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Uranium occurrences in Malakand granite and granitic gneisses, Malakand Agency, N.W. Pakistan

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ABSTRACT: *Uranium prospection in granitic rocks of Indian plate has yielded numerous radiometric and geochemical uranium anomalies. Detailed investigation on some of radioactive anomalies in alkaline granite of alkaline igneous province revealed that they are mostly thorium dominant. In most of the rocks, uranium is locked in refractory phases such as monazite and thorite, precluding any significant late stage uraninite crystallization.. The detailed foot radiometric survey in Malakand granite gneiss, however, resulted in locating anomalous radioactivity of uranium dominant character with uraninite as a radioactive mineral. A highly radioactive zone at Baru near Kot village was subjected to details surface and subsurface exploration through diamond core drilling. The collected data revealed that high chemical uranium values are due to uraninite, which occurs as inclusion in biotite along joint planes parallel to regional foliation. The joint planes are generally associated with pegmatites.*

Secondary mineralization in the form of torbernite, metatorbernite and uranophane were also noted along some fracture of water seepage. The occurrence of uraninite seems to be related with pnematolytic stage with some limited metasomatic alteration. This paper presents the type, nature and intensity of uranium mineralization in Malakand granite in general and Baru prospect in particular. The paper also assesses the potential of Baru prospect for a viable uranium deposit.

INTRODUCTION

Geoscientists from Atomic Energy mineral Centre (AEMC) Lahore and Peshawar have identified several radioactive anomalies in close association with Main Central Thrust (MCT) in Upper Kaghan Valley in 1991, 1997 and 1999. Chaudhry et al., (1976) reported the existence of MCT in Malakand area. The existence of a major thrust enhances the importance of granitic rocks because it generates the fluid of heated origin which mobilize uranium and concentrate it in reduce zone at depth. Due to this favorable phenomenon, a detailed foot radiometric survey was initiated in Malakand and surrounding area. As a result of this survey, three anomalous zones were located at Baru, Jabagai and Mekhband locality. Among these, the most extensive zone showing high chemical uranium value, the Baru anomalous zone was selected for detail surface and subsurface exploration through diamond core drilling to assess its potential for an economic grade uranium deposit.

REGIONAL GEOLOGY OF MALAKAND QUADRANGLE

Many workers (Tipper, 1905; Hayden, 1915; Chaudhry et al., 1974; 1976; Hamidullah et al., 1986) have conducted a lot of geological investigation on Malakand granite and Malakand granite gneisses. Recently detail investigation regarding the contact relationship between metasediments and Malakand granite gneisses are made by Khaliq et al. (this volume). A revised geological map has been prepared on 1:50,000 scale (Fig.1). The investigation revealed that contact between Malakand granite (Southwest part) and metasediments is intrusive in nature with marked chilling effect with no indication of M.C.T.

Regional geology of Malakand and adjacent area consists of metamorphic and granitic rocks of different ages. The geological units can be broadly divided into the following:

Metamorphic rocks

According to the Metamorphic rocks of the area can be divided into following types (Chaudhry et al., 1974; 1976):

1. Pelitic rocks
2. Calcareous rocks
3. Arenaceous rocks
4. Meta igneous rocks (amphibolites)

Granitic Rocks

Granitic rocks of the area can be divided into the following:

1. Malakand granite gneiss (Permian)
2. Malakand granite gneiss

DESCRIPTION OF BARU ANOMALOUS ZONE

The anomalous zone is located at Barur, Kot village near the contact of metasediments and granitic rock at grid reference 792495 of toposheet No. 38-N/14.

