Incidence of uranium and thorium mineralization in quartz-pebble conglomerate of Koira Group, Singhbhum Craton, India

Pawan Kumar Yadav
Senior Geologist
Geological Survey of India,
SU: Bihar, Lohia Nagar, Kankarbagh, Patna-800020

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ABSTRACT *Five small bodies of quartz-pebble conglomerate (QPC) belonging to Koira Group hosted uranium-thorium mineralization are reported for the first time in Kosira-Patna area, Keonjhar district, Odisha. QPCs are mainly matrix supported conglomerates which are made up of sericitic, fuchsitic and chloritic matrix. Clasts are predominantly made up of quartz and are mainly pebble to granule in size, sub-rounded, rounded, sub-angular and angular in shapes. QPCs display encouraging results of U and Th varies from 5 to 18 ppm and 6 to 82 ppm respectively. These results are conspicuously higher than the crustal abundance values of U (1.8ppm) and Th (7.2 ppm). Three samples show higher values of uranium (15ppm, 17ppm & 18ppm) which is approximately 7 to 10 times higher than the crustal abundance of uranium and one sample shows very high value of Th (82ppm) is predominantly 11 times higher than the crustal abundance of thorium.*

Keywords: *Quartz-pebble conglomerates (QPCs), Uranium-thorium mineralization, Koira Group, Singhbhum Craton, India*

Introduction

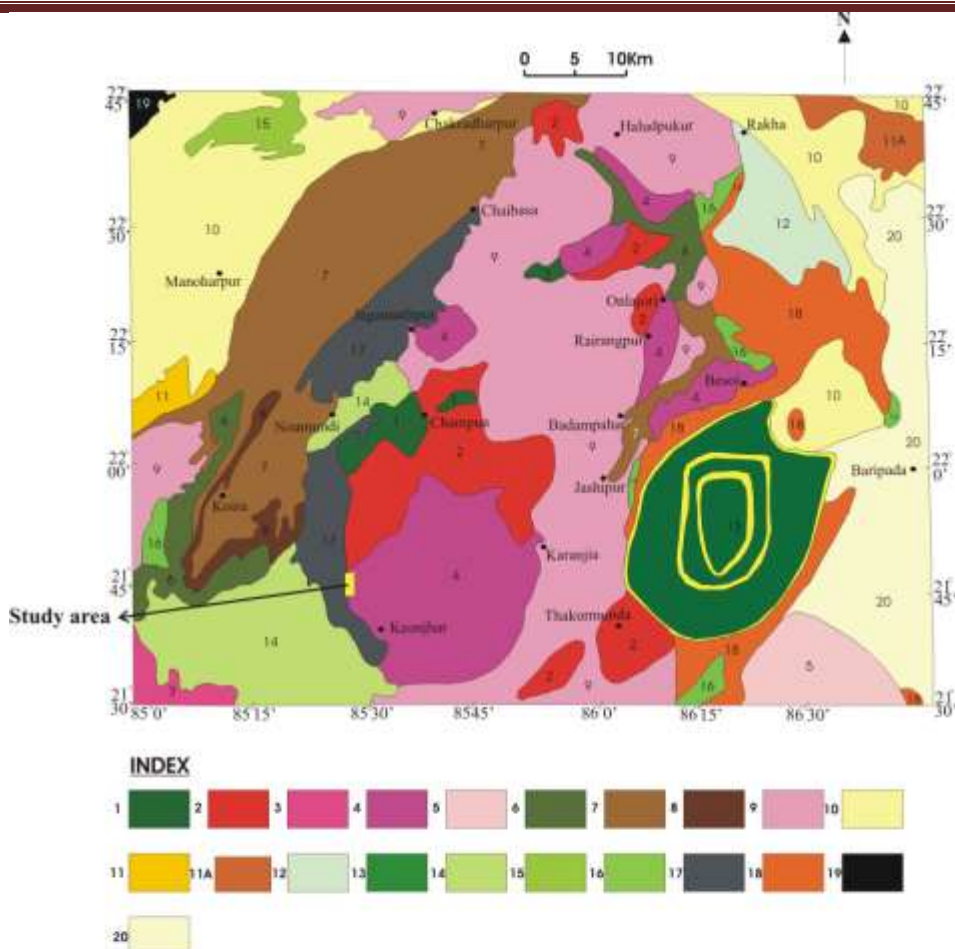
The Late Archaean-Early Proterozoic uranium-thorium bearing quartz-pebble conglomerates (QPCs) were deposited in a fluvial system over a cratonised granite-greenstone basement and are very well-known for hosting of uranium, REE and gold deposits in different parts of world, especially in Witwatersrand Supergroup and Huronian Supergroup in South Africa, Elliot Lake and Woodburn Lake of Canada and Jacobina, Moeda and Goias Velho in Brazil (Mossman and Harron, 1983; Scarpelli, 1991; Greiner and Duke, 2001). QPCs are mainly restricted to the Neoarchaean and Paleoproterozoic and do not occur in sediments younger tan about 2.2Ga (Theis, 1979; Mossman and Harron, 1983; Mahadevan, 1986; Fareeduddin, 1990; Phillips and Law, 2000; Frimmel and Minter, 2002; Yang and Holland, 2002; Bekker et al., 2004; Mikhailov, 2006; Hazen et al., 2009; Cuney, 2010; Chakrabarti et al., 2011; Kumar et al., 2012; Chakrabarti et al., 2013; Ronald E. Seavoy, 2015). In India, traces of gold and radioactive mineralization in quartz-pebble conglomerates (QPCs) are mainly reported from Precambrian Dharwar craton and Singhbhum craton by mainly the Atomic Minerals Directorate (AMD) and Geological Survey of India (GSI) (Haque and Dutta, 1996, 1999, 2001; Sunilkumar et al., 1998; Mishra et al., 1997; Pandit, 2002; Mishra et al., 2008; Kumar et al., 2009; Chakrabarti et al., 2011; Kumar et al., 2011; Kumar et al., 2012; Chakrabarti et al., 2013). Gold-uranium-thorium bearing QPCs are mainly noticed at the base of Iron Ore Group (IOG) basins and Dhanjori basin in Odisha and Jharkhand.

