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Research Article

GEOLOGICAL STRUCTURES THAT HAVE CONTROL ON GROUNDWATER OCCURRENCE OF CHAMARAJANAGAR TALUK, CHAMARAJANAGAR DISTRICT, SOUTHERN KARNATAKA

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ABSTRACT

Geology of this area is ranging from Precambrian age for the rocks of granite, gneisses, schist and quartzite rocks, to recent age overlain by thick layers of alluvial deposits. This study aims to evaluate geological and structural influences on groundwater of Chamarajanagar taluk. It is an essential resource in outcrop and structures of the area, because of local field conditions, such as rock type and complex structure. The rocks comprise the major hydrogeological units of the deep groundwater system in the study area. The tectonics was important in establishing the distribution of the rocks that control the present flow patterns of groundwater. The study area is affected by tectonic that caused faulting, folding, and fracturing. The main structures that are investigated include faults, fractures, folds etc. These structures greatly influence the groundwater occurrence and flow. Two types of folds (anticline and syncline) act as accumulation and drainage stream channels of groundwater flow and also act as aquifer in the study area. Structural geology observed in the study of fractures in drill holes, the subsurface structures about 150 m- 200 m depth at the boreholes are similar to surface structure, which have been helpful in assessing the surface structure.

Keywords: *Geological, Structures, Groundwater Occurrence*

INTRODUCTION

Water is the important component of the development of any area. The human settlement depends on a large extent on the availability of water resources. In the recent years, the consumption of water is greatly increased due to the increase in human population in the study area.

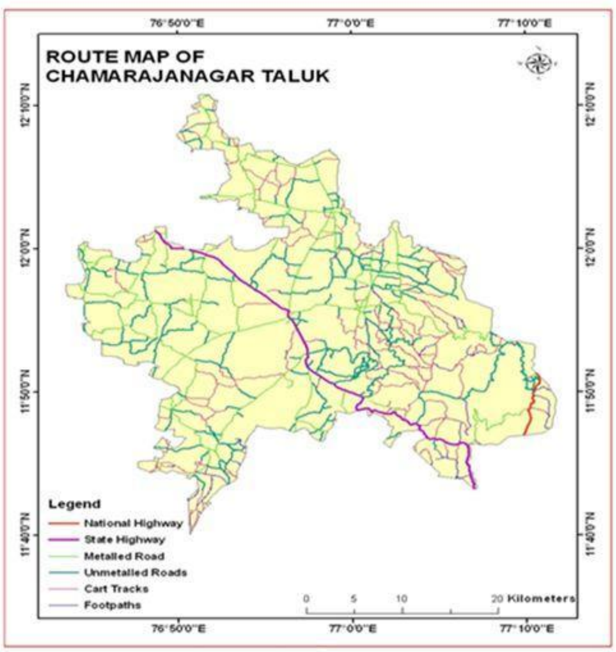

Figure 1: Location of the study area

Moreover, there has been a lot of quarrying of granite mining expansion and farming activities as live stock within the area. These factors have influence over groundwater demands in the area. So the present research is very important for understanding the factors influencing the distribution, flow, yield and quality of groundwater. The study area is located in the central part of the Chamarajanagar district. The area ranges in elevation 696 above mean sea level. The area is bounded by latitudes $76^{0}50^{1}$To$77^{0}10^{1}$E and longitudes$11^{0}40^{1}$To $12^{0}10^{1}$N, which is about 1226.67Sq.km (Figure 1). The distribution of groundwater is not uniform in hard rock areas. The spatial and temporal variation in rainfall, geomorphology, geology, and structural aspects has lead to uneven distribution of groundwater.

Groundwater is simply water that occurs in the ground; in the pore spaces between mineral grains or in weathering, cracks and fractures in the rock mass. It is usually formed by rain water or snow melt water that sweeps down through the soil into the underlying rocks. Crystalline bedrocks in this paper we refer to igneous rocks as granite and metamorphic rocks, such as, gneisses, schist, and quartzite, where the inter granular pore spaces are negligible and where almost all groundwater flow takes place through weathering, cracks and fractures in the rocks. The formation of the study area was accompanied by tectonic movement as fractures, joints, faulting, folds, and veins.

