Electrical Resistivity Modeling of Quartz Reef and Dolerite Dyke in Granite Hard Rocks

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Abstract

Hard rocks are well known to be complex for groundwater occurrences because of inherent anisotropy, heterogeneities, differential weathering-fracturing, etc. In India, groundwater over-exploitation towards the need of increasing population for their domestic, irrigation and industrial purposes has led to a severe decline in the groundwater level and results in failure number of wells. The bore wells are being deepened in order to tap the water from deeper horizon. The present situation has made the earth scientists to explore the deep potential aquifers for sustenance of mankind. The lineaments may play an important role in the groundwater dynamics and act as indicator for bore well siting. Lineaments can be either potential or non-potential in terms of groundwater resources. Various attempts have been made by several researchers to characterize the lineaments for their groundwater potentiality.

Work has been carried out here to investigate the quartz reef intrusive for its groundwater potentiality through geophysical method. Such intrusive bodies obviously have thick weathered zone that are favourable for groundwater, and it is of interest to characterize their 2D and 3D geometry. For this purpose, seven ERT field surveys have been carried across and along the quartz reefs in granite rock in Andhra Pradesh (India). Resistivity parameters were confirmed with the drilling and logging results. To understand the geoelectrical signature of quartz reef intrusive body embedded in granite, synthetic simulation has been carried out using RES2DMOD (2D Model) for different physical conditions such as: fresh intrusive body with unweathered at contacts, fresh intrusive body with weathered contacts, and also fissured intrusive body with weathered contacts.

Results reveal that the quartz reef usually at contacts is characterized by a significant deepening of the weathering front with highly weathered materials, which is potential for groundwater occurrences. However, sometimes the center of the quartz reef body itself could also be potential for groundwater occurrences because of local deep fissuring due to weathering. Although quartz reef and dolerite dykes both are intrusive, they have different characteristics. Geoelectrical signature of quartz reef has been compared to the one of dolerite dyke. Weathering is found quite deeper in the quartz reef body compared to surrounding granite, which is not in dolerite.

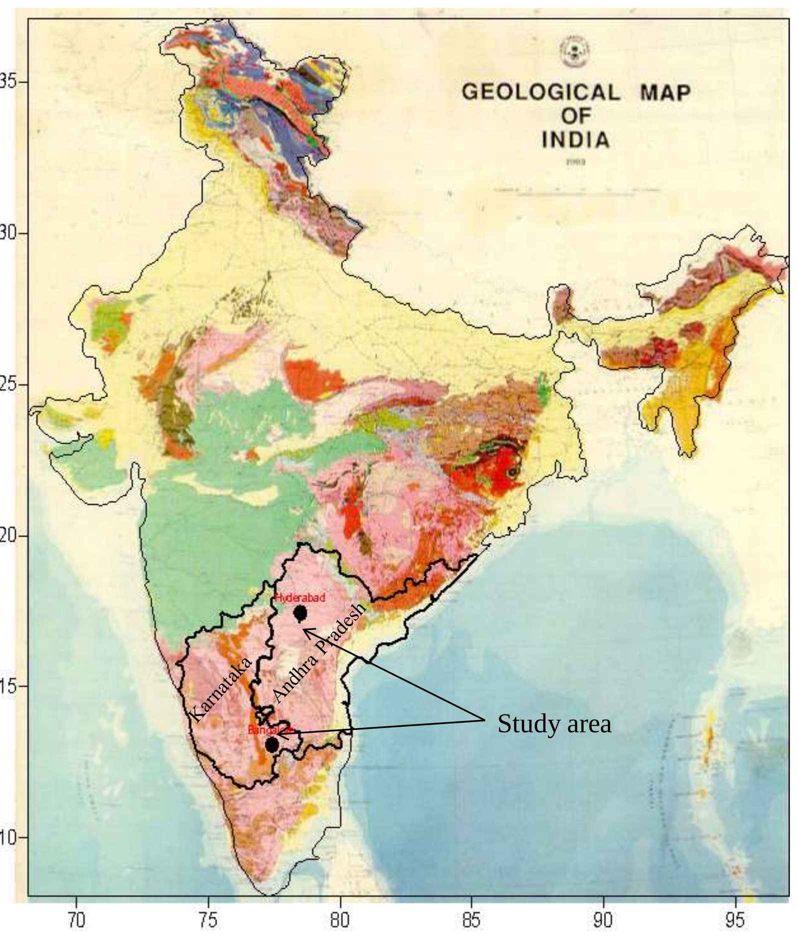

Fig. 1. Location map of the study area

Introduction:

