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GEOLOGICAL ASPECT OF THE LODES OF CORNWALL.¹

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INTRODUCTION.

Although the west of England mining region of Cornwall and Devonshire has not recently been in a flourishing condition, its past fame entitles it to a claim on the attention of those interested alike in the genesis of tin and copper ores and in the antiquity of mining.

During the last few years a section of the field staff of the Geological Survey of Great Britain has been engaged in remapping the Cornish peninsula and as this work is nearly completed the most recent geological information concerning the region is available. There is quite an extensive literature dealing with the west of England geology and mineralogy, and as this has been acknowledged in the Memoirs of the Geological Survey it will be unnecessary to refer to it here.²

HISTORICAL.

ANTIQUITY OF THE MINING IN CORNWALL.

The earliest records of the connection of Cornwall with the

¹ Communicated by permission of the Director of the Geological Survey of England and Wales.

² The Geological Survey Memoirs dealing with Cornish Mining are as follows: (1) "Geology of the Lands End District"; (2) "Geology of Camborne and Redruth"; (3) "Geology of Newquay"; (4) "Geology of Plymouth and Liskeard." Other memoirs are in course of preparation.

tin trade are the extracts from the lost writings of Pythias by the Greek historians Strabo and Diodorus Siculus.

Although it is believed that a century before the voyage of Pythias, the Carthaginian Himilco had visited Cornwall with a view to stimulating the tin trade between that country and the continent, there was in the time of Pythias an overland trade between Cornwall and Marseilles—possibly also a sea-borne trade between Cornwall and Cadiz.

When Pythias was in Cornwall he was informed by the inhabitants that the tin, after being cast into ingots, was conveyed to the island of Ictis, which was accessible to foot passengers, at low tide. From here it was taken to the mouth of the river Loire and thence to Marseilles. As to the identity of the island of Ictis there has been considerable discussion in the past, but recently Mr. Clement Reid has shown how the Isle of Wight might have been the Ictis referred to by Pythias,¹ as at that time it is possible that there was a natural causeway between the isle and the mainland which has since been worn away by the scour of the sea. This view is combated by Mr. T. Rice Holmes who, on historical grounds, inclines to the other supposition that the old Ictis and St. Michael's Mount are the same.² In either case the antiquity of the tin mining in Cornwall cannot be doubted and with fluctuating activity the production of tin has been continuous to the present time.

The tin mines in the twelfth and thirteenth centuries were under the control of the Kings of England who granted privileges for working them, but for the last 300 years the production of both tin and copper ores has been of national importance.

TOTAL YIELD OF TIN AND COPPER FROM CORNWALL.

An exact estimate of the total metalliferous yield of the county of Cornwall is practically impossible to obtain owing to the absence or uncertainty of the older records. In a brochure by the present writer published in 1907 by the Geological Survey, an estimate of the total known production of the minerals of Corn-

¹ "The Island of Ictis," *Archæologia*, Vol. 59, 1905.

² "Ancient Britain and the Invasions of Cæsar," 1907.

wall was made within the limits of a possible error of 10 per cent., as follows:

Total Produce of Metallic Tin from Cornwall.

Between 1201 and 1749 A. D.....711,990 tons

Between 1750 and 1905 A. D.....755,900 tons (from black tin containing
65.02 per cent. of tin).

(Of 283,000 tons of tin yielded between 1201 and 1600 A.D. 75,000 tons were obtained from alluvial deposits, and of 573,800 tons produced between 1601 and 1800 A. D., 473,000 tons were obtained from alluvial deposits.)

Total Produce of Metallic Copper From Cornwall.

Between 1501 and 1725 A. D..... 20,000 tons.

Between 1726 and 1905 A. D.....883,350 tons (from ore containing 7.89
per cent. of metallic copper).

For the amounts of ores yielded from the mines of Cornwall individually the reader is referred to the Memoirs already mentioned.

