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PROCESS TEST WORK FOR THE RECOVERY OF TANTALITE - COLUMBITE CONCENTRATES FROM RARE METAL PEGMATITES OF NASSARAWA AREA, CENTRAL NIGERIA

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ABSTRACT

The Nassarawa Pegmatoids which intrude gneisses, schists and metabasites occur in the northeastern part of half – degree sheet 209. The study aims at elevating the knowledge of economic potentials of Ta – Nb mineralization in the area and enhancing the recovery and extraction percentage of the Ta – Nb concentrates in the weathered (eluvial) and whole rock occurrences.

Ten samples of both the alluvial and whole rock pegmatoids were studied. 10kg of the weathered eluvial samples were prepared and subjected to gravity concentration by panning, wilfy laboratory shaking table and a Mozley laboratory separator before being analysed.

Result show that the recovery of Ta and Nb in the – 2.0mm fractions for eluvial samples was 33. 4% and 28.3% at the combined concentrate grade of 12.2% Ta_2O_5 and 5.89% of Nb_2O_5.

A further 13.2% of Nb_2O_5 and 11.3% of Ta_2O_5 reported to + 2.0mm panned concentrate grade of 2,400 pmm Nb and 5000 ppmm Ta. Back calculated grades of Nb_2O_5 and Ta_2O_5 were 77pmm and 190ppm respectively. The whole rock gave combined concentrate at 23.5% Nb_2O_5 and 31.5% Ta_2O_5 with recoveries, at 70.6% and 70.5% respectively. The back calculated head grade subjected to gravity processing was 128 ppm Nb_2O_5 and 172ppm Ta_2O_5. This test work results show that the two types of ores can be processed to produce Ta –Nb concentrates at economic grade.

Key words: Pegmatoids, concentrates, elluvial, whole rock, recovery.

INTRODUCTION

The Nigerian Basement Complex forms part of the Pan African mobile belt which lies between the West African and Congo cratons and south of the Tuareg Shield (Black 1980) It is commonly divided into three: the migmatite – gneiss complex, the schist belts and the Pan African (ca 600 Ma) granites. The Basement rocks are intruded by pegmatites. This study area falls within the north central zone of a well defined ENE –WSW trending pegmatite belt stretching from the edge of the Jos Plateau in central regions to Ibadan area in the south west. This one was first recognized by Jacobson and Webb (1946) and later elaborated by Wright (1970). The study area is about 2 km. South of Nasarawa town in Nassarawa State (Fig. 1) It is located in the northeastern part of half degree sheet 209. The boundary co – ordinates are $7^0$39.5E; $7^0$47.5E; 8^0 22.9^0 N and $8^0$30.5^{0}N. The study aims at evaluating the potential recoveries of tantalite and columbite from both eluvial and fresh pegmatite bodies and thus elevating the knowledge of the economic potentials of rare

