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PETROGRAPHY OF THE UPPER LITRA AND CHAUDHWAN FORMATIONS, UPPER SIWALIK GROUP, ZINDA PIR ANTICLINE, NORTHERN SULAIMAN RANGE

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ABSTRACT

The Zinda pir anticline of northern Sulaiman fold belt exposes, along its periphery, the Siwalik Group which comprises Vihowa, Litra and Chaudhwan Formations (in younging order). Petrographic studies of the upper Litra and Chaudhwan Formations indicate that the sandstones of these formations are texturaly similar. Moderate angularity and sorting, along with high content of feldspar, indicate textural imaturity of these sandstones. The Litra Formation is characterised by the abundance of almandine garnet and blue-green hornblende, indicating substantial contribution from the northern provenance (i.e., Kohistan island arc). Whereas petromict orthoconglomerates of the Chaudhwan Formation indicate a predominant western provenance (i.e., Fort Monro anticline).

INTRODUCTION

Neogene molasse sequence of Pakistan, the Siwalik Group, has attracted the attention of numerous research activities for more than a century (e.g., Blanford, 1883; Pilgrim, 1915). During the past two decades extensive bio-magnetostratigraphic and sedimentologic studies have been carried out in the Kohat-Potwar Plateau of northern Pakistan (Barndt et al., 1978; Opdyke et al., 1979; Barry et al., 1980; Tauxe & Opdyke, 1982; Johnson et al., 1985). However, the Siwalik Group exposed in the Sulaiman fold belt appears to been one of the least attracted areas in Pakistan due to hostile climate and tribal politics. Hemphil & Kidwai (1973) proposed new names for the molasse sequence of northern Sulaiman fold belt. Only recently some very interesting studies have been carried out involving surface and subsurface investigations (Banks & Warburton, 1986; Jadoon et al., 1989; Lillie et al., 1989; Jadoon et al., 1990; Humayon, 1990). Considering this, efforts have been made to study the petrography of the upper Siwalik Group rocks of the northern Sulaiman Range for understanding the provenance of these rocks. Lithologic correlation of the Siwalik Group of the Sulaiman Range with the similar rocks of Kohat-Potwar Plateau and Trans-Indus Ranges will help in developing a broader understanding of the temporal as well as spatial evolution of the Himalayan orogen and its related foreland basins, in Pakistan.

The Siwalik Group in Sulaiman fold belt comprises a molasse sequence of about 3000 m, that has been divided into three formations (Hemphil and Kidwai, 1973). This sequence includes (in younging order) Vihowa, Litra and Chaudhwan Formations. The Vihowa Formation is predominantly composed of red to maroon sandy and silty claystone, with subordinate greenish-gray, thick bedded sandstone. An unconformity between Vihowa Formation and the underlying Chitarwata Formation has been reported from a locality close to the present study area (Eames, 1952). Further north (in Bannu quardrangle), where the Chitarwata Formation is missing (or not recognised), the contact with the underlying formation is disconformable and sharp. The upper contact of the Vihowa Formation with the Litra Formation is transitional. The Litra Formation represents middle part of the Siwalik Group in the Sulaiman fold belt. Light gray fraible sandstone makes up the larger portion of this formation. Some red to reddish-brown clay beds are also present. Upper contact with the Chaudhwan Formation is apparantly conformably in the study area. The Chaudhwan Formation forms the upper most formation of the Siwalik Group in this area and predominantly comprises calcite-cemented conglomerates. Towards the base subordinate amounts of pale-brown sandstone and mudstone are present interbedded with the conglomerate. Upper contact of this formation with the overlying boulder bed is unconformable, and is indicated by the differential tilt of the beds.

The study area, vicinity of Sakhi Sarwar, is located in the southern portion of the Zinda Pir anticline, near Dera Ghazi Khan, in the Sulaiman fold belt (Fig. 1). Fort Monro anticline is the ominant structural feature in this area and exposes upper Cretaceous and Cenozoic rocks. Present investigations incorporate upper 700 m of the Litra Formation and 571 m thich Chaudhwan Formations, forming upper part of the Neogene molasse Siwalik Group. This part of the Siwalik Group has been assigned Plio-Pleistocene age on the basis of priliminary magnetstratigraphic studies (Ahmad, 1990).