For over 150 years Cornwall has had formidable rivals in the tin-fields of the East Indies (Bangka and Billiton islands) and while still holding a high place in the world's production of tin ore its output is exceeded by Bolivia, Australia, Siam and Malay—the last country producing about ten times the quantity raised in Cornwall.

In addition to ores of tin and copper Cornwall has yielded considerable amounts of argentiferous-galena, zinc ore and iron pyrites, arsenic, wolfram and of iron ores, ochre and umber. Smaller amounts of bismuth, antimony, nickel ore and uranium have been yielded as by-products or in a small way.

GEOLOGY.

GENERAL GEOLOGICAL DESCRIPTION OF CORNWALL.

With the exception of a few undetermined points the geology of Cornwall has been recently worked out by the Geological Survey. The small key map (Fig. 28) shows the general arrangement of the Palæozoic sedimentary rocks of which the

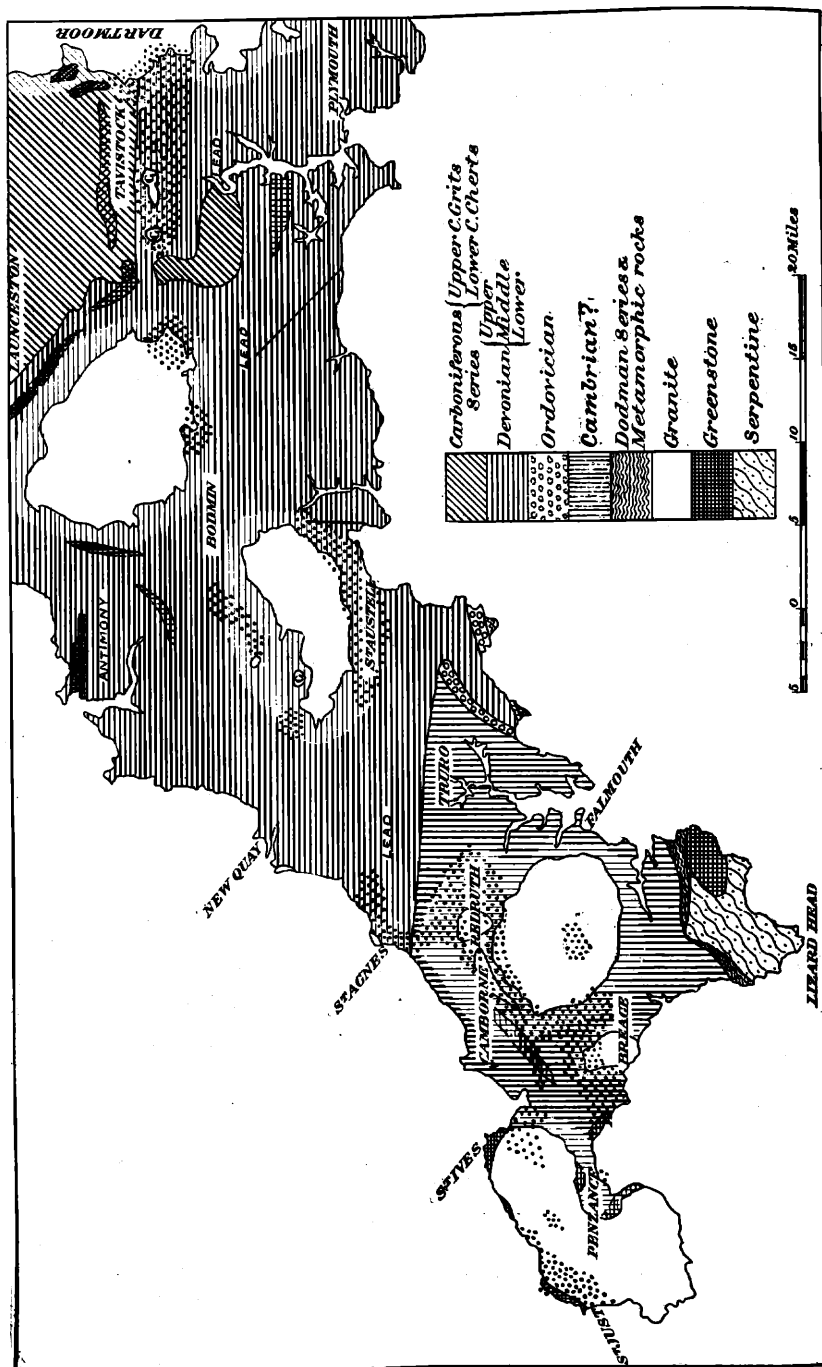


FIG. 28. Geological map of the Cornwall Region, England.

region is composed together with the igneous masses which were intruded at different periods during the disturbances which have upheaved, folded and cleaved them.

The sedimentary rocks of the western part of the region, south of an east and west line situated north of Truro, are of Lower Palæozoic age as determined by trilobites in the region south of St. Austell, and consist of argillaceous slates of purplish and green color with fine sandstones. The rocks are thoroughly cleaved, folded and overthrust, and contain interbedded quartz lenticles, and in those beds which consist of alternately hard sandy and soft shaly bands there is crush-breccia or pseudo-conglomeratic structure due to the fracturing of the harder bands which under pressure became crushed into lenticular fragments separated by softer argillaceous material. The Lower Palæozoics have been separated into five subdivisions not indicated on the map. These rocks have a strike of E. 30° N. and are supposed to have as a whole an anticlinal arrangement.¹