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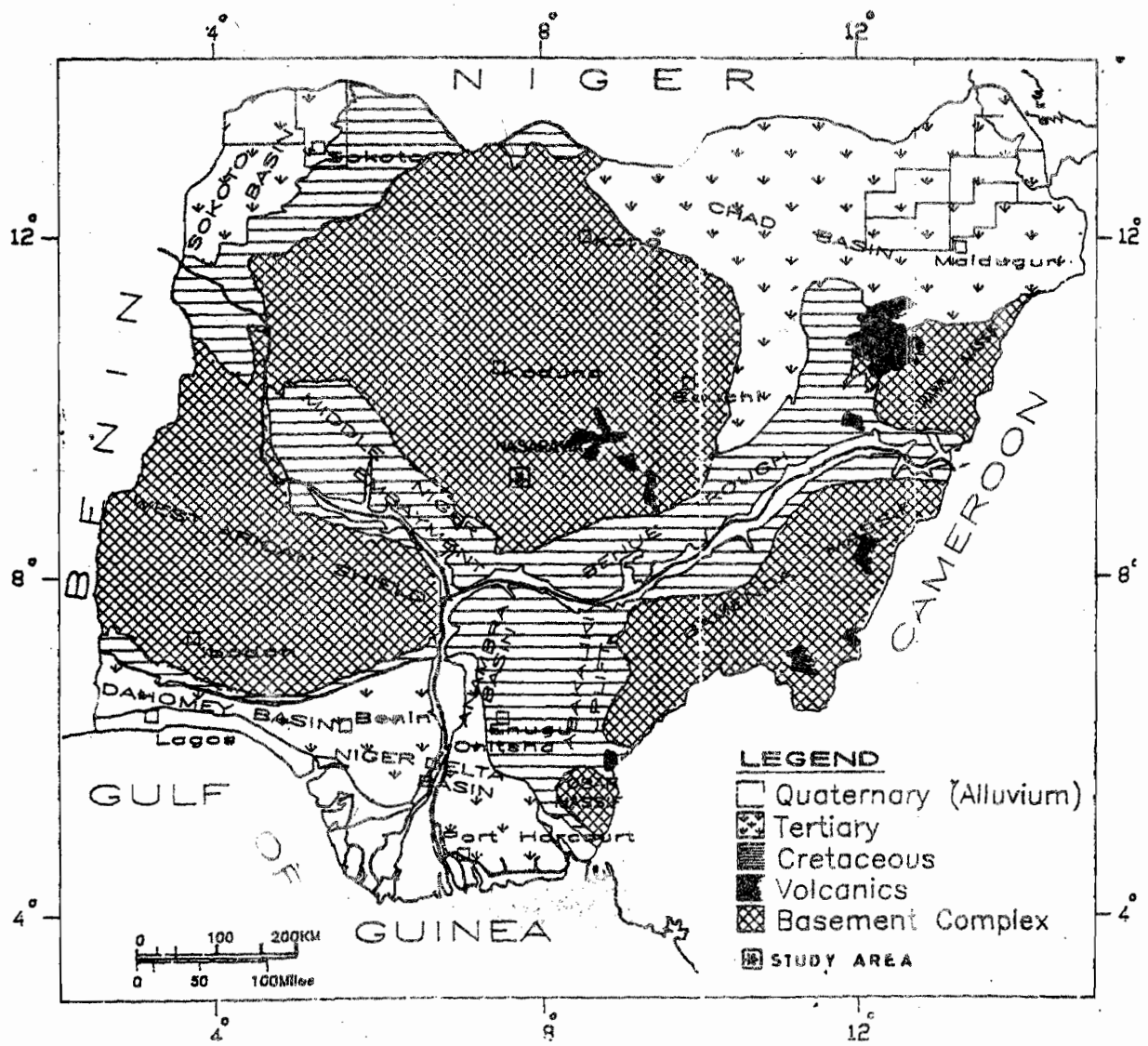

Fig.1: Outline Geological Map of Nigeria Showing Location of Study Area.
(Modified After Okunlola, 1998)

metal. Ta, Nb mineralisation in the Nassarawa pegmatite bodies.

GEOLOGY

The study area is underlain by biotite gneiss, mica schist, phyllites. biotite granites, pegmatites and quartz veins. (Fig. 2)

Granite gneiss occurs mostly in the northeastern portion of the study area and occupies about 15% of the area They occur as low lying elongated bodies, greyish to dark grayish in colour. They are mostly medium – coarse grained. They consist of biotite, hornblende, quartz and microcline.

