BRITISH MINING No.5

MEMOIRS 1977

✡ ✡ ✡ ✡ ✡

Hunter, J. 1977 “An Exercise in Mineral Exploration - Dartmoor 1974”
British Mining No.5, NMRS, pp.1-6

Published by the

THE NORTHERN MINE RESEARCH SOCIETY
SHEFFIELD U.K.

NB
This publication was originally issued in the A4 format then used by the society. It has now been digitised and reformatted at A5. This has changed the original pagination of articles, which is given in square brackets.

ISSN 0309-2199

AN EXERCISE IN MINERAL EXPLORATION – DARTMOOR 1974

J. Hunter B.Sc.

This account is a synopsis of a report submitted in partial fulfilment of a post-graduate course at the University of Leicester. The report concerns a mineral exploration exercise involving nearly three weeks field work on Dartmoor, and a number of days spent in the laboratory analysing samples and data. The field work included three stages of a hypothetical exploration program to search for concentrations of tin, lead and copper in selected areas of Dartmoor.

These three stages are as follows:-

- Stage 1 Geochemical stream sediment reconnaissance over W. Dartmoor.
- Stage 2 Follow-up stream sediment sampling in areas of interest indicated by Stage 1.
- Stage 3 Detailed and systematic exploration of a favourable area selected from the results of Stage 2.

A natural extension of this work for a mining company would be to trench, drill or otherwise obtain sufficient samples to outline zones of economic mineralisation and obtain an ‘indicated’ ore reserve estimation. This is assuming that the results of the stage three activities were indicative of anomalous concentrations of one or more minerals, and the mineral rights and other legal matters were in hand.

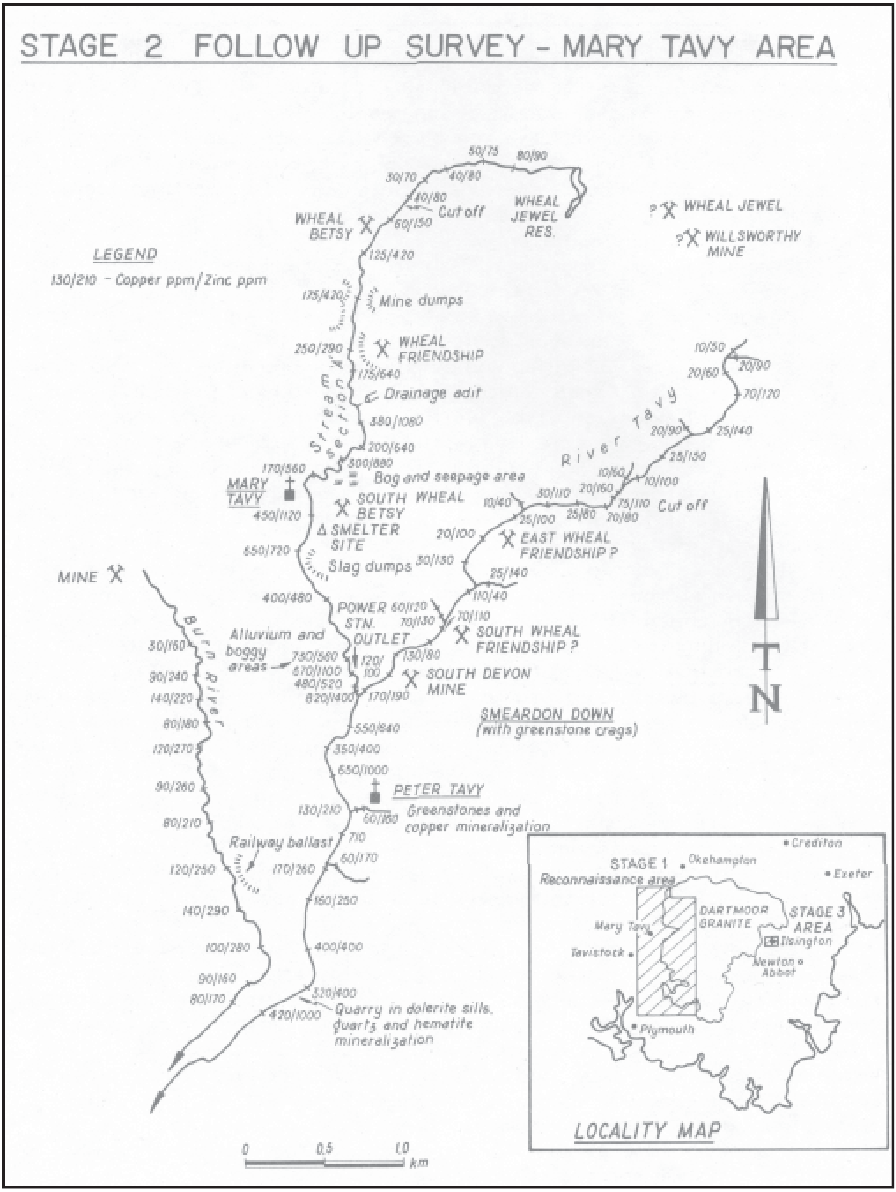
It must be pointed out at this stage however that a mining company is unlikely to use all the geophysical methods used in this exercise, mainly because of the time and expense involved, and the various methods used here are for a comparison of results and effectiveness in this type of terrain.

