains tourmaline and traces of cassiterite.

The Tin Deposit.

The place where most development has been done, and which is worked for cassiterite is a pegmatitic mass in a small dome-shaped elevation of light-coloured muscovite granite, within the surrounding gray granite, a short distance south of the Dalhousie road as before stated. In the gray granite near its margin are some small veins of quartz and of aplite running approximately north and south. The aplite has the same constitutents as the muscovite granite and doubtless came from the same magma, showing that the light -coloured more acid granite was a later intrusion than the gray, or at any rate was later in cooling. A good system of jointing prevails in the light-coloured rock,- vertical, about north-east and south-west, and at right angles to that, and also, nearly horizontal.

In thin section, the quartz is seen to be in much smaller proportion than the feldspar. The orthoclase is microperthitic and much decomposed. Plagioclase is abundant with pericline and albite twinning. The largest extinction angle, 20°, shows it to be andesine. Muscovite, which is plentiful is slightly pleochroic. A mineral which is probably topaz is present in some quantity. Its index of refraction is too high for a feldspar. It shows an occasional cleavage line, and grains without cleavage

give an interference figure difficult to determine. A grain cut perpendicular to an optic axis could not be found. It does not dissolve in hydrochloric acid.

An analysis of this rock was made by Rosiwal's method. To insure greater accuracy, measurements were extended to two hundred times that of the diameter of the average grain. The sum of linear measurements thus obtained of each constituent multiplied by the specific gravity of that mineral gave proportional weights of the constituents. Conversion into percentages yielded the following result.

Quartz.	22.04%
Orthoclase	44.53%
Plagioclase	21.92%
Muscovite	8.26%
Topaz	1.25%
Chlorite	1.95%
	99.95%

The pegmatite outcropped as a mass of kaolin and quartz crystals a few feet in area, the country rock surrounding it . A shaft has been sunk to the depth of twenty feet, which to some extent reveals the nature of the deposit. The mass has no well-defined wall, the pegmatite merging irregularly into the country rock. Direction is given to the deposit, by a zone of quartz crystals, about two feet in width. This zone runs east 25° north, and has a dip near the surface of 55° north, and near the bottom of the shaft, 70° north. The crystals are

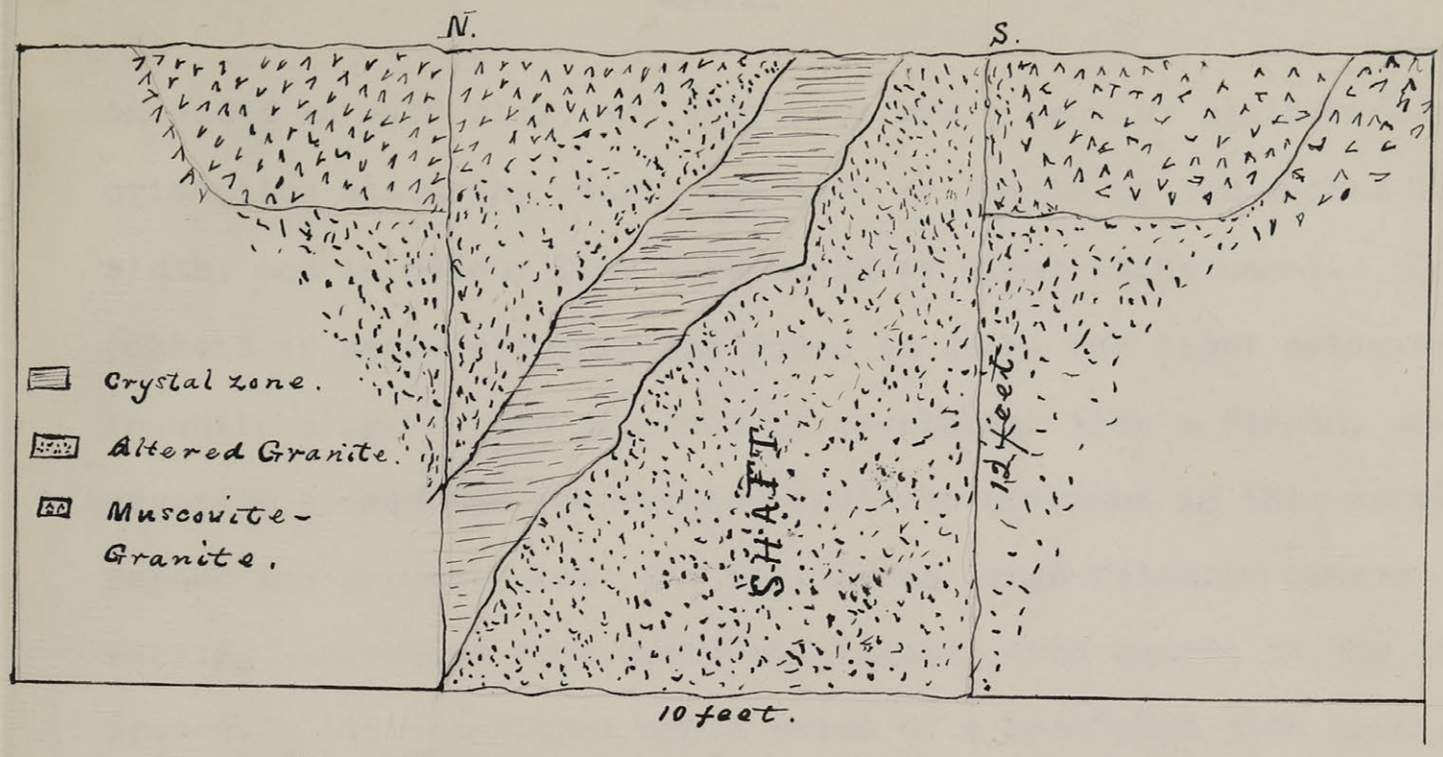


Fig. 3. Shaft sunk in pegmatite, showing zone of quartz crystals, altered and unaltered granite. (Section, North and South.)