Generally, structures play different roles in ground water quantity and quality, and variations include the following: groundwater reservoirs occurring in igneous, sedimentary, and metamorphic rocks; voids between minerals and grains; and joints, fractures, and faults. In the study area suvarnavathy reservoir found occurring of metamorphic rocks. The distribution and composition of these rocks affect the availability and chemical constituents of groundwater. In general, a geological study should include a lithological phase covering mineral composition, grain size, sorting and packing; a stratigraphic phase describing the age, unconformities, and geometrical relationships between different lithologies; and a study of structural features. Collection of this information gives a rather clear picture of the subsurface geology, leading to a better understanding of various water bearing formation and distributions. Structures as hydrodynamic contacts impact on the groundwater flow pattern of an aquifer, as well as, the major structural features impacting on groundwater are fractures and folds.

Fractures are subdivided into joints, fissures and faults, which are formed by brittle fracturing of rocks (Roberts, 1982). Folds are produced by ductile deformation, and the extent of this deformation reflects on the magnitude of the features formed i.e. synclines and anticlines. Fractures are not homogeneously distributed in the rock mass, and because the permeability of the fracture system is very sensitive to the fracture aperture and degree of fracture connectivity, it is very difficult to predict the yield of a well or borehole in crystalline bedrocks (David and Nick, 2002).

Aims and Objectives

The main objectives of this study are

1. The identification, description and evaluation of structures.
2. The interpretation of structures and their impact on ground water flow.
3. The relationships between structures and groundwater.

Geological Setting

In the study area, (Figure 1a**)** the crystalline basement is exposed extensively in northeastern part there are outcrops of rocks belonging to the crystalline basement complex, which are composed of granites, gneisses, schist, and quartzites. The ages of these rocks in most localities are assigned to the Proterozoic period. The rocks of the basement complex are gradually overlain by a series of mostly unfossiliferous formations composed of unconsolidated material of sands, and clays which are commonly termed the Superficial deposits or alluvial in recent age.

Detailed geological studies for rock samples and their field relationships representing the complexes were carried out to be compared and correlated with those complexes surrounding the study area. The basement complex in the study area is affected by tectonic activities, which resulted into widely distributed joints, faults, foliation and folds, which including igneous–metamorphic rocks. The gneisses have a general foliation trend of north to south with a dip angle varying towards the northeastern direction. In most localities, the gneisses are highly weathered. In hand, specimens the gneiss rocks are compact, fine to coarse grained, grayish brown to light in colour. The essential mineral consists of biotite, plagioclase and quartz (Figure 2 to 5). The granitic gneisses rocks in the eastern part and southern part of area which had been folded strongly in some places and symmetrical alternate (chevron) folds anticline and syncline pairs, which representing elastic deformation and brittle deformation also deduced in hand specimens essential mineral horn blend, biotite and quartz. This quartzite composed essentially of quartz mineral in fine to medium grained in texture.

