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Petrographic classification and Provenance study of Bhander Sandstones of the Vindhyan Supergroup, in the N-W Part of Bhopal, Madhya Pradesh, India

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Abstract: **Detailed field, petrographic and modal study of the sedimentary sequence of Bhander Group of the Vindhyan Supergroup explains that these sedimentary rocks deposited under shallow marine condition are the quartz arenites dominantly composed of quartz, presence of overgrowth and irregular and circlular inclusions in the quartz grains indicate the probably source of these sediments as falsic igneous rocks. The Modal analysis (QFL) data plotted on ternary plots also suggest the probable source of these rocks as craton anterior / continental block provenance.**

Keywords- Bhander group, petrography, classification, provenance, source rock.

1. Introduction

In the North Western portion of Bhopal a vast stretch of Vindhyan sequence of Neoproterozoic age is well exposed. This rock sequence is dominantly arenaceous with sub ordinate argillaceous and rudaceous units. In the present study petrographic and modal analysis and volumetric mineral analysis of these rocks carried out to classify the sedimentary rocks (Okada, 1971; Folk, 1974). In order to establish the provenance and nature of source of these rocks QFL ternary plots have been plotted and analyzed (Dickinson et al.; 1983; Dickinson, 1988).

The main objective of the present study is to delineate the proper classification, provenance and source of these arenaceous rocks using petrographic data (Mackie, Wm. 1896; Russel and Taylor, 1937; Krumbein 1940; Powers, 1953).

2. Study Area:

The present study area of Bhopal lies on the Survey of India Toposheets no. 55 E/7 and 55E/8. It is bounded by 23˚15' to 23˚30' North latitude and 77˚15' to 77˚30' East longitude covering an area of approximately 522 sq. km. the area is the North – Western part of the Bhopal district. Which is bounded by Guna district on the north, Vidisha district on the northeast, Raisen district on the east, Sehore and Rajgarh districts on the southwest and west respectively? Bhopal city is the district as well as state headquarter and is well connected with all parts of country by rail and some air routes are also open.

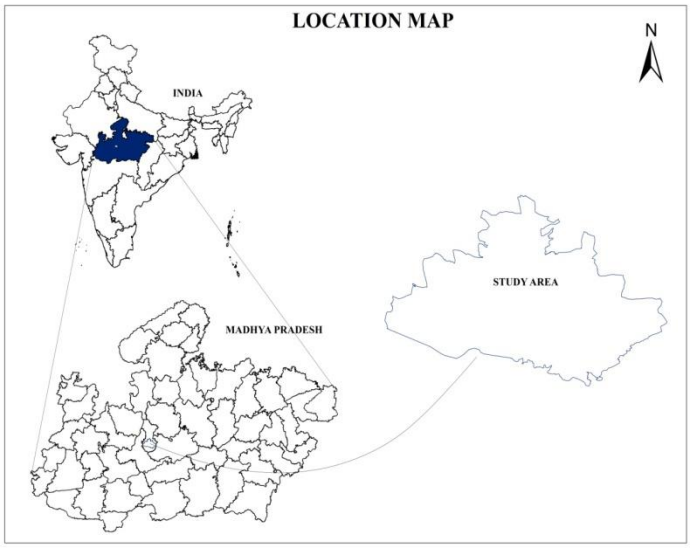

Fig. 1 Location map of the study area

3. Methodology:

Rock samples collected from different localites of the present area studied megascopically as well as the representative rocks were selected for thin section preparation and studied microscopically using polarizing microscope (Leica, DM 4500 PLED) and these thin sections thoroughly scanned for mineralographic and textural study. For the modal analysis the Swift point counter were used these studies carried out at the laboratories of Geological Survey of India, Bhopal. The results of the above analyses tabulated in tables and used to delineate the provenance of these rocks by plotting on various standard ternary plots.

4. Geology

The main rock formations exposed in the area are sandstones of arenaceous nature along with the basal conglomerates and intercalation of shales. Chronologically these lithounits are of Neo to Mesoproterozoic age and are the part of Upper Bhander Group of the Vindhyan Supergroup and surrounded or overlained by the basaltic lava flows of Deccan Trap activity. These rocks were studied by Oldham (1856) and subsequently studied by some pioneer workers of their times like Mallet (1869), Medlicott (1859) and Auden (1933). Auden was the first worker who described the stratigraphy of these rocks. The Vindhyans of the present area are thickly bedded, the rocks are hard and compact and undeformed, resistant to weathering as a result devoid of soil cover. Primary sedimentary structures namely ripple marks, cross bedding, convolute laminations and thin horizontal lamination are well developed on these rocks.

