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Revelation of tin and niobium occurrences in Southern Uis Region of Namibia through a geological reconnaissance study

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Abstract: The paper presents the results of a geological reconnaissance carried out by the author in the Southern Uis region, Namibia. During the present reconnaissance geological studies, close grid sampling was carried out in the investigated area covering about six sq km and a total of 153 individual samples were collected and analysed for their tin, niobium and tantalum contents. The analysis of the samples shows that 14 of them have high positive anomalous values of SnO_2 and 58 samples gave good values of Nb_2O_5. The samples showing positive values are mainly eluvial in nature and are located in the central portion of the investigated area. As such this area can be mined manually by small group of miners.

Key words: *Reconnaissance, tin, niobium, tantalum, Uis, Namibia.*

Resumen: Se destacan los resultados de una prospección geológica realizada en una área de 6 km^2 en el sur de la región de Uis (Namibia). Durante ésta, fueron recogidas un total de 153 muestras y analizadas para determinar su contenido en Estaño, Niobio y Tántalio. Una proporción relativamente importante de las mismas registran valores positivos altos de SnO_2 y buenos de Nb_2O_5 y proceden de depósitos eluviales localizados en la parte central del área estudiada, que podría ser explotada manualmente por pequeños grupos de mineros.

Palabras clave: *Prospección geológica, Estaño, Niobio, Tantalio, Uis, Namibia.*

Generally tin, tantalum and niobium occur in association with one-another. Pegmatites are supposed to be the largest source of tantalum in the world and an important tin producer. Owing to their petrogenetic significance, the oxides of tin, tantalum and niobium have been extensively studied which throws light on the genesis of granitic pegmatites enriched with rare elements (Cerny et al., 1985; Cerny & Ercit, 1985, 1989; Fuente and Izard, 1998; Fuente et al. 2000; Robles et al., 1999; Bekasmi et al., 2000; Aurisicchio *et al.*, 2001).

Africa is an important resource centre for tin, tantalum and niobium and their mineralization occurs in various countries across the African continent. However, their exploitation is restricted to a few countries. The African countries having a history of tantalum minerals include Namibia, Ethiopia, Mozambique, Uganda, South Africa, and Zimbabwe where alluvial and eluvial deposits are being mined using small-scale techniques.

Based on the regional geological reconnaissance work carried out by the author in an area of about 3000 sq km, some potential areas were identified (Singh, 2007a) and subsequently detailed surface and subsurface exploration works were undertaken for the purpose of geological mapping, surface sampling, trenching, pitting, drilling and bulk sampling (Singh, 2007b, c). Studies carried out by Singh (2007a,b, c) indicate that the pegmatites in this region are LCT type of Cerny's classification given in 1991 but in places they show mixed features between LCT and NYF pegmatites.

The aim of this paper is to present the reconnaissance geological work that has been carried out in about six sq km area of southern Uis region which is a part of Erongo region of Magisterial district Omaruru, Namibia (Fig. 1). This area is included in the Uis-Cape Cross rare element pegmatite belt (GSN, 2000) and has given positive anomalous values in tin (79 ppm of SnO_2), tantalum (0.45 wt. % of Ta_2O_5) and niobium (0.20 wt. % of Nb_2O_5) in previous geological reconnaissances as it is pointed out by Singh (2007a). Taking into account these facts, this study was focussed on the study of pegmatite bodies of this area for assessing the potential occurrences of tin, tantalum and niobium.

