Volume : 3 | Issue : 3 | March 2014 • ISSN No 2277 - 8160

Research Paper | Earth Science

Qualitatative and Quantitative Aspects For Exploration And Exploitation of Limestone Resources of Malkhed Area, Gulbarga District, Karnataka

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ABSTRACT

Malkhed limestone resources in Bhima basin northern part of Karnataka, especially in Gulbarga district which encompasses a major part of the Bhima basin. Drilling exploration in the area has provided 10.870 million tonnes of cement grade (Murthy and Raina, 2000). Kagina river a tributary to Bhima flows through the study area and joins Bhima river near Honnakunta.

Massive limestone is seen as hard and compact fine grained grey and thickly bedded, contrasting colour is amenable for differentiation in to purple green, dark grey, buff and light grey limestone and the contacts are gradational. Based on the physical and chemical characteristics the limestone resources have been evaluated and categorized in to different grade up to a depth of 130m. Further the need for optimum utilization and sustainable development of the resources is emphasized.

KEYWORDS: Malkhed limestone resources, Bhima basin, categorization, sustainable development

Introduction

Bhima basin is one of the youngest basins among the Proterozoic formation of India. The sedimentary formations of the basin are well exposed on the northern margin of Dharwar Craton of peninsular India. It has the spatial extent of about 5200Sq Km spread mainly in the northern part of Karnataka (Gulbarga and Bijapura district) and to some extent in the western part of Andrapradesh.

Bhima basin represents and simple predominantly horizontal sedimentary sequence of grey to pink coloured, coarse grained granitic rock exposures (basement gneiss) are commonly seen around Doranahalli and Gogi in the Southern contact of the Bhima basin such contact zones between Bhima formation and basement gneiss are also well exposed to the east of Rabanapalli. The thicknesses of conglomerate and sandstone reserve are less predominant and occur as rims in the basin. The pebbly Orthoconglomerate near Muddebihall and sandstone near Rabanapalli are well known. The exposures are mostly weathered. Shale is the most dominant lithology in the basin. It is broadly either Calcareous or Ferruginous in nature, ferruginous shale is reddish purple and Calcareous shale is yellowish to greenish in colour. Limestone formation succeeds the clastic deposition and thick piles of deposits have produced. Three major varieties like variegated, massive and flaggy limestone are predominant in the basin.

The classification of Bhima basin is attempted by several investigators (Foot, 1876; King, 1872; Mahadevan, 1947; Janardhan Rao et al, 1975; Mathur, 1977; Misra, et al, 1987; Kale, 1991 and Jayaprakash, 1999). Extensive deposits of good quality limestone deposits are found around Malkhed and their relationship to other lithological units has been inferred from outcrops and quarry excavation. In the study area representative samples different lithological units with mineralogical and structural, textural variations have been collected. Besides flaggy and siliceous limestone, however, not all the litho sequences of Bhima basin are exposed in the study area. Based on the geological mapping (Map.1) and surveying and exploratory drilling data to fulfill the objectives of systematic evaluation of the limestone resources.

Geological setting

The study area forms the central part of the Bhima basin and has witnessed the thickest deposition of the sediments. It is largely a plane tract with gentle undulations and is characterized by the general horizontality of beds. Soil cover is widespread. Exposures of rocks are observed in road, well and nala cuttings. However, not all the litho units of Bhima basin are exposed in the study area. Based on the geological mapping and surveying and exploratory drilling data. The following generalized sequence is derived for Malkhed area. The study area constitutes a part of Bhima basin, a Proterozoic epicratonic shallow marine basin in the Southern peninsular India. Conglomerate, sandstone, shale representing clastic facies and limestone. The chemical facies with a total thickness of about 300m constitute the Bhima basin. However, in the study area limestone is dominant lithology followed by shale and with thin cover of basalt at some places.