The sedimentary rocks of central and east Cornwall are mainly of Devonian age and consist of shales, sandy beds, grits and calcareous bands with an east-and-west strike. The series is much folded and cleaved, the Lower Devonian rocks occurring on the south, and the Middle and Upper on the north. In Watergate Bay, north of Newquay, the sandy and argillaceous Lower Old Red series is seen to occupy the axis of an anticline, the overlying Lower Devonian beds occurring on both the north and south side of that feature. A similar anticlinal structure is discoverable in the Upper Devonian series in the district on the west of Kit Hill in East Cornwall.

The Carboniferous rocks of the region comprise both the Upper and Lower Divisions. The Lower Carboniferous shales and radiolarian cherts, as well as the Upper Devonian shales, are overlain unconformably by the Upper Carboniferous plant-bearing grits and shales.

¹The discovery of Devonian conglomerates near the Helford river just north of the Lizard serpentine appears to confirm this supposition since, according to Mr. J. B. Hill, they are correlatable with the Devonian shales and sandstones north of Truro.

The igneous rocks of the region comprise the greenstones, lavas and schalsteins, granites, quartz porphyries and mica traps. Under the term greenstone are included a series of pre-granitic basic intrusions comprising diabases, proterobases, porphyrite and epidiorite, most of which have been sheared and more or less altered, particularly near the granite. The lavas are typically represented by spilite—fine-grained rocks belonging, according to Dr. J. S. Flett, to the Essexite group and characterized by exceptional amounts of albite feldspar. The schalsteins occur in patches in both the Upper Devonian and Carboniferous rocks of East Cornwall.

The igneous rocks of Post-Carboniferous age do not as a rule show any foliation or shearing since they were intruded, only at the close of, and as a relief to the great Post-Carboniferous movements to which the folding and cleavage of the Palæozoic sediments are due. The most important of these are the five granite intrusions shown in the figure, together with their fine-grained hypabyssal types, the elvans or quartz-porphyry dykes and the comparatively rare mica traps or minettes.

STRATIGRAPHICAL TABLE.
SEDIMENTARY ROCKS.