Local Geology of Baru anomalous zone

The granitic rocks of anomalous zone consist of fine to medium grained weakly foliated granitic rocks. The rocks are reddish brown in color due to presence of weathering encrustation (a few mm to few cam thick) consisting of silica and feldspar with hematitic coating. A detailed geological map of Baru anomalous zone has been prepared on 1:1000 scales at grid pattern. The map has shown following textural and lithological varieties (Fig. 2):

1. Aplite veins
2. Pegmatites
3. Porphyritic granite (flaser granite)
4. Fine to medium grained weakly foliated granite
5. Garnet bearing granite bands
6. Granite gneisses (in patches form)
7. Metasediments

The granites rocks are traversed by large number of aplite and pegmatite dykes running parallel to regional foliation. The prominent feature is the presence of a garnet bearing granite band with prominent reddish coating due to weathering of magnetite. The garnet seems to be formed due to reaction between biotite and muscovite. The contact of granite with metasediments is intrusive in nature with marked chilling and baking effect. The garnet has been developed in metasediments due to thermal effect of emplacement of granitic magma (visible in Baru nala). Chaudhry et al. (1992) previously marked this contact as MCT.

Evaluation of Baru anomalous zone for uranium potential

A model zone of 1000 m x 500 m was selected for detailed surface and subsurface investigation through trenching and deep drilling for evaluating its potential for uranium deposit.

