CHAPTER 7

TECTONIC SETTING OF SEDIMENTATION IN ALWAR BASIN

7.1 Introduction

Geochemistry of sedimentary rocks has been widely used to interpret the tectonic setting prevailing during sedimentation (e.g. Bhatia, 1983; Bhatia and Crook, 1986). The geochemical data-derived interpretations regarding tectonic setting of ancient sedimentary basins is largely based on fundamental assumption that the nature of source terrain is intimately related to tectonic processes controlling the origin and evolution of adjacently lying sedimentary basin (Bhatia and Crook, 1986). In recent years the geochemical compositions of clastic sedimentary rocks have been widely used to distinguish the tectonic conditions prevalent during their deposition (e.g. Bhatia and Crook, 1986; Roser and Korsch, 1986; McLennan, et al., 1993). Even though the fields representing various tectonic settings identified by these authors are originally intended for Phanerozoic clastic sedimentary rocks, they have gained wide application in Precambrian sedimentary rocks (McLennan, et al., 1995; Kalsbeek et al., 1998; Yang et al., 1998; Bhat and Ghosh 2001; Raza et. al., 2010a,b; 2012). Variations in major and trace element concentrations reflect distinct provenance types and tectonic setting for sedimentary sequences (Bhatia 1983; Bhatia and Crook, 1986). McLennan, et al. (1993; 1995) described five major provenance types on the basis of geochemistry (Table 7.1).

7.2 Tectonic Setting of Alwar basin

The high K_2O/Na_2O ratios shown by our samples of quartzites (avg. 17.48) and metapelites (avg. 32.70) of Delhi Supergroup of the Alwar basin classify these rocks as quartz- rich type (Crook, 1974), suggesting their deposition in plate interiors either at stable continental margin or intracratonic basin. The K_2O/Na_2O-SiO_2 plot (Roser and Korsch, 1986, Figure 7.1) indicates the deposition of sedimentary fill of

Alwar basin in a passive margin tectonic setting. In Na-Ca- K ternary diagram of Bhatia (1983), most of our samples again fall in the field of passive margin setting (Figure 7.2). The geochemical composition of these sediments as discussed in chapter six suggest their derivation from a granitic-dominated old continental crust. According to McLennan et al., (1990) this crustal component constitutes old stable cratons and old continental foundation of active tectonic settings. To further asses the tectonic environment of Alwar basin sedimentary rocks, we use here in the discrimination diagrams based on relatively immobile trace elements such as La, Th, Sc, Y, Cr, Zr, Co and TiO_2 as discriminant parameters (Bhatia and Crook, 1986).

The tectonic setting of the Alwar basin is evaluated using various discrimination diagrams based on concentration of these elements (e.g. Bhatia and Crook, 1986). On, Th-Sc-Zr/10 discriminant plots, (Figure 7.3), most of our samples fall within or very near to field D representing passive margin setting. Although, the fields on this plot were originally defined for sandstones but in recent years the diagrams of Bhatia and crook (1986) have been proved useful even for metapelitic rocks (e.g. Yang, 1998; Gu et al., 2002; Tran et al., 2003).

In Ti/Zr - La/Sc discriminant plots, (Figure 7.3) the samples of Alwar basin clastic rocks are generally scattered. However, most of the samples fall in or very near to field B and D representing continental island arc and passive margin settings respectively. As discussed in chapter six, the clastic sedimentary rocks of the Alwar basin have been derived from BGC basement. It has been suggested (Raza et al., 2010a) that the BGC evolved through accretion and tectonic amalgamation of pre-existing continental arcs comprising TTG and granitic bodies. Thus, there is a possibility that the continental arc signatures derived from their source terrain might be preserved in the chemistry of our samples due to which some samples are plotted in or near to field B of Figure 7.3 and 7.4. The sedimentary rocks of the Alwar basin are interbedded with mafic volcanic flows of tholeiitic composition. These mafic rocks show strong continental flood basalt (CFB) affinity. Geochemical studies of these basaltic rocks (Raza et al., 2007) suggest that the tholeiites were erupted in Alwar basin along with sedimentary processes operating on the crust. Therefore, the Alwar basin is considered to have been originated as a rift at the margin of the BGC craton (Raza et al., 2007). Geochemical study of recent sedimentary rocks of East African Rift System (EARS; Mapila et al., 2009) suggests that they are compositionally very similar to those of passive margin settings. They also exhibit LREE enriched patterns, which are similar to those of PAAS. Therefore, the geochemical data of sedimentary rocks of the Alwar basin further support a rift basin tectonic setting.