Upper?	Culm grits and shales	CARBONIFEROUS	Upper Palæozoic
Middle			
Lower Culm shales and radiolarian cherts.			
Upper, Middle and Lower Devonian grits, calcareous slates and shales		DEVONIAN	
Lower Old Red shales and fine sandy beds (Dartmouth Beds)			
Gorvan Haven beds		UPPER SILURIAN (Wenlock)	
Veryan slates, sandy beds and quartzites and thin limestones and cherts		ORDOVICIAN	
Portscatho slates and sandstones			
Falmouth slates		CAMBRIAN?	
Mylor slates and Dodman (?) Phyllites			

IGNEOUS ROCKS.

Granite	LATE OR POST-CARBONIFEROUS
Quartz porphyry (Elvan)	
Mica trap	
Tuffs and lavas	CONTEMPORANEOUS CARBONIFEROUS
Greenstones	
Pillow Lavas and Schalsteins. Greenstones	UPPER AND MIDDLE DEVONIAN
Pillow Lavas	OLDER PALÆOZOIC
Greenstone (hypabyssal)	
Gabbro	
Serpentine of the Lizard, with granulite intrusions	

It is with these granite masses that the mineral wealth of the west of England is connected.

The metamorphic rocks include the hornblende and mica schists and quartzites of the Lizard; and the contact-altered rocks in the vicinity of the granite masses.

THE LODES.

The stippled areas on the map indicate the chief tin and copper districts of Cornwall and South Devon. It will be noticed that in all cases the lodes occur concentrated in districts connected with the granite masses or their metamorphic contact zones, but this position is generally further characterized by the presence of post-granitic dykes of quartz-porphyry (Elvan), which, like the lodes, have directions similar to that of the cleavage of the sedimentary rocks which they traverse. As a whole the ores appear to represent the final phase of plutonic activity in the region, the sequence of events being: (1) Intrusion of the granite masses with thermal metamorphism of the slates surrounding them, (2) intrusion of Elvans, (3) formation of the tin and copper lodes accompanied by extensive mineralization of both sedimentary and igneous rocks.

LODE STRUCTURES.

The tin and copper lodes as a whole may be described as fissures of varying size and form, which contain a variety of ores of tin, copper and other metalliferous minerals together with characteristic veinstone accompaniments.

The structure of the lodes indicate to some extent their mode of origin; and while some of them are mere joints or cracks of the thickness of a knife blade, others are of great width and contain much fragmental crushed material indicating that they are probably of the nature of faults.

The variety of structures which the vein stones may assume under such circumstances is fully represented in Cornwall and as a whole may be classified into one or more of the following groups:

1. Fissure, or series of close parallel fissures filled with metalliferous and other minerals.
2. Mineralization of the walls of the lode by impregnation or metasomatic replacement.
3. Mineralization of crushed rock or breccias contained in the lode.

In the first class are included all simple infilled fissures, together with the large workable ore-bearing masses known as stockworks in which a series or group of close parallel fissures often crossed by another series, is worked out as one lode. Stockworks in the granite, killas and elvan are common in all the districts of Cornwall but are not the most profitable types of lodes.

Under the second heading come all the metalliferous portions of the lode which occur as metasomatic replacements of the country rock. As a rule this impregnated zone varies in width from a few inches to a foot or more. It does not yield the highest percentage of mineral but can be profitably extracted with the true lode material. Most of the lodes are associated more or less with this altered band, but abnormal developments known as "Carbonas" sometimes occur. The best known examples of the Carbonas are those of St. Ives and other places in West Cornwall in which long, wide, irregular bodies of schorl, quartz and tinstone occur as an alteration product of the granite

in the vicinity of small fissures running at right angles to the ordinary lodes.

Under the third heading comes the most important of all the lode structures in Cornwall, namely the lodes characterized by breccias and other crushed material of the country rock. In some important mines the width of these brecciated zones varies from a few feet up to many fathoms. The lodes near Camborne and Redruth are typical examples of mineralized breccias but this type of lode occurs in modified form throughout Cornwall. The lodes of the region between Camborne and Penzance generally contain brecciated veinstones, but movements in the lode have resulted in slicken-siding and the rounding of much of the material so that it has now the form of a conglomerate to which the term crush-conglomerate is applied. This leads to a variety of lode structures, composed of breccias and conglomerates cemented by tin stone, copper and iron pyrites, zinc blende, and other minerals, the whole being traversed by strings of quartz, chlorite, fine-grained tourmaline, etc., and constituting the veinstones.

