THE TIN-DEPOSITS OF NEW ENGLAND, N.S.W.

Part i.—The Elsmore-Tingha District.

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(Plates lix.-lxiv.)

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Chapter i.—Introduction.

Tin-mining in New South Wales is chiefly carried on in the New England District, which comprises the Northern Tableland. There are two well defined tin-bearing areas, one having Emmaville as its centre, and the other embracing the country about Tingha. These are separated by a barren tract consisting of a series of slates and claystones largely covered by basalts. This unprofitable zone is some 20 to 30 miles in width, and has been worked for tin only in the neighbourhood of Wellingrove. Both tin-bearing areas are associated with granite and allied rocks.

The geology of the Emmaville district has been investigated in detail by Professor David, and the results of his work constitute a valuable memoir published by the Geological Survey of New South Wales.*

The same gentleman has also contributed to our knowledge of the Tingha district, and the map published by the Mines Department of New South Wales, from a partial geological survey by Wilkinson and David, has been of much assistance to me in my study of this field.

A later writer, Mr. E. E. Andrews,† also of the Geological Survey of New South Wales, has also contributed a series of papers embracing both areas, and has studied the ore-deposits more from a genetic standpoint.

A few useful observations on these New England tin-deposits were made by Mr. G. H. F. Ulrich‡ shortly after their discovery, but, with this exception, practically all the work that has been done has been accomplished by officers of the Geological Survey.

My experience has so far been limited to the Tingha area, and the observations made in this paper refer to that district. No attempt will be made here to explain in any detail the genesis of the ore-deposits; as it is rather my intention to collect as much evidence as possible from other occurrences and laboratory investigation before discussing at any length the question of origin. The contents of this paper, then, consist of a brief record of the observations made during a four months' study in the Tingha

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*David, T. W. E., "Geology of the Vegetable Creek Tin-Mining Field." Mem. Geol. Survey New South Wales. Geology, No. 1 (1887).

†Andrews, E. C., "The Geology of the New England Plateau.—Part i., Physiography"; Records Geol. Surv. New South Wales, Vol. vii. p. 281, 1904; Parts ii. and iii., with special reference to the Granites of Northern New England; *op. cit.* Vol. viii., p. 108, 1905; Part iv., Petrology, *op. cit.* p. 196, 1907; Part v., Additional Notes on the Origin of New England Ore Deposits, *op. cit.* p. 239, 1907.

‡Ulrich, G. H. F., "Observations on some of the recent Tin-Ore Discoveries in New England, New South Wales." Quart. Journ. Geol. Soc. Vol. xxix., p. 5, 1873.

area. The observations are grouped and correlated, as, it is hoped, will best serve as a basis for a genetic discussion later on.

Geography.

Tingha is situated about 16 miles south by east from Inverell, and may be reached by coach from that town. Elsmore lies some 12 miles north by east from Tingha, on the Inverell to Glen Innes mail coach route. Most of the tin-bearing country lies between the latitudes fixed by these two towns, though tin has been found in small quantities some miles south of Tingha. The area found to be tin-bearing is represented on the accompanying map, and its extent may be roughly estimated at about 300 square miles. The drainage of the area conforms to two river-systems, the Macintyre and the Gwydir, which form respectively its northern and western boundaries. The Inverell-Armidale road runs along the ridge forming the watershed of these rivers.

Topography.

It is necessary under this head to anticipate the section on geology to the extent of stating that the geological units consist of slates and claystones, granites, and basalts. Each of these units give rise to a characteristic topography and vegetation.

The slates and claystones are much metamorphosed, and resist very strongly the attacks of weathering. Consequently, they stand out as high, rugged ridges, and are scored with steep gullies. They are invariably strongly jointed, and weather into sharp, angular fragments which make travelling difficult.

The granites, though varied in structure and composition, present a uniform set of topographical characteristics. Huge tors and piles of granite-boulders are common throughout this granite-area. The boulders present a general ellipsoidal appearance with their long axes vertical, and are, as a rule, somewhat flattened on the south side. Several very interesting sketches of these are given in "Mines and Mineral Statistics of New South Wales" published by the Department of Mines in 1875.

The granite hills are more rounded and less precipitous than those in the slate country, and usually more soil is present. It is not uncommon, however, to find very large areas of bare rock generally steeply sloping on the side of a hill. (See Plate lix., fig. 1). This is a very prominent characteristic of the granite hills at Howell. Here, many of the hillsides consist of clean bare rock of a reddish color, and the whole presents a most striking appearance. This feature I have always observed to be developed on the northern slopes of the hills, where changes of temperature and rock-disintegration are most rapid.

The coarser-grained types of granite are more prone to decomposition than those of finer grain, and hence the higher granite hills are usually of the latter kind. The porphyritic granite is the most prone to decomposition, the phenocrysts becoming dislodged, before being appreciably decomposed, by the disintegration of the finer matrix surrounding them.

The basalts constitute the youngest rocks, are seen to overlie slate and granite alike, and to fill in the pre-basaltic valleys and watercourses. There is considerable variety in the basalts, and the relative resistance to weathering of consecutive flows frequently gives rise to a terrace-like structure on the slopes of the basalt-hills. This is well developed in the neighbourhood of Elsmore. Conical basalt-knobs are not infrequent, but are much rarer than in most volcanic areas. A much more common feature is the very striking development of long level-topped ridges of basalt terminating rather abruptly in steeply sloping ends. This suggests that the outpourings of the lavas are related to fissures rather than to foci of eruption.

The river-system is consequent. The fall in the general surface of the country is to the west, the rate of fall being about 1000 feet in 30 miles. One marked feature is the development of the streams along the junction of geological formations and lines of structural weakness. Streams have been noticed flowing for quite a distance along, or close to and parallel with, the junctions of granite and basalt, of basalt and slate, and also of slate and granite. The pre-basaltic stream-courses were subject to the same preferential development, many junctions of granite and slate being now obscured by basalt filling the ancient valleys between these older formations. Several interesting cases were also observed where the direction of the streams has been determined by faults, and in some cases the master-joints have been sufficiently well developed to produce a similar result.

Chapter ii.—Geology.

It will be convenient, here, to make reference to the plan of the accompanying geological map, which is somewhat unusual. The lode tin-deposits are associated with the older rocks of the district, and have no genetic relations with the basalts, which are much younger. Hence, it was considered best to construct a geological map showing only such rocks as are concerned in the origin of the ore-deposits. This plan necessarily makes the geological map rather general, as the boundaries of the older formations have to be approximated to where they are concealed by the overlying basalt. Nevertheless the boundaries may be accepted with confidence as close approximations. Much of the information, more especially with regard to the granite and slate boundaries, has been very kindly furnished by officers of the Department of Mines working in the same area. Where the boundaries are shown in continuous lines, they have been accurately determined, either by the officers of the Department of Mines, or by myself. The broken lines represent that the boundaries have been approximated to by numerous observations. I have made a study of the two granite-types indicated on the map, and in many places have traversed the contacts. Only those ore-deposits which are specially mentioned in this paper, are shown on the map. The work done on scores of smaller ore-bodies has been condensed and generalised under the descriptions of the different types of deposits. The dotted areas indicate those in which tin has been found, and the density of the dotting is intended to convey an idea of the concentration of the cassiterite.

Two sections accompany the geolcgical map. These, it should be remembered, are drawn in harmony with the plan of the map, and hence do not show the necks and fissures which served as outlets for the Tertiary lavas. The sections will, it is hoped, make clear the intrusive nature of the "Acid Granite," and its close association with the ore-deposits.

The general geology of the area to be considered may be represented by three units:—

(1). A series of altered sediments.
(2). A series of granites and allied rocks.
(3). A series of basalts and allied rocks.

Age of the Rocks.

The complete failure of all investigators, up to the present time, to find any fossils in the sedimentary rocks, makes a definite statement of their geological age impossible. Any provisional age assigned to this series must rest upon such evidence as lithological characters and continuity with, or proximity to, rocks of known geological age. Lithologically, these sediments, which consist of slates and claystones, appear to me very similar to rocks of Ordovician age occurring both at Berridale and Tallong. The New England sedimentary rocks, however, appear to be more metamorphosed, so much so in fact, that at no place was I able to obtain reliable dips for the strata. In qualification of this statement it is only proper to remark that no place investigated was distant more than three miles from an igneous contact.

The slates cannot be traced continuously into rocks of known geological age, neither are there any similar rocks of known geological age in close proximity. The series has previously been provisionally classed as Carboniferous on the evidence contained in the following statement from Mr. Gower's report of 1874, to the Department of Mines:—"On Newstead Station, thin bedded shales of bluish-grey and yellow colour crop out, dipping at an angle of 15° in one place and almost vertical in the other, with a general northerly strike. I could not detect any fossils in them, but from their lithological character there is little doubt but that they form part of the carboniferous formation of which the Rev. Mr. Clarke's report states: 'that the middle beds of this formation, those of the Hunter and Hawkesbury, are widely distributed on the western border of the country between New England and the interior.'"

Unfortunately I have not seen the occurrence thus described by Mr. Gower, though I am well acquainted with Newstead. There can be no doubt, however, that the occurrence, so far from being typical of the sedimentary formations in this district, is most exceptional. The nearest related rocks are those described by Professor David from Vegetable Creek. In these he found rather obscure fossil remains, and has concluded that the series is Upper Silurian or Siluro-Devonian.

Another point in favour of the geological antiquity of the rocks is the occurrence in them of ore-bodies other than tin. At "The Brothers," near Newstead, a small reef was opened up for silver and lead, and similar bodies of galena and arseno-pyrite are common in the slates about eight miles south of Tingha. Hence lithological characters favour a correlation with Ordovician and Silurian rocks, and the system may provisionally be classed as Silurian.

The age of the granites must, on this basis of classification, be regarded as Post-Silurian, as evidence of their intrusion into the slates is abundant. Professor David has classed the intrusive tin-bearing granite at Emmaville as Permian, for the following reasons. (1) It may be correlated with the granite which has intruded the Permo-Carboniferous rocks at Ashford. (2) No granites in New South Wales have appreciably disturbed Triassic rocks.

Another fact in confirmation of this proposed age for the granites, is the statement by the Rev. W. B. Clarke* that "geologists at Home have settled it that the stanniferous granites are Palæozoic, Pre-Permian, and Post-Silurian."

Again Mr. David Forbes† said at the Geological Society's meeting in December, 1871, that he had received specimens of the granite from the New South Wales tin-region, in the year 1859, and that he found them to be "perfectly identical with the stanniferous granites of Cornwall, Spain, Portugal, Bolivia, Peru, and Malacca."

*Mines and Mineral Districts of New South Wales, 1875, p. 86.
†*Ibid.*

From these considerations, then, it is highly probable that the granites are of Permian age.

The Basalts present clear evidence of Tertiary age. At Elsmore there is, interbedded with the basalts, a bed of clay-ironstone, in which abundant plant-remains are to be found. This bed may be traced some three miles both to the north and east of Elsmore. Numerous aneroid determinations indicate that this horizon preserves a constant level, and the inference is that it was formed as a swamp or lake-deposit. The forms collected were kindly identified by Mr. W. S. Dun, and proved to be *Cinnamomum* sp., *Artocarpidium Gregorii* Ett., *Quercus (?)* cf. *Darwinii* Ett., *Cinnamomum* sp., a leaf like Ettingshausen's *Alnus*, *Cinnamomum* cf. *polymorphoides* McCoy, *Carpolithes, Cinnamomum polymorphoides*, and (?) Ettingshausen's *Eucalyptus*.

Another collection of fossil leaves from the Elsmore Valley Deep Lead, some 300 feet lower than the horizon above-mentioned, was also examined by Mr. Dun. The following forms were determined—*Banksia myricæfolia* Ett., *Cinnamomum Leichhardtii* Ett., *Eucalyptus Diemenii* Ett., *Cinnamomum (?)*, *Ficus (?)*, *Dryandra præformosa* Ett., and *Ficus* cf. *Phillipsii* Ett. Similar fossil leaves and Unio shells were collected from Elsmore some years ago by Mr. Wilkinson, and these were identified as belonging to the late Tertiary period.

