

PS Depositional and Diagenetic History of the Lower Siwalik Subgroup (Miocene), Northwest Himalaya, Jammu (India)*

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Abstract

In the Northwestern part of the Himalayan Foreland Basin, the Jammu region exhibits 6 km thick sedimentary succession of Siwalik Group exposed on the northern and southern limbs of the thrust cored Suruin-Mastgarh anticline and forms a link between the Siwalik rocks exposed in Pakistan in the west and beyond the Ravi River (India) in the east. These rocks are disposed in parallel folded zones and generally dip towards the southwest or the northeast at varying angles between 80 (Lower Siwalik) to 10 (Upper Siwalik) degrees.

The Ramnagar area of the Udhampur District in Jammu and Kashmir State exposes a thick pile of the Lower Siwalik rocks sandwiched between the Murree Group and the Middle Siwalik Subgroup on both the limbs of the doubly plunging Udhampur Syncline. Detailed sedimentological study has been carried out on two stratigraphic sections (Kalaunta and Ramnagar) in this area to establish the depositional and diagenetic history. Here the rocks consist of brown, reddish brown, grey and buff sandstones, reddish brown to dark brown siltstones, and light brown to reddish brown mudstones.

The stratigraphic accumulation of facies associations and evolution of fluvial style during the deposition of these rocks has developed in two stages. The stage first started with deposition of predominance of fine grained facies (mudstone and siltstone) as facies association FA1 in the Kalaunta section followed by dominance of flood flow and crevasse splay sediments characterized by lateral accreted cross stratified sandstone deposits of facies association FA2 in the Ramnagar section. Facies association FA3 comprises a sequence of fine to very fine sandstones, siltstones, and mudstones overlying the sand-mud dominated association and was deposited during these two stages as interfluvial deposition. These rocks are interpreted to have been deposited by a changing river system from fine grained meandering in the lower Kalaunta section to flood flow dominated meandering system in the upper Ramnagar section.

Diagenetic signatures observed in the sandstones of the area show a reduction in porosity from 42 to 15%. The major cause of the reduction in the porosity was due to cementation in the Kalaunta section and compaction in the Ramnagar section. Porosity versus depth relationship plots suggests a depth of burial in the range of 933 to 2000 m for the Kalaunta section and 800 to 1500 m for the Ramnagar section.

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DEPOSITIONAL AND DIAGENETIC HISTORY OF THE LOWER SIWALIK SUBGROUP (MIOCENE), NORTHWEST HIMALAYA, JAMMU (INDIA)

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ABSTRACT

In the Northwestern part of Himalayan Foreland Basin, the Jammu region exhibits c.6km thick sedimentary succession of Siwalik Group exposed on the northern and southern limbs of the thrust cored Suruin-Mastgarh anticline and forms a link between the Siwalik rocks exposed in Pakistan in the west and beyond the Ravi River (India) in the east. These rocks are disposed in parallel folded zones and generally dip towards the southwest or the northeast at varying angles between 80 (Lower Siwalik) to 10 (Upper Siwalik) degrees.

