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Geochemical exploration around the pegmatitic Sn-Nb-Ta mineralization of Southwest Nigeria

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Abstract: A metallogenetic belt of pegmatitic Sn-Nb-Ta-mineralization stretches for about 400 km in Southwest and Central Nigeria with only a few sites where active mining occurs. To explore other parts that may have additional economic mineralization, a geochemical orientation survey was initiated in Southwest Nigeria in three areas of alluvial small scale mining.

At the reconnaissance level, a geochemical stream sediment survey indicated cold extractable Li as the most useful indicator for outlining mineralized pegmatitic source rocks. A heavy mineral survey at the same scale proved to be very inconsistent due to the lack of a well developed perennial drainage system; its application should be restricted to the last stage of detailed surveys.

A geochemical soil survey with a density of 1 sample per square kilometer around the former mining area of Ijero indicates that the best reflection of the pegmatitic parent rocks are given by the elements Mg/Li, Li, Rb, Cs, Be in decreasing order of significance. Interpretation of all five pathfinders will render the best results.

Investigations of F as an additional pathfinder and the application of the presented methods in the mining area of Egbe were made.

INTRODUCTION

The Nigerian tin production has two sources, the most productive one being the Jurassic alkali-granitic ring-complexes of the Jos area whilst the other which contributes less than 5% is derived from pegmatitic Sn-Nb-Ta-mineralization of Southwestern and Central Nigeria (Fig. 1). The latter are related to the emplacement of the so-called "Older Granite suite" of the late Precambrian to Cambrian PanAfrican Orogeny (Jacobson & Webb, 1946). They follow a distinct Southwest-Northeast direction over a distance of about 400 km which ends finally in the most productive Jos tinfields (Wright, 1970).

Mining is reported along this metallogenetic belt of Sn-Nb-Ta-mineralization only in a few places (Fig. 1). The typical small scale mining is mainly carried out on alluvial and eluvial placers. However, in the northeastern part of the belt the pegmatites have been worked directly, resulting in an increase in the mine output from southwest towards the northeast. To explore the unexposed parts of this mineralized belt that may have further economic potential, the most promising method considered was a systematic geochemical research programme (Matheis, 1975). This programme has been incorporated into the newly established postgraduate training in Mineral Exploration at the Department of Geology, University of Ife.

LOCATION AND REGIONAL GEOLOGY

The present study which is essentially a geochemical orientation survey restricts itself to three small scale mining areas southwest of the River Niger, namely Iregun,

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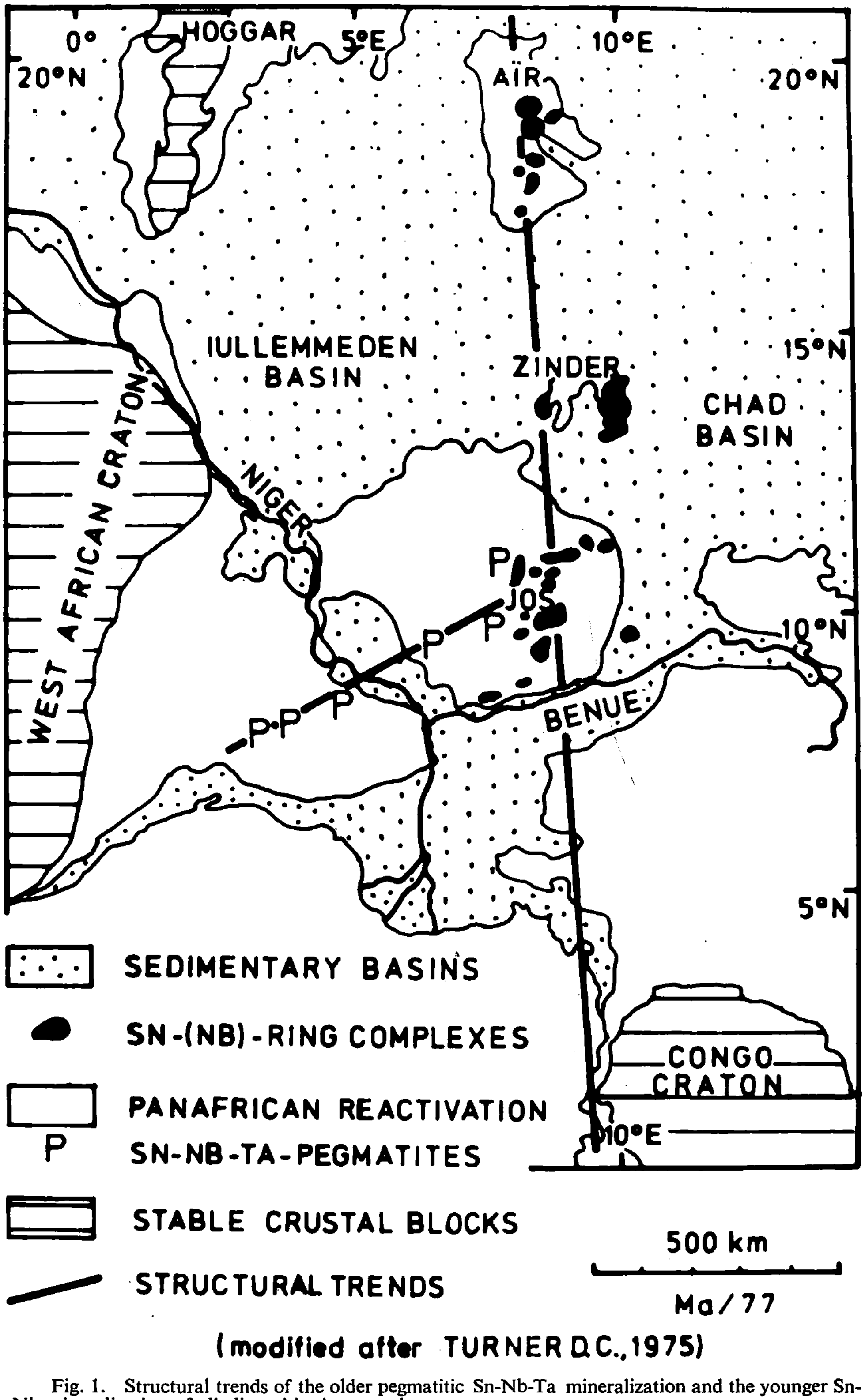

Fig. 1. Structural trends of the older pegmatitic Sn-Nb-Ta mineralization and the younger Sn-Nb mineralization of alkaligranitic ring-complexes.

Ijero and Egbe (Fig. 2). The humid tropical climate predominates throughout, but rainfall decreases from Iregun in the southwest with 1600 mm/year towards Egbe in the northeast with 1200 mm/year. The length of the dry season changes from December/February in the south to November/April in the north. The areas around Iregun and Ijero are situated in the zone of tropical rain forest whereas Egbe area is dominated by the Guinea savannah type.

