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Petrography of Clastic Sedimentary Rocks of the Palaeoproterozoic Alwar Basin, North-Eastern Rajasthan

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Abstract: The Alwar basin, occurring in the central part of NDFB, contains ~6000 m thick package of volcanic and sedimentary rocks comprising eleven formations. The lower most three formations are included in Raialo Group, overlying four formations in Alwar Group and the upper most four formations in Ajabgarh Group. In the studied quartzite of the Alwar basin the dominant constituent is quartz with small proportion of mica, feldspar followed by some heavy minerals including tourmaline, garnet, rutile and zircon. Presence of alkali feldspar indicates their source is both plutonic and metamorphic rocks which suggest that sediment of Alwar basin were derived from mixed source.

Keywords: Petroraphy, Provenance, Alwar Basin, Rajasthan

1. INTRODUCTION:

The Delhi Supergroup Supracrustal rocks constitute a linear volcano-sedimentary belt which is broadly divided as South Delhi Fold Belt (SDFB) and North Delhi Fold Belt (NDFB). However, the rocks of these two sub-belts show mark differences in various characteristics such as volcanic/sediment ratio, nature of mafic-ultramafic rocks, base metal mineralization (Deb and Sarkar,1990). Heron (1953) divided the rocks of the Delhi belt into two units: the lower Alwar Series and the upper Ajabgarh series now referred to as groups. The Alwar Group is dominantly arenaceous and is represented by phyllites – schists, arkosic quartzite, amphibole quartzite, marble etc. The Ajabgarh Group is characteristically calcareous and argillaceous with a large amount of volcanic products.

1.1 . South Delhi Belt:

The belt contains carbonate facies rocks, mafic-ultramafic volcanics, and mafic plutonic rocks such as gabbro, and leucogabbro and felsic volcanites. An ophiolitic association comprising pillowed basalts, layered gabbro, serpentenites, pyroxynite and sometimes sheeted dykes and andesites occurs as a linear zone along the entire length of South Delhi belt (Khan et al., 2005). The rocks of South Delhi belt are regionally metamorphosed upto amphibolite facies metamorphism (Sharma, 1988).

1.2 . North Delhi Belt

The northern part of Delhi belt, occurring to the north of Ajmer is constituted by three sedimentary sub-basins. These are from east to west: the Bayana sub-basin, the Alwar sub-basin and the Khetri sub-basin (Singh, 1988). These sub-basins developed as grabens in a gneissic basement and sedimentation was largely controlled by vertical tectonism. The volcano-sedimentary infills of these basins have been classified into Alwar and Ajabgarh groups (Heron, 1953) in each basin. The sedimentation in north Delhi belt commenced with carbonate shelf deposits in two isolated areas followed by coarse clastic sediments of Alwar Group (Singh, 1988). The present study thesauruses type of rocks are present in the study area, locate the provenance of the sedimentary sequence of Alwar Basin, tectonic setting of sedimentary basin and palaeoclimatic conditions prevailing during sedimentation.

2. GEOLOGY OF THE ALWAR BASIN:

The present study area is part of Alwar basin that constitutes the central part of NDFB covering parts of north eastern Rajasthan. The NDFB, which occurs as a considerably narrow linear belt in south and central Rajasthan, fans out over a wider zone in north eastern Rajasthan (Figure 1.1). This fanning resulted because in this part of Delhi basin sedimentation took place in several partially isolated depositaries (Singh, 1982). Alwar basin formed one such depocentre which was separated from Bayana in the east and Khetri basin in the west by Pre-Delhi basement complex (Figure 1.1). The area of present study constitutes the eastern part of Alwar basin.

The detailed account of stratigraphy and sedimentological aspects of Delhi Supergroup of Alwar basin in Rajgarh area has been given by Singh (1982). The rock types found in the belt are chiefly sedimentary metamorphites comprising various types of schists, phyllites interlayered with massive

quartzite, conglomerates, marbles, and amphibolites. The metasedimentary fill of the Alwar basin is divided into the Raialo (mafic volcanics, marble, quartzites) the Alwar (dominantly arenaceous) and the Ajabgarh (argillaceous and calcareous) Groups (Table 1.1).

The Alwar basin is nearly 6000 m thick package of volcanic and sedimentary rocks comprising eleven formations. The lower most three formations are included in Raialo Group, overlying four formations in Alwar Group and the upper most four formations in Ajabgarh Group (Singh, 1982) (Table 1.1). The rock types found in the basin are chiefly sedimentary metamorphites comprising various types of schists, phyllite interlayered with massive quartzite, metagreywacke, marbles, calc-silicate rocks and amphibolites.