In some brecciated lodes in which very little movement has taken place the rock has merely been comminuted and the lode consists of a mass of interlacing strings of lode mineral.

In some districts the lodes where they traverse the slaty rocks ("Killas") show abnormal developments arising out of the structure of the killas itself. These are the so-called "floors" which although occurring in the St. Just and other mining districts are mostly typically developed at the "Park of Mines" at the western end of the St. Austell granite mass where the tin ore occurs in interbedded layers forming lateral offshoots of narrow veins which cut across the cleavage of the slates. The whole zone in which the layers of tin ore occur was removed bodily.

RELATIONS OF THE ORES OF TIN AND COPPER TO THE GRANITE.

The tin and copper ores occur together in intimate association, but in some important cases these ores occupy different horizons in the lodes. The best known case is that of the lode on the

northern edge of the Camborne granite, extending from Camborne to near Redruth, a distance of over three and a half miles (the Dolcoath Mine Lode). In this lode the ores of copper mixed with tin ore occupy the upper part of the lode and extend from the surface to varying depths down to about 200 fathoms below surface. Below this the principal bodies of tin ore occur to a depth of 500 fathoms from surface. In this case the upper part of the lode is in killas and the lower part is in granite. This zonal arrangement is exhibited in several important mines in Cornwall, among which may be mentioned Levant Mine (near St. Just) where the tin and copper ores occur together in a long "chute" in the sheared killas and greenstone for a mile seaward, parallel with the subterranean surface of the granite and at right angles to its margin. The copper ores at the edge of the granite in Tresavean Mine, near Redruth; the tin and copper mines near St. Austell and other places, illustrate the localization of the ores in certain horizons, the ores of tin and copper occurring either mixed or apart from one another and generally not far from the granite.

In a more general way the Cornish mineral areas are designated tin or copper districts according to the relative proportions in which these minerals occur, but all the districts contain both classes of ores.

NATURE OF THE VEINSTONES.

The veinstones present a large variety in structure and composition, from the simple banded or sheeted structures in simple fissures in which minerals have been successively deposited, to the complex mineralized breccias characteristic of the largest lodes in the county.

In examining the veinstones under the microscope it is seen that they are merely a repetition of the lode structures carried to a microscopic degree of fineness, so that it is unnecessary to describe them again.

In the arrangement of the minerals and in other features the study of the lode material by the microscope affords the information necessary for forming an idea as to their origin.

The ores which enter into the composition of the lode materials

comprise cassiterite, stannite, copper pyrites and dark sulphides of copper, oxides of copper, Fahlerz, carbonate and silicate of copper and native copper; mispickel and other arsenical ores; wolfram, scheelite; phosphates, arsenate and carbonate of lead; silver ores, zinc blende, bismuthine, cobalt and nickel ore, manganese, pitchblende and other ores, among which are embraced various ferriferous minerals.

Among these will be recognized a number which have been formed from alteration (oxidation, etc.) of previous minerals. The others are stable, and are practically incapable of being decomposed under ordinary conditions.

In describing the ores it is important to recollect that they fall into two groups. In the first group is included the original minerals of the lodes such as cassiterite, wolfram, copper and iron pyrites, mispickel and various other sulphides. The second group embraces the ores which originated as a result of the decomposition, migration and redeposition of the primary minerals, including such ores as cuprite, melaconite, native copper, malachite, chrysocolla and various secondary sulphides of copper and other metals.