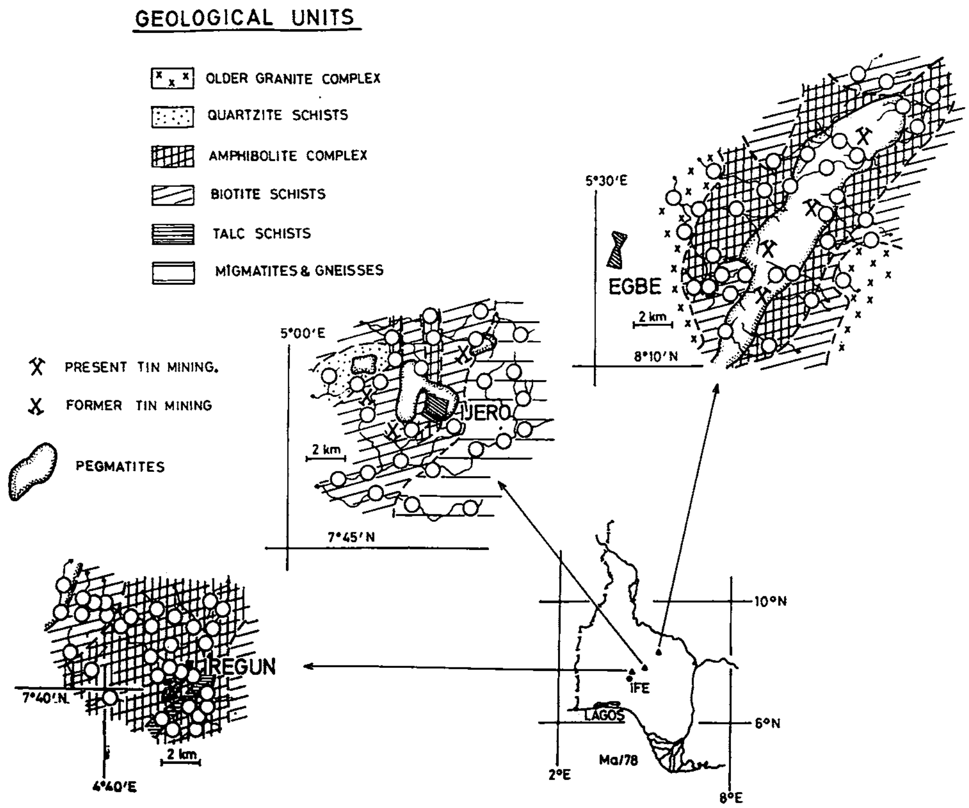

Fig. 2. Geological setting of the three mining areas under study.

There are only a few rivers draining this area throughout the year but a dense network of seasonal smaller tributaries exists. The general topographic relief is gently undulating with some prominent broken ridges and inselbergs in the northeastern part. The typical tropical weathering penetrates down to 30 m depending on the parent rock type and results in the formation of a lateritic soil. The frequency of rock exposures increases from the rain forest to the savannah areas.

Southwest Nigeria covers the area southwest of River Niger with the major geological units being part of the Nigerian Basement Complex. To the east and south, the Basement Complex is covered by Cretaceous to Recent sediments along the Coastal Basin and the Niger Basin (Fig. 1). The Precambrian Basement Complex forms part of the eastern margin of the West African Craton. Four major rock units have been recognized (Rahaman, 1976) namely the Undifferentiated Migmatite Complex, the

Older and Younger Metasediments including paraschists, quartzites, and meta-igneous rocks, and the Older Granite Complex including pegmatites and charnockites. According to Rahaman (1976), radiometric data indicate at least two metamorphic-igneous events, i.e. the Eburnean (1950±250 m.y.) and the Pan African (600±150 m.y.) orogenies; a third event of Kibaran age (1150±140 m.y.) is not generally agreed upon.

THE SN-NB-TA-BEARING PEGMATITES

The three areas of alluvial mining selected are located within the Younger Metasediments of mainly biotite-schist and amphibolite composition which show iso-clinal folding with axial traces in the south-southwest to north-northwest direction (Fig. 2). The potential pegmatitic source rocks differ strongly in the degree of exposure from Iregun in the southwest towards Egbe in the north-east (Fig. 2):

—near the present mining site southwest of Iregun, pegmatites occur very limitedly in strongly weathered outcrops and do not form a clearly detectable body.

—the town Ijero is located on a very distinctly zoned pegmatite body emplaced in a series of hornblende-mica-schists with varying mafics composition. There are two smaller occurrences to the northwest and northeast with lower degrees of exposure. The location of former mining sites suggests that all three pegmatitic bodies contributed to the ore in the alluvial concentrates.

—the largest occurrence is situated east of Egbe where pegmatites are emplaced conformably into an amphibolite series in a south-southwest to north-northeast direction. All four present mining sites are located within the pegmatites distribution area.

Mineral composition

Based on their geological field relation, these pegmatites are believed to be associated with the final stages of the Pan African Older Granite suite (Jacobson & Webb, 1946) although the majority of these pegmatites do not occur in close contact with the granites. Jacobson & Webb (1946) established two phases of formation, the first phase causing the emplacement of simple pegmatites composed of quartz, microcline, oligoclase, muscovite, biotite, garnet, and black tourmaline and a second phase being resresponsible for an intensive albitization combined with the economic mineralization of cassiterite, the columbite-tantalite solid solution series, and the typical accessories beryl, lepidolite, and some more tourmaline.

In places, well zoned pegmatites developed as in the main body around Ijero. Here, the core zone is dominated by nearly pure quartz with a few larger booklets of muscovite and rare black tourmaline. The intermediate zone is composed of quartz, microcline, oligoclase, muscovite, and biotite as the main components, and garnet, tourmaline, apatite, zircon, and beryl as accessories. The border zone with quartz-tourmaline to pure tourmaline hornfels is best developed in contact with biotite-schists which also contain tourmaline (Emofurieta, 1977). Un fortunately, no cassiterite or columbite-tantalite was detected in this recent investigationalthough the area investigated is near to the former mining sites and areas with indications of these minerals in a stream sediment survey (Fig. 4).

Mining activity

Alluvial and eluvial placer concentrates form the basis for the small scale mining presently taking place around Iregun and Egbe as well as the former mines around

Ijero. All these sites are situated very close to pegmatitic bodies as shown in Fig. 2. This proximity may be attributed to the high degree of physical and chemical weathering which desintegrates the coarse grained source material very easily. The resulting short distance of transportation by seasonal streams caused a very inconsistent pattern of deposition which is reflected in the erratic mineral production of such places.

Mining around Iregun, started in the nineteen forties for gold whose production continuously declined, finally the switch was made to tin mining in the fifties with some columbite and tantalite as by-products. The recorded output from 1950 to 1970 is 21 long tons (l.t.) of cassiterite (Schatzl, 1971), the figure for columbite-tantalite is however, not on record. The present output of cassiterite and probably columbite-tantalite has increased slightly.

The Ijero area produced on records from 1944 to 1970 about 247 l.t. of cassiterite (less than one permille of the total Nigerian production during the same time range), 13 l.t. of columbite, and 5 l.t. of tantalite (Schatzl, 1971). Scheelite mineralization was reported from the pegmatite northwest of Ijero by Jacobson & Webb (1946).