3. METHOD OF STUDY:

Present study is focused on petrography and provenance of quartzite of Alwar Basin. Mineralogical studies provide very important information pertaining to provenance of sandstone. The key relation between provenances to basin is governed by plate tectonics, which thus ultimately controls the distribution of the different types of sandstones. In present study the petrographic study has been carried out on thin sections of quartzites of Delhi Supergroup, from the Alwar basin to determine their detrital composition. The mineralogical composition is used to constrain the provenance characteristics and tectonic setting of Alwar basin clastic rocks. To determine the detrital mineral composition of quartzite samples of Alwar basin, both qualitatively and quantitatively, 48 samples were studied under the microscope. These include 11 samples from Tehla Formation, 22 from the Rajgarh Formation, 4 from the Pratapgarh Formation, 3 from the Kushalgarh Formation, 3 from the Seriska Formation and 5 from the Thana Ghazi Formation. The samples were selected in such a way so as they cover uniformly, both laterally and vertically, the outcrops of six formations. For quantitative analysis about 150-200 points per thin section were counted for determining the mode composition of rocks under investigation.

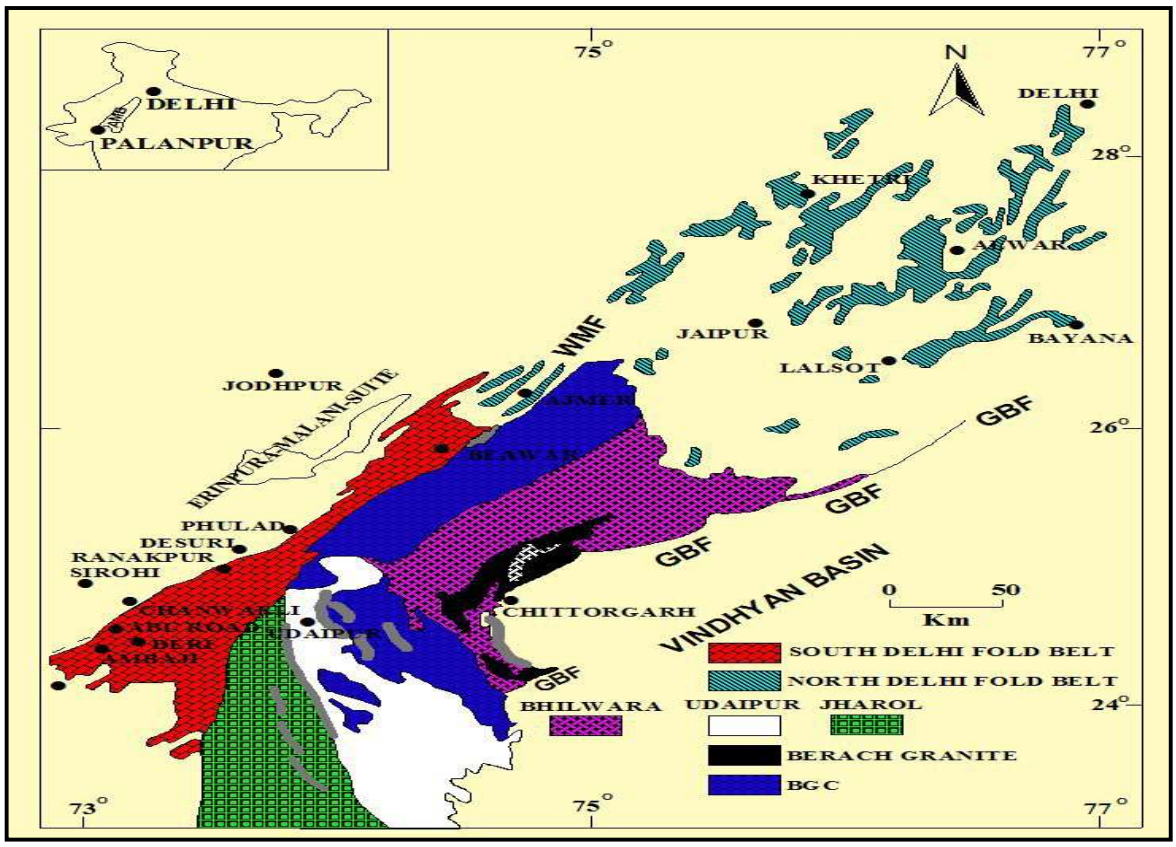

Figure 1.1 Geological map of Aravalli Craton showing distribution of Aravalli – Delhi Supracrustals sequences, large sedimentary basins, and basement complex. After Roy (1988).