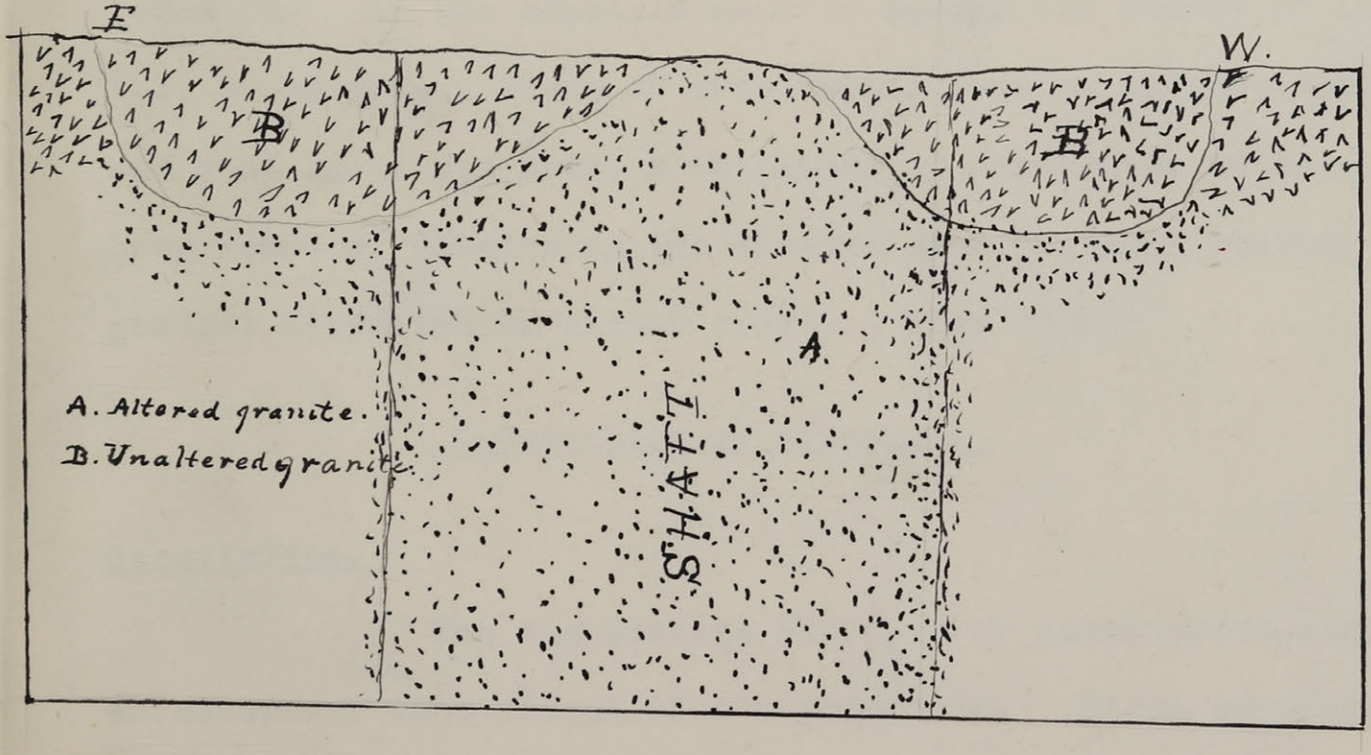


Fig. 4. Section East and West, showing the altered granite where capping has been removed. (same scale as fig. 3.).

embedded in soft clay, and vary from small tabular habit to large prismatic measuring nearly two feet in length by ten inches in width; and in colour from dark smoky to clear translucent. Small pockets of smoky crystals are found in dark, and light coloured, in white clay. The presence of something like a flucan, and of crystals broken and re-cemented indicate movement in this zone. Beyond the crystal zone, the wall shows large feldspar masses varying in colour from white to pinkish, with quartz in the interspaces. An occasional small patch of a beautiful pink lithia mica, and dots of a pale blue amblygonite are also seen. At the bottom of the shaft, the crystal zone lies in the north wall, while in the south wall ten feet away, the country rock still shows alteration. As the crystals seem to occupy the middle of the mass, this would give a width of over twenty feet to the deposit. East and west about six feet, a thickness of three feet of capping has been removed, disclosing the altered granite, thus proving the general direction as stated above. (Figs. 3 & 4)

Description of Minerals.

Cassiterite.

The tin dioxide. ($Sn\ O_2$) or cassiterite occurs as an accessory constituent of the pegmatite. Black crystale varying from a quarter to half an inch in length were thus found. Although not showing good faces, they have the characteristic form of a stout square prism, with pyramidal ends. The hardness of the

mineral is about 6.5, specific gravity , 6.8. The streak is gray, and the lustre high adamantine. The decomposed material in the pegmatite mass is said to contain a very small percentage of tin oxide.

Apatite.

This is a fluo- phosphate of calcium. Dark blue hexagonal crystals less than half an inch in length occur. The hardness is 5, the specific gravity 3.13. It is distinguished from beryl by its inferior hardness.

Lithia Mica.

A pinkish, or rose coloured mica, which is probably lepidolite, is found in scaly aggregates in the pegmatite.

Tourmaline.

This is a complex boro- silicate of aluminium and alkalies, with iron and magnesium, containing also water and fluorine. Its colour is black. The crystals are long, slender, hexagonal prisms. It is brittle with a sub-conchoidal fracture. Hardness 7, specific gravity, 3.1.

Fluorite.

Through the pegmatite, a great deal of this fluoride of calcium (CaF_2) is disseminated. It is a purplish black variety, and was mistaken by the workmen for cassiterite. Its colour, streak which is white, its hardness, (4), specific gravity, 3.2, and its crystalline form readily distinguish it from the tin oxide.

Again, when heated, it loses its colour, likely due to combustion of constituent hydrocarbons. This fluorite is very pretty in thin section. It is perfectly isotropic, and its purple colour and finely developed cleavage lines show to advantage.

Scheelite.

This is a somewhat rare mineral, a tungstate of calcium ($CaWO_4$). It occurs in square bipyramids. Its colour is white; lustre vitreous; hardness, 4.5; and gravity, 6.

Wolframite.

A tungstate of iron and manganese((Fe Mn) WO_4)) is found associated with scheelite. Its black colour, high specific gravity and brittleness caused it also to be mistaken for cassiterite. It is, however, not so hard (H = 5.5), and its specific gravity (7.3) is somewhat greater than that of the tin oxide. The streak is darkish red; its crystallisation is monoclinic, its cleavage perfect; and it fuses to a magnetic bead. An almost pure tungstate of manganese hubnerite is also found here.

Columbite and Microlite.

What was most generally mistaken for an ore of tin during the development of the deposit, was a dark heavy substance which upon examination in thin section proved to be made up of three separate minerals, columbite, microlite and probably small grains of quartz. Thin sections were made from known columbite and wolframite for the purpose of identifying these others.

Columbite is a niobate of iron and manganese. It is a black opaque mineral with submetallic lustre and high specific gravity, about 5.5. In thin section it has a reddish colour and is pleochroic. It belongs to the orthorhombic system. Sufficient tungstic acid is present to give the reaction for that acid as well as for niobic.