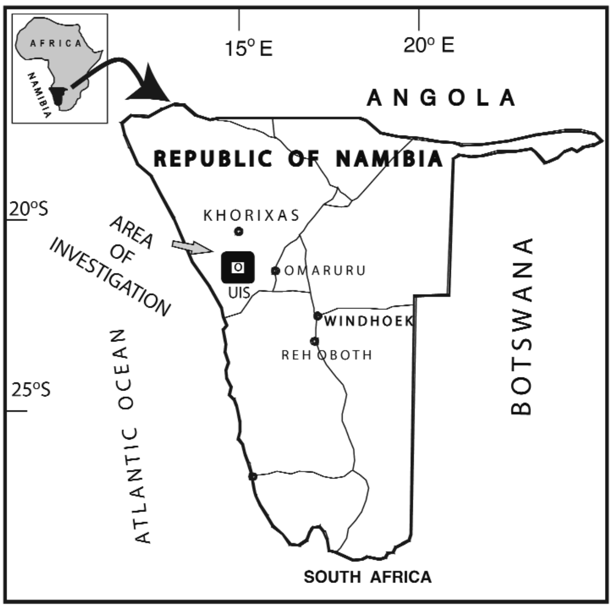

Figure 1. Map of Namibia showing Uis , the area under investigation.

Geological Setting

The younger sediments of the Kalahari and Namib deserts cover nearly half of the Republic of Namibia. Nevertheless, the varied geology of this country encompasses rocks spanning from the Archean to the Phanerozoic age and covers more than 2600 Ma of the earth's history. The metamorphic inliers that consist of highly deformed gneisses, amphibolites, meta-sediments and associated intrusive rocks occur in the central and northern parts of the country, and represent some of the oldest rocks of Paleoproterozoic age (2200 to 1800 Ma) in Namibia (Geological Survey of Namibia, 2000).

In the Southern Uis region, meta-sedimentaries, belonging to the Amis River Formation, Swakop Group of 1000-545 Ma (GSN, 2000) crop out. They are the oldest rocks occurring in the area and include quartzite, phyllite, quartz-schist, quartz-mica-schist and mica-schist. They strike in NE-SW to N-S direction and dip towards the south to southeast. Extensive erosion has taken place at regional scale but the resistant rocks can be seen as ridges and hills in the area.

These meta-sedimentaries are intruded by granites and granite gneisses. The intrusive rocks include mainly quartz and alkali-feldspar while tourmaline occurs as an accessory. These intrusive granites and granite-gneisses, normally trend in the strike direction of the meta-sedimentaries. The alkali feldspars in the granite gneiss are medium to coarse grained. At the contact of the intrusive granite with the sedimentaries extensive feldspathization can be observed. The granites, granite-gneisses and meta-sedimentaries have further been intruded by younger pegmatites and aplites, thereby constituting an integral component of the geo-tectonic setting of the area. These pegmatites also trend parallel to the strike of the meta-sedimentaries while in some places they cut across in the form of veins. These veins vary in width from a few metres to sometimes more than 25 metres. However, they do not show noticeable internal zoning. They contain several minerals formed by rare elements in addition to minerals such as quartz, microcline, albite, and muscovite. The accessory minerals include cassiterite, members of columbite-tantalite series of minerals and, in places, zircon and lithium minerals like amblygonite. The rare element pegmatites of the Uis-Cape Cross pegmatite belt were emplaced between 550 and 460 Ma (GSN, 2000). They are considered to be a major source of tin in Namibia. Figure 2 shows the geological map of the investigated area.

Dolerite dykes also occur as intrusive rocks cutting across the formation and intruding all the older rocks. At few places they form ring like structure called 'ring dykes' (Singh, 2007a).

