

Shear controlled uranium mineralization in Kho-Dariba area of Alwar sub-basin, District Alwar, Rajasthan

The Alwar sub-basin is one of the three Mesoproterozoic basins developed in the North Delhi Fold Belt (NDFB)¹. The basin encompasses the meta-sedimentary sequence of Delhi Supergroup unconformably overlying the basement rocks of pre-Delhi age. The latter comprises of amphibolites, migmatites, schists and gneisses of the Mangalwar complex of the Archaean and some presumed component of the Aravalli Supergroup of rocks of Palaeo-proterozoic age². The meta-sediments are divided into three distinct groups. The lowermost Raialo Group is dominantly chemogenic dolomitic marble, quartzite and basic volcanics followed by arenaceous and argillaceous rocks of Alwar and Ajabgarh groups, in order of superposition.

In Kho-Dariba area, the Raialo Group of rocks form a second-order antiform³, which resulted due to refolding of a first generation synform. These are composed of dolomitic marble, phyllite, quartzite, carbon phyllite and basic volcanics traceable from Naraini mata to Ghatra (Figure 1). Raialo quartzite unit is a hard and compact rock with preponderance of quartz grains. This is named as serrate quartzite due to its serrated geomorphology. They are overlain by conglomerate and quartzite of the Alwar Group. The eastern limb of the Alwar Group forms an antiform represented by lenses of boulder conglomerate that grade laterally into quartzose phyllite, feldspathic quartzite and arkose towards the south. A few basic bodies intruding these lithologies are noticeable north-east of Baldevargh, along the closure of the antiform and in Dariba mines area.

A number of fault zones affecting both the basement and cover sequence are prominently developed in the southern part (Figure 1). In Dariba, along the eastern limb of the antiform, a prominent fault has caused the dislocation and repetition of serrate quartzite. The fault has evolved into a shear zone. The effects of shearing are manifested in the form of change in grain size, development of microfractures and foliation, slicken slides, polished surfaces, grooves, striations, boudins and veins.