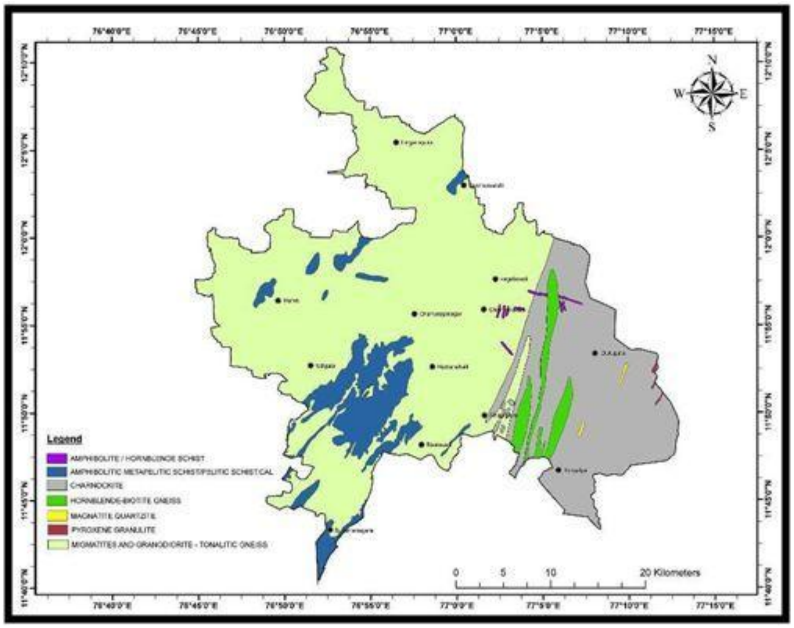

Figure 1a: Different lithology of the study area

The geological contacts between hydraulically different lithologies, they have virtually no primary porosity and they have secondary structures developed from the tectonic events. These include porosity, lithological boundaries, faults, fracturing and weathering, which permits the flow and storage of groundwater. In the study area main groundwater aquifers namely; Quaternary, and fractured basement. It's recharged directly from the rainfall and indirect from the basement rocks through fracture systems.

Figure 2: Field photographs showing quartz, hornblende biotite, and plagioclase near aralikatte

Figure 3: Field photographs showing anticline and syncline folded near chikkahole

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Figure 4: Field photographs showing folded weathered gneiss near kaggalipur

Figure 5: Field photographs showing granitic gneiss near hegguthara

Quaternary aquifer is followed and recorded and hand dug wells in especially in the Department of mines and geology, in Chamarajanagar District.

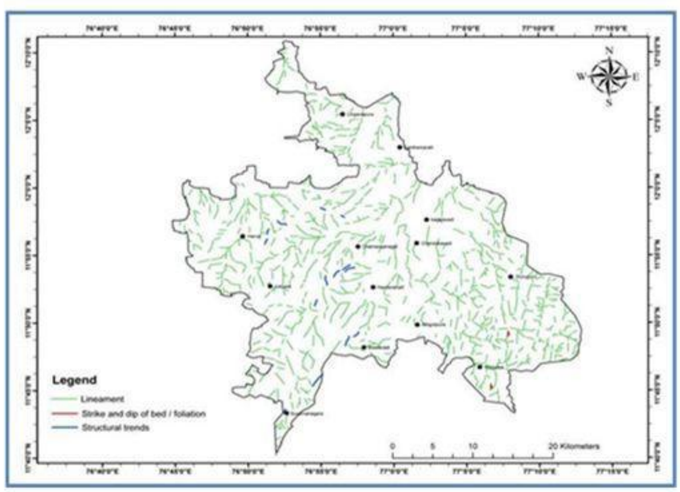

Figure 6: Showing the lineament/fault of the study area

Structures evidence

The study of structures and their role in flow control and their understanding the fundamental geological features of an area. The nature of the stratigraphic units and the composition of the lithological units, both of these acts as structural controls to flow. Structures in the study area show strong influence on the topography and on the surface **drainage patterns**. The morphology of structural or **residual hills** are controlled by large-scale rock structures and lithology. Since the rocks in this unit are hard and compact, they act as run-off zones; limited infiltration can take place along the weak planes like joints faults, fractures, folds, *dykes and veins* (Singhal and Gupta, 1999). Divided the residual hills into upper to lower as inselberg, pediment, buried pediment, valley fill, and pediment inselberg complex respectively. Discontinuity is a collective term used to include joints, fractures, folds, veins, mineral cleavage, foliation, shear zones, faults and other contacts etc.

