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Tin distribution over granitic rocks in the Kinta Hills area, Perak, Peninsular Malaysia

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Abstract: In the Kinta Hills area marble, quartzite, schist and argillite have been intruded by coarse-grained porphyritic biotite granite. At the margins of masses of the coarse-grained porphyritic biotite granite are zones of medium- to fine-grained granite and leucogranite. Veins of quartz occur as fracture fillings. Accompanying the emplacement of the leucogranite and quartz bodies were primary mineralizations of tin, tungsten and iron which are of economic importance in the region. Deep tropical weathering has produced a thick soil-cover over most of the area.

A geochemical programme of soil, stream and rock sampling was undertaken to search for eluvial tin deposits in the area. It resulted in the delineation of eluvial concentrations of tin in the soil.

The tin-anomalous zones are found to form a pattern very closely associated with directions of major fractures which were most probably the conduits of the mineralizing solutions. The tin concentrations are also most prominent in soils over vein quartz and leucogranite which are much younger than the coarse-grained granite. Tin values in soils over the coarse-grained granite are low. Therefore it appears that tin mineralization is not disseminated in the coarse-grained granite but is mainly associated with vein quartz and leucogranite.

Unaltered biotite granites contain trace amounts of tin and they are clearly insignificant contributors to the rich placer deposits of the Kinta Valley, which must be largely derived from the visibly altered and mineralized rocks.

INTRODUCTION

The Kinta Valley is the most famous tin-ore producing region in the world. Tin, in the form of cassiterite, is recovered from alluvium in the plain of the Kinta River and its tributaries. Tin has also been mined from lodes, veins and stockworks in limestone, schist and granite. Scheelite from a lode in limestone was mined at Kramat Pulai. Haematite was recovered from limestone hills at Gunung Panjang and Gunung Rapat. Ilmenite, monazite, zircon, wolframite and other heavy minerals are recovered as by-products of the tin mining industry (Ingham and Bradford, 1960).

The Kinta Hills area is located 7 miles east of Ipoh which is also in the Kinta Valley (Fig. 1). The area surveyed is approximately 18 sq. miles with elevations ranging from 250 ft. at Sungai Raia to 1,732 ft. at Bukit Tumpul. The streams in the area are tributaries of the Kinta River, and most of the area is covered with primary jungle.

A geochemical sampling programme was undertaken in 1970 to isolate areas with potential for eluvial and weathered primary tin deposits and also to seek a much better understanding of the tin content in rocks, soils and stream-sediments. Some of the data have been published by Taylor (1974).

METHODS

In the programme, soil mainly over granitic rocks were sampled along north-south traverse lines 1,000 feet apart. The soil samples were taken from the A horizon

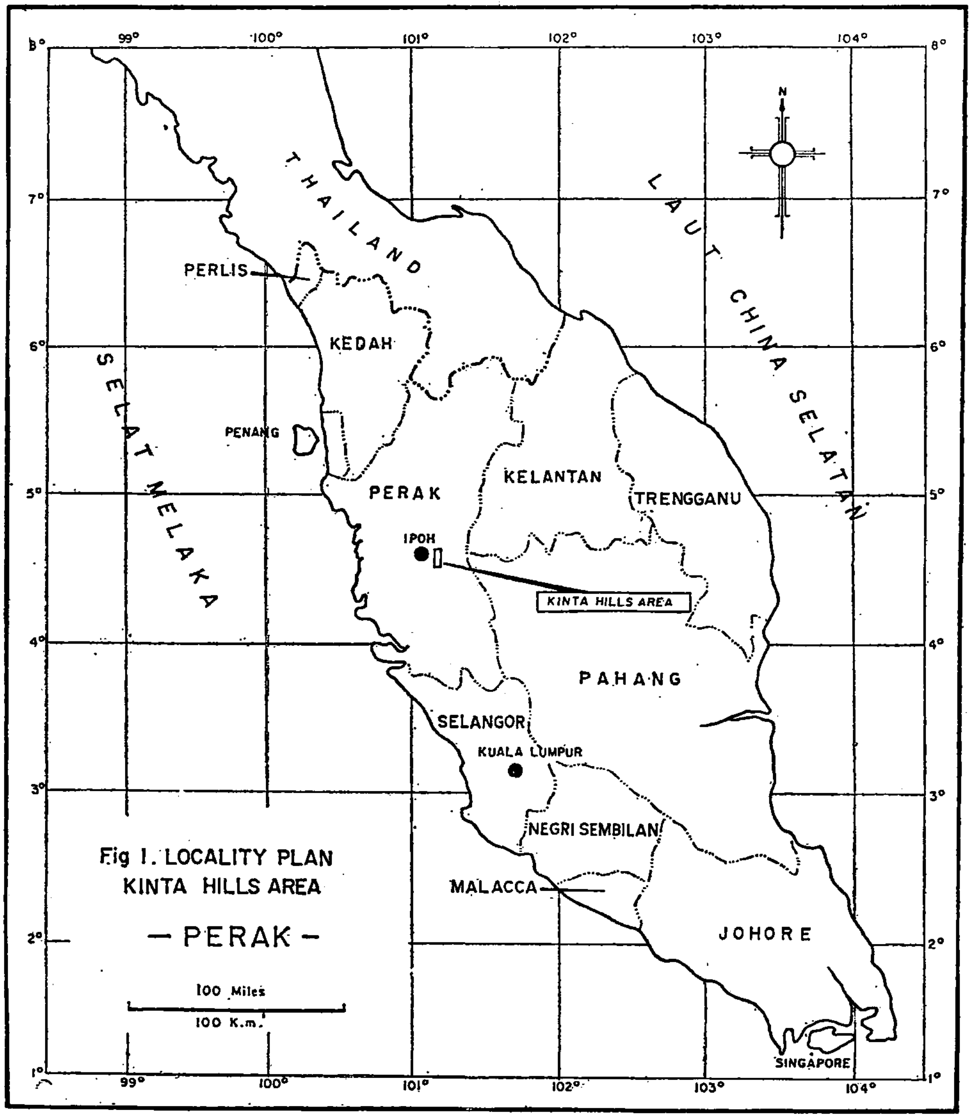


Fig. 1. Locality plan, Kinta Hills Area, Perak.

using an auger at 250 feet intervals. Rock samples were taken from outcrops and float wherever they were traversed.

Minus 80-mesh fractions of the samples were analysed for tin. Rock samples were chipped, crushed to minus 100-mesh and analysed. Minus 80-mesh fractions of stream-sediment samples were also analysed. For one limited area total soils were analysed in separate plus and minus 80-mesh fractions. The analyses were done by colorimetric methods given by Stanton (1966).

GEOLOGICAL SETTING

The area is situated at the eastern margin of the Kinta Valley. Most of it is underlain by granite with inliers of low-grade metamorphosed sedimentary rocks, mainly schist. The geology is as shown in Fig. 2. The oldest rocks in the area are schist, quartzite and argillites. They are normally highly folded, of low metamorhpic grade, and overlain by limestone which has been slightly metamorphosed mostly to crystalline marble which dips uniformly to the west.

The granite is intrusive into these older rocks and appears in its various differentiates. Coarse-grained porphyritic biotite granite predominates as "cores". On the margins of these "cores" are medium- to fine-grained leucogranites which show signs of alteration. Medium- to fine-grained biotite granite forms minor parts of the margins of the coarse-grained porphyritic biotite granite. Vein quartz is common in the leucogranite.

Stream valleys of low elevation adjacent to the area sampled are infilled with Quaternary to Recent alluvium.

Suntharalingam (1968) has worked out the stratigraphy of the area west of Kampar, south of the Kinta Hills area, with fossils which date from pre-Middle Devonian to Middle Permian. By correlation, the schist and limestone in the Kinta Hills area are possibly Lower Devonian or earlier.

Available radiometric ages of the Main Range granites range from Silurian to Mesozoic (Bignell, 1972). A radiometric date on lepidolite and muscovite of stanniferous pegmatites near Gopeng, to the south of the area, gave an age of 175 m.y. (Singh & Jaafar, 1974). No ages have yet been published on the intrusion and mineralization in this area though the granites here are spatially related to the Main Range granites.