Table1.1: Stratigraphic sequence of Delhi Supergroup in eastern part of Alwar basin (Singh, 1982a)

Group	Formation	Lithology	Max. Thickness
	Arauli- Mandan	Carbonaceous phyllites with thin intercalations of grey quartzites	80 m
	Barkol	Quartzites, phyllites and schists	150 m
Ajabgarh	Thana Ghazi	Carbonaceous phyllites, thin bands of grey brecciated quartzites grey marble.	150 m
	Sriska	Ferrugenous quartzite, siliceous marble, thin bands of phyllite	150 m
	Kushalgarh	Siliceous marble, calc gneiss, amphibolites, amphibole quartzite, phyllite, quartzite	200 m
----------unconformity----------			
	Pratapgarh	Quartz- sericite schist, massive quartzite, minor conglomerate	900 m
	Kankwarhi	Quatz- sericite schist, schistose quartzite, siltstone and marble	250 m
Alwar			
	Rajgarh	Arkose and feldspathic quartzite polymictic conglomerate	1200 m
----------unconformity ----------			
	Tehla	Mafic flow with conglometate, quartzite, phyllite, marble and calc gneiss	2020 m
Raialo	Serrate quartzite	Quartzite, conglomerate and sericite schist	300 m
	Dogeta	Marble, thin quartzite , schist and phyllite interbeds, conglomerate	900 m
----------Major Hiatus ---------- **Pre- Delhi Basement** **Granites, pegmatites, schists, marble, shales phyllite, quartzite, amphibolites and Banded Iron Formations**			

4. DETRITAL MINERALOGY:

The detrital content of studied quartzites (meta-arenites) is mainly composed of several varieties of quartz followed by feldspars and mica. Average detrital mineralogy in the studied rocks includes monocryslalline quartz (73.06 %), polycrystalline quartz (18.4 %), feldspar (3.5 %), and mica (5.0 %).

4.1. Quartz:

Quartz is the most dominant constituents. Most of the quartz grains are monocrystalline along with some polycrystalline quartz grains. The varieties recorded are: common quartz (72.51 %), vein quartz (0.55 %), recrystallized metamorphic quartz (6.30 %) and stratched metamorphic quartz (12.4 %).

Common Quartz It is the dominant constituent and forms 8.72 to 100 % by volume with an average of 72.51 %. The grains are monocrystalline (Figure 1.2 A) and present a clear appearance having inclusions of tourmaline, mica and opaques. The grains show straight to slightly undulose extinction. *Vein Quartz* It constitutes 0.91 to 10.47 %, with an average at 0.54 % of the detrital fraction.

Recrystallised Metamorphic Quartz Recrystallised metamorphic quartz comprises 0.91 to 10.47 % and averages at 0.54 % of the total detrital constituents.

Stretched Metamorphic Quartz It constitutes 2.4 to 96.7 % and averages at 6.30 % of the detrital fraction. It occurs as a polycrystalline grains which are mostly made of elongated and lensoid sub-individuals of micro-quartz and fine grained quartz.

4.2. Mica:

Both muscovite and biotite (Figure 1.2 B) occur as tiny to large elongate flakes with frayed ends. The percentage of mica range from 0.23to 18.48 % percent and averages at 15.37 %. Detrital mica grains belong to two varieties and are brown and green coloured.

4.3. Feldspar:

Feldspar constitutes 0.91 to 10.47 % with an average of 0.54 %. Three varieties of feldspar have been recognized which include orthoclase, plagioclase and microcline. The size of feldspar grains generally ranges from 0.6 to 0.17 mm and is almost the same as that of the accompanying quartz grains. Feldspar grains are generally sub-equal with mostly sub-rounded to well round outlines (Figure 1.2 C).

4.4. Accessory mineral:

Tourmaline (Figure 1.2 D), garnet, rutile and zircon (Figure 1.2 E) represent the heavy minerals and occur in minor amounts.