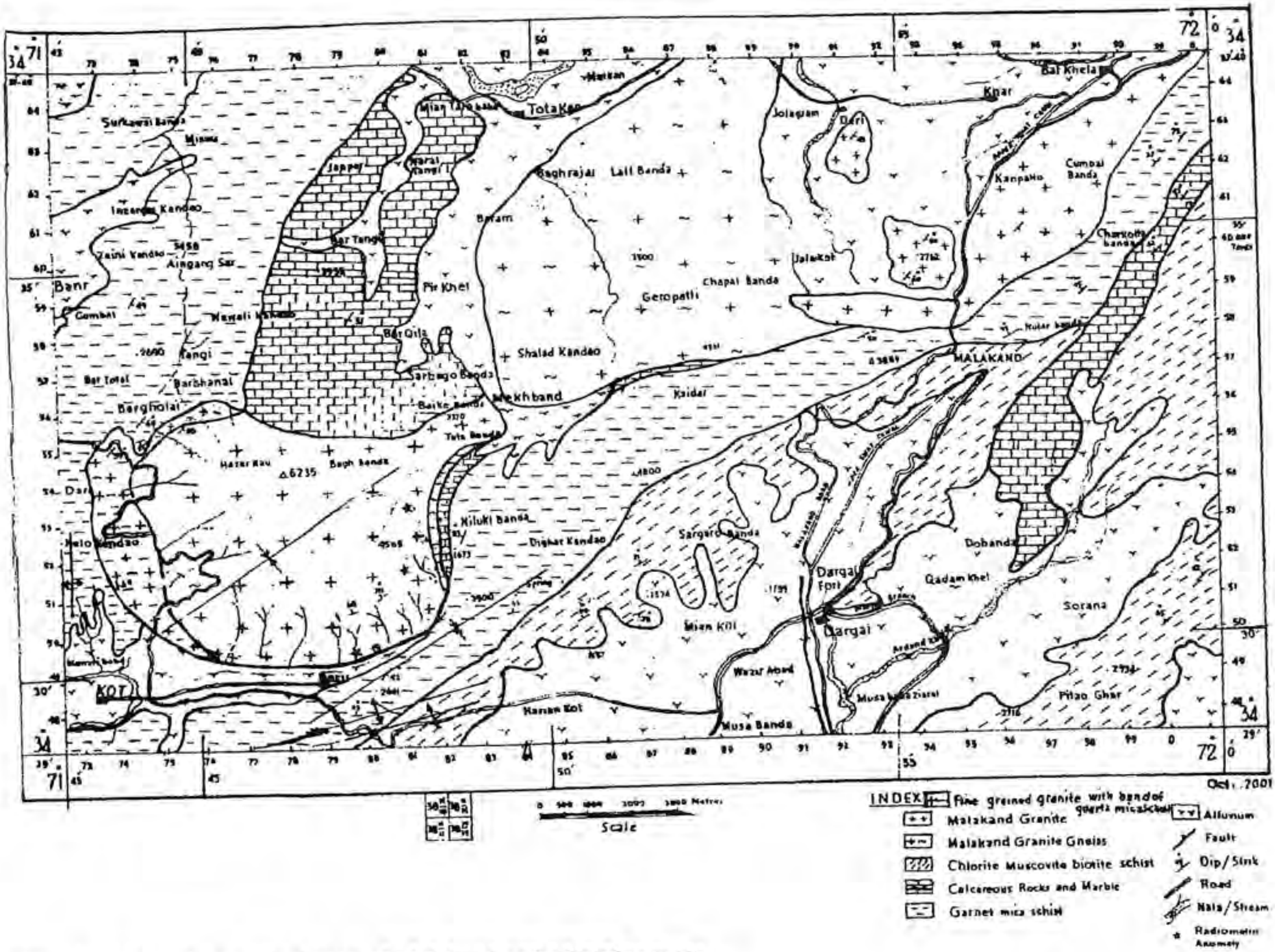

Fig. 1. Revised geological map of Malakand and adjoining areas.

