

Petrography and Provenance Study of South-Central Part of Kaladgi Basin, Belgaum, Karnataka, India

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Abstract: The area under investigation covers the south-central part of Kaladgi series comprising of sedimentary rocks, mainly quartzarenites. From the geological point of view the study area comprises southcentral part of Kaladgi basin covering around 54 km² which encompasses rocky hills of moderate height, showing three types of facies i.e., argillaceous, arenaceous and rudaceous. Among these three, arenaceous facies is more prominent in the area. These sedimentary rocks rest unconformably over gneisses. Detailed study of the rocks exposed are done by studying the petrological aspects of the rock samples which were subjected to microscopic studies, bifurcating different minerals and counting each parameter of the minerals which is plotted in the QFR ternary diagram and further illustrating the tectonic provenance of the area. Present work mainly focuses on the studies related to petrological, diagenesis and provenance of the study area where the rocks exposed in the vicinity are quartz arenites indicating that these sediments were deposited in a riverine condition.

Keywords: Feldspar, Intra basin conglomerate, petrofacies, quartzarenites, rock fragments.

Introduction

The rocks exposed are sedimentary in origin, many field characters have been observed. Most important observation is the distinct unconformable relation between sedimentary and Archaean gneisses which are separated by conglomeratic horizon. However, such exposure is not available everywhere due to soil cover, vegetation and many other features. As observed in the field there are different colored arenites among which purple/black arenites are more prominent. The rocks exposed are characteristically bedded and thickness of the beds varies from 2cm to 5cm (thinly bedded) to 30cm-60cm (moderately thick bedded) up to a meter or more (thickest bed). The thickness of these beds is not prominent and taper into lensoidal type and the arenites are exposed at higher altitude. The overall trend of these beds is E-W while in some parts direction, is NE-SW and N-S in the eastern part of the study area. Intra basin conglomerate are observed in few areas. Total exposed thickness ranges about 150 meters. At certain places these arenites display current bedding (Fig. 1) ripple marks (Fig 1.2 B) and graded bedding (Fig 1.1 A and C) indicating right side up. Ripple marks are very well developed in the study area mainly east of Sirsangi temple indicating the tidal surface. It is also observed that, the crest and trough of these ripple marks are perpendicular to the bedding plane indicating multi directional tide/wave movement. Combination of intra basin conglomerate and graded bedding indicates the deep-water tidal facies. The strike, dip direction and dip angle differ from place to place. However, two prominent strikes have been noted, namely East-West and N50°E – S50°W, likewise the dip angle varies from almost horizontal (5°) to vertical dipping beds (70°).

Materials and Methods

The emphasis of the current study is to carry out petrographic analysis of the rocks exposed and analysis of facies, point counting method for determination of the rock types and to analysis the provenance and tectonic setting of the area.

The study area was selected on the basis of the study of the geomorphological charters of the rocks present. Later the study of different types of rocks encountered were classified depending on their characters in the field. The rocks showing distinguishing characters were subjected to laboratory analysis.

Results and Discussion

Petrographical Characters

The classification and nomenclature of sandstones has been done following Dott (1964), Folk (1980) and Pettijohn et al. (1987). Detailed account of the petrography and petrofacies of the sandstones of the study area is discussed subsequently.

During the field investigation, many rock samples were collected on the basis of distinctive field characters like grain size and colour variation. On the basis of colour, following varieties of arenites were determined.

1. Blackish/purple arenites
2. Pink arenites
3. White/greenish arenites
4. Grey arenites
5. Red arenites

Out of these categories, rocks with greyish or pink colour are most common. In some of the areas, pink and purple coloured rocks were also noted. In few areas such as north-eastern part of the Mullur Gath compact bedding of arenites were observed, but at some places thickly beds occur. In southern part of the Mullur Ghat, coarse grained purple arenites were found showing quartz. Each grain is found up to 1cm in size (Fig 1C). Intra basin conglomerate are seen with quartz, jasper and other associated minerals. The succession by Pujar et al. (1989) has been adopted in the present study.

