

10. Kaur, A., Ha, C., Sands, V. E. and Soepadmo, E., *Bot. J. Linn. Soc.*, 1986, **92**, 78–88.
11. Martinez-Gomez, P. and Gradziel, T. M., *Sex. Plant Reprod.*, 2003, **16**, 135–139.
12. Gupta, P., Shivanna, K. R. and Mohan Ram, H. Y., *Ann. Bot.*, 1996, **78**, 67–72.
13. Frost, H. B. and Soost, R. K., In *The Citrus Industry* (eds Reuther, W., Batchelor, L. D. and Webber, H. B.), University of California, Berkeley, 1968, vol. 2, pp. 290–324.
14. Prakash, J., Kasera, P. K. and Chawan, D. D., *Curr. Sci.*, 2000, **78**(10), 1185–1187.
15. Satyavati, G. V., In *Economic and Medicinal Plant Research* (eds Wagner, H. and Farnsworth, N. R.), Academic Press, London, 1990, vol. 4, pp. 39–56.
16. Chopra, R. N., Nayar, S. L. and Chopra, I. C., *Glossary of Indian Medicinal Plants*, Council of Scientific & Industrial Research, New Delhi, 1956.
17. Chopra, R. N., Chopra, I. C., Handa, K. L. and Kapur, L. D., *Chopra's Indigenous Drugs of India*, M/S U.N. Dhur, Calcutta, 1958, 2nd edn.
18. Geetha, K. A. *et al.*, *Trees*, 2013, **27**, 567–581.

ACKNOWLEDGEMENTS. Financial support for this work was provided by the Indian Council of Agricultural Research under the National Agricultural Innovation Project in the form of fellowship provided to the first author.

Received 22 April 2014; revised accepted 26 June 2014

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Uranium occurrence in Proterozoic Chilpi Group, near Kanhari, Kawardha district, Chhattisgarh

Proterozoic Chilpi Group of rocks were deposited in a 30 km long and 4–7 km wide N–S zone along the northwestern margin of Chhattisgarh Basin¹. Paleo-Meso Proterozoic Chilpi Group overlies Paleoproterozoic Nandgaon Group of rocks in the east and Paleoproterozoic Malanjhand granitoids in the west with pronounced unconformity marked by a conglomerate horizon at the base. The Group comprises sediments deposited in a cratonic rift or island arc-related basin and consists of conglomerate, coarse arenite (grit), shale and quartzite². These are well exposed in Kanhari, Koyalarjori, Mohagaon and Chilpi Ghat section. The Chilpi Group of rocks are unconformably overlain by the unmetamorphosed argillaceous, arenaceous and calcareous sediments of Mesoproterozoic Chhattisgarh Supergroup (Figure 1).

Several NNW–SSE, NW–SE and E–W faults have dissected both the basement rocks and overlying sediments of Chilpi Group in parts of Kawardha district. A NNW–SSE trending fault, SE of Kanhari village (Figures 1 and 2) has affected both Nandgaon bimodal volcanic sequence and Chilpi sediments, and shows development of slickenside, brecciation, fault gouge and intense fracturing (Figure 1). Various sedimentary structures such as bedding, colour banding, ripple marks and penecontemporaneous deformation structures are recorded in Chilpi

