

The new Ventilation laboratory which is still, after a year or more, not completely equipped and in use, would provide excellent facilities for ventilation and support studies.

During the Christmas vacation of this year, students of the Third Year visited South Wales and the Bristol area. The tour included visits to several coal mines, a coking plant and the Mond Nickel refinery at Clydach, South Wales, and the Imperial Smelting Company at Avonmouth.

Next year it is hoped to visit places of interest in the Midland area, centered on Nottingham, including a possible visit to the oil-field at Eakring.

The financial strain on the student's pocket has been somewhat relieved by subsidies from the School and from a generous mining company. Another great saving resulted from the accommodation made available at the Halls of Residence of the Universities of Bristol and Wales. The advantage of moderately priced accommodation is offset by the fact that visits are restricted to areas in which a university or the like, is situated.

The other new vacation course took the form of a Geochemical Prospecting Camp. The purpose of this Easter camp was to acquaint the student with the hazards of geochemical prospecting and Banka drilling in realistic conditions. The camp was a complete success despite the inclement weather. The site at Castle-an-Dinas was only a short distance from Camborne and at the slightest hint of rain there was a mass exodus from the camp of students seeking home comforts and a sound roof over their heads.

During the year there have been numerous rumours relating to the incorporation of the School into the organisation of the Cornwall Technical College. At the School Dinner Mr. J. G. Harries, the Secretary for Education of the County, clarified the position by stating that the County Educational Committee had no intention of taking over the control of the School and that the existing arrangements would remain.

Although there is a lot to be said for the School remaining independent, association with the Technical College would be fully justified if, by the association, better working conditions and facilities were made available to the students. At the moment conditions at the School leave a lot to be desired.

After reading through the magazine, provided that the reader has the will-power to do so, it will be seen that we are not so humorous as usual. The reader will have to content himself with the excellent technical articles.

Further Applied Geochemical Studies in the Vicinity of Castle-an-Dinas Wolframite Mine, Mid-Cornwall

BY

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P. G. CURTIS, A.C.S.M.

Synopsis

RECENT applied geochemical studies involving the determination of tin, tungsten and arsenic in soil samples from the northern flank of Castle-an-Dinas have demonstrated the close relationship between the known distribution of these elements in the mine and in the soil-cover.

The results also suggest that the main lode may extend under the fields immediately to the north of the mine. However, if this is so it has been displaced by some 370 ft. to the west and is sub-economic — certainly near the surface.

During the Easter Vacation 3rd-year students of the Camborne School of Mines spent a week in the vicinity of the idle Castle-an-Dinas wolframite mine in order to gain experience in the application of various methods of prospecting under realistic conditions. The results of one of the exercises form the subject of this paper. Briefly, the exercise involved investigating the distribution of tungsten, tin and arsenic in the soil over the northern flank of Castle-an-Dinas with a view to determining to what extent the distribution patterns of these elements in the surface cover reflect their known occurrences in the mine. It also aimed at discovering if the main lode extends under the fields immediately to the north of the mine, and if it did, tracing it northwards.

General geology of the area.

Although both the superficial and underground geology of Castle-an-Dinas have been described in some detail by Kear (1951-52, pp.129-140) and Dines (1956, pp.521-525) the following brief account is a necessary prelude to the main theme of this paper.

Castle-an-Dinas, upon which the wolframite mine stands, is 703 ft. O.D., and just to the north of the Hensbarrow granite mass from which it is separated by the high-level tin-bearing alluvial flats of Goss Moor. The hill is composed essentially of thermally metamorphosed slate, of Lower Devonian age, which dips steeply northwards, is often highly contorted, and in the vicinity of the main lode and its companion veins is intensely tourmalinised. Both the

