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A note on qualitative appraisal of Radiometric Investigations along the Goa-Kushtagi profile

D.Himabindu and G.Ramadass

Center of Exploration Geophysics, Osmania University, Hyderabad – 500 007

ABSTRACT

Regional radiometric investigations were carried out along the 320-Km long, E-W Goa-Kushtagi profile, covering the major portion of the northern part of the western Dharwar craton. The various geological boundaries and contacts corresponding to the three major geologic formations of the region, viz., peninsular gneisses, schists and younger granites and structural features such as faults and shear zones are qualitatively inferred from the radiometric signatures. These are categorized into four major tectonic blocks bounded by three deep-seated faults along the profile.

INTRODUCTION AND GEOLOGY OF THE STUDY AREA

The Archaean to Proterozoic Dharwar craton has been attracting the attention of the national and international earth science community. The craton is distinguished by a complex course of geological evolution with intense magmatic activity and periods of deformation alternating with extremely long periods of comparative stability that allowed physico-chemical forces to express themselves in the geological landscape. The three major rock constituents in chronological order of decreasing age in the area are peninsular gneisses, schist belts and younger granites (Radhakrishna & Vaidyanadhan 1997).

Though the Dharwar craton has been well researched geologically (Naqvi & Rogers 1987; Chadwick, Vasudev & Ahmed 1996; Chadwick, Vasudev & Hegde 2000), relatively few geophysical and petrophysical studies have been reported. Most of the geophysical studies (Kaila et al. 1979; Kaila & Bhatia 1981; Mita Rajaram, Harikumar & Balakrishnan 2001; Subramanyam & Verma 1982; Krishna Brahmam 1993) pertain to evaluation of the crustal configuration of the region or mapping intra-continental geophysical signatures while the petrophysical studies relate to the measurements of physical properties (Subramanyam & Verma 1981; Ramadass et al. 2002). Even though the radiometric method is a valuable tool for geological mapping, reported radiometric studies in the craton are limited and confined to detailed investigations for locating auriferous veins in the southern part of the Chitradurga thrust (Ramachandran et al. 1997), or as a qualitative tool in the structural elucidation of the Gadwal schist belt in the eastern Dharwar craton (Himabindu et al. 2001).

A major part of the 320-Km long Goa-Kushtagi profile (Fig.1) cuts across the northern part of the western Dharwar craton, traversing almost all the geological formations occurring within the peninsular gneissic basement that formed between 3400 to 3000 million years ago (Ma) (Beckinsale, Drury & Holt 1980; Taylor et al. 1984 and Bhaskar Rao et al. 1991). An Older Gneissic Complex (OGC) of age 3300 to 3000 Ma and a Younger Gneissic Complex (YGC) of age 3000 to 2600 Ma can be distinguished within this complex (Bhaskar Rao et al. 1983 and 1991). The OGC and YGC are sheared along the Chitradurga boundary thrust (CT) and roughly correspond to the western and eastern Dharwars, respectively (Drury et al. 1984).

The greenstone and schist belts of the craton consist of volcano-sedimentary material that lies unconformably over the gneissic basement (Swami Nath, Ramakrishnan & Viswanath 1976). The Dharwar type of schist belts range in age from 2900-2600 Ma, and are younger than their eastern counterparts. These belts have a large sedimentary component with considerable development of quartzite, argillaceous and carbonate sediments (Chadwick et al. 1991 and 1992, Nutman et al. 1996). The Gadag and the Dharwar schist belts are the major schist belts of the Dharwar type. The younger granites (Chadwick, Vasudev & Ahmed 1996) mark the end of the Dharwar cycle around 2600 Ma.

Thus, when we look at the transect as a whole (proceeding west to east) the Goa-Kushtagi profile runs on an undulating traverse with reliefs varying between 0-650m. Dispersed occurrences of greywacke with conglomerates (classified along with Dharwar schists), laterites, meta-basalts, meta-gabro / biotite schists, younger granites and even a small instance of the younger gneissic complex within the older gneissic complex are encountered. This complex geological assemblage is the result of intense deformation undergone by the Dharwar schists. The Dharwar schist belt is sheared with the Older Gneissic Complex along the Bababudan Nallur (BN) shear. East of the Gadag schist belt is seen the Younger Gneissic Complex. This Younger Gneissic Complex hosts the Closepet batholith that marks the eastern end of the transect. The western boundary of the batholith occurs between Naregal on the west and Gajendragarh on the east.