GEOCHEMICAL RESULTS

(a) *Tin content in rocks*

The rock types analysed are: coarse-grained biotite granite, medium-grained biotite granite and microgranite, leucogranite, schist and other metamorphic rocks, vein quartz and associated rocks; and haematite and geothite samples. The results of tin analyses are plotted in Fig. 3 and tabulated in Fig. 4.

Fig. 3 shows that the anomalous tin values are found in the leucogranite areas and on the margins of the coarse-grained biotite granite, close to leucogranite.

(b) *Tin content in soils*

A total of 828 soil samples were analysed for tin and the results were plotted and contoured as shown in Fig. 5. From frequency graphs (Fig. 9), the tin values show a background range of 0–33 ppm Sn. The background values and the anomalous values (which are usually well above 50 ppm Sn) form two distinct groups. The tin values are much more anomalous in the northern part than in the southern part of the general study area, reflecting the predominance of coarse-grained porphyritic biotite granite in the south and leucogranite in the north.

The conspicuous trends of the tin anomalies in the −80 mesh fractions are:— (1 ENE–WSW, 2) E–W, 3) N–S and 4) NW–SE; the ENE–WSW being the most important.

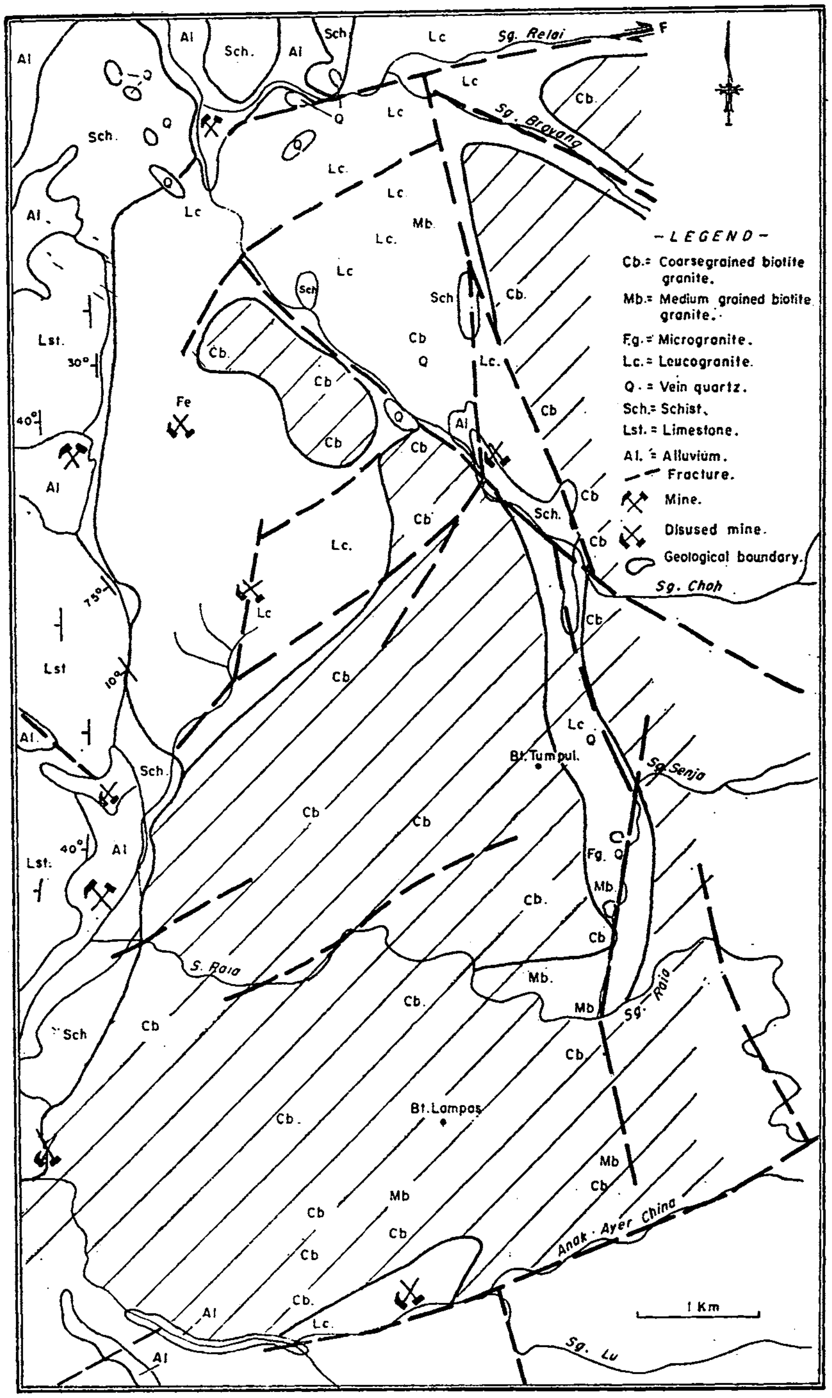


Fig. 2. Geological map, Kinta Hills.

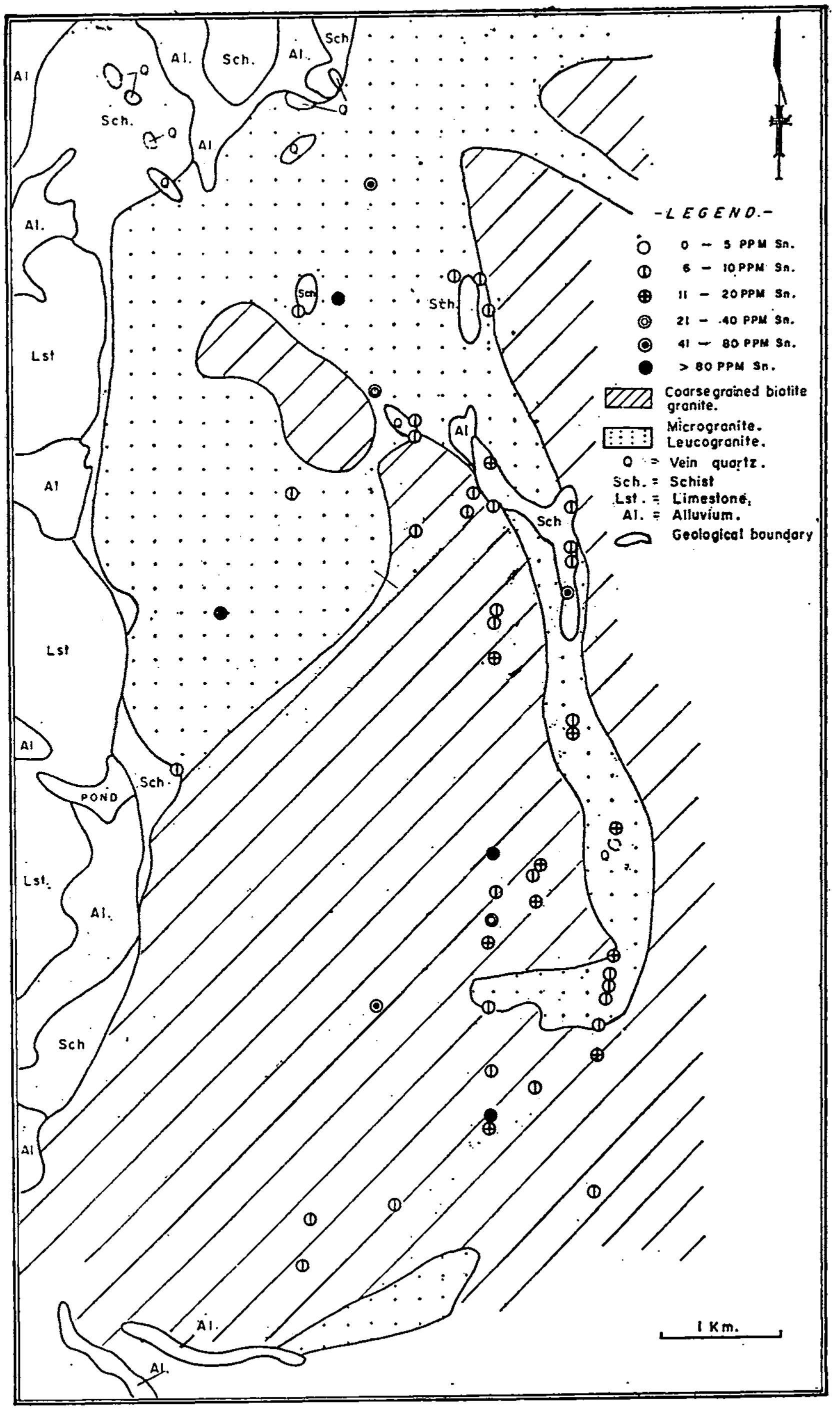
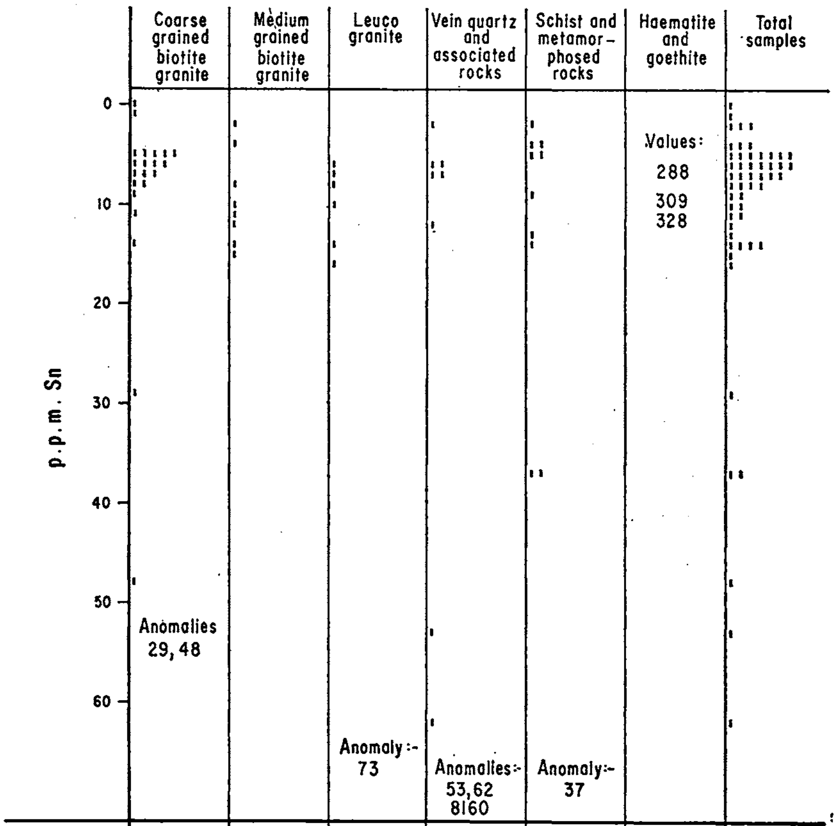