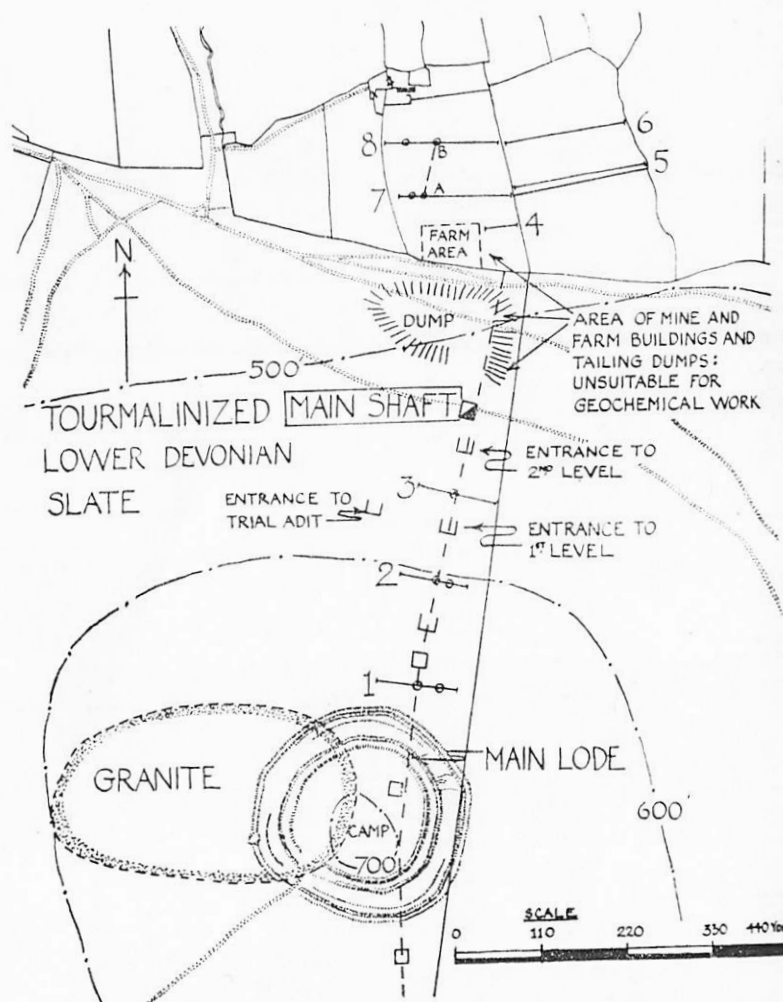


FIG. 1. Sketch plan of the northern part of Castle-an-Dinas wolframite mine showing the lines along which soil samples were taken. Tungsten-high soil zones are indicated by points enclosed in circles.

slate and the veins have been penetrated by a granite tongue which outcrops as an oval just to the west of the apex of the hill (fig. 1). Over the higher uncultivated parts, the soil, which varies from c. 6 to 18 in. in depth, consists essentially of humus-rich A horizons — in all a few inches thick — and an underlying B horizon of brown clay. A more typical brown earth profile has developed on the

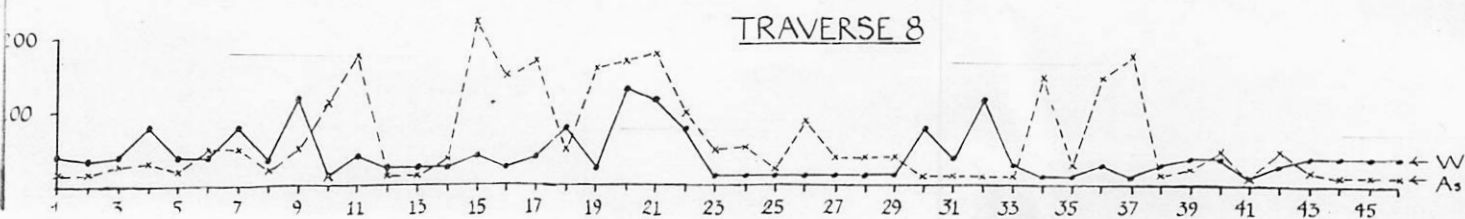
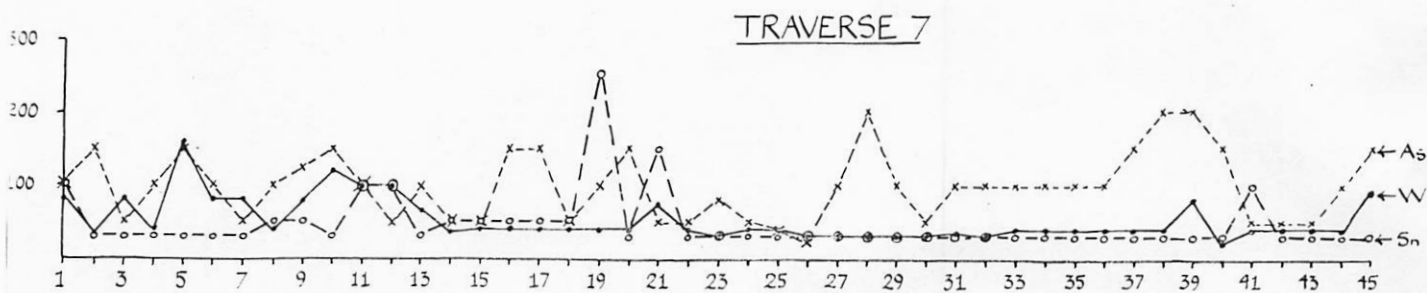
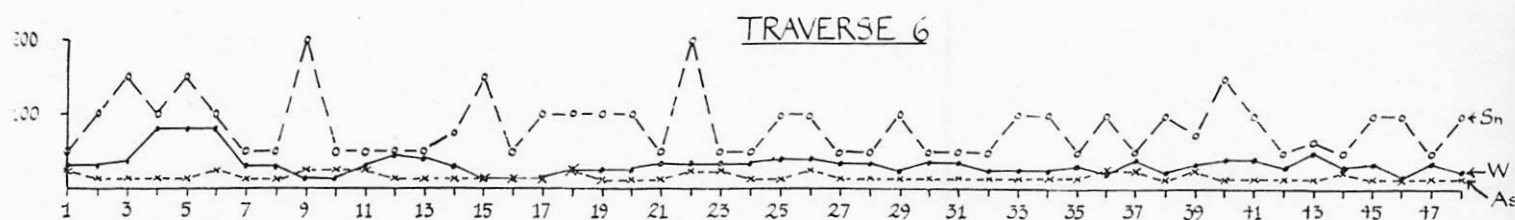
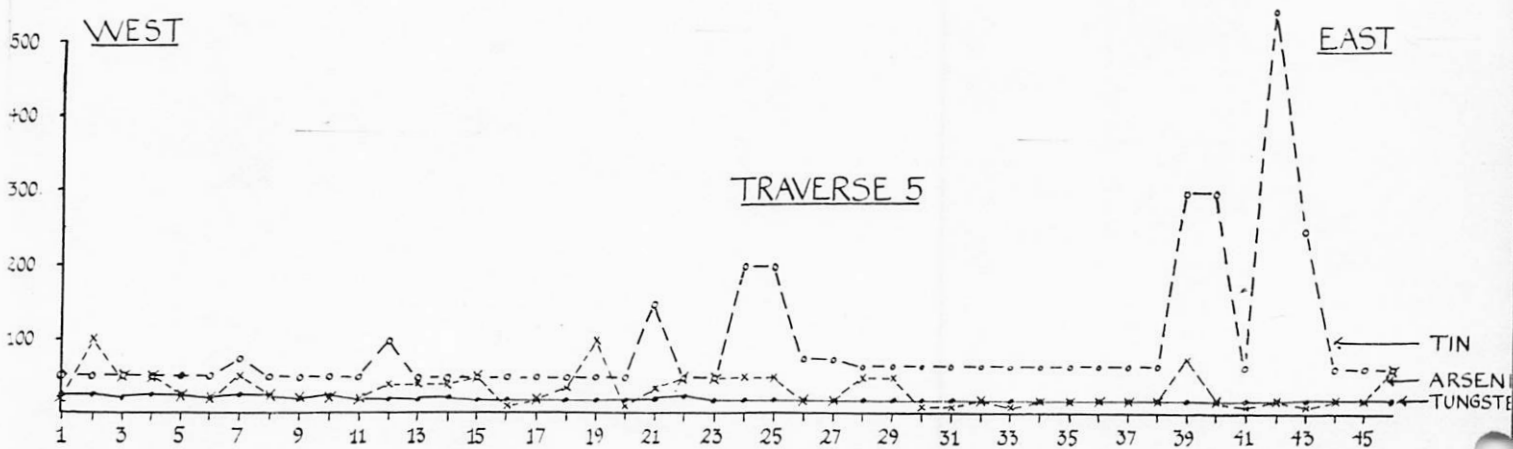
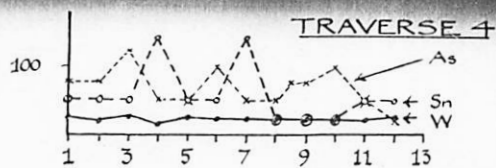
lower farmed land and there the soil may be 30 in. thick. The crown of the hill is covered with heather and other lime-hating plants, whilst the lower levels were, during the study period, in grass.