5. TECTONO-PROVENANCE:

Dickinson's classification (1985) puts emphasis on tectonic setting of the provenance which apparently exerts primary control on sandstone composition. However, secondary factors such as relief, climate, transport mechanism, depositional environment and digenesis can also play important role in determining the sandstone composition. The present study revealed that monocrystalline quartz (Qm) is the dominant mode of our samples. Its percentage ranges from 0.91 to 100 with an average of 80. Polycrystalline quartz (QP) includes both recrystallized and stretched metamorphic quartz. Polycrystalline recrystallized quartz ranges from 3.65 % to 45.29 % and averages 20 %. The relative abundance of monocrystalline quartz to that of polycrystalline quartz in the studied quartzites appears to reflect the maturity of the sediments because polycrystalline quartz of the sediments is eliminated by recycling and disintegrates in the zone of weathering as does strained quartz (Basu, 1985). The occurrence of small percentage of feldspar and lithic fragments in the studied quartzites may be attributed to the fact that they are lost in the soil profile in warm, humid climate with low relief or by abrasion during transit or lost in solution during diagenesis.

6. RESULT AND DISCUSSION:

The quartzites of Alwar Basin contain quartz, both of igneous and metamorphic origins as well as feldspar and micas. The most abundant quartz is common quartz. It is mainly derived from granitic batholithic or granite gneisses. The recrystallized quartz indicates an origin from metaquartzites, highly metamorphosed granites and gneissic rocks. The stretched quartz was probably derived from granites, schists or quartz vein. Presence of Alkali feldspar indicates their source as both plutonic and metamorphic bodies. These characteristics suggest that the sediments of Alwar Basin meta-arenites were derived from a mixed provenance.The dominance of quartz in these quartzites suggests that

sedimentary detritus were prominently derived from a source terrain consisting predominantly of felsic rocks (Folk, 1972).

Three important aspects of the Alwar basin quartzites are (i) high proportion of polycrystalline quartz, (ii) general absence of feldspar and (iii) high degree of textural maturity. These aspects need to be critically examined to evaluate the influence of various factors especially palaeoclimate on the composition of these rocks. The highly quartzose nature of the meta-arenite is generally attributed to humid tropical palaeoclimate and elimination of feldspar during diagenesis (Dickinson, 1985). The presence of high percentage of mica after quartz suggests that sand is derived from metamorphic source which indicates mature detritus of a truly stable platform succession.