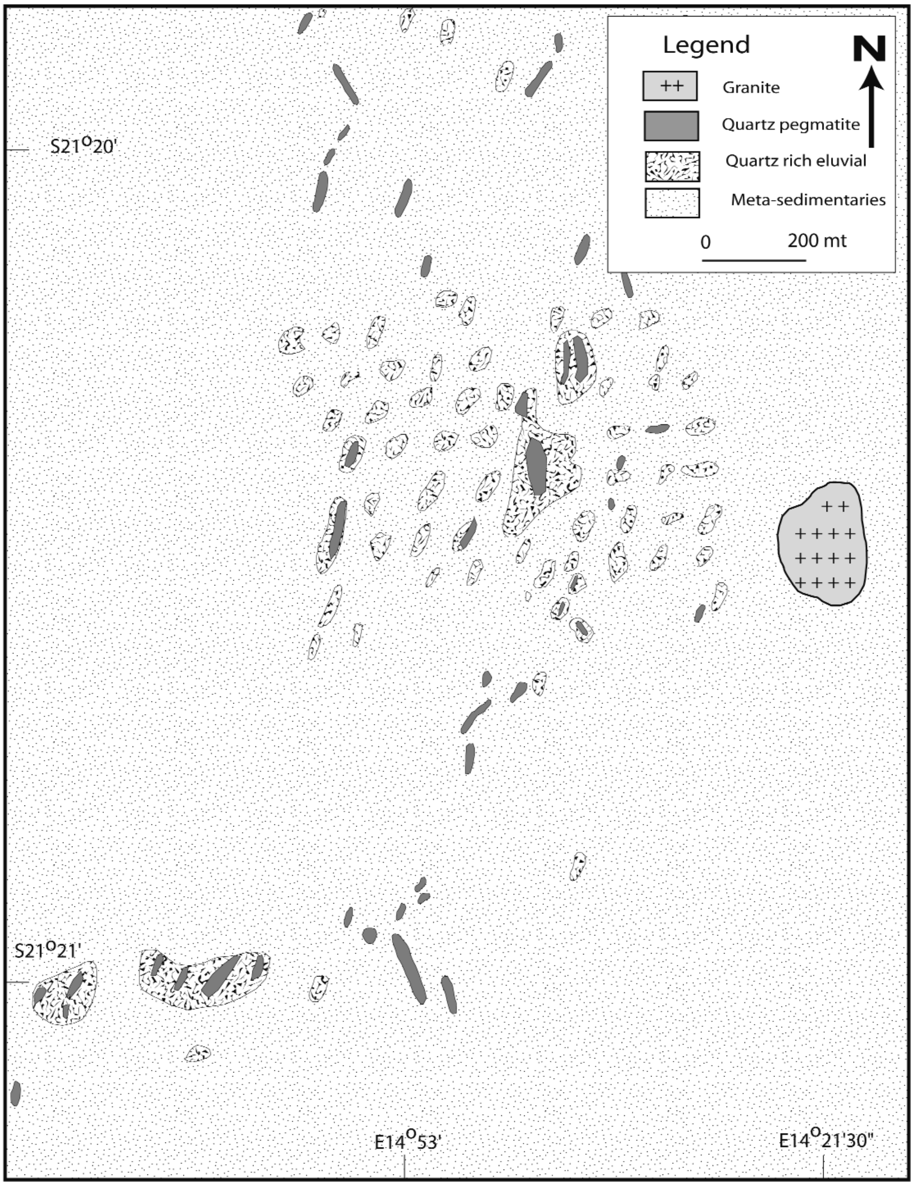

Figure 2. Geological map of southern part of Uis, Namibia.

Method of study

The geological traverses were taken in such a way that the entire area was covered and all the outcrop exposures were studied more specifically. A grid of 100 x 100 m was followed in and around the main pegmatite body of the area which falls in the central portion of the investigated area, while at the peripheral part the samples were collected from the exposed quartz bodies as well as from the eluvials rich in quartz fragments. While collecting the samples within the grid, we took both the exposed rock samples as well as the eluvial samples with quartz fragments. In total 153 samples were collected from the area and were subjected to the analysis for their tin, tantalum and niobium contents. Rock samples were collected from the major exposed quartz-pegmatite bodies and sample locations and were located using a GPS. Figure 3a shows the sample locations of all the 153 samples collected in the present investigation.

The approximate size of the rock samples was about 20 x 20 x 10 cm while about 5 kg of eluvial samples were collected. The collected samples were processed (split, crushed and pulverized) at the 'Analytical Laboratory Service', Windhoek, Namibia and were subsequently analyzed for their tin, tantalum and niobium contents in the Research and Development Centre of NMDC, Ltd., Hyderabad, India, in ICP-MS (Perkin Elmer).