These secondary ores are confined to the upper parts of the lodes in a zone which may extend to a depth of 200 fathoms from surface. They are easily recognized to have been the last minerals deposited in the lodes as they occur in cracks traversing other minerals, or as incrustations. Some of the carbonates of iron or copper together with pigotite are of such recent origin as to be found encrusting the walls of old levels.

The veinstones, or non-metalliferous gangues, characteristic of the tin and copper lodes of Cornwall are quartz, chlorite, tourmaline, fluorspar and kaolin with other less common minerals.

In describing the microscopic structures of the veinstones it is convenient to divide them into two groups. In the first group is included the material occurring as a deposit in open fissures and, in the second, the veinstones derived by the alteration of the adjacent country rock.

Of the material deposited in the open fissures little need be said since the structures of the veinstones are so largely dependent

on the forms of the openings in which the ores were deposited, as already described.

From the relations of the various ores to one another, however, it appears that the order in which the minerals arrived was as follows:

1. Tin ore, wolfram, sulphides of copper, zinc and arsenic; quartz, fluorspar, chlorite and tourmaline.
2. Copper ores and other sulphides with possibly some silver and lead; quartz, chlorite, fluorspar.
3. Silver-lead ores and carbonates; quartz and fluorspar.

The veinstones derived from the alteration of the country rocks are of more interest since the mineralogical changes which have gone on in the rock through the effects of mineralizing vapors or solutions enable conclusions to be drawn as to the nature of the reactions which took place.

In addition to silicification the granite near the lodes may be tourmalinized, propylitized and greisenized.

The killas or slaty rocks show development of silicified types and tourmalinized bands, while in greenstones garnet is often formed.

PNEUMATOLYTIC ALTERATION AND METASOMASIS.

1. *Granite*.—Granite is the best rock in which to study the changes brought about by pneumatolysis since the coarse-grained nature of its minerals enables the changes to be readily identified.

Tin ore which occurs in such fine pseudomorphs after porphyritic crystals of orthoclase at Huel Coates near St. Agnes is commonly found throughout Cornwall as a partial or complete replacement of the ordinary felspar of the ground mass, while sulphidic minerals such as copper pyrites are frequently found along with tinstone in the decomposed parts of the same crystals or in small cracks traversing the mass.

The changes which the minerals undergo are briefly: (1) A conversion of felspar into lithia-bearing mica or hydrated mica (lepidolite or gilbertite); but also mainly through the action of moisture, the felspar by loss of silicate of potash is extensively, in

some places, converted to china clay, as in the St. Austell region.

The silica liberated during such reactions is deposited elsewhere with the formation of tough silicified rock types.

Where boron vapors have been active there is a conversion of feldspar into blue tourmaline which occurs generally as fibrous aggregates. Fluorspar, quartz, tourmaline, copper pyrites, tin-stone, topaz, kaolin and pale hydrated or lithia mica all occur as secondary products after feldspar, through the action of original vapors containing fluorine, boron, tin, lithia, sulphur and much moisture.

The mica of the granite is either bleached, with separation of oxide of iron, and conversion to hydrated pale varieties or it may be converted to chlorite with considerable migration of the material. In the ore districts the conversion of biotite to brown tourmaline is universal. These brown crystals are frequently fringed with later growths of acicular blue tourmaline.

The chloritic material and the brown tourmaline are the characteristic alteration products of the biotite.

With the exception of considerable corrosion of the original quartz of the granite this mineral is often quite unaffected. Much secondary silica is produced by the alteration of the rock. This occurs throughout as a granular mosaic where the rock is altered to any extent.

2. *Killas*.—The veinstones occurring in the contact altered sediments surrounding the granite masses have a few features of special interest.

The alteration types include mica schists, and flinty biotite hornfels, andalusite hornfels with exceptional cordierite and pinite. The more gritty bands of the rocks are converted into quartzitic types. In the originally calcareous grit bands tough banded calc-hornfels is produced by contact metamorphism, with development of epidote, axinite, pale pyroxene and garnet.