The present study reported for the first time, occurrences of five small bodies of quartz-pebble conglomerates (QPCs) belonging to Koira Group in Kosira-Patna area, Keonjhar district, Odisha which indicates anomalous values of uranium and thorium mineralization.

Geological Setting

The study area forms a part of the Eastern Indian Shield and is located at the contact of Bonai-Kendujhar belt and Singhbhum craton (Fig.1). The supracrustals of the Older Metamorphic Group (OMG) are considered to be the oldest rocks (3.5-3.6Ga) in the Singhbhum craton (Saha, 1994) and comprise mainly para and ortho-amphibolites, pelitic and psammopelitic schist and meta-arenite. The OMG rocks are intruded by the TTG gneisses (biotite-hornblende-tonalite gneiss) which are termed the Older Metamorphic Tonalite Gneiss (OMTG) and represent the vestigial first stable continental crust dated at 3.44Ga (Acharya et al., 2010). Both the OMG and OMTG are surrounded by the 3.2-3.3Ga Singhbhum Granite Complex (SGC) expansive over nearly 10,000 km^2 (Fig.1) covering major part of Archaean nucleus of this craton.

Koira Group of rocks of the western IOG mainly comprises of quartz-pebble conglomerates (QPCs), basal sandstone-quartzites, volcanic formation, lower shale formation, banded iron formation, upper shale formation and mixed facies formation. The entire area is folded into a series of asymmetrical/slightly overturned anticlines and synclines. Various types of iron ores found in the area are massive, laminated, shaly, powdery and flaky ores. They suggested that the Singhbhum Granite and Bonai Granite along with its enclaves of metamorphosed sediment constitute the basement for the Koira Group.



1- Older Metamorphic Group; 2- Older Metamorphic Tonalite Gneiss; 3- Pala Lahara Gneiss; 4- Singhbhum Granite Phase-A (includes phase I and II); 5- Nilgiri Granite; 6- Iron Ore Group lavas; ultramafics; 7- Iron Ore Group shales, tuffs, phyllites; 8- BHJ, BHQ and sandstone-conglomerate of Iron Ore Group; 9- Singhbhum Granite Phase B; Bonai Granite: Chakradharpur Granite; 10- Singhbhum Group pelites, psammipelites; 11- Singhbhum Group quartzite; 11A- Quartzites-pelites; 12- Quartzite - conglomerate-pelite of Dhanjori Group; 13- Simlipal lavas; 14- Jagannathpur lavas; 15- Dalma Lavas; 16- Proterozoic Gabbro-anothosite-ultramafics; 17- Kolhan Group and equivalents; 18- Mayurbhanj Granite; 19- Chhotanagpur granite gneiss (CGG) 20- Alluvium; Tertiaries

Fig.1: Generalized geological map (modified after Saha, 1994) of central Singhbhum Craton, North Odisha showing location of the study area.