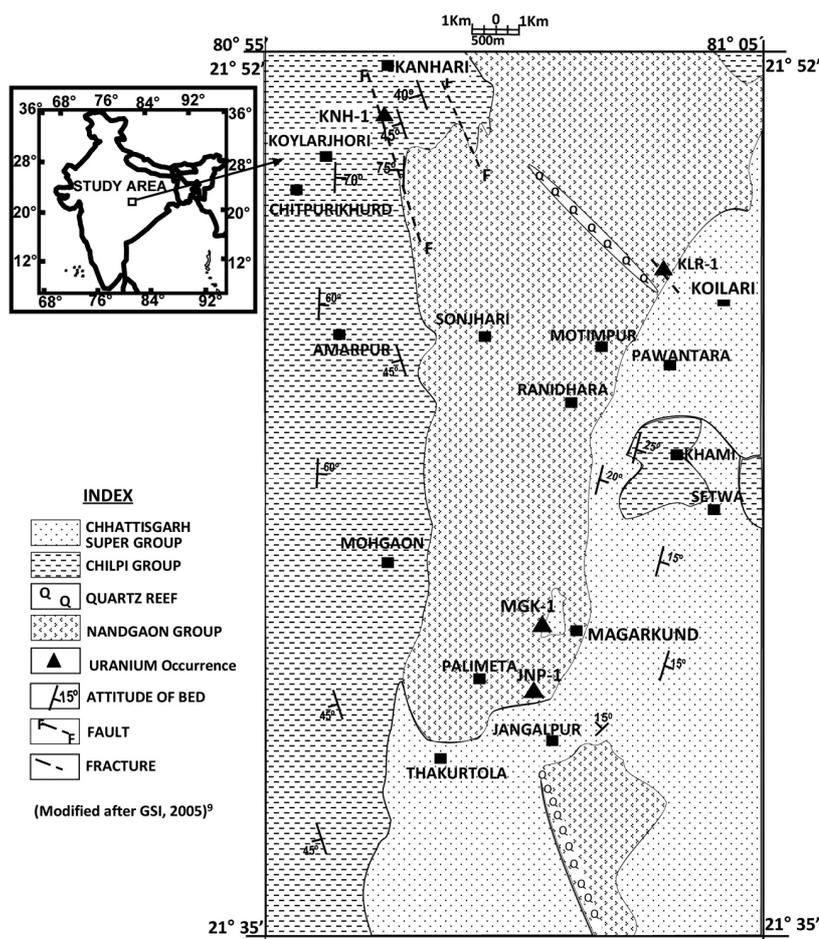
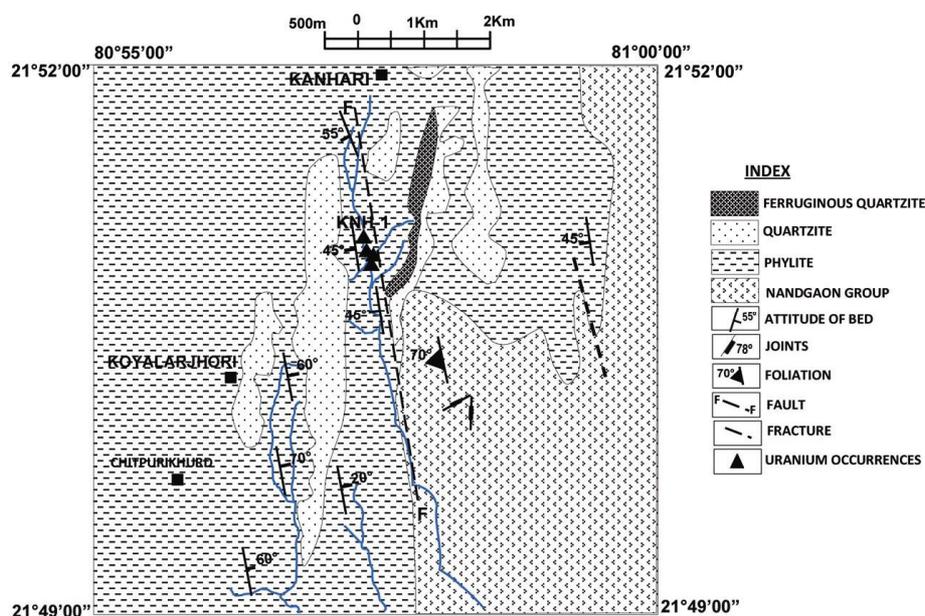


Figure 1. Geological map showing uranium mineralization in Kanhari–Koilari–Magarkund–Jangalpur areas, Kawardha and Rajnandgaon districts, Chhattisgarh.

Table 1. Generalized stratigraphic succession of the study area³

Litho unit	Group	Supergroup
Shale and limestone	Raipur Group	Chhattisgarh
White, thickly bedded quartzite with ripple marks	Chandrapur Group	Supergroup
Brown feldspathic and gritty sandstone		
Hard and compact purple quartzite		
Conglomerate		
Unconformity		
Limestone		
Pebbly gritty sandstone		
Grey phyllite		
Shale and phyllite	Chilpi Group	
Fe-quartzite and purple quartzite		
Conglomerate/gritty sandstone quartzite		
Unconformity		
Quartz vein/reef		
Rhyolites, meta-basalt, andesites, rhyolitic tuffs and agglomerates	Nandgaon Group	

**Figure 2.** Geological map showing uranium mineralization in Kanhari area, Rajnandgaon district, Chhattisgarh.

sedimentary rocks². The generalized stratigraphic succession³ of the study area is given in Table 1.