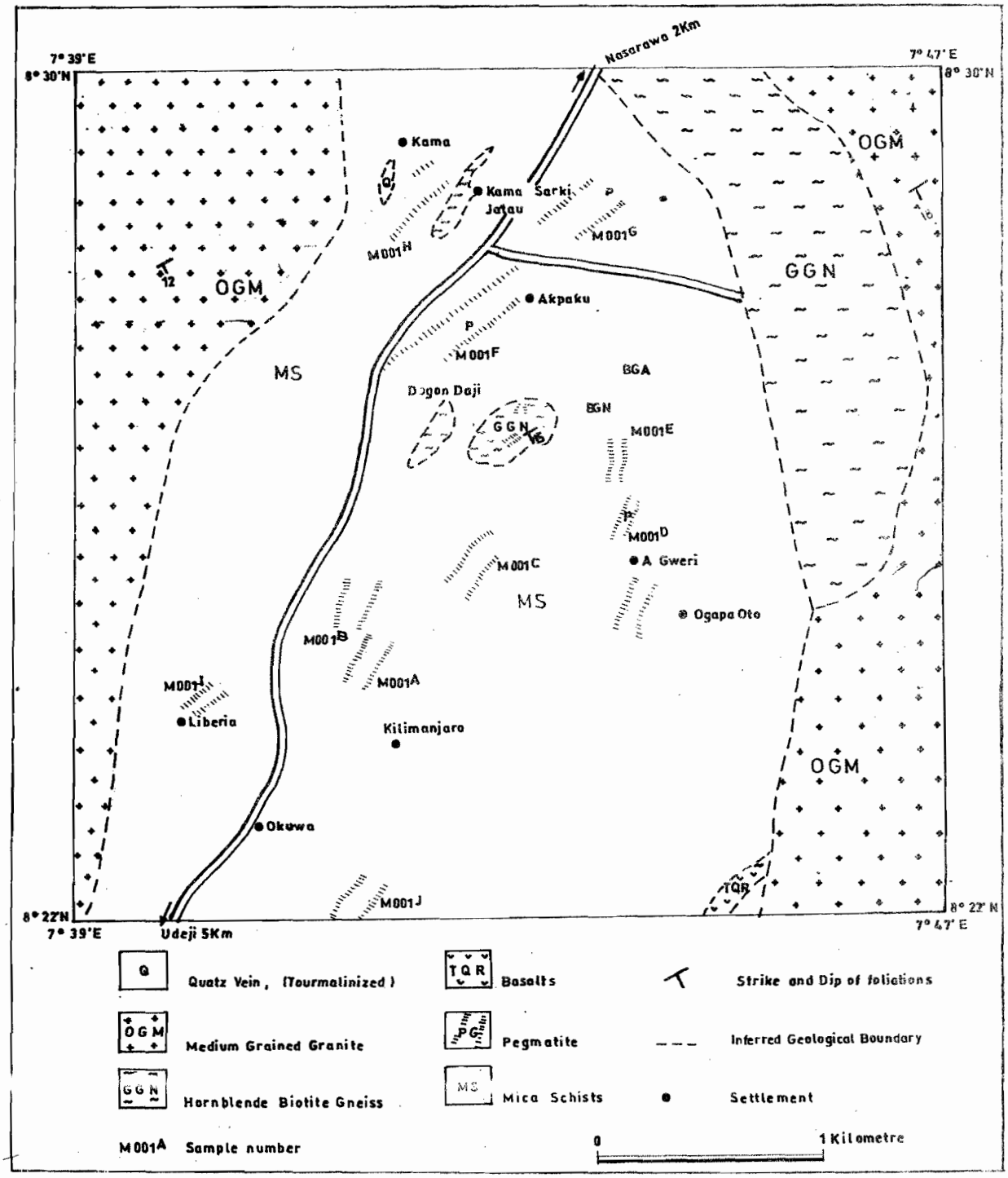

Fig. 2 : Geological map of Study Area.

Table 1: Average rare metal content of concentrate of Nassrawa pegmatites recovered by sample panning method.

n = 10	T_2O_5%	Nb_2O_5%	U_3O_8 +	ThO
Nassarawa	40.33	13.8		

Table 2. Rare metal grade of Nassarawa pegmatites (in ppm)

		Ta	Nb	Sn	Li	Be	Ta/Nb
Eluvial	Range	32-740	12-199	7-136	3-3900	7-195	1.103-3.63
(Weathered)	Average	238	108	55.27	389	54	2.61
n =10							
White rock	n = 10	108 - 888	25-321	6-85	40-400	6-100	2.1-4.3
(Hard rock)	Average	341	201	44	512	61	3.1
n = 10							

The schists occur as layered relicts and as lensoid bodies. They are largely crenulated pelites, and mica schists. The older granites form a continous ridge system in the western parts of the study area. They are fine to medium grained light to grayish in colour. They are slightly foliated with the foliation marked by a sub parallel alignment of elongated and closely packed feldspar phenocrysts mainly miccroline. Mineralogically, they comprise biotite, hornblende, quartz, orthoclase and micorcline.

The pegmatites occur as flat lying sheets covering about 70% of the study area. They intrude the schist mainly. They are coarse grained, and with a general milky white appearance. They some extend for about 1.5 km continuously and about 400m wide.