7.3 Implication for Regional Tectonics and Continent Assembly

The present study suggests deposition of Alwar basin fill in a continental rift setting. The result is consistent with the envisaged tectonic setting of sedimentary basins of NDFB based on geochemical studies of mafic volcanic (Raza et al.,2002, 2007) . These studies have suggested that at about 1880 Ma, the continental lithosphere in the norteastern region of Rajasthan stretched, attenuated and fractured in response to a rising plume resulting in the development of intracratonic rifts at the margin of the BGC craton. On the basis of geochemistry of intercalated volcanic rocks and massive sulphide deposits, the Khetri basin is considered to have been evolved as a successor sedimentary sequence deposited in an extensional back arc basin, close to ~ 1832 Ma continental margin arc terrains (Raza et al., 2007). In the light of these information the configuration of different

Table 7.1. Summary of geochemical characteristics of provenance types (after McLennan et al., 1993, 1995)

Terrain type	Eu/Eu*	Th/Sc	Other geochemical features	Description
Old Upper Continental Crust (OUC)	~0.60-0.70	~1.0	Evolved major element composition (e.g. high Si/Al, CIA): High LILE abundances; uniform compositions	Old igneous/metamorphic/Sedimentary terrains affected by intracrustal differentiation stable cratons, old foundation of active settings
Recycled Sedimentary Rocks (RSR)	~0.60-0.70	≥1.0	Evidence of heavy mineral concentrations in trace elements (e.g. Zr, Hf for zircon, REE for monazite)	Recycled sedimentary/metasedimentary rocks specifically identified. If not separately identified, part of OUC.
Young Undifferentiated Volcanic Arc (YUA)	~1.0	<1.0	Unevolved major element composition (e.g. low Si/Al, CIA); Low LILE abundance; variable compositions	Young mantle-derived volcanic/Plutonic arc rocks dominate fore arcs, component in continental arcs, back arcs.
Young Differentiated Volcanic Arc (YDA)	~0.50-0.90	variable	Evolved major element composition (e.g. high Si/Al, CIA); High LILE abundance; variable compositions	Young mantle-derived volcanic/plutonic arc rocks affected by intracrustal differentiation. similar environments as YUA but more mature arcs or more dissection

Exotic components: Chemical signature depends on the nature of the component. For example, very high Mg. Cr, Ni, V and Cr/V would be distinctive of ophiolitic sources.

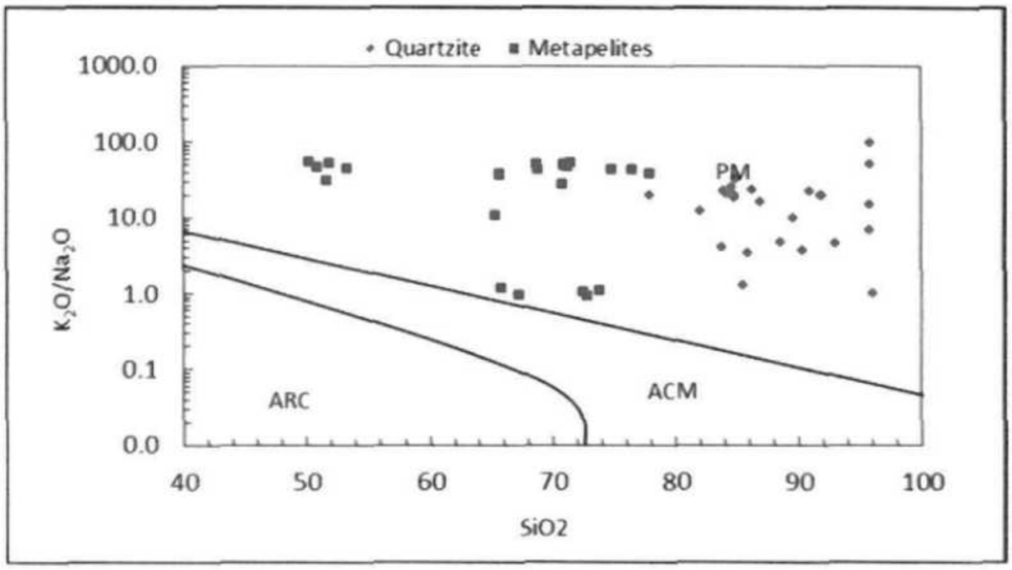

Figure 7.1. SiO_2 versus K_2O/Na_2O discriminant diagram (Roser and Korsch, 1986) showing deposition of quartzites and metapelites of Alwar basin in a passive margin tectonic setting. ACM = Active Continental Margin, PM = Passive Margin, ARC = Magmatic arcs.