The oldest mining area is around Egbe where mining started in 1913 and ups and downs in mining activities were experienced. Recent mining was revived about three years ago. The major product is cassiterite with additional columbite and tantalite, the latter may, at times, be more abundant. The decline of mining activites is indicated by the production of 97 l.t. of cassiterite and 38 l.t. of columbite-tantalite for 1950–60 against 20 l.t. and 1 l.t. respectively for 1960–70 (Schatzl, 1971). In the same area, local miners reported, some production of gold and sometimes occurrences of "heavy feldspar" which is most likely scheelite.

GEOCHEMICAL EXPLORATION FOR SN-NB-TA-MINERALIZATION

The traditional method of panning to trace primary and secondary tin mineralization has been incorporated in the present exercise. It is however considered to be not a sufficiently reliable method for the area of investigation due to the irregular pattern of heavy minerals that results from the lack of a well developed perennial drainage system. The geochemical dispersion patterns of stream sediment and soils are not affected in the same way.

Although various attempts to apply such geochemical exploration methods have been reported, the particular immobile nature of tin during chemical weathering combined with its low average distribution and the lack of easy and fast detection methods did not lead to a commonly accepted mode of application. Successful detection of Sn-mineralization through geochemical exploration has been carried out by Millman (1957) and Hosking (1971) in Cornwall but the association Sn-Cu-Zn-Pb-Ag in Cornwall is not typical for tin deposits in general. Investigations of mineralized Australian granites by Flinter (1971) and Hesp (1971) indicated 10 ppm Sn as a cutoff between stanniferous and barren types. This low concentration of Sn requires sensitive analytical methods with detection limits of 1 ppm Sn or better and a time saving procedure for effective use in exploration work.

In the case under study, outcrops are scarce due to intensive tropical weathering and the resulting weathering products, i.e. stream sediments and soil, would have lower Sn concentrations than the source rocks, thus requiring even more sensitive analytical tools. Based on these problems, the application of potential pathfinder elements was considered to be more successful than the application of the ore forming Sn, Nb, and Ta.

Potential pathfinder elements

The selection of potential pathfinder elements is based on the element associations which are characteristic for the pegmatitic Sn-Nb-Ta-mineralization of the area, and which produce well detectable dispersion patterns in the tropical weathering processes.

Beus & Sitnin (1968) discussed the "Geochemical specialization" of granitic/pegmatitic complexes from the U.S.S.R. and their potential for rare metals (Li, Be, Sn, W, Ta, Nb) using as indicators Sn, Li, Rb, Mg/Li, and Zr/Sn; their specific values have been compiled in Table 1. It is obvious that Li, Rb, and the ratio Mg/Li have contrasts between barren and mineralized host rocks quite similar to Sn itself. Their detection also causes less analytical problems due to the higher concentrations in the weathering products and due to the more economical analytical instrumentation, e.g. the atomic-absorption-spectrometry.

TABLE 1

GEOCHEMICAL INDICATORS OF RARE-METAL AND TA DEPOSITS IN GRANITIC AND PEGMATITIC ROCKS (MODIFIED AFTER BEUS & SITNIN, 1968)

indicator element or ratio	rare-metal deposits in granites			Ta deposits in apogranites and pegmatites		
	ore bearing	barren	contrast	ore bearing	barren	contrast
Sn	15± 4	5± 1	3.0	—	—	—
Li	80±20	37± 6	2.2	120±20	60±10	2.0
Rb	—	—	—	300±15	200±15	1.5
Mg/Li	75±30	270±80	3.6	30± 5	200±50	6.7
Zr/Sn	30±10	76±20	2.5	—	—	—

The importance of Li and also of F as a potential guide for mineralization of the granitophile elements was emphasized by Flinter and others (1972) and Bailey (1977) among others. Further research has been done or is under way within the framework of the IGCP "Mineralization Associated with Acid Magmatism" (Stemprok, 1974). A successful application of F through the use of selective ion electrode in soils for concealed tin deposits in Malaysia is reported by Teh and others (1975).

Geochemical stream sediment reconnaissance survey

A geochemical mapping programme, conducted as a systematic approach for the evaluation of the mineral potential, was initiated in 1974 to cover the Precambrian metasedimentary belts of southwest Nigeria (Matheis, 1977a) including the areas of pegmatitic Sn-Nb-Ta-mineralization.

Cold and hot extraction methods: The outlined area of investigation totals 5,100 km² to date and has been fully covered by a stream sediment reconnaissance survey with a sample density of 1 sample per seven square kilometer. Both cold and hot leaching method of the -80 mesh fraction were applied; the trace elements Ag, Co, Cr, Cu, Li, Ni, Sr, and Zn were analysed by atomic-absorption-spectrometry (AAS). The analysis for Sn concentration was unsuccessful. At this initial stage of the exploration exercise, the outlay was not restricted to potential pegmatitic mineralization only.

The Li pattern proved to be most pronounced around the known pegmatites of Ijero and Egbe areas. To stress the relation between the stream sediment pattern and the potential source rocks of the established Sn-Nb-Ta-mineralization, the presentation of the cxLi and Li concentrations in Figs. 3a and 3b is restricted to the mining areas around Iregun, Ijero, and Egbe, i.e. these geochemical maps cover only 337km²

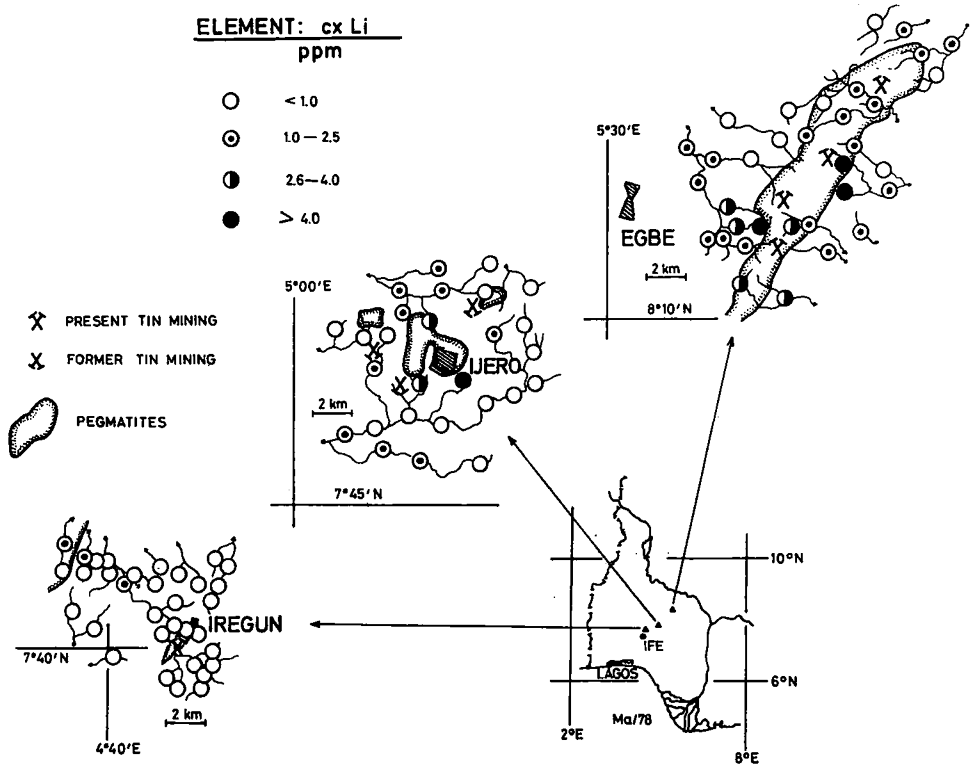

Fig. 3a. Cold extractable Li distribution in stream sediments (-80mesh fraction) around the mining sites.

out of the total study area of 1,650km² worked on by Hughes (1976), Oni (1976), and Sanni (1976) respectively. This larger area forms the basis for the data displayed in Table II which compares various concentration ranges of the three individual mining areas. Usually, the threshold was selected at the 75% margin of the lowest values of a given area, however, the comparative display caused some remarkable shifts in the abundances of the background range: e.g. Ijero represents nearly the normally applied margin, the weakly mineralized Iregun has a higher percentage in the lower concentration ranges, and the Egbe area shows a distinct higher portion in the upper concentration ranges accordingly (cf. Table II).