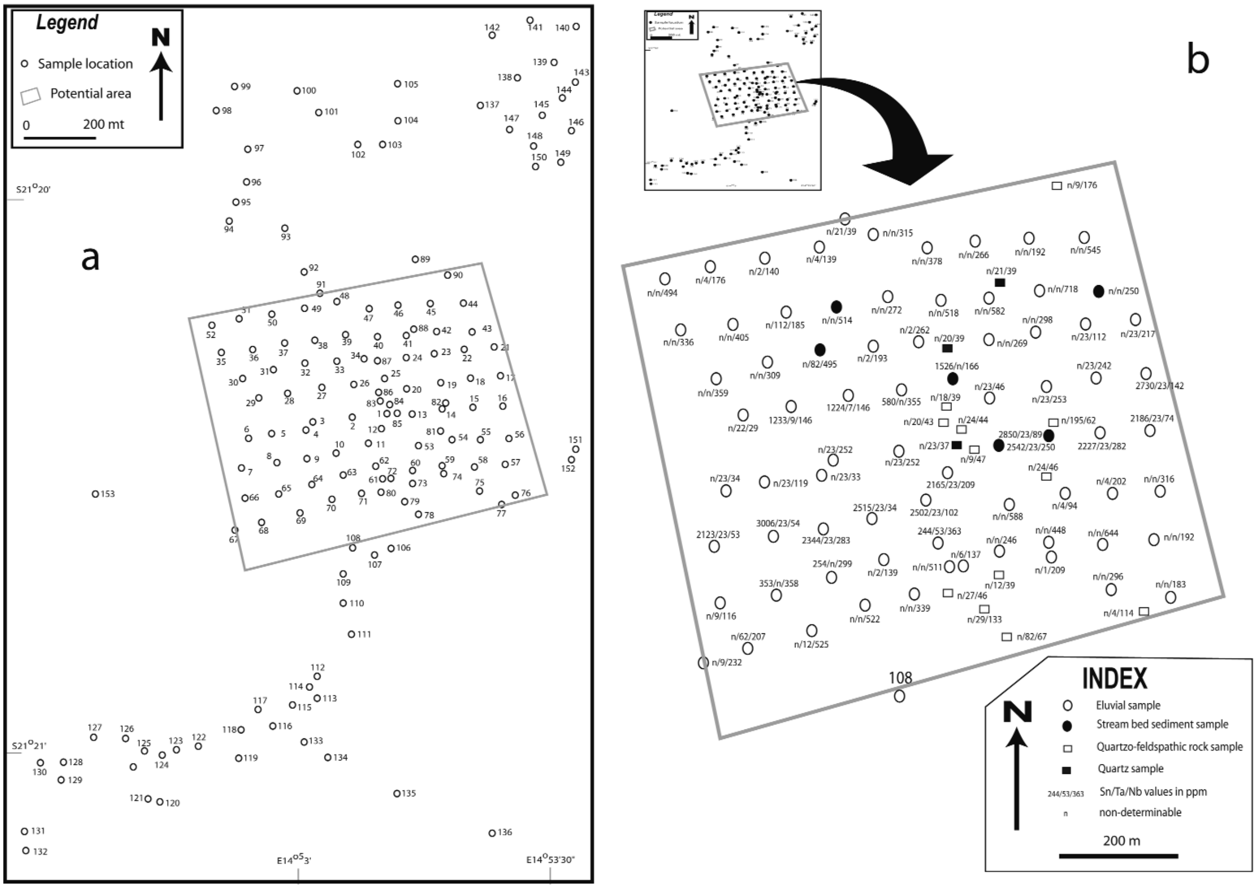

Figure 3. Map showing location of samples in the southern Uis region, Namibia (a) and location of samples (b) with assay values in potential block.

Results and discussions

While carrying out the geological traverses, special attention was focussed on the study of the pegmatite bodies for assessing the potential occurrences of tin, tantalum and niobium.