However, structurally the area displays shears, joints, faults, lineaments which appear to be moderate in the intensity of development .They are small to moderate in extent with variable dipping. They too have played some role in ground water percolation. As joints, fractures, and shears are smaller and localized, they could not be quantified through remote sensing data (Figure 6 and figure 7). Most of the drainage network in the study area is controlled by these lineaments.

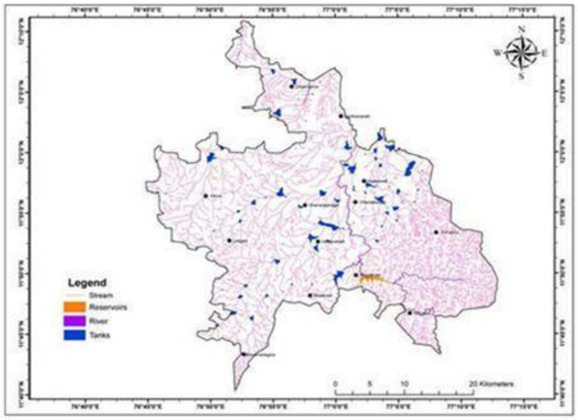

Figure 7: Showing Drainage of the area

Figure 8: Field photographs showing Residual and hill near Halepura

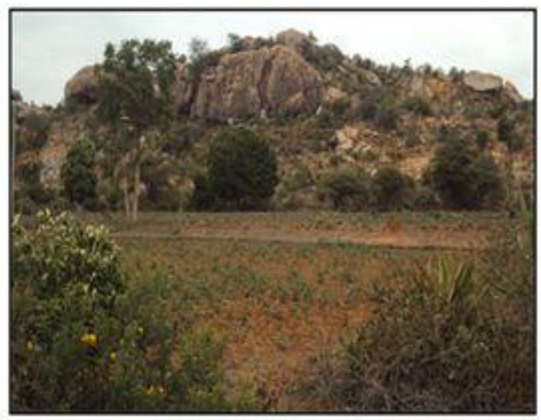

Figure 9: Field photographs showing Residual hill with pediplain near kaggalipura

In this discussion using a genetic approach, the discontinuities into the following categories:
1- Foliation.
2- Fractures (joints).
3- Faults and shear zones.
4- Other geological discontinuities.

Structures can be defined for purposes of this study as two dimensional features that affect flow rates by reducing hydraulic conductivity across them or increasing it several folds, acting as barriers or conduits to flow. The main hydro-geological significance of structures in the study area that were considered can be classed as follows:
(a) Contacts (geological).
(b) Primary structures (bedding).
© Secondary structures (tectonic, fractures and folds).

Secondary structures are those resulting from the events producing the major folds, shear zones, fractures, the large faults and lineaments. These features are observed throughout the study area and thus have the greatest effect on flow. The different responses to deformation and the intensity of this deformation caused differing levels of fracturing of the brittle rock. The type and intensity of fractures then imparted secondary permeability in the form of joints along beds and transverse to folds (Nakhwa, 2005).

Joints occur as well-defined sets along the bedding planes at right angles to the bedding (longitudinal), cross-joints are normal to these, and oblique-joints cut at acute angles to the cross joints (Figure 10). The longitudinal and cross-joints are formed by extension fractures, but near fold hinges longitudinal joints may form conjugate shear fractures (Roberts, 1982). High intensities of joints lead to increased permeability and connectivity, whilst bedding planes allow for preferential flow.

Figure 10: Field photographs showing major joints near malur

From field evidence it appears that the bedding joints are the dominant master joints in the folded (Figure 2-5 and 10). The different structures influenced, and control on flow, by acting as low permeability zones (barriers) or high permeability zones (conduits).