The superficial horizons of the hill-top were much disturbed in the early Iron Age when the circular banks and ditches there were engineered. Further disturbance of the ground has occurred — particularly on the northern slope — as a result of prospecting and mining during the past 40 years.

The underground workings extend in an approximately north-south line under the crest of the hill and are situated along the strike of the near-vertical main lode, which has developed along a shear fault, and from which most of the wolframite has been obtained. It varies in width from a few inches to 3 ft., but in the steeper it is usually from 18 to 24 in. wide. Towards the southernmost limits of the mine the lode splits into a series of small wolframite-impoorished stringers, whilst in the northern workings it also becomes distinctly poorer, and there it has been displaced 12 ft. to the right by one east-west fault, and 12 ft. to the left by another. It consists essentially of wolframite and quartz, but considerable quantities of loellingite occur in some horizons, and zinnwaldite, phlogopite, tourmaline, fluorite, topaz, native bismuth, bismuthite, russellite, wavellite, native copper, cuprite, scorodite, rashleighite and cassiterite have been recorded. The last mineral occurs in small amount in the wall-rock and in minor veins near the main lode much more commonly than in the main lode itself. Despite the presence of an unusual suite of species which have developed in the zone of oxidation, the ore-body has not been greatly altered by supergene agents, and near the hill-top much practically fresh wolframite has been won from just below the surface. Although the main lode, in common with all the other veins in the mine, is earlier than the granite tongue, yet the richest ore haloes this intrusive, and the distance from the surface to material of economic grade increases as the lode is traced north and south from the crest of the hill. (fig. 2). This suggests that the ore developed over a granite cusp (as it did, for example, at the Aberfoyle Mine, Tasmania), but at Castle-an-Dinas the 'parent' igneous mass has been obscured by the emplacement of the later granite tongue. The smaller, partly-developed ore-shoot in the northern section may have developed over a subsidiary cusp on the flank of the main one.

Within the mine Kear (op. cit.) recognises the following additional lode and vein systems which are earlier than the main lode and are economically unimportant, but which cannot be ignored during a geochemical study as some of them contain wolframite and other heavy minerals.