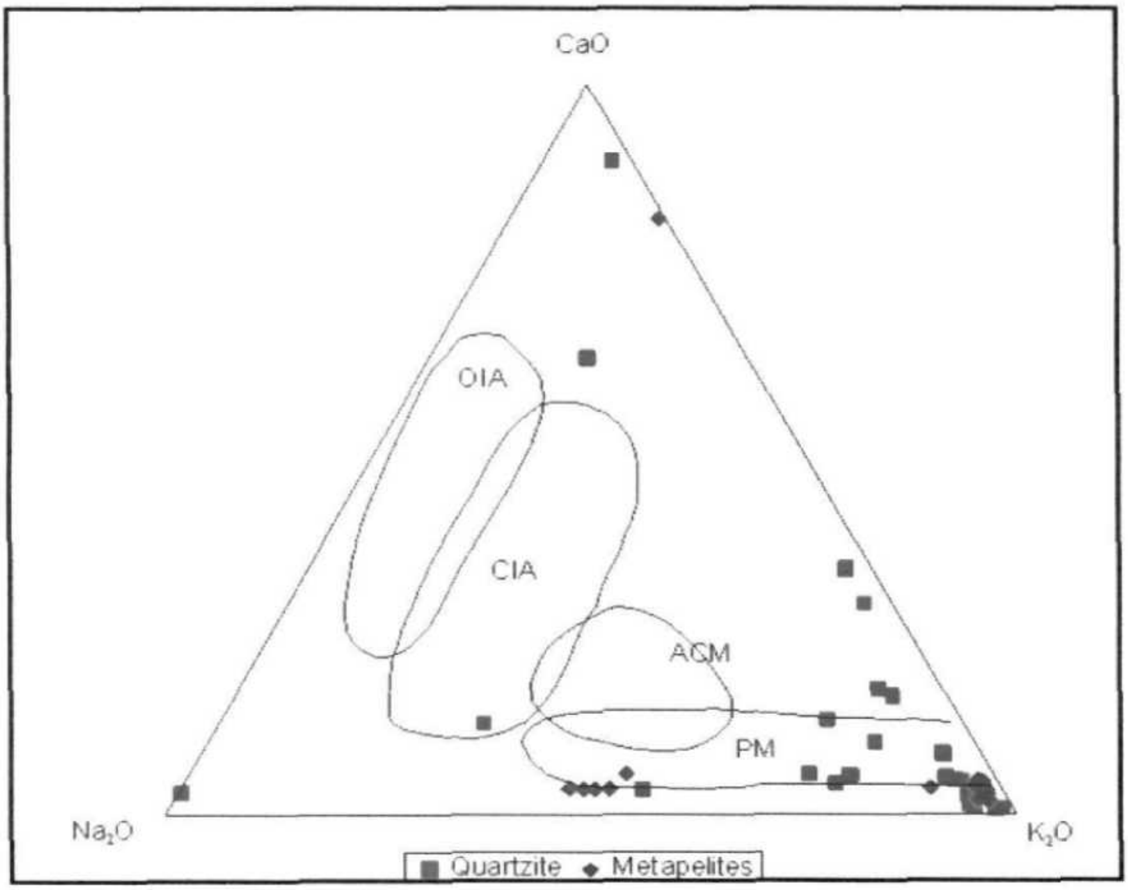

Figure 7.2. Na_2O- CaO- K_2O ternary diagram of Bhatia (1983), showing deposition of quartzites and metapelites of Alwar basin in a passive margin tectonic setting.