Faults Analysis

Faults act as conduit. It may make rocks good aquifers. On the other hand faults act as drains, lowering water table and thus affecting the distribution of groundwater (Mulwa *et al.*, 2005). In the study area, central part of the area is lowest water table as well as northern part of the area is high water table. Further, faults act as barriers to the flow of groundwater if filled with impermeable material such as silts and clays. These factors have a strong influence on the aquifer yields through boreholes, static water levels, flow, and hence distribution of groundwater. Therefore the amount of water available in a faulted region would be influenced. Generally a comprehensive understanding of the influence of structures on groundwater is necessary for the boreholes in this area and in other areas of similar geological setting. In the study area a number of different types of faults/lineaments were identified in the field. One of these minor faults showing exposed at southwestern part, the long and wide of fault approximately thousands to tens meters respectively. This is high permeability in the shear zone. There would be both vertical and horizontal components of flow in this shear zone, and there are indications of possible conduit flow in this site. There are dentritic and sub dentritic drainage pattern in the study area (Figure 7). The southeastern part is covered in sub dentritic and remaining parts are dentric drainage pattern.

Fractures and Joints Analysis

The relationship between the occurrence of ground water and fracture traces for aquifers, particularly in lineaments underlain by zones of localized weathering, increased permeability, and porosity. The fracture morphology can be important factor of fracture porosity and permeability is the morphology of the fracture planes. This morphology consists of three basic types of natural fracture plane morphology as follows:-

1- Open fractures.
2- Mineral-filling fractures.
3- Deformed fractures (Slickenside fractures).

The structures within the study area are the extensively developed joint systems. These have been recognized for their importance in groundwater flow. Probably of greatest importance is the role of the joints, making up the predominant bedding planes and sets of interconnected joints. These have been shown to be distributing the study area, and their cumulative effect on flow is considerable.

Fractures in rocks may affect groundwater recharge, (Figure 11-12) movement and particular importance as barriers or conduits for flow of groundwater. In this regard, both surface and subsurface fractures at the location can be characterized in two classes: open or closed.

Open fractures can be simple apertures or permeable zones, some of which contain open cavities (Figure 11). Closed fractures can consist of simple fractures with hairline apertures or wider apertures sealed by secondary mineralization. In the study area the core and log analysis of the dug well has been used successfully to delineate fracture occurrence and distribution in the wellbore.

Figure 11: Field photographs showing groundwater recharge pit near muttige

Figure 12: Field photographs showing groundwater recharge with open fracture near badaneguppe

Folds Analysis

Fold structures are important in their flow control on a large scale, which are restricting flow, where the folds become an impermeable boundary on all sides of the asymmetrical including anticline and syncline pairs except the weathered folds, as well as, the flow along the strike of the folds is also very significant Figure 3. In the study area Folds obvious in the southeastern parts of the study area. These granitic rocks strike N10^{0}E-S10^{0}W to N30^{0}E to S30^{0}W with varying easterly dips of 60^0 to 80^0.

Hydrogeology

Groundwater is the main source of water supplies in the study area. The occurrences, distributions, and quality of groundwater aquifers controlling by different factors such as structures, geomorphology, climate changes, type of rocks and minerals. Groundwater occurs under semi-confined to confined conditions in fractured crystalline gneisses and charnockites in the study area.

The aquifer recharged directly from rainfall and through structures systems. Most wells in quaternary aquifer presence in the study area are shallow wells with limited production reaching below 165 g/h. The thickness of weathered zone generally from to 5.00 m to 35.0m.groundwater occurs under phreatic (unconfined/water table) condition in weathered zone and alluvium.The depth to water levels ranges from 0.38 mbgl to 17.21 mbgl during pre-monsoon period (May- 2011) and from 0.20 mbgl to 17.30m bgl during the post-monsoon period(November 2011). But, generally the depth to water level ranges between 2 m bgl and 10.0m bgl and shallow water levels of less than 2m bgl are observed in canal irrigation area of neighbouring taluk (Yalandur and Kollegal taluks.) of the study area, totally dependent on this source and the proximity of the aquifers means continued exploitation as demand increases.