They strike generally in the ENE- NNE – SSW directions. The main mineral assemblages are microcline, albite, quartz, muscovite, sericite tourmaline (Black and green). Secondary associated minerals include columbite – tantalite and cassiterite. Detailed geological description could be sourced from Okunlola (1998).

MINERALISATION

The rare metal minerals are mainly tantalite and columbite. Cassiterite occurrence is rare here. The tantalite-columbite which occurs together as discrect grains are usually black, striated and

irregularly shaped. They occur mainly embedded in the feldspar matrices and at intergranular boundaries between the feldspar and muscovites plates. However there seem to be a preferred concentration in areas rich in albite rather than microcline or orthoclase. The average Ta_2O_5 Nb_2O_5 contained in the concentrate recovered by simple panning of the eluvial is 40.33% and 13.8%.

The Ta_2O_5 content in the eluvial (weathered) and whole rock (Hard rock) pegmatite averages 236 ppm and 341 ppm while Nb_2O_5 is 108 ppm and 201 ppm. Ta/ Nb ratio is 2.6 and 3.1 for eluvial and whole rock respectively (Okunlola 1998) (Table 2)

PROCESS TEST WORK:

Method of analysis:

Laboratory test work was carried out at the Camborne School Mines, UK on representative specimens of both eluvial (weathered) and fresh pegmatite to evaluate the potential recoveries of tantalite and columbite. Ten samples each of the eluvial and Hard rock (whole rock) samples were treated differently. For the eluvial samples, a weighted composite sample of 10kg was prepared by combining sub samples in proportion to original sample weights. The weights are given in Table (3). The composite sample was wet screened at 2.0mm and the oversize material subjected to gravity concentration by panning.

The panned concentrate and tailings were dried, weighted and prepared for Ta, Nb, Sn analysis. The 20mm fraction was further screened at 1.0, 0.25, and 0.0075 mm. The size distribution of the eluvial composite is given in Table 4. Each fraction was treated separately on a 1/8-size wilfey Laboratory shaking table. The recovered concentrate was further treated on mozley laboratory separator to produce a cleaner gravity concentrate. The gravity concentrate from both the shaking table and seperator were further upgraded using magnetic seperation technigues. A hand magnetic fraction was further processed using a Box mag Laboratory dics separator to split the samples into fractions of different magnetic succeptibilities.

The Hard rock samples were weighed and using

Table 3. Eluvial sample weights.

Sample	Original Sample Weight(kg)	Weight used in Test(kg)
M001A	7.4	2.34
M001B	6.8	2.15
M001C	6.0	1.90
M001D	5.3	1.60
M001E	6.1	1.93
M001F	6.7	2.31
M001G	5.8	1.85
M001H	6.0	1.90
M001I	7.4	2.34
M001J	6.1	1.95

Table 4. Size analysis of elluvial composite.

Size mm	Weight (kg)	Weight(%)
+2.0	5.350	51.9
-2.0 +1.0	1.163	11.3
-1.0 + 0.25	1.426	13.8
0.25 + 0.075	1.377	13.3
-0.075	1.000	9.7
	10.316	100.0

a combination of jaw and rolls crushing. The samples contained coarse mica (up to 30mm) was impossible to crush and this material was removed at each successive screening. The weights of samples are given in Table 5. The crushed-1.0mm samples were riffled to provide sub samples which were then recombined in accordance with the weight proportions of the original rocks to provide a representative samples for gravity concentration. This was further screened at 250um the two size ranges were treated on a 1/8 size willfey laboratory shaking table.

The rougher gravity concentrates so obtained were further cleaned on a mozley laboratory seperator and the gravity cleaner concentrates retained individually. The tailings from the cleaner operations were added to the willfey tailings in each case. The gravity cleaner concentrates were dried, weighed and treated magnetically. Magnetite was removed using a hand magnet and the non magnetic fraction was treated on the Boxmag disc laboratory seperator just like the eluvial samples.

About 0.5 to 1gm of each sample material was ground to a very fine powder in an agate mortar. The powder was fused in borax and sodium carbonate flux. The glass produced from the fusion was ground to very fine powder in a tungsten carbide ball mill. The powder was then analysed for Nb_2O_5, Ta_2O_5 and S_nO_2 with Phillips PW1212 X- ray fluorescence spectrometer. Calibration and drift correction was by means of standards prepared for chemically analysed columbite- tantalites of various compositions.