Deccan basalts
Shale
----------Unconformity----------
Limestone
Shale
----------Unconformity----------
Basement rock

Physiography

The study area is plain to plateau in nature. Most of the area is covered by black cotton soil, outcrops of limestone and associated rocks are occasionally seen along the road and well cuttings, stream courses etc, around Malkhed out crops are weathered to sub weathered. Most of the out crop beds are horizontal and only occasionally show dipping thickness of the limestone beds can be measured at quarry cuttings. Among the different litho units, limestone exposures predominate. They are fresh to sub weathered and exposed as thin slabby to thick bouldery stones. In the weathered portions the bedding plane consists are filled by secondary clayey minerals. Out crops of shale are gradational. Basaltic cover in the western and northeastern parts is thin with 0-2m thickness. Out crops of basalt are dark and they normally showing spheroidal weathering effects.

Location and accessibility

The study area longitude 77° 10′ to 77°15′ and latitude 17° 10′ to 17° 15′ is covered in survey of India toposheet no 56G/4. It is well connected by road and rail. State highway connecting Gulbarga and Sedam passes through Malkhed. It is also connected by broad gauge railway line to Mumbai, Hyderabad, Chennai, Bangalore and Tirupathi, Wadi, which is 45Km from Malkhed is the nearest railway junction. Besides, the area is well connected with other places in the basin by good all weather roads and the entire study area is well accessed for any type of field investigation.

Rock types: the deposition of shale beds has taken place mainly in two episodes, i.e. pre and post dated to limestone formation. While the lower sequences of shale have been inferred from drilling, the outcrops of later sequence are exposed. Out of the estimated 300m of the total thickness of the basin at the deepest portion (Malkhed) of the Bhima basin, Shale alone measures a combined thickness of about 145m. The thickness in other areas varies considerably. It is shaly, calcareous and flaggy in nature and varies remarkably in colour and thickness of the beds. It is silty to shaly in grain size and exhibit perfect facility. The two prominent varieties of shale observed are. 1. Ferruginous shale, 2. Calcareous shale.

They are found in two horizons viz. below and above the limestone

beds. The calcareous variety which is in the close proximity with limestone beds in both the horizons shows gradation. Thin elongated lensoid bodies of iron oxides are occasionally observed, and they are parallel to the bedding planes.

Ferruginous shale

Ferruginous shale is purple, brown to brownish in colour, with well developed bedding planes. Structures like minor wrinkle marks and small scale ripples are observed occasionally. It is generally horizontal with minor gradient of 2°. Minor folding, mostly due to intra formational disturbances are sometimes noticed. Minor faults are also not uncommon. Owing to different shades of colours (caused by weathering) the contacts between ferruginous and calcareous shales is invariably obscured.

Calcareous shale

Calcareous shale is greenish grey, buff and dull green in colour. It occurs as finely fissile layers**,** wavy undulations are occasionally seen. The thickness of individual beds ranges from few millimeters to 4 centimeters. Recrystallized grains of hematite, chlorite and magnetite provide incipient growth and spotted look at some places. Though its contact with limestone is also gradational, it is more revealing owing to the difference in colour and texture of the two rocks.

Limestones

Limestone has the most predominant and extensive exposures around Malkhed. Quarrying has revealed striking occurrence of these rocks as thick horizontal beds. Drilling exploration has shown the thickness to be of around 130m in its thickest accumulation. It shows perfect horizontal bedding planes. In few places, however, significant dipping at 45°N is noted. From quarry sections and borehole data, varying nature of limestone can be inferred and its sequences are as shown below:

Upper flaggy limestone
Grey massive limestone
Lower flaggy limestone
Variegated limestone
Variegated limestone

The variegated siliceous limestone is only seen in quarry sections. It is noticed at a level of about 55m from the surface and extends for a good thickness and finds contact with the lower series of shale. It is light grey to creamy and bluish in colour and exhibits thin bands of intercalated chert. The chert layers of silica and limestone are conspicuous. Thin streaks and flakes of secondary minerals like chlorite, iron oxides and fine to coarse crystals of pyrite are frequently noticed. These minerals are generally aligned to the bedding planes. This limestone shows upward merging with lower flaggy limestone. This variety is very well exposed in the quarries of Rajashree cement.

