Fissure System and Mineralization in Cornwall.

By K. F. G. Hosking.

(1) Relative ages of intrusives and lodes.

A decade or so ago it was customary to regard the formation of the acid intrusives and associated lodes of Cornwall to have taken place in the following sequence :—

Earliest (1) Granite intrusion.

(2) Intrusion of porphyry dykes (and minettes?)

(3) Intrusion of aplites and pegmatites.

(4) Development of the Sn—W—Cu lodes.

(5) Development of the Pb—Zn—Ag lodes.

(6) Development of the barren faults.

To-day there is evidence to show that this is an over-simplification of the case.

(1) Ghosh and others have shown that each of the larger exposed masses of granite in Cornwall represent at least three intrusions[1], and although it was generally believed that there was no metallization until well after all the granite had been emplaced, the fact that the wolfram lode at Castle-an-Dinas (St. Columb) is penetrated by granite apophyses, shows this concept to be incorrect[2].

It is interesting to wonder whether the somewhat pegmatitic deep-seated wolfram lode situated well below the granite-slate contact at South Crofty represents the pegmatitic phase of a granite intruded into the exposed Carn Brea granite and therefore later than the main mineralization of the area. (On the other hand it may be simply an entrapped mass of those same mineralizing agents which formed the other lodes of the district).

(2) Emmons has brought forward evidence that pegmatite facies may be developed before, during, or after the

main period of mineralization, but it is probable that the largest were formed immediately before the period of mineralization and are the connecting links between normal granite veins on the one hand and normal metalliferous veins on the other[3]. Late post mineralization pegmatites are probably represented by small pockets such as are met with occasionally in de Lark quarry. They are the consolidation products of entrapped volatile — rich magma "pockets" in the consolidating granite ore.

(3) Collins many years ago stated that some tin veins were formed before and some after the development of porphyry dykes, and instances Great Wheal Fortune, where the "Conqueror Branches" (tin veinlets) were clearly heaved by a porphyry dyke[4].

(4) Finally, in the recently published "Memoir of the Lizard District" it was suggested that some of the porphyry dykes to the south of Carn Menellis may possibly be earlier than the main granite mass[5].

Theories regarding the origin of fissures and their application to the Cornish problem.

In Cornwall there is usually a close parallelism between the strike directions of lodes and adjacent dykes, and it would therefore appear that a common set of factors controlled the directions of both these bodies.

(1) Ghosh working on the Carn Menellis granite concluded that the positions of both veins and dykes were determined by the joints within the granite, and that these in turn (which are much more complex than is generally believed) were determined by regional stresses of varying magnitude and operating at different times from different directions[6]. His conclusions are similar to those derived by Brammell as a result of examination of the Dartmoor granites.

(2) Emmons, on the other hand, as a result of a close study of mineralization associated with acid intrusives

throughout the world, is of the opinion that the fissures occupied by, or determining mineralized areas are a function of the shape in plan of the associated intrusive. Thus fissures associated with an elongated granite mass such as that of Carn Brea will tend to develop parallel to the long axes of the granite, whilst an approximately circular mass such as that of the Land's End will tend to develop a radial vein pattern. He further states that veins showing an anomalous strike are due to the opening up of pre-existing lines of weakness, and that the initiation and subsequent development of all the veins is due to the fact that at a certain temperature-point during the crystallization of the magma, water and probably other substances suddenly develop a great vapour pressure which is sufficient to fracture the granite "hood" and overlying country rock. The cracks so formed are opened up by general slumping, (normal faulting) and having been filled, may be re-opened by further adjustment due to slumping. This "explosion theory" is based on an experiment by Morey, who in 1921 found that a melt having the composition K_2O — 17.37%, H_2O — 9.1%, SiO_2 — 73.6%, showed no vapour pressure at 500° C., but at 420° C. it developed a vapour pressure sufficient to lift about a mile of granite[7]. These "explosion centres" are very reminiscent of Dines' "Emanative Centres" which were postulated to explain the phenomena associated with Primary Zoning in Cornwall.[8]

