A NOTE ON THE GEOLOGY AND GEOCHEMISTRY OF RADIOACTIVE PALAEOSOL ON BASEMENT GRANITES OF ARAVALLI SUPERGROUP, CHITTORGARH DISTRICT, RAJASTHAN

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A few centimetre to 3 m thick palaeosol has developed on 2585 Ma old Berach granite along the unconformity that separates the Aravalli Supergroup (2500 – 2000 Ma) from the former. The Berach granites are represented by a mineral assemblage of potash feldspar, sodic plagioclase, quartz and minor ferromagnesian minerals like biotite, hornblende and epidote etc. The subsequent palaeo-alteration is characterized by relative enrichment of Al_2O_3, K_2O, FeO(T) and MgO. Besides, anomalous concentration of U, Th, Y and Zr have also been noted. The criss-cross veinlets of limonite with adsorbed uranium in the palaeosol indicate the presence of anomalous uranium in the system and post- formation solution activity.

Introduction

Archaean and Proterozoic strata-bound alteration profiles have been studied in detail in recent years. Many of these have been interpreted as palaeosols and used to determine the nature of early exogenic processes on the earth (Holland and Zbinden, 1988). The correct identification of these profiles and the processes involved in their formation is of utmost importance to carry out such studies. In this note, an attempt has been made to study palaeosol developed over the Berach granite with respect to its mode of occurrence, petrography, geochemical characters and its impact on stratigraphy and uranium mineralisation in the area.

Geology of the Study Area

The study area comprises of a wedge shaped basin, occurring within Berach granite which is an integral part of Banded Gneissic Complex (BGC). The stratigraphic status of the cover sequence lying over BGC remained a matter of debate in this area. Earlier these rocks have been designated as Bhadesar and Hora Formations of Archaean sequence and grouped under the Pre-Aravalli "Bhilwara Supergroup" (Balmiki Prasad, 1982). Sinha-Roy (1989) opined that these rocks evolved in pull apart basins and are possibly time equivalent to Aravallis.

The Bhadesar Formation mainly comprises of silicified and cherty quartzites directly resting over the basement (Berach granite), which in turn are overlained by purple to grey phyllites. The contact of Bhadesar quartzites with BGC is represented by an erosional unconformity and is tectonised over majority of length. The Hora Formation consists of mainly quartzites which unconformably overlie the BGC as well as Bhadesar Formation. At Kathodiya, a synformally disposed quartzite outlier of Hora Formation overlies the Berach granite where the palaeosol has been identified (Figs. 1 and 2). The palaeosol is greenish grey, fine to very fine grained with some scattered specs of white minerals like sericite and devoid of any sedimentary structures. It occurs all around the fringe of a shallow plunging syncline beneath the quartzites overlying the Berach granite. This alteration profile is restricted to one specific stratigraphic level and does not repeat in sequence, ruling out the possibility of its origin by metamorphic processes. Radioactivity has been noted both in the palaeosol as well as overlying pebbly quartzite.

Petrochemistry

Comparison of major element chemical composition of both Berach granites and the palaeosol are given in Table 1 and Fig. 3. In general K_2O, Al_2O_3, FeO (T), MgO and TiO_2 contents have increased from parent rock to the palaeosol whereas SiO_2 and Na_2O decrease. Significant changes can be observed in concentration of K_2O and Al_2O_3 from parent rock to palaeosol. K_2O increases from average 5.70% in parent rock to 11.08% in the palaeosol whereas Al_2O_3 increases from 12.6% to 25.7%. Concentration of K_2O in the palaeo-alteration zone and leaching of Na_2O from the parent profile results in a very high K_2O / Na_2O ratio (up to 26) in the palaeosol compared to a ratio of 2.4 in the parent rock. A two fold increase in the Al_2O_3 and K_2O in the weathering profile (palaeosol) over the granites may be attributed to alternate humid and dry climates in the tropical