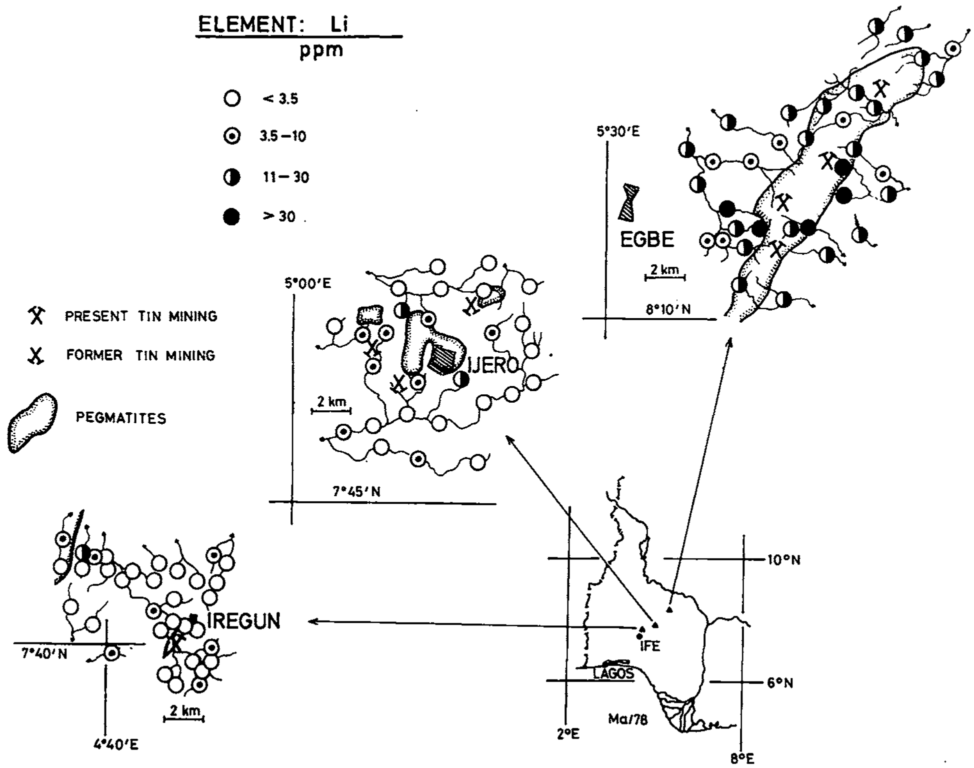

Fig. 3b. Hot extractable Li distribution in stream sediments (–80mesh fraction) around the mining sites.

For both the cold and hot leaching methods, the Iregun area gives the lowest values without any traceable connection between Li and pegmatite occurrence. The only higher values are derived from a more extensive pegmatite occurrence towards the northwest which is however, without any mining activity or known mineralization.

More significant Li concentrations are obtained from the two other mining districts, cxLi is distributed around Ijero and Egbe at nearly equal levels and gives distinct anomalies around the main pegmatite at Ijero and the southwestern part of the Egbe pegmatite. The hot leaching Li values show a steady increase from southwest towards northeast going somehow parallel with the mining output. However, the contrast is less clearly defined around Egbe, the pegmatites being not as clearly marked against the surrounding rock units as by the cxLi values.

At the reconnaissance scale, Li may outline larger pegmatitic bodies, particularly by the cx-values, but it is not possible from the available data to distinguish reliably between mineralized and barren areas.

Heavy mineral survey: Running parallel with the stream sediment reconnaissance, the distribution of economic heavy minerals was investigated in the three mining areas (Hughes, 1976; Oni, 1976; Sanni, 1976). Samples were collected by a hand-auger from the base of the recent alluvium, panned and the –25 mesh fraction retained. The con-

TABLE 2

ABUNDANCES AND DISPERSION PATTERN FOR LI IN STREAM SEDIMENT SAMPLES, EXPRESSED AS RANGE, MEAN VALUE, AND FREQUENCY DISTRIBUTION

No. of Samples/Area		IREGUN 46 samples/143 km²	IJERO 121 samples/907 km²	EGBE 108 samples/600 km²
Li	range	0.5 –19.5 ppm	1.0 –28 ppm	1.0–61 ppm
	mean	2.6 ppm	5.4 ppm	12.4 ppm
cxLi	range	0.12– 1.50 ppm	0.25– 6.0 ppm	0.4– 6.0 ppm
	mean	0.51 ppm	1.38 ppm	1.0 ppm
Li	<3.5	81%	72%	10%
	3.5–10	17%	24%	48%
	11–30	2%	4%	36%
	>30	—	—	6%
cxLi	<1.0	87%	66%	56%
	1.0–2.5	13%	28%	36%
	2.6–4.0	—	3%	5%
	>4.0	—	3%	3%
Source		Hughes (1976)	Oni (1976)	Sanni (1976)

centrates were then separated by magnetic separation into four fractions: <0.25Amp, 0.25–0.5 Amp, 0.5–1.5Amp and > 1.5Amp. The mineralogical identifcation under the binocular was supported by the application of UV-light, for scheelite, monazite and zircon and the zinc dish test for cassiterite. The resulting distribution of cassiterite, columbite-tantalite, monazite, and zircon is presented in Fig. 4.

The qualitative heavy mineral pattern around Iregun gave the most dense accumulation of detectable cassiterite at the various sample stations. The mining site is however not particularly well defined when compared with the Li distribution (cf. Figs. 3a, b). It is difficult to relate the widespread occurrence of cassiterite and columbite-tantalite to the small weathered pegmatite southwest of Iregun alone and there might be further concealed and completely weathered bodies that were not traceable by Li.

Also the Ijero area shows irregular scattering of the primary indicator minerals that could hardly be correlated with the former mining sites. The same is true for the Egbe area although cassiterite was detected only in streams which drain part of the known mining sites.

The heavy mineral distribution at reconnaissance scale did not develop a significant pattern in the study area, but even a more dense sample grid would face the problem of the irregular accumulation of the concentrates. Chemical investigations of the heavy mineral concentrates by X-Ray Fluorescence methods are in progress but results available are not encouraging due to the low abundances of tin, niobium and tantalum bearing minerals.