A consideration of the foregoing facts has led to the following classification, in which the positions assigned to the various formations have been determined by their relations to the slates, granites, and basalts.

RECENT		Allvuials
TERTIARY		Basalts Calcareous and Siliceous Deposits
PALÆOZOIC	Permian	Dykes The "Acid Granite" The Tingha Granite
	Silurian	Slates and Claystones
UNDETERMINED		Quartz-Porphyry Felspar-Porphyry Quartz Orthoclase Porphyry

The Silurian System.

The oldest rocks are undoubtedly the slates and claystones, which are so widely distributed over New England. All attempts to find fossils in the field have proved unsuccessful, and microscopic investigations have failed to reveal any trace of organic remains.

The slates vary in colour from dark blue to green, and are very fine-grained. A freshly broken piece may very readily be mistaken for a fine-grained basalt. They occur in masses frequently surrounded by igneous rocks, and exhibit signs of intense metamorphism.

At Newstead, the contact of the eastern side of the tin-bearing granite with the slate has given rise to a great development of garnet-rock. The slate here is green in colour, with brown streaks and aggregates of fine brown garnet.

Again, at the contact of granite and slate, at a point about five miles west from Tingha, a mica-schist is developed containing crystals of garnet up to 3mm. in diameter. The intrusive granite in this locality is the Tingha Granite.

The evidences of the intrusion of the granite into the slate are (1) Contact-metamorphism, (2) Veins and dykes of granite in the slate, (3) Inclusions of slate in the granite.

The development of garnet-rock above mentioned is evidence of contact-metamorphism; another evidence is the common development of quartzite in the slates near the igneous contacts.

An excellent example of an intrusive dyke of granite into slate is to be seen in the bed of Darby's Branch Creek at the north-west corner of Portion 214, Parish of Cope's Creek. Here, a tongue of the granite, about two feet in width and several yards long, has intruded a typical slate-mass. One specially noticeable feature is the very sharp contact between the granite and slate. There is no trace whatever of any zone of digested rock. This is worthy of note in support of the application of Daly's theory of overhead stoping to this area. The very marked rectilinear contact also favours this explanation. The intrusive granite is here strongly tourmaline-bearing, this being a characteristic of the numerous smaller veins which also intersect the slate. A sketch of this is given in text-fig. 1.

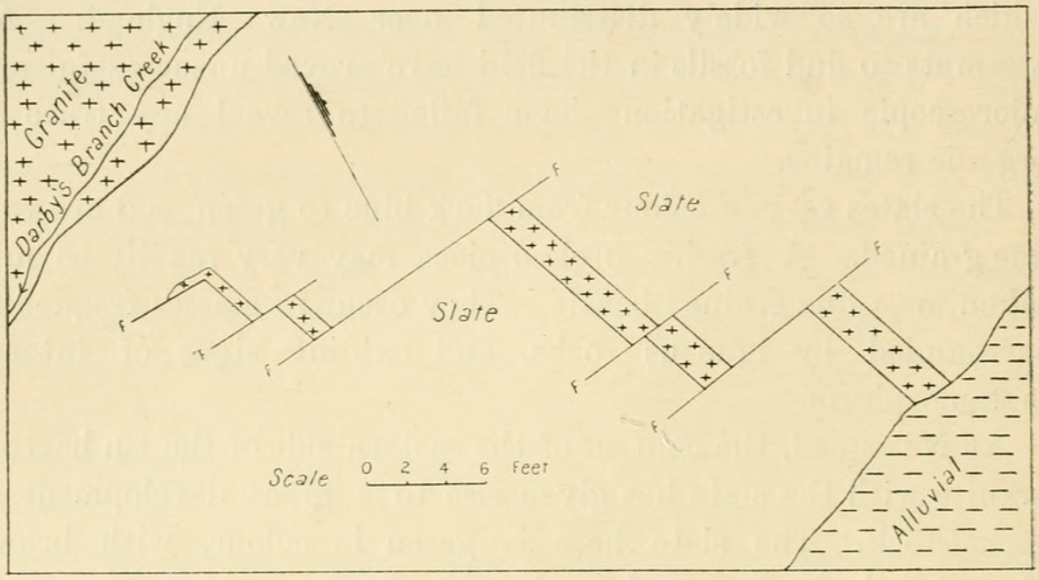

Fig. 1.—Plan of " Acid Granite " intrusion into slate. F, F, faults.

At King's Gap, on the Inverell-Bundara Road, there is another contact of granite and slate. The slate here is converted into a mica-schist, a number of subangular fragments of which may be seen as inclusions in the granite.

The Permian System.

Under this system have been included the intrusive granites. These fall naturally into two groups, namely—(1) The "Acid Granite" (of Andrews). (2) The Tingha Granite.

Of these two types, it is the "Acid Granite" which is closely associated with the tin-deposits. The most primitive distinction between these two granites is, that the "Acid Granite" is a red granite, and the Tingha Granite a blue granite. The latter type is not, however, the same as that named the " Blue Granite " by Mr. E. C. Andrews, and which occurs in another part of New England.

The Tingha Granite.—Of the two granites, the Tingha Granite is certainly the older, as it has been found in many places to have been intruded by the "Acid Granite." The contact is never very sharp, a zone of rock intermediate in composition being usually present. In some instances, as at King's Gap, for example, fragments of the Tingha Granite may be seen included in the "Acid Granite."

The Tingha Granite is typically developed around Tingha, chiefly to the south of Cope's Creek. A glance at the accompanying map shows its extent. It is characteristically a porphyritic granite, the phenocrysts being felspars and quartz. The felspars are chiefly plagioclases, and may be seen rather more than an inch in length, though typically they form almost square crystals, about half an inch in length. A considerable amount of biotite, and an almost equal quantity of hornblende are present. Apatite is an accessory mineral. The quartz grains are seldom larger than a pea, and are less numerous than the felspar phenocrysts. The ground-mass consists of a second generation of felspar and quartz. The felspar phenocrysts cause the rock to present a striking appearance on weathering. It is remarkable that the felspars, usually so prone to decomposition, stand out in bold relief, often projecting a quarter of an inch or more above the surface of the rock. This is due, no doubt, to the more rapid weathering of the second generation of felspars, causing the rock to disintegrate round the phenocrysts.

This granite occupies a considerable area, and was the first to intrude the sedimentary rocks. An isolated area of it occurs in the neighbourhood of Copeton, and extends a few miles to the north of that town. This granite is represented by Plate lix., fig. 2. A somewhat similar granite, which may be regarded as an allied type, is the *Oakey Creek Granite.* This rock extends from near the Inverell to Copeton Road, for a considerable distance to the west. It is extremely porphyritic, the felspars attaining a length of nearly three inches in rare cases. The average size is considerably more than an inch in length. Pegmatite veins are common, and dykes of a fine-grained felspathic nature containing a good deal of tourmaline are also abundant. Quartz veins containing large prismatic crystals of tourmaline are also to be found.

Stream-tin has been discovered in small quantities throughout the area, but no lodes have been worked. The cassiterite has been recovered chiefly from the diamond-bearing gravels of Tertiary age, which have been preserved by cappings of basalt.

A further modification of the Tingha Granite occurs a few miles to the south of Tingha. The difference is, however, mainly one of texture. No phenocysts are present, and the granite is rather fine-grained.

The "Acid Granite."—This granite varies considerably in texture, but very little in structure and composition. At Elsmore the granite is rather coarsely crystalline, the crystals being about the size of a pea. The rock is here composed almost entirely of quartz and felspar. The felspar is predominantly orthoclase, while albite is present in small quantity. The quartz-crystals are frequently more or less idiomorphic, and micrographic intergrowth of quartz and felspar is common. Occasionally the granite takes on a porphyritic habit, the felspars attaining a length of about an inch. A very small amount of biotite and magnetite are usually present, but in places even this is wanting. The granite has a reddish colour. It is worthy of note, in this connection, that the tin-bearing granite of the Waterberg District in the Transvaal has been named the "Red Granite." (See Plate lx., fig. 2.)

The granite near Auburn Vale is similar to that at Elsmore; rather more biotite is present; and a fine-grained modification of it occurs. Micrographic intergrowth of quartz and felspar are also very common.

The granite at Howell is similar to the coarse type at Auburn Vale; and the same type of rock occurs again intruding the Tingha Granite at King's Gap. (See Plate lx., fig. 3.)

A modification of the "Acid Granite" occurs as an intrusion into the Tingha Granite, about four miles south of Tingha. Here the granite, while possessing the usual characteristics of the "Acid Granite," contains a good deal of microcline. It is in this belt that Hong Hay's Pipe occurs.

Another modification of the "Acid Granite" occurs at, and near Tingha. This type occurs in small patches only, and is notably tourmaline-bearing. It is miarolitic, the drusy cavities being lined with quartz and tourmaline crystals. A fine exposure is to be seen in the bed of Murray's Water, about a mile from its junction with Cope's Creek.

One noteworthy feature of the "Acid Granite" is, that it frequently occurs at the contact of the older Tingha Granite and the slates. Indeed, if the accompanying geological map be examined, it will be noticed that the large body of the "Acid Granite," is wedged between the slates on the north and the Tingha Granite on the south. In some places the margin of the slates is separated from the Tingha Granite by a belt of "Acid Granite," a score or so of yards in width. This marginal distribution of the "Acid Granite" is doubtless due to the fact that the contact of the older formations was a surface of structural weakness; and that the "Acid Granite," taking advantage of this, was able to rise, and, by stoping and pressure, to considerably increase its extent.

Aplitic Dykes.—Closely following on the consolidation of the "Acid Granite," a number of aplitic dykes were forced into the granite-systems. These are best observed in the neighbourhood of Oakey Creek and Copeton, because here numerous adits have been driven into the granite hills for the purpose of working the diamond-bearing gravels. The dykes are fine-grained quartz-felspar rocks, and are frequently strongly tourmaline-bearing. In several localities where these have been exposed by weathering, the stock and native animals have worn bare and smooth, many square yards by licking the rock, which evidently contains some palatable constituent. The dykes weather to a soft milk-white friable rock of a highly felspathic nature.

(b) *Felsite-Dykes.*—At Copeton, about half-way between the Post Office and the Public School, a dyke of felsite may be seen crossing the race from the "Star of the South" diamond-mine. The rock is greenish in colour, and is felsitic in structure. A similar dyke passes through the "Banker" diamond-mine, and may be traced for at least half a mile on the surface.

(c) *Dolerite-Dykes.*—In the same locality a coarse dolerite-dyke has been found. This is situated on Oakey Creek and has been found to be diamond-bearing. It is not quite certain whether the occurrence is a pipe or a dyke, but there can be no doubt that this interesting rock is a true diamond-matrix. Several other rather similar occurrences have been observed, but need further investigation.

The Tertiary Rocks.

Siliceous Springs—After the final intrusions of the "Acid Granites," a long period of quiescence prevailed, during which denudation and stream-action profoundly modified the topography. Many tin-bearing reefs were disintegrated, and their metallic contents concentrated in the valleys and watercourses. At length the time was ripe for the initiation of another cycle of igneous activity. This period of Tertiary vulcanism was ushered in by the development of siliceous springs. The effect of these is evident on every hand. At Newstead, perhaps, the most striking effects are to be seen. Here, on the eastern slope of the granite hill, there occurs a very hard and highly siliceous rock covering an area of some acres. This is locally known as "The Glassy Bar." It is of no great thickness, usually from 3 to 10 feet, and invariably overlies the normal granite. It occurs casing the present slope of the hill to a height of about 100 feet above Newstead Creek. It is a very compact rock, consisting entirely of fine-grained quartz-granules firmly cemented by silica. At a little distance from, and higher than the "Glassy Bar," a shaft was sunk on an outcrop of quartz. The shaft was continued for some distance on the same type of quartz, which did not present any resemblance to a lode. Fine crystals of cassiterite were found included in the quartz, which was rather glassy in appearance. A few yards to the west another shaft was sunk on a dark, almost black-looking quartz. I am of the opinion that the cassiterite contained in the quartz was not derived from an extraneous source, but that it crystallised from the siliceous solution. This massive quartz-structure rises through the solid granite massif.