PETROGRAPHY OF THE UPPER LITRA AND CHAUDHWAN FORMATIONS

Petrographic studies of the upper Litra and Chaudhwan Formations, exposed along the Sakhi Sarwar nala, in the southern Zinda Pir sturcture, are carried out on the basis of thin sections of sandstone samples, conglomerate phenoclast- composition study in field, and thin section study of conglomerate matrix. These studies provide important clues regarding the nature of the source rock, history of uplift and evolution of the orogenic belts in the source area.

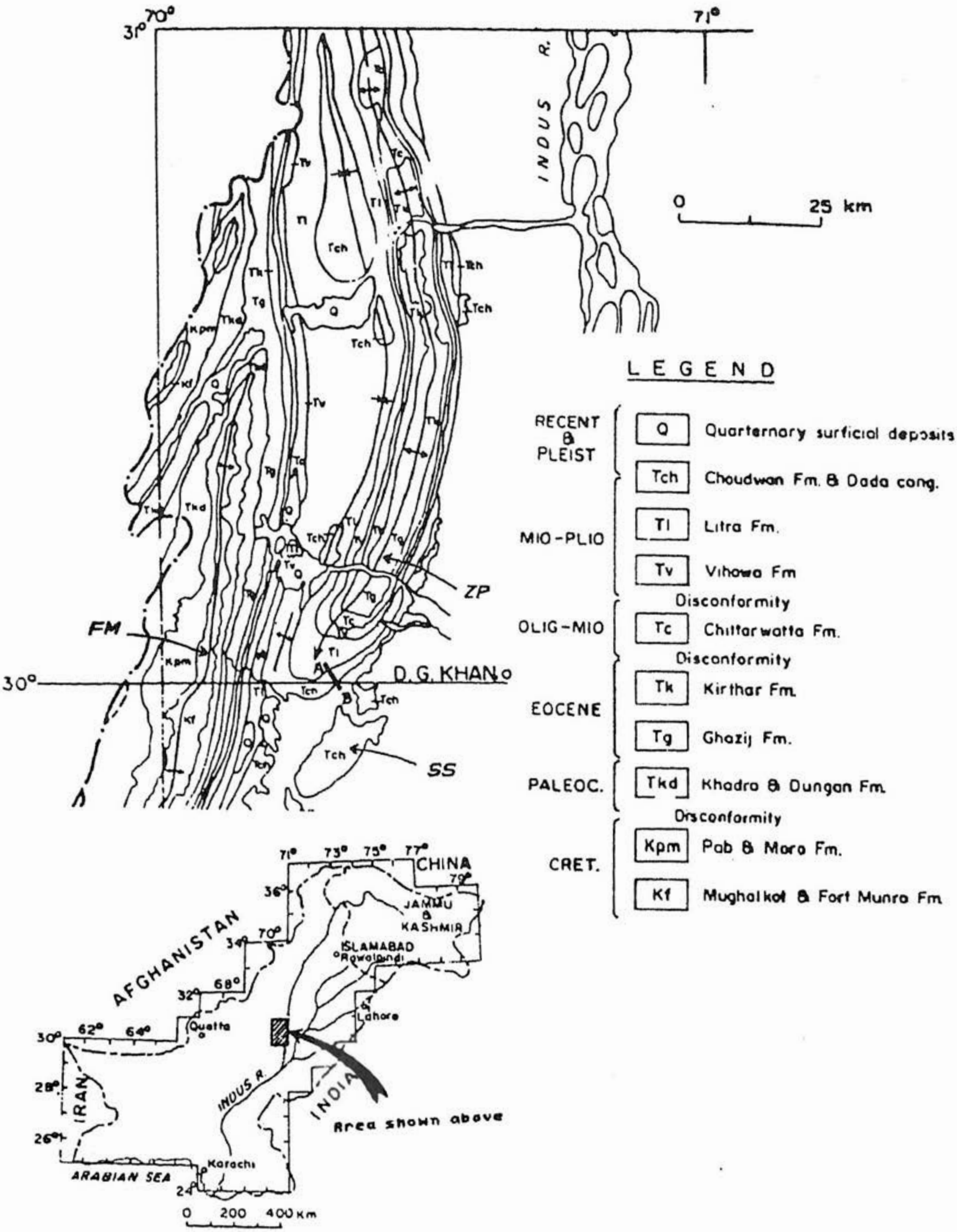


Fig. 1. Map of the Sulaiman Range showing location of the studied area. FM = Fort Monro Anticline; ZP = Zinda Pir Anticline; SS = Sakhi Sarwar Anticline.