GEOCHEMICAL SOIL SURVEY

The main objective of the present study is to work out reliable geochemical parameters to explore the unexposed sections between the known mining sites along the geologically outlined belt of pegmatitic Sn-Nb-Ta-mineralization. Thus, more emphasis has been placed on the more detailed geochemical soil survey than on stream sediment reconnaissance.

Lateritic soils are typical residual products of the underlying rock units. Their most important components are clay minerals and accumulations of colloidal Al, Fe, Mn hydroxides/oxides all of which show a high degree of absorption and ion-exchange capacity. The movement of the cations is in the vertical rather than in the horizontal direction. These characteristics support the application of trace element compositions of lateritic soils in predicting the underlying parent rock. The application of geochemical soil surveys has been used successfully in the amphibolite complex south of the present study area (Matheis, 1977b). A similar approach was used to outline the potential source rocks of the pegmatitic Sn-Nb-Ta-mineralization in the areas of Iregun (Oyekunle, 1977) and Ijero (Moughalu, 1977). Further analytical work was carried out in the latter and results are presented below.

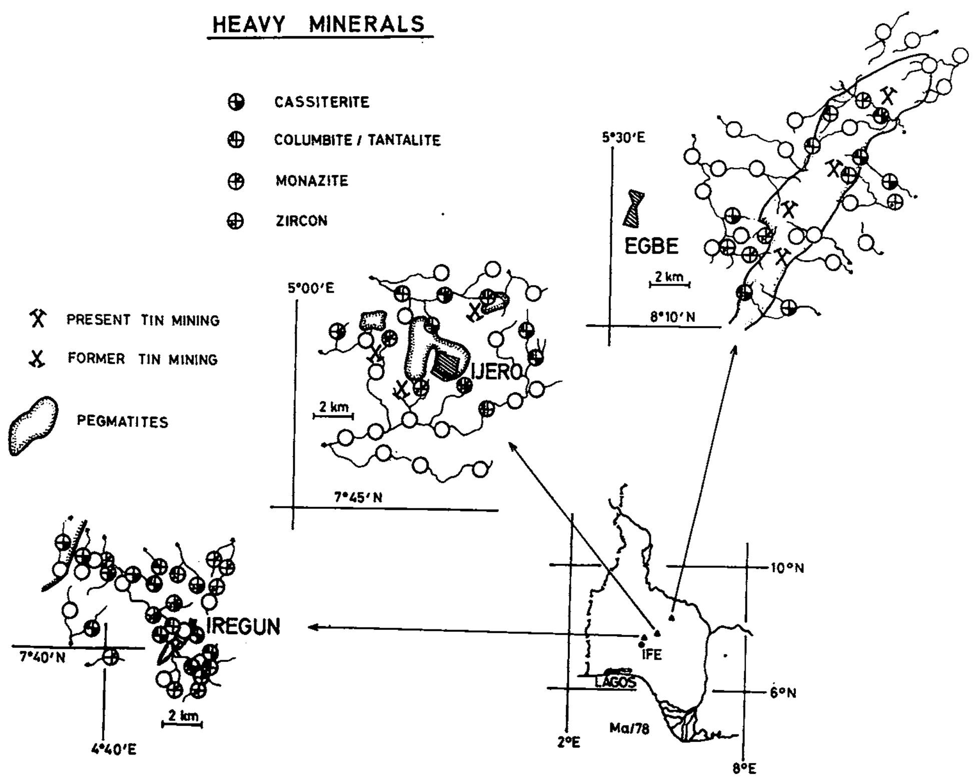

Fig. 4. Qualitative distribution pattern of selected heavy minerals (–25mesh fraction) around the mining sites.

Geochemical parameters of Ijero Pegmatites: Parallel with the soil survey, pegmatitic rocks from different localities in southwest Nigeria, among them samples from Ijero and northwest of it, from Ikoro, have been investigated geochemically (Emofurieta, 1977). Trace element data of Be, Li, Rb, Zn, and the Mg/Li ratio of Ijero and Ikoro pegmatites and closely associated country rocks are presented in Table III. Cs was below detection limit and Sn gave no reliable results. Ore microscopic study of the same rock samples did not reveal any mineralization.

TABLE 3

TRACE ELEMENT COMPOSITION OF IJERO PEGMATITES AND RELATED ROCKS

No.	Be	Li	Rb	Zn	Mg/Li	rock type
7	10	36	215	50	22	pegmatite, Ijero
14	30	47	238	60	19	" "
19a	30	67	200	70	9	" "
19b	40	37	132	82	31	" "
30	20	75	277	50	9	" "
34	40	26	391	35	12	" "
49	20	49	681	n.d.	6	kaolinitic pegmatite, Ijero
32	20	9	10	140	1800	quartz-tourmaline-rock, "
37	20	9	10	230	2300	" " " "
43	12	8	10	60	700	mica-schist, Ijero
46a	10	21	540	25	35	pegmatite, Ikoro
62	100	41	415	100	41	" "
74a	25	32	710	100	57	" "

(Analysis of Be, Li, Mg, Zn by AAS, Rb by XRF)
(Analysts: A. Szolgyemy, W.O. Emofurieta)

TABLE 4

TRACE ELEMENT DISPERSION PATTERN IN SOIL SAMPLES OF IJERO AREA

	range	mean $\bar{x}$	a	ranges of geochemical soil maps (increasing pegmatitic indication) b	c	d	$\bar{d}$	contrast $\bar{x}:\bar{d}$
Be	3– 10.5	6.3	< 5.0	5.0– 7.0	7.5– 9.0	> 9.0	9.8	1.55
Cs	12– 30	18.6	< 15	15 –20	21 – 25	> 25	26.8	1.44
Li	2– 71	13.0	< 10	10 –20	21 – 30	> 30	39	3.00
Rb	7–140	68.2	< 40	40 –70	71 –100	>100	112	1.65
Mg/Li	6–250	70.5	>100	100 –61	60 – 30	< 30	15	4.70

(Analysis by AAS; Analysts: A. Szolgyemy, P.A. Muoghalu)

Only the strongly weathered kaolinitic (sign of former high grade albitization?) pegmatite in the northwest corner of the Ijero body (Fig. 5a-e) contain concentrations of Li, Rb and Mg/Li ratio close to that indicated by Beus & Sitnin (1968) for ore-bearing granites and pegmatites (Table 1). All other pegmatites have too low Li and Rb values, whilst the Mg/Li ratios are at the lower end of the proposed indicative range.

Soil dispersion pattern around Ijero: An area of 100 square kilometers was covered by 95 soil samples taken from the upper 50 cm of the B-horizon by hand-auger. The sample pattern follows roads and motorable tracks with a distance of 500 m between sample points (in places with outcropping pegmatites this was reduced to 100 m). Precaution was taken to avoid contamination by collecting samples at least 10 m off the roads. Materials from both road sides at each sample station were matched to one composite sample to obtain a wider interpretation radious. The –200 mesh fraction was leached by a 7:3 perchloric-nitric acid mixture on a sandbath at 180°, and analysed for Be, Co, Cr, Cs, Cu, Li, Mg, Mn, Ni, Pb, Rb, Sr, and Zn by AAS.