Lower flaggy limestone

About 6 to 8 m thick sequence of flaggy limestone succeeds the variegated siliceous variety. The individual beds are 0.5 to 2 inches in thickness and occur as continuous bands. It exhibits light grey, creamy and greenish colours. Thin laminations of coloured (yellow and cherry red) shale are occasionally seen along the bedding planes. Thin stringers of elongated streaks of chlorite are also not uncommon. It is mostly fine grained, hard but breaks easily along the bedding planes.

Grey massive limestone

Massive limestone is seen as hard and compact fine grained grey coloured beds with an individual bed thickness of 0.25m to 0.5m. The thickness of this massive variety is about 35m. It breaks as thick blocks along the bedding planes and jointed fractures. This is particularly the case at the upper surface of this horizon (4-6m from the surface). For this reason, it is sometimes described as blocky limestone. It is occasionally traversed by thin veins of calcite and quartz. Vertical joints are frequently seen in this variety. It is dominantly grey to dark grey in colour and breaks with sharp edges.

Upper flaggy limestone

The massive limestone is overlained by thin beds of (upper) flaggy limestone, which have 2 to 8m thickness with individual bed thickness of about 2 millimeters to 5 centimeters. It is grey to dull black in colour. The weathering effect wherever exposed is conspicuous in the form of dark pitted appearance. Thin layers of dull purplish coloured clays are occasionally noted at some places. When broken, it splits into thin slabs. Good exposures of this variety are seen around Tengli, malkhed and Chittapur. It exhibits perfect facility.

Stylolites

Stylolitic structures are frequently seen in surface exposures. In deeply weathered zones the joints have yielded for fine clay mineral formation. Good exposures of this variety are seen in the Rajashree cement limestone mines near Malkhed. Coarse cubic crystal of pyrites is frequently seen. Mineralogically it chiefly consists of calcite, with minor amounts of quartz and argillaceous material. It is fine grained. However, coarse recrystallized and clastic grains of calcite, quartz and feldspars are frequently seen. Recrystallization of calcite is very conspicuous and it provides a type of porphyritic texture, because of the growth of larger of phenocryst like calcite in the fine grained mass of carbonates. Many recrystallized calcite grains exhibit perfect rhombohedral growth. But lack in cleavages. Conspicuous development of coarse pyrite crystals are noticed in some zones of massive limestone. These varieties also reveal the presence of thin laminated shaly layers. But they lack in continuity. The presence of iron oxide which occurs as subhedral to irregular coarse patches is characteristic.

Petrography

Formation of thick piles of horizontal limestone deposits in the Bhima basin is a significant event from the point view of their inorganic precipitation in the marine conditions. Besides, the all limestone varieties show very fine grained nature, which confirms the non-detrital mode of their formation. The obvious choice is the inorganic precipitation of these sediments. As these deposits settled in an epicratonic condition (Kale and Peshwa, 1995; Jayaprakash, 1999), the sedimentary source was chiefly the surrounding gneissic rocks. The low Mg nature of limestone also supports the dominantly acidic nature of source rocks. Since the inorganic precipitation of any substance normally requires its saturation in the medium in which it is present, the time span involved in the $CaCO_3$ concentration of the marine waters must have been long. However, localized changes in the concentration of carbonate solutions and varied physical-chemical conditions must have precipitated minor amounts of carbonate, as revealed by the fine grained calcite aggregates in the lower series of shale. The transition from the calcareous shale to the overlaying variegated limestone is evident from this. Impure varieties (Variegated) which are more conspicuous in pheripheral zones elsewhere in the basin suggests that they are formed as landward carbonate mud flats by wave influenced water column (Kale and Peshwa, 1995). Considerable amount of impurities in these varieties indicate the presence of much non-carbonate detritals such as clay, silt or sand (Pettijohn, 1984). But the continued supply of carbonate solutions and the fine detrital mass has produce variegated variety of limestone in the central parts of the basin also. The presence of quartz, feldspathic clasts and clay particles in flaggy and variegated varieties, though in varying proportions, indicated their periodic supply to the basin. However, the variegated variety below the flaggy variety in the lower series shows considerable silica. It's very fine grained and close inter granular locking indicates its chemical origin. Considerable amount of silica in the form of fine nodular aggregates and alternate layers of chert which sometimes exhibits recrystallization in variegated limestone is indicative of its primarily precipitation with the carbonates. The geological setting and field characteristics in the Bhima basin, so far, have not revealed any signature of submarine volcanic activity. Obviously, either the seawater became saturated in silica in certain period of time to form cherty bands or some locally prevailing favorable conditions precipitated the chert. The epicratonic nature of the basin, which could be possibly different than an open marine condition, could also have contributed for the precipitation of silica. The absence of chert bands in the upper sequences (grey massive and flaggy), also suggests limited episodic event of chert deposition.