Lineament has generally been used as an indicative tool for locating groundwater potential zone (Lattman and Parizek 1964; Mabee et al. 1994; Chandra et al., 2006). The intrusive lineaments such as quartz veins/reefs, dolerite dykes, etc. are most common structural feature associated particularly with the hard rocks. The contact zones of the intrusive body with granite are considered as weak zone because of the fact that when two different kinds of materials get crystallized at different times, the contact zones become weak and while intrusion; cracks/fractures get developed along the contact in the host medium. Water enters along this zone and facilitate for weathering. Therefore, the contact zone can be a groundwater potential. The weathering and fissuring of the granite at contact zone causes swelling and hence consequently fissuring/fracturing get developed in the surroundings. Thus main quartz reef body could also be fissured/fractured provided it is susceptible for fracturing. The quartz reef can also be groundwater potential provided it is well connected with the contact zone through open fracture network. Hence there is a need to characterize the quartz reef in order to understand its role for groundwater occurrences. Kothur quartz reef intrusion is with granitic host medium. With the above assumption, deepening of the weathering front is expected on either side of the quartz reef. A conceptual model has been prepared for quartz reef intrusion in granitic host medium.

Fig. 2. Photo of quartz reef (left) and dolerite dyke exposed on the surface

Field photographs of dolerite dyke and quartz reef have been shown in figure 2. The rock exposure of the quartz reef shows several impressions of cracks/fractures/fissures, however boulders are seen over the dolerite dyke, which indicates that although doletite dyke is also an intrusive, but the weathering/fissuring pattern in it is quite different than the quartz reef. With the field experience and literature review, schematic diagram of quartz reef and dolerite dyke have been made (figure 3). The fissures are penetrating quite deeper level in the quartz reef, however in dolerite dyke it is limited to shallow level only.

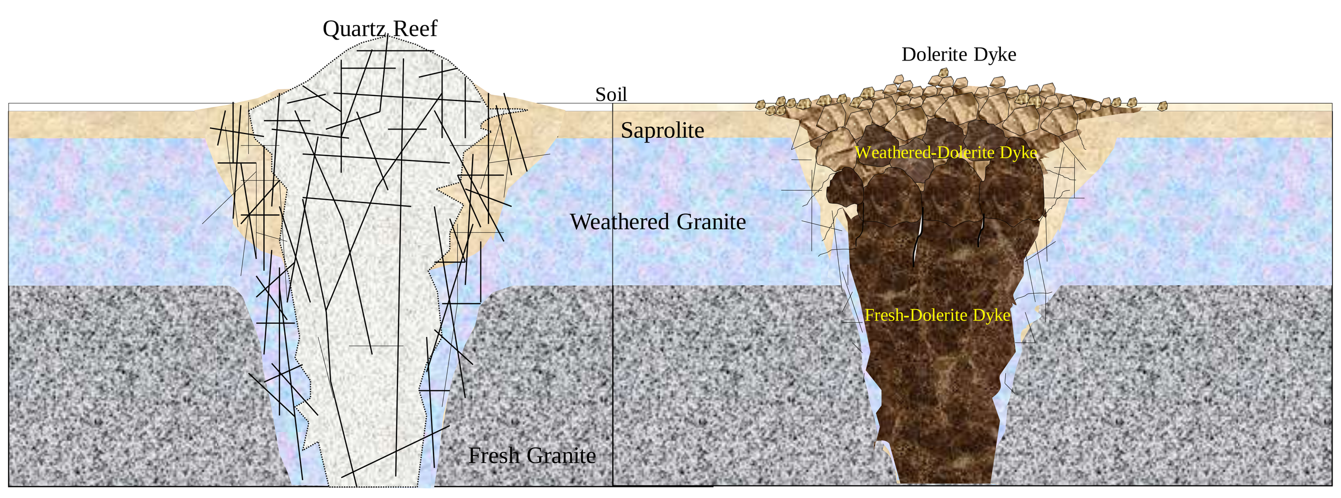

Fig. 3. Schematic Diagram of: Quartz Vein (left) and Dolerite dyke (right) in Granite

Quartz Reef

Studies have been carried out to understand the characteristics of quartz reef embedded in granite. Synthetic ERT simulation of ~15m thick quartz reef with Wenner-Schlumberger configuration have been attempted. Fresh as well as fissured intrusive in the granite host medium with fresh as well as weathered-fissured contacts have been simulated. Figure 4a shows the quartz reef of 640 ohm.m resistivity embedded in granite with geoelectrical layers, which are the representation of degree of weathering/fissuring. Since degree of weathering/fissuring decreases with depth and hence when saturated with water the resistivity also varies with depth. Therefore the geoelectrical layers are expected.