- (1) **Early relief quartz veins.** These strike at 85 deg., are approximately parallel to the local cleavage, and like it they dip steeply northwards. They are



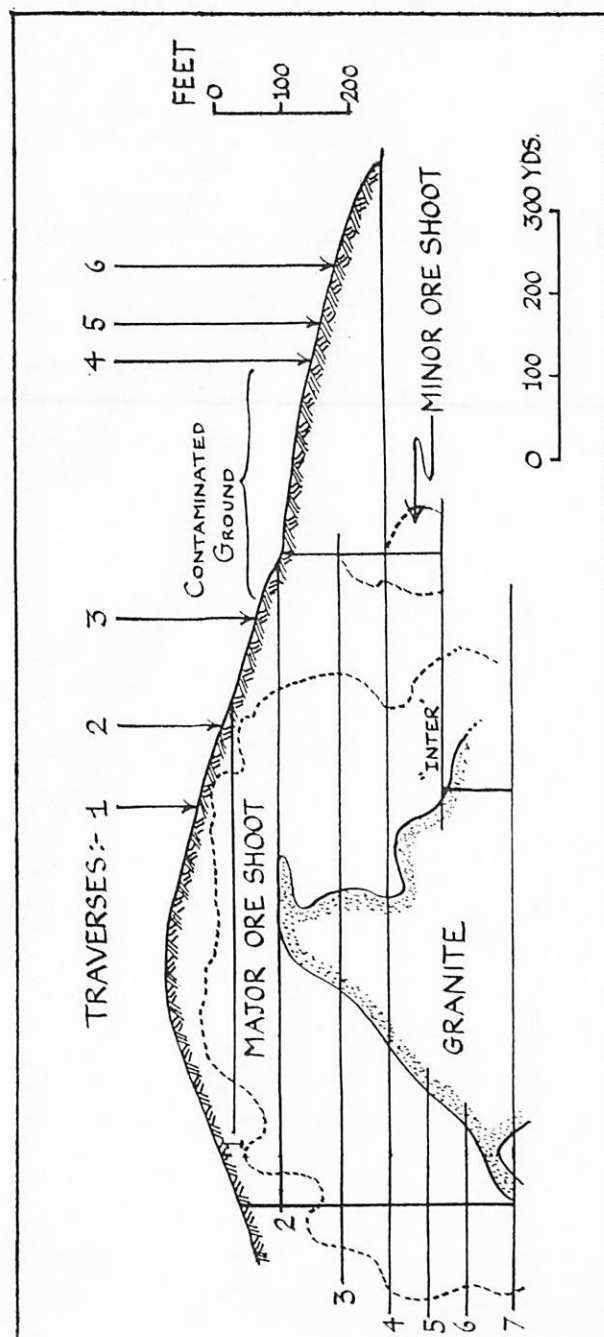


Fig. 2. Section along the Main Lode at Castle-an-Dinas Mine, showing the steeper areas, the post-lode granite intrusive and the approximate positions of the geochemical traverses.
(Based on a section at South Crofty Mine, Ltd.)

- (2) **Early tension fracture lodes.** These narrow lodes strike at 350 deg. (plus or minus 5 deg.), dip steeply westwards, and contain quartz, together with a little wolframite.
- (3) **Early shear lodes.** These are represented by two sets of lodes which strike at 325 deg. and 15 deg. respectively, but the latter is the much better developed. These, essentially quartz veins, contain a greater percentage of wolframite than the earlier lodes, and both tourmaline and pale-green mica are sometimes present.

Field and laboratory work.

Earlier geochemical studies on the south of the hill (Hosking and Montambeault, 1956) demonstrated that the determination of tungsten in the minus 80-mesh fraction of samples taken from the B horizon at points 20 ft. apart on appropriately-spaced traverse lines enabled the main lode to be traced well beyond its economic limit. They also showed that even the presence of a series of small wolframite-bearing veinlets could be revealed by this means. Therefore, during the recent investigation essentially the same procedure was adopted, but as it was decided to study the dispersion characteristics of tin and arsenic, in addition to those of tungsten, and as tin was adjudged to be present in comparatively small amount, and, in any case, would be unlikely to have moved far from the parent deposit, it was decided to restrict the sampling interval to 10 ft.

Samples were taken along traverses 1, 2 and 3 in order to determine, primarily, the extent to which the tungsten, arsenic and tin distribution patterns in the soil reflected the known distribution of these elements in the mine, and also to locate any parallel lodes and to evaluate the effects of any contamination due to the construction of the Iron Age camp and to comparatively recent prospecting and mining activities. Traverses 4, 5 and 6 covered the ground in which any northward extension to the main lode was most likely to occur in the view of the owners, whilst traverses 7 and 8 were established in order to locate the lode should it have been displaced to the left as a result of faulting. (The comparatively large gap between traverses 3 and 4 is due to the fact that the intervening ground is occupied by mine and farm buildings, dumps and roads. This has prevented samples from being taken over the comparatively deep-seated minor shoot—a fact to be regretted as these results would have facilitated the interpretation of those obtained from samples taken along the more northerly traverses.) These traverses were laid out by tape and compass, and augers were used to obtain the samples which were stored in resin-impregnated envelopes. The minus 80-mesh (B.S.S.) fraction was subsequently analyzed by students under the direction of one of us (P.G.C.) in a temporary field laboratory. Tungsten was determined by the

D.S.I.R. dithiol method (North, 1956), tin by a modification of Wood's gallein method (Stanton and McDonald, 1961) and arsenic by a modified Gutzeit method (Almond, 1953).

Discussion of the results. (See figs. 3A and 3B.)