About half a mile to the west of these shafts, a most interesting occurrence of cemented conglomerate is to be seen.

It is known as the "Karoola Cemenced Run." This was a prebasaltic stream running in a northerly direction, and has been traced from the granite-hill at Newstead, for about half a mile to the north, where it ends abruptly. This channel was, in places, exceptionally rich in cassiterite, but the very hard nature of the cementing silica rendered it difficult to work economically. It appears probable that the silica which is responsible for the formation of the "Glassy Bar" and the "Karoola Cemented Run," had its origin in thermal springs issuing from rather large channels in the granite.

In several other localities, namely Elsmore, Topper's Mountain, Stannifer, on the Inverell to Armidale Road east of Stannifer, and at the Lion Lode, I have seen similar cemented drifts. The rock found in these places is a hard grit consisting of quartz-grains, from 2 to 5 mm. in diameter, cemented by silica. Frequently a considerable amount of iron oxide is present in the cementing material. In the proximity of reefs, this rock is often rich enough in cassiterite to pay for extraction, and at Elsmore a quantity of the rock has been treated. Here I have studied the deposit in some detail, and have found that the rock is normally an even-grained compact rock, the grains of which are of the same size as those in the underlying and adjacent granite; the grains are not at all waterworn. In places the rock is rendered porphyritic by the inclusion of large angular fragments of reef-material. Several tin-bearing reefs were noted in this rock. Thus, while the nature of the cemented rock, with its cassiterite-content, indicates its age as younger than the "Acid Granite," the presence in it of the tin-bearing reefs points to the opposite conclusion. The explanation of this is, that the cemented rock has been formed from the residual quartz resulting from the decomposition of granite *in situ*. The reefs in the granite, being composed chiefly of quartz, are very resistant, and have remained practically intact in some cases; while the felspar in the surrounding granite decomposed, leaving only a residue of quartz-grains for a depth of several feet.

In many cases these deposits are overlaid by basalts, and the cementing may have been accomplished by the squeezing out of magmatic water from the basalt on cooling. At all events, the process worked on a disintegrated rock, and from above downwards; for frequently only the upper portion has been cemented, while a similar uncemented rock exists below. This is well shown in Plate lx., fig. 1.

Calcareous Springs.—Amongst the earliest phases of volcanic activity was the development of calcareous springs. Deposits of lime-carbonate from these have been found in several localities. These occur lying on the bed-rock (either granite or slate), and not disintegrated with the basalts.

The next product of vulcanism seems to have been an ejection of mud. There occurs in many places a very red clay, which underlies the oldest basalt. That this is not a decomposition-product of a basalt-flow *in situ*, is shown by the fact that, at Newstead, a fragment of gum was found embedded in the clay.

The Basalts.—Closely following this mud-deposit came the first outpouring of the basalts. This manifestation was widespread over the greater part of New England.

From the fact that the lavas have covered the older river-courses of the "Cañon Cycle," it is evident that the basalts were extruded at the close of the period of uplift which gave rise to this cycle. The period of uplift which elapsed between the formation of the "Stannifer Peneplain," of Andrews, and the extrusion of the basalts was far greater than that between the latter and the present day. This follows from the fact that, in most places, erosion has not yet been sufficient to expose the deep leads, even where the streams have been working in basalt. The orogenic movements which caused the uplift of the "Stannifer Peneplain" were probably responsible for the fractures through which the basalts were extruded.

After the first outburst, a period of rest ensued, during which erosion was active. That the period of rest following the earlier basalts was a considerable one, may be gathered from the following—At Elsmore a series of clays and lignites, filling a broad valley and extending for some miles, have been formed by the denudation of the earlier lavas. This series has been shown to attain a thickness of about 200 feet.

This period of quiescence was followed by another outpouring of lava which buried swamps and marshes, and so preserved abundant plant-remains.

Both periods of volcanic activity gave rise to numerous separate flows of lava. No less than eight flows can be distinguished in the neighbourhood of Elsmore.

Recent Alluvials.—The alluvial deposits lie naturally along the present watercourses. The extrusion of the basalts filled the main valleys developed in the "Cañon Cycle," and as the streams have not yet had time to mature, there are, in consequence, no large alluvial deposits. Dredging is vigorously carried on along the beds of the creeks, but the payable ground is seldom 100 yards in width. The depth of alluvial is rarely more than 40 feet, while the tin-bearing portion is seldom as many inches in thickness. Nevertheless, it is from these recent alluvials that the great bulk of the New England tin has been won.

Rocks of Undetermined Age.

Quartz-Porphyry.—Flanking the eastern margin of the tin-bearing district, there has been found, in several places, a typical quartz-porphyry. The junction of the rock with the granites and slates was unfortunately covered by basalt wherever observed; hence its age cannot be determined from its relation to these rocks. The trend of this belt is, as may be seen from the map, nearly north and south.

Felspar-Porphyry.—The quartz-porphyry just mentioned, is bordered partly on its eastern side by a related, but quite distinct, type of rock. This rock is a felspar-porphyry, quartz being almost entirely absent. The phenocrysts are plagioclases of about 2 mm. in diameter. It is best developed in the neighbourhood of Wandsworth.

Quartz-Orthoclase-Porphyry.—Still further to the east, a very striking quartz-orthoclase-porphyry was observed. The orthoclase-crystals are of a pink colour, and are from 2 to 3 mm. in length.

The rock was noted as far north as Glen Innes, and as far south as Guyra; and it is probable that it forms a continuous belt running in a north and south direction. It was shown, in a former paper,* to be intrusive into the slates near Guyra.

The three rocks above mentioned are certainly older than the Tertiary basalts; and are probably also older than the Tingha Granite, and younger than the slates.

Chapter iii.—The Tin-ore Deposits.

The Tin-Ore Deposits.

The deposits map be grouped into three classes as follows—

(1). The Alluvial Deposits.

(2). The Deep Leads.

(3). The Vein-Formations (including Stockworks and Impregnations.

(1-2) *The Alluvial Deposits and Deep Leads* are being studied in detail by the officers of the Department of Mines. Consequently only such mention of these will be made, as is necessary to indicate the distribution of the tin-deposits. Alluvial tin has been found at Elsmore, Newstead, Stannifer, Gilgai, Tingha, Howell, Copeton, Oakey Creek and Auburn Vale. Deep leads have been worked at Elsmore, Newstead, Stannifer, Tingha, Gilgai, Copeton, and Oakey Creek. At the two last-mentioned places, tin has been recovered in connection with diamond-mining.

(3) *The Vein-Formations.*—At all the localities aforementioned, the tin occurs as cassiterite, and has been derived from the vein-formations. The tin-deposits are intimately related to the "Acid Granite," numerous deposits having demonstrated that these ore-bodies occur normally at, or near, the junction of this rock with either the Tingha Granite, or the slates. Those occurrences distant from these junctions occupy the crests of the granite-ranges, and were probably close to their contact with the overlying slates, which have been removed by denudation. This

* Cotton, Leo A, "Note on the Guyra Lagoon." These Proceedings, 1909, p. 233.

preferential concentration of metallic contents near contacts, is a feature which has been observed in many other parts of the world. Of the occurrence at Vegetable Creek, Professor David* has written : "On consulting the geological map accompanying this report it will be noticed that the commencement of most of the veins is situated near the junction of the claystone with the intrusive granite, so that the upward limit of the veins may be said to be the bottom of the claystone and top of the granite. The map also shows that, as a rule, the granite at a distance of over $1\frac{1}{4}$ mile from its junction with the claystone ceases to be tin-bearing."

In commenting on this statement with regard to its application to the Stanthorpe area in Queensland, Mr. Skertchly† says : "The tin-bearing beds are here shown to be the slates near the granite junction, and just those parts of the granite which were assuredly once covered with slate, and, moreover, by far the larger area of the granite where it is coarsely crystalline and must have solidified at great depth under great pressure, is barren of tin. The acknowledged richness of the country on either side of the junction of the granite and slate must be admitted, and it is no argument against this view that in the Stanthorpe area the richest deposits are often many miles from the boundary, unless it can be shown that the slates never existed there."

Mr. E. C. Andrews‡ dealing with the New England tin-ore deposits remarks with regard to them that "The ores in almost every important example are arranged peripherally with respect to the acid granite massifs."

Again with respect to the ore-distribution of Cornwall, Reid and Flett§ have stated : "Tin and copper mining in Cornwall

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* *Loc. cit.*

† Skertchly, S. B. J., "On the Geology of the Country round Stanthorpe and Warwick, South Queensland, with especial Reference to the Tin and Gold Fields and the Silver Deposits." Published by Queensland Geological Survey. 1898.

‡ *Loc. cit.*

§ Reid, C., and Flett, J. S., "The Geology of the Land's End District." Memoir Geol. Surv. England and Wales, 1907.

has been carried on mainly near the margin of the granite where that rock is in contact with altered slate or greenstone. The distribution of the ores is, however, extremely partial, for the margin for long distances yields nothing of value, whilst other parts are exceptionally rich. So irregular is the distribution of the lodes, as laid down on the map, that at first sight it does not seem necessarily to indicate any close connection with the granitic intrusions, for many of the lodes are far distant from any granite mass seen at the surface. When, however, we take into account the contour of the buried granite masses and their proximity to the surface, as suggested by the extent of the metamorphism, and also the probable nearness in certain places of the slaty dome which once covered what is now bare granite, the close relation of the lodes to the intrusion of the granite becomes more evident."

The deposits at Altenberg and at Zinnwald exhibit the same characteristic distribution. Here the tin-bearing rock is a granite intrusive into granite-porphyry at Altenberg, and into "Teplitz" quartz-porphyry at Zinnwald. The tin occurs in both places as stockwork, the impregnated granite receiving the name of "Zwitter" rock. The granite itself, as far as can be judged by handspecimens, is very similar to a fine-grained tin-bearing granite containing microcline, to the south of Tingha.

Whilst it is true that most of the tin-deposits in this part of New England occur at or near the margin of the intrusive "Acid Granite," the converse, that all such contacts are tin-bearing, cannot be said to be true. As in Cornwall much, if not most, of the contact-zone is barren or unproductive.

The System of Fractures.

For a genetic investigation of ore-deposits, few factors are more important than the relations of the ore-bodies to the systems of fracture of the country. The importance of these relations was early recognised by Elie de Beaumont, in his work on the Fracture-Systems of Europe. An investigation of the fissure-systems of Cornwall, by Moissenet*, has proved of much value in the economic working of the mines.

It is proposed to devote some attention to the fracture-systems of the Elsmore-Tingha area. These may be considered with relation to dykes, faults, ore-filled fractures, and joints. At Elsmore an area about one-quarter of a mile square has been bared by surface-sluicing, and the tin-bearing reefs lie exposed on the surface in a most exceptionally favourable manner for studying their distribution. A series of sections was made in a direction nearly perpendicular to the previously ascertained general bearing of the reefs, and, from the data collected, the accompanying plan (text-fig. 2) has been constructed. The point marked A is 850 yards distant, in a direction S. 4° E., from the south-west corner of Portion 246, Parish of Anderson, County of Gough. The general north-easterly trend of the veins is at at once apparent.

From the tabulated list given (Table i., p. 757), which includes all the veins shown on the plan, it may be seen that rather more than 97 per cent. of the reefs lie within that third portion of the possible azimuths lying between N. 5° W., and N. 55° E. This tabulated list has been arranged to show the tendency of the reefs to cluster round certain directions. The two most prominent directions are N. 25° E., and N. 39·4° E., the latter being most strongly developed. As will be seen from the plan, these different systems of fracture often intersect. The system bearing 0° has some important fractures, and the systems bearing 16·5°, 51·8°, 45° and 53·2° east of north are all well developed.

Though many of the reefs intersect, it is quite common for one reef to terminate where it junctions with another. This abrupt termination of one fracture on another is very characteristic of fissures produced by torsion. Daubrée† and Becker‡ have

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* Moissenet, Prof. L., "Observations on the Rich Parts of the Lodes of Cornwall." Translated by J. H. Collins, 1877.