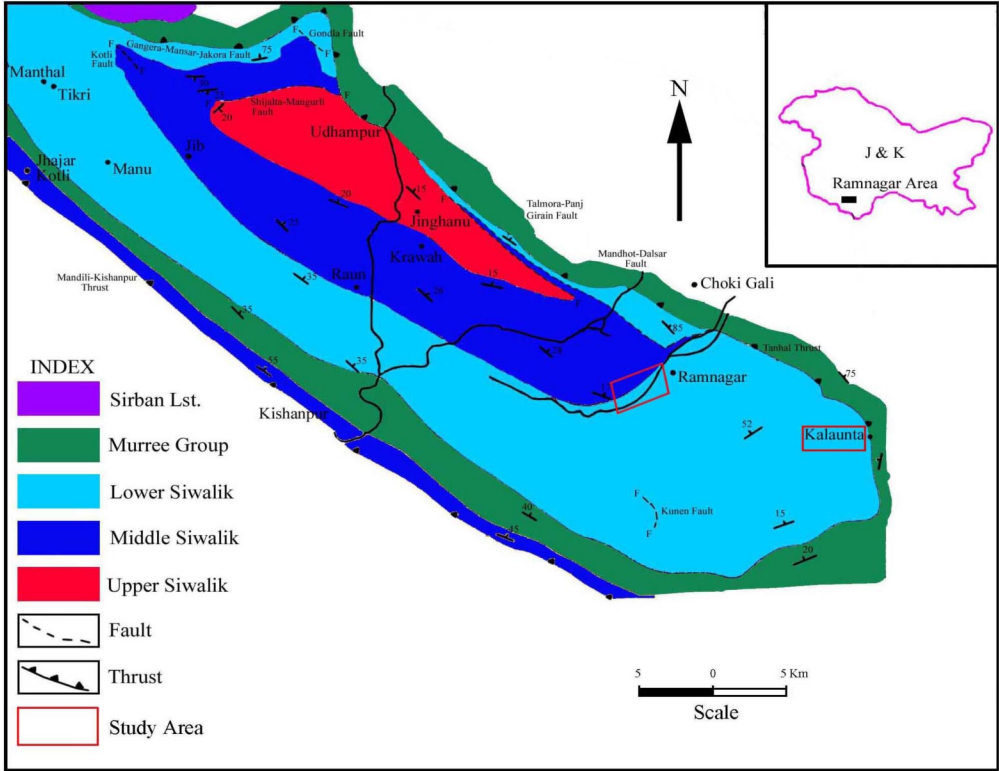
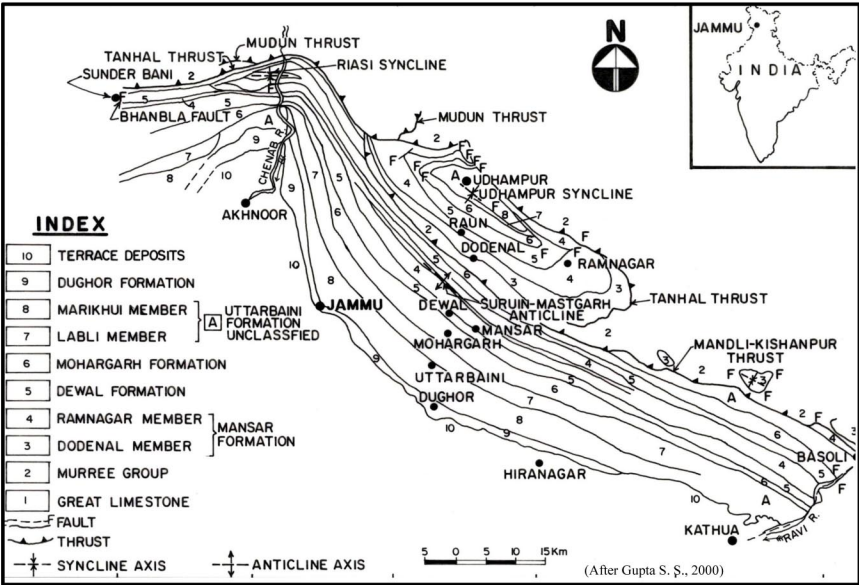
The Ramnagar area of the Udhampur District in Jammu and Kashmir State exposes a thick pile of the Lower Siwalik rocks sandwiched between the Murree Group and the Middle Siwalik Subgroup on both the limbs of the doubly plunging Udhampur Syncline. Detailed sedimentological study has been carried out on two stratigraphic sections (Kalaunta and Ramnagar) in this area to establish the depositional and diagenetic history. Here the rocks consist of brown, reddish brown, grey and buff sandstones, reddish brown to dark brown siltstones and light brown to reddish brown mudstones.

The stratigraphic accumulation of facies associations and evolution of fluvial style during the deposition of these rocks has developed in two stages. The stage first started with deposition of predominance of fine grained facies (mudstone and siltstone) as facies association FA1 in the Kalaunta section followed by dominance of flood flow and crevasse splay sediments characterized by lateral accreted cross stratified sandstone deposits of facies association FA2 in Ramnagar section. Facies association FA3 comprises of sequence of fine to very fine sandstones, siltstones and mudstones overlying the sand-mud dominated association and was deposited during these two stages as interfluvial deposition. These rocks are interpreted to have been deposited by a changing river system from fine grained meandering in the lower Kalaunta section to flood flow dominated meandering system in the upper Ramnagar section.

Diagenetic signatures observed in the sandstones of the area show a reduction in porosity from 42 to 15%. The major cause of the reduction in the porosity was due to cementation in the Kalaunta section and compaction in the Ramnagar section. Porosity versus depth relationship plots suggests a depth of burial in the range of 933 to 2000m for the Kalaunta section and 800 to 1500m for the Ramnagar section.

INTRODUCTION

The Himalaya originated due to continental collision between the Indian and the Eurasian plates that took place during the Late Cretaceous to Early Eocene times. Ongoing convergence has led to flexural down wrapping of the overridden Indian plate, forming the Himalayan molasse basin, the world's largest terrestrial foreland basin. There is well exposed, continuous record of detritus shed from the Himalaya into this basin called as Himalayan Foreland Basin (HFB). The rock sequence in the HFB includes Murree (Dharamsala) Group of Latest Eocene (or Oligocene) to Early Miocene age and the overlying Siwalik Group of Middle Miocene to Early Pleistocene age.