Out of the 153 samples analysed, one gave a value of tin (SnO_2) higher than 3000 ppm, ten between 2000 and 3000 ppm and three between 1000 and 2000 ppm. The rest of the samples showed a tin content of below 1000 ppm. These values reveal their richness due to mineralization. As far as niobium concentra-

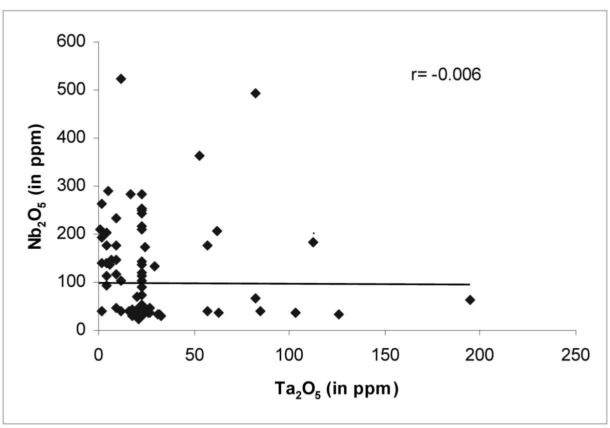

Figure 4. Scatter plot of concentrations of Ta_2O_5 and Nb_2O_5.

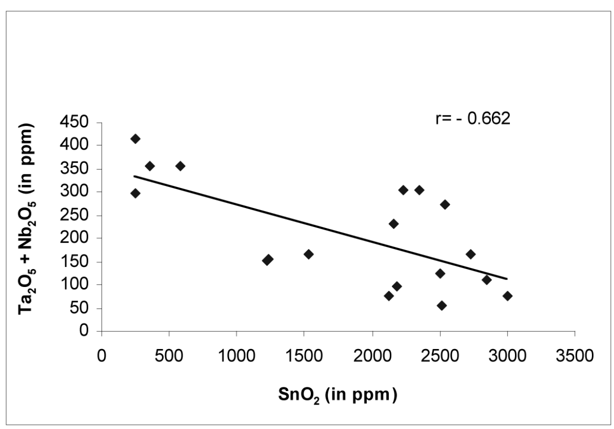

Figure 5. Scatter plot of concentrations of SnO_2 and Ta_2O_5 + Nb_2O_5.

Table I. Details of the samples and their corresponding SnO_2, Nb_2O_5 and Ta_2O_5 contents. ND-not determinable due to low concentration.