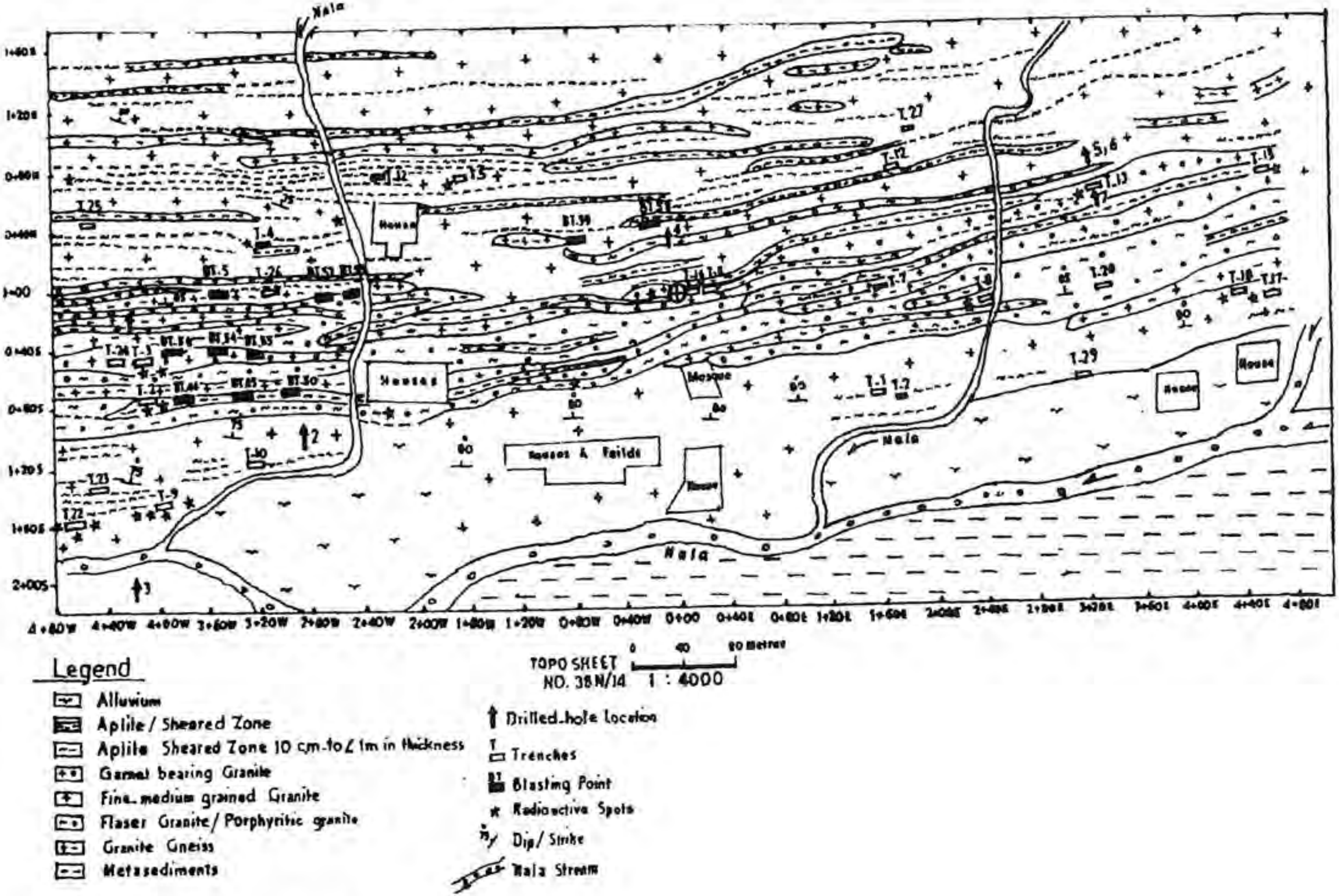

Fig. 2. Geological map of Baru anomalous zone.

SURFACE EXPLORATION

Radioactivity

The radioactivity ranges from 500 cps 15000 cps against background of 250 cps. The radioactive zone/spots were studied in detail to find its source, nature, structural control and dimension. It was observed that high radioactivity is mostly due to uraninite grains associated with biotite cluster along mica rich joint planes having pegmatite and aplite (Table 1).

TABLE 1. DETAILS OF RADIOACTIVITY, ITS CONTROL AND DIMENSION IN BARU MODEL ZONE

S. No.	Trench No.	Radioactivity range against background (cps)	Radioactivity control	Total No of Joints/ No of Rad. joints	Total length of joint/ length of Radioactive part of joint	Thickness of Radioactive joints (cm)
1.	T-1	44-600/200	Mica rich joint plane with pegmatite	3/1	Single spot	-
2.	T-2	500-7000/280	-do-	12/1	5m/4m	< 1 cm
3.	T-3	500-2500/250	-do-	9/5	4m/1.5m	-do-
4.	T-4	700-2500/250	-do-	11/1	4m/1.5m	1-2 cm
5.	T-5	600-1500/200	-do-	6/1	Single spot	-
6.	T-6	700-1500/250	-do-	5/1	2m/1m	< 1cm
7.	T-7	600-1000/200	-do-	6/2	2 & 4m/. 5 & 1m	-do-
8.	T-8	250-300/180	-do-	-	Single spot	-do-
9.	T-9	700-2500/300	-do-	3/1	3m/1m	< 1cm
10.	T-10	700-1000/250	-do-	5/1	2.7m/2.5m	-do-
11.	T-11	700-2000/250	-do-	5/2	1.4 & 1.2m/1.4 m	-do-
12.	T-12	600-1500/200	-do-	5/1	Single spot	-do-
13.	T13	600-2500/200	-do-	5/3	4, 2 & 2.7m/1.8 & 2m	-do-
14.	T-14	800-3000/250	-do-	4/1	4m/2m	3cm
15.	T-15	500-1200/250	-do-	3/2	1m & 2m/. 8m & 2m	< 1cm
16.	T-16	700-2000/250	-do-	4/1	2m/1m	-do-
17.	T-17	500-900/250	-do-	5/2	2.6 &. 4m/1.8m & 2m	-do-
18.	T-18	500-1500/250	-do-	-	Single spot	-do-
19.	T-19	500-1000/200	-do-	3/1	1m/. 3m	-do-
20.	T-20	500-1200/200	-do-	1/1	1m/. 2m	-do-
21.	T-21	700-2000/250	-do-	4/2	3, .8m/1.5 & .2m	-do-
22.	T-24	500-2000/250	-do-	6/3	1,1 & 1m/.5,.5 & .5m	-do-
23.	T-25	600-1000/200	-do-	7/1	2.2m/1.3m	1cm
24.	T-26	600-3000/200	-do-	18/1	2.6m/1.4m	1cm
25.	T-27	600-2500/250	-do-	6/1	3m/.9m	< 1cm
26.	T-28	300-500/250	-do-	7/1	Single spot	-do-
27.	T-29	300-600/250	-do-	2/1	Do	-do-
28.	T-30	500-1000/250	-do-	1/1	Do	-do-

