Journal of Himalayan Earth Sciences 43 (2010) 10-10

Petrography of sandstone of the Lumshiwal Formation from the Samana Range, Hangu, northwestern Pakistan: Implications for provenance, diagenesis and environments of deposition

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The Cretaceous Lumshiwal Formation is exposed along a road-cut in the Samana Range, situated in Hangu, northwestern Pakistan. It largely consists of sandstone with some intercalations of shale and limestone. A total of 28 samples were collected at a regular interval of 5 m from the sandstone unit of the Formation for detailed petrographic studies. The studied samples of sandstone consist of abundant quartz (ranging up to 97 %), which may or may not be accompanied by accessory amounts of feldspars (averaging ~3 %) and traces of rock fragments and a variety of heavy minerals. The heavy minerals include tourmaline, monazite, zircon, muscovite, chert, rutile and goethite. Silica as quartz overgrowth is the dominant cementing material in the studied sandstone samples. A few of the samples however contain ferruginous cement. Due to very high modal abundance of quartz, all the samples classify as quartz arenite. This feature suggests that the Lumshiwal sandstone is mineralogically mature. The moderate degree of sorting and sub-angular to rounded outlines of framework constituents however point to the texturally sub-mature character of the sandstone. The mono-crystalline quartz is much more abundant than the poly-crystalline type, and the poly-crystalline quartz grains mostly consist of two to three sub-grains. Besides, the majority of the mono-crystalline quartz grains are non-undulose or only weakly undulose. These features suggest derivation of quartz from an igneous source rock. Furthermore, the presence of alkali feldspar and heavy minerals such as tourmaline, monazite, zircon, muscovite and rutile point to a source dominated by acidic plutonic igneous rocks.

Precipitation of silica as overgrowth cement in pore spaces, presence of long and sutured boundaries, absence of concavo-convex and tangential contacts and alteration of feldspar grains to clay minerals are the prominent diagenetic modifications in the studied sandstone. These changes represent the final phase (phyllomorphic) of diagenesis, deep burial, increased geothermal gradient and pressure as is also evident from quartz overgrowths, stylolitic boundaries of some of the grains and healing of intra-granular fractures in quartz and feldspar with ore minerals. The almost total absence of matrix and abundance of framework quartz suggest the falling sea level, i.e. high energy conditions. The presence of glauconite also supports shallow marine conditions for the deposition of the studied sandstone.