S.No	Sample No	Nature of Sample	SnO2	Ta2O5	Nb2O5
			(ppm)	(ppm)	(ppm)
1	1	White quartz with black specks	ND	23	37
2	2	Eluvial sample	ND	23	252
3	3	Eluvial sample	ND	23	252
4	4	Eluvial sample	ND	23	33
5	5	Eluvial sample	ND	23	119
6	6	Eluvial sample (quartz fragments dominate)	ND	23	34
7	7	Eluvial sample	2123	23	53
8	8	Eluvial sample	3006	23	54
9	9	Eluvial sample	2344	23	283
10	10	Eluvial sample (quartz fragments dominate)	2515	23	34
11	11	Eluvial sample	2502	23	102
12	12	Eluvial sample (quartz fragments dominate)	2165	23	209
13	13	Stream bed sediment	2542	23	250
14	14	Stream bed sediment	2850	23	89
15	15	Eluvial sample	2227	23	282
16	16	Eluvial sample	2186	23	74
17	17	Eluvial sample	2730	23	142
18	18	Eluvial sample	ND	23	242
19	19	Eluvial sample	ND	23	253
20	20	Eluvial sample	ND	23	46
21	21	Eluvial sample	ND	23	217
22	22	Eluvial sample	ND	23	112
23	23	Eluvial sample	ND	ND	298
24	24	Eluvial sample	ND	ND	269
25	25	Stream bed sediment	1526	ND	166
26	26	Eluvial sample	580	ND	355
27	27	Eluvial sample(near stream bed)	1224	7	146
28	28	Eluvial sample	1233	9	146
29	29	Eluvial sample	ND	22	29
30	30	Eluvial sample	ND	ND	359
31	31	Eluvial sample	ND	ND	309
32	32	Stream bed sediment	ND	82	495
33	33	Eluvial sample	ND	2	193
34	34	Eluvial sample(near stream bed)	ND	2	262
35	35	Eluvial sample	ND	ND	336
36	36	Eluvial sample	ND	ND	405
37	37	Eluvial sample	ND	112	185
38	38	Stream bed sediment	ND	ND	514
39	39	Eluvial sample	ND	ND	272
40	40	Eluvial sample	ND	ND	518
41	41	Eluvial sample	ND	ND	582
42	42	Eluvial sample	ND	ND	718
43	43	Stream bed sediment	ND	ND	250
44	44	Eluvial sample	ND	ND	545
45	45	Eluvial sample	ND	ND	192
46	46	Eluvial sample	ND	ND	266
47	47	Eluvial sample	ND	ND	378
48	48	Eluvial sample	ND	ND	315
49	49	Eluvial sample (Near stream bed)	ND	4	139
50	50	Eluvial sample	ND	2	140
51	51	Eluvial sample	ND	4	176
52	52	Eluvial sample	ND	ND	494
53	53	Eluvial sample	ND	ND	588
54	54	Eluvial sample	ND	4	94
55	55	Eluvial sample	ND	4	202
56	56	Eluvial sample	ND	ND	316
57	57	Eluvial sample	ND	ND	192
58	58	Eluvial sample	ND	ND	644
59	59	Eluvial sample	ND	ND	448
60	60	Eluvial sample	ND	ND	246
61	61	Eluvial sample	ND	ND	511
62	62	Eluvial sample	244	53	363
63	63	Eluvial sample	ND	2	139
64	64	Eluvial sample	254	ND	299
65	65	Eluvial sample	353	ND	358
66	66	Eluvial sample	ND	9	116
67	67	Eluvial sample	ND	9	232
68	68	Eluvial sample	ND	62	207
69	69	Eluvial sample	ND	12	525
70	70	Eluvial sample	ND	ND	522
71	71	Eluvial sample	ND	ND	339
72	72	Eluvial sample	ND	6	137
73	73	Quartzo-feldspathic rock sample	ND	12	39
74	74	Eluvial sample	ND	1	209
75	75	Eluvial sample	ND	ND	296
77	77	Quartzo-feldspathic rock sample	ND	4	114
78	78	Quartzo-feldspathic rock sample	ND	82	67
79	79	Quartzo-feldspathic rock sample	ND	29	133
80	80	Quartzo-feldspathic rock sample	ND	27	46
81	81	Quartzo-feldspathic rock sample	ND	24	46
82	82	Quartzo-feldspathic rock sample	ND	195	62
83	83	Quartz sample with black specks	ND	20	43
84	84	Quartz sample with black specks	ND	24	44
85	85	Quartz sample with black specks	ND	9	47
86	86	Quartz sample with black specks	ND	18	39
87	87	Quartz sample	ND	20	39
88	88	Quartz sample	ND	21	39
89	89	Quartz sample	ND	21	39
90	90	Quartzo-feldspathic rock sample	ND	9	176
91	91	Eluvial sample	ND	21	39
92	92	Quartzo-feldspathic rock sample	ND	21	39
93	93	Quartz sample	ND	22	39
94	94	Quartz sample	ND	85	39
95	95	Quartz sample	ND	22	39
96	96	Quartz sample	ND	21	39
97	97	Quartzo-feldspathic rock sample	ND	21	24
98	98	Quartz sample	ND	22	39
99	99	Quartz sample	ND	18	43
100	100	Eluvial sample	ND	12	41
101	101	Eluvial sample	ND	5	289
102	102	Eluvial sample	ND	12	102
103	103	Quartzo-feldspathic rock sample	ND	20	39
104	104	Quartzo-feldspathic rock sample	ND	22	39
105	105	Quartzo-feldspathic rock sample	ND	22	39
106	106	Eluvial sample	ND	24	172
107	107	Quartz sample	ND	20	39
108	108	Quartz sample	ND	22	39
109	109	Quartz sample	ND	21	39
110	110	Quartzo-feldspathic rock sample	ND	22	36
111	111	Stream bed sediment	ND	22	39
112	112	Stream bed sediment	ND	17	282
113	113	Quartz sample	ND	20	39
114	114	Quartzo-feldspathic rock sample	ND	22	37
115	115	Quartzo-feldspathic rock sample	ND	22	39
116	116	Quartzo-feldspathic rock sample	ND	57	39
117	117	Quartz sample	ND	18	39
118	118	Stream bed sediment	ND	12	39
119	119	Eluvial sample	ND	2	40
120	120	Quartz sample	ND	17	39
121	121	Quartzo-feldspathic rock sample	ND	17	39
122	122	Quartz sample	ND	16	39
123	123	Quartz sample	ND	18	39
124	124	Quartz sample	ND	17	39
125	125	Quartz sample	ND	17	39
126	126	Quartzo-feldspathic rock sample	ND	16	39
127	127	Eluvial sample	ND	16	39
128	128	Quartzo-feldspathic rock sample	ND	57	176
129	129	Quartzo-feldspathic rock sample	ND	31	34
130	130	Quartzo-feldspathic rock sample	ND	32	33
131	131	Quartzo-feldspathic rock sample	ND	27	37
132	132	Quartz sample	ND	26	39
133	133	Quartzo-feldspathic rock sample	ND	24	39
134	134	Quartzo-feldspathic rock sample	ND	24	40
135	135	Eluvial sample	ND	20	69
136	136	Quartzo-feldspathic rock sample	ND	20	26
137	137	Quartzo-feldspathic rock sample	ND	126	33
138	138	Quartzo-feldspathic rock sample	ND	33	29
139	139	Quartz sample	ND	22	27
140	140	Quartz sample	ND	23	39
141	141	Quartz sample	ND	24	39
142	142	Quartz sample	ND	26	37
143	143	Quartz sample	ND	24	36
144	144	Quartz sample	ND	24	39
145	145	Eluvial sample	ND	23	136
146	146	Quartzo-feldspathic rock sample	ND	103	36
147	147	Quartzo-feldspathic rock sample	ND	28	ND
148	148	Quartzo-feldspathic rock sample	ND	18	30
149	149	Quartzo-feldspathic rock sample	ND	20	33
150	150	Quartz sample	ND	20	34
151	151	Quartz sample	ND	63	37
152	152	Eluvial sample	ND	23	47
153	153	Quartzo-feldspathic rock sample	ND	22	40