The modifications of these altered rocks in the vicinity of the lodes are principally those produced by silicification, tourmalinization and impregnation with ores.

Where the slaty rocks are impregnated with tin-ore and sul-

phide of copper the minerals occur in small cracks or along cleavage planes.

As a rule the walls of lodes traversing slates are much crumpled and sheared and there has been an extensive infiltration of quartz which occurs in small lenticles following the contorted cleavage of the slates.

One of the most beautiful and conspicuous of the metasomatic alterations of the killas is that effected by tourmalinization. In the more massive shales the development of tourmaline has taken place for a distance of several inches and even feet on either side of the veins; but where they are banded and consist of alternate thin seams of grits and shales, the tourmaline has only been developed along the impure argillaceous layers, leaving the grit bands quite unaffected. As the rocks are much folded on a small scale, gnarled, sheared and brecciated, all the contortions and general structure of the rocks are preserved and accentuated. In the specimens examined the alteration of the sediments by pneumatolysis has been superimposed on that of contact metamorphism.

In the calc-hornfels bands instead of tourmaline which is only sparingly developed axinite as a product of penumatolytic action on lime-bearing rocks occurs in abundance in association with amphibole, pale and green pyroxene, epidote and garnet. These minerals are well developed in the district north of St. Austell and in the cliffs at St. Just.

3. *Greenstone*.—Like the calc-hornfels the greenstones give rise to lime-bearing minerals such as axinite, fluorspar, epidote, pyroxene and amphibole, and garnet. Tourmaline is uncommon. The garnet occurs in the form of veins which traverse the greenstone like an ordinary veinstone, and in association with it quartz and pyritic minerals are found. By the dim light of the miners' candles this rock has occasionally been sent to surface in mistake for tin-ore in Levant Mine (St. Just).

These garnetiferous veinstones are known to occur in Dolcoath Mine, at Lostwithiel, also on the north of Dartmoor and other places; while they occur abroad in Arizona, Hungary, the Urals, New South Wales and Queensland and in Sweden. In the de-

velopment of the garnet there has probably been an addition of silica to constituents derived from the greenstone, while the changes took place under thermal conditions.

GENESIS OF THE ORES.

The nature of the minerals of the lodes indicates that the vapors and solutions from which the ores were derived contained, in addition to the metals, such materials as fluorine, boron, sulphur, silica, lithia, probably a little carbon dioxide and much moisture. As pointed out long ago by Daubrée and Élie de Beaumont the period at which this type of ore deposits were formed followed closely on the consolidation of the granite mass, the solutions being withdrawn from the magma as it crystallized. In the form of fluorides, sulphides and other compounds the metals and silica were extracted in this way at high temperature and deposited in fissures in the cooler rocks accompanied by the typical mineralization already mentioned.

As elaborated by Professor Vogt, the Cornish ores belong to the subgenetic type, "copper-tin" lodes, or tin lodes characterized by large amounts of copper and other sulphidic ores. The presence of tourmaline recalls the tourmaline copper veins of Mexico on the one hand and the tourmaline wolfram veins of Tirpersdorf (Bohemia) on the other; while the occasional presence of argentiferous galena in the lodes suggests a genetic type having affinities with the Bolivian silver and tin lodes.

The secondary concentration of the sulphidic ores in the upper parts of the lodes has already been referred to. The action of surface waters containing oxygen or carbon dioxide in solution has decomposed original sulphides of the lodes causing them to be carried downwards in the lodes in the form of sulphates or carbonates. Meeting with iron pyrites or other sulphides the sulphates were reduced and the ore precipitated as sulphide.

Secondary enrichments of copper ores in the upper parts of the lodes have yielded in some cases extremely rich bodies of copper ore.

THE SILVER-LEAD VEINS.

The principal lead districts of Cornwall were those of the central and eastern part of the county. That of central Cornwall occurs on the north of Truro while the east Cornwall region is situated in the parishes of Menheniot and St. Ives. In Devonshire the parish of Beerferris was once an important lead producer but like those of Cornwall has been abandoned many years.