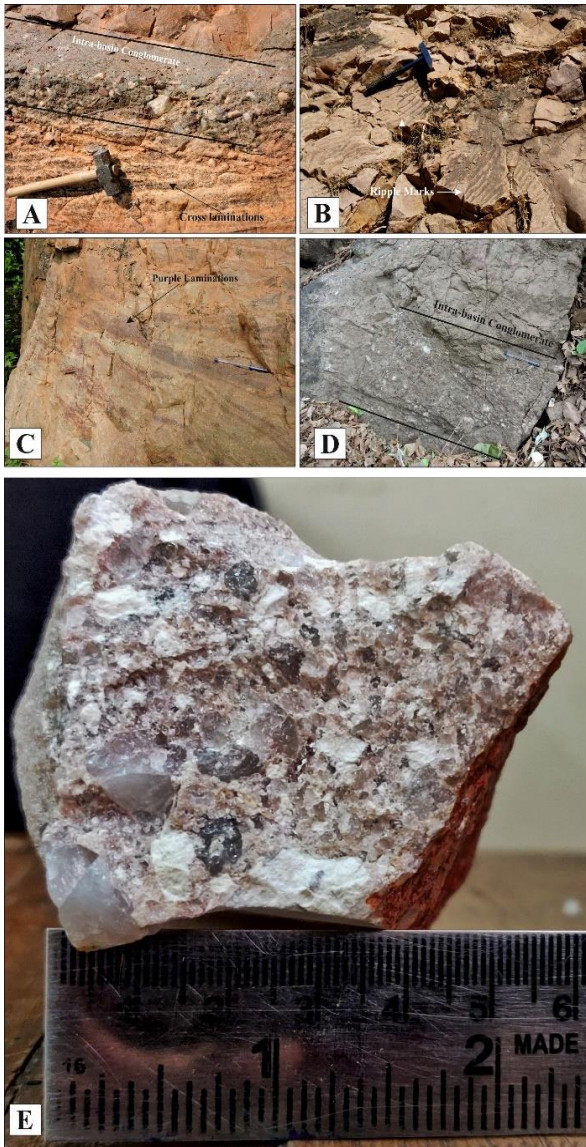


Fig. 1 Quartzarenites of Kaladgi basin indicating; A: Intra-basin Conglomerate along with cross-laminations.; B: Ripple marks.; C: Purple coloured laminations.; C: Intra-basin Conglomerate.; E: Coarse grained arenites, the grains are of mainly quartz measuring up to 1cm in size. The white powdered material is due to kaolinization of feldspars.

Classification of Arenites

In order to classify the arenites, on the basis of different mineral contents, 20 samples were subjected to point counting analysis (Table 1).

Table 1 Modal parameters used in the present analysis.

COUNTED PARAMETERS	
1.	Q = Qm + Qp Q = Total Quartz Minerals Qm = Total Quartz Monocrystalline Minerals Qp = Total Quartz Polycrystalline Minerals
2.	F = Feldspars
3.	RF = Rock Fragments
4.	H = Heavy Minerals

The average mineral composition (in percentage) is given,

Quartz (Qm+Qp) – 94.7%

Feldspars (F) – 2.05%

Rock Fragment (RF) – 2.60%

Heavy Minerals (H) – 0.35%

These values obtained are almost equivalent to the values obtained by Pujar et al. (1989) for quartzarenites exposed in and around Manoli. The analysis reveals that the rocks under investigations are mainly composed of quartz, very less amount of feldspars, rock fragments and heavy minerals. According the data plotted in the Ternary Diagrams of Pettijohn et al. (1973) for arenites and arkose, the samples fall under the category of Quartz arenites (Fig. 2). Pujar and Hegde (1989) covering Mudakavi-Lakhmapur-Manoli area. Rock fragments are noticed in all the samples (Fig. 1, 3 B and C). This is because whatever the fragments are observed, the assemblages of many small individual grains of quartz and other essential minerals bound upto form a bigger one. The rock fragment normally comprises of 2-3 different minerals (Pujar, 1989). Quartz is major mineral which has been classified into two subdivisions that is quartz monocrystalline (Qm) and quartz polycrystalline (Qp). The size of the quartz mineral differs from sample to sample ranging from fine grained to coarse grained. The presence of feldspars differs much as compared to rock fragments, but both quartz and feldspars vary from rock to rock. Hence in some samples, feldspars are expected more and in some sample few to less than 3%. This variation can be considered as quartz-fels-arenites or least subarkose (Pujar, 1989).