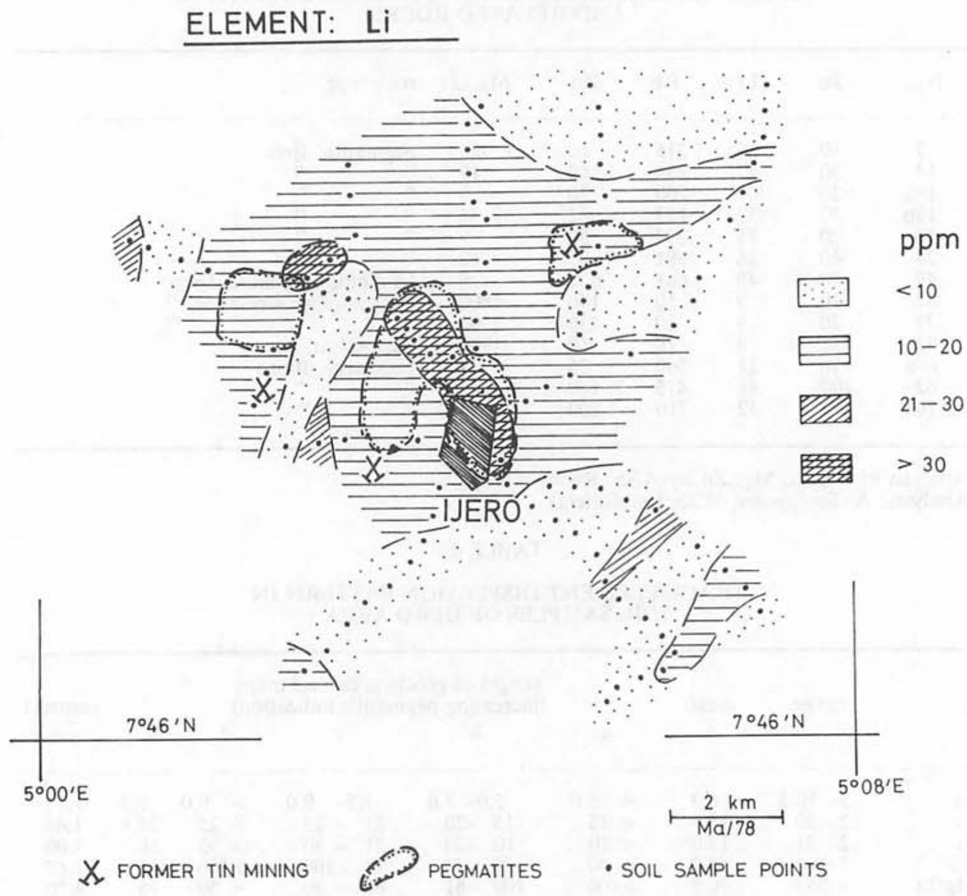

Fig. 5a. Hot extractable Li distribution in lateritic soil (–200 mesh fraction) around Ijero.

The geochemical data were plotted along the sample traverses and different concentration ranges displayed as distribution fields (Figs 5a-e). The selection of these concentration ranges follows the average trace element distribution of the most characteristic rock types which are known to occur in the study area. The average values are derived from literature sources (e.g. Handbook of Geochemistry) and the writers' investigations of outcropping rocks in the study area (Table III; Matheis, 1978). Thus, the soil dispersion pattern are not strictly related to the usual background—anomaly calculations for exploration purposes like the earlier discussed stream sediment dispersion.

Out of the 13 elements analysed, Be, Cs, Li, Rb, and Mg/Li were found to be of particular interest in outlining potential pegmatitic bodies. Geochemical maps for these five indicators are presented in Figs. 5a-e and their dispersion pattern summarized as range of values, mean, distribution ranges of the geochemical maps, and the contrast between the mean of all samples and the mean of the highest distribution range in Table IV.

The Li distribution (Fig. 5a) resembles quite closely the result of the stream sediment pattern in Fig. 3b. The maximum concentration overlaps in the northwest—southeast trending part of the Ijero pegmatitic body, whereas the remaining area has uniformly low abundance. This contrast is reflected by the Li content of the Ijero pegmatites and the surrounding mica-schists respectively in Table III.

A more distinct pattern is obtained from the Mg/Li ratio (Fig. 5b). The Ijero pegmatite is nearly fully outlined with values below 30, which is in accordance with the

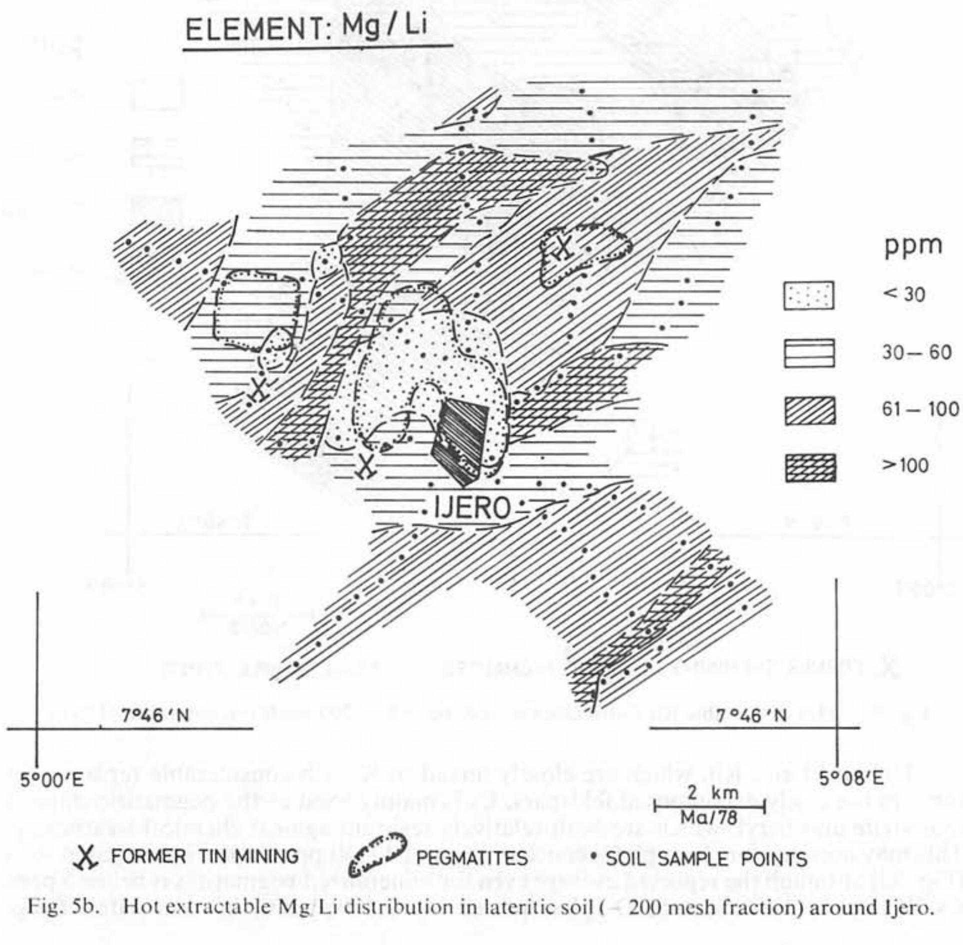

Fig. 5b. Hot extractable Mg Li distribution in lateritic soil (– 200 mesh fraction) around Ijero.

rock values shown in Table III. The maximum zone which flanks the pegmatite along its western border coincides with the actual outcrops of large boulders of quartz-tourmaline rock and their extremely high Mg/Li ratio. Similarly, the higher Zn content of this rock type (Table III) is reflected in a narrow zone of 130–160 ppm Zn in the soil. The lower Mg–Li ratios of the soils compared to the rocks are due to the higher Mg mobility and lower clay absorption than for Li.