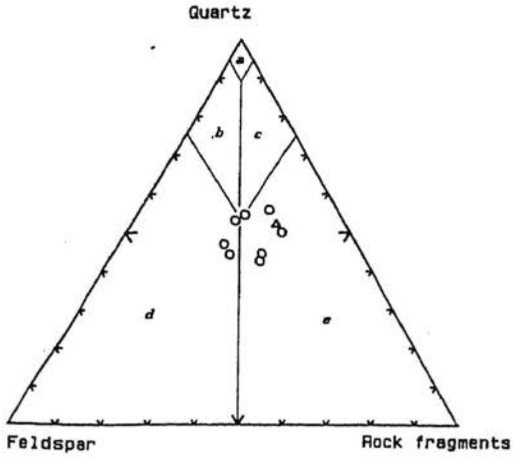
Sandstone Petrography

The texture and major framework components of the sandstones of the upper Litra Formation and the Chaudhwan Formation are generally similar. According to the classification of Dott (1964), the sandstone compositions of the upper Litra Formation range from feldspathic arenites to lithic arenites, whereas the sandstone of the Chaudhwan Formation is lithic arenite (Fig. 2; Table 1). The most eye-catching differences observed are absence of garnets, and near absence of hornblende in the Chaudhwan Formation, in contrast to upper Litra Formation. On the QFL provenance discriminantion diagram of Dickinson et al., (1983) these sandstones fall in the field typical of collision orogens and suture belts (Fig. 3).

TABLE 1. REPRESENTATIVE MODAL POINT-COUNT DATA OF THE UPPER LITRA AND CHAUDHWAN FORMATIONS

S.No.	Qm	Qp	Feld	Lm	Ls	Sf	Lf	Hb	Bt	Ms	Ep	Gt	Op	Ch	Rock Name
1	26.7	8.0	17.7	3.7	14.3	1.3	6.3	7.0	2.0	1.3	5.0	1.7	3.7	1.3	Lithic Arenite
2	40.3	6.7	21.7	3.0	9.0	1.0	7.0	2.3	3.3	1.3	2.3	Tr	2.0	-	Feldspathic Arenite
3	38.0	9.3	18.7	2.7	15.0	-	5.7	-	3.7	0.7	4.0	Tr	2.0	0.3	Lithic Arenite
4	36.3	2.3	21.7	4.0	19.0	0.7	6.3	8.0	2.0	0.7	2.0	Tr	2.7	0.3	Lithic Arenite
5	33.3	6.7	25.7	2.0	11.3	-	6.3	2.0	7.0	3.0	1.7	-	0.7	0.3	Lithic Arenite
6	34.7	3.7	85.7	2.0	13.7	-	6.3	2.0	4.7	2.0	2.7	0.3	0.7	1.7	Feldspathic Arenite
7	47.7	2.0	13.7	2.3	15.7	2.0	8.0	1.7	0.3	-	4.3	1.3	1.0	-	Lithic Arenite
8	45.0	2.7	14.7	-	17.3	6.7	9.0	-	1.0	-	2.0	Tr	1.7	-	Lithic Arenite
*9	43.0	5.7	14.7	3.3	14.3	1.0	11.7	1.7	1.7	-	3.7	-	0.3	-	Lithic Artenite

Abbreviations used: QM = Monocrystalline quartz, QP = Polycrystalline quartz, Feld = Feldspar, Lm = Metamorphic lithics, Ls = Sedimentary lithics, St = Shell fragments, Hb = Hornblende, Bt = Biotite, Ms = Muscovite, Ep = Epidote, Gt = Garnet, Op = Opaque phase, Ch = Chlorite. Classification of Dott (1964) used for naming the sandstones.



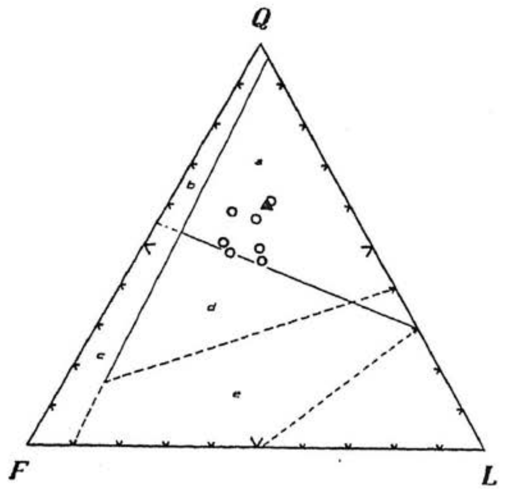


Fig. 2 (Left). Plot of point-count data of upper Litra (circles) and Chaudhwan (triangles) Formations, on the ternary diagram of major framework components (rock classification after Dott, 1964). Fields shown are (a) = quartz arenite, (b) = subarkose, (c) = sublitharenite, (d) = feldspathic arenite, (e) = lithic arenite.