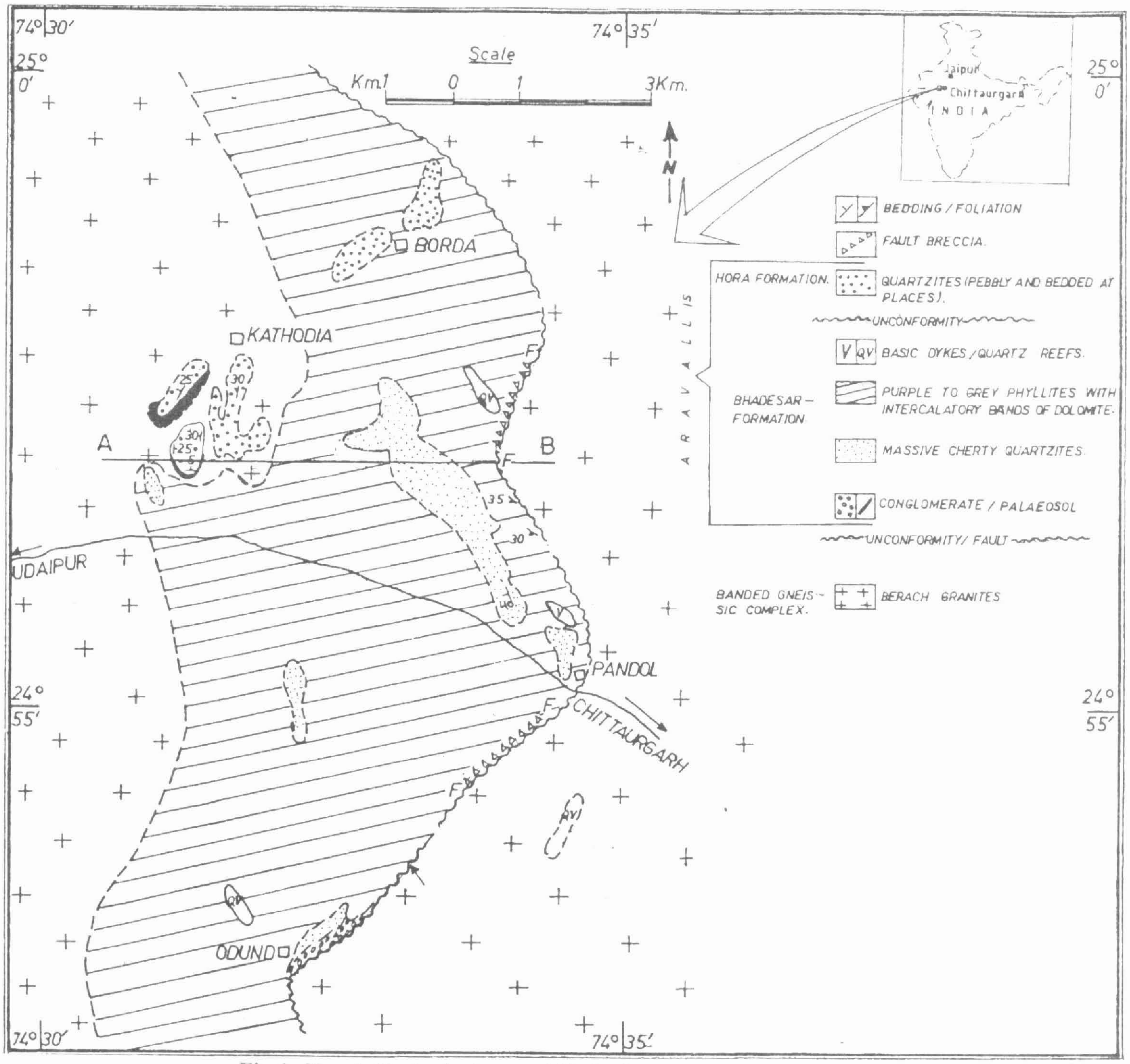

Fig.1. Sketch Geological map of Kathodia area, District Chittorgarh.

regions. The increase in the MgO and FeO may be attributed to downward migration of solutions and formation of chlorite (Wiggering and Bukes, 1990). The presence of chlorite in the palaesol has been confirmed by petrographic studies. Significant losses are recorded in Na_2O and CaO from parent

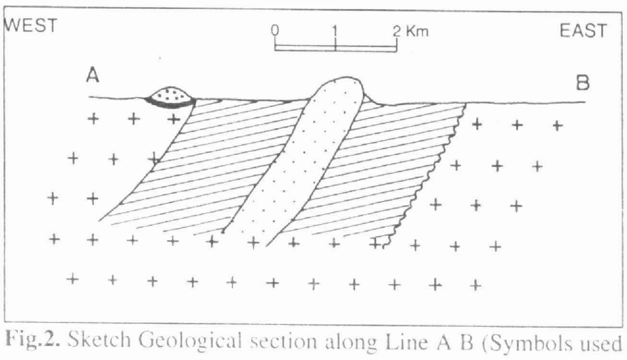

Fig.2. Sketch Geological section along Line A B (Symbols used are same as in Fig.1).

rock to palaeosol due to their high mobility during the weathering process.