TABLE 2. CHEMICAL ANALYSIS OF SAMPLES COLLECTED ACROSS STRIKE, BARU MODEL ZONE

S.No.	Sample No.	Chemical U_3O_8 (ppm)	S.No.	Sample No	Chemical U_3O_8 (ppm)
1	MB-1 (A)	70	10	MB-10 (A)	5
2	MB-2 (A)	13	11	MB-11 (A)	58
3	MB-3 (A)	8	12	MB-12 (A)	10
4	MB-4 (A)	58	13	MB-13 (A)	9
5	MB-5 (A)	9	14	MB-14 (A)	7
6	MB-6 (A)	9	15	MB-15 (A)	5
7	MB-7 (A)	10	16	MB-16 (A)	5
8	MB-8 (A)	10	17	MB-17 (A)	7
9	MB-9 (A)	6	18	MB-18 (A)	7

TABLE 3. CHEMICAL ANALYSIS OF SAMPLES ALONG STRIKE, BARU MODEL ZONE

S. No.	Sample No.	Chemical U_3O_8 (ppm)	S.No.	Sample No.	Chemical U_3O_8 (ppm)
1	MB-63 (B)	51	13	MB-75 (B)	6
2	MB-64 (B)	7	14	MB-76 (B)	8
3	MB-65 (B)	8	15	MB-77 (B)	13
4	MB-66 (B)	13	16	MB-78 (B)	7
5	MB-67 (B)	11	17	MB-79 (B)	9
6	MB-68 (B)	9	18	MB-80 (B)	6
7	MB-69 (B)	16	19	MB-81 (B)	7
8	MB-70 (B)	20	20	MB-82 (B)	8
9	MB-71 (B)	18	21	MB-83 (B)	14
10	MB-72 (B)	9	22	MB-84 (B)	8
11	MB-73 (B)	10	23	MB-85 (B)	8
12	MB-74 (B)	11	24	MB-86 (B)	10
13	MB-75 (B)	6	25	MB-87 (B)	5

Trenching

A total of 30 trenches were excavated on hot spots of anomalous zone for sample collection and structural studies. These trenches were studied in detail. The number of total joints and radioactive joints in each trench were counted and documented. Proper measurements regarding the length and width of all radioactive joints were taken. The data revealed that the joints have very limited extension and radioactivity is spotty in nature with very low U_3O_8 values (Table 1).

Sample analysis and its interpretation

A total of 195 unbiased samples were collected on grid pattern for chemical and mineralogical analyses to understand the behavior and pattern of uranium mineralization. The samples were collected across and along the strike from all textural and lithological varieties. Samples taken across the strike show average 8 ppm chemical uranium (Table 2), which is normal and does not show any significant uranium concentration in an anomalous zone. The chemical results along the strike give average uranium content of 11.6 ppm (Table 3), which look to be slightly high compared to average uranium content in granitic rocks. The enhanced value is due to pegmatite and aplite dykes with uraninite grains. The chemical analysis of the samples indicates that the radioactivity and corresponding uranium concentration is spotty in nature and lack the proper structural control and large dimension.

SUBSURFACE EXPLORATION

Trenching

A total of 12 additional trenches were excavated at barren points between hot trenches to find out the continuity of radioactive joints plane/fracture along strike. It was noted that the radioactivity is discontinue, restricted and randomly distributed. To know the subsurface behaviour of radioactivity and find possible zone of uranium concentration below weathering zone, deep drilling was initiated at anomalous zone.