ND-not determinable due to low concentration

tion is concerned, 58 samples have shown above 150 ppm of Nb_2O_5. However, the investigated area is almost devoid of tantalum and only one sample has shown above 150 ppm of Ta_2O_5. The details of the analysis showing concentrations of tin, niobium and tantalum is displayed in Table I. Figure 3b provides the assay values of sample along with their locations in the map within the potential block of the present study. From the analytical data it is evident that most of the better values where tin and niobium concentrations are high, are located in the central part of the investigated area. Moreover, the high values are concentrated in the eluvial samples, and the quartz samples from the exposed pegmatite quartz bodies do not reveal anomalous values. The scatter plot (Fig. 4) for concentrations of Ta_2O_5 and Nb_2O_5 in this area shows a poor correlation coefficient (R = - 0.006). However, the scatter plot (Fig. 5) between SnO_2 versus Ta_2O_5 + Nb_2O_5 reveals that with the increase in the concentration of Sn, there is concomitant decrease in the concentration of Nb + Ta and vice versa.

Conclusions

A total of 14 samples out of 153, have given a positive anomalous value of SnO_2 while 58 samples have shown above 150 ppm of Nb_2O_5. However, the investigated area is devoid of tantalum and only one sample has shown above 150 ppm of Ta_2O_5. The analysis reveals that both tin and niobium are located in the central part of the investigated area which covers about 0.64 sq km.

Considering the mineralization in this part of the region, an area of around 800 x 800 m (~ 0.64 sq km) may be considered ideal for manual quarrying or shallow mining of the eluvials by the small groups of miners in the area, as shown in Figure 3a and b.

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