Mineralogy of Quartzarenites

While describing the classification of arenites, percentage of their mineral constituents have also been discussed. Framework of these rock samples has revealed the presence of quartz, feldspars and heavy minerals in the quartzarenites of the study area. Details of these minerals are explained as under.

Quartz

In the area under investigation, the rocks exposed are dominated by quartz minerals with the modal average percentage of 94.7% (Table 2). These quartzarenites vary in color and these colorations is due to the color of the grains of quartz in the rocks. Most of the quartz

grains are anhedral to subhedral in outline in some cases elongated quartz are also observed and few are equidimensional. Majority of the grains show uniform extension (Qm), but some exhibit typical undulatory or wavy extension (Qp).

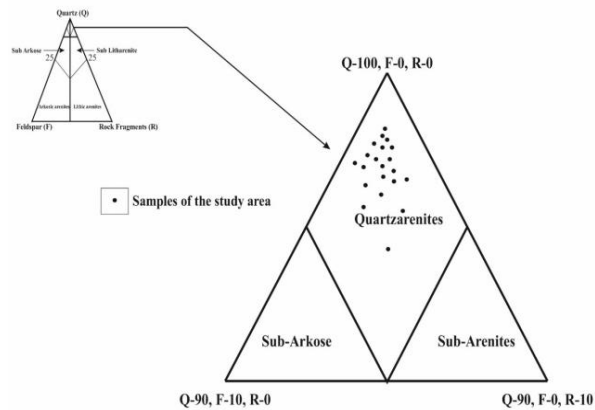


Fig. 2 B Ternary Plots (QFL) with enlarged Quartz arenites. Series of area covering at and around Sirsangi as a part of research area (Triangular Variation Diagram of Pettijohn et al. 1973).

The percentage of quartz monocrystalline is more as compared to quartz polycrystalline in the rocks exposed in the study area. Deformation bands and overgrowth of the quartz grains are also observed. Inclusion of accessory minerals like needles of tourmaline and apatite have been noted within the quartz mineral. Few grains of quartz appear to be individual grain in polarized light, are seen to be composed of several other individual smaller grains of quartz and other minerals. In the plain polarized light, the smaller quartz grains show no color but only the indistinct outline but other associated minerals show complete black color. Such black colored mineral are mostly heavy minerals associated with quartz minerals, which is called rock fragment (Fig 3 B and C). Some mineral grains under cross nicols, extinct in different positions, and do not get extinguished in one position of stage of the microscope. Such mineral contents are bifurcated as quartz polycrystalline (Fig. 3 A, B, and C). According to Blatt and Christine (1963), strictly speaking these are not called rock fragments

Feldspars

Feldspars are the second largest mineral association in the quartzarenites having very less content of about 2.05% (Table 2). From the study of hand specimen, these feldspars are recognized by white altered spots, formed due to kaolinization of the original mineral (Fig. 1 E). Under thin sections, these feldspars are very difficult to identify which are heavily altered to opaque kaolin. However, in some thin sections these feldspars can be easily identified (Fig. 3). It appears that some of the plagioclase feldspars are present but again due to high alteration the exact identification cannot be made. In the absence of unaltered clear grains of feldspars, development of overgrowth around them could not be studied in detail.

Table 2 Framework components of 20 samples of quartz arenites exposed in the study area.

Sl. No	Sample Name	Qm	Qp	Q	F	RF	H	Total
1	M53	89	6	95	3	2	0	100
2	M47	90	5	95	2	2	0	99
3	M80	88	5	93	2	5	0	100
4	M13	90	3	93	1	4	2	100
5	PM3	90	4	94	2	4	0	100
6	M36 (S1)	89	6	95	1	3	1	100
7	M20(S2)	87	6	93	2	5	0	100
8	M89 (K7)	89	5	94	3	2	0	99
9	M1	92	3	95	3	1	0	99
10	M92(KW1)	90	5	95	2	3	0	100
11	M17(KW2)	91	3	94	3	2	1	100
12	M25	89	6	95	3	1	0	99
13	M3	92	4	96	1	3	0	100
14	M1(a)	91	3	94	2	4	0	100
15	M2	90	5	95	2	2	1	100
16	M1(b)	92	4	96	1	3	0	100
17	M3(B)	89	7	96	1	2	1	100
18	M3(1) 4	91	4	95	2	2	0	99
19	M4	90	5	95	3	1	1	100
20	KW1	91	5	96	3	1	0	100
Average Value of 20 Samples		94.7%	2.05%	2.6%	0.35%			