The successive thick beds of massive varieties of limestone were mostly developed as a result of the seaward side movement of the carbonate material with the immense influx from the source. This is probably the thickness of the massive limestone is predominant at the central part of the Bhima basin.

The upper series of flaggy limestone represents the waning stages of carbonate formation in the basin.

Summary and conclusion

Limestone formations and associated sedimentary rocks in and around

Malkhed covering about 350Sq km area have been investigated in the present study to understand their compaction, mode of formation, source of sediments and their low grade limestone. Limestone is low value mineral. It is pertinent to select a quality control method which does not contribute to any appreciable increase in the cost of the product. Presence of clay in deeply weathered zones the joints have yielded for fine clay mineral formation. Shaly parting and structural problems make quality control difficult. Keeping in view of the above problem, limestone deposit has been estimated qualitatively. It is also amenable for physical differentiation by colour variation which can be used for adopting selective mining. It also aids in conservation of limestone by proper blending of various grades. In the investigation area, the different grades of limestone are visually identified. It is observed that their contacts are gradational. It is overlying the lower calcareous shale series. It occurs at a depth of 55m from the surface and continues up to 130m depth. It is fine grained and light grey to bluish grey creamy in colour. Due to frequent intercalations of chert bands 1mm to 2cm thick and segregations of chert, besides detrital grains of quart it is siliceous in nature. This variety is inferior in grade for manufacturing cement, due to mainly high silica 14-40%. Thus several cement industries in this region have concentrated only on high grade limestone and neglected the variegated variety which is in huge abundance ~30.000 million tonnes in 350sq km. Flaggy limestone occurs below and above the massive variety, without much difference in the two setting it attains the thickness of 6 -8m in both the horizons. It is grey, dark, blackish, bluish and creamy in colour. The beds show perfect feasibility and can be easily separable into thin slabs along the bedding planes. The grey massive limestone variety is hard, compact fine grained and dark grey to grey in colour. It attains a thickness of about 35m and breaks as thick blocks along the joints. In areas of deep weathering, it reveals embedded clayey material. Stylolitic structures in the form of small rounded and interconnected pits are commonly noticed on the surface exposures. Veins of quartz and calcite have penetrated the irregular fracture at some places. This variety is the most sought after material for cement manufacturing in this region.

The limestone formation in the study area have been deposited in one prolong episode of carbonate precipitation in the shallow water conditions of Bhima basin, the provenance being the surrounding gneissic rocks. An inorganic precipitation for the carbonates is advocated in the present study, owing to no other convincing signature, especially of biogenic to claim the responsibility of precipitating carbonates in the marine environment. The thick accumulation of carbonate sediments in the central part (study area) mostly suggests that, they were deposited during a strong seaward movement of carbonate rich material in solution, accompanied by minor detritals and detrital wash. Minor changes in the physical-chemical conditions of marine environment and variation in sediment influx have produced slightly texturally, mineralogically, chemically varying beds of limestone.

Conclusion

Limestones are thick, massive, compact, fine grained and non-crystalline throughout the area. The colour of limestone varies from purple, brown to brownish dull green, greenish grey dark grey, buff, light grey, bluish grey, blackish and creamy with a variety of intermediate shades. All the litho-units have gradational contacts with subtle facies variation both along and across the bedding plane. The contrasting colour variation is amenable for differentiation in to several mappeable litho-units with the aid of regionally well established.