Besides occurring in fine grains associated with columbite, a small piece of microlite was found quite free from impurities. This shows a high index of refraction, a specific gravity of 5.21, and in thin section is quite isotropic. It is infusible and insoluble in hydrochloric acid, and gives the characteristic reactions for a niobate or tantalate. Its colour is pale yellow; lustre, resinous; and fracture conchoidal. A quantitative analysis of the pure material was made by Mr. R. Mohan under the supervision of Mr. J.W. Ince of the Chemistry Department, with the following result:-

Nb_2O_5 Ta_2O_5	75.76%	74.20%
CaO	16.1	

Mr. Mohan adds that "owing to the small amount of mineral available (less than.5 grs.) and the number of tests to be made, a very small loss made a large percentage error". The radioactivity of the mineral is quite above that of the ordinary rock, so that a small percentage of the oxide of uranium may enter into its composition. A specimen from Virginia holds 1.59% UO_3 .

Amblygonite.

This is a fluo-phosphate of aluminium and lithium. It yields water in the closed tube, so that according to " Brush and

Penfield", it is a montebrasite. In colour it is light blue. In thin section, it shows a medium index of refraction, and polarisation colours ranging from reddish brown to yellowish. Where cleavage lines show, these colours are higher than where none are seen. Spots of blue appear throughout the slide which are strongly pleochroic. An extinction angle of about 14° is obtained with a cleavage line. Small grains of quartz and of chlorite are found in the section.

Durangite.

A mineral allied to amblygonite, a fluo-arsenate of aluminium and sodium occurs here.

Monazite.

The rare phosphate of didymium ($(Ce,La,Di,)\ PO_4$) which contains thorium is also found in the pegmatite. It occurs in small yellow crystals.

Mispickel.

An arseno-sulphide of iron, arsenical pyrites, or mispickel, (Fe AsS) occurs in quartz near the pegmatite. It is an opaque, silver-white mineral with a grayish-black streak. Its hardness is 5.5; specific gravity;6. It fuses to a magnetic bead, and gives off arsenical fumes.

Beryl.

A pale green variety of the silicate of beryllium and aluminium, beryl, was found in the pegmatite. The crystals are small with fine faces and would likely be good gem stones. Its hardness is 7.5; specific gravity 2.7. It is insoluble in acids.

The following minerals are from the New Ross district but have not been found in the same deposit as the cassiterite.

Sphalerite.

This is a sulphide of zinc (ZnS) and is usually known as zinc blende. Its brittleness, adamantine lustre, high index of refraction and difficulty of fusibility caused it to be mistaken for cassiterite. Its hardness, 3.5, specific gravity 4, and its pale yellow streak serve to distinguish it. It is also decomposed by hydrochloric acid, and sulphur fumes are given off when it is heated in the open tube. In thin section it is isotropic.

Chalcopyrite.

A sulpho- ferrite of copper, chalcopyrite ($CuFeS_2$) is found here. It is brass yellow in colour; its streak is greenish black; its lustre metallic. It is opaque and fusible; hardness 4; specific gravity, 4.2.

Molybdenite.

This molybdenum disulphide (MoS_2) resembles graphite very closely. Its hardness is about 1; specific gravity, 4.6; lustre, metallic; colour, lead gray. It is sectile and greasy to the touch. It has a bluish cast, and leaves a bluish gray trace on paper which helps to distinguish it. It gives off sulphurous fumes in the open tube, or on charcoal in the oxidising flame, and is decomposed by nitric acid.

Bismuthinite.

The trisulphite of bismuth, (Bi_2S_3) occurs in small blebs

and needles in quartz. It is sectile. Its hardness is 2; specific gravity, 6.4; lustre, metallic; and streak and colour, bright lead gray. Its action on charcoal is characteristic. It first gives off sulphurous fumes, then fuses with spirting, and coats the coal with yellow bismuth oxide.

In addition to the minerals described above, either as hand specimens or in thin section, as constituents of the granite, there are reported also as occurring in the district, pyrolusite and manganite, ores of manganese, limonite, hematite, magnetite, and siderite, ores of iron, and a silver-bearing lead sulphide, galena.

--- Probable Origin of the Deposit. ---

The fact that aplite veins having the same constituents as the light coloured granite cut the surrounding dark, less acid granite some little distance from its margin leads one to the conclusion that the light coloured granite was still in a liquid state when the other had solidified. The prevalence throughout the district of the minerals that are associated with the cassiterite in the pegmatite of the light coloured granite suggests a connection in origin between these outlying occurences and the light-coloured granite. These outlying bodies may be segregations in the dark-coloured granite of the country; but it is more probable that they are the outcrops of dykes or veins which connect with the tin-bearing mass.