Drilling

Seven holes totaling to the depth of 824.45 m (Table 4) were drilled on anomalous spot showing high chemical uranium value in surface sample. No zone of uranium concentration was detected at depth. The core sample revealed that pervasive hydrothermal alteration is completely lacking.

SECONDARY MINERALIZATION

Secondary mineralization in the form of meta-torbernite and uranophane was noted along some fractures in trenches. The detailed investigation revealed that the phenomenon is restricted to a few fractures of limited water seepage. The surface water dissolved uraninite from pegmatite making a mineralization haloes around uraninite grain in one trench only. So this phenomenon of present day water seepage is very limited and does not warrant any large scale secondary mineralization for a viable deposit.

ASSESSMENT OF BARU ANOMALOUS ZONE

The interpretation of data collected from Baru anomalous zone revealed that high radioactivity is mostly due to uraninite grain occurring as inclusion in biotite along mica rich joints planes, associated with pegmatite and aplites. The joints/fractures probably produced in the rocks by underlying magma still molten due to upward pushing. The residual fluid having elements that were not accommodated in crystallization of granite was flushed out through these joints and mineral such as biotite, garnet, magnetite and fluorite were formed along joint planes. The mineral paragenesis indicates compressional environment of magmatic origin followed by pnematolytic stage of limited metasomatic alteration resulting in formation of thin quartz feldspathic veinlets. No late stage pervasive hydrothermal alteration is visible at Baru anomalous zone.

CONCLUSIONS

The data collected as a result of detailed investigation spread over almost five years revealed that despite of some high chemical uranium value (0.6% U_3O_8) at certain localities, Malakand granite offers very little potential for a viable uranium deposit. The Malakand granite, however, has a significant phenomenon of uraninite mineralization as compared to other granitic rocks of alkaline province which are thorium dominant and the available magmatic uranium is locked in primary fractionate of thorium enriched phase. The late stage reworking by pervasive hydrothermal alteration or supergene process are lacking in Malakand granite, which is decisive processes making an economically exploitable uranium deposit.

TABLE 4. DRILL HOLE DATA OF BARU ANOMALY, MALAKAND AGENCY

S. No.	Hole No.	Location	Angle	Depth drilled (Meters)	Depth of Sample From (m)	To (m)	CU_3O_8 (ppm)	ETh (ppm)	Remarks
					71.00	74.00	10	13	
1.	MKB LY-1	0+30 S	75°	120.00	90.00	92.00	23	28	
		4+13 W			96.00	99.00	17	8	
					3.50	5.50	14	32	
2.	MKB LY-2	1+10 S	90°	124.00	43.00	47.00	16	N.D	
		2+80 W			71.00	74.00	9	18	
					15.00	20.00	8	23	
					36.00	39.50	4	14	
					50.50	53.50	3	31	
					55.00	58.00	3	16	
3.	MKB LY-3	2+21.7 S	80°	98.50	61.00	63.00	2	22	
		4+13 W			65.00	68.00	3	Tr.	
					70.50	74.00	2	Tr.	
					76.00	78.00	3	Tr.	
					42.50	95.00	3	6	
					15.50	16.00	12	14	
					18.25	18.75	50	14	
					47.47	47.97	20	25	
					57.50	58.00	22	33	→97 c/p on log
					75.08	75.58	22	14	
4.	MKB LY-4	0+43 N	70°	154.50	89.50	90.00	39	21	→100 c/p on log
		0+06 W			101.00	101.50	13	N.D.	
					115.25	115.75	16	9	
					137.80	138.30	39	18	→168 c/p on log
					146.80	146.75	41	36	→105 c/p on log
					32.50		11	26	
5.	MKB lY-5	0+86 N	83°	68.50	33.00		51	22	
		3+28 E			34.00		23	10	
					34.50		50	10	
					52.55		24	24	

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