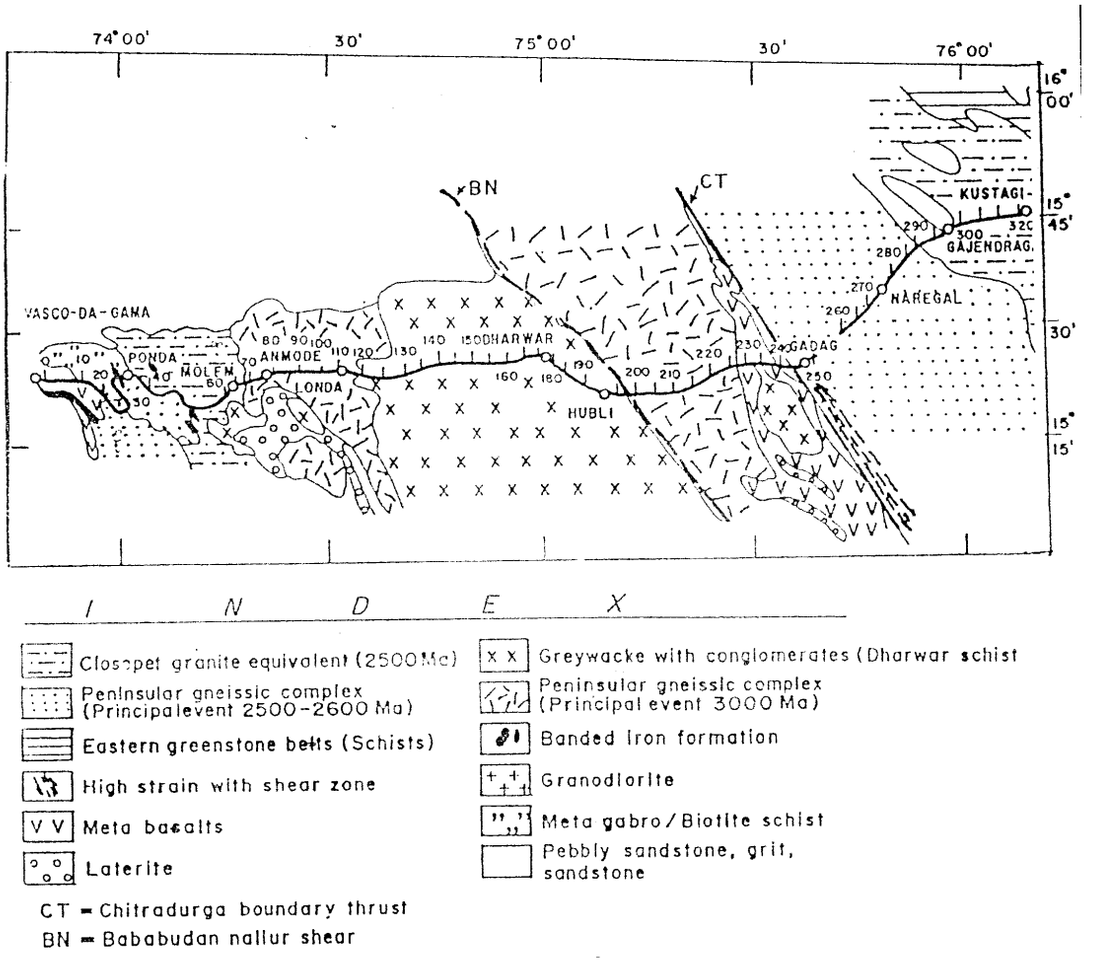

Figure 1. Surface geological map with geophysical layout of the Goa-Kushtagi profile.

In continuation of the relatively few reported geophysical studies, and in view of the significant radiometric variation between the peninsular gneisses and schists (major constituents of the western Dharwar craton), a qualitative appraisal of litho-structural variation along the Goa-Kushtagi transect was made in terms of the radiometric responses.

RADIOMETRIC INVESTIGATIONS

Radiometric measurements are sensitive to lateral litho-variation and therefore suitable for mapping surface geology (Darnley & Ford 1987). They can be used in the interpretation of major and minor fault/shear zones (Ramachandran et al. 1997 and Balakrishna Rao 1999). Since the different rock types in the area have sufficiently varying natural radiation facilitating radiometric resolution, natural radioactivities were measured with a station interval of 0.5 Km from Goa to Kushtagi using the ECIL Scintillometer type SM 141. This scintillometer is a lightweight portable radiation measuring instrument with solid-state design and is ideally suited for radiometric investigations. It is powered by ordinary torch cells and has a time constant of 5.5 seconds (nominal). It is directly calibrated in mr/hr and measures radiation intensity with an accuracy of 15 %. A range setting provision in the instrument allows measurement of intensities varying over wide ranges with the same display scale by setting the range to any of the three ranges (0-200 mr/hr, 0-2000 mr/hr and 0-40 mr/hr) supported, appropriately. Accordingly, the instrument sensitivity varies between a high of 0.1 mr/hr to a low of 1 mr/hr at full-scale deflection.