Previous uranium exploration based on unconformity model resulted in delineation of several thoriferous anomalies in Chilpi sediments with 0.008–0.020% U_3O_8 and <0.010–0.39% ThO_2 at Sahaspur, Kesada, Khami and Bothli areas (Verma and Vijayraj, unpublished). However, chert-breccias of basement rocks at the faulted contact with Chilpi Group near Banjari nala have analysed up to 0.026% U_3O_8 with negligible ThO_2 (Verma and Vijayraj, unpublished).

Recent exploration in Chilpi sediments near Kanhari village has resulted in the identification of uranium occurrence associated with grey phyllite and ferruginous shale proximal to NNW–SSE trending fault. Four uraniumiferous outcrops of KNH-1 are exposed along the nala, located SE of Kanhari village (21°50'02"N–21°51'18"N; 80°57'08"E–80°57'19"E). Uranium occurrences have varying dimensions of 3–100 m length × 4–22 m width, spread over 550 m stretch (Figure 2). The strike of radioactive grey phyllite and ferruginous shale varies from N–S to N30°W with 45°–70° westerly dips.

Mineralization associated with grey phyllite and shale is essentially uraniumiferous, whereas basal conglomerate and gritty sandstone exhibit mixed uranium–thorium anomalies (Figure 3). Basal conglomerates ($n = 6$) have assayed 0.003–0.008% U_3O_8 and 0.006–0.039% ThO_2 . Gritty sandstones ($n = 12$) have assayed 0.003–0.010% U_3O_8 and 0.006–0.022% ThO_2 .

Phyllite samples ($n = 52$) collected from this area have analysed <0.010–0.045% U_3O_8 (average = 0.015%, Figure 4) and with negligible ThO_2 . Higher values of uranium (0.033–0.045% U_3O_8) are confined to fractures and joint planes

within grey phyllite, suggesting lithostructural control of uranium occurrence.

Chemical analysis of uraniferous phyllites ($n = 14$) by flourimetry method, revealed 0.004–0.038% U_3O_8 (av. 0.023%) 56.09–72.96% SiO_2 (av. 62.85%) was determined by spectrophotometer; 9.99–23.14% Al_2O_3 (av. 17.74%), 6.03–14.49% FeO (T) (av. 9.58%), 1.13–2.88% MgO (av. 1.68%), <0.01–0.12% MnO (av. 0.040%), 0.12–0.25% CaO (av. 0.16%) was determined by AAS;

<0.010–2.06% Na_2O (av. 0.34%), 1.63–6.00% K_2O (av. 4.49%) by flame photometry, and <0.010–0.11% P_2O_5 (av. 0.03%) by spectrophotometry. The K_2O/Na_2O ratio varies widely (2.24–579) in Chilpi phyllite with an average of 305.06 as against 3.42 in Proterozoic cratonic shale (PCS)⁴ and 3.08 in Post-Archaean Average Australian Shale (PASS)⁴. However, the average SiO_2/Al_2O_3 of 3.74 in Chilpi Shale is comparable to that of PCS (3.61)⁴ and PASS

(3.32)⁵. Trace element analyses of these samples have indicated anomalous contents of Cu (av. 114 ppm), Ni (av. 185 ppm), Co (av. 53 ppm), Cr (av. 712 ppm), V (av. 183 ppm) and Zr (av. 454 ppm). In the study area, Chilpi sediments are resting over bimodal volcanic rocks of Nandgaon Group (Figure 1). Hence higher contents of Cr, Ni, Co and Zr probably have been contributed by the Nandgaon bimodal volcanic rocks as they are enriched in these elements⁶.

Petrographically, the radioactive samples have been identified as ferruginous shale (Figure 5 a and b) and sheared phyllite (Figure 5 c and d). Sericite, quartz and chlorite are the major minerals. Fine-grained sericite is masked with brownish-yellow stains of limonitic material imparting dark colouration to the samples (Figure 5 a). Quartz occurs as very fine grains (<0.01 mm size) forming segregations and thin bands alternating with sericite (Figure 5 a). Goethite, limonite, hematite and pyrite are identified as ore minerals. Goethite occurs as tiny spherical as well as cubic-shaped grains along with sericite matrix. Pyrite occurs as very fine grains partly replaced by goethite along the peripheries. Solid-state nuclear track detection studies on polished thin sections using cellulose nitrate film (LR 115) and etched in alkaline medium at 50°C for 72 h, have registered alpha tracks (Figure 5 b and d) due to adsorbed uranium associated with goethitic and limonitic materials. It has been observed that uranium was not found in shale and phyllite free of goethite and limonite. No discrete uranium phase was identified in chromogram test. Intimate association of uranium with goethite and limonite indicates secondary mobilization of uranium in the system.