The pegmatite that occurs in the light-coloured

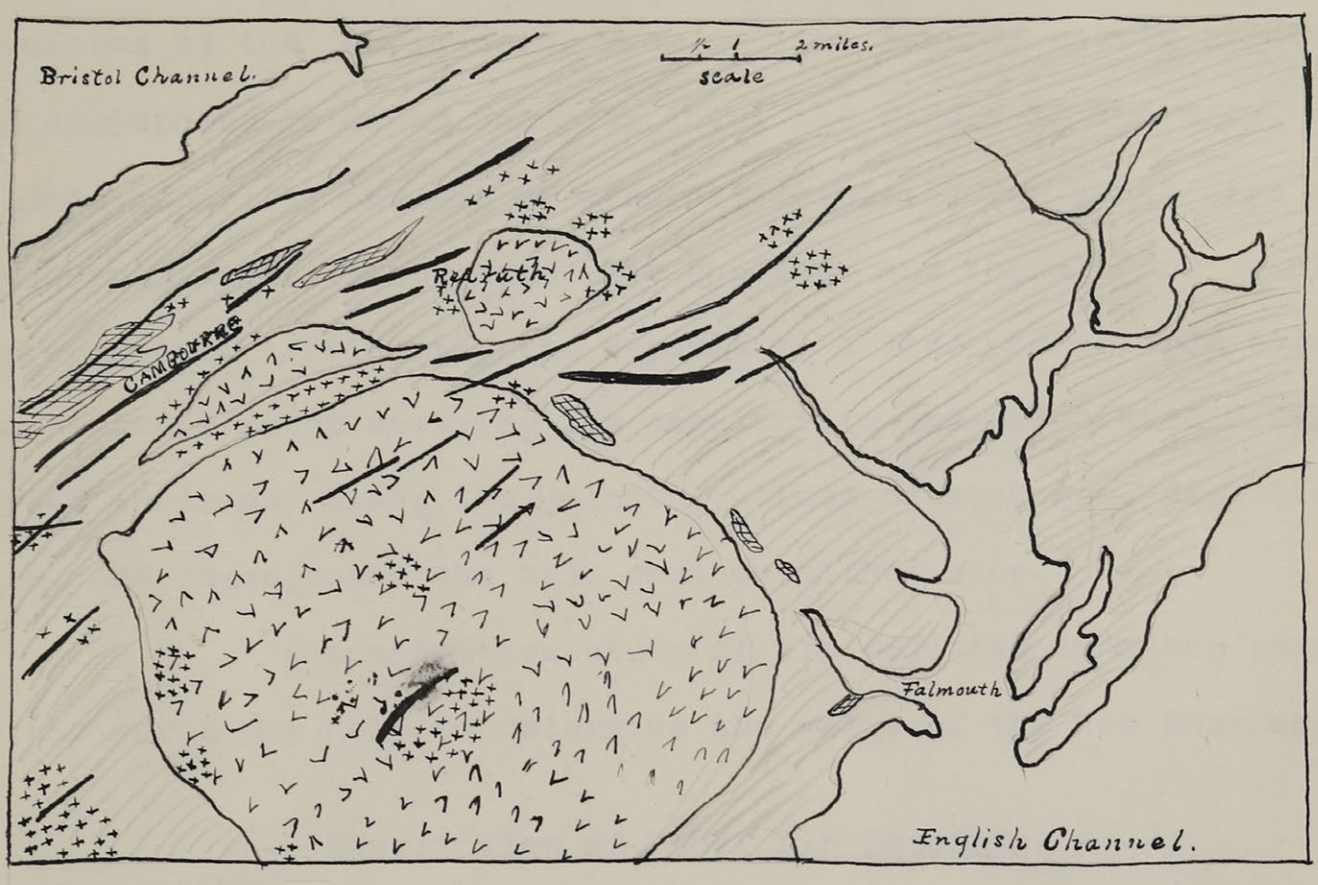


Fig. 5. Sketch Map to Illustrate the Geology of Cornwall.
(After Hill and MacAlister.)

granite appears at the surface at only one point; on all sides it is capped by the surrounding rock. The zone of quartz crystals and decomposed feldspar occupies about the middle of the mass, and follows generally one set of vertical joints. The great size of the quartz crystals suggests slow cooling, and the altered granite, impregnation. Evidently the deposit is a lode formed from solution. The heated vapours carrying the cassiterite and associated minerals forced their way along the jointing, lines of weakness, deposited minerals, and impregnated the wall rock on either side.

A comparative study of tin deposits in other parts of the world may help to determine the value of the New Ross occurence.

---- Description of Other Tin Deposits. ----

Cornwall.

The Cornish mines, having been worked for a long time and examined very carefully, afford a typical example of a tin area. The tin district embraces the country around Camebourne and Redruth, and extending towards Falmouth on the south east coast. The low-lying country consists of metamorphosed clay slates called " Killas". These are of Devonian age and were intruded by large masses of granite, which ~~would~~ make the hills of the district. The granite masses are fringed with smaller granite intrusions, and the Killas is cut by a great number of dykes of quartz porphyry, called " elvan courses" which extend down into the granite, and by greenstone sheets and mica trap. (Fig. 5)

The granite, an intrusion of Post-Carboniferous age,

is a muscovite-biotite, "in which tourmaline is a common constituent, andalusite frequently present, and in which apatite and zircon sometimes occur." The quartz contains large fluid cavities with mobile bubbles. Large feldspar phenocrysts are common, and the rock is sometimes veined with pegmatite and aplite. Muscovite-tourmaline granite and muscovite granite are also met with in the district. An east-north-east set of vertical points is a characteristic feature. Another set is at right angles to these, also vertical, and a third set is approximately horizontal.

Cassiterite occurs in lodes in close proximity to the elvan dykes and near the margin of the granite, more especially where the latter plunges at a low angle beneath the killas. The lodes have the same general direction as the elvans, which is, roughly speaking, east 25° north. The lodes have resulted from the infilling of fissures and impregnation of the country rock and from the impregnation of friction breccia in a fissure. The vein-stone is usually chlorite and quartz with some clay, a blue schorl rock, or a paler blue schorl that contains some kaolin. The altered granite known as " greisen" is muscovite and quartz with topaz and kaolin, and is often a rich tin ore. Where it is poor in tin, it is called " capel". Associated with the cassiterite are quartz, lithia mica, tourmaline, topaz, fluorite, mispickel, wolframite, native bismuth and molybdenite.

Besides the veins parallel to the elvans, "caunter lodes" run east and west, and often join the other veins.

" Cross Courses" contain no tin, but outside the tin district, they hold lead and silver.

Generally speaking, the lode narrows with depth and becomes less valuable. An exception to this, is the Dalcoath mine, from which is obtained about one-third of all the tin produced in Cornwall. Begun as a copper mine in the killas, as the granite was approached, it became poor in copper but with a larger quantity of tin, and gradually the copper disappeared altogether, and the mine became rich in tin. Work is now going on at a depth of about 3500 feet; the impregnated strip is 30 feet thick, and yields 25 lbs. of black tin to the ton.

Tin lodes that yield over 1% of tin are economically workable. A rich stringer-lode is called by the Cornishman a "Carbona" or "floor." Veins that interlace and run in various directions through the country rock make what is called a " stockwork".

Stream tin was the first source of the metal in Cornwall. This was the result of enormous erosion in post-glacial times. The eroded material was carried towards the south, and the cassiterite is always found on or near the rock-shelf covered by river alluvium sometimes of great depth. The stream tin industry in this district is now a thing of the past. "The " stream working " of to-day is the extraction of tin stone from the tailings of the stamp mills," which has collected in the valleys.

Saxony and Bohemia.

The mountainous district of the Erzgebirge was for more than 400 years noted for its tin mining industry. The older sedimentary rocks of these mountains, gneiss, mica schist, and clay slate were broken through by a porphyritic fine-grained granite. At Altenberg within this intrusive mass, an area about 1200 by 800 feet has been converted into a kind of gneisen, locally known as " Zwitter". Its constituents are quartz, lithia-mica, topaz, chlorite, specular iron, wolframite, mispickel and cassiterite. Rich zones occur in the Zwitter, and through it, extend and interlace quartz veins about 8 inches in width which carry in addition to the other minerals of the Zwitter, molybdenite, and bismuthinite. This mass makes the typical German, " Stockwerk". It is said to yield from 1/2 to 1/3% of tin ore, but does not extend to a great depth. The tin stone impregnation extends into the surrounding porphyry and gneiss. Dr. Karl Dalmer says that the Zwitter is unquestionably the result of metasomatic alteration of the granite. In Zinnwald the rich zones are concentric, while in a few places the tin ore occurs not only in the granite but in fissures in the slate.