The Ramnagar area of the Udhampur District in Jammu and Kashmir State exposes a thick pile of the Lower Siwalik rocks classified as Ramnagar Formation by Gupta and Shali (1989) and is famous for its rich vertebrate fossil record. These rocks have been divided into Dodenal (=Kamlial Formation) and Ramnagar (=Chinji Formation) Members by Gupta (2000). Since the Ramnagar area has thick vegetation cover and the rocks are exposed along the streams, two representative lithosections of the Dodenal and Ramnagar Members, one in Kalaunta (194m) and other at Ramnagar (310m) were properly measured and documented.

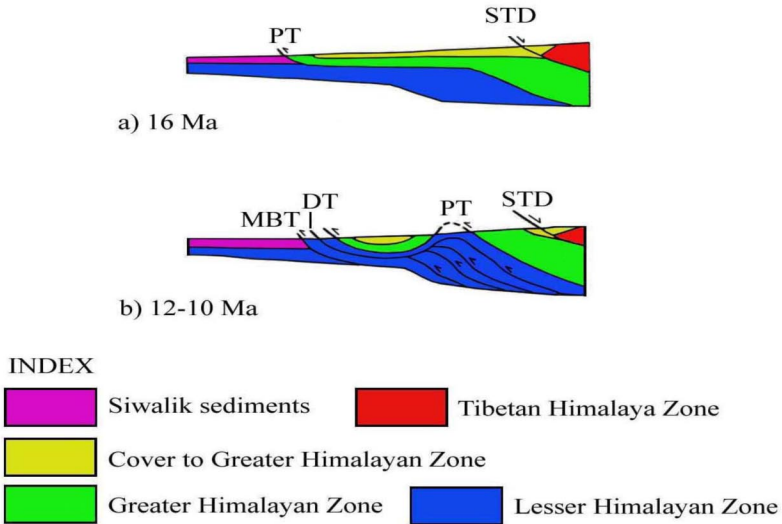
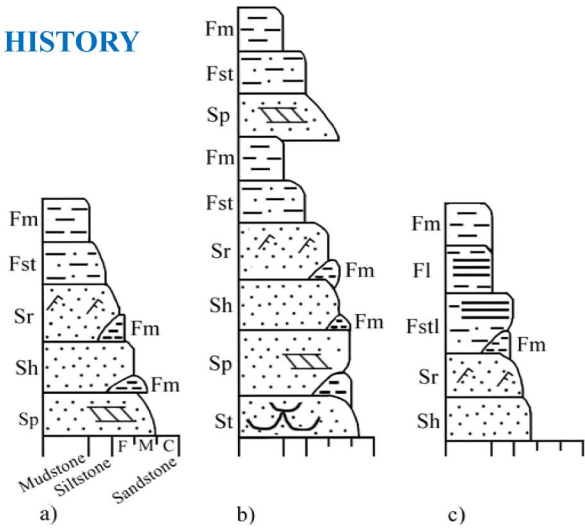


Fig: Schematic cross-section through the Himalayas to show orogenic evolution during Siwalik deposition (Modified after Szulc *et al.*, 2006). STD, South Tibetan Detachment; PT, Panjal Thrust; MBT, Main Boundary Thrust; DT, Diddol Thrust

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DEPOSITIONAL HISTORY



a) Facies association-1 (FA1) is interpreted as the product of a fine grained meandering system with associated floodplain deposits. The predominance of fine grained facies (mudstone and siltstone), bioturbation and presence of calcareous nodules suggest extensive floodplain deposits which were exposed for a long time at the surface.

b) Facies association-2 (FA2) is characterized by lateral accreted cross stratified sandstone deposits reflecting bed load of meandering channels. Variegated mudstones beds were formed on floodplains. The frequency and thickness of mudstone/siltstone bodies suggest extensive flood plain deposits which were exposed for a long time at the surface. The combination of these features supports the interpretation of a flood flow dominated meandering system. Abundance of laterally accreted sandstones, which increase stratigraphically upward and sandstone ratio may suggest a change in the meandering system from a distal setting to a proximal setting.

c) Facies association FA3 has been deposited during these two stages of sedimentation. In the present study area the facies consists of very fine-grained sandstones, laminated and structureless mudstones deposited in the inter-channel or the interfluvial areas (upland area) with the meandering river system (e.g., Bhat *et al.*, 2008). Interfluvial areas in most of the fluvial basins are low-lying features showing development of floodplain, swamps and ponds (Singh *et al.*, 1999). These typically low-lying areas with respect to the river channels are characterized by the facies architecture that indicates crevasse splay and suspended fall-out of fine-grained sedimentation. The predominance of bioturbated, pigmented mudstone/siltstone and the presence of calcareous nodules suggest extensive floodplain deposits which were exposed for long time at the surface. Intense mottling related to bioturbation suggests a slow rate of deposition.