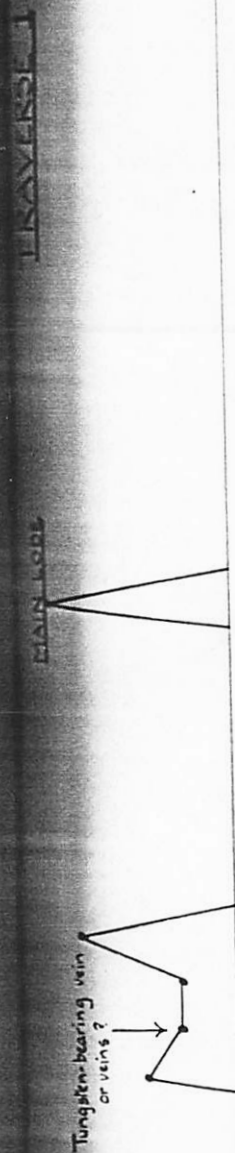
When the plotted results of the analyses of the soils from traverses 1, 2 and 3 (i.e., from the ground over the intensely-mined northern flank of the hill) are compared with the known distribution of wolframite, loellingite and cassiterite in the mine, it is evident that the former reflect the dominant characteristics of the latter very clearly. Marked tungsten anomalies indicate the precise position of the main lode — even along traverse 3 which is situated over a part which is too poor in wolframite to be stoped. The tendency for cassiterite to prefer veins other than the main lode is indicated by the distribution of tin along traverse 1, and even more markedly along traverse 2. That cassiterite does, on occasion, occur within the main lode is suggested by the coincidence of the tin and tungsten anomalies on traverse 3. The occurrence of wolframite and loellingite in veins other than the main lode is indicated particularly clearly by the minor tungsten and arsenic anomalies bordering those due to the main lode on traverses 2 and 3.

The possibility that contamination may be largely responsible for the generally high tungsten values over the whole of traverses 1 and 2 needs careful consideration. Certainly the engineering of the banks and ditches of the Iron Age camp (which is over the richest part of the main lode, and just where high wolframite values occur immediately beneath the soil) must have resulted in a considerable local dispersion of tungsten-rich debris. However, this dispersion was largely confined to the camp itself as the material taken from the outermost ditch was used to construct the bank inside it. Furthermore, along traverse 1 there is no evidence (such as a buried A horizon) that material from the camp site was placed there.

Unquestionably the extensive prospecting and mining activities over the northern slope have been responsible for the development of a number of contaminated spots: however, these are restricted in size and can be fairly easily recognised, and excepting near trial pits, adits and shafts the contamination is virtually confined to the uppermost soil horizons.

A certain amount of ore also fell from the north-south aerial conveyor system, particularly near the pylons where the buckets were jolted as they passed by, and, in addition, some wolframite, etc., must have been transferred from the boots of the miners to the numerous paths which criss-cross the hill.

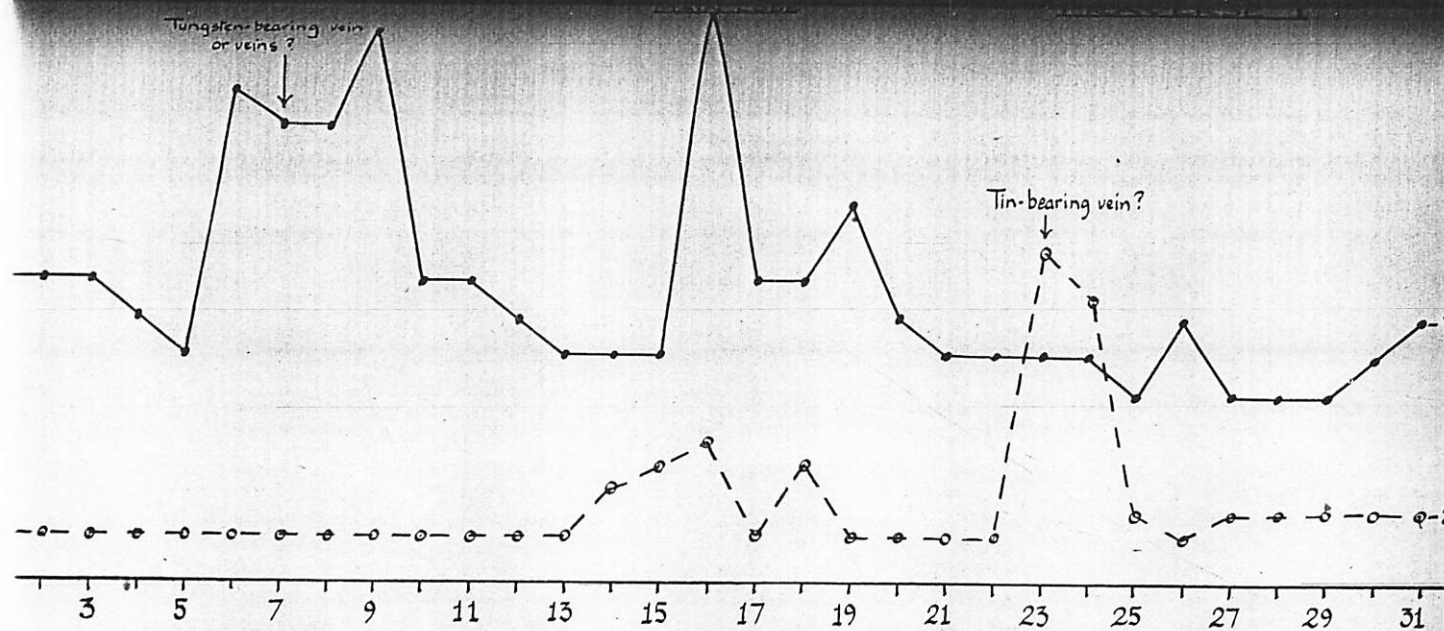
Naturally, the traverses were sited with a view to avoiding, as far as possible, contaminated zones, and despite the fact that there are many such places the writers believe, for reasons given above,