Systematic radiometric investigation led to the identification of uranium min-

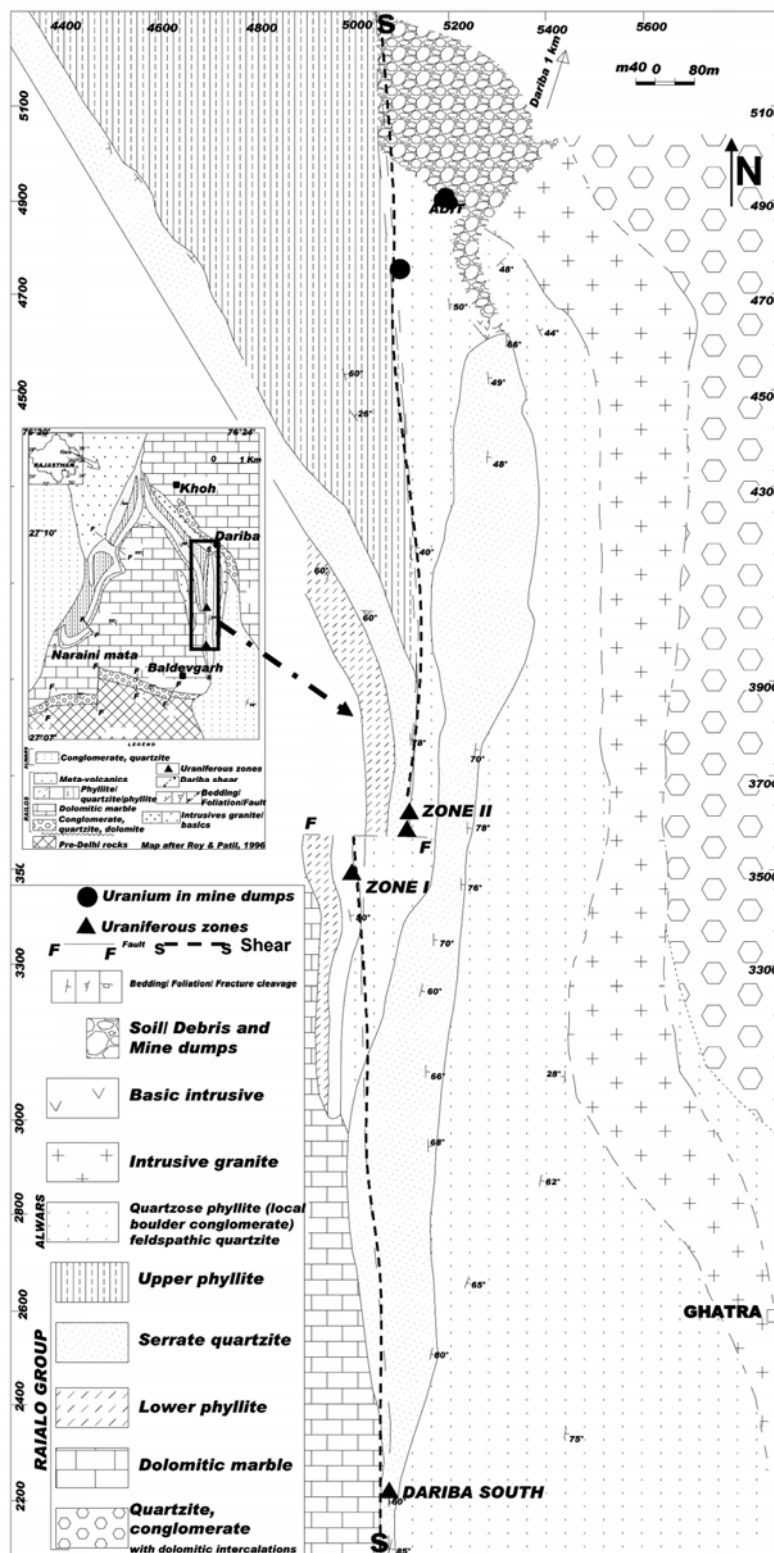


Figure 1. Detailed geological map of Dariba area, District Alwar (after O. P. Yadav, unpublished).

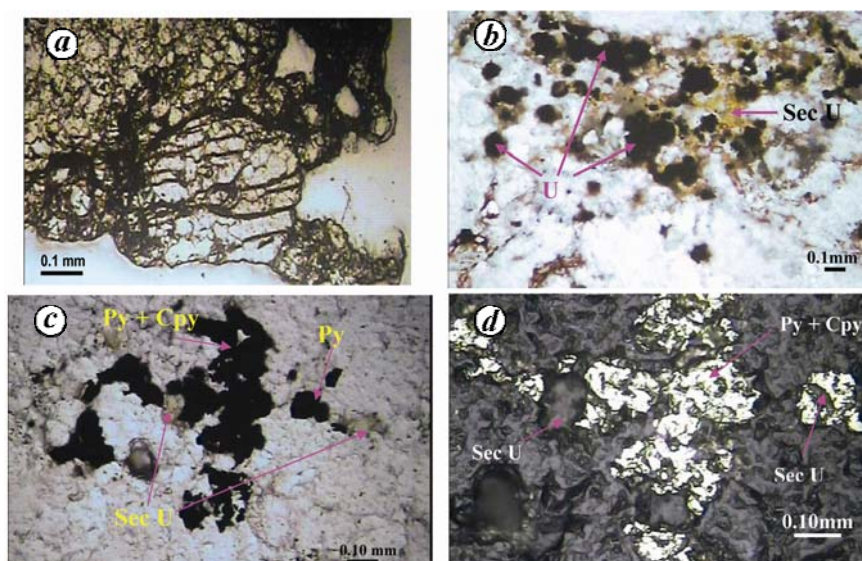


Figure 2. *a*, General view of the fracture zone of quartzite containing secondary U-minerals as well as U associated with Fe and Ti. The brownish ferruginous material developed along the fractures and along grain boundaries, TL, 2X. *b*, Discrete grains of uraninite (U) along fractures in quartzite, TL, 5X. *c*, Secondary U minerals associated with metals (pyrite–chalcopyrite), TL, 4X. *d*, Association of secondary U, pyrite and chalcopyrite.

