Geochemical Surveys in Cornwall

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A comparison of the results of two independent surveys of the copper content of the sediments of certain Cornish streams.

During January, 1961, and again in July, 1963, the copper contents of sediments from certain streams draining the Sn/Cu/Pb/Zn fields of the St. Agnes/Perranporth district of West Cornwall were determined. The studies were made by two quite independent groups, but each analysed the minus-80-mesh (BSS) fraction and used the name analytical method.

The results were strikingly similar and indicate that in an environment of the type found in the study area the copper distribution pattern of stream sediments shows little variation over a period of several years or from one season to another.

The close agreement of the results also suggests that copper may be added to the sediments at a more-or-less constant rate and that the combined action of the "mechanisms" which determines the character of the finer fractions at any given point may remain, over a period of 2—3 years, virtually constant.

Introduction

IN the summer of 1963 the writers, as part of an extensive investigation of the distribution of heavy metals in the superficial deposits of the tin/copper/lead/zinc fields of the St. Agnes/Perranporth district of West Cornwall, determined the copper content of the *minus*-80-mesh (BSS) fraction of sediments from all the streams there.

After the work had been completed, Mr. R. G. Taylor, a geological research student of the Imperial College of Science and Technology, London, mentioned that during January, 1961, under the direction of Dr. Tooms, he and several others who were then taking the D.I.C. course in mineral exploration had also determined the copper content in the *minus*-80-mesh fraction of sediment samples collected from the same streams and that the same dithizone method of analysis had been used. There was, however, a slight difference in the collections of samples, in that whilst Taylor and his co-workers selected the finer material from the middle of the stream, the present writers invariably sampled across its whole width.

By chance, many sampling points were common to both investigations and the remarkably close agreement between the copper content found on each occasion at most of these points prompted the writing of this paper. As far as the writers are aware a similar case history does not occur in the literature.

The area (Fig. 1) consists essentially of non-calcareous Devonian sediments which were invaded by granite magma in Permo-Carboniferous times, and outcropping granite occurs at St. Agnes and Cligga. It is probable that the St. Agnes and Cligga granite cusps are the "high spots" of an otherwise buried ridge with an undulating crest-line which trends approximately N.E.—S.W. between St. Agnes and Perranporth and then swings eastward towards the St. Austell granite mass.

Economic Geology

The area contains numerous lodes which are genetically related to the granite and which for the most part strike approximately N.E.—S.W. Primary zoning is very marked in the area so that, in plan, the tin-rich lodes lie within, or close to, the emanative centres of St. Agnes and Cligga and these are in turn surrounded by a zone in which copper lodes are dominant, this then being bordered by the lead-zinc zone.

In Pliocene times all the area, apart from the "island" of St. Agnes, was submerged and that the latter was then an island is indicated by the littoral deposits of that age which now surround it.

During the subsequent emergence of the land in stages, the near-N-S river systems developed. These intersect many of the lodes of the district, and as might be expected from their age, the valleys they occupy are still comparatively immature.

Although the post-Pliocene history of the area is considerably more complex than what has been said above would suggest, to deal with it in any greater detail here would serve no useful purpose.

Stream Sediments

The heavy-metal content of the stream sediments is in part derived from neighbouring or intersected lodes by wholly natural processes, but probably the greater part of that of the active sediment fraction is due directly or indirectly to the intensive mining activity which once characterised the district.

When the mines were working, large quantities of tin, copper, etc., were added to streams by way of tailings from the far from perfect mills, and subsequent to the closure of the mines further additions were made during the operation of small mills designed to recover cassiterite from the dumps of waste mine rock. In addition, surface water is constantly transporting solid material from mine dumps into bordering streams, together with metals in solution which have been leached from these accumulations of rock.

Finally, water emerging from adits is continually adding appreciable quantities of metals in solution, particularly copper and zinc, to the streams, and it is probable that much of the dump- and adit-derived metals which reach the streams in solution are rapidly transferred to the sediments by being absorbed on to colloidal material.