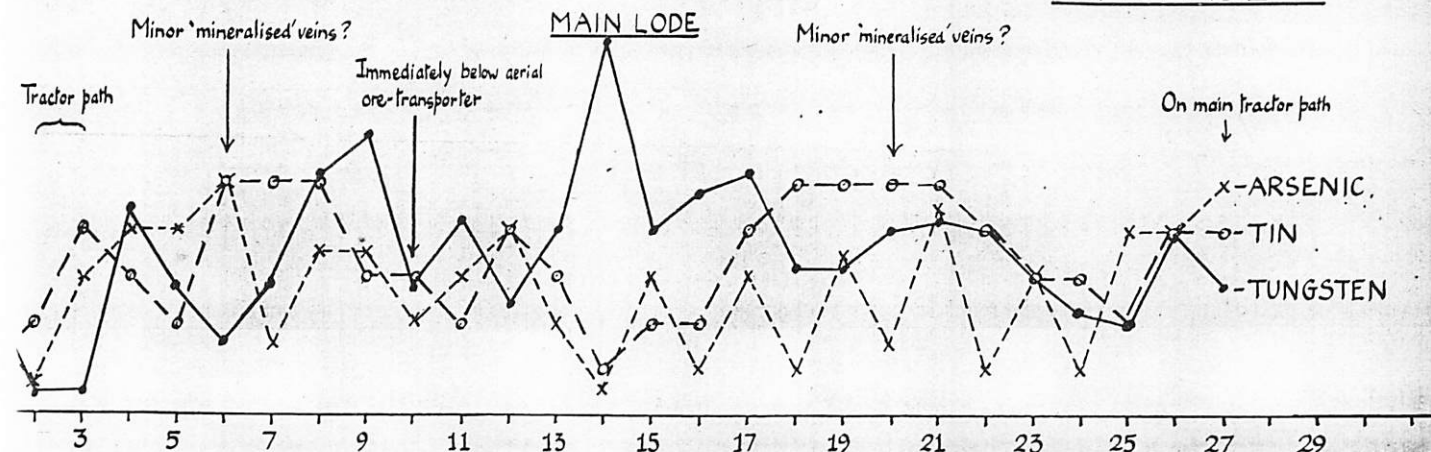
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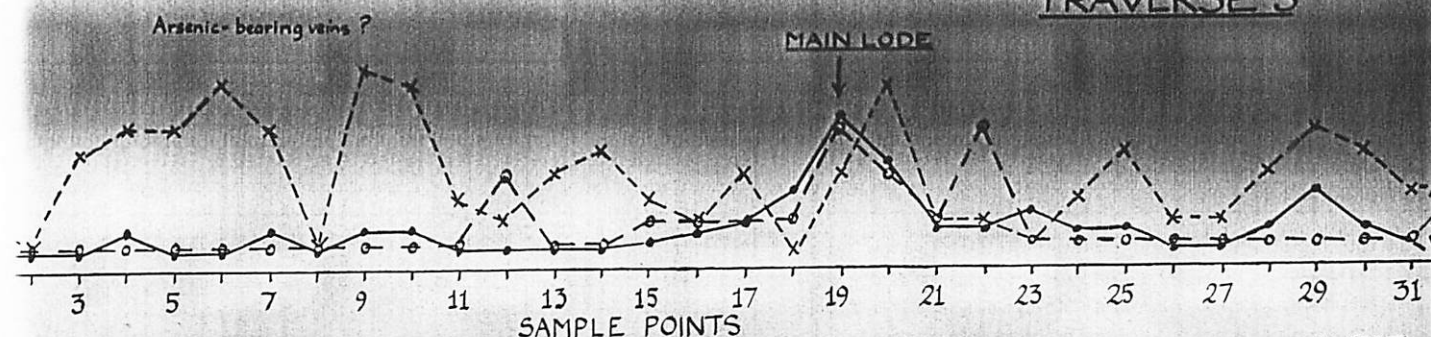
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TRAVERSE 2



TRAVERSE 3



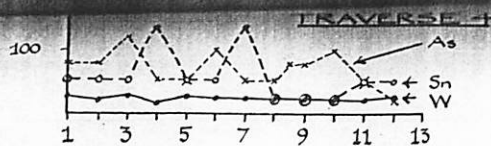
SAMPLE INTERVAL :- 10ft.