The limestone is conformable with the underlying shale and the contact between limestone and shale is gradational. The basal limestone (dull purplish limestone) is marked by argillaceous partings. However, the argillaceous parting in the limestones decrease towards the top eventually resulting in to the transition from the calcareous shale to the overlaying variegated limestone is evident from these impure varieties (Variegated) which are more conspicuous in peripheral zones elsewhere in the basin.

The grade-wise classification and estimation of reserve will be of significance in selective mining. Further the optimum utilization of the limestone and conservation of the mineral is stressed for sustainable development. The methodology adopted collection and interpretation of the data is valuable in evolving model for other areas.

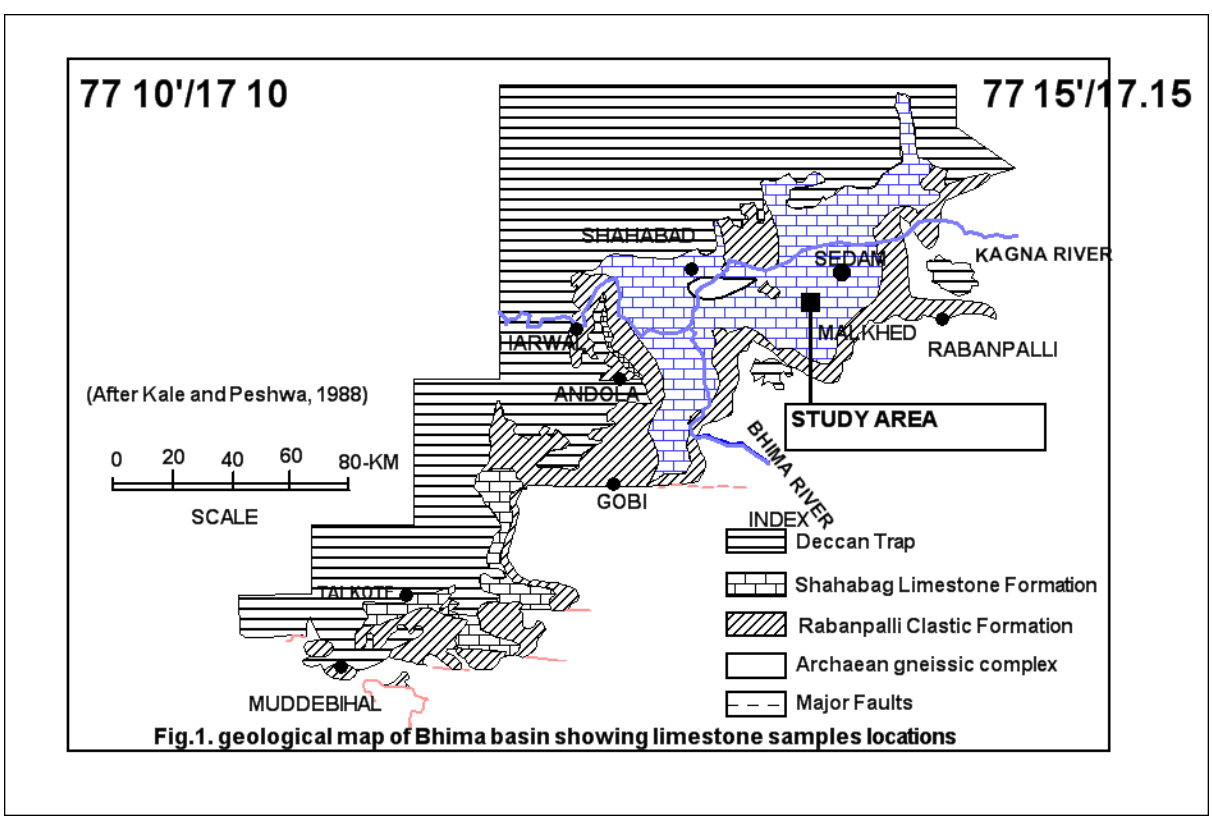

Fig.1. geological map of Bhima basin showing limestone samples locations

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