Discussion of the Results

The entire results obtained from both teams are shown on Map 1, but in addition, the copper contents of samples taken by each from approximately the same locations have been collected, for ease of reference, in Table 1.

When the degree of accuracy of the analytical method ($\pm$ 20 per cent at the 95 per cent confidence level over the range of 3 to 10,000 p.p.m.Cu.) is borne in mind it is clear that the level of correlation between the two sets of results is of a surprisingly high order.

From the point of view of the applied geochemist this is of considerable importance, because it indicates that in a climatically and otherwise similar area to the one under discussion, he can, if he is concerned with the distribution of copper in the *minus*-80-mesh fraction of stream sediments, collect his samples over a period of several years and at any season, and still get results which are strictly comparable. Whether the same applies to other metals has yet to be demonstrated, but it is likely that those which like copper are added to the drainage systems largely in solution, or adsorbed on colloids, may well behave in much the same way as does copper.

The results are also of particular importance to those who are interested in the nature of metal dispersion patterns in stream sediments. It is certain that the active sediments are always being transported to the sea, so that the sample taken from a given point on a stream in 1963 is not a fraction of the sediment which was there in 1961. If then the copper contents of the samples taken in 1961 and 1963 from the same point are essentially the same this must mean that copper is being added to the active sediments at a more or less constant rate, and that the "mechanisms" controlling the transportation and local concentration of the finer fractions of the active sediments must also have operated in an essentially constant manner during the period of the study.

In the writers' opinion a constant supply of copper to the sediments can only be achieved by the addition of copper-charged water to the stream system followed by the removal of the copper in a constant manner, largely by adsorption on to colloids. It is thought that the copper-charged water responsible for the copper in the sediments is essentially ground water which is discharged as seepages and from springs and adits into the stream systems, as additions from such sources would be made at very frequent intervals, if not continuously, throughout the year. Additions of copper made by surface