Fig. 2a shows the radiometric profile for the Goa-Kushtagi traverse. The coefficient of variation of the radiometric data was computed (Fig.2b) using a moving 9-point average window to improve the signal to noise ratio. This figure shows an alternating sequence of highs and lows that can be attributed to lithologic units, geological boundaries and faults along the transect. From an examination of Figs 2a and 2b, it is evident that a radiometric response of 10-15 mr/hr is observed between stations 0-25. This can be attributed to the meta-basalts in the region (Fig. 2c).

The low (6.5 mr/hr) between station 25 to 40, and the small high (12 mr/hr) following it immediately could be due to the meta-gabbro / biotite schist and a small intrusion, respectively. The high (12 mr/hr) following this (station 65) could be due to intrusives in the region.

The granite-gneisses between stations 60 to 74 show a characteristic high response (6-13 mr/hr). Station 74 marks a faulted contact between the upper Dharwar sediments and the younger granites in the region.

Between stations 74 to 85, a small low (2-4.5 mr/hr) with an aereal extent of 5 Km, attributable to meta-sediments can be seen. This is followed by the Closepet granite equivalents that have an aereal extent of 20 Km and show a characteristic high of about 12-15 mr/hr.

The Dharwar schist (from station 120 to station 198) also shows a broad low radioactivity (3 – 10 mr/hr) with small intermittent highs that reflect intrusions within the schist. The Dharwar schist is bounded by the Bababudan-Nallur shear on its east (station 198) that is a deep seated fault, while the Gadag schist is reflected by a low that follows a small shear zone at station 247.

Since major faulting/shearing is associated with the passage of large volumes of fluids with attendant leaching of radioactive minerals and correspondingly low radioactivities, it is evident that shear margins are reflected by small sharp lows. Thus the Bababudan –Nallur shear (station 198) as also the Chitradurga thurst (station 247) are reflected by small lows of 2-3 mr/hr.

From station 260 a high increase, attaining a maximum value of 25 mr/hr is seen. This region is characterized by exposures of peninsular gneisses and, east of station 307, where radiometric signatures are highest, is the Closepet batholith. At the eastern extremity of the profile, there is a decrease in the anomaly where the radiometric intensity falls to 12 mr/hr. This relative low is on account of the peninsular gneiss exposure at Kushtagi.

From a finer examination of Figs 2a and 2b, four broad tectonic zones I, II, III and IV, limited by three deep-seated