Fig. 3 (Right). Point-count data from upper Litra (circles) and Chaudhwan (triangles) Formations plotted on QFL provenance discrimination diagram of Dickinson et al., (1983). Fields are (a) = recycled orogen, (b) = transitional continent, (c) = basement uplift, (d) = dissected arc, (e) = transitional arc, (f) = undissected arc.

Texture: The upper Litra Formation and Chaudhwan Formations comprise of friable light-grey and pale-brown sandstones, respectively. Generally, the sandstone is medium grained, but some sand bodies are fine grained. Most of the detrital grains are subrounded to angular (Fig. 4), but some quartz and lithic grains show comparatively high roundness. The sandstone is generally moderately sorted (Fig. 4). Elongated grains of mica show preferred orientation defining thin beds or laminae in the sandstone (Fig. 4). Mechanical deformation of mica due to compaction during burial and later tectonics is also observed in the sandstone (Fig. 5). Detrital grains are mostly framework supported (Fig. 4). At places where the sandstone is well-cemented, the intergranular spaces are completed occupied by sparry calcite. Moderate angularity and sorting, along with the high content of feldspar evince the textural immaturity of these sandstones.

Framework Components: Quartz, feldspar and rock fragments are the dominant framework components of the sandstone that are useful for provenance determination. These framework components are described below.

Fig. 4. Photomicrograph (plane light) showing moderate sorting and parallel alignment of elongated grains of biotite in sandstone of upper Litra Formation.

ig. 5. Photomicrograph (plane light) of mechanically deformed biotite grain in the sandstone from the upper Litra Formationa.

Quartz is the most common detrital constituent. It generally makes up from 46% to 60% of the framework components of the studied sandstones. Based on their optical properties, quartz grains were grouped into two catagories; 1) monocrystalline grains with undulatory and nonundulatory extinction, and 2) polycrystalline grains. Meta-quartzite fragments, where present, were counted as polycrystalline quartz. Some quartz grains contain inclusions of muscovite and epidote.

Feldspar is a prominent detrital constituent and makes 16% to 32% of the framework components. It occurs predominantly as orthoclase with subordinate plagioclase and microcline. Feldspars are mostly fresh but some show the effects of sericitization. Inclusions of epidote, zircon and tourmaline are commonly present in the feldspars.

Rock fragments form a major component of the framework constituents, ranging from 22% to 34% of the total framework components. The metamorphic lithics are mainly schists with some gneiss fragments. Sedimentary lithics include sandstone, siltstone, limestone (both, micritic and sparry), shell fragments (mostly forams), and some chert. The sedimentary lithics such as siltstone are derived from within the basin of deposition by erosion of previously deposited silt and clay. Sandstone rock fragments are mostly of the Cretaceous Pub Sandstone exposed in the Sulaiman belt west of the study area. Most of the carbonate lithics have been derived from the Eocene shelf sediments (as indicated by the presence of nummilities shells) also exposed in the Sulaiman belt (Fig. 6).

Heavy minerals are a major discriminating factor on the basis of which the sandstones of the upper Litra and Chaudhwan Formations can be easily distinguished. The heavy minerals identified in the Litra Formation include amphibole, epidote, biotite, muscovite, garnet, chlorite, opaques and traces of tourmaline. Whereas the heavy mineral assemblage observed in Chaudhwan Formation includes biotite, traces of epidote, opaques (hematite and some magnetite), and muscovite.

Amphibole occurs as elongated flakes with irregular broken edges. It commonly exhibits well developed cleavage and is strongly pleochroic. The amphibole from upper Litra Foramtion is the blue-green hornblende, chemically ranging from tschermekite to magnesio-hornblende (Fig. 7). Among micas, biotite is the dominant type. It forms the major heavy mineral phase in both upper Litra and Chaudhwan Formations. At places the biotite grains are covered by iron-oxide coating making them almost opaque and difficult to recognize. Subordinate amounts of muscovite is also present. Epidote is a common heavy mineral in upper Litra Formation. In this formation the epidote grains are commonly fractured and have irregular outline. In Chaudhwan Formation only a scant amount of epidote was observed. Opaque minerals are dominantly hematite, magnetite and probably ilmenite.