† Daubrée, A., Etudes synthét. de Géologie expérimentale, 1879.

‡ Becker, G. F., "The Torsional Theory of Joints." Trans. Am. Inst. Min. Eng. xxiv., 1894.

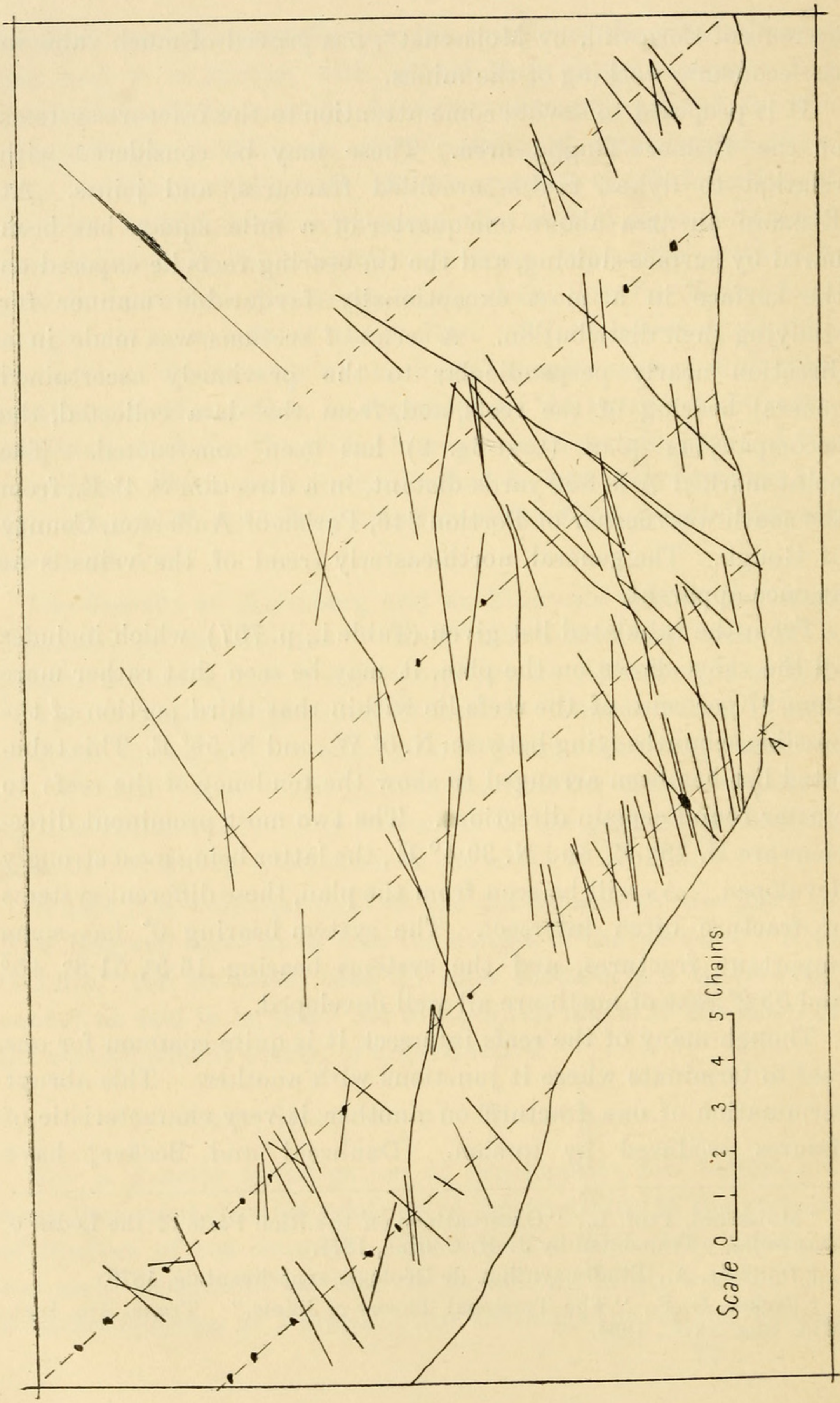

Fig. 2.—Plan showing trend and disposition of the reefs on Elsmore Hill.

experimentally established this result by torsion-experiments upon glass rods. They have also proved that the planes of fracture make angles of about 45° with the axis of torsion. In extreme cases, where great deformation took place before rupture was effected, the planes of fracture made angles as large as 60° with the axis of torsion. Daubrée has further shown that simple pressure on a body of a somewhat plastic nature, comparable to a rock-mass, gives rise to fracture-planes making 45° with the line of pressure.

As, then, in the area considered, the main fracture-system is about N. 39° E., the direction of pressure or axis of torsion must have been along a line bearing about N. 84° E.

In a body which is neither uniform, nor capable of great deformation before rupture, fractures may occur parallel to the direction of pressure. Near the north-west corner of Portion 214, Parish of Cope's Creek, County of Hardinge, an intrusion of the "Acid Granite" into the slates has been intersected by a series of faults. As the granite is the intruding body, and the slate the resisting one, we may assume that the slate has remained stationary, and that the granite has moved. This gives the direction of the thrust on the granite. The intrusion is that previously referred to in text-fig.1.

The creek has removed the soil, and the section is beautifully exposed. The intrusion took place as a long, narrow, approximately rectangular tongue, narrowest where it joins the granite-mass. Here it is only 9 inches in width, whereas at its extremity remote from the granite, it attains a width of 2 feet. This end abuts rather sharply against the slate, and has probably been faulted. Any continuation that may exist to the south is covered by alluvial. The direction of the intrusive tongue is S. 20° E., while a series of faults varying from N. 60° E., to N. 80° E. have thrown the tongue to the west. This is approximately the direction(84°) deduced from the axis of pressure or torsion which has acted on the Elsmore mass.

It is noteworthy that the main direction of fracture(N.39·4°E.) observed for the Elsmore granite-mass, corresponds very closely with that observed by Professor David for the Emmaville District. The mean of fifty-four lodes was a bearing of N. 39° 15′ E., and the average bearing for the richest lodes was N. 35° E. From the data in Professor David's book, I have tabulated a list (Table v.) of the bearings of the veins at Emmaville. A comparison of this table with that of the Elsmore veins, shows a striking resemblance. It would seem that the same system of forces was common to both areas. Even considerably to the north of Emmaville the fracture-system preserves its direction. Speaking of the disposition of the veins at Stanthorpe, as compared with those at Emmaville, Mr. Skertchley* observes:—"Hundreds of similar cases occur in the district. . . . . Their direction is always within a few degrees of north-east and south-west."

It is reasonable to suppose, and the assumption is based upon experience in the area here considered, that mining-towns have grown up upon those portions of the field where the ore-deposits are most abundant. If a line be drawn from Stanthorpe to Tingha, it is found to pass about 4 miles west of Emmaville, and midway between Elsmore and Newstead. Thus this line, which is about 100 miles in length, passes through the middle of each tin-mining centre. The bearing of this line is about 28° east of north. Thus it is evident that the general trend of the tin-bearing country approximates closely with its system of fractures. That there is very probably a genetic relation between these two directions, is indicated by the fact that the same close correspondence has been observed in the tin-deposits of Cornwall. With regard to these Cornish lodes, Moissenet* has written:—"Of 292 lodes registered by Mr. Henwood, the angle of 40° contained between E.W. and E. 40° N., includes 177, *i.e.*, 60 p.c. are contained in a range of 22 per cent. of the circle. . . . The E.N.E. direction which generally prevails for the lodes is also that of the great metalliferous zone distinguished by Capt. Chas. Thomas, who remarked that the profitable mines were all

* *Loc. cit.*

included in a zone about 12 miles wide, extending from the Land's End to Exeter, a distance of about 108 miles in an E.W. (mag.) direction."

Mr. Skertchley has observed the same relation at the Queensland end of the New South Wales tin-belt. He states—"The tin-belt at Stanthorpe has no relation to the present ranges; it is neither parallel with the Herries nor the Dividing Range, and indeed the ranges struck me as being axes of denudation rather than of upheaval. The tin-belt is quite independent of them,

Table i.—Bearing of Reefs and Joints at Elsmore.

Number of Reefs..	1	14	4	10	19	14	27	10	10	2
				14						
	-10	-5	9	15	21	29	36	43	50	59
		-5	10	15	22	30	36	44	51	62
		-5	11	16	22	30	36	44	52	
		-2	11	16	23	30	37	44	53	
		-1		17	23	31	37	44	53	
		0		17	24	31	37	45	54	
		0		18	24	32	38	45	54	
		0		18	24	32	38	46	55	
		0		19	24	32	38	47	55	
		1			26	33	38	48	55	
		3			26	33	39			
		3			26	34	39			
		5			26	34	39			
		6			26	34	40			
					26		40			
					27		40			
					28		40			
					28		41			
					28		41			
							41			
							41			
							42			
							42			
							42			
							42			
							42			
							42			
Average Bearing...	-10°	0°	10·2°	16·5°	25°	31·8°	39·4°	45°	53·2°	60·5°

and is in direct relation to the stress-axis which induces the singularly persistent north-east and south-west joints and cleavages described in the chapter on granite. These stresses probably took place after the solidification of the granite."

The rather scanty observations made by me on the bearings of the dykes, lodes, and joints in the Oakey Creek granite (Table ii.)

TABLE ii.—BEARINGS OF DYKES IN THE OAKEY CREEK GRANITE.

0	13 20		35			55	65				105		

TABLE iii.—BEARINGS OF REEFS AND JOINTS IN THE MAIN ACID GRANITE AREA.

-4 0 0 5 5	15 17	23 25	30 32 35			55		72		98			158 160

TABLE iv.—BEARINGS OF REEFS AND JOINTS IN THE TINGHA GRANITE.

-5	20	25 25			43 48	50 53 55 55 56 57 58 59	65 65 65 65 66	72 72 74 78	80 84 85 88 88 88 88 90 90 91 92 94	96 98 98 100 103 103	106 107 111 111	125 132 133	155 157 158 165

and in the "Acid Granite" area (Table iii.), indicate that the fracture-systems in these areas are also related to those of the Tingha-Stanthorpe belt. The observations made on the lodes and joints in the "Tingha Granite" (Table iv.) show that, though the Elsmore system of fractures is represented, yet the main lines of weakness approximate to east and west rather than to north-east. As this east and west system is almost absent from the "Acid Granite" belt, it is probable that the Tingha system was earlier than the " Acid Granite " system, and may have been contemporaneous with the intrusion of the latter granite.

TABLE V.—BEARINGS OF EMMAVILLE LODES AND JOINTS.

	3	10	26	30	36	43	50	63	70	80	100	110	118
		15	26	30	37	43	50	65	70	80	105	110	120
		15	26	30	38	43	50	65	75	85		112	
		20	26	30	38	43	50	65	75	87		114	
		20	28	31	38	44	50	65	75	91			
		20	28	32	38		52		77				
		20	28	34	38	47	53	66					
			28	35	39		53	67					
				35	40		55	67					
				35	40		55	68					
				35	40		56	69					
					40		58						
					40		58						
					40								
					41								
					42								
					42								
					42								
					42								
Average Bearings...	3°	17°	27°	32·5°	39·6°	44°	53·1°	66°	73·7°	84·6°	111·5°		119°

N.B.—The bearings in the tables are all measured clockwise from the north azimuth, which is taken as 0° or 360°.

Having now discussed the distribution of the lodes, and their relations to the systems of fracture, the next important consideration is the nature of the ore-deposits.

Nature of the Ore-Deposits.

It is not the purpose of this paper to discuss in any detail the genesis of the ore-deposits, but rather to lay the foundation for such a discussion by a faithful record of their field-occurrence. It would be premature to attempt any such discussion without chemical and microscopical investigation. It is my desire to undertake this important phase of the work after having examined the deposits at Emmaville.

The question arises whether a classification should be made upon a morphological basis, or upon the nature of the vein-material. The usual method is the former, in which a classification is made into fissures, impregnations, stockworks, bedded deposits, etc. As, however, the form of an ore-deposit may have little to do with its genesis, the latter method is considered preferable for this paper.