Table 1. Physical assay results of samples

Mineralized zone	Sample no.	%eU ₃ O ₈	%U ₃ O ₈	%ThO ₂
Zone I	DMB/1	0.091	0.094	<0.01
	DMB/1A	0.30	0.30	<0.01
	DMB/2	0.049	0.064	<0.01
	DMB/3	0.036	0.051	<0.01
Zone II	DMB/EXTN/1	0.061	0.061	<0.01
	DMB/EXTN/2	0.048	0.059	<0.01
	DMB/EXTN/3	0.013	0.014	<0.01
Dariba south	DMB/4	0.011	0.021	<0.01
	DMB/5	0.015	0.019	<0.01
Radioactive boulder	DMB/B/1	0.15	0.18	<0.01

eralization. This is associated with sheared, silicified and altered serrate quartzite of the Raialo Group close to the contact of quartzose phyllite of the Alwar rocks (Figure 1). Detailed radiometric study of the outcrops, trenches, pits and shielded-probe logging has revealed three radioactive zones ranging in length from 30 to 120 m, with width varying from 30 cm to 3 m. Radiometric assay results of grab samples collected from these zones vary from 0.014 to 0.30% U₃O₈ ($n = 9$; Table 1). These bands are aligned linearly along the shear zone and make a cumulative mineralized strike length of 1.3 km; the intervening areas are covered by thick talus. Further, the

presence of sporadic radioactive boulders all along the hill slopes corroborates the continuity and persistency of mineralization on the surface. Shielded-probe logging of nine trenches/faces made across the mineralized zones revealed grade \times thickness varying from 0.011% eU₃O₈ \times 0.30 m to 0.088%eU₃O₈ \times 3.00 m, showing continuity over a length of 200 m in zones I and II, and 100 m in Dariba south.

Chemical analyses of the mineralized samples reveal ranges of U₃O₈ (total) from 0.042 to 0.098% and U₃O₈ (leachable) from 0.037 to 0.058 along with high SiO₂ content (96.85–97.79%), indicating intense silicification. Association of higher values of copper (114–631 ppm),

lead (56–181 ppm) and cobalt (84–155 ppm) is also apparent in the zone of uranium mineralization.

Petromineralogical studies have identified that the mineralized rock is sheared ferruginized quartzite. This is a fine-grained rock consisting predominantly of a mosaic of fine, anhedral, highly strained, elongated and preferably aligned quartz in which muscovite, biotite and sericite occur in minor amount and zircon, pyrite, chalcopyrite and hydrated ferruginous material form the accessory component. Pyrite occurs as a fine-to-medium, disseminated, subhedral to anhedral grain along healed fractures of the rock. Chalcopyrite occurs as fine, irregular grain often associated with healed rock fractures. Ferruginization along the fractures is a common feature (Figure 2 *a–d*).

Uraninite is the primary radioactive mineral with abundant presence of secondary uranyl minerals and minor uranium associated with Fe–Ti gel. Uraninite occurs as discrete subhedral to anhedral grains associated with pyrite. Secondary uranium minerals are associated with sulphides as well as ferruginous material and often occupy micro-fractures and inter-granular spaces. U \pm Fe \pm Ti gel has infiltrated micro-fractures and inter-granular spaces, implying remobilization and concentration. Minor radioactivity is

also contributed by zircon grains (Figure 2 a–d).

Dariba shear zone hosts copper deposits. In the early 80s radiometric investigations in some underground levels of a copper mine revealed sporadic, high-grade (up to 1.57%) uraniferous patches (G. V. G. Sharma *et al.*, unpublished). The mine dumps and excavations comprising schists, phyllonites and metabasics also show higher level of radioactivity. Petrographically, underground uraniferous samples indicate uraninite as disseminations and veins along with polymetallic association of bornite, chalcopyrite, pyrite and molybdenite, suggesting epigenetic hydrothermal type of mineralization (M. K. Khandelwal *et al.*, unpublished).