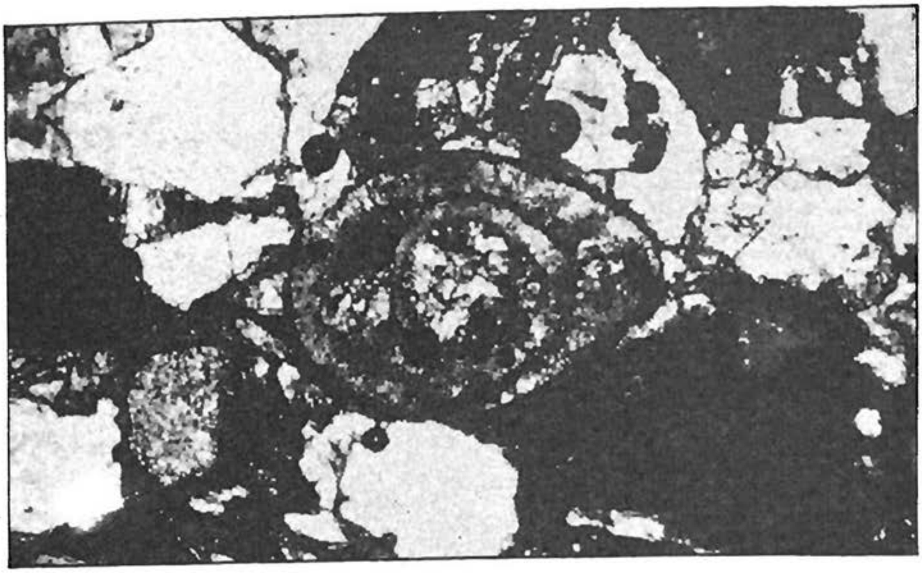


Fig. 6. Photomicrograph (crossed nicols) showing nummulitics shell in the sandstone from the upper Litra Formation.

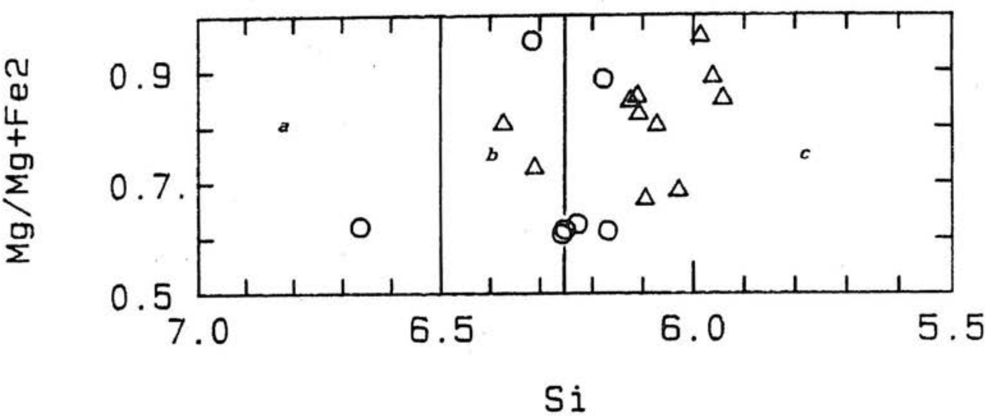


Fig. 7. Amphibole analyses from upper Litra Formation (circles) and Kohistan Island Arc (triangles) (Bard, 1983). Fields defined are (a) = magnesio-hornblende, (b) = Tschermakitic hornblende and (c) = Tschermakite (Leake, 1978).

A prominant feature of the Litra Formation is the presence of garnets. The garnets occur as subrounded grains and can be easily identified due to their isotropic behavior under cross- polarized light and high relief. Chemically the garnets are dominantly of the almandine-rich variety (Fig. 8). No garnets were seen in the sandstone of Chaudhwan Formation.