The lead districts are situated in the killas at some distance from the granite masses.

The ores occur in a series of approximately north and south cross-courses or faults of tertiary age crossing the general strike of the rocks at right angles and thus belonging to quite a different set of movements to that to which the tin and copper lodes owe their origin.

The richest district has been that of Menheniot and St. Ive, but no lead ores have been raised from it since 1884. The yield of the district between 1848 and 1884 was as follows:

1848 to 1884 Dressed lead ore.....	92,000 tons.
Metallic lead obtained from the ore....	63,600 tons.
Silver (parted from lead).....	2,930,000 ounces.

The metalliferous minerals found in association with the lead ores are zinc blende, some copper ore, rich silver ores of various kinds, iron pyrites and mispickel and in one case a few tons of wolfram. The veinstone is composed of quartz, chalybite, calcite and fluorspar. These occur in successive superimposed layers in the lodes, the lead ores being intermediate in age between the first and last of the deposits of the veinstones. The brecciated nature of some of the lodes is a feature worth remarking.

In their genetic relations to the lead lodes of the world they may be regarded as falling into the sulphidic subgroup characterized by quartz, carbonates and fluorspar.

IRON LODES.

Like the lead lodes the iron ores occur in cross courses, but one of the most important of them—the Perran iron lode, near Newquay—has a direction of its own.

Little need be said of these lodes. They are generally of great width but somewhat variable in this. In the upper part they are brecciated and composed largely of hæmatite and limonite with a little manganese ore, while in depth there is a considerable amount of chalybite. Compared with other sources of iron supply these lodes are of no great industrial importance.

ALLUVIAL DEPOSITS OF TIN.

Throughout Cornwall and Devonshire the streams and upland basins or peat mosses draining the mineral districts have been extensively worked in days gone by for tin ore. Lately there has been some attempt to work the same deposits for wolfram which like the tin ore occurs not only as a shoad material, but in the alluvial flats where wolfram lodes are found.

The best known alluvial deposits are those on the north of St. Austell (the Goss Moor, Criggan Moor, Red Moor, etc.), all of which are wide shallow hollows, excavated in what is tentatively considered by Mr. Reid to be an ancient marine shelf sharpened up in Pliocene times at above a level of 400 feet.¹ The largest of these flats is the Goss Moor, one and one-fourth miles in width and three miles in length. The angle of slope is about 0°-30' towards the stream which drains it so that the gradient is that of torrential conditions. The material in these moors consists of peat, hard subangular stones and finer sands and clays, the tin ore occurring in channels at the base of the deposits. The detritus appears to merge laterally into the broken decomposed surface rock which covers the whole of the west of England and which appears to have been formed under special climatic conditions, probably similar to those of the steppes—cold and dry. As the district has never been glaciated the superficial fragmental rock has been allowed to accumulate, and under special conditions has crept or been washed by rains down the slopes into hollows, whence much of it has found its way into the moors above mentioned.

The alluvial deposits of the rivers draining these flats sometimes attain thicknesses of 30, 40 or 50 feet and consist of alter-

¹ See Lands End Memoir. Explanatory of sheets 351 and 358, 1907, p. 68.

nating beds of sands, clays and layers of peat. At the estuaries the tin ore has been worked below sea level at the bottom of the ancient submerged valleys. In some of the coves round the coast the beach sands have been treated for tin ore.

To the stranger there may be some ambiguity when speaking of the stream-tin. The stream-tin deposits just described are natural alluvial deposits which have been abandoned for many years and are only worked occasionally in a small way; but there is an important industry known as the stream-tin works for saving the tin ore from the tailings or waste thrown into the rivers from the dressing floors of the mines. As much as £40,000 worth of tin ore a year has been collected by the extensive dressing plants or stream-tin works situated on the rivers coming from the active mining districts of Camborne and Redruth.