Trace Element Geochemistry

Trace element geochemical variation from parent rock to palaeosol are displayed in Table 2. The significant increase in Rb and Ba in the palaeosol is obvious as it follows the K trend whereas Sr is depleted, which follows the Na trend. Elements such as Th, Zr, Y and Nb show significant concentration in the palaeosol during the weathering process due to their immobile nature. Concentration of U in the palaeosol may be attributed to secondary processes which operated after the formation of the palaeosol. The cris-cross minor veinlets of limonite with adsorbed uranium identified in the palaeosol support this inference. This observation also explains the concentration of V and Cr in the palaeosol due to their adsorption onto iron hydroxides and clay

Table 1. Major element composition (in wt%) of samples from Kathodia palaeosol

Oxides	Parent rock (granite) (n =2)	Palaeosol (n = 2)
SiO_2	74.44	57.59
TiO_2	0.07	1.26
Al_2O_3	12.64	25.71
FeO (T)	1.14	3.28
MnO	<0.01	0.01
MgO	0.32	1.73
CaO	0.14	0.10
Na_2O	2.38	0.43
K_2O	5.70	11.09
P_2O_5	<0.01	<0.01

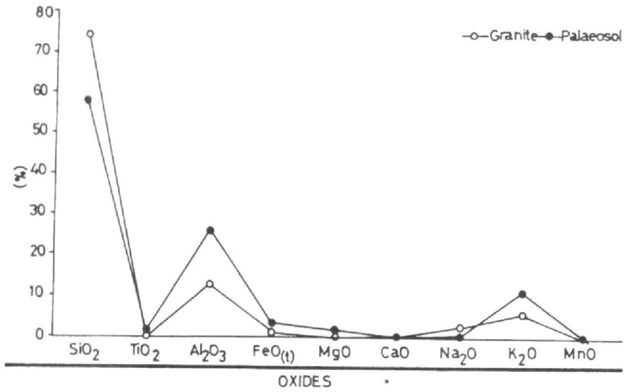

Fig.3. Major element (in wt% oxides) variation in parent rock and palaeosol.

Table 2. Trace element concentration (in ppm) in samples from Kathodia palaeosol

Elements	Parent rock (n =2)	Palaeosol (n =2)
V	7	129
Cr	15	45
Rb	276	426
Sr	35	47
Ba	250	913
Zr	112	1999
Nb	21	56
Y	19	86
Th	34	788
U	6	47

minerals. The absence of significant Mn-oxide in the palaeosol indicates that Mn was not transformed into the insoluble quadrivalent state during weathering processes (Wiggering and Beukes, 1990).

Selected radioactive grab samples from the palaeosol analysed 0.010 to 0.013 % U_3O_8 and 0.109 to 0.124 % ThO_2 with Th/U ranging from 9.4 to 11.1, whereas overlying pebbly quartzite analysed <0.010 % U_3O_8 and 0.069 to 0.094 % ThO_2 (Table 3). Results indicate concentration of both U and Th in the palaeosol.

Discussion and Conclusions

Texturally, the palaeosol consists of fine sand to gravel size (4-3 mm) randomly oriented clasts of quartz and feldspar embedded in a chloritic and sericitic matrix. Intense weathering along grain boundaries and relics of weathered feldspars, quartz and mica grains are clearly noticeable indicating palaeo-weathering effects. Muscovite, zircon, biotite, sphene and epidote occur as minor minerals. Criss-cross vienlets of hydrated iron-oxide with adsorbed uranium in fair concentration has been identified by petrological studies.

The geological, geochemical and petro-mineralogical features clearly indicate that the palaeo-alteration profile is related to weathering. This suggests the development of unconformity and thus the palaeo-alteration profile may be considered as a palaeosol. The perceptible change depicted in texure, mineralogy and chemical composition from fresh rock to palaeosol as described in the text further supports this inference. The presence of chlorite and sericite as the matrix indicate that the original profile contained high clay content which has been altered to sericite and chlorite. This suggests that the palaeo-weathering profile could have been formed under a relatively warm and humid climate and/or under high CO_2 partial pressure (Jenny, 1935). The significant enrichment of Al_2O_3 (12.6% in parent rock to 25.7% in palaeosol) also supports this inference (Brabers, 1974). The lack of any carbonate mineral phases in the palaeosol suggests acidic groundwater conditions whereas criss-cross veinlets of limonite with adsorbed uranium indicate post-formation solution activity and presence of anomalous labile uranium in the system. Such signatures close to the unconformity warrant systematic radiometric checking of the palaeosol as well as the cover rocks in this

Table 3. Radiometric assay results of Kathodia palaeosol (selected samples from highly radioactive spots)

Sample Nos.	% eU_3O_8	% U_3O_8	% ThO_2	Th/U	Rock type
OP – 1	0.056	0.012	0.110	9.4	Palaeosol
OP – 2	0.051	0.010	0.109	11.1	
OP – 3	0.057	0.013	0.124	9.9	
OP – 4	0.042	<0.010	0.094	—	Pebbly Quartzite
OP – 5	0.032	<0.010	0.069	—	
OP – 6	0.033	<0.010	0.077	—	

part of the basin which may form a possible target area for unconformity proximal uranium deposits.

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