ALL SAMPLES TAKEN FROM THE B HORIZON

MINUS 80-MESH (BSS) FRACTION ANALYZED

ASSUMED BACKGROUND VALUES :- W, c. 12 ; Sn, c. 25 ; As, <10.
(parts per million)

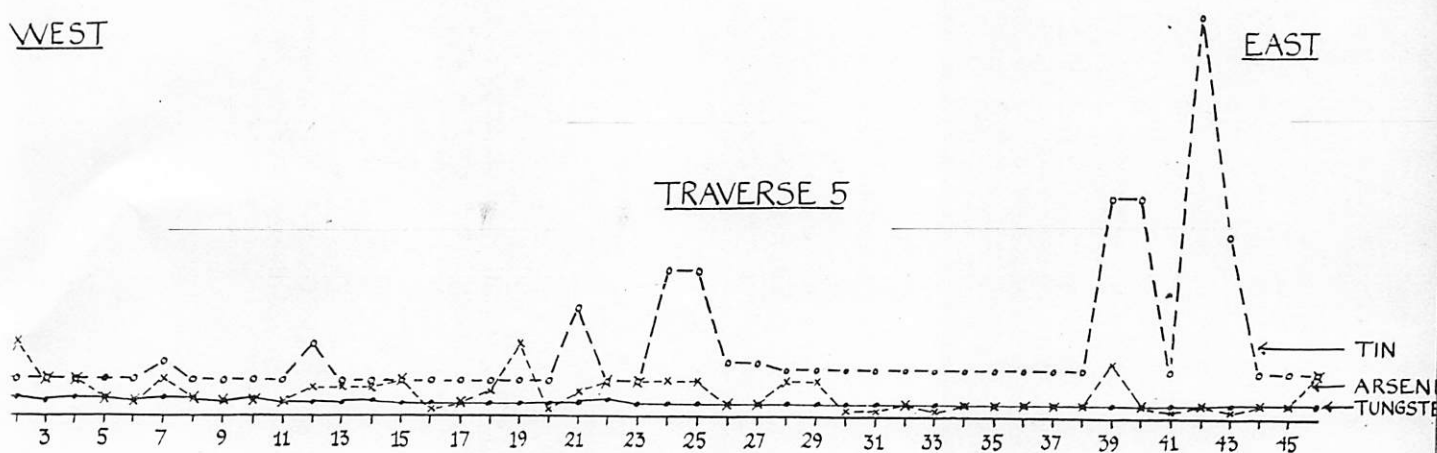
FIG. 3A. Graphs showing the distribution of tungsten, tin and arsenic in the soil over the intensely-mined northern portion of the Castle-an-Dinas wolframite lode.



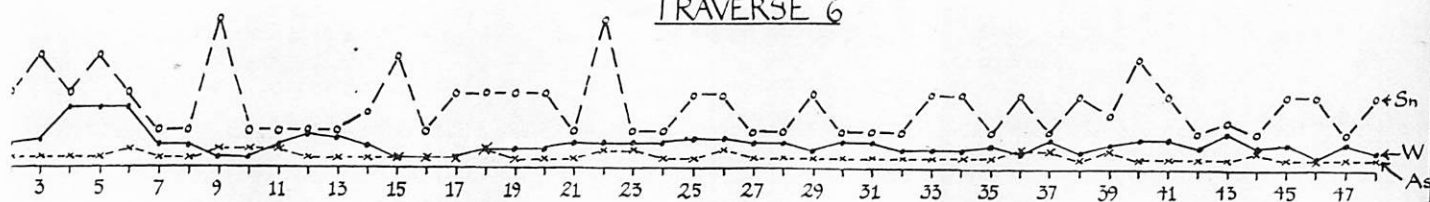
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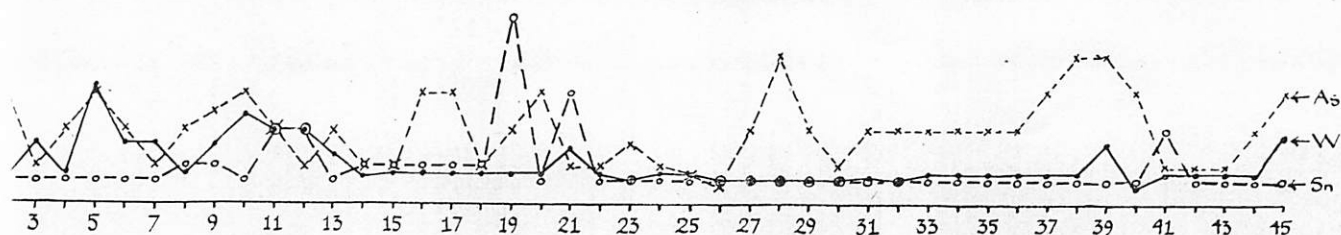
TRAVERGE 5



TRAVERGE 6



TRAVERGE 7



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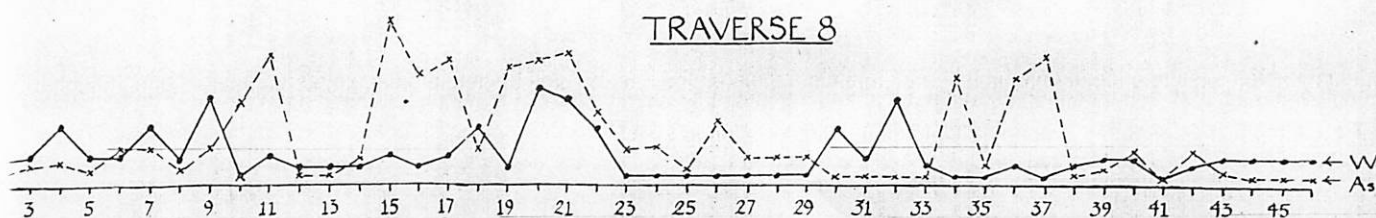