Stage 1 Activities – Western Dartmoor

The area selected in Western Dartmoor for the regional geochemical reconnaissance covers an area of 180 square miles of rugged moorland and cultivated Devon countryside centred around Tavistock. Most of the eastern side of the area is underlain by the Dartmoor granite massif, while the western si.de is underlain by folded Devonian and Carboniferous sedimentary rocks with occasional basic igneous intrusions.

The numerous abandoned mines and workings in the area are encouraging in a survey of this sort, however the contamination resulting from these and other industrial activities must be borne in mind in the interpretation of the results.

Samples were collected at ½ - 1 mile intervals along streams and at sites upstream of tributary junctions, giving a sample density of approximately 2 samples per square mile. Access to most of the area by road is good, and this enabled rapid collection of many samples close to bridges etc. At each sample site handfuls of sediment were taken from several parts of the stream bed and kept in numbered kraft paper envelopes. Details of the stream dimensions, flow velocity, bank type, bed load, contamination



STAGE 2 FOLLOW UP SURVEY – MARY TAVY AREA

and topography etc, were recorded at each site. Duplicate samples were taken at a smaller number of sites for replicate analyses to determine sampling and analytical errors.

Preparation of the samples consisted of drying and sieving, and -80 mesh sieve fractions were weighed into portions for analysis for Cu, Sn and Zn. The data was processed into inherent population groups using cumulative frequency plots, and three reasonably defined populations were obtained for [1] each element. These broadly represent the geochemical backgrounds for the two main rock types, i.e. granite and sedimentary rocks, and an anomalous population possibly connected with abnormal concentrations of these elements or industrial contamination. Four sub-areas containing consistent anomalous values were selected for Stage 2 follow-up work.

