Chapter-4

SUMMARY AND CONCLUSIONS

The present study is an attempt to understand the Proterozoic evolutionary history of the Indian shield by unraveling the evidences preserved in sedimentary sequences. The existence of several large and contemporaneous sedimentary basins (Purana Basins) in India always puzzled the geosciencetist community about the locations of the sources of sediments for the basins. It has, therefore, become necessary to decipher the provenance of sediments deposited in these basins for formulation of any geodynamic model for the evolution of the Indian subcontinental landmass. The Vindhyan Basin, being the largest of the basins, is selected for such a study. Additional interesting problems in the basin that attracted our attention and needed scientific investigations are: 1) the lack of accurate stratigraphic correlations between various sectors; 2) the lack of any physical evidence for Neoproterozoic glacial events; and 3) the lack of proper understanding of the reasons behind gaps in sedimentation in the supergroup. To find answers to these questions a geochemical approach through the use of major, trace elements and radiogenic isotope ratios in siliciclastics rocks was taken. To establish chronology of depositions, we utilized U-Pb dating of the detrital zircons and Sr-isotope stratigraphy (in carbonate horizon). The major conclusions of this study are listed below. The answers to the major objectives of thesis and other inferences achieved are summarized below:

1. Geochemical and isotopic data from siliciclastic formations of the Vindhyan Supergroup of Rajasthan suggest that most of their sediments were derived from a magmatic arc located to the west of the basin. We believe that the magmatic rocks of the Hindoli Group, Delhi and the Aravalli Supergroups formed part of this arc. The basement rocks of the Vindhyans such as the Berach Granite and the Khairmalia volcanics also appear to have been generated by this arc.
2. Normalized trace element patterns of the Vindhyan Shales mimic that of average continental crust which essentially indicates that the sources for the

sediments came from stabilized craton. This could also mean that all major tectonic activities, related to continental crust formation, were over in this part of the Indian shield prior to the deposition of the Vindhyans.

3. Bimodal distribution of $\varepsilon_{Nd}(0)$ in the Lower Vindhyan sediments (of Rajasthan) suggests involvement of two major groups of magmatic source rocks, whose average $\varepsilon_{Nd}(0)$ values are -23 and -19. The T_{DM} age distribution for these also support this inference by showing modes at 2.9 Ga and 2.3 Ga. Taking cue from the detrital zircon geochronology, which shows peaks of magmatism at 2.5 Ga and 1.9 Ga, we conclude that the older sediments (T_{DM} = 2.9 Ga) represent a mixture of sediments from ~2.5 Ga old granites (e.g. Berach) and >3.0 Ga old volcanics from the Archean basement (e.g. Mangalwar complex, BGC). The younger group represents mixture of sediments from again the ~ 2.5 Ga old granites and the 2.2 - 1.9 Ga old volcanics from the Hindoli Group and or the Aravalli/Delhi Supergroups and the Khairmalia volcanics.
4. History of sedimentation in the Upper Vindhyans of Rajasthan is very interesting, since the original sediment sources appear to have been different in the southwest (near Chittorgarh) and northwest (near Bundi-Lakheri) sectors of the basin. While the southwest sector, except for when the Kaimur Group was getting deposited, received sediments from same/similar sources as in the case of the Lower Vindhyans (T_{DM} = 2.3 Ga), the northwest sector received sediments from much younger (1.6 Ga to 1.0 Ga) magmatic rocks. This is very clearly evident from the mode of $\varepsilon_{Nd}(0)$ distribution at -17 and mode of T_{DM} at 1.5 Ga. The Kaimur Group sandstone (T_{DM}=1.3 Ga) in the southwest sector seems to share the same history. The sediments for these formations are believed to have come predominantly from the 1.9 - 1.6 Ga old volcanics (the Hindoli Group; Deonar Rhyolites and its equivalent in Rajasthan) and from much younger magmatism (1.2 Ga to ~ 800 Ma). Again, taking clues from the detrital zircon geochronology data (of Malone et al. 2008) it is inferred that the latter source could be the 1.4 -1.2 Ga old magmatic

activities in the Aravalli/Delhi Supergoups (for the Kaimur sediments) or the 0.9 - 0.8 Ga old magmatism in the Aravallis and in the Mailani Igneous Suite.

5. The absence of sediments with T_{DM} <1.2 Ga in the Upper Vindhyans of the Son Valley could either suggest that the sources in the west (Rajasthan) did not contribute sediments to the east (Son Valley) or that there existed a physical barrier within the basin. This could be the reason why it has always been difficult to correlate Vindhyans in various sectors.
6. Comparing the present results with those of Chakrabarti et al. (2007) it is concluded that, except for the formation of the Kaimur Group, most siliciclastic formations of the Vindhyan Supergroup in the Son Valley are broadly correlatable with those in Rajasthan, both in terms of time of deposition and type of provenance. The Kaimur Group in Rajasthan, however, appears to be chemically very different from its counterpart in the Son Valley.
7. The long recognized basin-wide unconformity between the Lower and the Upper Vindhyans appears to have a chemical signature too. Across this discontinuity there is a clear evidence for change in provenance of sediments, as discussed above. A similar change is also observed across the boundary between the Kaimur and the Rewa groups in Rajasthan.
8. With the help of detrital zircon geochronology it is established that the Sawa Sandstone Formation is younger than 1616±50 Ma and may contain volcanics similar to the ~ 1630 Ma rhyolites of the Deonar Formation in the Son Valley.
9. The results from Sr-isotope stratigraphy in the Balwan Limestone Formation of the Bhander Group suggest a minimum age of ~ 620 Ma. This age clearly confines the Vindhyan Supergroup to the Proterozoic Eon and increases the likelihood of finding physical evidences for one or more of the Neoproterozoic global glacial events.
10. The variations of $\delta^{13}C$ and $\delta^{18}O$ in the Balwan Limestone are not the result of any facies variation, instead represent basin wide, if not global, changes in organic matter burial. The negative excursion observed within the formation probably reflects a large scale reduction in biology and the positive excursion reflects sudden change in biodiversity.

11. Based on this study a two stage model for the evolution of the Vindhyan Basin in Rajasthan has been proposed. At first stage ~1900 Ma due to the Aravalli Orogeny a foreland setting got generated in the eastern flank of the Aravalli mountain chain which supplied the sediments to the Lower Vindhyans for about 200 million years. The initiation of Delhi orgoney in the western flank of the Aravalli Mountain marks the closing of the Lower Vindhyans. After completion of the major Delhi folding at ~ 1400 Ma, the second stage sets in and the Upper Vindhyans start getting deposited.

Future Scope

The present work carried out on the Vindhyan Supergroup of rocks in Rajasthan Vindhyans demands a thorough study of these sediments at various places in the basin for developing a comprehensive evolutionary model for the Vindhyan Basin. In view of this, future studies that can be pursued are as follows:

1. Identification of locations of the subduction zones in the Aravalli-Delhi mountain chain.
2. The basal volcanics such as Khairmalia in the Rajasthan and Jungel in the Son Valley should be studied in greater detail for their contributions to the sediments for the Vindhyan Basin.
3. The geochronological attempts should be made to date volcanism in the basement.
4. Nd isotope fingerprinting of various basement rocks should be done in the Aravalli-Delhi mountain chain, especially in the Hindoli Group and the Delhi Group of rocks.
5. More field and isotopic work should be done on the limestone formations to look for the physical and chemical evidences for the Neoproterozoic glacial events.