Fractured Basement Aquifer

Fractured basement rocks belonging to precambrian time are outcropped in the area .and composed of igneous and metamorphic rocks that are mentioned before. It’s characterized by high density of fractures beside the permeability of aquifer is of secondary type that is formed due to the effect of regional and local structural events. Rainfall is the main source of aquifer recharge and other fracture systems, where the quantities of rainfall affect the rate of recharge of groundwater. In the study area numbers of wells were dry due to the lack of recharge (precipitation) and the presence of structures that act as barrier preventing the ground water movement. In hard rock areas, weathered and fractured zones form aquifers. Even in a small area, the nature and extent of weathering vary a lot and depend mostly on the present of fractures at depth and favorable morphological features at the surface. In fresh rocks, joints and fissures tend to close at a depth of about 60-70meters and there will be practically no circulation of groundwater below this level. Pockets of weathered and fractured rocks may form isolated groundwater reservoirs (Verma *et al.,* 1980). Fracturing and folding result in a high degree of in homogeneity in the hydro geological characteristics of different aquifers. This inhomogeneous character causes aquifer yields and groundwater flow direction to vary over a whole area (Mulwa *et al*., 2005). The secondary weathered and fractures aquifer extends across the whole study area. The basement aquitard is the clay formation forms the aquitard between the lower aquifer (weathering and fractures) and upper aquifer (quaternary).

Groundwater Occurrence and Flow

Hydrogeology of igneous and metamorphic rocks has become very important because hard rock terrain covers good part of southeastern and southwestern. With the growing demand of water, groundwater exploitation in this terrain has become inevitable. More boreholes over these rocks

being vats (dry) in semi arid areas, their importance has become significant for development. Structures in the study area show strong influence on the topography and on surface drainage patterns. There is an established north and south trend to these features as there are for the faults. There is evidence that the same applies to groundwater flow at the local level and is probably also the case for deep flow.

RESULTS AND DISCUSSION

Results show that high yielding wells and to major lineament and corresponding structural features. Fractures in hydraulic connection with hard rock aquifers, weathered bedrock constitute best aquifers and the relation between tectonic settings of the area with groundwater potentiality. To understand the geological and structural influence on groundwater due to combination of lithology, and tectonics is under-scored by the dynamics. A good understanding of its various components and their interrelationships were achieved by the integration in this study of geology, structure, topography, and hydrology, geology. The study identified the different types of structures, namely geological contacts, fold systems, faults and joints. It provided detailed descriptions of these features from field investigation, and went further to evaluate the effects and controls they have on groundwater flow in the study area.

Conclusion

In generally, Remote sensing data, GIS, and geophysical data as well as detailed field work have been integrated to understand hydraulic characteristics of hard rock aquifers at any hard rock area in order to conserve and manage such fractured aquifers. It was found that there is a strong relationship between the fractures in the hard rocks and the surface drainage system and consequently its effect on the dynamic behavior of such hard rock aquifers in the studied region. Structural analysis has been carried out to analyze the main rock discontinuities which are representing in foliation, fractures (joints), faults and lineaments.

Structural feature were measured in the field and orientations compared with lineaments derived from both remote sensing data.

Aquifers on fault zones have the highest water yield; and are very deep as depicted by the depths of boreholes tapping water from such aquifers. The depths of these boreholes signify that faults have drained groundwater to deeper levels. Generally, hard rock and dense compact rock units underlying aquifers often act as controls to the downward migration of groundwater. In the study area contributed to migration of groundwater to deeper levels, especially along the joints and faults. The faults in the area are excellent aquifers and excellent conduits to the flow of ground water. The recharge zone is due to an immediate by joints and faults or rainwater infiltrating into the subsurface. Aquifers with high water yield are located on the up thrown side on the faults system. The discharge region is located on the downthrown block of the main faults. The excessively high yield from aquifers tapped through boreholes is due to the influence of the numerous faults in this region. The structures as faults and folds act as barriers or semi barriers to the groundwater flow, while joints trending facilitate the groundwater flow.

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