Stage 2 Activities – Mary Tavy

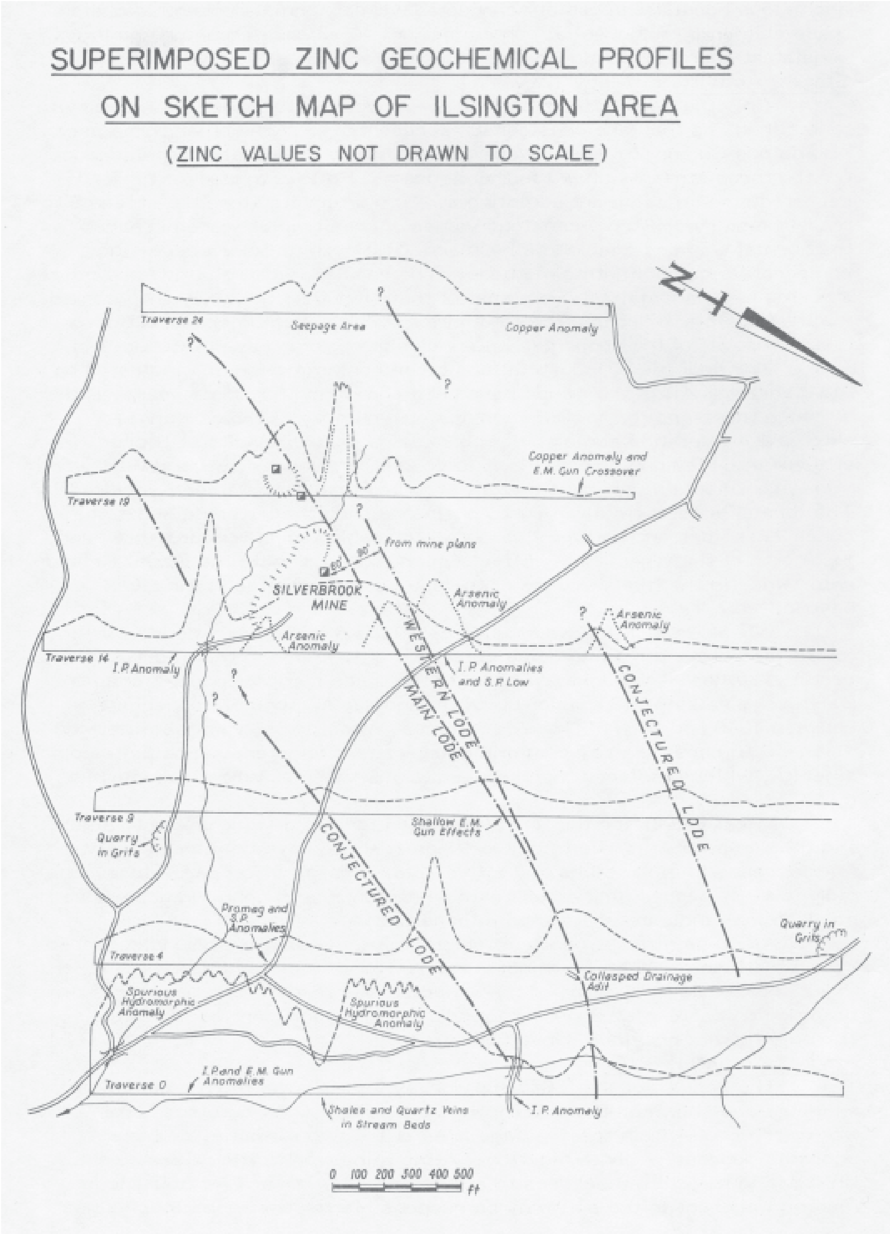
Only the results from the follow-up work in the Mary Tavy area will be outlined, as they are considered representative of the other three areas. Anomalous Cu and Zn values were obtained in the regional reconnaissance for the three streams shown in the diagram. Follow-up work consisted of repeated stream sediment sampling at 200m intervals along the streams to trace the source of the anomalous values. The samples were prepared in the normal way and analysed for Cu and Zn in a field laboratory using comparative colourimetric methods. The results, when plotted, showed the streams to be anomalous over most of their lengths, however when considering the possible sources of contamination, which are numerous in this case, most if not all of the abnormal values can be regarded as spurious.

The sources of industrial and other contamination are indicated on the diagram. All of the mines have been abandoned for some years, and although there are few visible remains of a number of the workings, extensive dumps line some stream banks and drainage adits still pour effluent into the running water. It is doubtful if Wheal Jewel and Willsworthy Mines contribute much base metal to the bed load of the stream labelled ‘A’. The former raised small amounts of tin ore, and the latter raised some cobalt arsenides and native silver. A noticeable cut-off occurs, however, just north of the Wheal Betsy Mine, which, together with the Wheal Friendship Mine, is the likely source of the spurious anomalies lasting well beyond Peter Tavy.

Wheal Betsy Mine was the largest lead mine on Dartmoor, working to 142 fathoms and raising some 1080 tons of lead ore in the mid 19th century. Wheal Friendship was one of the three largest copper mines on Dartmoor, raising 118 tons of black tin and 42,900 tons of copper ore between 1846 and 1883. The lode mined at Wheal Betsy was a ½ mile long north-south crosscourse, containing argentiferous galena, sphalerite and siderite, which displaced the east-west Cu-Sn vein at Wheal Friendship by 35 fathoms.

Metal values for the R. Tavy section tend to give consistent values, and the dumps from three mine workings seem to have only caused a twofold increase in zinc values and a five-fold increase in copper values. One more cut-off occurs further upstream whose source is unknown and whose position may indicate undetected mineralization.

As no significant geochemical anomalies indicative of undiscovered concentrations of Cu or Zn minerals were found in either this or the other three areas, the final stage of the exercise was transferred to an area near Ilsington on eastern Dartmoor known to have a significant geochemical anomaly from a previous survey of this sort.