The radioactive samples of Bijli rhyolites collected from Jangalpur (JNP-1), Magarkund (MGK-1) and Koilari (KLR-1) areas, Kawardha and Rajnandgaon districts, Chhattisgarh have analysed up to 0.14% U_3O_8 and <0.01% ThO_2 (Figure 1). The vast extent of rhyolite contains an average of 10 ppm U_3O_8 and 41 ppm ThO_2 and is traversed by several fractures and faults. The source of uranium for Chilpi sediments appears to be Bijli rhyolite. The remobilized uranium was precipitated under reducing environment caused due to hematitization⁷ with reduction of $U + 6$ to $U + 4$: $(UO_2)^{+2} + 2Fe^{2+} + 3H_2O = UO_2 + Fe_2O_3 + 6H^+$. Several faults have dissected

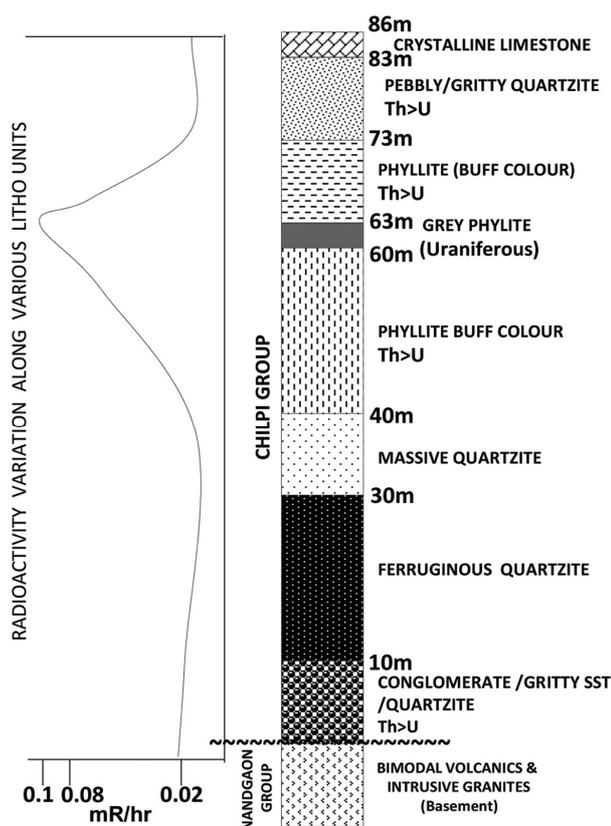


Figure 3. Stratigraphic column showing frequency of gamma-radiation in Kanhari area.

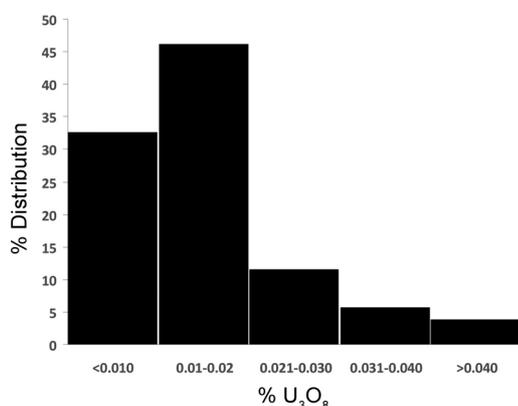


Figure 4. Percentage of uranium distribution in samples of Kanhari area.