Straits Settlements, and Banca and Billiton.

The world's greatest supply of stream tin, comes from the Malay Peninsula, and the East Indian Islands of Banca and Billiton. It is the product of the denudation of the elevated district that forms the backbone of the peninsula and that extends into the islands. A granitic range runs through the north and south, flanked by

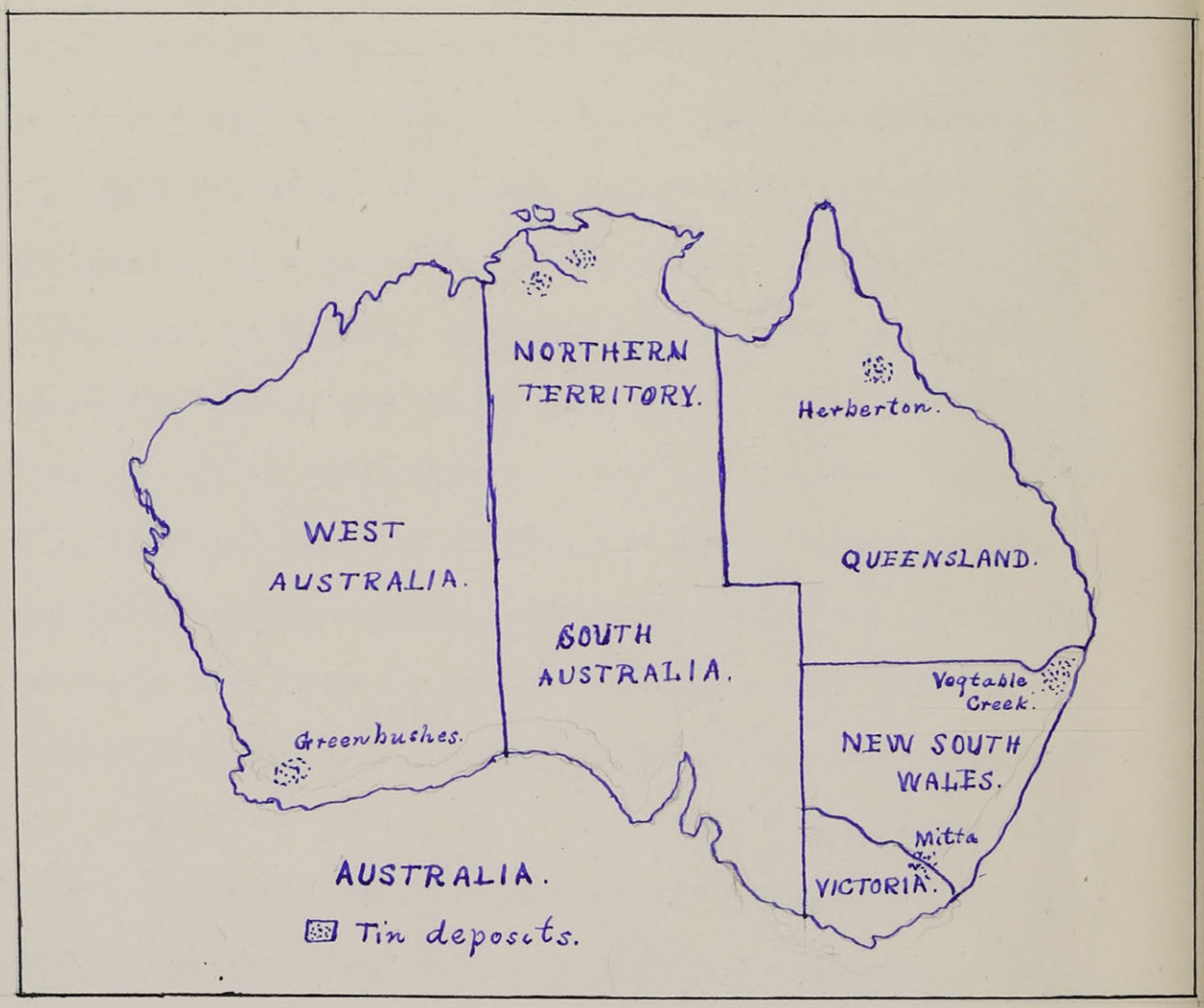
metamorphosed slates, schists and sand stones. Eruptive masses of diorite and felsite traverse both the granite and stratified rocks, while there overlies them in many places, crystalline limestone. In the streams and valleys that descend from the main axial range, is found the tin. It may be got disseminated in the deposit extending from the grass roots downward, or it may have a covering or " overburden" sometimes 40 feet or more in thickness. As a general thing, the tin-bearing alluvium extends to bed rock, which is granite or limestone. From 2 to 3% of tin in the alluvium is considered a rich product. "In the Kinta district of the Malay Peninsula, associated with the cassiterite is much tourmaline, hornblende, wolframite, and magnetite, with amaller quantities of muscovite, topaz, scheelite and sapphire; and it is said that small quantities of thorium and cerium minerals have been found in parts of the Peninsula."

Lode tin is worked on the east side of the Malay Peninsula, and is found in Banca and Billiton also, but the amount is comparatively small. The geology of Banca and Billiton is like that of the Malay Peninsula, and the production of tin similar.

France and Portugal.

In the Province of Brittany, the geological conditions are almost identical with those of Cornwall - Killas, granite intrusions and elvan dykes. Here, however, the resemblance as tin-fields ends, as very little tin has yet been produced here.