<u>Stage 3 Activities – Ilsington</u>

The results of the follow-up survey in this area from a previous exercise are shown on the accompanying diagram. Three disused mine workings occur within the drainage area of the two streams, and are probable sources of contamination. Atlas mine worked three east-west tin lodes in the culm measures to a depth of 35 fathoms. Residual lode material present in the soil may be responsible for the anomalous values [2] at the headwaters of both streams, but the occurrence of repeated tin anomalies down the northern stream cannot be explained by any known workings and may be due to spillage from the adjacent road which was a likely haulage route.

Smallacombe Mine exploited magnetite deposits in both surface and underground workings on a lode that may have been a continuation of the Haytor lode. No copper or zinc has been reported from this mine though, and it is unlikely that the mine affected the results of the survey.

The Zinc lodes mined at Silverbrook Mine were considered to be of more interest, and it was in this area that all of the detailed work was done. The follow-up analyses for Cu and Zn showed a very good cut-off upstream of the mine, and a similar cut-off was detected in the northerly stream which indicated possible extensions of these lodes across this stream.

To assist with the collection and interpretation of geophysical and geochemical data, a number of traverse lines were surveyed across the area of interest at right angles to the conjectured lode positions. The detailed geochemical survey consisted of the systematic collection of soil samples at 50ft intervals along the traverses using a soil auger. All the samples were analysed in a field laboratory for Cu and Zn, and those from line 14 were also analysed for arsenic .

An explanation of the different geophysical exploration methods used in the detailed survey is briefly outlined below:

a) Self Potential Survey - If two porous pot electrodes are placed in contact with the ground, a voltage exists between them. This potential difference is due to chemical activity in the ground, and large potential difference of the order of a few hundred millivolts occur around many ore bodies. The results are entirely qualitative and the interpretation is difficult, with spurious readings frequently due to buried iron pipes, chemical fertilizers and mine slags etc.

The apparatus consists of two electrodes connected to a potentiometer by thin cables, one cable being very short and the other comparatively longer. This gives a near and far electrode. pair, and readings are always taken in this configuration at each station, the near electrode occupying the position previously occupied by the far electrode.

Self Potential readings were taken in this fashion along all of the traverse lines at Ilsington, the lines being closed off and the whole survey forming a loop to allow for drift corrections. Only two S.P. anomalies were found, one being due to the Silverbrook lodes close to the mine, and the other due to an area of boggy and poorly drained ground which retains a lot of metal from groundwater filtering through.

b) Proton Magnetometer survey - The proton magnetometer is a portable and robust instrument used for measuring the earths total magnetic field and any deviations due to surficial or buried magnetic bodies. Survey readings taken along the traverse lines are rapid and easy due to the push-button operation of the instrument and the digital readout. Care has to be taken to avoid railway lines, roads, culverts buildings and power lines etc. and also personal objects. Few anomalies were found along the traverses except from the interferences from artificial objects, and this is understandable considering the non-magnetic nature of the zinc and lead ore. A magnetometer survey alone would have been of little value in this exercise.

[3]

c) Induced Polarization Survey - If a current is applied to the ground with two electrodes and potential measurements are made with a second pair of electrodes, the potential should instantaneously read zero when the current is switched off. However, slower decay of potential may occur if conductors are present in the ground, e.g. electrolytes in the rocks, or metals and sulphides in ore bodies, due electrical polarization induced in the individual mineral particles.

The apparatus is bulky and complex, requiring a heavy transmitter and receiver, a generator and reels of electrical cable. However, the method is good for detecting mineralization disseminated through out a rock and is now one of the most important and widely used geophysical methods.

Several I.P. anomalies were found in this survey, but the interpretation was difficult due to the coincidence of some of the anomalies with culverts, boggy areas and roads as well as the conjectured lode positions.

d) E.M. Gun Survey - Electromagnetic methods are very useful for providing information on mineral deposits without necessary contact with the ground. The E.M. gun can be used to locate vertical or steeply dipping conductors down to a depth of 0.7 times the transmitter-receiver distance. Horizontal or gently dipping conductors can be detected down to a depth of 1.5 times the separation distance. Electromagnetic fields are generated on the surface by the transmitter staff, and secondary fields are induced by any conductors present in the ground which interferes with the primary field. The transmitter is connected to the receiver by a feeder cable and interferences in the resultant field can be measured.