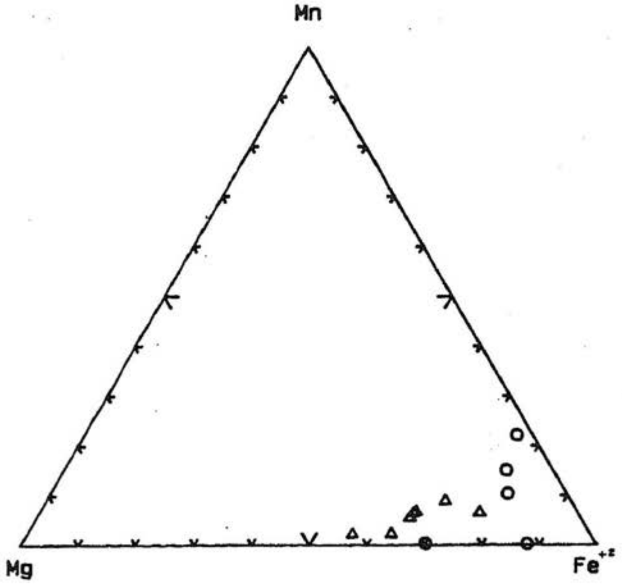


Fig. 8. Mn-Mg-Fe^{+2} ternary diagram of garnets from upper Litra Formation (circles) and Kohistan Island Arc (triangles) (Bard, 1983).

Conglomerates

Upper Litra Formation: The lenticular channel-fill conglomerates of the Litra Formation are dominantly polygenetic (polymictic) orthoconglomerates. Texturally, they have a framework of boulders, cobbles, pebbles and granules with coarse-sand-size grains of quartz, feldspar, limestone and shell fragments filling the voids. At places the voids are filled by sparry calcite. The largest boulders range in size from 25 to 35 cm. The boulders, cobbles and pebbles are generally rounded (Fig. 9), whereas the sand grains in the matrix are subrounded to angular. The phenoclasts comprise mostly of limestone (mostly Eocene as evinced by the presence of nummulities, Fig. 10), sandstone (some of which bear semblence to the Pab sandstone), quartzite, chert, along with some intrabasinal pebble-size rip-up clasts of mudstone. Almost 90% of the phenoclasts are limestone while sandstone and the other types account for the rest.

Chaudhwan Formation: Chaudhwan Formation is marked by the preponderance of petromict orthoconglomerates. Most of Chaudhwan Formation comprises of thick sequences of granule- and pebble-size conglomerates with lenses of cobbles and boulders (20 to 35 cm). The lenses become more prominent towards the top of the formation. The phenoclasts of Chaudhwan Formation are generally similar to those occuring in the channel-fill conglomerates of Litra Formation. The most prominent feature of these conglomerates is abundance of nummulities shells (Fig. 10). Generally, these conglomerates are cemented by sparry calcite. However, quartz and feldspar grains also occur in the voids.

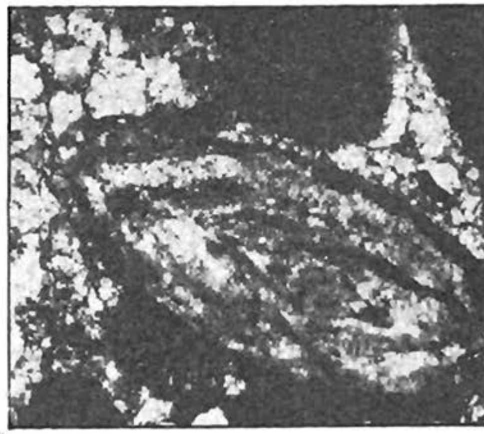


Fig. 9 (left). Conglomerate of the upper Litra Formation.

Fig. 10 (right). Photomicrograph (crossed nicols) of a nummulities shell surrounded by sparry calcite. Conglomerate from the Chaudhwan Formation.

CONCLUSION

Plio-Pleistocene fluviatile molasse sediments of the upper Siwalik Group exposed in the Sakhi sarwar nala, southern Zinda Pir anticline comprise Litra and Chaudhwan Formations. The Litra Formation dominantly comprises of sandstone, with subordinate siltsone/claystone. Whereas in the Chaudhwan conglomerate is preponderant. The sediments of the upper Litra Formation were predominantly derived from northern provenance (including Kohistan islan arc) as is indicated by the presence of tschermakite/magnesian-hornblende and almandine-rich garnet in these sediments. However, the sporadic occurance of limestone (Paleocene-Eocene) and sandstone (Pab Sandstone) bearing conglomerate at various stratigraphic levels in the upper Litra Formation indicates that uplifting along Fort Monro anticline had initiated by that time. Thus exposing Cretaceous Pab Sandstone and Paleocene-Eocene limestone.

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