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Hydrogeochemical investigation for targeting unconformity-related uranium deposits in the Badami Group of the western Kaladgi Basin, India

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Uranium exploration is crucial for supporting the clean energy transition, as nuclear power offers a stable, low-carbon energy source. Hydrogeochemical exploration is gaining significance for identifying sub-surface uranium mineralization due to the geochemical behaviour of uranium. This study investigates groundwater geochemistry in the Badami Group of the western Kaladgi Basin, India, to delineate targets for unconformity-related uranium deposits. The study area consists of relatively undeformed arenites, conglomerates and basal arenites of the Neoproterozoic Badami Group that unconformably overlie an Archean peninsular gneissic basement. A few unconformity-related uranium prospects hosted by the Badami conglomerates and basal arenite have been identified by the Atomic Minerals Directorate in the study area. A total of 217 groundwater samples were collected from operational agricultural bore-wells across the study area. The pH/Eh conditions of groundwater samples show mildly reducing to oxidizing environment and acidic to neutral conditions. The hydrogeochemical facies is dominated by Ca-HCO_3 type water. The groundwater samples of the Gibbs ratios indicate water-rock interaction. The R-mode factor analysis establishes geochemical association between U(0.85), Na(0.87), Mg(0.87), Ca(0.81), Cl(0.87), HCO_3(0.80), SO_4(0.70), and CO_3(0.59). High positive loadings on U, HCO_3, and CO_3 show the association of uranium with carbonate complexes. The uranium concentration of the groundwater samples ranges between 0.5-88 ppb. Concentrations greater than 10 ppb of total dissolved uranium occur at distances less than 1 km from NE-SW and E-W trending faults. This clearly indicates that the faults serve as conduits for uranium mobilization. Furthermore, locations of airborne radiometric survey anomalies matched well with locations of hydro-uranium anomalies. The ground radiometric mapping of quartz arenites and soil shows uranium values ranging from 0.4 ppm to 792 ppm. The result of the distance to the faults of ground radiometric anomalies reveals that uranium values greater than 5 ppm occur less than 0.5 km from NE-SW and E-W trending faults. These findings suggest the presence of deep-seated uranium deposits close to the mapped structures in the study area. This study delineated several potential target areas for unconformity-related uranium deposits for further sub-surface exploration.