The deposits may be grouped for purposes of description into eleven classes. Several of the classes merge into one another, and, indeed, the same reef may at different places fall into two or even more classes. Nevertheless, each class has its own special characteristics, and it is considered better at present to make the provisional classification rather more detailed than a final one may need to be.

The following is the proposed provisional classification :—

Class i.—Quartz-quartzose veins.
Class ii.—Quartzose.
Class iii.—Greisen.
Class iv.—Quartz-greisen.
Class v.—Quartz.
Class vi.—Quartz-felspar.
Class vii.—Chlorite-deposits.
Class viii.—Arsenical lodes.
Class ix.—Pipe-deposits.
Class x.—Cassiterite-veins in slate.
Class xi.—Stannite deposits.

Class i.—*Quartz-quartzose Veins.*

This class is most abundantly developed at Elsmore, where, indeed, it is the type-vein. The distribution of these veins has already been referred to, and may be seen at a glance from text-fig. 2.

The individual veins are seldom of any great length or width, few being traceable continuously for as much as 10 chains. As a rule, they either terminate by thinning out rather abruptly, or by abutting on to a similar vein.

The average width, as calculated from 105 determinations, is 10·5 inches. The greatest width is 3 feet, and the smallest veins observed were 1 inch in thickness. About 75 per cent. of the veins are between 6 and 18 inches in width. A number of expanded masses of reef-material, of a circular or oval shape, are of frequent occurrence. These are to be found chiefly at the intersection of two reefs, but also occur as bulges on the line of reef, or as isolated patches. These "blows," as they are called, are represented in text-fig.2 as black patches. This type of reef is not limited to, or excluded from, any of the fracture-systems represented at Elsmore, though the largest veins conform mostly to the system N.43°E. It cannot be said that any of the reefs show great uniformity,—rather the contrary. Most veins are from 2-3 chains in length. As no shafts have been sunk on this area, the reefs are not exposed vertically, save in a few shallow trenches. In these the reefs appear to be vertical. In only three cases were dips noticed, and of these one dipped E.43°S. at 63°, another E.41°S. at 61°, and the third E.26°S. at 53°.

The country-rock is a coarsely crystalline granite, which is so decomposed at Elsmore that it is impossible to obtain a hand-specimen anywhere from the area shown in text-fig.2. A few hundred yards to the east of this area, fresh granite may be obtained, and is typically the coarse "Acid Granite" previously described.

None of the reefs have been systematically worked, only the surface-shoots having been mined. There is probably no single reef which would pay for working, but, on the eastern slope of Elsmore Hill, the reefs are so close together that the whole might be worked by an open cut. The exact tin-content of the reefs could only be determined by a very large bulk-sample.

The reefs appear very similar to those occurring both in the Stanthorpe district to the north, and at Mount Rex in Tasmania to the south. Indeed, descriptions of the occurrences in these districts, coupled with the examination of hand-specimens, render it abundantly clear that the same processes have been active in the vein-formations of all three areas. Though well defined as reefs to the casual eye (see Plate lxi., fig.1), a close examination shows that they pass over almost imperceptibly from vein-stuff into the soft decomposed granite. A type-section through one of these veins is given in text-fig.9. The centre of the vein is composed of translucent quartz, as opposed to milk-white, opaque quartz on the one hand, and clear transparent quartz on the other hand. This central quartz passes rather abruptly, yet without discontinuity in composition, into a quartzose vein-stuff. This latter is highly siliceous, and is composed mainly of granular quartz, the grains being from 1-2 mm. in diameter. Intimately distributed through this matrix of quartz, and abundantly present, is a variety of mica. This is light to dull green in colour on a fresh fracture, but weathers reddish-brown on exposure. These mica-flakes are quite small, the largest attaining a diameter of about 2 mm. Inter-crystal cavities are quite abundant, and these are frequently filled with limonite (see Plate lxi., fig.2). The central quartz usually constitutes of about one-fifth, but occasionally occupies as much as one-half of the entire width of the vein. Vughs are common in both the central quartz and quartzose, and in some of the larger veins are as much as a foot in diameter. They are typically lined with crystallised quartz, the long axes of the crystals being normal to the walls of the cavities. Mica and hydrous iron-oxides are also common fillings of these vughs.

The central quartz band of the veins usually exhibits well developed comb-structure, and cassiterite may be found crystallised between the quartz-crystals. The cassiterite was invariably found near the centre of the veins, either irregularly distributed through the central quartz, or, as is more frequently the case, forming a casing on either side of it. Cassiterite also occurs in vughs. It is usually crystallised, the average length of the crystals being about one-quarter of an inch. In many instances crystallised quartz may be seen abutting on to crystallised cassiterite, the latter preserving its normal form, and thus indicating its prior crystallisation. The cassiterite is dark brown to black in colour, and assays from 73 to 76 per cent. metallic tin, after being cleaned by the "Willoughby." Fractured crystals frequently show a well marked series of layers parallel to the crystal-faces.

The minerals occurring in this type of vein are quartz, mica, wolfram, bismuth, molybdenite, and fluorite.

The *quartz* occurs both massive and crystallised, and in the centre of the reef. The crystallised quartz occurs most frequently lining the vughs, and projecting inwards. The individual crystals may be as much as 2 inches in diameter, and several inches long. Occasionally there is a peculiar development of very flat crystals, the distance between one pair of prism-faces being less than $\frac{1}{4}$ of the width of the crystal. Double-ended quartz-crystals are also very common. The crystallised quartz may be clear and colourless, translucent or smoky. Some of the smoky quartz-crystals contain so much impurity that they are quite opaque when only about $\frac{1}{4}$ of an inch in thickness. Occasionally both clear and smoky quartz-crystals are to be found invested in a sheath of milk-white, opaque quartz, the thickness of which is about $\frac{1}{10}$ the width of the crystal.

The *mica* occurring in these veins has already been remarked on. It cannot be certainly named until an analysis has been made. As, however, the type of vein is similar to that previously described* from near the Leviathan Mine, it is probable that the mica is allied to the paragonite group.

Wolframite is found both crystallised and massive. Its distribution in the veins is similar to that of the cassiterite, and both minerals may be obtained in the same hand-specimen. Platy crystals are common, and a yellow ochreous mineral has been observed between two diverging plates. The wolframite is not abundant, for very little is obtained when cleaning the tin for market. Its total weight is probably less than one per cent. of the tin present at Elsmore.

Topaz and tourmaline have not been observed, and cannot be present in any quantity.

* Cotton, Leo A., "Metasomatic Processes in a Cassiterite Vein from New England." These Proceedings, 190^c, p. 220.

Molybdenite occurs rather less abundantly than wolframite, and is to be found in small hexagonal flakes throughout the more siliceous parts of the veins.

Felspar is notably absent, except in close proximity to the edges of the vein, and even here it can only be recognised microscopically.

Beryl was reported by Mr. Ulrich* who states the following: "I discovered lumps of a ferruginous clayey substance full of thin light green and yellow hexagonal prisms of beryl associated with larger quartz-crystals. I also found beryl on crystallised cassiterite specimens in fragile prisms generally not thicker than a stout pin and up to an inch in length interlaced between the tin-ore crystals." Unfortunately, although I found abundant vughs containing "a ferruginous clayey substance," I did not see anything to correspond with Mr. Ulrich's discovery.

Fluorite occurs very sparingly, and has only been recognised microscopically.

Both *native bismuth* and *bismite* are rather sparingly present in the veins.

Class ii.—*Quartzose*.

This class is merely an extreme case of the previous one, in which the central quartz is not developed. The general remarks with regard to the size and continuity of the veins of Class i., also apply to this type of vein. A good example of this class is a reef situated on the south bank of the Macintyre River, near Elsmore. This was opened as a molybdenite mine. The molybdenite occurs rather plentifully throughout the reef, in small hexagonal flakes, the largest being rather smaller than a shilling. The quartz is translucent, and contains a small amount of a greenish-grey scaly mica, similar to that previously mentioned. Vughs occur plentifully, and these are frequently filled with mica and hydrous oxides of iron. The reef is about 18 inches wide, is vertical, and has been sunk on for about 12 feet.

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* *Loc. cit.*

Class iii.—*Greisen.*

These deposits occur typically in bunches, though irregular reefs do occur. The rock is highly micaceous, quite a subordinate amount of quartz being present. The mica is of the nature of that mentioned in Class i.

These greisen bunches are often exceedingly rich in cassiterite, as much as 15cwt. of that mineral to the ton having been obtained. The cassiterite is always crystallised, and of a black colour. The masses or reefs pass over, without any abrupt change in composition, into the surrounding granite. The reefs are usually less than one foot in width, and are much more irregular than those of Class i. The cassiterite may be either coarse (rather larger than a pea) or very fine. I have seen samples carrying more than 10 per cent. of tin, in which none was visible to the naked eye. It must not be supposed, however, that the greisen is always tin-bearing, for much is quite barren. Unlike the greisen of the Altenberg and Zinnwald districts, the Elsmore greisen contains no topaz.

The rock occurs abundantly on the eastern slope of Elsmore Hill, where large masses, 6 to 10 feet in diameter, may be seen. So much of the hill is greisenised, indeed, that it is difficult to obtain from this locality a specimen of unaltered granite. Near the Newstead Shaft another development containing very rich tin occurs, but the greisen occurs in a reef of small size in hard acid granite. It is commonly associated with the quartz-quartzose type of vein, occurring in small bunches at the side of the lode.

Greisen also occurs, but not abundantly, at the Leviathan Mine. It is strikingly absent from the lodes in and near the Tingha Granite.

Class iv.—*Quartz-Greisen.*

A few veins have been observed, consisting chiefly of greisen but containing a central vein of quartz. This quartz is usually of the milk-white, opaque variety, and has been observed to carry crystal-tin. The quartz and greisen are separated by a small band of the quartzose rock characteristic of Class i. There is typically about 1 to 2 inches central quartz, rather less than an inch of quartzose, and from 8-12 inches of greisen in these veins. They occur only, as far as I know, on the western slope of Elsmore Hill, and the largest vein is about 35 yards in length and 10 inches in width.

Class v.—*Quartz-Veins.*

Two kinds of veins may be included in this class—(a) Smoky Quartz-Veins; (b) Veins of Translucent Quartz.

(*a*) The veins of smoky quartz are always small, varying from a mere thread up to 2 or 3 inches in width. The quartz is fine-grained and granular, and contains small cavities filled with earthy iron-oxides. The veins pass gradually from almost pure quartz into the country-rock. They have been observed only in two localities—near the Leviathan Mine, and about 2 miles east of the Bischoff Lode. In both cases the country-rock is the Acid Granite.

(*b*) Veins of this kind are characteristic of the Tingha area, more especially. The reefs are never of large size, the largest averaging less than 2 feet in width. For the most part the so-called lodes are composed of more or less parallel bands of quartz, which vary from a small fraction of an inch up to 5 or 6 inches in width. They appear to be no more uniform or continuous than the quartz-quartzose reefs at Elsmore.

A good example of this type of vein is the Butchart Lode. This lode occurs in the "Acid Granite," near its junction to both slate and Tingha Granite. At its south-western extremity, which bears N.50°E., it has been trenched for about 150 feet in length. The lode lies on the slope of a hill facing south-west, and the depth of the trench varies from zero to about 25 feet. There is little to be seen in this part of the workings, as the ore has been quite removed. The lode was opened again a score or two of yards to the north-east. Here again, the ore was taken out of an open cut, which bears N.74°E., extends for over 100 feet in length, and is from 3 to 4 feet wide. The so-called lode consists of a number of small quartz-veins, more or less parallel to one another. These vary in thickness, from a mere crack up to 2 inches in width. Most of the veins are about $\frac{1}{4}$ of an inch wide, but there is a main vein, about 2 inches thick, which has determined the course of the workings. The small quartz-veins are very irregular, and pinch out abruptly. In constitution they vary from solid quartz to solid cassiterite. Where these veins are oblique to the direction of the trench, they may be seen prominently marking the sides, but are evidently too far-spaced and patchy for economic working. Most of the veins are sharply marked off from the granite, which is hard and undecomposed. No trace of greisen is present.