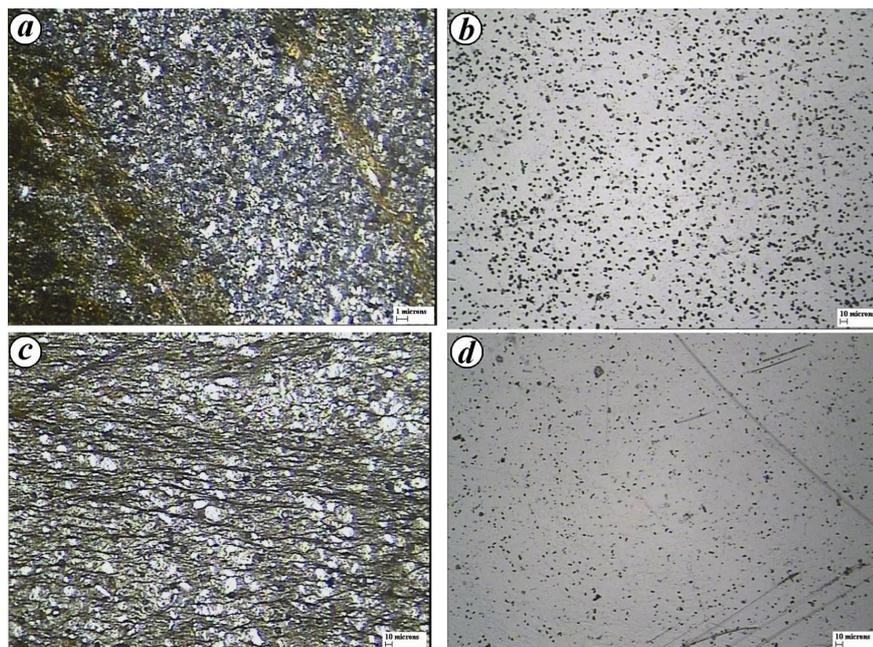


Figure 5. *a*, Sericite masked with limonite/iron oxide and very fine size quartz in radioactive shale. *b*, Alpha track matching with limonite and iron oxide on radioactive shale. *c*, Adsorbed uranium on radioactive phyllite corresponding with alpha track. *d*, Alpha track on radioactive phyllite.

basement and overlying sediments. These faults probably acted as conduits for transfer of uranium-bearing solution from basement rocks. Kanhari and adjoining areas can be looked for structurally controlled and fracture-bound unconformity type of uranium mineralization considering favourable geological set-up where Paleoproterozoic Nandgaon Group (Bijli Rhyolites) is unconformably overlain by Mesoproterozoic Chilpi Group.

This finding has opened up a new target area for future uranium exploration

within rocks of Chilpi Group and underlying basement rocks of Nandgaon Group.

1. Basu, A. K., *Geol. Surv. India, Spec. Publ.*, 2001, **55**, 181–204.
2. Thorat, P. K., Natrajan, A., Guha, K. and Chandra, S., *Geol. Surv. India, Spec. Publ.*, 1990, **28**, 167–180.
3. Tripathi, C., Ghosh, P. Thambi, P. I., Rao, T. V. and Sibendra, C., *Geol. Surv. India, Spec. Publ.*, 1981, **3**, 17–30.
4. Condie, K. C., *Chem. Geol.*, 1993, **104**, 1–37.

5. McLennan, S. M. and Taylor, S. R., *J. Geol.*, 1991, **99**, 1–21.
6. Sensarma, S. Hoernes, S. and Mukhopadhyay, D., *Proc. Indian Acad. Sci. (Earth Planet. Sci.)*, 2004, **113**(4), 619–648.
7. McKelvey, V. E., Everhart, D. L. and Garrels, R. M., *Econ. Geol.*, 1955, 15th anniversary volume, p. 491.

ACKNOWLEDGEMENTS. We thank the Director, Atomic Minerals Directorate for Exploration and Research (AMD) for encouragement and granting permission to publish this paper. We thank our colleagues from the Physics, Chemistry, XRF and Petrology laboratories, AMD, Nagpur for providing laboratory support.

Received 2 February 2014; revised accepted 16 June 2014

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Occurrence of Asian small-clawed otter *Aonyx cinereus* (Illiger, 1815) in Eastern India

The Asian small-clawed otter (*Aonyx cinereus*) is found across much of South and Southeast Asia, with a continuous population in Southeast Asia, Northeast India and Himalayan foothills and a purportedly disjunct population in the hill ranges of the Western Ghats in South India^{1,2}. Five subspecies have been identified, namely *Aonyx cinereus* (Illiger, 1815), *A. c. fulvus* (Pohl, 1926), *A. c.*

wurmbi (Sodi, 1953), *A. c. concolor* (Rafinesque, 1832) and *A. c. nirnai* (Pocock, 1940). Among these, the former three occur in Southeast Asia, *A. c. concolor* occurs in Upper Myanmar, Yunnan (China), Nepal, Bhutan, Assam, Arunachal Pradesh, Garhwal, southeast of Kumaon and the Himalayan foothills through Sikkim to Kolkata, and *A. c. nirnai* has been recorded from southern

India in Coorg (Kodagu), Karnataka; Ashambu, Nilgiri and Palani hills, Tamil Nadu and some places in Kerala^{3–5}. This species was earlier not recorded from the Eastern Ghats and other regions of Odisha. Here we report the occurrence of the species from this area, specifically from Odisha (Figure 1). Only one species of otter, smooth-coated Otter *Lutrogale perspicillata* (I. Geoffroy Saint-Hilaire,