ABSTRACT

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The south and south-eastern parts of Delhi are a plateau of 250-300 meters height, rising about 100 meters above the surrounding area is known as the famous Delhi ridge. The area provides an interesting place to study the important surface geochemical processes, because it occurs at the triple junction of Aravalli mountain, Thar desert and Indo-Gangetic plain and it possibly has some subsurface connection with the Himalayas. The extension of the Delhi ridge to the base of Himalayas is known as Delhi-Haradwar ridge. The present study on the quartzites, altered pegmatites and quartzites and the sediments provide a holistic approach to constrain upon the geological processes leading to geomorphological and geological transformation of Delhi region. The study involved textural, mineralogical and geochemical investigations on each of the geological units (lithologic and quaternary sediments). The involvement of surfacial and sub-surfacial agents for such a weathering and depositional process indicates a complex geological system. Delhi region has two important geomorphological features, the famous Delhi ridge and the alluvium of Yamuna. The Delhi ridge which covers the area of present study is predominantly made up of quartzites. These quartzites are intruded by pegmatites sporadically. These pegmatites had undergone alteration along with surrounding quartzites to give rise to deposits of china clay, silica sand and ferruginous sand (Badarpur sand). Spheroidal weathering of quartzites is abundant and the quartzites on their surfaces form weathering rinds of varying thickness. Besides the depressions on the Delhi ridge have accumulated the aeolian sediments of probable aeolian origin.

The study of Delhi quartzites using their geochemistry has been intended to understand their sources and processes by which they have been formed. The provenance is in turn important to understand the geological history, tectonic setting and therefore crustal evolution during the deposition of these sediments (Taylor and McLennan, 1985; Hemming et al., 1995; Fedo et al., 1996).

From the study of Delhi quartzites, it has been found that, although the quartzite has been subjected to diagenetic, metamorphic, and hydrothermal alterations, they are highly mature quartzites. It indicates that in the source region of the quartzites extensive weathering and intrabasinal recycling have played a major role. The weathering of protoliths in tropical to subtropical climatic condition on the stable craton would have made possible to make deep weathering profiles in the source region. The transportation of REE bearing phases and clays downward and their retention in the profile itself could have supplied quartzose sediments to the Alwar basin of the Middle Proterozoic time. Similarly, the occurrences of basal quartzites in the Precambrian cratonic facies of rocks can be explained. The average REE pattern of representative quartzites is similar to the PAAS with very low abundance. This shows that the provenance of these quartzites were evolved granitic in composition.

The Proterozoic metasedimentary quartzites of the Delhi Supergroup of rocks in the Delhi region has essentially very high content of silica with very low abundance of rare earth elements (REE), Zr and Y. In these weathering rinds developed on the quartzite there is nearly a two fold enrichment of REE in the moderately weathered zones, which also have the higher abundance of kaolinite. The REE patterns however are nearly identical to those of the unweathered core quartzite including in the strong negative Eu anomaly. In the strongly weathered outer zones both kaolinite and REE abundance decrease somewhat relative to the lower weak to moderately weathered zones. The weathering process here involved in the formation of kaolinite possibly by the breakdown of few grains of mica as well as in the oxidation of pyrites present in the quartzite. During this process, the REE seem to have been mobilised quantitatively by sulphate bearing solutions without any fractionation. In the process the outermost zones seem to have been made friable with lowered REE abundance. It is possible that the REE and Al depleted friable zones may have been physically eroded away. Thus, although the REE are mobile during weathering processes, they could be quantitatively retained in the weathering zones due to clay forming processes resulting in the production of silica rich, REE depleted supermature quartzite.

The study on the origin of kaolinite and sand deposits after pegmatites and surrounding quartzites has been aimed at understanding the conditions under which they have formed. This study provides an insight into the behaviour of REE and other elements in such an intensive leaching process under elevated temperatures. Using the REE as proxy for the actinides is important to understand the behaviour of the nuclear wastes under the similar geoenvironmental conditions (Rard, 1988; Wood, 1990).

The hydrothermal alteration of the pegmatites and quartzites to kaolinite and silica sand respectively have been mainly attributed to the nature of rock types, nature of the hydrothermal solution, and prevailing geothermal condition. For the origin of silica sand and ferruginous sand different mechanism seem to have been responsible, i.e., for the silica sand formation primarily pegmatitic impact and secondarily alteration of

feldspar was responsible and, for the ferruginous sand particularly ferrous-ferric complexion and silica removal was responsible. The heated meteoric water, which had acidic nature because of pyrite dissolution, was responsible for the alteration, but basic weathering condition also prevailed just below the transported sediments/soil to a few meters depth. Under the dominance of sulphate complexes REE were quantitatively mobilised, but locally particularly near the surface carbonate complexes were also important in the REE fractionation. The high REE and Sr in clay rich samples could be attributed to the florencite mineral, which were formed after apatite weathering/alteration. The hydrothermal solution with low REE abundance and strong positive Eu anomaly imparted its character during silica precipitation on to the growing quartz grains

Sediments present in the topographic lows on the Delhi ridge have been studied to understand their nature, aeolian, alluvial or residual. The textural, mineralogical and chemical signatures have been used to understand the processes involved in their transportation, and deposition and to evaluate the nature of their sources or provenance.

The sediments on Delhi ridge have textural, mineralogical and geochemical characteristics similar to those of loess sediments. Geochemically considering rare earth element abundances and chondrite normalised patterns, just as other loess sediments, DRS are similar to average exposed upper continental crust of Taylor and McLennan (1985). The chemical index of alteration, calculated from the carbonate free basis chemical data after Nesbitt and Young (1984, 1989) and other chemical parameters suggest a provenance of chemically least weathered ground up rocks. The last phase of the upliftment of the Himalayas, accompanied Pleistocene glaciation could have

provided a vast plain of glacial outwash deposits and the prevailing aeolian processes seem to have selectively transported fertile silt materials leaving behind infertile desert sands. The dust transport and their deposition by westerly to south-westerly winds are very important for the nutrient supply (base cations) and acid rain neutralisation in this region.

It is suggested that the surface geology of the Delhi region has been affected by Himalayan orogeny in many ways. Water and fertile sediments (soils) of the region have been brought from the Himalayas by the surface geological processes perhaps since Quaternary times. Subsurface processes probably caused or is still causing high temperature fluid flow from the thickened crust in the Himalayas to this region resulting in the physicochemical alteration of quartzite and pegmatite and the production of useful materials such as sand and china clay. It is well known that the seismicity of the Delhi region is due to the Himalayan collision.