5. Petrography

Megascopically the rocks are pink, purple to raddish brown, medium to fine grained, hard and compact essentially made up of quartz with ferruginous cement. Microscopically, quartz is the most common mineral in these sandstones and is covering almost upto 98% volume of the rock. The quartz grains are sub angular, sub rounded to round, and are represented by both monocrystalline and polycrystalline types (Fig. 1 a, b). Monocrystalline quartz grains generally appear with clear appearance having few inclusions of tourmaline, mica, epidote and magnetite as an opaque mineral (Fig. 2). These quartz grains showing straight to slightly undulatory extinction. Polycrystalline quartz grains are generally fine to medium grained with equant to sub-equant posture. It shows straight to undulatory extinction (Fig. 1 a). Reworked sedimentary quartz grains are characterised by abraded overgrowth, which is generally identified by iron coating over the pre-existing quartz grains. Mica occurs occasionally and is represented by both muscovite and biotite. The mica grains have been observed to curve around other detrital grains, which may have been developed during compaction of sand (Fig. 1 c). Feldspar is present in small amount in the form of orthoclase where as plagioclase is rare. Feldspars are mostly altered (Fig. 1 b, e). The heavy minerals are the mineral species which include opaques, zircon, tourmaline, etc. in the order of abundance. They vary from 0 to 4.6% in these rocks (Fig. 1 f, g) most sandstones contain a small proportion of accessory minerals of terrigenous origin. Small amount of rock fragments include grains of chert and those derived from low rank metamorphics, such as phyllites and siltstone. Cementing material of the studied sandstone is represented by siliceous and ferruginous materials (Fig. 1 b, d, h). Siliceous overgrowths are clearly demarcated from the detrital grains through thin coating of opaque material. Overgrowth is conspicuous indicating authigenetic growth of silica.

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The thin section study of the sandstones reveals the presence of acicular and irregular inclusions in the quartz grains. Mackie (1896) mentions that the acicular and irregular inclusions are characteristic of quartz derived from the granitic rocks, whereas the quartz grains of schists and gnisses contain regular inclusions, liquid and gas inclusions, however, acicular and irregular inclusions are common in quartz grains derived both from granites and gneisses.

Feldspars though in very minor amount. They are mostly represented by orthoclase, except for few grains of plagioclase. The volume percentage of feldspar in these rocks varies from 1 to 2%. At times authigenic growth of potash feldspar is also observed. In some rock sections the feldspars have been completely altered to sericite. Lithic fragments occur as sub rounded to sub angular, equidimensional fragments are relatively free from any replacement effect. They constitute 1 to 9 volume percentage of these quartz arenites.