In Portugal, tin occurs in alluvial gravels, in stock-



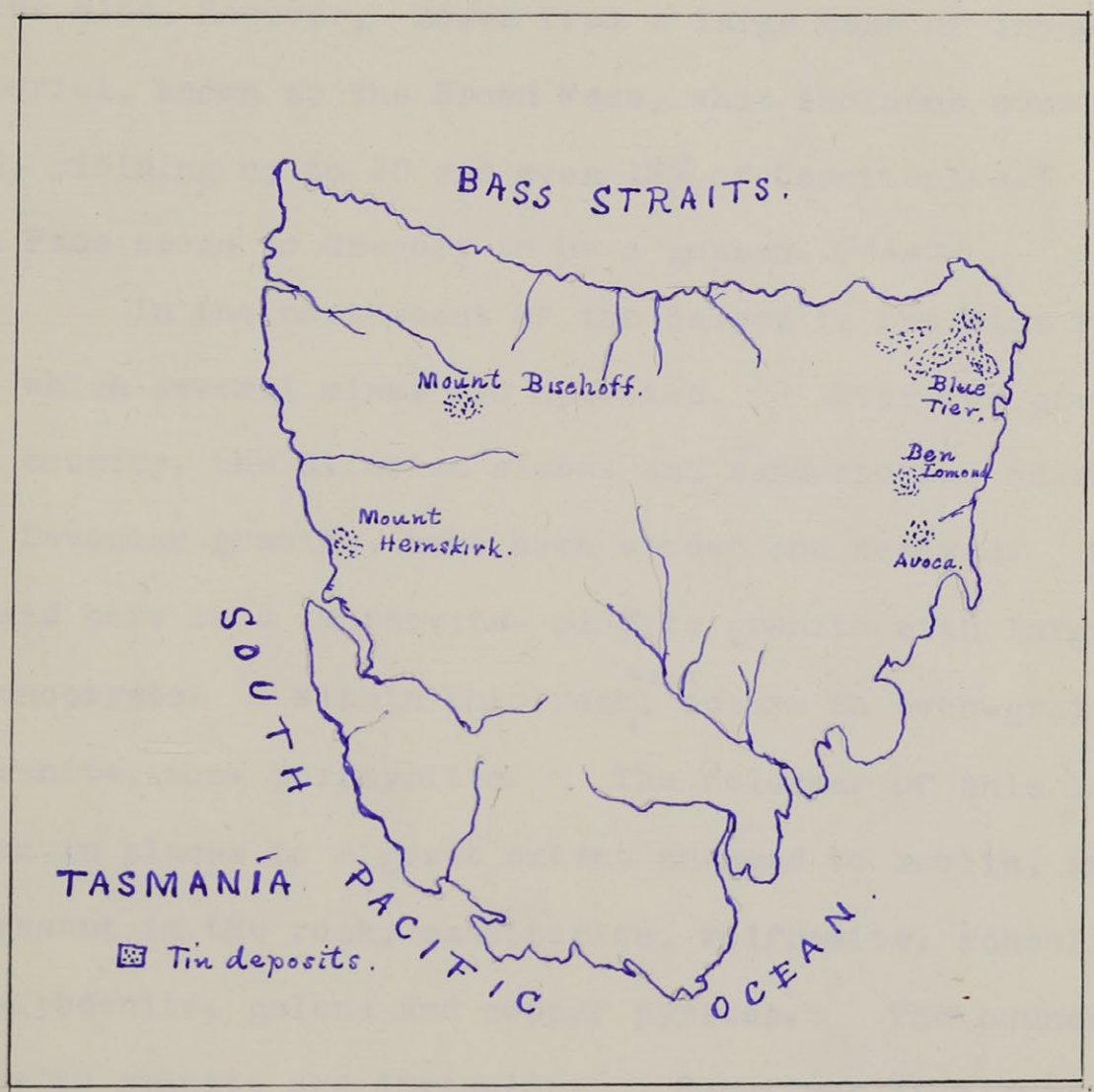
1. Map of Australia - Showing position of Tin deposits.
From Tin Deposits of the World. (Sydney Fawns.)

works in the granite, and as tin veins in the older slates. The quantity of ore produced is small.

Australia and Tasmania.

In every province of Australia, tin has been mined, both from the alluvium and from lode. But it is in Queensland and New South Wales that the industry has reached the greatest proportions. Geologically, the country shows the granite forced up from below into the older slates and sand-stones and achists with the usual accompanying dykes. In Queensland, the tin-bearing rocks a are quartz-reefs and eruptive dykes. Wolframite in sufficient quantity to make it a wolfram-ore occurs in some places. The lode tin of New South Wales, is found in fissure veins, in gash veins, in joints of the granite, in impregnations and in stockworks. The outer crust of the boss of granite is the tin-bearing portion. About 1½ miles from its junction with the slate, it ceases to be tin-bearing. The alluvial deposits are very rich. The deep beds are in some places overlaid by sheets of basalt. *(Map I.)*

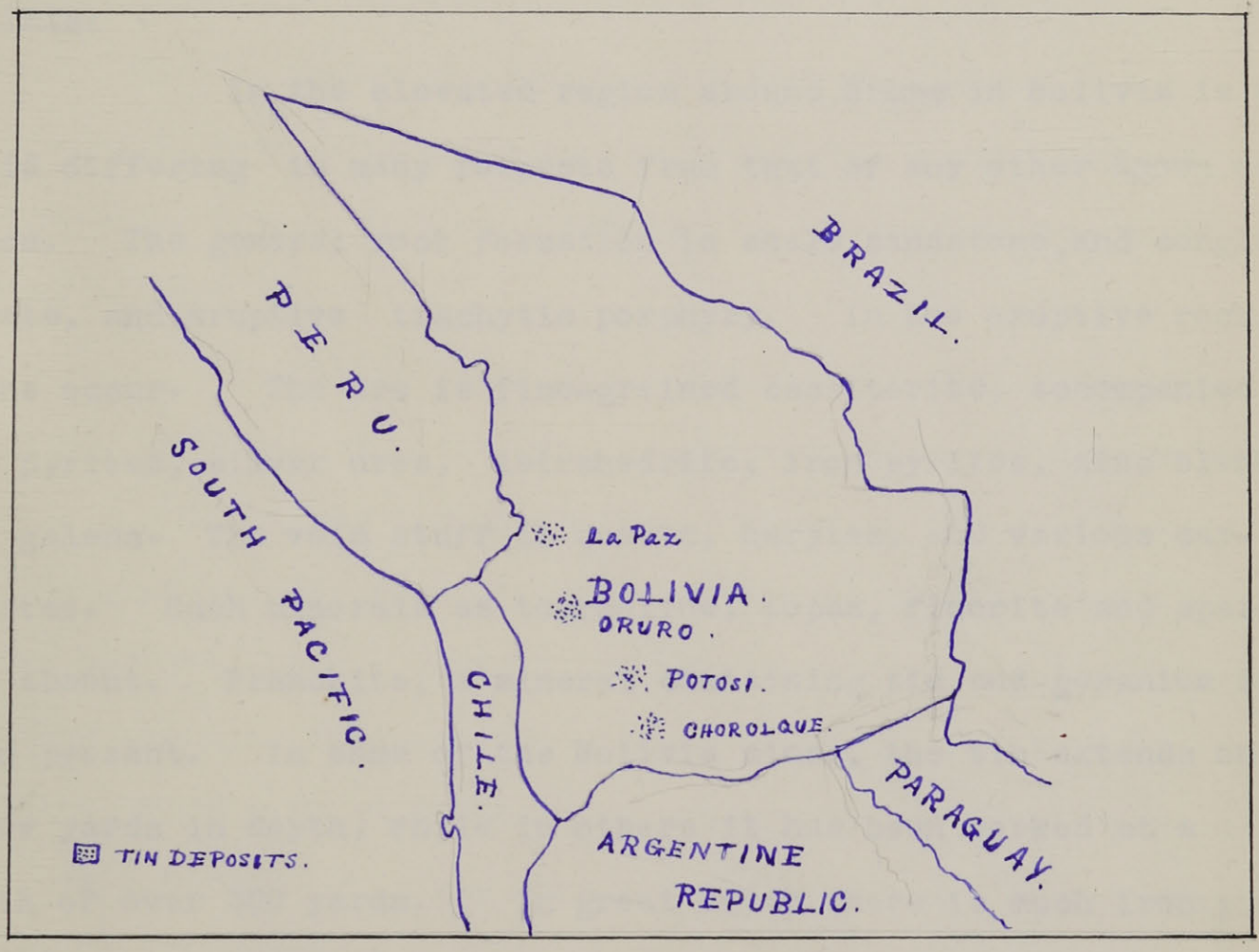
The Island of Tasmania is a large tin producer. In the north-western part of the island, is the Mt. Bischoff mine, one of more than passing interest. Prof. J.W. Gregory has given a brief description of it in a recent " Science Progress". He states that the mountain, rising above the surrounding basalt plateau, consists of folded Silurian rocks pierced by quartz porphyry dykes, in the shape of a horse-shoe. Branches from the dykes radiate into the surrounding country rock. A tin-bearing quartz vein, the Queen lode, follows along a porphyry dyke, cuts it, and continues