A prominent feature of this deposit is the number of iron-stained bands accompanying many of the veins. The veins are evidently of the nature of impregnations from the vein-fissure, at some stage in its formation. They occur sometimes on one side only, and sometimes on both sides of the quartz. The zone of iron-stained granite is usually wider than the quartz-vein. There are three phases of occurrence—

(i.) Iron-stained bands with neither quartz nor cassiterite.

(ii.) Iron-stained bands with central veins of quartz. These often contain cassiterite at the junction of the quartz and iron-stained granite.

(iii.) Iron-stained bands with central veins of cassiterite.

A section of the lode, as seen at the end of the open cut, is given in text-fig.3.

Class vi.—*Quartz-Felspar.*

This type is economically the most important, because not only are these deposits usually the richest, but are also the most easily mined. The association of the quartz and felspar is as follows:—

(i.) Veins of highly felspathic rock traversed by veins of translucent quartz.

(ii.) Quartz and felspar intimately intergrown.

(i.) A typical example of the first, is a reef about $\frac{1}{4}$ of a mile to the east of Sutherland's Water, about a mile from its junction with Cope's Creek. Here the lode has been sunk on, and some good ore has been taken out. The lode runs east and west. The

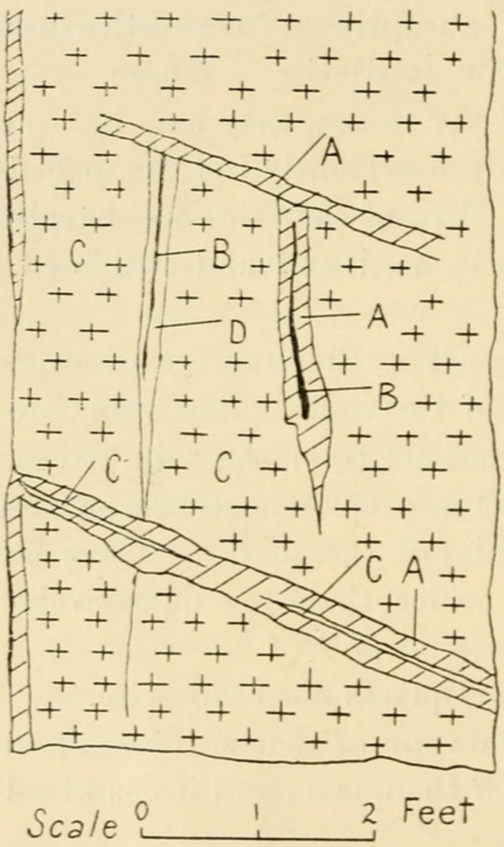

Fig. 3.

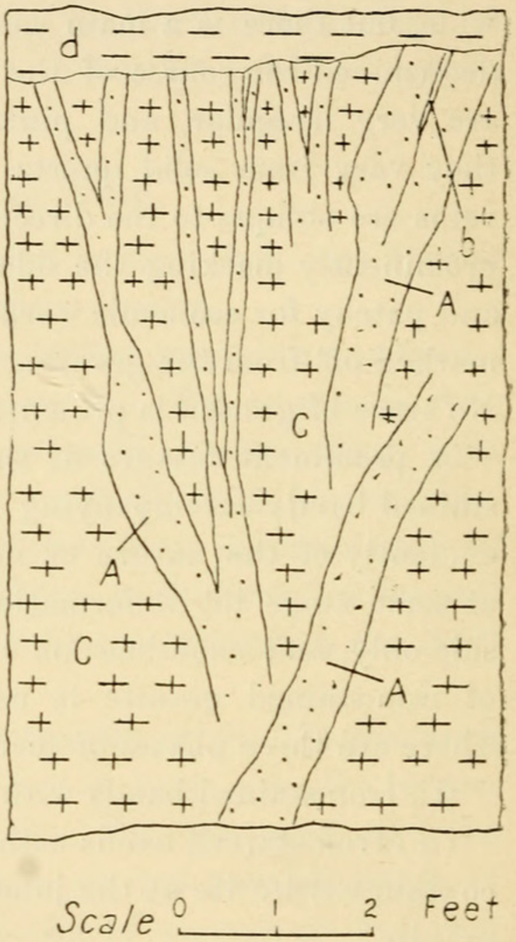

Fig. 4.

Fig. 3.—Section across the Butchart Lode. A, Brown iron-stained granite-bands; B, Cassiterite; C, "Acid granite"; D, Quartz.

Fig. 4 —Section across a quartz-felspar lode, near Sutherland's Water. A, Felspathic lode-material carrying cassiterite and a little quartz; b, Quartz-vein; C, "Acid granite."

eastern side of the shaft shows an irregular venation (text-fig.4). The felspathic rock contains a little quartz throughout, and is intersected by small veins of translucent quartz, which often contain cassiterite. More commonly, however, the cassiterite occurs on either side of the quartz-vein, and separates it from the felspathic rock. The country-rock is "Acid Granite," and this is invariably very soft and decomposed in the neighbourhood of the lode, though hard and fresh a few yards distant. The presence of this decomposition-product in connection with the lodes is, I think, very significant, and of genetic importance. The lodes of Cornwall frequently present the same characteristic. The veins of quartz intersecting the felspathic lode-material often pass into felspar or cassiterite, while still preserving the same width. Text-fig.5 illustrates this.

One curious case was observed in which the cassiterite arranged itself in two parallel planes, each entirely in the felspathic lode-

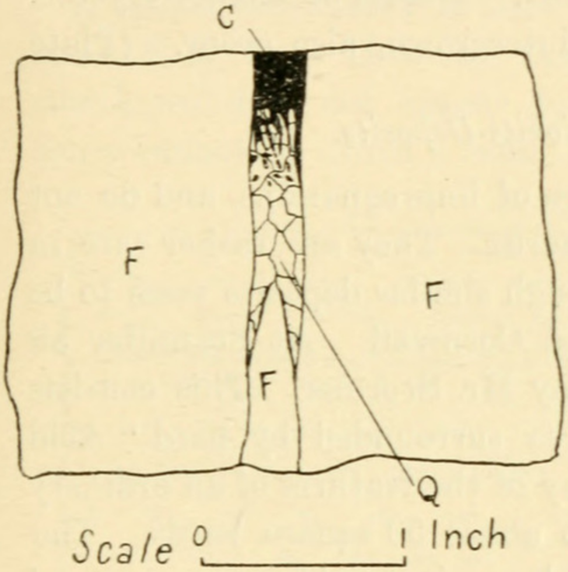

Fig. 5.

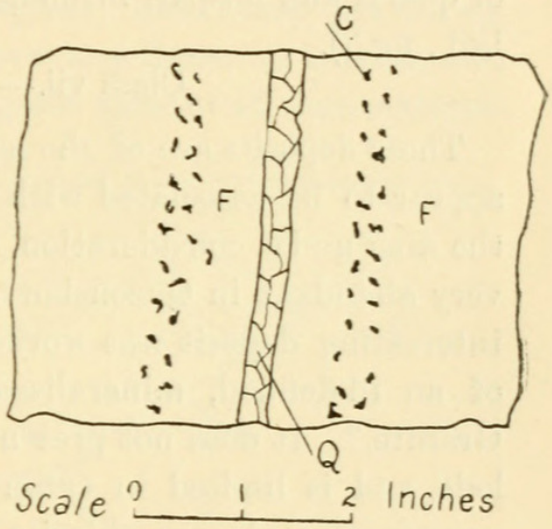

Fig. 6.

Fig. 5.—Portion of quartz-felspar lode, showing how the quartz-vein may pass into cassiterite or the felspar of the lode. Q, Quartz; C, Cassiterite; F, Felspar.

Fig. 6.—Section of quartz-felspar lode, showing peculiar disposition of cassiterite. Q, Vein-quartz; C, Cassiterite; F, Quartz-felspar lode-material.

material, and about an inch distant from the central seam of quartz(see text-fig.6).

(ii.) A number of lodes occur, which consist of a very intimate quartz-felspar mixture, the latter mineral predominating. In these, cassiterite, where it does occur, is distributed with a fair degree of uniformity. No bands or seams are to be seen, but it occurs as a constituent of the rock (see Plate lxii., fig.2). These lodes are frequently very soft and, as in the first group, the country-rock is soft and decomposed. In any particular lode much is quite barren, the cassiterite occurring in rich patches.

The quartz is well crystallised, and double-ended crystals are common. It is clear and of the glassy type. Cassiterite is sometimes included in crystals of quartz.

One occurrence deserves special mention. This is known as Hutchinson's Felspar-Lode, and is situated about 3 miles, south by east, from Tingha. Here large masses of crystallised felspar were found associated with very coarsely crystallised quartz. Felspar-crystals, several inches in length and with very perfect crystal-form, are still to be obtained. Masses of smaller crystals of quartz and felspar, intimately intergrown, also occur. (Plate lxii., fig.3).

Class vii.—*Chlorite-Deposits.*

These deposits are of the nature of impregnations, and do not appear to be associated with fissures. They are rather rare in the area under consideration, though similar deposits seem to be very abundant in Queensland, and Cornwall. At Stannifer an interesting deposit was worked by Mr. Stormer. This consists of an ill-defined, mineralised area surrounded by hard "Acid Granite." It does not present any of the features of an ordinary lode, and is limited in extent to about 50 square yards. The gangue-minerals are chlorite, hydrous iron-oxides, quartz and felspar. Handspecimens may be obtained, showing the passage from chlorite vein-stuff into the granite. In these the vein-stuff is seen to be chiefly chlorite and felspar, while the granite is almost wholly quartz and felspar. The deposit, then, appears to be an impregnation in which quartz has been replaced by chlorite.

About half a mile to the west of this deposit, lies the so-called Kelly's Reef. This was found in sinking for alluvial, at a depth of about 6 feet. The deposit was followed downward for about 25 feet, and appears to have been about 6 or 8 feet in diameter. The dip is about 40° in a direction S.35°E. The shape could not be accurately determined, but it appears to have been roughly cylindrical. Part of the vein-stuff still remains in the floor of the excavation. The main lode-stuff consisted of chlorite and felspar, and was separated from the country-rock by a zone of hydrous iron-oxide. The country-rock is the "Acid Granite," and is quite soft and decomposed in the neighbourhood of the deposit. From the excavated material a specimen of granite, strongly impregnated with some iron and much arsenical pyrites, was found. Another interesting specimen was a piece of pegmatitic quartz and felspar, passing into a fine-grained chlorite-rock. Scheelite is also present in small quantity.

Text-fig.7 shows a section of the west wall of the excavation, and indicates the relation of the lode-stuff to the country-rock.

A similar occurrence is that of the "Strand Mine," about 2 miles N.E. from Howell. The deposit, like those previously mentioned, does not appear to have any linear extension, and hence cannot be called a lode. A great amount of lode-material

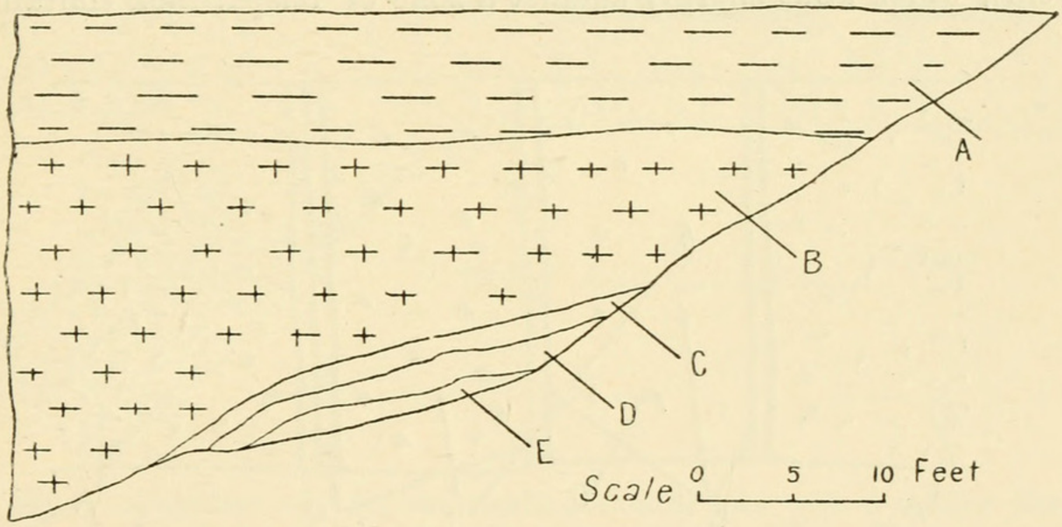

Fig. 7.—Kelly's Reef at Stannifer. A, Alluvial; B, Soft decomposed "Acid Granite"; C, Zone of yellow iron-oxide; D, Zone of mixed ironstone, chlorite, and felspar; E, Chlorite and felspar of lode-material.

has been excavated from a shaft sunk on the deposit. The lode-stuff consists chiefly of chlorite. There is more quartz associated with the deposit than at Stormer's and Kelly's reefs. This quartz is clear and crystalline, and occurs in bunches and veins showing comb-structure. These veins and bunches of quartz are almost invariably bordered by a zone of pink felspar. This is illustrated by Plate lxii., fig. 1. Scattered through the quartz are small bunches of galena, which have not been observed in either the felspar or chlorite. Vughs in the chlorite lined with quartz-crystals are of common occurrence. The country-rock is the "Acid Granite," and a regular transition can be made out between this and the chlorite lode-material.