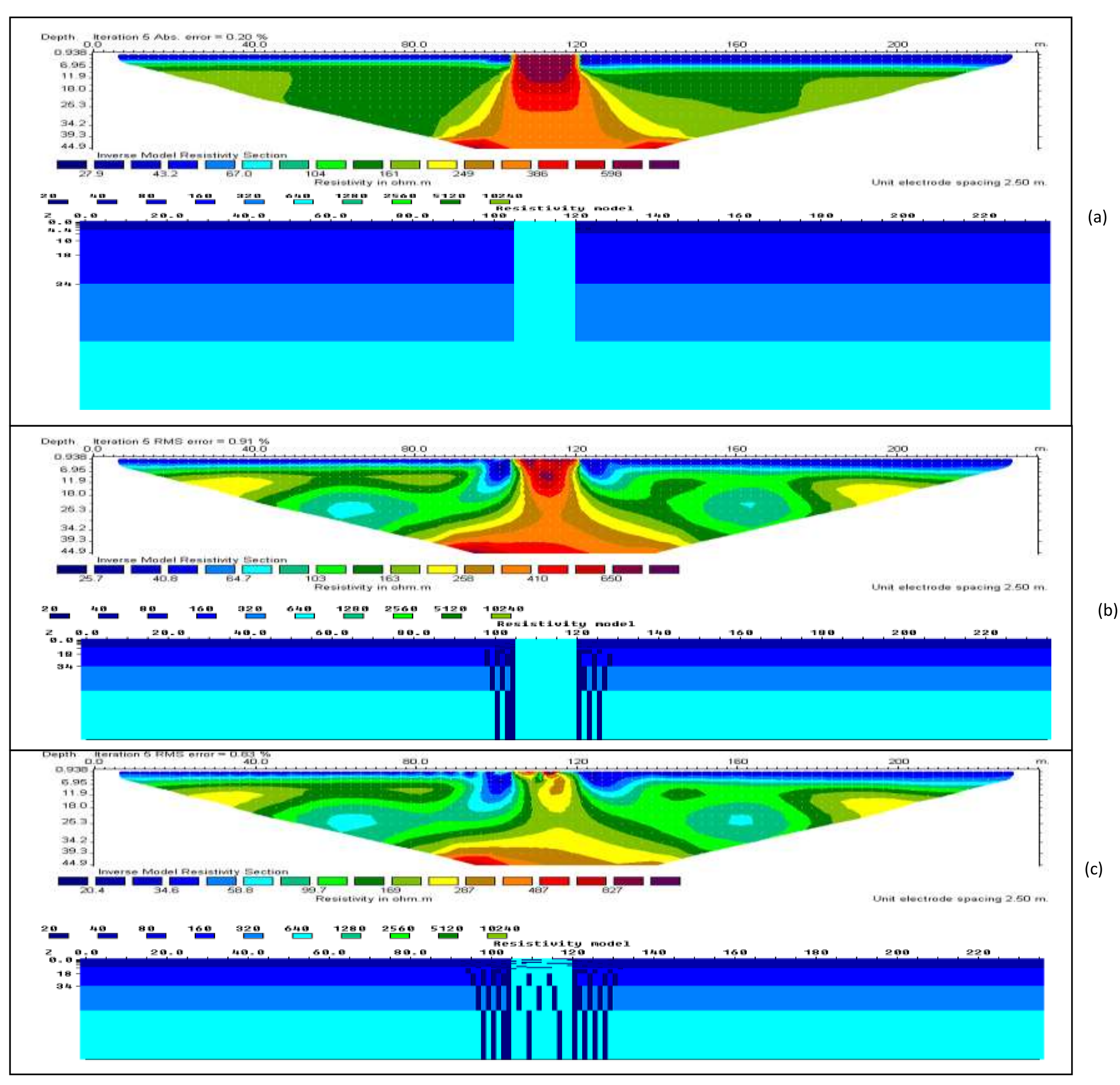

Fig. 4. Synthetic ERT model over (a) Fresh quartz reef, (b) fresh quartz reef with weathered- fissured granite contacts and (c) fissured quartz reef with weathered-fissured granite contact