The apparatus consists of simple two man operated equipment, connected by a cable commonly 100 ft or so in length. The method is sensitive to many minerals, including galena and pyrite, but like I.P. methods, ores that act as insulators e.g. sphalerite will remain undetected unless they occur in intimate association with a conducting accessory mineral. Spurious anomalies or masking effects may occur over clays, shales and waterlogged soils, especially if the water is saline. However the use of dual frequency equipment can give valuable information on the nature of shallow conducting effects.

Once again only a few anomalies were found, and only one of these coincided with the main Silverbrook lodes. The shallow E.M. profile for this survey may reflect a low pyrite and galena content of the ore, and the lodes may consist mainly of non-conducting sphalerite.

Interpretation of the Geochemical and Geophysical Results

Unfortunately, the geochemical and geophysical profiles are not as straightforward as had been hoped, and the interference by many local artificial factors makes interpretation of the results very difficult. Many of the inferences concerning the causes of anomalies are subjective, and the interpretation is only simplified by the known strike directions of the two lodes worked at the Silverbrook Mine.

Simple longitudinal sections of Silverbrook Mine are available and it seems likely that the portal of the adit marked on the section is the collapsed excavation seen two thirds of the way along traverse No.4. Assuming the lines drawn joining up the adit portal with the three shafts at the mine site approximates to the strike of the two veins shown on the [4] section, then this correlates reasonably well with the Zn and Cu anomaly peaks on traverses, 4, 9, 14 and 19.

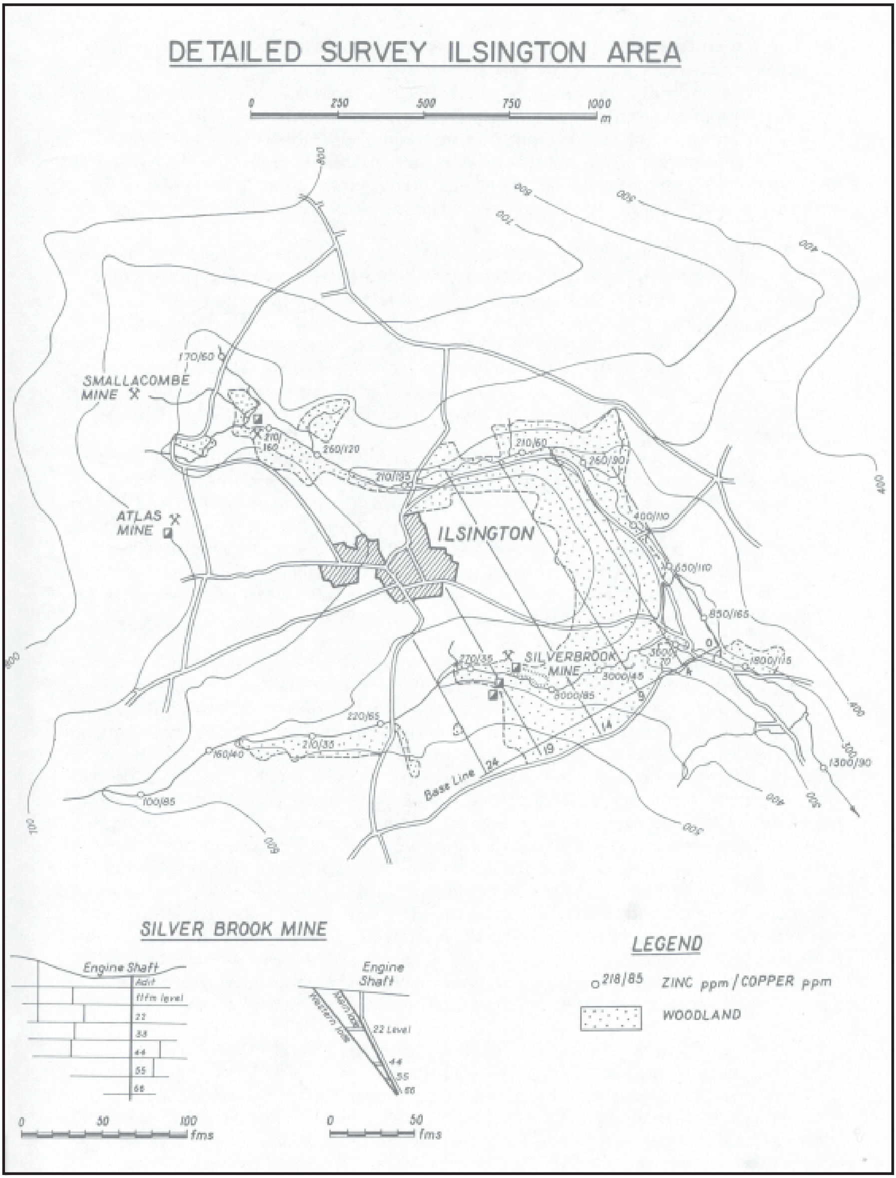
The anomaly on traverse 14 shows the best correlation, indicating a broad dispersion halo in the residual soil over the veins, with a partial lateral displacement to the west due to downslope movement of the soil. Very good I.P. readings were obtained here as well as an S.P. ‘low’. Assuming any other mineralization to be parallel to this north-east/south-west strike, two more conjectural lines may be drawn on each side of the Silverbrook veins.