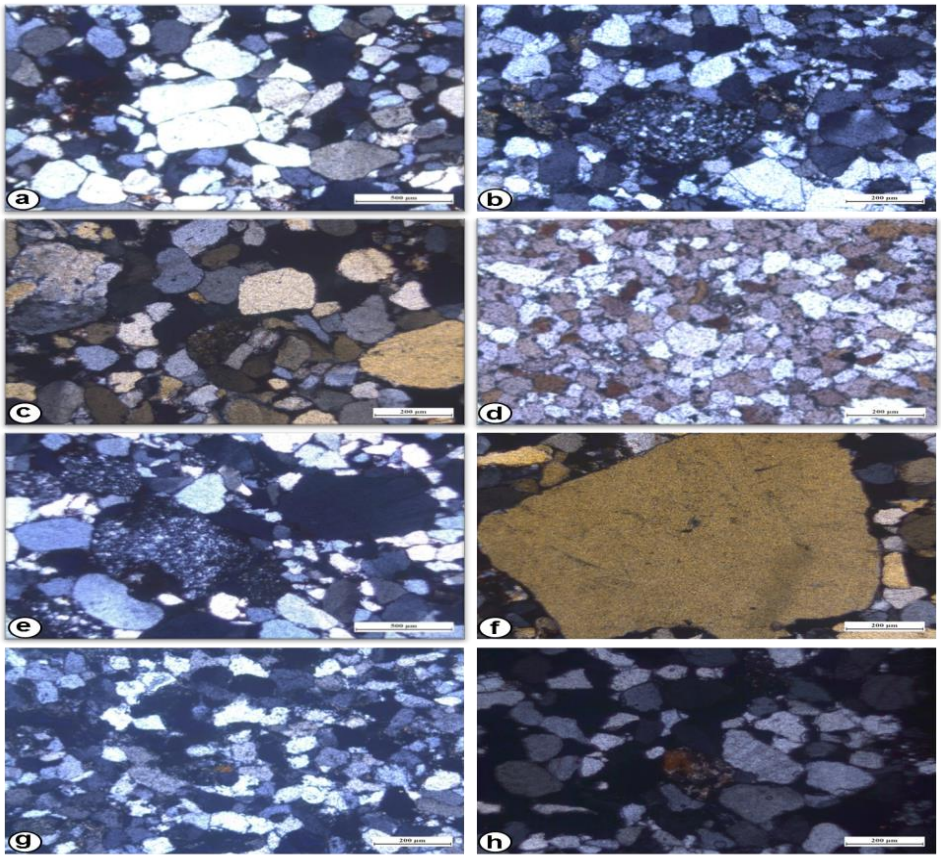

Fig. 2 (a) Photomicrograph showing undulating extinction of quartz grains

(b) Photomicrograph showing Orthoclase feldspar

(c) Photomicrograph showing mica grains

(d) Photomicrograph showing ferruginous and silicious material

(e) Photomicrograph showing altered grains of plagioclase and orthoclase feldspar

(f) Photomicrograph showing heavy minerals

(g) Photomicrograph showing minute specks of heavy minerals

(h) Photomicrograph showing cementing material

5.1 MODAL ANALYSIS

The results of modal analysis reveal that the Quartz (83-95%) is observed as dominant mineral constituent followed by rock fragments (1-9%), feldspar (upto 2%), opaque and other minerals making up the remaining (Table 1). The modal mineral abundance estimation shows a decline in percentage as well as in grain size of feldspar from the base to top of the sequence with an increase in percentage of monocrystalline quartz. The improved sorting from base to top of the sequence suggests a progressive textural and mineralogical maturity in the rock unit.

Table 1 Modal Analysis of Upper Bhander sandstone (all are in %)

Sr. No.	Quartz	Feldspar	Rock fragments	Cement	Other
1	94.5	1	3.5	1	0
2	93	A	1	5	1
3	92	A	3	2	3
4	94	A	4	1	1
5	83	2	8	3	5
6	92	A	3	2.2	2.8
7	83	A	9	5	3
8	94	1	4	1	0
9	92	1	3	2.5	1.5
10	87	2	4	4	3
11	94	A	5	0.5	0.5
12	95	1.5	2.5	0.5	0.5
13	92	0.5	4	2	1.5
14	93	0.6	5	1	0.4
15	95	A	3	1	1
16	83	1.8	8	3.2	4

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17	91	A	4	3	2
18	88.5	0.9	5	3.6	2
19	90	0.6	6	1.4	2
20	85	1.4	4	5	4.6

The results of modal analysis plotted on various ternary plots suggested by Okada (1971), Folk (1974), Dickinson et al. (1983), Dickinson (1988), Stunner et al. (1981), and Kumon et al. (1992). Okada (1971) proposed a triangular diagram plotted for modal percentages of quartz, feldspar and lithic fragments to classify the arenites (Sandstones), this diagram has been plotted for the rocks of present area (Fig. 3) which reveals that the rocks of the area under study are Quartz arenites. The results of modal analysis plotted on a ternary plot of Folk (1974), also reaffirm that the sandstones of the present area falls in the field of quartz arenite (Fig. 4).