Fig. 3. Tin distribution in rocks, Kinta Hills.



	Coarse grained biotite granite	Medium grained biotite granite	Leuco granite	Vein quartz and associated rocks	Schist and metamorphosed rocks	Haematite and goethite	Total samples
No. of samples:-	21	8	7	9	10	3	58
Range:-	0-48	2-15	6-73	2-8160	2-37	288-328	0-8160
Average:-	9.4	9.6	19.1	924	13	308	168.6
Sum of values:-	197	77	134	8316	130	924	9778
No. of background values:-	19	8	6	6	8	-	47
No. of anomalous values:-	2	0	1	3	2	3	11
Background range:-	0-14	2-15	6-16	2-12	2-14	-	0-16
Average of background values:-	6.4	9.5	10.2	6.7	7.0	-	$\frac{351}{47}=7.5$

Fig. 4. Tin values in rocks of the Kinta Hills area, Perak.

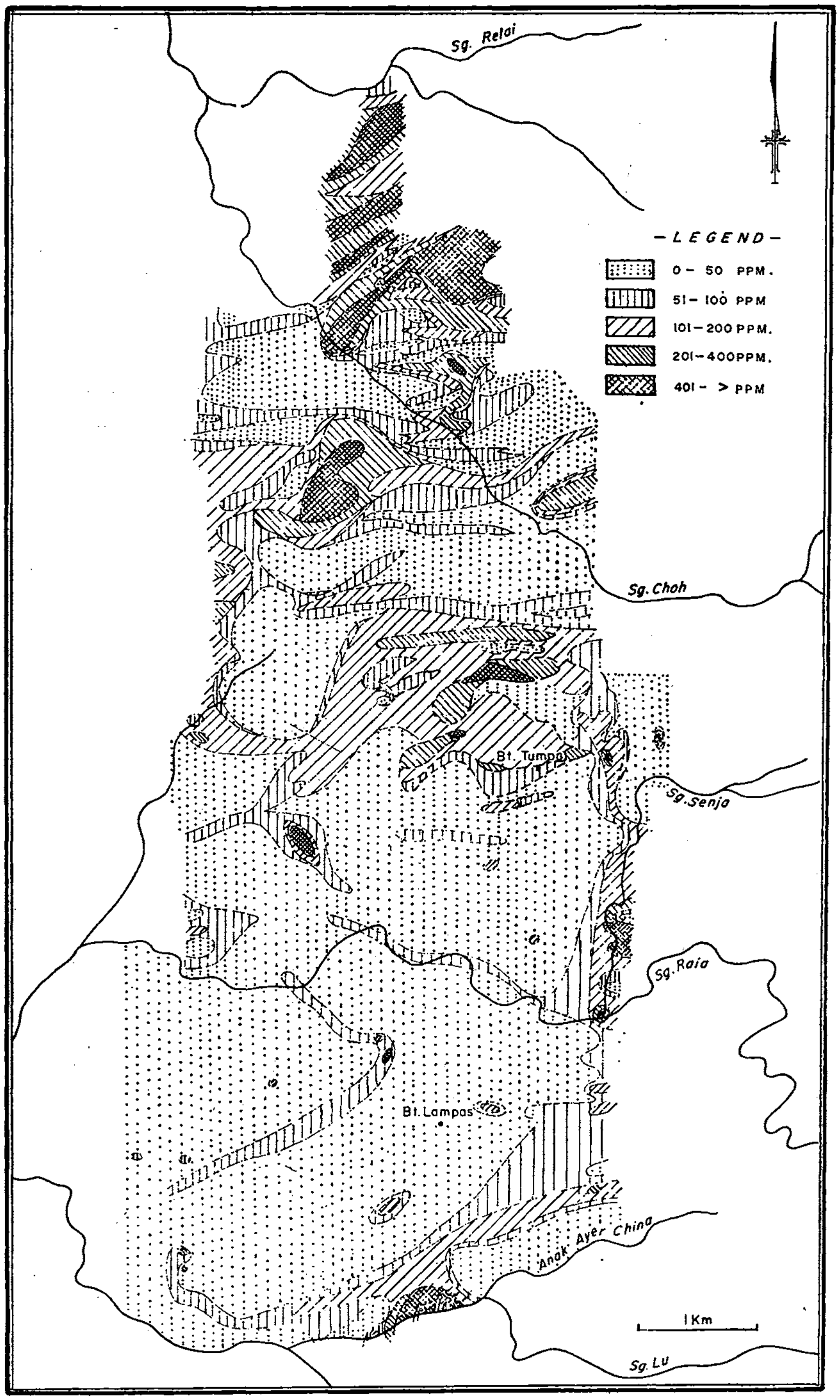


Fig. 5. Tin distribution in soils, Kinta Hills.