A rather different deposit of some interest is that known as Cox's Reef, situated about half a mile west of Murray's Water. A number of joint-planes in the granite have been impregnated with chlorite, and the country-rock, the Tingha Granite, has been altered for a few inches on each side of the vein. The veins are small (from one-quarter to half an inch wide), and consist of two groups, one bearing N.66°E., and the other E.6°S. In this occurrence the chlorite is associated with greenish glassy quartz-veins, which abut sharply against a zone of felspar-rock contain-

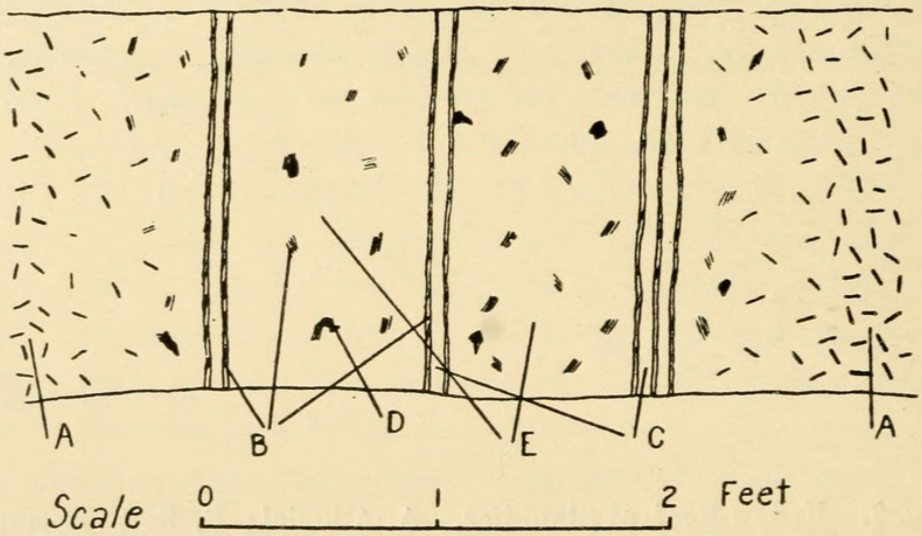

Fig. 8.—Section across Cox's Reef, near Murray's Water. A, The Tingha Granite; B, Chlorite in patches and veins; C, Quartz; D, Cassiterite; E, Felspar, constituting main bulk of lode-material.

ing chlorite and cassiterite. There also occur minute crystals of a green colour, prismatic in habit, which are probably beryl. The felspar-zone passes gradually over, by increases of quartz and a different development of the felspar, into the normal granite The total width of the lode-stuff is about 2 feet, and it is traversed by several of these chlorit-eveins. (Text-fig. 8).

Class viii.—*Arsenical Lodes.*

These lodes are of comparatively rare occurrence in this area. The first observed has rather a peculiar association, and will, therefore, be described.

In one of the typical quartz-quartzose reefs at Elsmore, a band of arsenical pyrites, about 3 inches wide, was found occupying the place of the typical central quartz-rib for about 20 feet along the vein. For a sketch-plan of this, see text-fig. 9. It will be noticed that the arsenical lode commences at the junction of two reefs of the quartz-quartzose type. At this junction is a mass

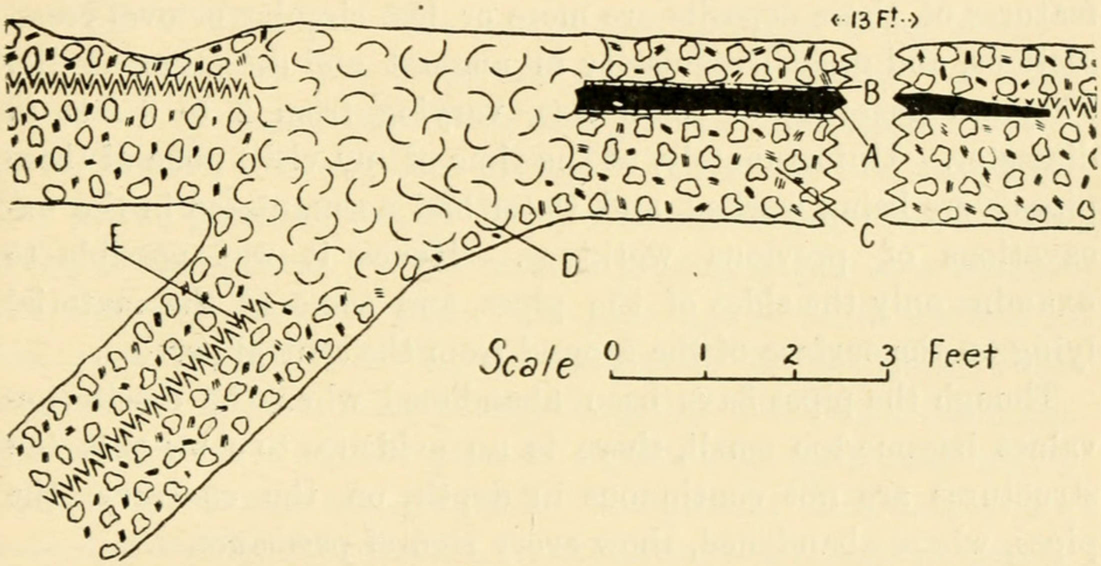

Fig. 9.—Junction of a typical quartz-quartzose vein with a similar one, rendered unique by the presence of arseno-pyrite. *Loc.* Elsmore. A, Band of arseno-pyrite; B, Bands of ironstone; C, Quartzose zone, consisting of granular quartz and mica; D, Massive ironstone; E, Comb-quartz, forming central band of lode.

of ironstone, from the southern margin of which the arsenical vein emerges. This arsenical band pinches out gradually, and the normal quartz-filling takes its place. On examination, the vein was seen to consist largely of mispickel, some of which had oxidised to arseniate of iron. The vein is cased, on each side, by a band of iron-oxide, about $\frac{1}{8}$ of an inch thick. It contains abundant fragments of quartz, and also double-ended quartz-crystals, such as are common in the central quartz of the quartz-quartzose veins.

About half a mile further east, and on the eastern side of a small gully flowing into the Macintyre, two arsenical lodes occur. These consist of mispickel, finely impregnated through a siliceous base. The cassiterite-content is small.

Several similar reefs occur at Stannifer, and mispickel is also present at the Leviathan Mine. I do not know of any such occurrence in the "Tingha Granite."

Class ix.—*Pipe-Deposits.*

These deposits are of a most interesting and unique type. Only a few occur in the area under consideration. The general features of these deposits are more or less circular or oval cross-sections, and great irregularity in amount and direction of dip. They are generally of small size, varying from 2 to 6 feet in diameter. Unfortunately, at the time of my visit, none of these pipes were being worked, and water had accumulated in the excavations of previous workings. Hence it was possible to examine only the sides of the pipes, and some of the material lying on the surface of the ground from the central portion.

Though the pipes have been abandoned when the cassiterite-values became too small, there is no evidence to show that the structures are not continuous in depth; on the contrary, the pipes, where abandoned, show every sign of permanence.

Smith's Pipe is situated in the Tingha Granite, a few hundred yards from its contact with the "Acid Granite." It is about three feet in diameter, and was followed down as a cylindrical deposit. The first eight feet from the surface was nearly vertical, after which it dipped steeply to the north, and continued in this direction to a depth of about 90 feet, at which depth it was abandoned. It is not safe to descend, so that all that can be seen now is, that the pipe occurs in solid Tingha Granite, apparently unconnected with any reef at the surface. Conditions are not favourable for observing whether any strongly marked joint-planes intersect the deposit. The central core of the pipe was composed of a highly felspathic material, and contained abundant cassiterite. The present walls of the pipe are soft and kaolinised. This change is connected with the genesis of the deposit, for the kaolinisation passes gradually from the centre outwards into solid undecomposed granite, a few feet distant.

A somewhat similar occurrence is known as *Hong Hay's Pipe.* This was examined by Mr. C. Saint-Smith and myself, and the following are our observations.

Though no work was being carried on at the time of our visit, we were able to descend for about 50 feet, and make a careful examination of the walls of the pipe. Though the central core, which was exceptionally rich in tin, had been removed, we were able to obtain samples of cassiterite from a number of places on the walls of the pipe. The pipe is oval in shape, being about 3 feet 6 inches in the long, and 2 feet 6 inches in the short diameter. It occurs in a hard fine-grained modification of the Acid Granite, which is here strongly jointed in two directions. The master-joints bear N.49°W., and the subsidiary ones N.55°E. None of these joints were altered by impregnations at a distance of three yards from the pipe. The pipe dips at 49° in the first 12 feet, in a direction S.35°W., and then at 35° for the next 40 feet of descent. It then takes a very steep dip in the same direction. The central part of the pipe is reported to have been highly felspathic, soft and easily mined. The present walls of the pipe consist of a white, fine-grained, friable casing of a felspathic nature, containing in places a good deal of cassiterite. At the end of the shallow dip there appeared, in the roof of the pipe, two oval holes which extended upwards for about three feet. One of these was about nine inches, and the other six inches in the longer diameter. Each possessed a smooth surface lined with the same friable felspathic casing aforementioned. About two feet to the west of these, a small vein of quartz, showing comb-structure, entered the pipe. There also occur, at intervals, in other parts of the pipe, veins of iron-stained material containing cassiterite, identical in character with those seen in the Butchart Lode.

About 50 yards distant, to the south-west, another pipe occurs. This was sunk on for a few feet, but no cassiterite was found. The pipe-material excavated has been left lying at the mouth of the shaft, and consists of a friable felspathic rock containing a good deal of quartz. This latter mineral is of the clear glassy type, and is crystallised in small prisms up to nearly an inch in length. The country-rock is the same as at Hong-Hay's Pipe.

These pipes are of a rather different nature from those described from the Transvaal, by Kynaston and Mellor.* These gentlemen have described a number of very interesting pipes, characterised by intense alteration of the granite in which they occur. In many of these pipes a characteristic zone of tourmaline borders the outer edge of the pipe, while the central portion consists chiefly of quartz and mica. It is possible that some of the Transvaal pipes, in which this tourmaline-ring is absent and the central filling is chiefly quartz and felspar, may be similar to those occurring at Tingha. These are regarded in the Transvaal as the simplest and least altered type of pipe-formation.

Class x.—*Cassiterite-Veins in Slate.*

Another type of deposit occurs in the slates, near the junction with the granite, about 3 miles south of Elsmore. Here the slate is intersected by minute veins, about 1 mm. in thickness, which consist of solid cassiterite. The mineral is sharply marked off from the slate, which does not appear to have suffered any change near the vein. These bands of cassiterite are too few and far apart to pay for economic working.