Geology of the study area

Five small bodies of quartz-pebble conglomerates (QPCs) belonging to Koira Group are mapped from Kosira to Patna area, Keonjhar district, Odisha which occurs in the hilly terrains and trending N-S to NE-NW (Fig.2). The longest body of QPC is exposed towards west of Kosira for 250-350m length extending in NS direction and width varies from 20m to 50m. Four bodies of QPCs are observed towards west of Patna which varies from 100 to150m in length and 20 to 50m in width. Its trends vary from N20°E to N50°W direction. The quartz pebble conglomerates contain quartz clasts embedded within arenaceous matrix (Fig.3a&b). These units are matrix-supported conglomerates but at few places showing a nature of clast-supported conglomerates. The matrix is white, grayish or reddish (ferruginous), medium grained, massive and at some places foliated. The clasts are of pebble size (1cm-6cm), rounded, sub-rounded and elliptical in shape and made up of white or smoky (Fig.3a&b). Smaller clasts of quartz are mostly sub-angular to angular in shape (Fig.3a&b).

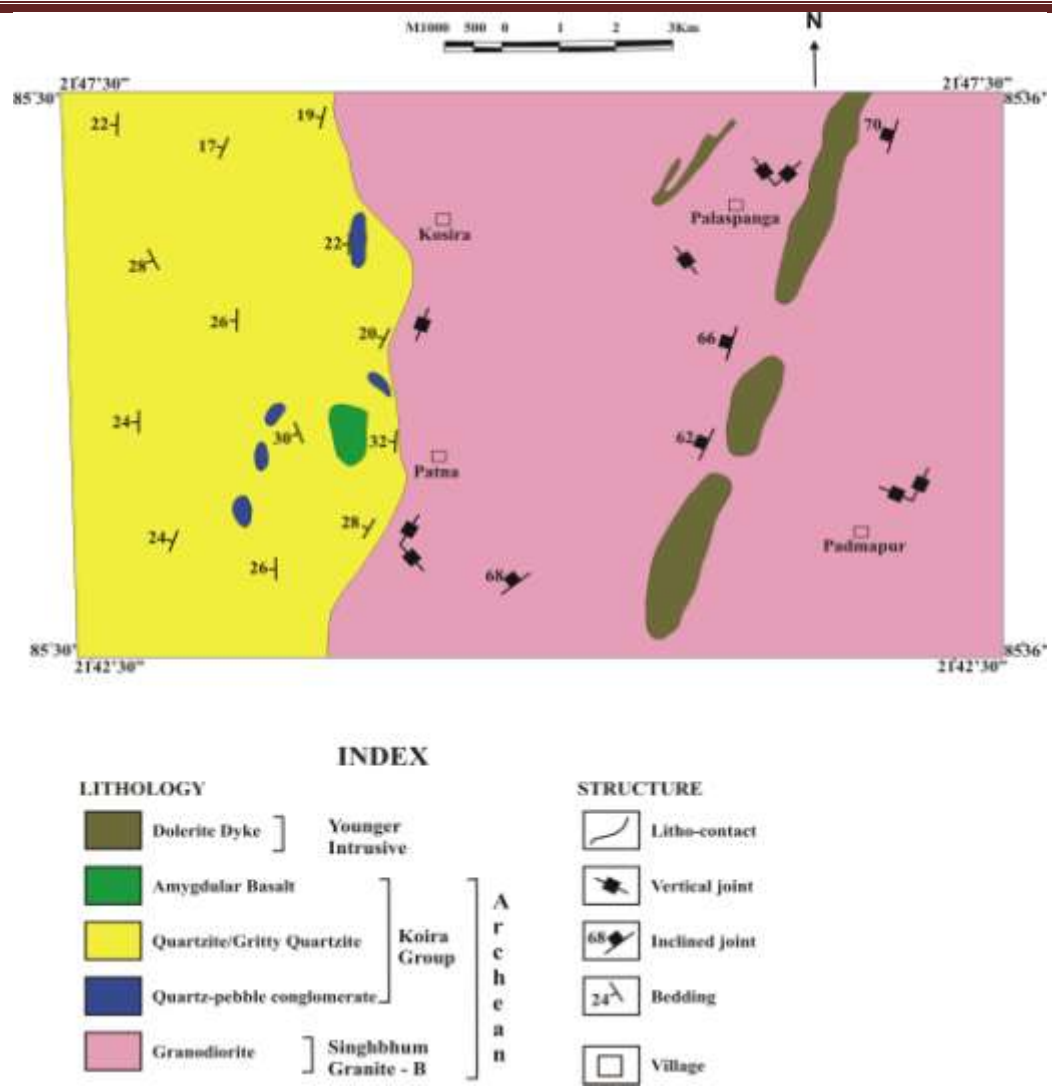


Fig.2: Geological map of the study area showing the occurrence of quartz-pebble conglomerates (QPCs), Kosira-Patna area, Keonjhar district, Odisha (Yadav et al., 2016).