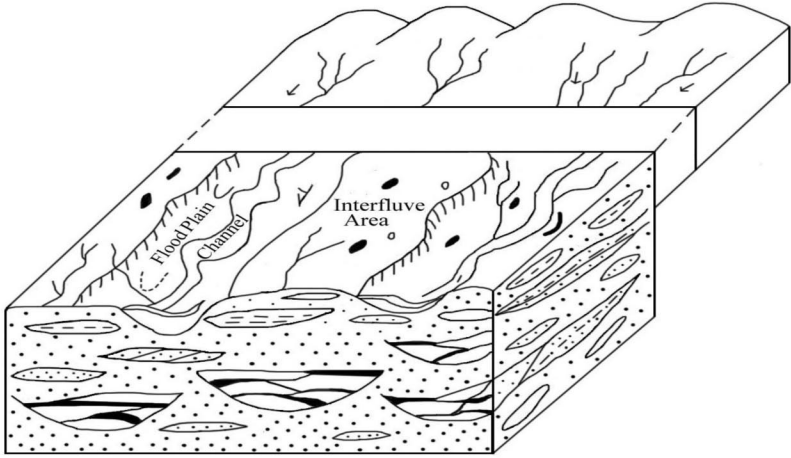


Fig.: Schematic block diagram showing the relationship of channel, flood plain and interfluv areas. Arrows indicate the direction of sediment movement. Thick lensoid bodies represent major rivers with multistoried build up along with overbank deposits (black). The bulk of stratigraphy is made up of fine-grained sediments comprising of mudstones and siltstones with thin sandy lensoid bodies representing minor rivers of interfluv areas. (Modified after Sharma *et al.*, 2001)

DIAGENETIC HISTORY

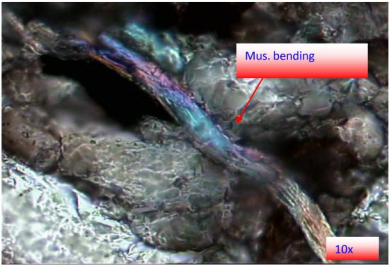


Fig.: Muscovite flake bending

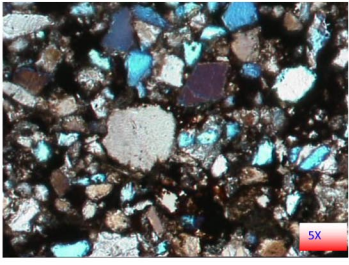


Fig: Detrital quartz grains floating in Fe calcite cement



Fig: Fractured/ strained quartz grains

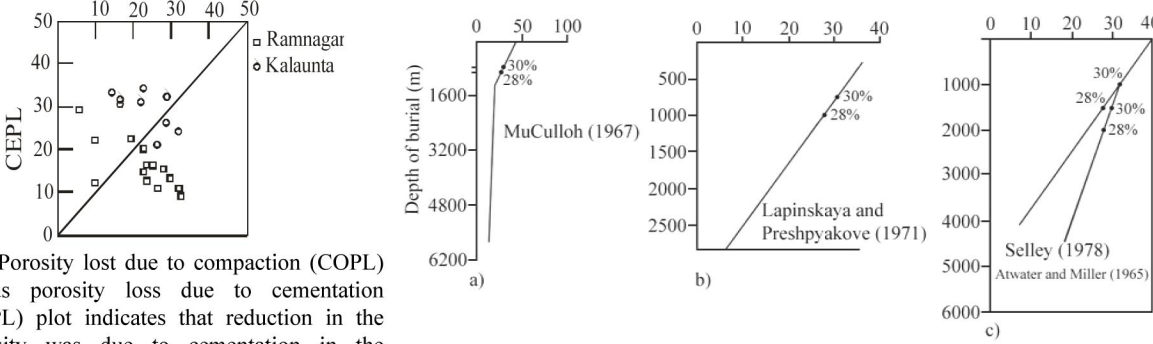


Fig: Porosity lost due to compaction (COPL) versus porosity loss due to cementation (CEPL) plot indicates that reduction in the porosity was due to cementation in the Kalaunta section and compaction in the Ramnagar section.

Fig.: Relationship between minus cement porosity (MCP) and depth of burial on three bivariate diagrams (a, b, c) determined in the study area

CONCLUSIONS

- The Lower Siwalik Group of rocks is interpreted to have been deposited by a changing river system from fine grained meandering in the lower Kalaunta section to flood flow dominated meandering system in the upper Ramnagar section.
- Diagenetic signatures observed in the sandstones of the area show a reduction in porosity from 42 to 15%.
- The major cause of the reduction in the porosity was due to cementation in the Kalaunta section and compaction in the Ramnagar section.
- Porosity versus depth relationship plots suggests a depth of burial in the range of 933 to 2000m for the Kalaunta section and 800 to 1500m for the Ramnagar section.