2. Map of Tasmania - Showing position of Tin deposits.
From Tin Deposits of The World. (Sydney Fawns.)

along beside it. " Cassiterite also occurs in masses and veins in contact with the porphyry dykes, in pockets and veins in the Silurian slates, and as impregnations in the porphyry. The main wealth of the mine, however, comes from a large mass of iron-stained material, known as the Brown Face, whic includes some coarse-bedded sand, yielding up to 10 and even 15% of Cassiterite." The whole Brown Face seems to Gregory to be a gossan. (Map 2.)

In the north-east of the island is the Blue Tier district in which several mines are operated. Over the greater part of the country, the Silurian slates and sand-stones, which were intruded by Devonian granite, have been eroded and removed. The rock thus laid bare is a muscovite- biotite granite with large feldspar phenocrysts. Within this rock area occurs an even-grained muscovite granite, non- porphyritic. The feldspar of this latter rock has been in places to a great extent changed to kaolin, and there are present in the rock, cassiterite, wolframite, scheelite, fluorite, molybdenite, galena and copper pyrites. The boundaries of the muscovite granite are irregular. Sometimes it occurs in the form of floors, and in one mine, it disappears under a capping of the country granite. Pegmatite veins cut through this tin-bearing granite, and are themselves sometimes tin-bearing. Mr,W.H. Twelvetrees, the Government Geologist, says of this district:-" The quality of the ore from the Blue Tier mine is excellent. There seems to be no rule for making use of the distribution of the ore in the tin granite. I could see nothing to show whether the tin has been concentrated in the middle of the formation more than



3. Map of Bolivia – showing position of Tin deposits.
From Tin Deposits of the World. (Sydney Fawns.)

towards the margin, or vice versa. The patches are quite irregular and will, I believe, be found to be more dependent upon the natural fissuring of the rocks than upon any law of segregation. In some places the stone is rich and heavy; elsewhere, practically barren Taking the formation as a whole, the probabilities are that the ore contents will range from a shade under 3/8 to about 5/8% block tin."

Bolivia.

In the elevated region around Oruro in Bolivia is a tin-field differing in many respects from that of any other known occurrence. The general rock formation is shale, sandstone, and conglomerate, and eruptive trachytic porphyry. In the eruptive rock, tin veins occur. The ore is fine-grained cassiterite, accompanied by tin pyrites, silver ores, tetrahedrite, iron pyrites, zinc blende, and galena. The vein stuff is quartz, barytes, and various carbonates. Such minerals as tourmaline, topaz, fluorite and apatite are absent. Franckite, a mineral containing tin and geranium is also present. In some of the Bolivia mines, the tin extends only a few yards in depth, while in others it has been worked at a depth of over 300 yards. In great depth there is much iron pyrites. (Map 3)

Mexico.