RESULTS

The result of the analysis are presented in table 6 7.

DISCUSSION OF RESULTS

The economic value of rare metal bearing pegmatoids is largely dependent on the degree of liberation of discreet grains concentrated in such ore bodies (de st Simon 1999). Previous assessment of recovery of Ta – Nb concentrates using water panning (gravity) methods from Nassarawa pegmatites reveal a recovery of 11% of Ta – Nb grains from eluvial ore bodies. This has been proved to be uneconomical and wasteful (Okunlola 1998).

Results from this study show that the recovery of Ta_2O_5 + Nb_2O_5 to size of –2.0mm for table concentrates for eluvial sample is 28.3% and 33.4% respectively for a combined concentrates grade of 12% Ta_2O_5 and 5.89% Nb_2O_5, while

Table 5 Sample weights of whole rock material.

Sample	Weight (kg)	Weight of mica (kg) used in test	% weight of Mica used in test
M002A	20.2	2.35	11.6%
M002B	7.549	1.64	21.7%
M002C	2.27	0.34	15.0%
M002D	1.88	0.02	1.1%
M002E	20.1	2.43	22.16%
M002F	7.35	1.81	18.52%
M002G	3.52	0.66	18.52
M002H	2.89	0.54	16.25
M002I	1.95	0.03	1.5
M002J	2.15	0.31	14.25

Table 6: Metallurgical Balance for Eluvial sample

Size (mm)	Product	Magnetics	Weight(g)	Weight%	Assay ppm			Distibution		
					Nb	Ta	Sn	Nb	Ta	Sn
+2.0	Panned conc.	-	43.6	0.43	2400	5000	200	13.2	11.3	1.1
+2.0	Panned tails	-	5210.0	50.93	31	80	76	20.4	21.5	50.8
-2.0	Table conc.	1A Mags	4.5	0.04	58900	122100	6300	33.4	28.3	3.6
		Non-mags	6.3	0.06	3200	500	11600	2.5	0.2	9.3
-2.00.0	Table tails	-	1163.0	11.37	151	493	73	22.2	29.6	10.0
-1.00.5	Table tails	-	1426.0	13.94	26	67	54	4.7	4.9	9.9
-0.5 + 0075	Table tails	-	1377.0	13.46	9	27	46	1.6	1.9	8.1
-0.0	Table tails	-	1000.0	9.77	16	46	49	2.0	2.4	6.3
Total			10230.4	100.0				100.0	100.0	100.0

Calculated Products	Weight(g)	Weight%	Assay ppm			Distribution		
			Nb	Ta	Sn	Nb	Ta	Sn
+2.0m head	5253.64	51.35	51	121	77	33.6	32.6	51.9
-2.0m head	4976.75	48.65	106	262	75	66.4	67.2	48.1
-2.0m table concentrate	10.8	0.11	26464	51289	9386	35.9	28.4	12.9

recovery for the panned concentrate up to +2.0mm is11.3% and 13.2% of 5% and 0.24%, combined grade for Ta_2O_5 and Nb_2O_5 respectively. There is obvious enhancement of 17% and 20.2% recovery from the table concentrate (which is a combination of the gravity and magnetic separation techniques) over the panned concentrate. The enhancement is significant and suggest its obvious economical advantage. The recovery from the non magnetics are predictably low at 0.2% and 2.5% for Ta_2O_5 and Nb_2O_5 respectively. The recovery from the tails show that table tails of up to –2.0mm to + 1.0mm liberates 29.6% and 22.2% of their Ta_2O_5 constituents at a grade of 0.05% and 0.01%, compared to a total of 9.2% range for Ta_2O_5 and 8.3% for Nb_2O_5 for the size range of 10mm to 075 at combined grades of 0.015% and 0.05% for Ta_2O_5 and Nb_2O_5 respectively. Back calculated results show that at –2.0mm, table concentrate gives a recovery of 28.4% and 35.9% for Ta_2O_5 and Nb_2O_5 at assay grades of 5.12% and 2.64% respectively. Up to +2.0mm, there is a slightly higher calculated recovery of 32.8% and 33.6% for both Ta_2O_5 and Nb_2O_5 significant deduction from the above discussion is that the liberation size for optimal recovery is at –2mm for table concentrate and +2mm for the panned concentrate. Lower size fall within the tailings and the recovery is not encouraging. From size of 2.0mm to –2mm for a combination of panning, gravity and magnetic methods a total recovery of 6.1% for Ta_2O_5 and 65.0% for Nb_2O_5 is possible. This obviously shows that for a large tonnage high grade deposit like that of Nassarawa Okunlola 1998 st. Simons 1999: NIMAMOP 1999) the recovery in the eluvial ore is not only economical, but compares favourably with others like Wodgna in Australia and China (Cerny 1989). The results also suggests that upgrading of the concentrate by magnetic separation yields slight less than 1kg per tonne of ROM (Run of mine) containing 16% Ta_2O_5. Results for the whole rock (fresh rock) show that table concentrate from