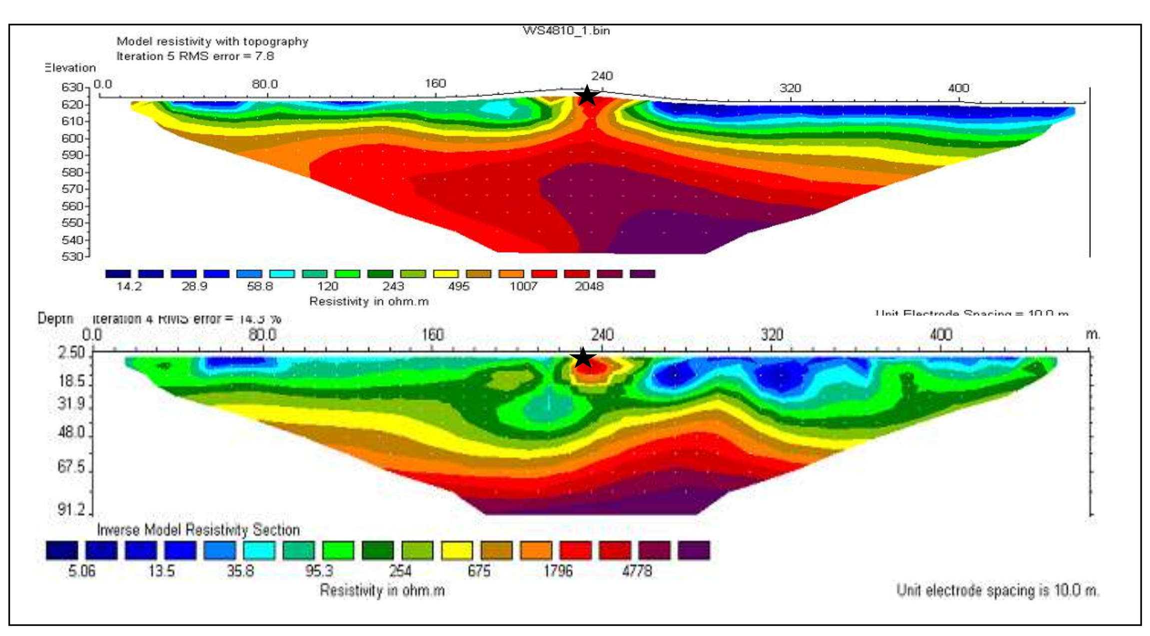

Fig. 5. Field ERT image across (CD and EF) and along (i.e. GH and IJ) at Kothur quartz reef and MN (across) profile over quartz reef at IFP1 site

The second simulation was done for quartz reef with assigning low resistivity to some cells at the contact representative of cracks/fissures/fractures. ERT image has shown the lowering of the conductive anomaly at the contacts. The third simulation has been done with assigning the low resistivity of 20 ohm.m to the cells at the contact as well as inside the reef. With this idea ERT was conducted in the field (Fig. 5) and found quite close response to the figure 4 b&c supporting the logic of weathering-fissuring of the contacts as well as quartz reef itself.

Dolerite Dyke

Synthetic simulation has been done for dolerite dyke intrusive in granite with fresh contact (Fig.6 a&b). as well as weathered-fissured contacts (Fig.6 c&d). As discussed above, low resistivity has been assigned to the cells at the contacts even up to deeper level, but limited to shallow level over the dolerite body.

High resistive vertical anomaly has been achieved and found similar response in the field ERT (Fig. 6e) supporting that the weathering –fissuring at the contacts could be common in the both the cases of quartz reef and dolerite dyke intrusive, but fissuring inside the intrusive up to deeper level is limited to the quartz reef only. The dolerite dykes are weathered-fissured upto shallow level only.