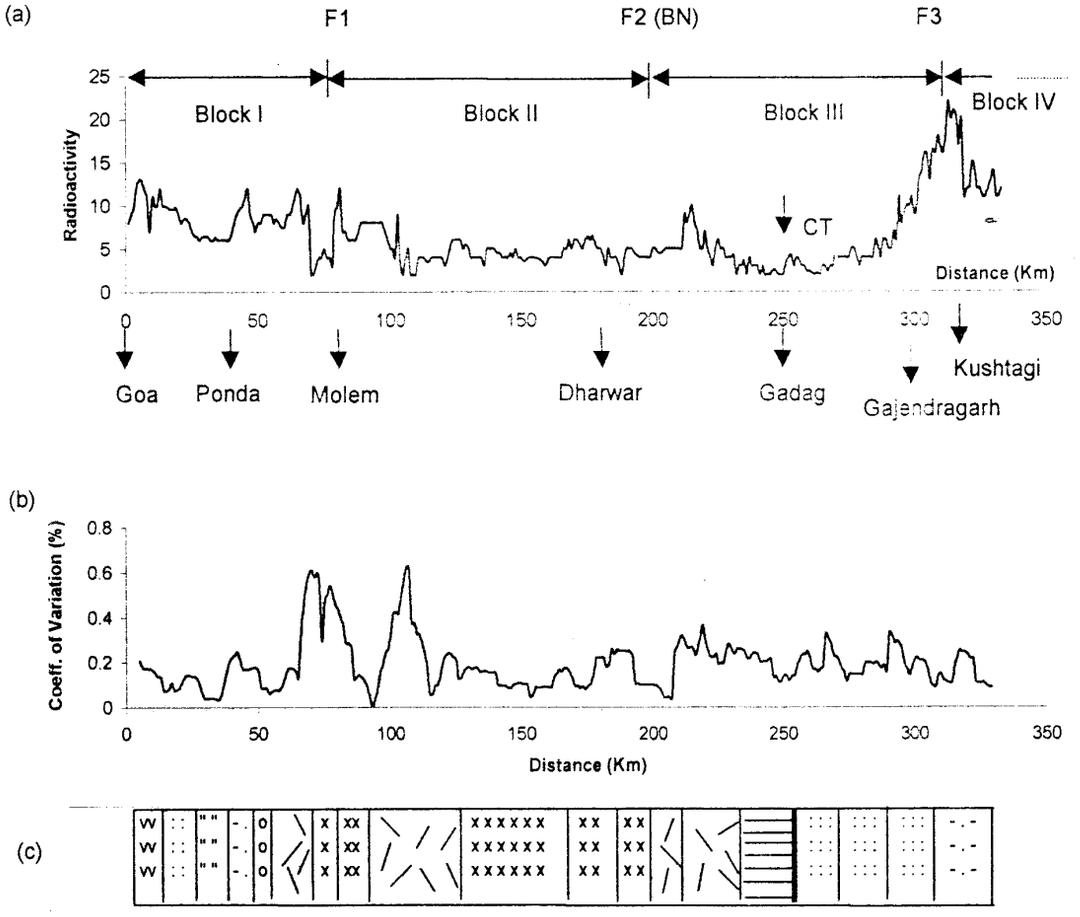

Figure 2a) Radiometric profile: Goa- Kushtagi, b) Coefficient of variation of radiometric intensities and c) Geologic section: Goa-Kushtagi profile (Index as shown in Fig.1).

faults, F1, F2 and F3 can be identified. F1 occurs east of Molem (station 74), and separates the Upper Dharwar sediments from the younger granites in the region. F2 (station 198) corresponds to the Bababudan-Nallur shear and F3 (station 307) coincides with the western margin of the Closepet granites. The average radiometric responses for these blocks are 8.38 mr/hr (stations 0-74), 5.03 mr/hr (stations 74-198), 5.56 mr/hr (stations 198-307) and 15.67 mr/hr (stations 307- 350).

In block I (stations 0 to 74), the westernmost block bounded by F1 east of Molem, there are 5 discontinuities/ contacts that correspond to the contacts between meta-basalts, laterites, meta-gabbro and the peninsular gneisses. This block is characterized by low-grade granite-greenstone belts with iron and manganese ores. The deep-seated faults are associated with gentle gradients of radiometric intensity along the profile.

Block II (the region from station nos. 74 to 198 and bounded between F1 and F2) corresponds to the extensive Dharwar schists bounded by the Bababudan-Nallur shear (F2) on the east. Six discontinuities/contacts can be deciphered within this block. In block III (region between F2 and F3), the most significant feature is a shear zone, the Chitradurga thrust fault (CT) that occurs east of Gadag at station 247. The younger granites (from station 198 to station 225), Gadag schists (from station 225 to station 247) and two intrusions separated by host peninsular gneisses (from station 248 to station 288) are also identified in this block from the radiometric profile. Between stations 288-307 are exposed the peninsular gneisses. This block is reflected by a broad radioactivity low that extends from the Bababudan-Nallur shear to the western contact of the Closepet granite. Interestingly, Srinivasan & Sreenivas (1972) opined that the region between the Bababudan-Nallur shear and the western margin of the Gadag schist represented a domal structure However, from our investigations, we believe that the extent of domal structure is wider, on its eastern side it stretches up to the western contact of the Closepet granites, rather than only up to the Gadag schists. East of F3 to the eastern end of the profile and beyond corresponds to block IV.

CONCLUSIONS

From the radiometric intensities along the Goa-Kushtagi profile, which showed a total range of 25 mr/hr, lateral litho-variation and surface geology including minor/major fault shear zones were mapped. Broadly Closepet granites registered with high radioactivity, while the schists were found to be associated with low radioactivity. Further, the radiometric profile also indicated the presence of four tectonic blocks (I-IV), bounded by three deep-seated faults F1, F2 and F3, corresponding with the fault separating the Upper Dharwars from the younger granites east of Molem, the Bababudan-Nallur shear, and the western margin of the Closepet batholith, respectively. The tectonic block bounded by F2 and F3 appears to be a domal/intrusive structure.

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