Heavy Minerals

Heavy minerals together comprise least in the quartzarenites. Their percentage content is about 0.86% (Table 2). Heavy minerals comprise zircon, which is light grey to dark colored, usually found in overgrowth of some mineral boundaries but in the case of tourmaline and apatite, is found inside the quartz grain. Apatite shows high order polarization whereas tourmaline shows dichroism to bluish color. Negligible amount of hematite and magnetite are also observed which show an opaque and discrete grains of aggregates.

Provenance

Derivation of sediments in the sedimentary rocks constitutes one of the most important aspect. This involves the tracing up of the source rocks that had supplied the sediments. Detailed study of the grain shape, size and mineral assemblages and the agents of transportation can answer the provenance of the deposited sedimentary rocks.

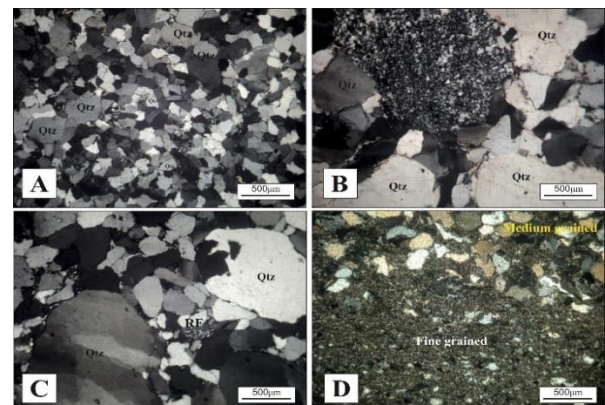


Fig. 3 Photomicrograph of quartzarenites of Kaladgi Basin indicating; A: Medium grained texture with assemblages of quartz (Qtz), and Feldspars (Fls); B and C: Coarse grained texture with rock fragment (RF); D: Grading of minerals from medium to fine grain texture.

Source rocks

This is with respect to the consideration of rock under investigation and their assemblage of minerals

Kaladgi basin can be considered as the parent rock which have undergone weathering, disintegration and decomposition in the geological past.

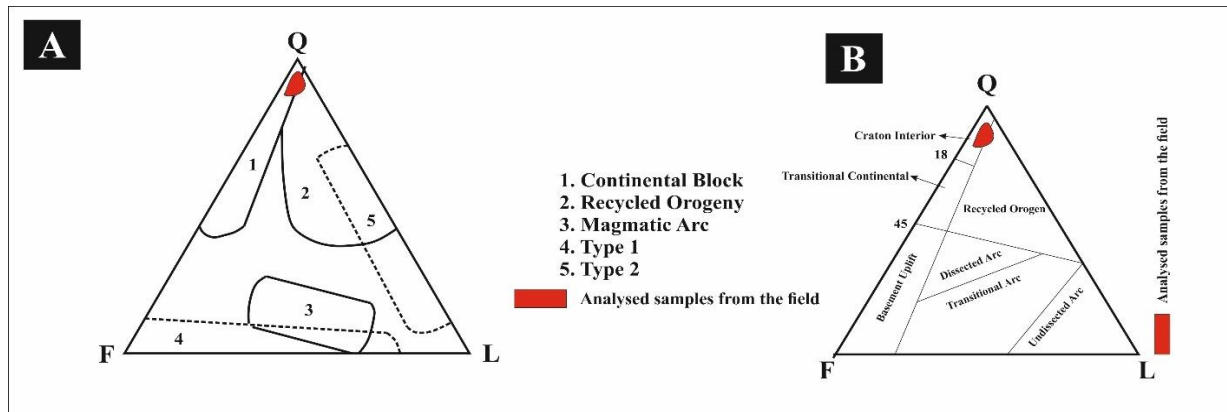


Fig. 4 QFL Ternary diagram illustrating the tectonic provenance of the study area; (A): QFL ternary diagram (Dorsey 1985) shows that these rocks of Kaladgi basin lie in Continental block and few in the recycled orogen.; (B): QFL ternary diagram (Provenance fields are from Dickinson, 1985) further bifurcation of the Continental block illustrates that the modes of Kaladgi quartzarenites are of Craton interior and few come under the recycled orogen.