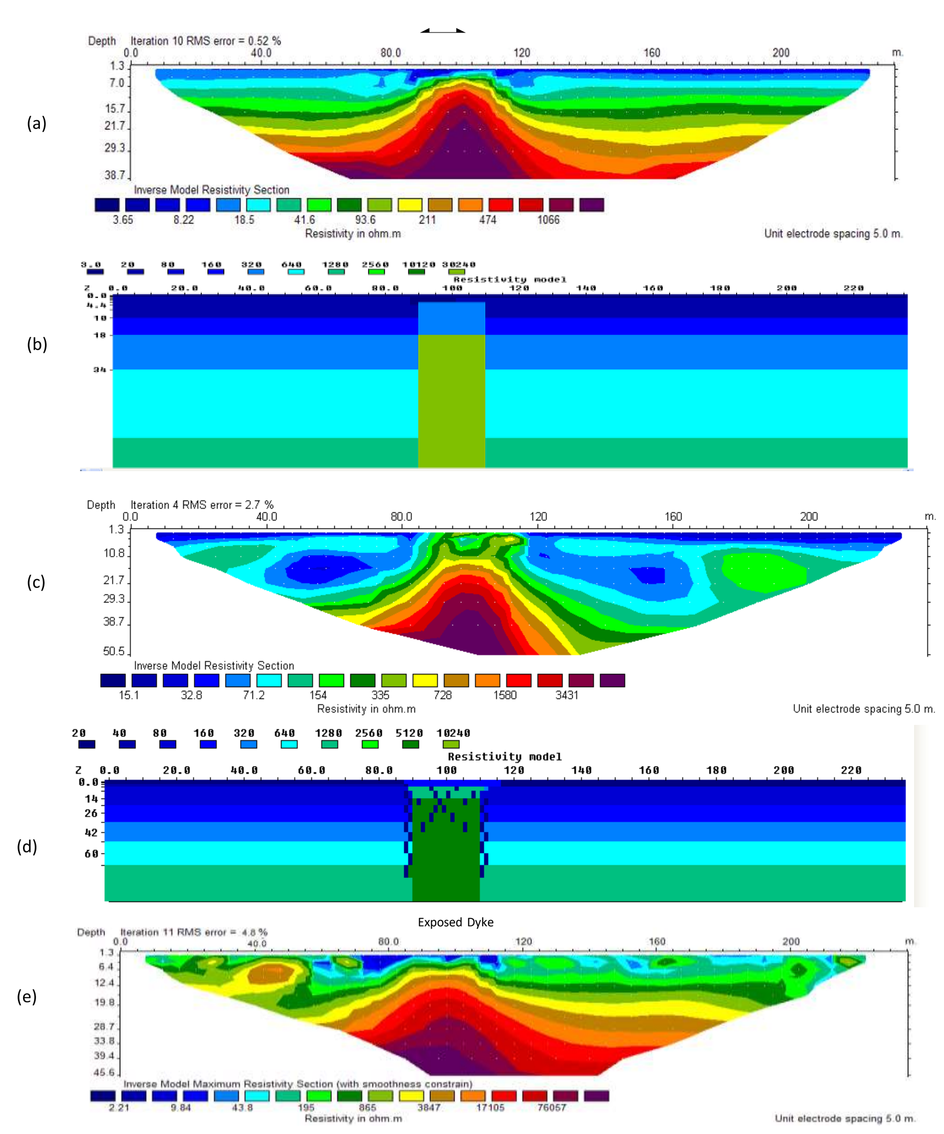

Fig. 6 (a) ERT image of dolerite dyke from synthetic data; (b) Physical representation of dolerite dyke intruded in granite host medium with; (c) ERT image of dolerite dyke with weathered-fissured contacts; (d) Physical representation of dyke intrusive in the layered subsurface with weathering at the top and weathering-fissuring at the contacts (e) field ERT image across the dyke (D-5) at Bairasagara watershed, Karnataka (India)

Conclusion

The above studies concludes that the surface geophysical method particularly ERT is an efficient tool to characterize the lineament such as quartz reef in granite host medium. Study reveals that although dolerite and quartz reef are intrusive but their characteristics are different for groundwater dynamics. Quartz reef get weathering-fissuring at the contacts as well as fissuring in the quartz reef body, even extended up to quite deeper level, whereas weathering fissuring is limited to the contact in case of dolerite dyke.

The quartz reef traversing the granite rock can be very useful for locating a potential aquifer. The contact zones of quartz reef may provide potential groundwater zone as deepening of the weathering front is found over there. The ground water flow from up stream side to down stream get accumulated in the zone and make favourable location for siting a high yielding well. Thus quartz reef can also be groundwater potential zone provided it is well connected with the contact zone through open fractures.

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