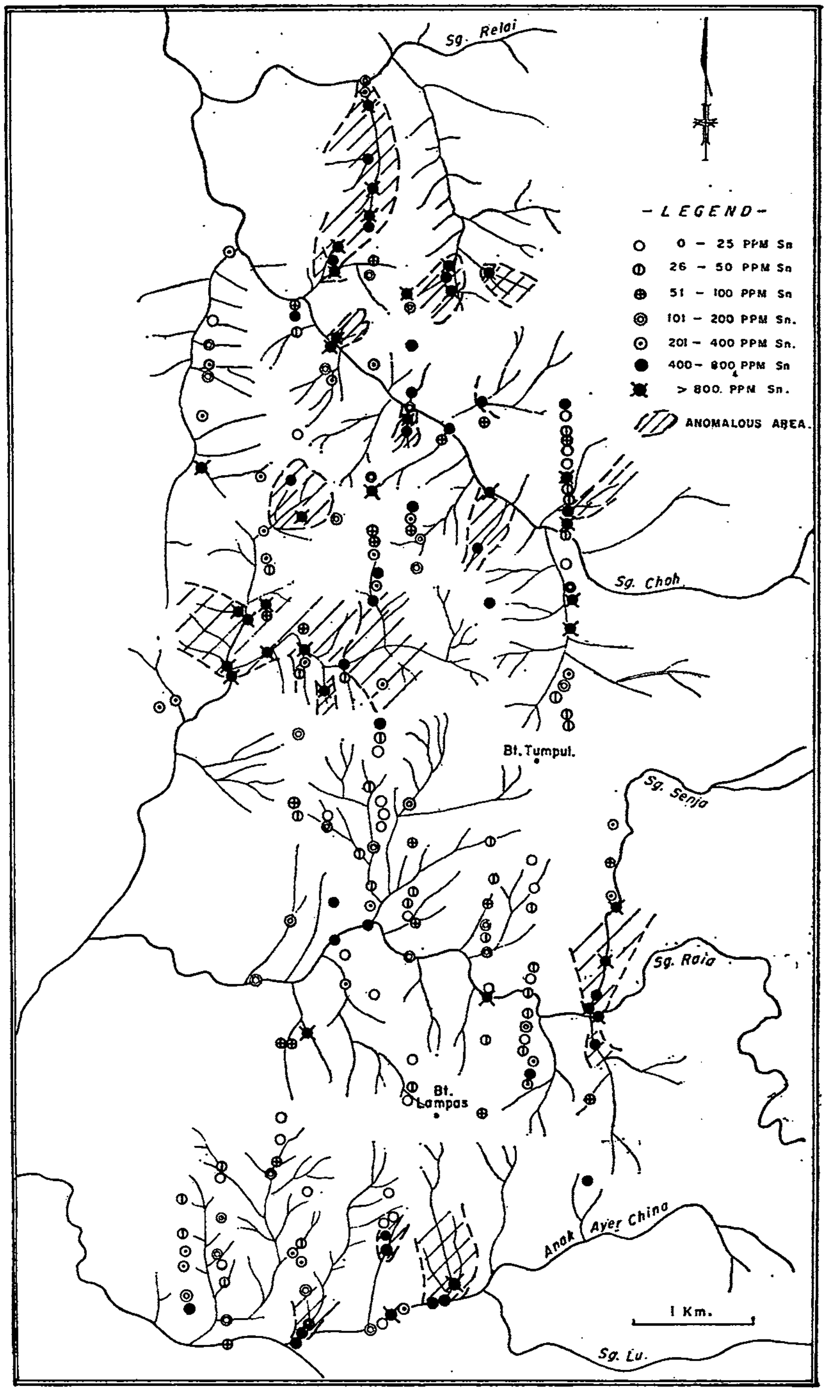


Fig. 6. Tin distribution in stream sediments, Kinta Hills.

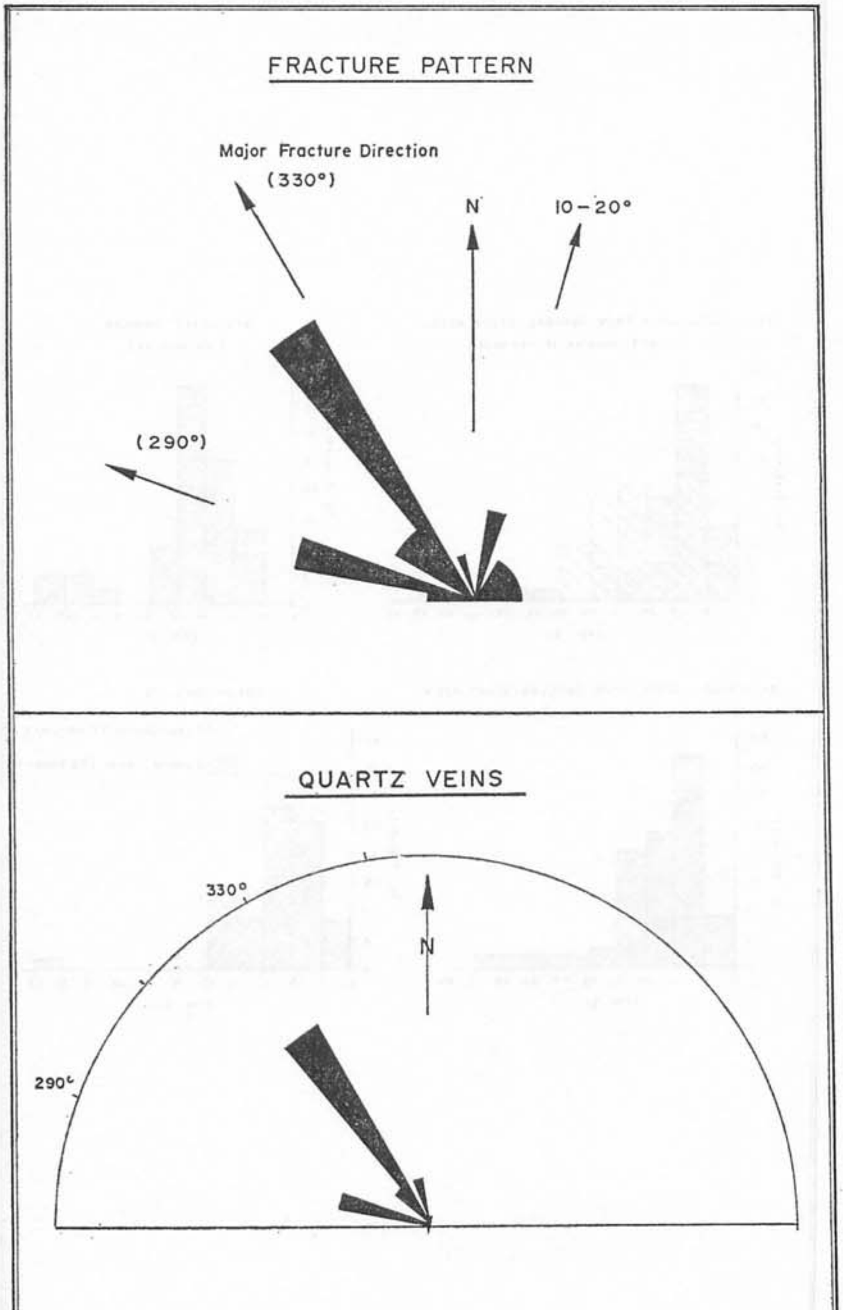


Fig. 7. Comparison between fracture pattern and pattern of quartz veins.

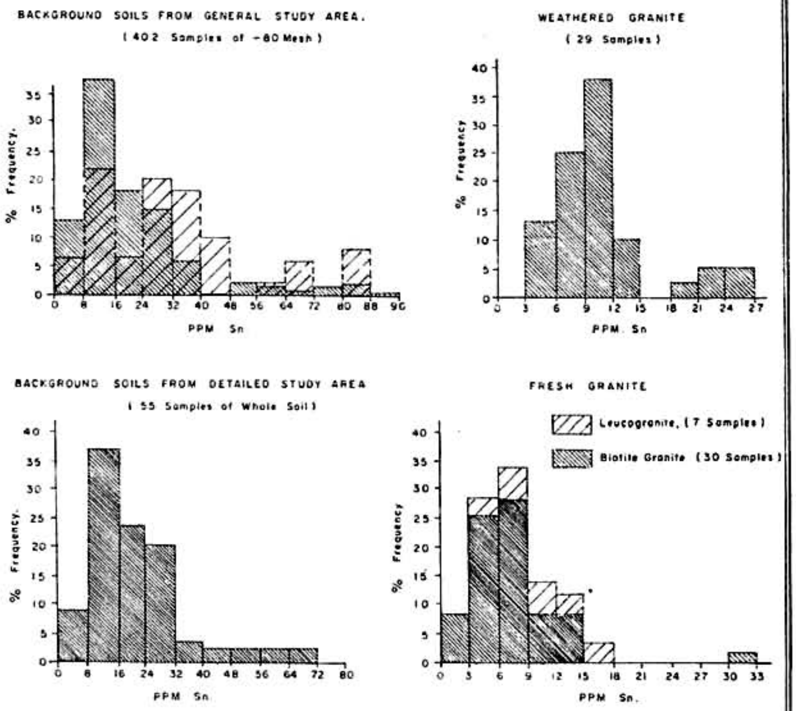


Fig. 8. Frequency distribution of tin in granite, weathered granite, soils in the general study area and from the detailed study area, Kinta Hills.