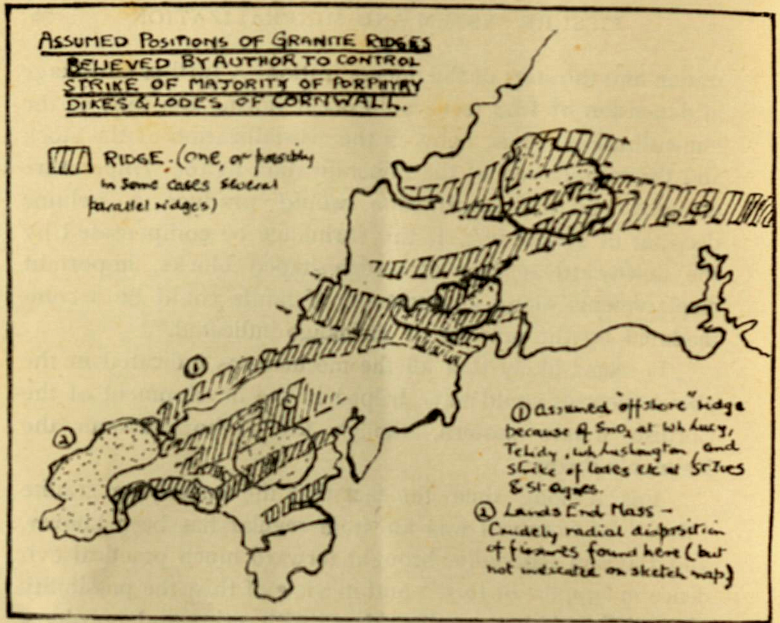
(3) Finally Hulin, whilst believing that fissure system patterns in plan in mineralized districts are functions of the shape of the associated intrusive, is of the opinion that these fissures are initiated by contraction during the cooling of the intruded mass, and that mineralization took place considerably later than the period of main intrusion. His deductions are clearly indicated by the following quotation : "— if it be assumed that the granitic rock crystallises at about 700° C. and that the mineralization starts at 300° C. and terminates at 150° C., a stock 5,000 feet in diameter would decrease in dimension by about 87 feet in the interval between its crystall-

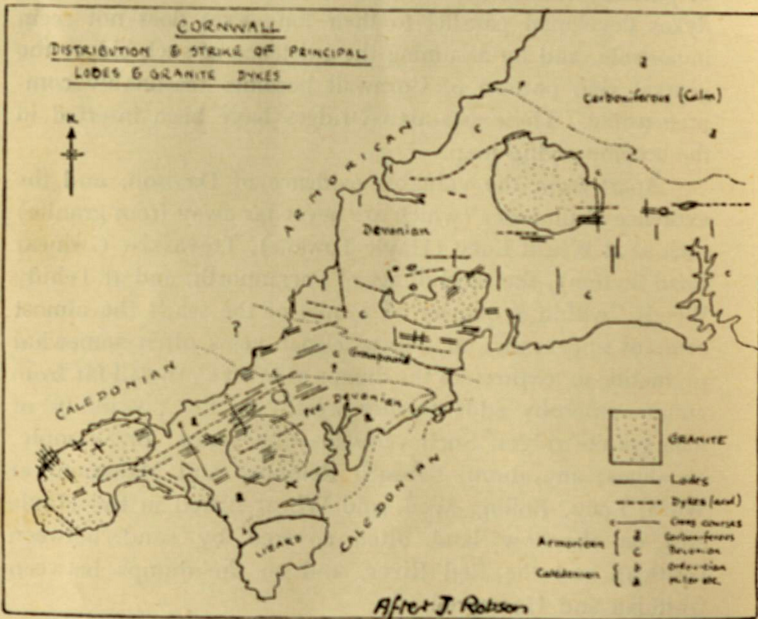
ization and the start of the mineralization. A further shrinkage in dimension of 13.5 feet would occur during the time of the mineralization. Thus, between the crystallization of the stock and the termination of the mineralization at the temperature assumed, thermal contraction would produce a volume decrease of almost 6%. If this shrinkage be compensated by the downward settling of wedge-shaped blocks, important displacements along a succession of faults could be accommodated by the amount of shrinkage indicated.''[9]

It seems likely that all the mechanisms indicated in the above theories could have helped in the development of the Cornish fissure pattern, though the author favours the Emmon's theory.