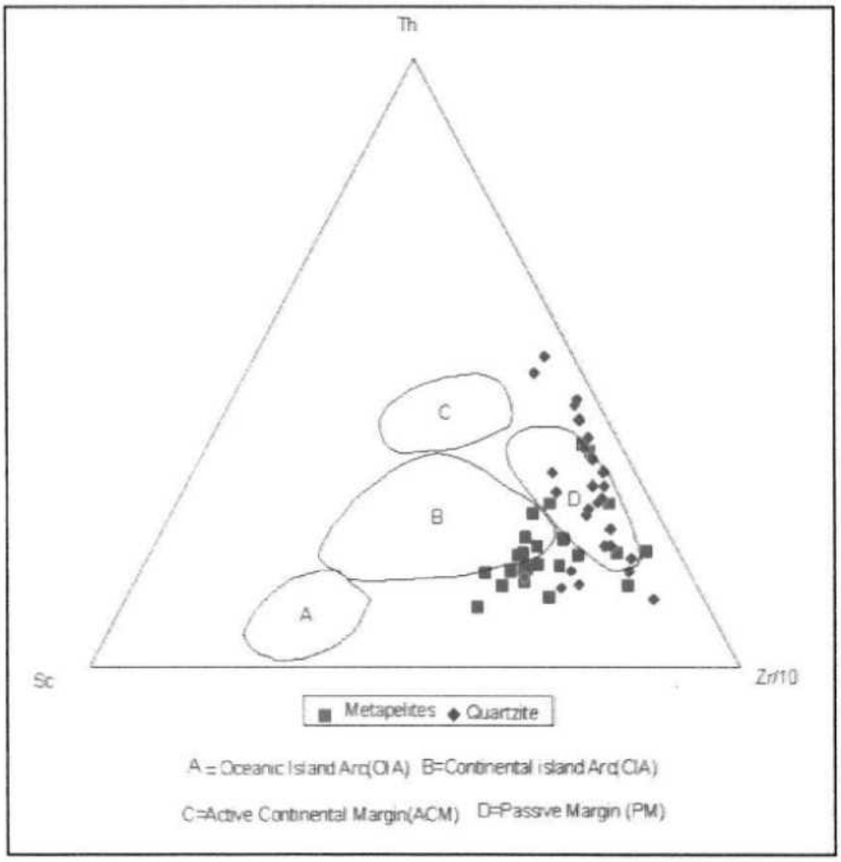

Figure 7.3 Th-Sc-Zr/10 ternary plot of clastic sedimentary rocks of the Alwar basin. Fields A-D are after Bhatia and Crook, 1986; A = Oceanic Island Arc (OIA), B = Continental Island Arc (CIA), C = **Active Continental Margin (ACM) and D = Passive Margin (PM).**

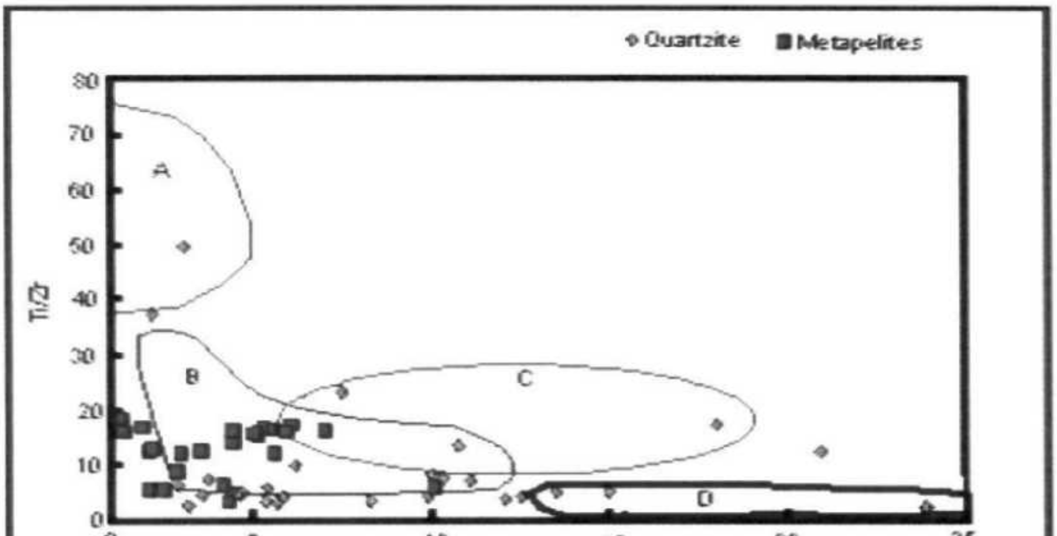

Figure 7.4 Ti/Zr vs. La/Sc discriminant diagram for the KCB Pelites and quartzites. Fields after Bhatia and Crook, 1986; A = Oceanic Island Arc (OIA), B = Continental Island Arc (CIA), C = Active Continental Margin (ACM) and D = Passive Margin (PM).

sedimentary basins of NDFB in terms of their tectonic settings is proposed herein and presented in (Figure 7.5). The tectonic settings of different sedimentary basins (Figure 7.5) occurring in the northern part of Aravalli mountain belt have great bearing on the tectonic evolution of north Indian shield. In the following paragraphs, we discuss the significance of these basins in tectonic evolution of North Indian shield and its implication on continent assembly during early Proterozoic.