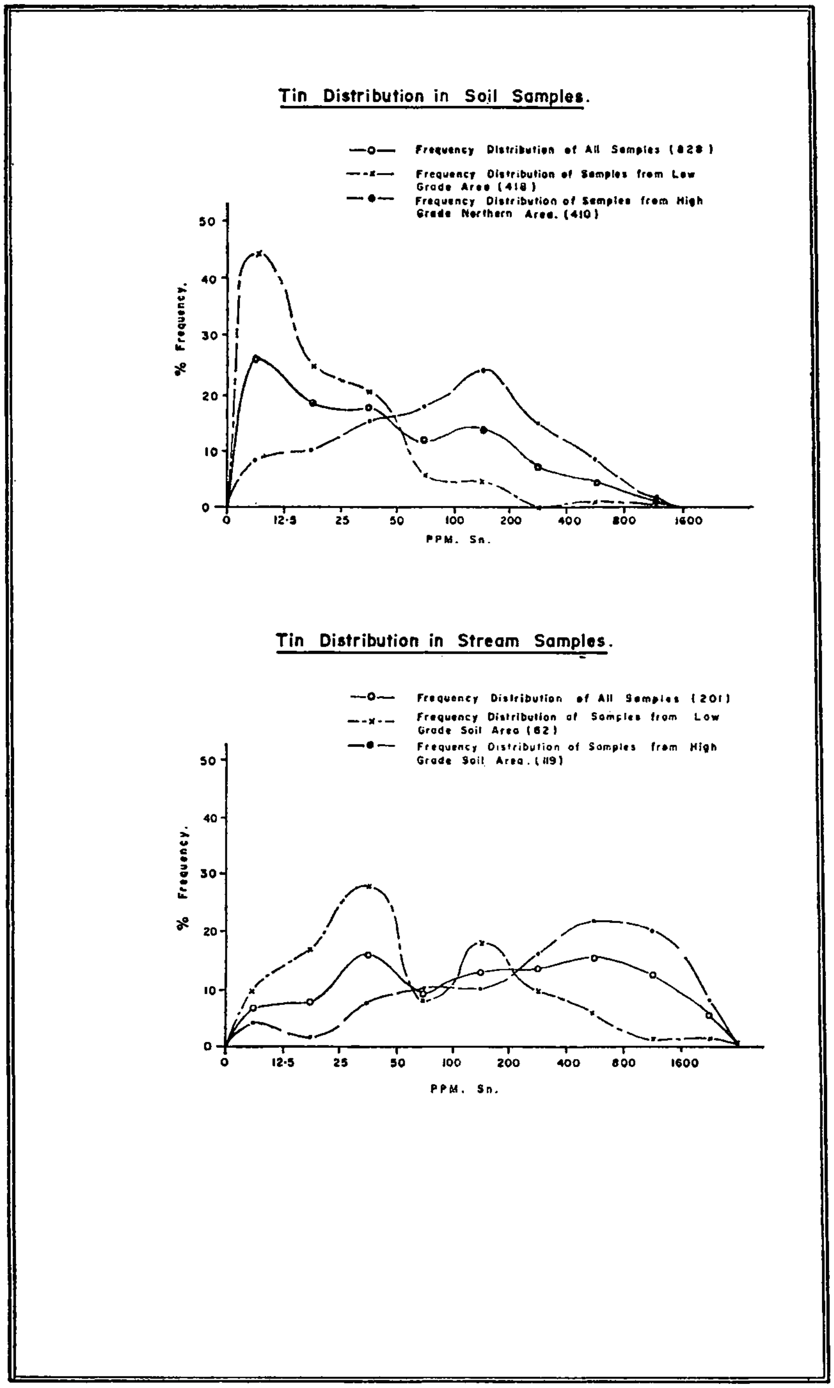


Fig. 9. Frequency distribution of tin in soils and stream sediments, Kinta Hills.

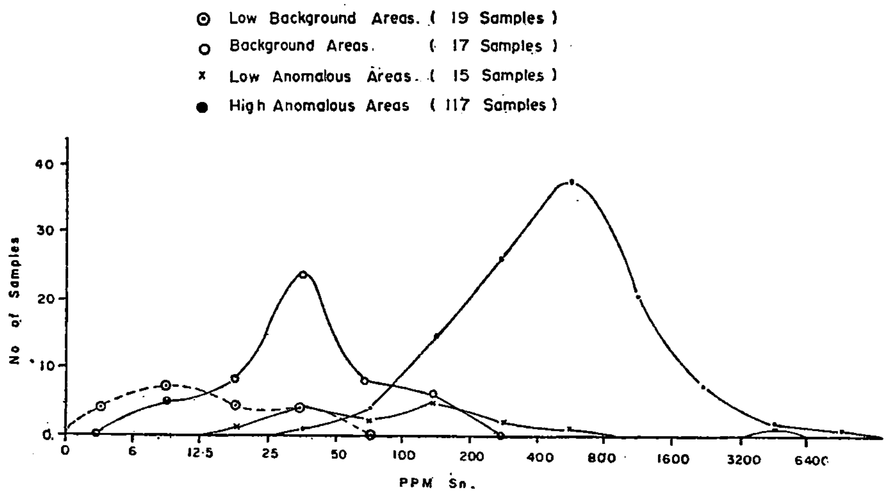


Fig. 10. Frequency distribution of tin values in stream sediments, Kinta Hills.

In a follow-up programme of detailed sampling, soil samples were analysed in both the –80 and +80 mesh fractions. The tin distribution and calculated tin content in the two fractions were plotted in separated diagrams (Figs. 13, 14 and 15). Both show a similar pattern.

Cassiterite grain sizes show almost equal frequencies throughout the size ranges (Fig. 12). The results in the –80 mesh fractions are therefore representative of the tin distribution in the area.

Bulk samples were taken from the detailed study area. From these, the density of the ground was measured. The mineral composition was noted and the tin content of the ground was found by the physical recovery of cassiterite. Fig. 16 compares the tin values from the physical recovery with that obtained by geochemistry. The bulk sampling results show that 0.2 kpcy (katis* SnO_2 per cubic yard) of cassiterite is equi-

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*1 kati = 1.33 lb. (0.605 kg.)