Class xi.—*Stannite-Deposits.*

Only one deposit of this nature is known; this occurs at the Conrad Stannite Mine, near Howell. The lode is a true fissure-deposit in granite, and is primarily a lead-silver ore-body. The stannite occurs as a minor constituent of the lode, and is associated with galena, zinc-blende, arseno-pyrite, and copper-pyrites.

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* Kynaston, H., and Mellor, E. T., "The Geology of the Waterburg Tin-Fields." Memoir No.4. Geological Survey of Transvaal, Department of Mines.

Any account of the tin-deposits of this district would be incomplete without some mention of the occurrence near Auburn Vale, where the Hillcliff and Leviathan Mines are situated.

The Hillcliff Mine has been opened up by several shafts on two reefs about 10 yards apart. The country-rock is a coarse "Acid Granite," similar to that at Howell. In one part, near the lode, the granite is found strongly impregnated with arseno-pyrite. This mineral occurs as crystals, and appears as much an original constituent as the quartz or felspar of the granite. Manganese and iron-oxides are also present in the lodes. Here, also, apatite was found crystallised along one side of a quartz-felspar vein.

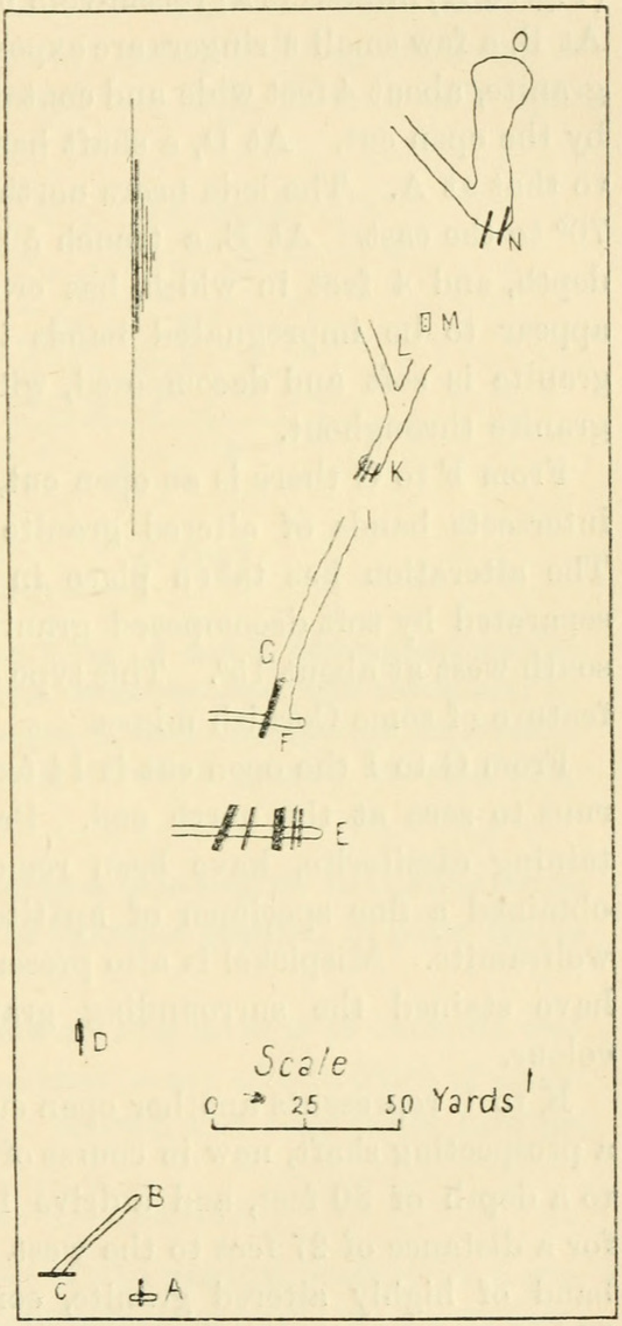

Fig. 10.—Plan of workings of Leviathan Mine. The lettering is referred to in the text.

The Leviathan Mine is about one mile to the south-west of Hillcliff. It is of rather a complicated nature, and contains several of the proposed classes of veins. The country-rock is coarse "Acid Granite," similar to Hillcliff. Considerable work has been done at the mine, and several hundreds of tons of ore have been removed by open cut workings. Text-fig.10 represents a ground-plan of the workings. The lodes or impregnated bands run in a N.N.E. direction, and have been opened by a series of open cuts, and cross trenches. The southernmost of these (Fig. 10, A) intersects a greisen-vein underlying slightly to the east. At B, a few small stringers are exposed. At C, a lode of silicified granite, about 4 feet wide and containing mispickel, is intersected by the open cut. At D, a shaft has been sunk on a lode similar to that at A. The lode bears north and south, and underlies at 70° to the east. At E, a trench 50 yards in length, 10 feet in depth, and 4 feet in width, has cross-cut several lodes. These appear to be impregnated bands in the granite. Part of the granite is soft and decomposed, with hard patches of silicified granite throughout.

From F to G there is an open cut, about 8 feet in width. This intersects bands of altered granite of a peculiar appearance. The alteration has taken place in horizontal layers, which are separated by soft decomposed granite. These layers dip to the south-west at about 15°. This type of impregnation is a common feature of some Cornish mines.

From G to I the open cut is 14 feet deep at the south end, and runs to zero at the north end. Bands of altered granite, containing cassiterite, have been removed. From this locality I obtained a fine specimen of apatite intergrown with plates of wolframite. Mispickel is also present, and its oxidised products have stained the surrounding granites a characteristic green colour.

K to L represents another open cut, of a similar nature. M is a prospecting shaft, now in course of development. This is down to a depth of 80 feet, and a drive has been put in at this level for a distance of 27 feet to the west. At a distance of 10 feet, a band of highly altered granite, constituting a lode, was met. This was driven through for 17 feet, where the normal granite was again appearing. The lode-material consists of quartz, mica, arseno-pyrite, and chlorite; and the central portion, for about two feet in width, carried crystallised cassiterite. The lode-material passes rapidly over into the "Acid Granite." Further to the north is another open cut, from N to O(text-fig.10). This is the largest excavation, and presents an interesting feature, in that there is here a considerable development of copper-carbonates. A parcel of rich tin-ore was obtained from C(text-fig.11). This occurred in a soft, iron-impregnated, sandy material lying close to a slickensided wall, which separated the lode from a soft and

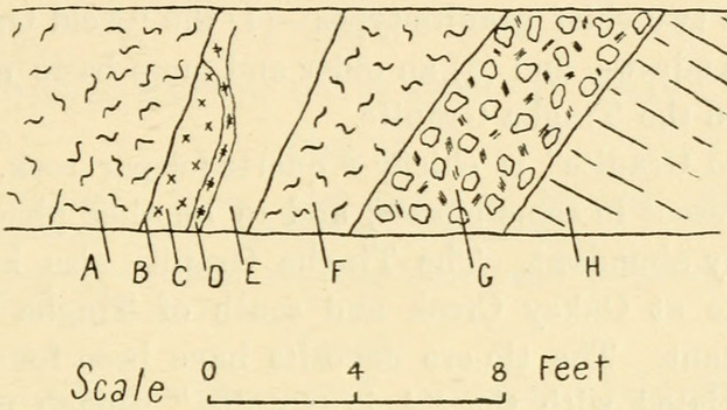

Fig. 11.—Section across Leviathan Lode. A and F, decomposed granite; B, slickensided wall of lode; C, Soft ironstone-band with cassiterite; D, Hard ironstone-band with less cassiterite; E, Dark siliceous rock, constituting lode; G, Lode of quartzose-type; H, Silicified granite, showing platy structure.

decomposed granite. G represents a lode similar to the quartzose type at Elsmore. H is a belt of silicified granite, in platy layers dipping to the south-west.

The occurrence of copper-ores at this mine is of interest and importance, in view of the fact that many of the lodes of Cornwall were originally worked for copper, and only made into tin at a depth.

Chapter iv.—Conclusion.

The foregoing is a description of the general geology of a portion of New England, with special reference to the tin-ore deposits of that district. The area represented on the accompanying map, lies within the rectangular block, at whose corners are situated the towns of Inverell, Bundarra, Glen Innes, and Guyra. It is mainly in the western portion of this block that the tin-deposits occur.

There are three geological units within the tin-field—(1) a series of slates and claystones; (2) a series of granites; (3) a series of basalts; while a fourth flanks its eastern side. The slates are Palæozoic, and are probably of Silurian age. The basalts are the youngest of the formations, and their age has been determined as Tertiary. The granites are intrusive into the Palæozoic slates, and their age has been provisionally stated as Permian.

There are two chief granite-types—(1) the "Acid Granite" of Mr. E. C. Andrews, and (2) an older and more basic rock which I have called the Tingha Granite.

The "Acid Granite" is chiefly a quartz-felspar rock. A little biotite is present in some phases; and in another phase tourmaline is fairly abundant. The Tingha Granite also has several phases, those at Oakey Creek and south of Tingha being the most important. The tin-ore deposits have been found always closely associated with the "Acid Granite," though post-dating the solidification of that rock. It is very common to find the ore-deposits close to the contact of this rock with the older Tingha Granite and the slates. Where the ore-deposits occur at a distance from such contacts, there is usually evidence to show that there has really been a contact at no great vertical distance, and that this has been removed by denudation.

On examining the fracture-systems of Elsmore, Emmaville, and Tingha, it was concluded that the force causing these was a thrust from the east, or a torsional stress having the axis of torsion approximately east and west. It was noted that the system of fractures corresponds closely with the general trend of the tin-bearing belt, both being best developed in a direction about N.E. by E.

The tin ore-deposits have been grouped into a number of classes. The chief of these are (*a*) the quartz-quartzose type; (*b*) the quartz-felspar type; (*c*) the pipes; and (*d*) the chlorite-deposits.

In conclusion, I should like to record here my indebtedness to the following gentlemen: to my brother, Mr. C. M. Cotton, who accompanied me during the greater part of the field-work, and rendered much assistance by his observations and suggestions; to

Mr. J. E. Carne, and Mr. C. Saint-Smith for very kind and valuable assistance throughout; to Mr. W. S. Dun, Professor T. W. E. David, and Dr. W. G. Woolnough, of the Sydney University, for practical help and sympathy in my work at the University; to Mr. Penberthy of Elsmore; to Mr. Stormer of Stannifer, and to many other miners whose kindness and cooperation have enabled me togather much of the material that is now presented in this publication.

EXPLANATION OF PLATES LIX.-LXIV.

Plate lix.

Fig.1.—The Macintyre River, south-east from Elsmore, showing bare granite-rock on the northern slope of the hill.

Fig.2.—The Tingha Granite, showing biotite and porphyritic felspars: two-thirds nat. size.

Plate lx.

Fig.1.—Cemented rock on Elsmore Hill, showing hard band with inclusions of reef-quartz overlying soft, uncemented rock of the same composition.

Fig.2.—The "Acid Granite," from near Elsmore : half nat. size.

Fig.3.—The "Acid Granite," from King's Gap : half nat. size.

Plate lxi.

Fig.1.—Elsmore Hill, showing reef running from pile of stones to observer.

Fig.2.—Specimen from quartz-quartzose reef at Elsmore, showing vughs lined with quartz-crystals; the black patches are cassiterite: half nat. size.

Plate lxii.

Fig.1.—Lode-material from Strand Mine, near Howell. Q, crystallised quartz; F, felspar surrounding quartz; C, chlorite: nat. size.

Fig.2.—Cassiterite in quartz-felspar lode-material : half nat. size.

Fig.3.—Quartz and felspar intimately intergrown, from Hutchinson's Felspar-Lode ; half nat. size.

Plate lxiii.

i.—Section, from Elsmore to Kelly's Creek; represented by P-P on geological map. Formations represented as on geological map.

ii.—Section, from Oakey Creek to Wandsworth; represented by Q-Q on geological map. Formations represented as on geological map.

Plate lxiv.

Geological Map, illustrating the Palæozoic Geology of the Elsmore-Tingha Tin-field, New England District, N.S.W.