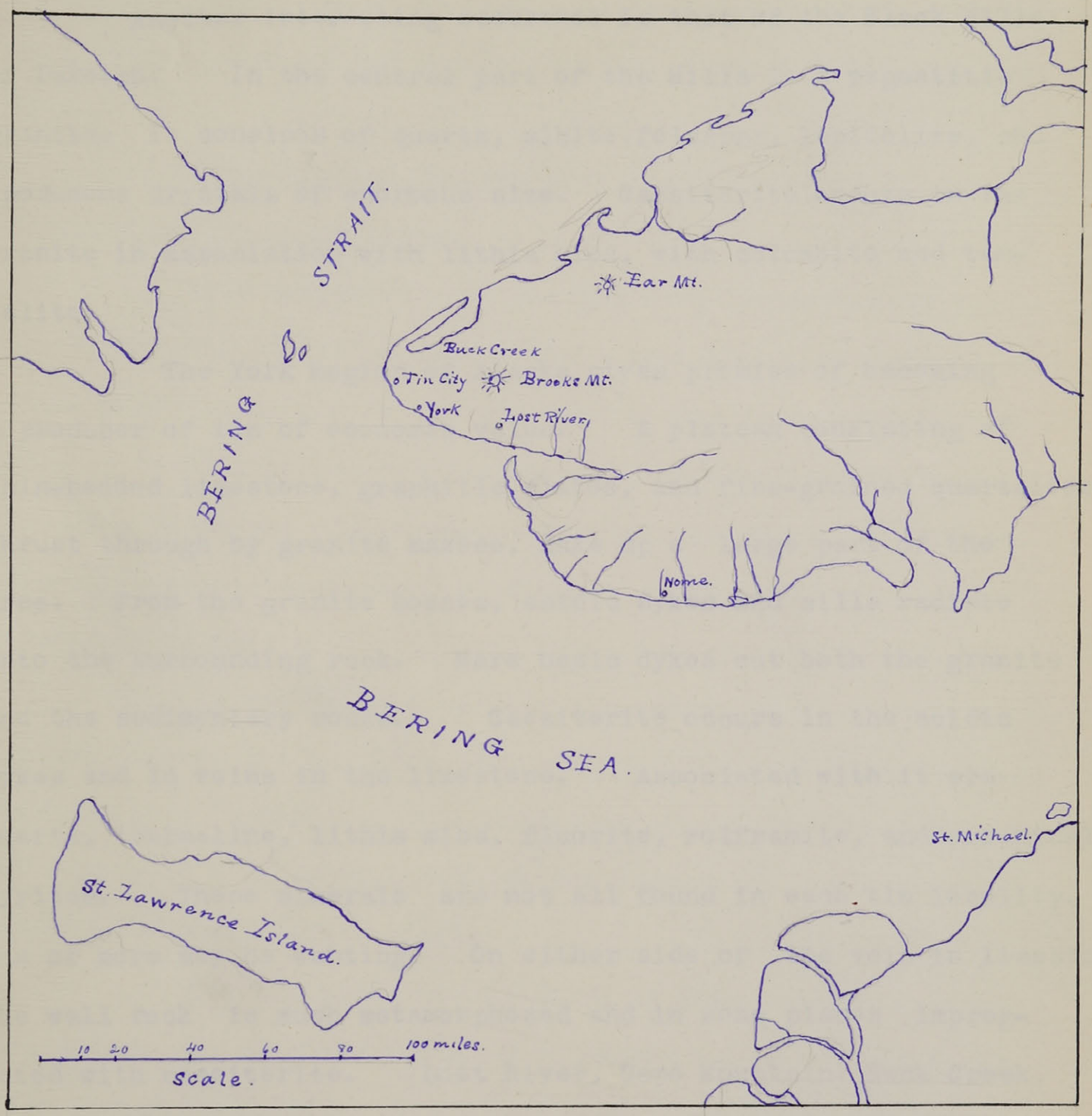
The country rock of the tin area of Mexico is generally rhyolite, rhyolite tuffs and quartz porphyries. The cassiterite occurs in small veins, in irregular bunches, and nodules. It is associated with topaz and other fluorine minerals, chalcedony and

hyalite, and with antimonial and arsenical compounds. Wolframite is rare.

United States of America.

Sydney Fawns in his "Tin Deposits of the World", states that tin in small amounts has been found in no less that seventeen States and Territories of the United States; Alabama, Alaska,California. Colorado. Connecticut,Georgia, Idaho, Maine, Massachusetts, Missouri, Montana, New Hampshire, North Carolina, South Dakotah. Texas, Virginia, Wyoming. A few of these will be referred to here.

In the northern part of South Carolina, and extending into North Carolina, is a tin belt of about 35 miles in length following in a general way the direction of the King Mountain Range. The older gneisses and crystalline schists have been invaded by granites and diabases. Cutting the granite and adjacent metamorphic rocks are numerous pegmatite dykes. The pegmatite ranges in composition from that of a muscovite granite with a little garnet and ilmenite, to that of a gneisen, chiefly quartz and mica. The feldspar is sometimes much kaolinised and monazite sometimes occurs. It is in this pegmatite that cassiterite is found, more especially in the mica-rich variety. Several mines have been opened up in this district; but up to the present, little success has attended the operations.



~~Fig.~~ 4. Outline Map showing location of the York Region.
(After Survey Map.)

Another interesting occurence is that of the Black Hills of Dakotah. In the central part of the Hills is a pegmatitic granite. It consists of quartz, albite feldspar, lepidolite, and spodumene crystals of enormous size. Cassiterite occurs in the granite in association with lithia mica, with columbite and tantalite.

The York Region of Alaska gives promise of becoming a producer of tin of economic value. A plateau consisting of thin-bedded limestone, graphitic slates, and fine-grained quartzites, thrust through by granite masses, make up a large part of the area. From the granite bosses, acidic dykes and sills radiate into the surrounding rock. More basic dykes cut both the granite and the sedimentary rocks. Cassiterite occurs in the acidic dykes and in veins in the limestone. Associated with it are quartz, tourmaline, lithia mica, fluorite, wolframite, and arsenical pyrites. These minerals are not all found in each tin locality. One or more may be wanting. On either side of the vein in limestone the wall rock is much metamorphosed and in some places impregnated with cassiterite. Lost River, Cape Mountain. Buck Creek, and Ears Mountain, are the chief places where tin-bearing ore has been located, while placer deposits are found in various streams and creeks.

At Winslow in Maine, cassiterite occurs in small veins in limestone, associated with purple fluorite, mica, quartz, and mispickel; and at Lynn and Jackson in New Hampshire, it is found

in small quartz-veins in micaceous slate and granite near a trap dyke, with arsenical and copper pyrites, fluorspar and phosphate of iron.

Comparison of the New Ross tin occurence with the deposits of other countries.

By a comparison of the New Ross tin occurence with those deposits described above, it is seen that they have in common (1)-- a location in a region where an acidic igneous magma has been intruded into, or erupted through the overlying sedimentaries, (2)--The boron- and fluorine-bearing minerals as well as other minerals usually associated with cassiterite, and (3)--- rocks more or less of the same geological age.

In geology and petrography, there is a strong resemblance between the New Ross occurence and the Blue Tier deposits of Tasmania; and should the muscovite granite of the former prove to be itself tin-bearing, outside the pegmatite, the deposits would be almost exactly similar.

The presence, nevertheless of rare phosphates, and arsenates, and minerals of the rare earths associated with the cassiterite in various localities throughout North America suggests a connection less remote than that existing between these deposits and those of the Eastern Hemisphere. The Purple fluorite and the mispickel of the Maine occurence, likewise, would seem to establish its close relationship to the New Ross occurence.

Economic Value of the Deposit.

Our present knowledge of the New Ross deposit shows it to be practically valueless from an economic standpoint. The geological conditions are, however, so favourable that prospecting and development should not rest in its present stage. The pegmatite mass where the shaft has been sunk should be further exploited and the other pegmatites and quartz exposures throughout the district should receive attention. A careful examination should, also, be made of thelight-coloured muscovite granite, as well as of the gray biotite-muscovite granite, particularly around their margins.

It is of interestto note that the minerals, amblygomite, durangite and microlite found in this deposit are new to Canada.

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For the description of deposits in other parts of the world, the following books and papers, among others were consulted:-

" Geology of Falmouth and Cambourne," by J.B. Hill and D.A. MacAlister,

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" Treatise on Ore Deposits," by Phillips and Louis.

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" Tin Mining and Smelting at Santa Barbara,Guanajuato, Mexico," by A.H. Bromley.

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