encountered. The lithology of the area is monotonous, because most of the area is comprised of arenaceous and a smaller area is covered by argillites and rudaceous rocks. These rudaceous rocks are seen in the form of conglomerates. Arenaceous facies belong to quartzarenites to which it has been explained before in the section of classification of arenites. However, due to dominance of arenaceous rocks it can be inferred as acidic composition (Pujar 1989) Presence of quartz-fels-arenites suggest that the parent rock contains feldspars as one of the constituents. From the mineralogical point of view parent rock can be considered as acidic rocks like granites and granodiorites, which form the source rock. Due to erosion and mode of transportation, these sediments have been derived and deposited to form the Kaladgi basin. Although, the Kaladgi basin is in the sharp contact between the Archaean gneisses on the southern and eastern parts. Therefore, it can be inferred that the source rocks for Kaladgi basin are derived from the Archaean gneisses and granites together with the Dharwarian schistose rocks constitute the provenance.

The dominance of arenites can be defined by a pre-existing rock like quartzite or sandstone and on their weathering and deposition the rock formed is rich in quartz. In addition, the roundness of the quartz explains the long transportation. One of the prominent rocks in the Dharwarian schist is banded hematite quartzite (BHQ) and banded hematite jasper (BHJ). These rocks are the source for the conglomeratic horizon containing pebbles of jasper in the study area (Fig. 1 A and D). Purple color alteration in the quartzarenites may be due to sediments derived from the banded hematite quartzite or banded hematite jasper.

Thus, rocks like granites, gneisses, banded hematite quartzite, banded hematite jasper and different types of schists which are exposed or surrounding around the

Lithification, Diagenesis and Metamorphism

The sediments observed were subjected to lithification, diagenesis and compaction, which result in the formation of quartzarenites and conglomerates etc. Under petrographic studies, the overgrowth of quartz grains was observed that is due to the lithification, diagenesis and these rocks were also subjected to low level metamorphism as indicated by the mosaic texture in some of the samples. Yet another evidence of metamorphism as explained by Pujar et al. (1989) is that the purple colored patches which are seen in some quartzarenites have diffused borders. Gradual merging of these purple colors with the surrounding rocks is also seen. The diffusion of feldspar into white patches (Fig. 1 E) is known as kaolinization which is a part of metamorphic condition as well. For the feeble metamorphic condition, heat is necessary, as these rocks were subjected to burial at shallow depth and the dominance of ruptured structures have led to the alteration of these rocks (Pujar et al. 1989).

The quartzarenites, conglomerates and surrounding rocks are subjected to deformation which has resulted in the development of faults, fractures, shears and many ruptured structures. The slight elongation of quartz minerals and also the undulose extinction are the evidence of deformation. Fracturing and rupturing of the quartzarenites has given rise to breccia from these rocks.

Conclusion

Based on the data collected and analysis it can be inferred that the area under investigation has arenaceous, argillaceous and rudaceous facies. The arenaceous facies dominates over the other two. Intrusions of the quartz veins are observed, because these rocks rest unconformably over the Archaean

granitic gneisses. Among the arenaceous type, quartzarenites are seen and there also occurs breccia. But breccia is due to cataclasis of the original quartzarenites. The different colored alteration like purple bands are specifically due to presence of considerable amount of Fe, Al and K. Presence of conglomerates are observed in the area indicating deposition of the sediments under riverine condition. Presence of conglomerates suggests the fluctuating depth. Pebbles of quartz and jasper are associated and occur in between the beds showing the coarsening upward sequence and are classified as intra-basin-conglomerate.

Point counting analysis of the samples collected in the field area are plotted in QFL ternary diagram which showed that these rocks fall under *quartzarenites group*. The ternary diagram illustrating the tectonic provenance indicates that the area falls under the craton interior region. The petrofacies and other evidences of area indicate that these sediments were transported from the river flowing from south, involving traction and saltation. Quartzarenites were formed under the beach environment in the shallow depth indicated by presence of cross laminations. It is concluded that have undergone feeble degree of metamorphism which may be due to the change in the temperature with depth and as well as tectonic events.

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