Table 7: Metallurgical Balance for Hard Rock sample

Size (mm)	Product	Magnetics	Weight(g)	Weight%	Assy ppm			Distibution		
					Nb	Ta	Sn	Nb	Ta	Sn
-1.0 + 0.25	Table conc.	1A Mags	1.34	0.02	219200	297400	5300	34.4	34.9	4.9
	Table conc.	Non-mags	7.55	0.11	4500	1600	1900	4.0	1.1	3.8
-0.25	Table conc.	Hi-mags	0.32	0.00	41900	47200	2900	1.6	1.3	0.2
	Table conc.	1A mags	1.22	0.02	253000	334000	5000	36.2	35.6	1.6
	Table conc.	Non-mags	1.83	0.03	5800	4500	4700	1.2	0.0	2.3
-1.0 + 0.25	Table tails		4766.5	71.75	33	50	57	18.4	20.8	72.3
-0.25	Table tails		1864.8	28.07	19	34	36	4.2	5.5	17.9
Total			6643.6	100.0				100.0	100.0	100.0

Calculated Products	Weight(g)	Weight%	Assay ppm		Distribution			
			Nb	Ta	Sn	Nb	Ta	Sn
Combined concentrates, 1.0A magnetics	2.56	0.04	235308	314842	5157	70.6	70.5	3.5
Gravity concentrates (feed to magnet)	12.26	0.18	53865	68831	3024	77.4	73.6	9.9
Back calculated -1.0+0.25mm	4775.4	71.9	101.6	96.2	45.9	56.9	56.8	78.0
Back calculated -0.25mm	1868.2	28.1	197.0	37.8	33.0	43.1	43.2	22.0

magnetics at – 1.0 to –25 show a possible recovery of 70.6% for Ta_2O_5 and Nb_2O_5 respectively for a combined grade of 31.5% Ta_2O_5 and 23.5% Nb_2O_5 respectively. 26.5% and 22.6% of Ta_2O_5 – Nb_2O_5 is recovered from the tails. These results suggest that recoveries are much enhanced in the fresh pegmatities using straight magnetics and gravity methods than in the eluvial. Where a combined panning, gravity and magnetics gives a total 61% recovery for Ta_2O_5.

The above results though on laboratory scale and thus still preliminary show that columbite – tantalite ores (eluvial and fresh rock) are amendable to gravity and magnetic separation and that three quarters of tantalite is contained within 0.25mm. it will thus be necessary to crush and mill the R. O. M. to this size. Simple panning of the eluvial ore yields only 11% contained tantalite. This is a possible reason of the low recoveries experienced by informal miners in the Nasarawa area.

CONCLUSION

The Nassarawa pegmatites are members of the Late Pan African series of pegmatites intruded into gneisses, schists, and granites, forming a NNE-WSW trending belt. The Nassarawa pegmatoids have been shown to contain economic grades for Ta – Nb mineralisation.

The ore as both eluvial and fresh pegmatite have been studied for their recover abilities and results confirm their amenability to gravity and magnetic separation with economic recoveries at 70% and 61% for Ta_2O_5 in fresh and eluvial ores and 65% of 70% for Nb_2O_5 in the fresh rock and eluvial ore too. Though the tests are under laboratory conditions and obviously preliminary, the results show that for a large tonnage, high grade deposit like that of Nassarawa (Okunlola 1998: St. Simon 1999: NIMAMOP 1999) the recovery is not only economical but compares favourably with other world class deposits.

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