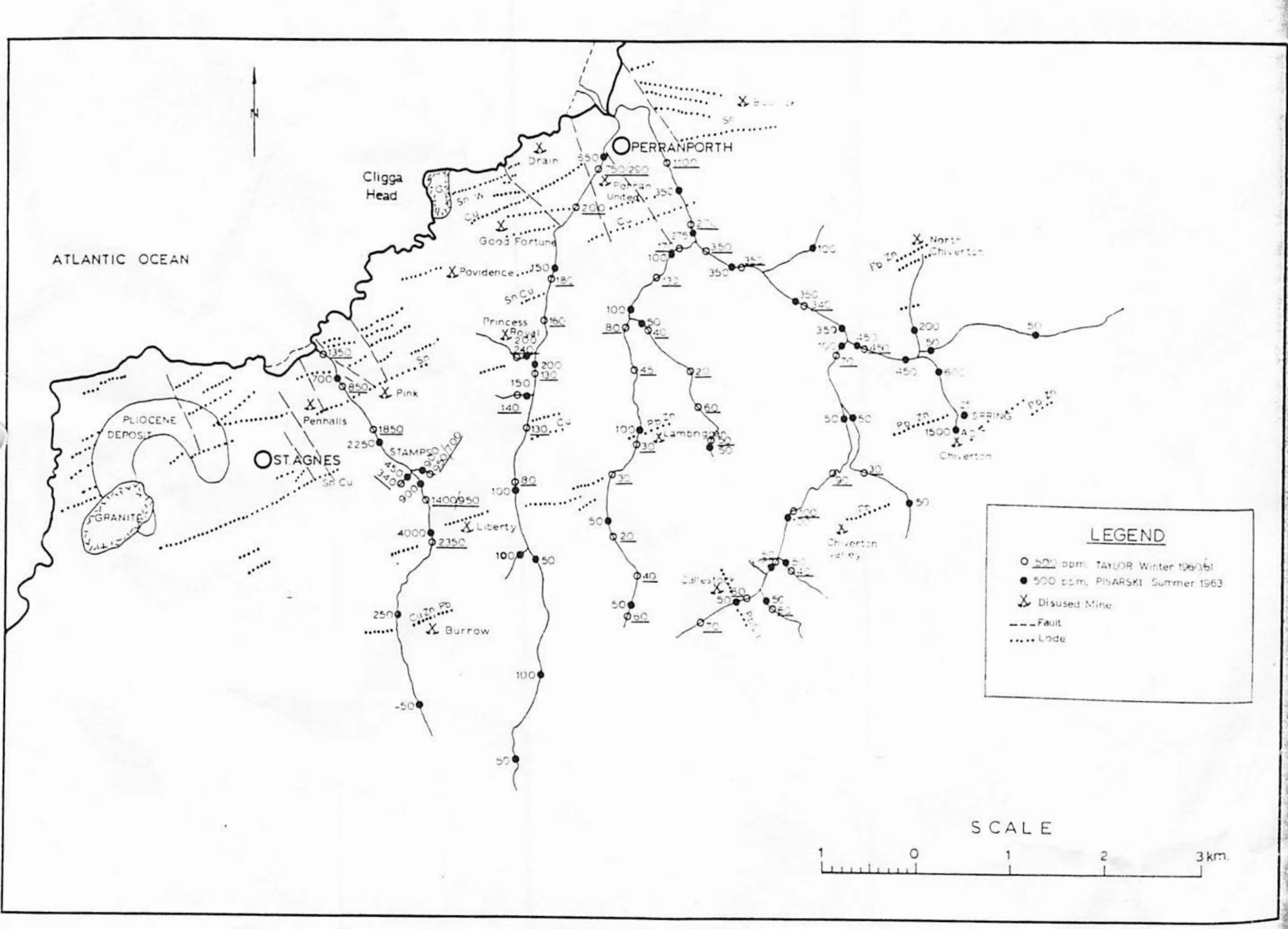

Fig. 1. Copper content of sediment samples in the St. Agnes-Perranporth streams

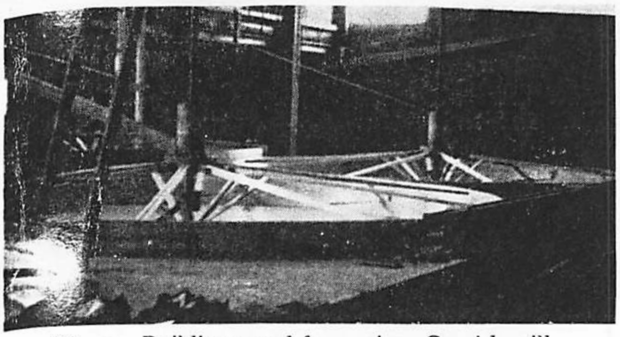

Fig. 2. Building round frames in a Cornish mill.

un-off from dumps following periods of rain would be much nore irregular, and as such water is only in contact with opper-bearing solids for a very short space of time its copper ontent would be relatively small. Similarly, additions of olid copper-bearing matter to the stream systems, as a result f surface run-off, wind, and gravity, would also be made in a ery irregular way, and, because of the heterogeneous nature f the dumps, the copper in these solids would be very ariable. Furthermore, it would often not be particularly reat as leaching tends to remove the copper from the fine uperficial fractions of the dumps and it is these uppermost ractions which would tend to be carried into the rivers.

Acknowledgments

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Table 1.

A comparison of the copper contents in p.p.m. of the *minus*-80-mesh fraction of stream sediment samples taken in the winter of 1960/61 with those collected from approximately the same spots in the summer of 1963.

River	*Sample No.*	*Winter* 1960/61	*Summer of* 1963
A	A3	850	700
	A4	1850	2250
	A5	340	450
	A6	950	900
	A7	950	900
	A8	2350	4000
B	B2	750	650
	B3	180	150
	B4	130	200
	B5	240	200
	B6	140	150
	B7	80	100
C	C1	170	100
	C2	80	100
	C3	40	50
	C5	30	100
	C6	20	50
	C7	60	55
D	D4	270	275
	D5	350	350
	D7	340	350
	D9	70	100
	D13	100	100
	D14	40	50
	D15	50	100
	D17a	60	50
	D17b	60	50
	D18	450	450