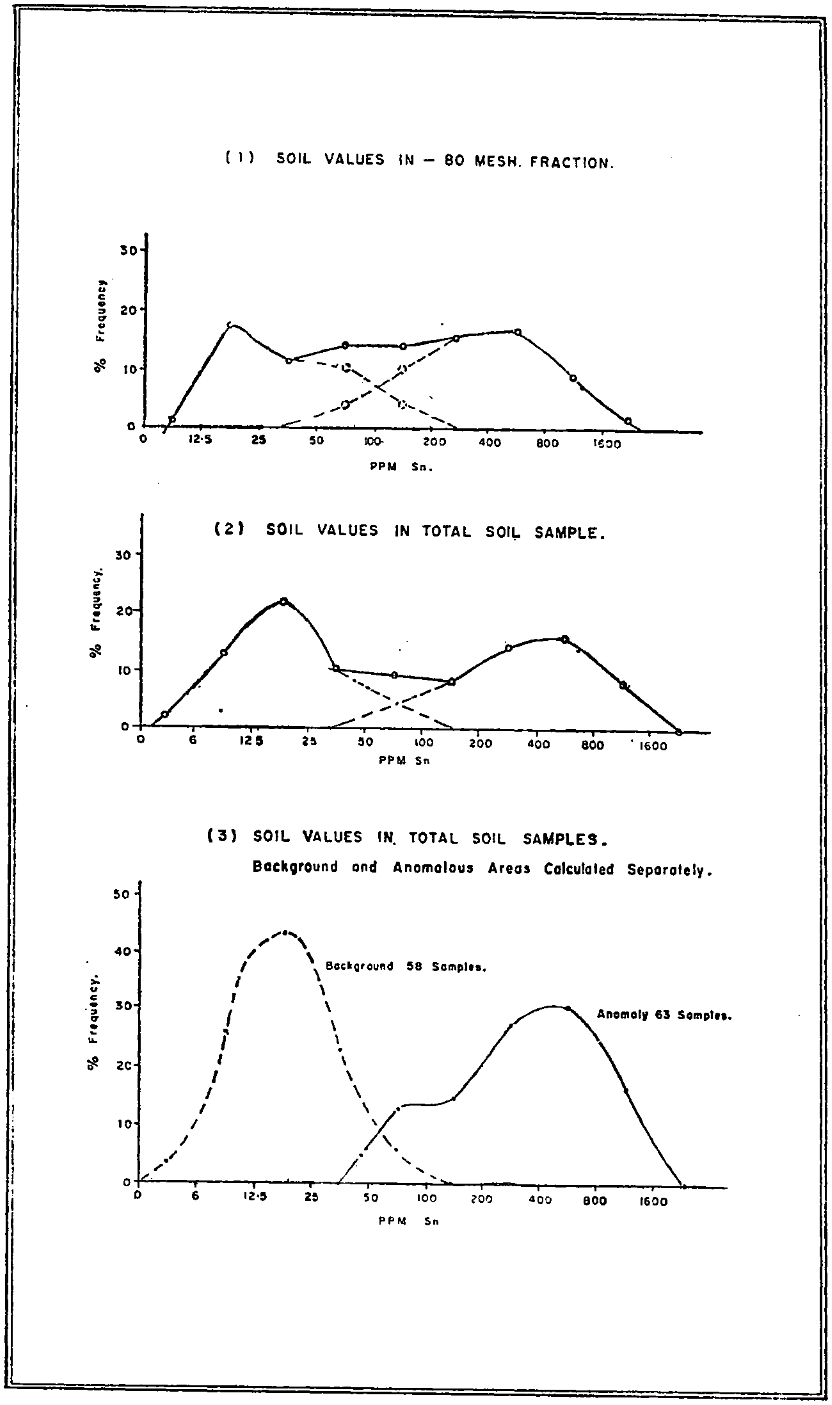

Fig. 11. Frequency distribution of tin values in soils from detailed study area, Kinta Hills.

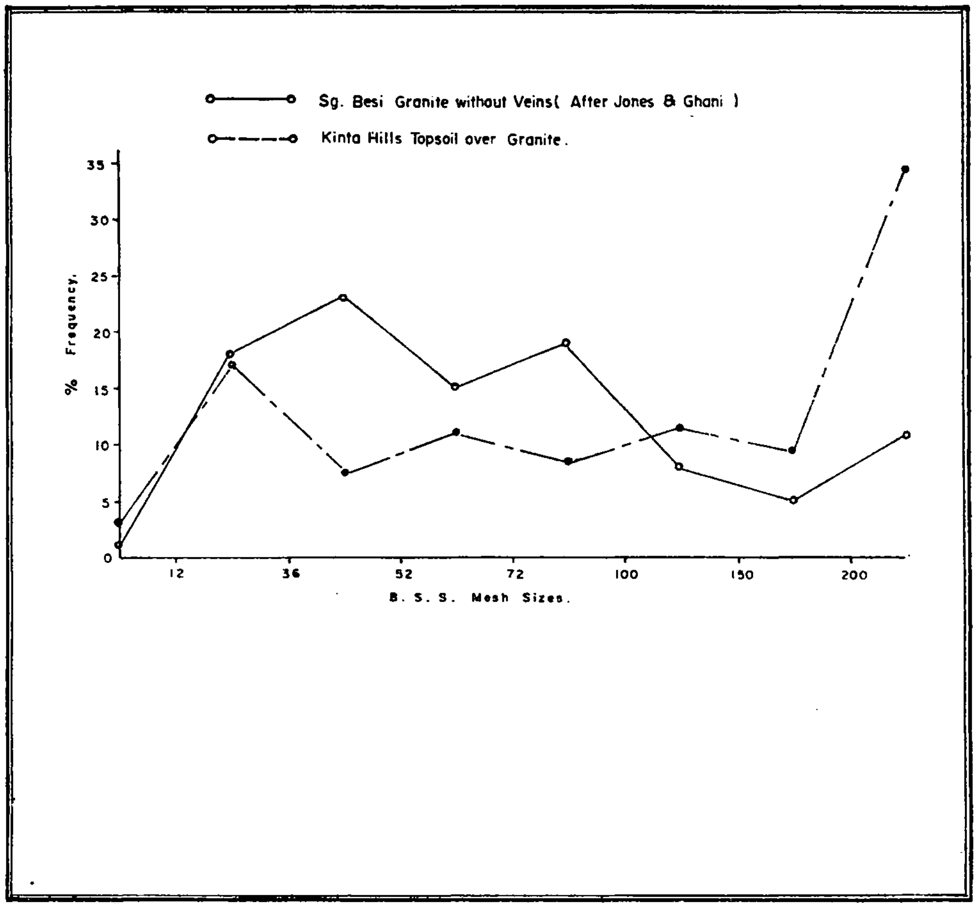

Fig. 12. Frequency distribution of cassiterite grain sizes from topsoil over granite, Kinta Hills as compared with cassiterite in Sungei Besi.

valent to about 165 ppm Sn in the −80 mesh fraction and 145 ppm Sn in the +80 mesh fraction.

(c) *Tin content in stream-sediments*

From the 222 stream-sediment samples collected the minus 80 mesh fractions yielded tin values ranging from 0 to more than 30,000 ppm Sn; with an average of 637 ppm Sn. The background values range from 0–75 ppm Sn. Stream-sediment geochemistry alone could pick out the anomalous areas (Fig. 6).

(d) *Background tin values in rock, soil and stream sediment*

	Rock	Soil	Stream sediment
Density	2.7	1.1	1.9 (approx.)
Background tin values	0–16 ppm	0–33 ppm	0–75 ppm

	Rock	Soil	Stream sediment
Composition		By weight, 47% quartz and concentrates, 51% clay, 2% organic matter	Mainly quartz and concentrates
Change		$\xrightarrow[\text{reduction}]{\text{Density}}$	$\xrightarrow[\text{clay and organic matter}]{\text{Removal of}}$

Bulk sampling has shown that surface soil densities average 1.1 gm/c.c. From geochemical sampling, the background tin values are 0–16 ppm, 0–33 ppm, and 0–75 ppm, in rocks, soils and stream sediments respectively. The upgrading of tin content from rock to soil is due to the density reduction (D. Taylor, personal communication The increment in tin content in stream sediments is due to the removal of clay and minor organic matter from the soils as they are washed in the stream.

The tin content in soils is about twice that of the rocks, and in stream-sediments about 5 times that in the rocks.

STRUCTURAL FEATURES

Fractures which have been measured in the field as well as plotted from aerial photographs in the Kinta Hills have the following trends:

1) ENE–WSW	(wrench; right-lateral)
2) NW–SE	(wrench; left-lateral)
3) (i) NNE–SSW (ii) NNW–SSE	generally N–S (tension)
4) (i) ESE–WSW (ii) E–W	generally E–W (extension)

The trends of vein quartz measured in the field commonly trend at 330° and 290°; following a wrench and the extension direction respectively (Fig. 7).

The fracture pattern here agrees with the one on a regional scale where the joint pattern and faulting in the Kinta region is attributed to a stress field with the principal stress varying somewhat in direction but averaging 97°(Gobbett, 1971).

The tin anomalous zones in the soil, which reflect the pattern of primary tin mineralization, appear to be concordant with the main fracture directions. The ENE-WSW and the N-S fracture directions are the most important trends of the tin anomalous zones.

MODE OF PRIMARY TIN MINERALIZATION

The coarse-grained porphyritic granites are unaltered in most parts, and tin values in them are generally low, with an average of 9.4 ppm Sn. Tin values in soils over the coarse-grained porphyritic granite are also normally low. This rock type is not so highly fractured.