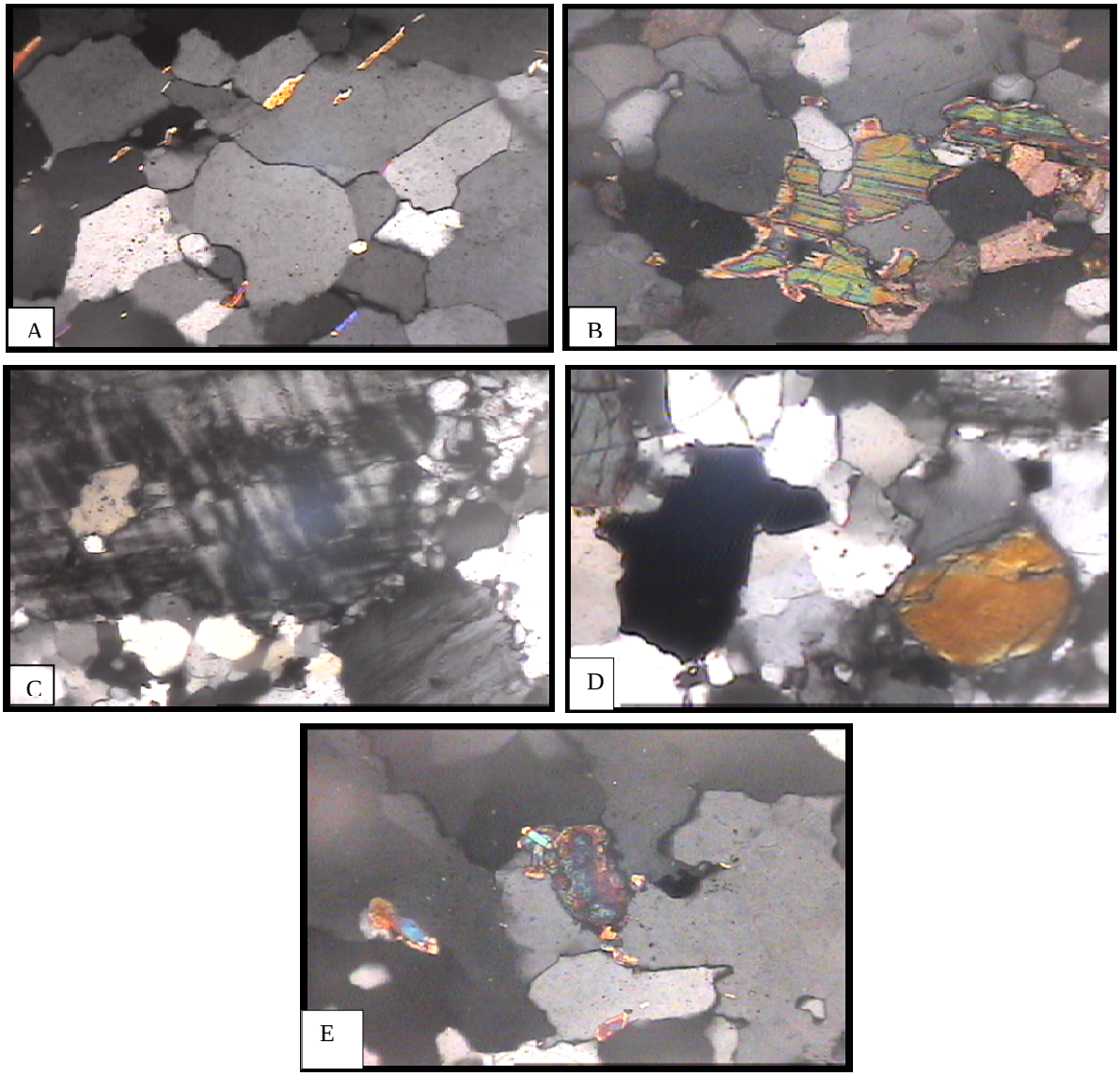

Figure 1.2- Microphotographs of A- Monocrystalline quartz grains, B- Biotite C- Feldspar grain, D- Tourmalline, E- Zircon

Table 1.2 : Percentage of detrital minerals in quartzites of the Alwar basin CQ=common quartz, VQ=vein quartz, RMQ= recrystallised metamorphic quartz, SMQ=stretched metamorphic quartz

	Mono Quartz		Poly Quartz		Mica		Feldspar			Rock Fragments
							K-Feldspar		Plagioclase	
	CQ%	VQ	RMQ	SMQ	Biotite	Muscovite	Orthoclase	Microcline		
	Tehla Formation									
Range	18.25-100.00	0.00-0.00	0.00-18.25	0.00-35.71	0.00-7.33	0.00-14.29	0.00-1.57	0.00-8.53	0.00-7.64	0.00-0.00
Average	65.66	0.00	6.88	15.18	3.82	4.17	0.26	2.74	1.27	0.00
	Rajgarh Formation									
Range	0.00-100.00	0.00-10.48	0.00-98.58	0.00-96.73	0.00-9.98	0.00-9.60	0.00-0.00	0.00-6.05	0.00-2.09	0.00-17.21
Average	73.44	0.53	9.09	10.72	1.93	1.94	0.00	1.36	0.21	0.78
	Pratapgarh Formation									
Range	35.56-91.70	0.00-0.00	0.00-16.58	0.00-31.54	0.23-3.61	1.44-4.28	0.00-12.57	0.00-3.74	0.00-0.00	0.00-0.00
Average	55.57	0.00	11.09	19.08	1.84	3.10	7.58	1.75	0.00	0.00
	Kushalgarh Formation									
Range	36.47-64.62	0.91-9.92	0.00-3.65	31.77-57.14	0.61-2.17	0.00-1.22	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00
Average	47.82	4.09	1.22	45.29	1.18	0.41	0.00	0.00	0.00	0.00
	Seriska Formation									
Range	39.38-100.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00	0.00-60.63
Average	73.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.24
	Thana Ghazi Formation									
Range	50.74-100.00	0.00-1.97	0.00-13.21	0.00-37.93	0.00-1.45	0.00-1.51	0.00-0.00	0.00-0.00	0.00-0.00	0.00-0.00
Average	80.08	0.39	5.19	13.55	0.29	0.50	0.00	0.00	0.00	0.00

7. CONCLUSIONS:

On the basis of petrographical data of the quartzites of Alwar Basin the following denouement have been drawn:

1- Petrographic investigations indicate that the detrital content of studied quartzites (meta-arenites) is mainly composed of several varieties of quartz followed by feldspars and mica. The average detrital mineralogy includes monocryslalline quartz (73.06 %), polycrystalline quartz (18.4 %), feldspar (3.5 %), and mica (5.0 %) in addition to accessory minerals tourmaline, garnet, rutile and zircon.
2- In the studied sample higher proportion of common quartz suggests that the provenance of these rocks will be granitic batholiths or granite gneiss.
3- Presence of Alkali feldspar indicates their source as both plutonic and metamorphic bodies.

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