Two spurious Zn anomalies form distinct peaks on the profiles of traverses 0 and 19. The anomaly on traverse 0 is extremely large with a maximum zinc content of 0.6% Zn in the soil. This abnormal zinc concentration is most likely to be a hydromorphic effect due to metal retention in the waterlogged and badly aerated boggy meadow soil. Adequate zinc is probably available in solution from trapped mine water filtering out of the collapsed adit a little way upstream. Similar causes can be assumed for the spurious anomaly in waterlogged soils below the mine shafts on traverse 19.

The geochemical profiles for copper generally follow those for zinc and the slightly displaced anomaly peaks reflect the more restricted mobility of the element. A few Cu anomalies occur where there are no Zn peaks, particularly at the ends of traverses 19 and 24. The cause for these anomalies can only be assumed to be dolerite dykes. The mobility of arsenic in the area will be limited by co-precipitation with limonite in the soils, and the low arsenic peaks on line 14 correlate very well with the two known Silverbrook lodes and the two conjectured lodes.

Conclusions

The value of preliminary research and local knowledge of abandoned mineral workings in an exploration program is evident from this exercise. The numerous sources of contamination and interference made most of the geophysical results unreliable and the interpretation of the geochemical data more difficult. Geochemical soil sampling methods, particularly the arsenic estimations, proved to be by far the most useful in



delineating four linear zones of mineralization. The zones of mineralization are assumed to be of vein type and parallel to the strike indicated on the mine records.

From the relative sizes of the anomaly peaks on the geochemical profiles, it would appear that the most important area of mineralization, i.e. in the vicinity of the Silverbrook Mine, is already worked out. However, it would be recommended that detailed arsenic estimations be made on the other traverse lines before any further work is done or before the hypothetical prospect is abandoned. Analysis of soil samples for lead would also be recommended as this relatively immobile element may have a similar resolving potential for Zn-Cu-Pb vein type mineralization in this kind of terrain.

Finally, as a postscript, I would mention that further information acquired from more detailed geochemical surveys carried out by the Department of Geology at Leicester in 1975 upheld the general conclusions from the 1974 fieldwork. The Department now feels, however, that the mineralization at Silverbrook is more likely to exist in pockets, possibly en echelon. Such an orebody geometry would obviously make the geochemistry difficult to interpret, and would not be apparent from the less detailed results of the 1974 survey.

[5]

Acknowledgements

I would like to record here my thanks and appreciation to the Geology Department of the University of Leicester for permission to publish this article. Special thanks are extended to Dr. C.H. James, Dr. A. Khan, Dr. J. O'Leary and Dr. P. McGuire for their reading of this manuscript and for their helpful and entertaining supervision of this field exercise.

I would like to emphasise, however, the non-academic nature of the work and the article, the generality of the conclusions, and the fact that the paper is based solely upon a student project.

References

Dearman, W.R. 1962, Geologists Association Guides, No.33 Dartmoor.
Edmonds, et al 1968, Mem. Geol. Survey, Okehampton Sheet No.324.
Reid, et al 1912, Mem. Geol. Surv, Dartmoor, Explanation of Sheet No.338.
Ussher, W.A.E. 1913, Mem. Geol. Surv, Newton Abbot, Explanation of Sheet No.339.