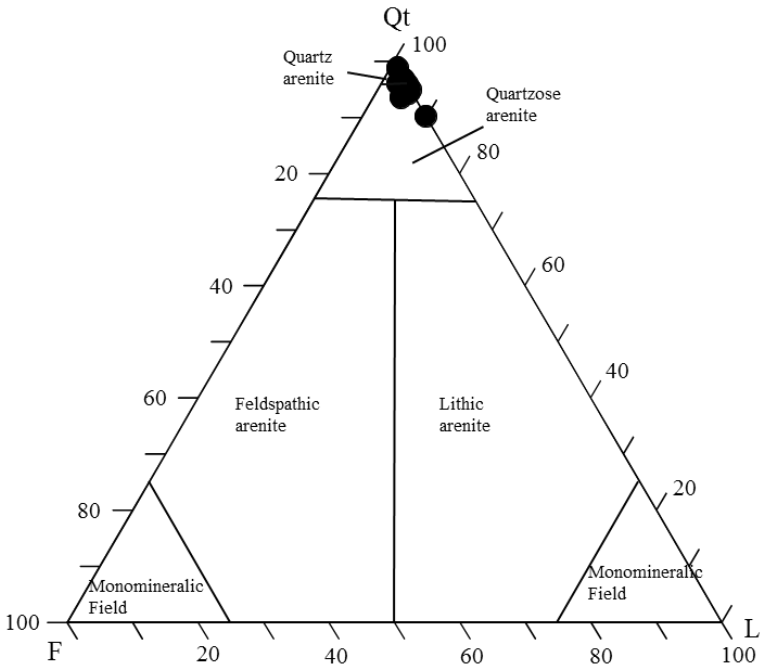

Fig. 3 Quartz-Feldspar-Lithic fragment plot (after Okada, 1971)

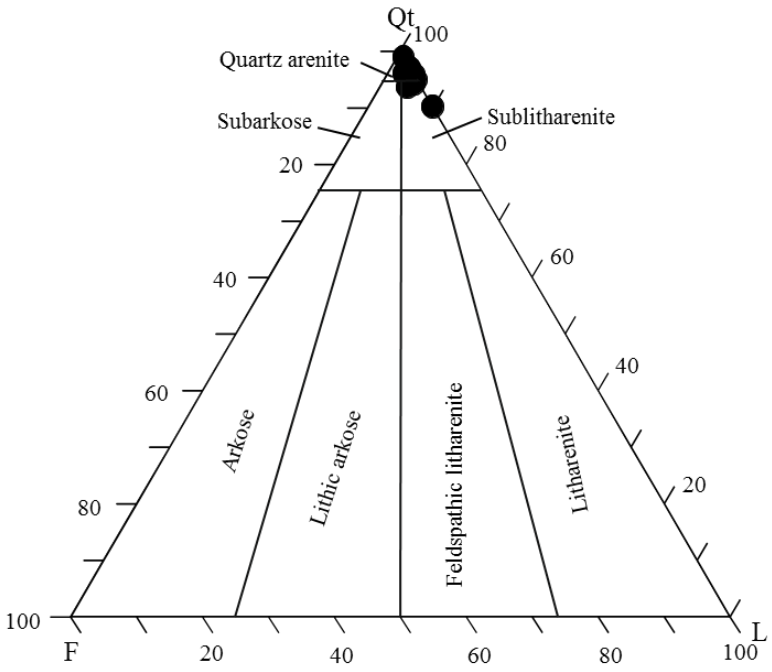

Fig. 4 Quartz-Feldspar-Lithic fragment plot (after Folk, 1974)

Dickinson et al. (1983) and Dickinson (1988) proposed the triangular plots based on the modal percentages of quartz, feldspar and lithic fragments to decipher the provenance of sedimentary rocks. The modal analysis results of the rocks of the area of present study plotted on this ternary plot after Dickinson et al. (1983) states that these rocks show their provenance between Craton Interior and Recycled orogen (Fig. 5).