On the other hand, the leucogranite is usually extensively altered. It is normally devoid of biotite and has been greisenized, tourmalinized and chloritized. The tin va-

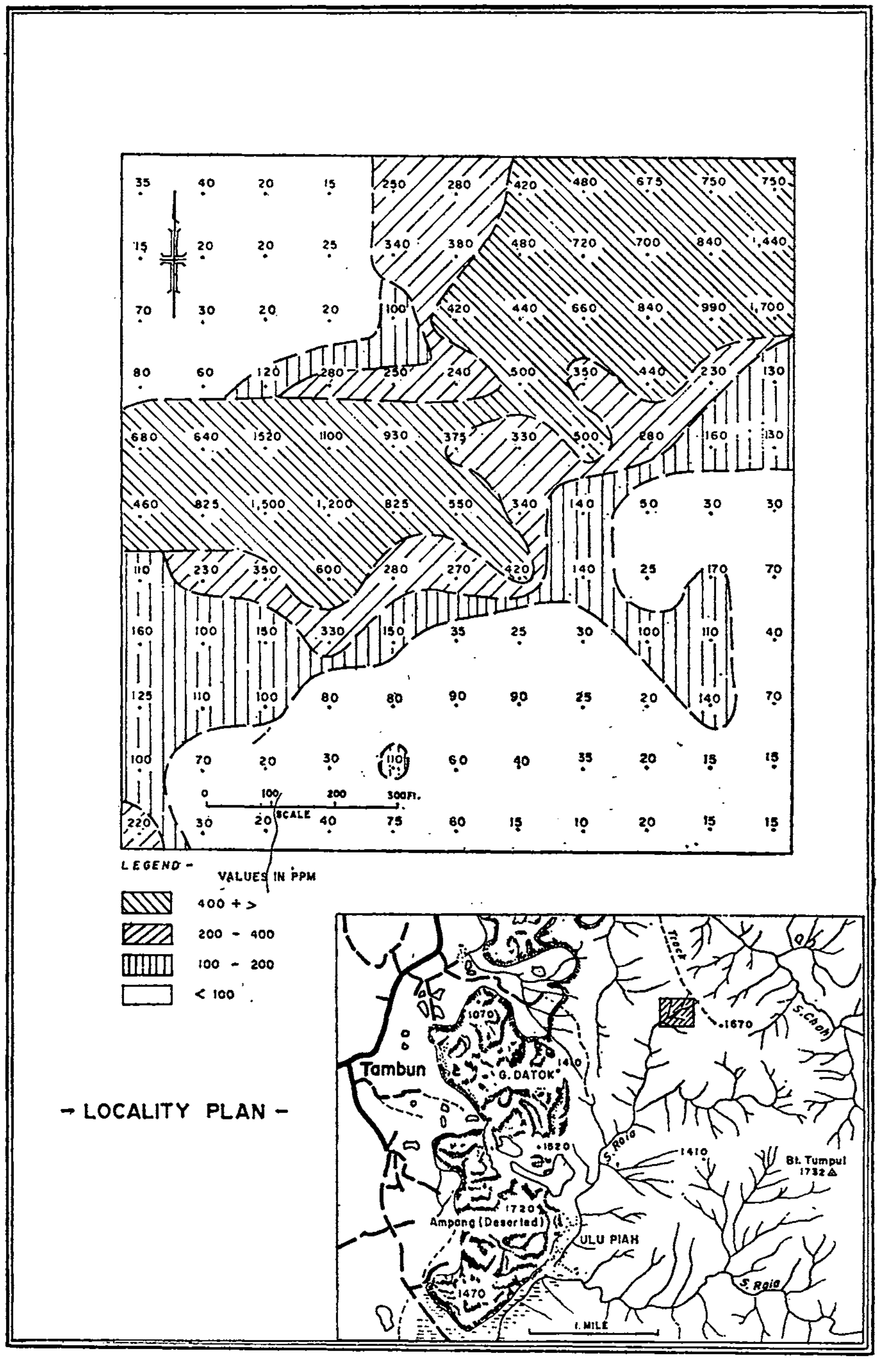

Fig. 13. Tin distribution in the—80 mesh fractions, detailed study area, Kinta Hills.

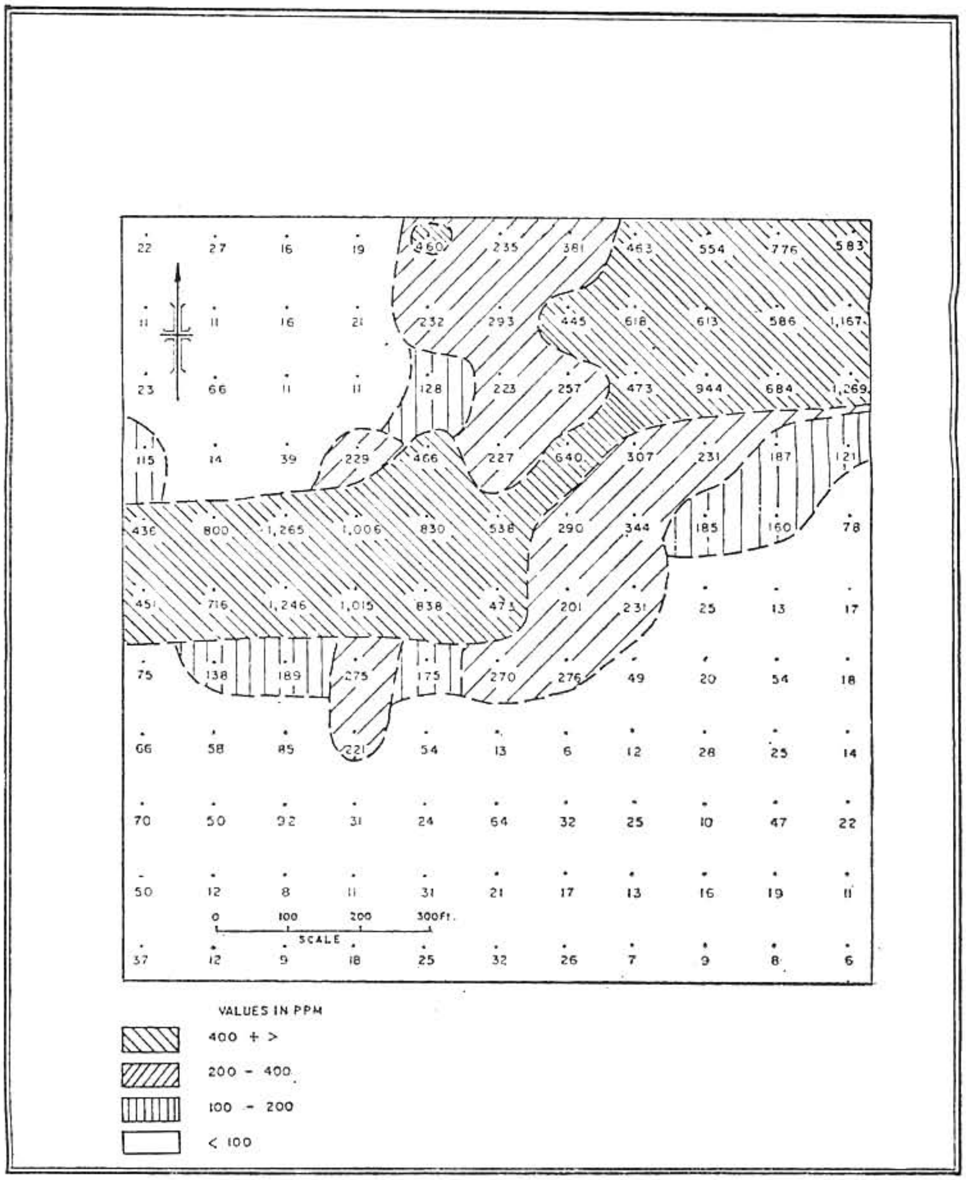

Fig. 15. Calculated tin content of each total sample, detailed study area, Kinta Hills.

lues in soils over leucogranite are usually anomalous. The leucogranite is usually highly fractured with greisen-bordered veins, tourmaline-quartz veins and quartz veins. It is common to find cassiterite occuring with the quartz veins. The abundance of hydrothermal minerals points to the fact that tin mineralization was mainly hydrothermal.