The Rb distribution (Fig. 5c) shows the highest values around all the three known pegmatitic occurrences in the study area, the values being distinctly lower than the data from wholerock analysis.

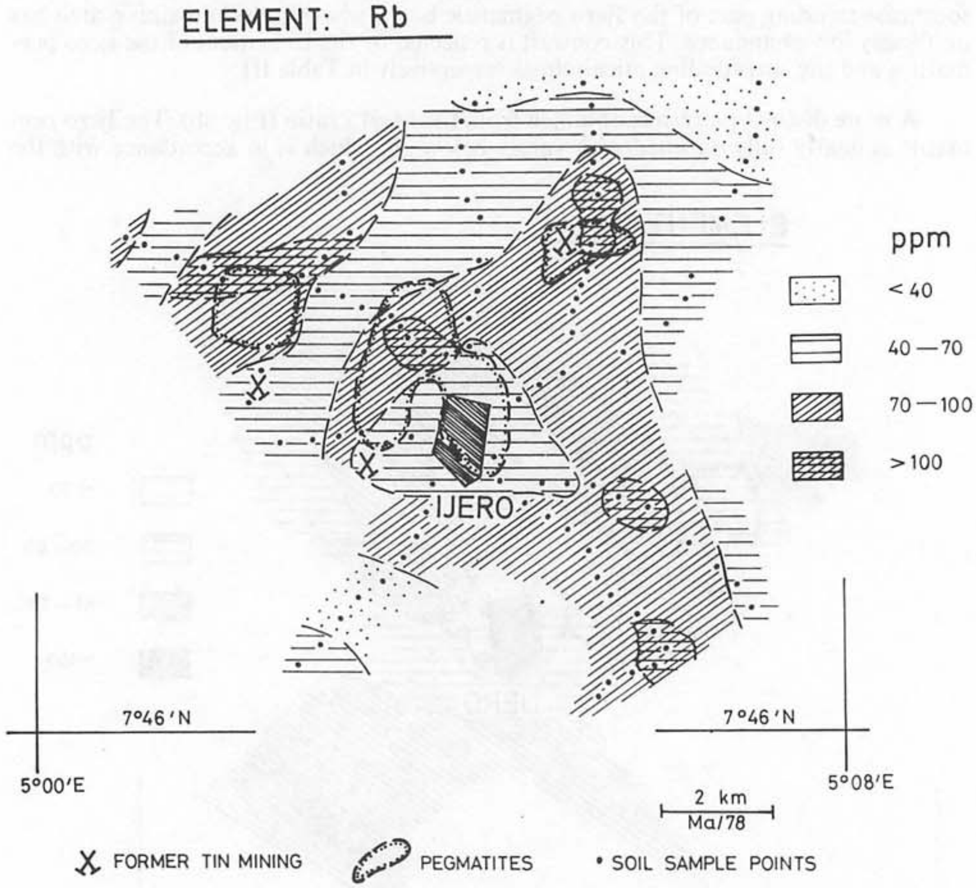

Fig. 5c. Hot extractable Rb distribution in lateritic soil (−200 mesh fraction) around Ijero.

Unlike Li and Rb, which are closely linked to K with considerable replacement for it in the easily decomposed feldspars, Cs is mainly fixed at the pegmatitic stage in muscovite and beryl, which are both relatively resistant against chemical weathering. This may account for the high Cs concentration of 12–30 ppm in the investigated soils (Fig. 5d) although the reported average even for mineralized pegmatites is below 5 ppm Cs. Wedepohl (1968, Sect. 55-D-1) has quoted 140–3,400 ppm Cs in muscovites of pegmatitic association. Muscovite flakes are very abundant in the soils of the known pegmatitic areas and since perchloric-nitric acid attack is known to break up phyllosilicates high Cs values were recorded in the soil samples. Highest Cs concentrations overlap with those of Rb around all three pegmatitic areas.

Although beryl has been reported from the Ijero pegmatites, it was not detected in the present study; the low Be contents in the rocks (Table III) also do not support any significant beryl occurrence. Wedepohl (1968, sect. 4 F–6) quoted 360–940 ppm

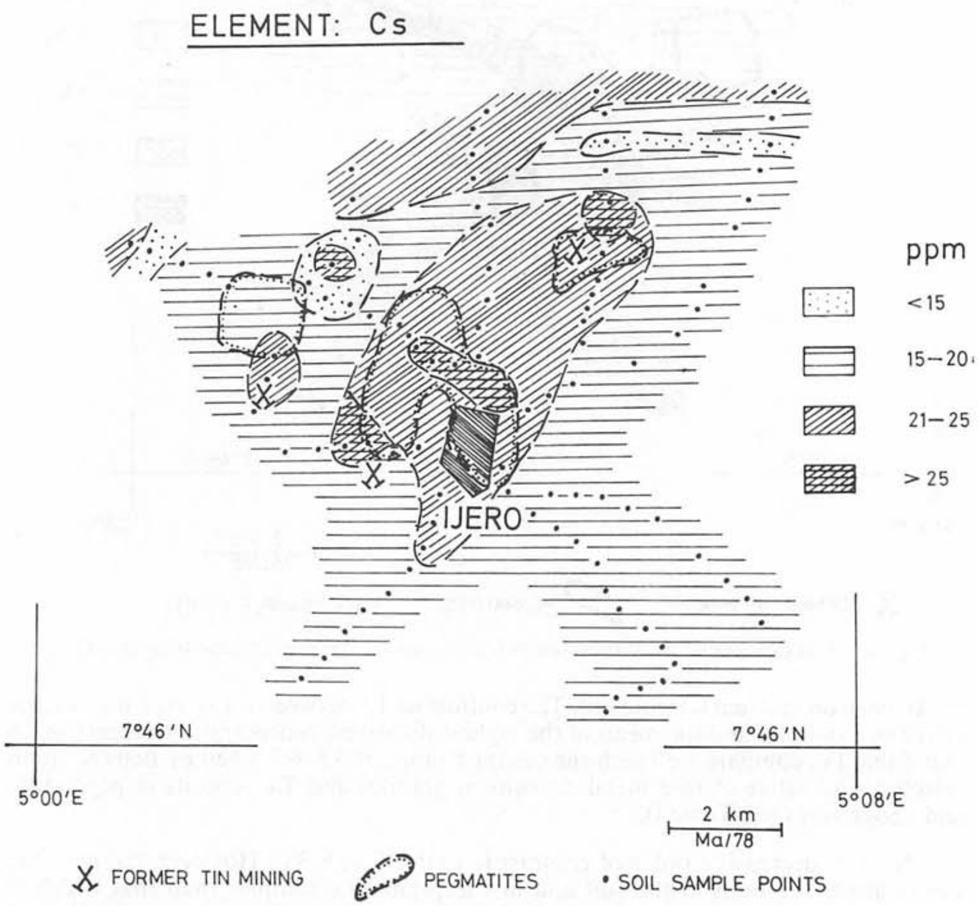

Fig. 5d. Hot extractable Cs distribution in lateritic soil (−200 mesh fraction) around Ijero.