The uranium-mineralized shear zone of Dariba copper mine continues further south and extends over 2 km. The area offers ample scope to look for high-grade uranium mineralization. The shear zone

bears significant importance in hosting uranium mineralization in the Kho-Dariba area. It is pertinent to mention here that lateral and vertical facies variation is well demonstrated along the shear zone. The shear zone cutting through hard quartzite on the surface passes through carbonaceous pelites at depth. The carbonaceous pelites with iron and copper sulphides provide a favourable host for uranium mineralization. Thus a conducive geological environment for precipitation of uranium is evident and a shear-controlled uranium mineralization can be envisaged at depth.

1. Sinha-Roy, S. and Malhotra, G., *J. Geol. Soc. India*, 1989, **34**, 127–134.
2. Banerjee, A. K. (ed.), *Geol. Surv. India Mem.*, 1980, **110**, 137.
3. Patil, M. L. and Roy, A. B., In *Crustal Evolution and Metallogeny in NW Indian Shield* (ed. Deb, M.), 2002, pp. 293–306.

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Pulsed inflation in the hummocky lava flow near Morgaon, western Deccan Volcanic Province and its significance

Inflation is a widespread process of emplacement of magmas from recent shield volcanoes and in parts of ancient Continental Flood Basalt provinces. It is the process by which lava at low effusion rates accumulates endogenously within its own viscoelastic crust to develop bulbous forms. Inflation transforms a lobe that is a few centimetres thick to greater than 10 m. Inflation is a fairly continuous process, but at times is disrupted due to waning of lava supply either from the vent or within the flow field due to temporary stoppage, blockage or diversion. This results in discontinuous inflation, popularly called as ‘pulsed inflation’.

A large area of the west-central Deccan Volcanic Province (DVP) is occupied by pahoehoe lavas¹. Pahoehoe flows range from the typical hummocky² and sheet-flow types to the more viscous varieties like slabby pahoehoe (Table 1). The recent studies^{3–6} have conclusively demonstrated that inflation has played a major role in the emplacement of the pahoehoe flows from the DVP. Locally, however, there are several instances where lava morphology indicates emplacement by a less conspicuous mechanism of ‘pulsed’ inflation. The present account is of one

such occurrence near Morgaon (74°18′20″; 18°16′55″), southeast of Pune, where evidence of pulsed inflation in the form of a ridged lobe having a distinct morphology is being reported.

The lobe containing evidence of pulsed inflation is exposed on the bed of Karha River near Morgaon (Figure 1). The area around Morgaon is dominated by an undulating topography. The Karha River and its tributaries drain the area⁷. Quaternary alluvial sediments cover the area. The thickness of the alluvium is variable and ranges from 1.5 to 15.8 m. It is seen that a basal conglomerate consisting of boulders and cobbles of basalt is present in many sections. This is followed by silt and clay, with intercalations of sand and conglomerate. Towards the upper parts of the section, calcrete deposits are present. Calcrete is of nodular, bedded and hard-pan varieties. In some sections, a ~50 cm thick layer of volcanic ash is exposed^{8,9}.

The Morgaon flow containing the lobe is reddish, fine-grained, and exposed as discontinuous outcrops within the bed of the Karha River. The surface of the flow is hummocky. The crust is vesicular and vesicle banding is common. Numerous

inflation clefts are present in the crust and these are occupied by squeeze-ups. In one of the outcrops near the bridge over the Karha River, a small (~1.5 m), fragile lobe is exposed on the surface. The crust of the lobe is highly vesicular. The vesicles are small (2–4 mm), spherical and their density is high compared to the surrounding lava (Figure 2). The vesicles from the ridged lobe themselves do not define any preferred orientation or lineation.

The lobe is distinguished from the surrounding as it consists of a prominent ridged surface (Figure 3). Individual ridges range from 11 to 30 cm. Closer observations reveal that the ridges constitute several bumps or bulges. There is no distinct symmetry in the bulge geometry and the amplitudes of the bulges vary considerably. The ridges constituting the bulges resemble folds of ropy lava¹⁰, but are distinct in that they are separated by deep grooves. Moreover, the ridges have no flow directional convexity as seen in ropy lavas.

Morphologically, the feature in question could easily be mistaken for lava squeeze-ups. The squeeze-ups preserved elsewhere in the Karha River bed are