FIG. 3B. Graphs showing the distribution of tungsten, tin and arsenic in the soil immediately to the north of Castle-an-Dinas wolframite mine.

that the values recorded are due, virtually entirely, to the distribution of the elements in question by 'natural' causes. At no sampling point was there any evidence that the B horizon had been previously disturbed by man, and even worms, which might effect the transportation of 'erratic' wolframite from the surface to the deeper horizons avoid the stiff, poorly-aerated clay-rich zone. This means that contamination of the B horizon could only have arisen as a result of the downward migration of tungsten, arsenic and tin in solution. That this has taken place is very unlikely because although it must be conceded that the tungsten of wolframite and the arsenic of loellingite can be mobilised by weathering agents, the tin of cassiterite would not be — at least to any appreciable extent. So, as tin anomalies flank the main lode anomaly, and as anomalous arsenic and tungsten values, on occasion, coincide with those of tin, it is reasonable to assume that all are due to the liberation of these elements from the underlying veins and country rock. It is also clear from the examination of a number of ore-containing blocks scattered over the hill-side that the wolframite has suffered no obvious chemical attack since it was mined, whilst the loellingite which has been attacked, has, for the most part, simply been partly converted to scorodite. Finally, it is to be expected that the flanking veins should be most heavily mineralised where they are adjacent to the richest parts of the main lode, and so it is reasonable to find considerably higher tungsten values along traverses 1 and 2 than along those further to the north. It would have been worthwhile extending traverses 1 and 2 considerably beyond their present limits but a number of factors militated against this.

No significant anomalies occur on those parts of traverses 4, 5 and 6 which cover the soil beneath which any northward extension of the main lode was most likely to lie. There are three possible explanations for this: firstly, the lode may have died out to the south of traverse 4; secondly, it may continue, undisturbed to any great extent by faults, into this area, but it may be so impoverished near the surface in tungsten, etc., that it has failed to enrich the overlying soil in the elements in question to any marked extent; thirdly, it may extend into this northern area and may still be sufficiently rich in wolframite near the surface to give rise to distinctly anomalous tungsten values in the soil but it may have suffered considerable displacement as a result of faulting. None of these possibilities can be entirely discarded, and should the second be the true solution then economic ore could occur in depth, and, in this connection, it is worth emphasising again that the distance from the surface to the ore shoots increases as the distance from the crest of the hill increases. However, the geochemical work lends strongest support to the third possibility as two distinct anomalies (labelled A and B on fig. 1) occur in the western part of this horizon zone. The one is on traverse 7 and the other on traverse 8, and the line joining these is approximately parallel to the strike of the mined

portion of the main lode. Thus it seems that the main lode may have been displaced some 370 ft. to the left by faulting. Although faulting, as noted earlier, has displaced the lode within the northern confines of the mine, the displacement has been on a very modest scale, and so, after all, the anomalies A and B may be due, not to the main lode, but to a parallel vein. Certainly the magnitude of these anomalies—which, so far as tungsten is concerned are smaller than that on traverse 3 over a sub-economic part of the main lode—suggest that this body would be of no economic importance—at least, near the surface.

Acknowledgements.

The writers wish to thank the Directors of South Crofty Mine, Ltd., who own Castle-an-Dinas Mine, for permission to publish this paper. They also wish to express their gratitude to the farm-owners for allowing them access to their fields. To all the students who worked so diligently in the field and the laboratory they extend their thanks.

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High Finance

BY D. BRIGGS, A.C.S.M.

THE purpose of this article is to describe some fields of investment and to offer financial advice to graduates newly entering the mining profession.

The information which I am giving applies to the United Kingdom. Engineers abroad must either find parallel investments in the countries where they are working or, for those with family ties in Britain, arrange to have purchases made on their behalf in this country.

Broadly speaking the main classes of investment are :—

1. **Fixed Interest** — Where the return does not vary from year to year. These may be sub-divided into :—

(a) **Capital Assured** — Where there is no chance of capital gain or risk of capital loss.

e.g. Mortgage loans to local authorities.

Government Defence Bonds.

National Saving Certificates — free of British income tax.

Deposits with Building Societies. If choosing a Building Society do not be drawn by the tempting rates of interest offered by various small concerns. Accept a little less return from one of the larger Societies and have complete security. Note that Building Society interest as quoted is free of normal British income tax.

Endowment assurance policies. It is my opinion that, where the investor has no need to consider dependants, insurance policies are a poor investment in spite of usual income tax allowances.

(b) **Capital Not Assured** — Where the capital sum invested will tend to vary according to whether money is 'cheap' or 'dear' and according to the general pattern of supply and demand on the Stock Exchange.

e.g. Government stocks. Dated Government stocks, i.e. those which have a date when they will be redeemed at a definite price, can be attractive since they often offer the chance of a good tax free capital gain besides a fair annual interest. Undated Government stocks can be tricky. After the last war, when interest rates were low the Government issued large amounts of low interest undated stocks to the unsuspecting public. Now, some fifteen years later, interest rates have nearly doubled with the result that the capital value of some of the stocks has just about halved, thus causing enormous capital losses to the holders, quite apart from the inflation effect which is described later. Interest rates now seem fairly well static at about 6%, therefore current purchases of undated stocks