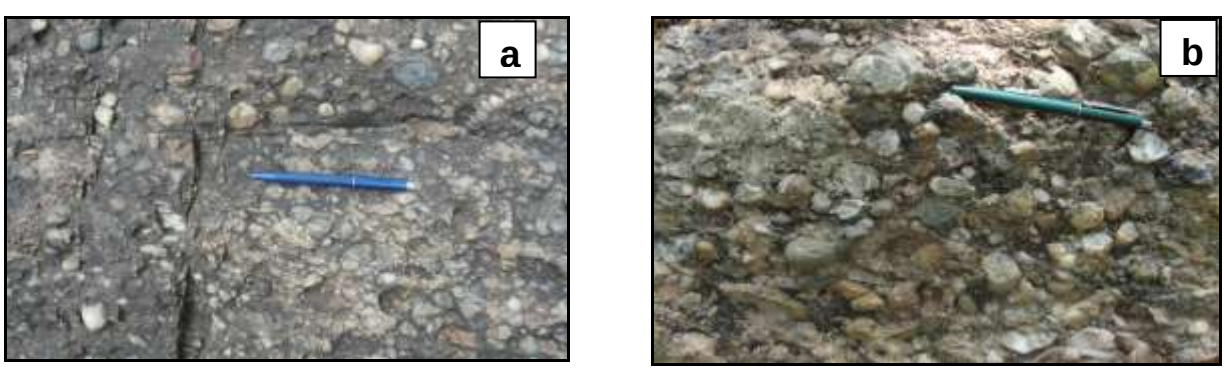


Fig.3: (a & b) Quartz pebble conglomerates (QPCs) show random distributions of sub-angular to rounded clasts of quartz (white and smoky) within arenaceous matrix.

Geochemistry

Analytical technique

Ten samples of quartz-pebble conglomerates (QPCs) were collected and analyzed for major oxides and trace elements by X-ray Fluorescence (XRF) at Geological Survey of India, Eastern Region, Kolkata.

Whole rock geochemistry

Quartz-pebble conglomerates are enriched in SiO_2 contents that vary from 85.99 to 96.16 wt%. The percentage of Al_2O_3 and TiO_2 varies 1.43-9.57 wt% and 0.06-1.31 wt% respectively. The result shows significant presence of uranium-thorium-gold values in QPCs.

U and Th values vary from 5 to 18ppm and 6 to 82ppm respectively in QPCs. These values are noticeably higher than the crustal abundance values of U (1.8ppm) and Th (7.2ppm). Three samples show higher values of uranium (15ppm, 17ppm & 18ppm) which is approximately 7 to 10 times higher than the crustal abundance of uranium. One sample of QPC shows very high value of Th (82ppm) which is predominantly 11 times higher than the crustal abundance of thorium (7.2ppm). Significant abundance of chromium (Cr) is also recorded which ranges from 113ppm to 7394ppm with an average of 1294ppm (n=10). Cr value of 7394ppm is recorded in one sample of QPC which is predominantly 739times higher than crustal abundance of Cr (100ppm). All the samples of QPCs show average chromium values are twelve times higher than the crustal abundance of chromium. The value of zirconium (Zr) varies from 10ppm to 897ppm which is significantly higher than the crustal abundance of Zr (165ppm). The gold (Au) value of 10 nos. of QPCs samples ranges from 50ppb to 340ppb.

Major oxides and trace elements data point to following facts:

- High Cr-value (113-7394ppm) is noticed in QPCs matrix may be due to the presence of Cr-bearing minerals like fuchsite, mica and opaque (chromite and magnetite).
- Incidence of titaniferous mineral phase's like Rutile, U-Ti-bearing minerals presence in the matrix of QPCs which is responsible for very high Ti-content (1.31 wt%).

Conclusion

Five small bodies of quartz-pebble conglomerates (QPCs) belonging to Koira Group hosted uranium-thorium-gold mineralization are mapped between Kosira and Patna area, Keonjhar district, Odisha. These units are mainly matrix supported conglomerates but at places showing nature of clast-supported conglomerates. The clasts of QPCs are predominantly made up of quartz which is white, smoky and reddish. Clasts are largely boulder to pebble in size, sub-rounded, rounded, sub-angular and angular in shape. QPCs show high contents of SiO_2 (85.99-96.16 wt%), Al_2O_3 (1.43-9.57 wt %) and low TiO_2 (0.06-1.31 wt %). U and Th values vary from 5 to 18ppm and 6 to 82ppm respectively in QPCs. Three samples show higher values of uranium (15ppm, 17ppm & 18ppm) and one sample shows very high value of Th (82ppm) which is approximately 7 to 11 times higher than the crustal abundance of uranium and thorium. Apart from that, significant values of chromium (Cr), zirconium (Zr) and gold (Au) are also recorded within this unit.

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