The coarse-grained biotite granite is virtually unmineralized as far as tin is concerned. Mineralization has been controlled by the fracture pattern which was later

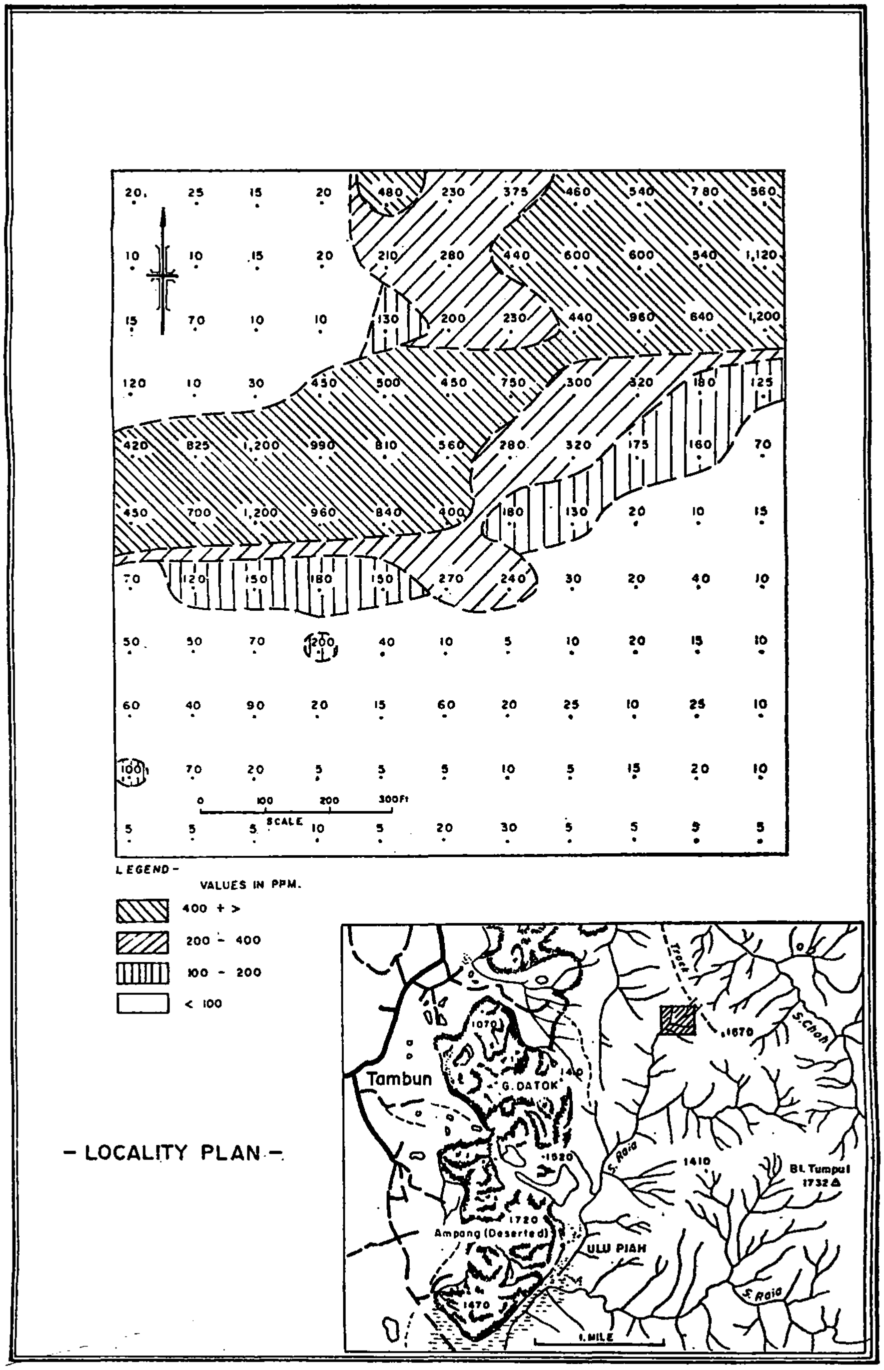

Fig. 14. Tin distribution in the+80 mesh fractions, detailed study area, Kinta Hills.

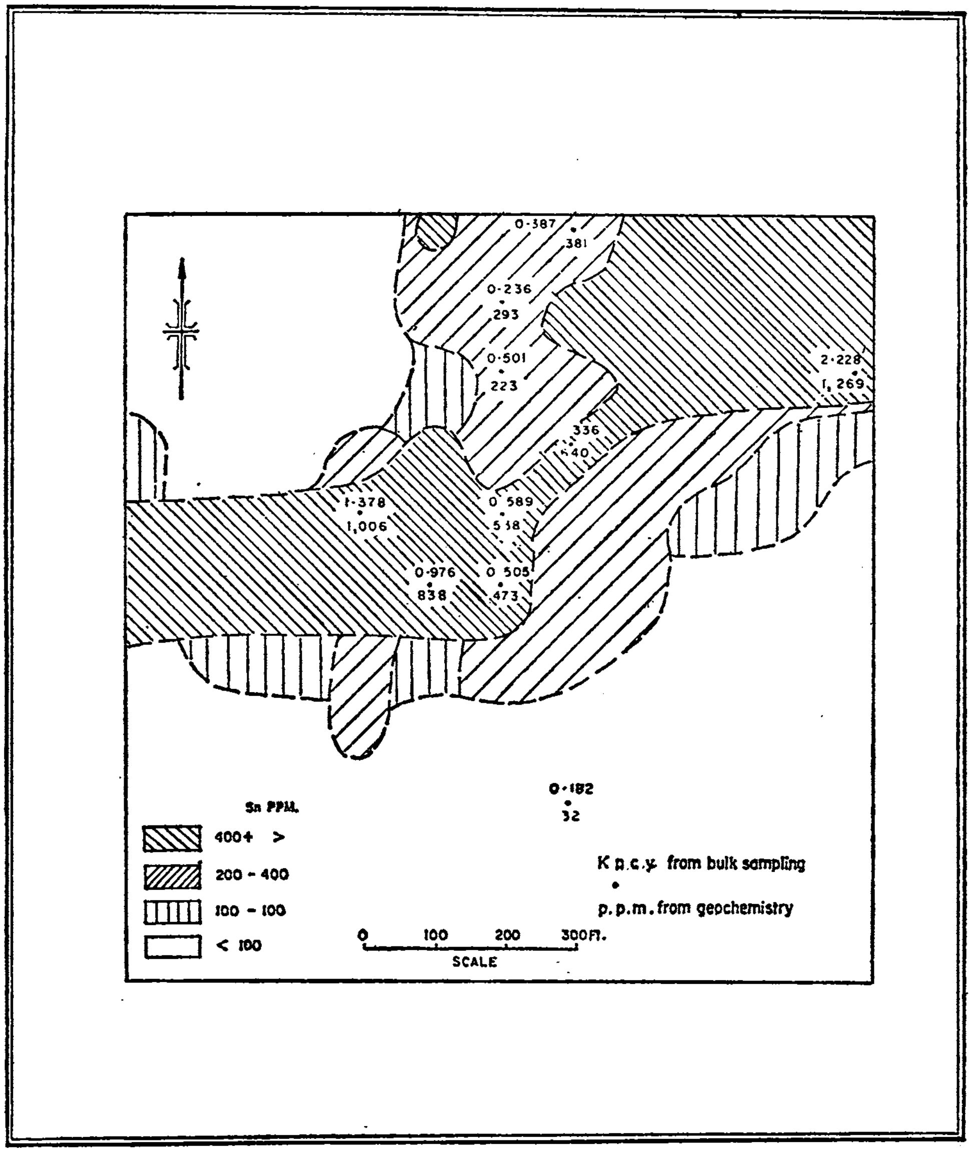

Fig. 16. Value of ground in k.p.c.y. compared with p.p.m. from geochemistry, detailed study area, Kinta Hills.

than the coarse-grained biotite granite intrusion. The age of tin mineralization is therefore post granitic (possibly post-Cretaceous).

CONCLUSION

The tin anomalies are closely associated with leucogranite and vein quartz. This conforms with a hydrothermal mode of origin of tin mineralization.

The pattern of the tin anomalous zones strongly suggests that primary tin mineralization was controlled largely by the major fracture directions, mainly the ENE-WSW (wrench, right-lateral) and the N-S (tension) fracture directions.

The progressive increase in background tin content from rock to soil to stream-sediment is due to a reduction in density when the rock is weathered to soil, and to reduction of clay and organic material when they are washed out as stream-sediment. The density of the cassiterite plays little or no part in the enrichment until the stream sediment is transported out of the mountain terrain. The critical factor is its resistance tochemical weathering.

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