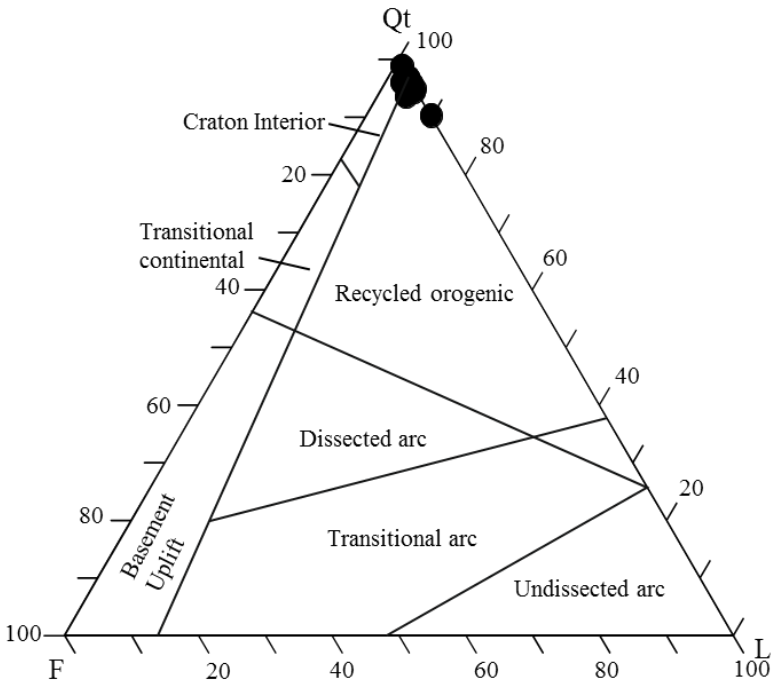

Fig. 5 Qt-F-L plot (after Dickinson et al., 1983)

However the results of the plot on the diagram proposed by Dickinson (1988) indicate the possible source of sediments between Continental block to Recycled orogen provenance (Fig. 6). The abundance of monocrystalline quartz over polycrystalline quartz reflects higher maturity index. Lower abundance of feldspar and volcanic rock fragments is suggestive of recycled sedimentary source and presence of muscovite also supports the recycled sedimentary provenance (Dickinson, 1988). The rocks of present study is abundant in microcrystalline quartz grains with few grains of muscovite their deficiency in feldspar, which suggests that present rocks are more mature and might have derived from recycled source.

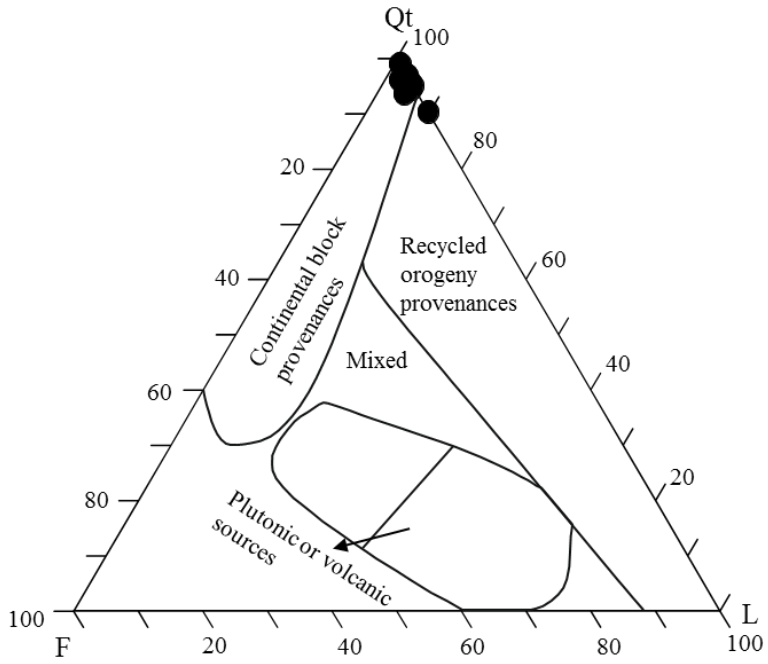

Fig. 6 Quartz-Feldspar-Lithic fragment plot (after Dickinson, 1988)

6. Conclusion

The present study carried out to classify and to delineate the possible source of these sandstones of Upper Bhander Group using petrography and modal analysis suggest that the present rocks are dominantly contain quartz with lesser amount of feldspar, rock fragments and heavy minerals include minor concentration of tourmaline, apatite and zircon. The quartz grains are monocrystalline and polycrystalline, the quartz grains contain inclusions these inclusions are acicular and irregular, Mackie (1986) mentions that these inclusions are suggestive of granitic source. Quartz as an over growth also present which is indicative of diagenetic over growth. The QFL plots of these rocks (Okada, 1971; Folk, 1974) disclose that these sandstones belongs to arenite to quartz arenite class. The QFL plot of Dickinson et al. (1983) reveals that the source of these sandstones is between Craton Interior of recycled orogen where as Dickinson (1988) plot indicates its Continental Block Provenance as source of these rocks. Thus it may be concluded that the felsic rocks were the most probable source of these rocks, which were derived from craton Interior or Continental provenance.

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