For a long time the fact that the underlying granite ''floor'' of Cornwall was far from regular has been known, and Davison especially, brought forward much practical evidence in support of this,[10] and in view of this, the possibility of partially hidden granite ridges, with veins and porphyry dykes developed parallel to their long axes does not seem impossible, and by assuming the existence of such ridges the general vein pattern of Cornwall becomes reasonably comprehensible. These postulated ridges have been inserted in the accompanying map.

Apart from the valuable evidence of Davison, and the existence of tin lodes (which are never far away from granite) such as at Wheal Lucy (Hayle Towans), Trevaskis(Gwinear Road Station), the sand dunes of Perranporth, and at Tehidy Woods ''within a quarter of a mile of the sea,'' the almost constant appearance of quartz-felspar veins often somewhat pegmatitic in texture, on the dumps of West Cornwall far from granite outcrops adds further weight to the possibility of such granite ridges. Such veins may be found, for example, on almost any dump between Relubbas and Marazion, at Wheal Lucy, Boiling Well, and Wheal Alfred in the Hayle area, on the low land, often covered by sand, between Gwithian and the Red River, and on the dumps between Gwithian and Horsepool.


ASSUMED POSITIONS OF GRANITE RIDGES BELIEVED BY AUTHOR TO CONTROL STRIKE OF MAJORITY OF PORPHYRY DIKES & LODES OF CORNWALL.
RIDGE. (one, or possibly in some cases several parallel ridges)
① Assumed "offshore" ridge because of SnO2 at Wh. Lucy, Tehidy, Wh. Leslington, and strike of lodes etc at St Ives & St Agnes.
② Lands End Mass – Crudely radial disposition of fissures found here (but not indicated on sketch map)


CORNWALL
DISTRIBUTION & STRIKE OF PRINCIPAL LODES & GRANITE DYKES
N
Carboniferous (Culm)
ARMORICAN
Devonian
?
Grampound
CALEDONIAN
Mid-Devonian
CALEDONIAN
LIZARD
GRANITE
Lodes
Armorican
Caledonian
After J. Robson

A geological map will readily show how, for example, the distribution of the lodes in the Perranporth district may be accounted for by assuming a curving granite ridge whose axis runs from St. Agnes, through Cligga and Budnick and then plunges eastward towards the St. Austell mass. That this ridge exists is also indicated by the stanniferous granite outcrop at Budnick. Similarly, a ridge is exceptionally well indicated in the region occupied by Kit Hill, etc., between the Bodmin Moor Mass and Dartmoor.

The postulated ridges closely follow the anticlines of the County and their position may well have been determined by these folds, just as the inter-sections of Armorican and Caledonian folds seem to have determined the positions of the larger granitic outcrops.

Nothing has yet been said about the frequently barren fissures which cut across the lodes discussed above, and these would appear to be due to the general settling down of the area due to contraction of the cooling granite and also to the general relief of regional stress. That such fissures should develop at right-angles to the long axes of the ridges is consistent with mechanical laws. It would seem, however, that their formation varied considerably in time and that some of the earliest of them penetrated sufficiently deep to tap the last remaining metalliferous (Pb—Zn—Ag) solutions and finally the residual siliceous solutions. Dines, on the other hand, is of the opinion that some of the late Pb—Zn—Ag deposits may have been formed by solutions which first ascended, then circulated in the country rock and finally descended into suitable fissures and deposited minerals.[11]

Space does not allow of discussion regarding the emplacement of dykes, veins of pegmatite, the development of stock works and the numerous patterns associated with a given major fissure, nor of the numerous effects of faulting; they do not however call for any modification of the theory of fissure pattern as set out above.

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