The coeval formation of many rift- related basins such as Bayana, Alwar, Bhilwara and Aravalli basins (Raza and Khan,1993; Raza et al., 2001, 2007; Deb and Thorpe, 2004) in Aravalli Block and Gwalior, Bijawar and Lesser Himalayan basins in Bundelkhand block (Raza, 1981; Bhat and Ghosh, 2001; Absar et al., 2010), suggests that the North Indian Craton (NIC) suffered a major intracratonic extension during Palaeoproterozoic (Deb, 1993; Mazumder et al., 2000; Mallikharjuna Rao et al., 2005). This event appears to represent an important extensional regime that triggered the commencement of dispersion of earth's first super continent which amalgamated at ~2.4 Ga involving cratons of South Australia, East Antarctica, India and North China (Zhao et al., 2003; Stien et al., 2004; Barley et al., 2005).

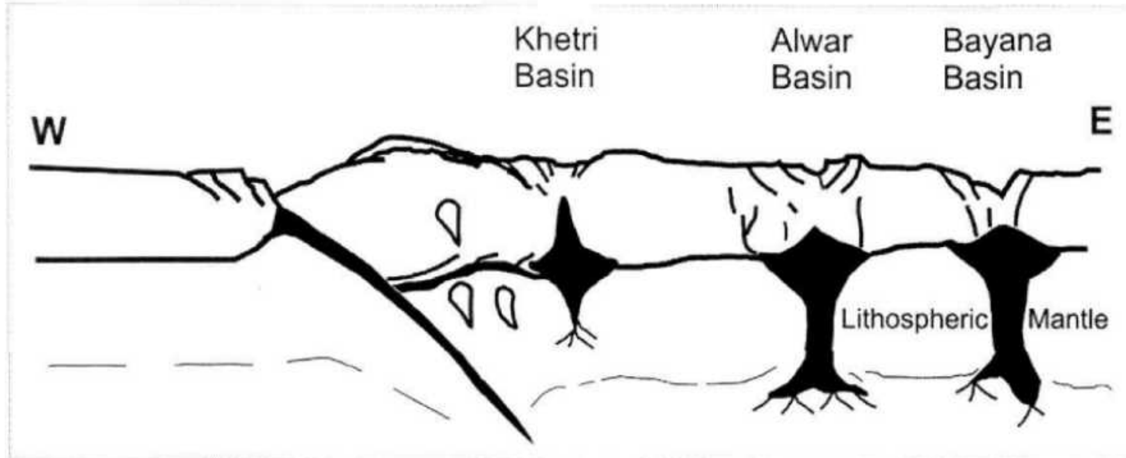

Figure 7.5 Cartoon illustrating development of sedimentary basins of NDFB and associated magma generation.

The occurrence of a sequence comprising arc-derived sedimentary rocks and subduction related mafic volcanics in Khetri basin (Raza et al., 2007) in the northern part of Aravalli orogen opens the possibility that an arc belt existed there at about 1832 Ma. The proposed model of Deb, and Sarkar (1990); Sugden et al., (1990); and Ahmad et al., (2008b) argues for the existence of an active continental margin in the SDFB that appears to be a possible southwards extension of the NDFB. These authors explained the evolution of SDFB through subduction /collision process. These features suggest a similar pattern of geodynamic evolution of the Delhi belt from north to south. Thus, the Khetri belt may represent part of a volcanic rock belt extending at least about 800 km in a NE-SW direction. Arc related volcanic rocks of the same age (1832 Ma; Guerot 1993) are also found in the Hindoli belt (Raza and Siddiqui, 2012) that occurs along the easternmost fringe of the Aravalli block.

Occurrence of arc related sequences of almost the same age on the western and eastern margins of the Aravalli orogen has an important bearing on the tectonic evolution of the NIC. The exact timing of the subduction episode is not perfectly known, but it could be at about 1832- 1850 Ma i.e. the age of volcanic rocks of the Khetri and Hindoli belts. Available lithostratigraphic, tectonothermal, geochronological and paleomagnetic data have established the presence of the Columbia supercontinent during 2.1 – 1.8 Ga. Studies also suggest that India was a constituent landmass in the Columbia configuration (Rogers and Santosh 2002; Zhao et al., 2002).The Indian block in the Columbia assembly grew by subduction and amalgamation processes. The subduction related rocks occurring along the margins of the Aravalli cratonic block point to the amalgamation of the North Indian Craton (NIC) and the Columbia assembly by subduction processes.