Be for border and intermediate zones of mineralized albite-microcline-pegmatites. The Be soil values of 3–10.5 ppm in Fig. 5e do not show the enhancement effects (up to 60x) of clay absorption reported by Beus (1956). The highest concentration is located around the kaolinitic pegmatite (No. 49 in Table III) just northwest of Ijero which also shows high values for other pegmatitic trace element indicators.

Significance of soil data: The geologically mapped pegmatite occurrences around Ijero are reflected most significantly by the Mg/Li ratio of the –200 mesh fraction of

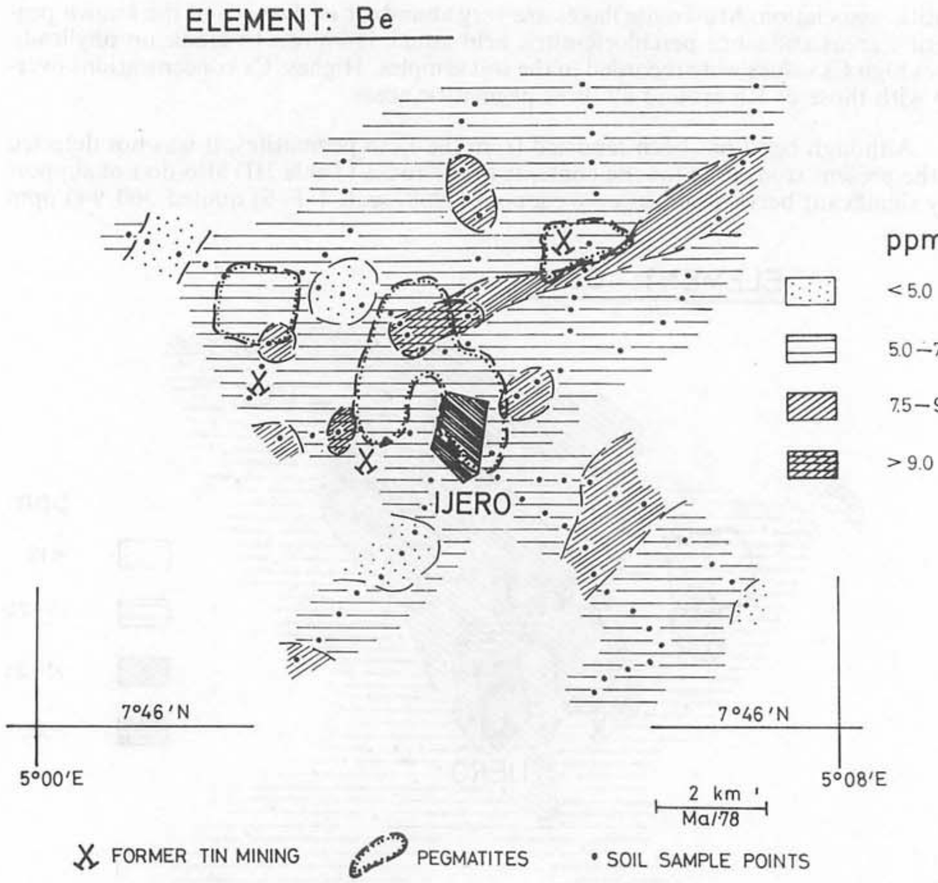

Fig. 5e. Hot extractable Be distribution in lateritic soil (– 200 mesh fraction) around Ijero.

the B–horizon residual lateritic soil. The contrast of 4.7 between the overall mean value of the soil samples and the mean of the highest displayed concentration range(Fig. 5b and Table IV) compare well with the contrast range of 3.6–6.7 given by Beus & Sitnin (1968) as indicative of rare metal deposits in granites and Ta deposits in pegmatites and apogranites (cf. Table I).

Next in decreasing order of contrast is Li itself with 3.0. However, the absolute values are lower both in the soil and in the pegmatitic samples than that which is quoted for ore bearing rocks. Rb, Be, and Cs have nearly similar contrast of 1.65, 1.55 and 1.44 respectively but still reflect areas of known pegmatitic occurrences. Comparing the geochemical maps for Li, Mg/Li, Rb, Cs, and Be (Figs. 5a-e), the pegmatitic main body at Ijero is significantly outlined, being most pronounced around the kaolinitic variety about 1 kilometer northwest of Ijero town with maximum values of the pegmatitic geochemical indicator elements. A similar smaller body is shown at the northeast corner of the Ikoro pegmatite west of Ijero. The third mining site northeast of Ijero, where only pegmatitic debris indicate the parent rock, does not show a significant reflection in the soil composition except for some irregular distributed higher values of Rb and Cs.

CONCLUSIONS

Before exploring further unexposed parts of a metallogenetic belt of pegmatitic Sn-Nb-Ta-mineralization in southwest Nigeria, geochemical pathfinders are investigated in areas of known pegmatite occurrences and related alluvial small scale mining. Owing to the rapid and intensive weathering processes of the tropical environment combined with the lack of a well developed perennial drainage system in the study area the heavy mineral pattern is very irregular with inconsistent accumulations of concentrates and alluvial mining sites are generally situated close to the pegmatitic source rocks.

Based on these considerations, the traditional panning method for cassiterite was not found suitable at the initial and advanced stages of regional reconnaissance for outlining potential mining districts. However, it has its merits in the detailed follow-up stream sediment and the soil surveys once potential pegmatitic source rocks are traced by the geochemical methods proper.

A sample density of 1 sample per seven square kilometer was applied at the reconnaissance scale for a stream sediment survey. Li was selected as a pegmatitic pathfinder and proved to be able to outline known pegmatite occurrences in tin mining areas of Ijero and Egbe sufficiently; cxLi gave a better contrast than the hot extractable Li.

Main emphasis was placed on a geochemical soil survey with a density of 1 sample per square kilometer which still allows its application on a regional scale but gives information detailed enough to trace potential rock bodies of some hundreds of metres in either dimension. The former mining area of Ijero was selected for this exercise. The most significant pathfinder association was Mg/Li and Li which gave the best contrast between the pegmatites and a variety of surrounding country rocks of the metamorphic basement complex. The contrast value for Mg/Li in the soil is comparable with equal ranges quoted for Sn-Nb-Ta-mineralization elsewhere (cf. Tables I and IV). Rb, Cs, and Be gave lower contrasts but still reflect the pegmatitic parent rocks. To obtain the most reliable information, the combination of all the indicative elements, namely Mg/Li, Li, Rb, Cs, and Be should be applied.

Investigations of the F dispersion by selective ion electrode in stream sediment reconnaissance and a more detailed soil survey of the present study area are under way. To crosscheck the reliability of the conclusions derived from the Ijero mining area, a similar soil survey and geochemical study of the pegmatites is being carried out in the Egbe mining area where a larger ore potential is combined with distinctly higher Li values obtained by hot extraction analysis of the stream sediment.

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