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DEPOSITIONAL ENVIRONMENTS OF THE HISSARTANG FORMATION ATTOCK–CHERAT RANGE, PESHAWAR

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ABSTRACT

Hissartang Formation forms the middle part of Silurian-Devonian stratigraphic sequence exposed in the Attock-Cherat Range. Detailed petrographic, textural and structural studies reveal that this formation consists of two facies described as follows.

1. Agrillite facies :
   a. *Lower Argillite (99.12m) thin bedded, grey in colour.*
   b. *Upper Argillite (72.73m) thin bedded variegated in colour.*

2. Quartzose Sandstone facies :
   a. *Lower Quartzose Sandstone : (88.80m), thin to thick bedded, white to light grey in colour.*
   b. *Upper Quartzose Sandstone : (105.99m), medium to thick bedded, white to light grey in colour.*

Only a few stratigraphic horizons of the upper quartzose sandstone show cross beds. Whereas thin to thick strata and thin laminae are commonly present in both, argillites and quartzose sandstone facies. Lack of various sedimentary and biogenic structures, fine grain size of quartzose sandstone and association of argillites suggest the supratidal to subtidal environments. Fine grain size of quartz and absence of barrier ridge sandstone suggest the large distance of transport of quartz particles and lesser amount of terrigenous material available.

INTRODUCTION

The Hissartang Formation comprises middle part of the Silurian-Devonian stratigraphic sequence of the Attock-Cherat Range. The type section and other sections are easily accessible and well connected by metalled and fairweather road.

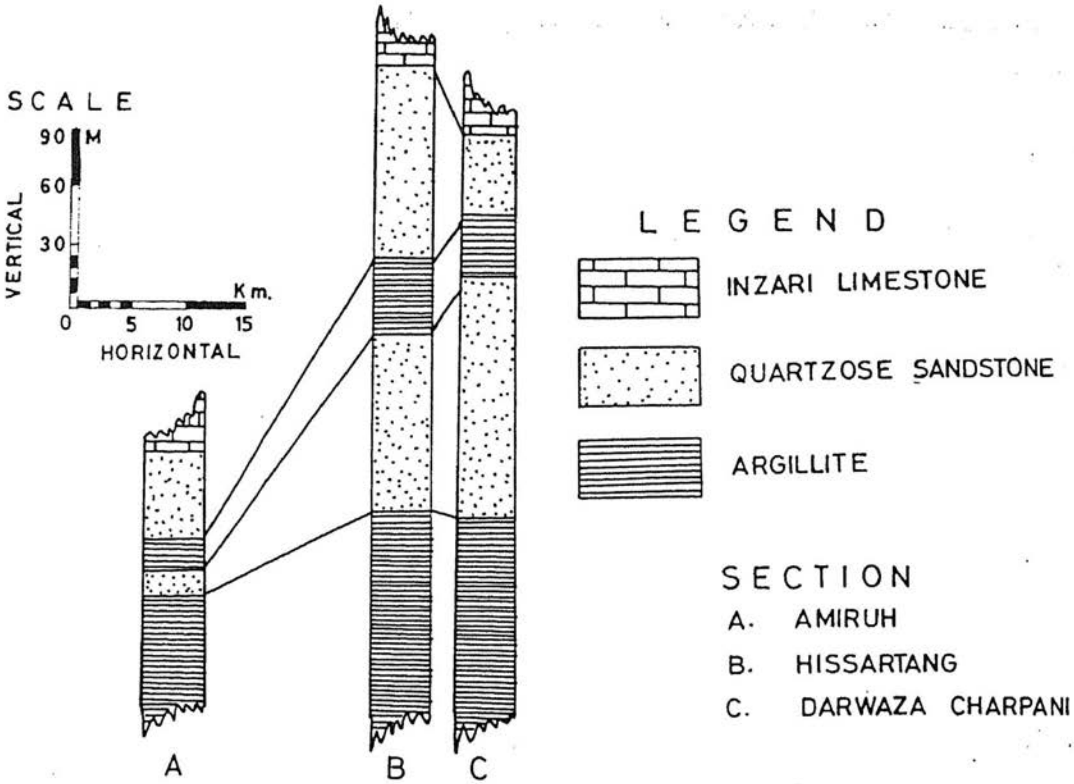

Fig. 1. Stratigraphic column of the Hissartang Formation as measured in different sections.

According to Hussain (1984), "the Hissartang Formation is composed of thin bedded agrillites, thin to thick bedded quartzose sandstone and both, agrillites and quartzose sandstone are nonfossiliferous".

The formation is well exposed in Hissartang (type section), Darwaza-Charpani, Inzari, Kahi, and Amiruh sections. The formation is continuous without any interruption between the northern slope of Jalalsar and Darwaza-Charpani villages for a distance of about 48 km.

On the basis of lithology, the formation has four units (Fig. 1) :

Upper Quartzose sandstone
Upper Agrillite
Lower Quartzose sandstone
Lower Agrillite

1. *Lower Agrillites :*

These are thin bedded, grey in colour and very fine grained. Some strata show rusty brown colour due to leaching of iron minerals and golden sheen due to weathering. These are characteristically thinly laminated. Thickness at type section is 99.12m, at Darwaza-Charpani 95.86m and at Amiruh 57.28m.

2. *Lower Quartzose Sandstone :*

These are thin to medium bedded and coloured variously from white to light grey and light brown to brown. Specks of iron are found throughout this unit.

Thickness of this unit at type section is 88.80m, at Darwaza-Charpani 122.99m and at Amiruh 7.44m.

3. *Upper Argillites :*

This unit is thin bedded and highly fractured. The colour is variegated, green, grey, light greenish-brown to reddish-brown. The unit shows fine laminae and within one centimeter more than twenty laminae can be counted. On the exposed surface these show iron leaching.

Total thickness of this unit at type section is 21.73m, at Darwaza-Charpani 30.78m and at Amiruh 20.52m.

4. *Upper Quartzose sandstone :*

These are white to light grey in colour, thin to thick bedded, hard and compact. At some places these look greyish-brown to greenish-brown. The unit shows darker coloured laminae and iron specks. The important features of this unit are cross beds which are present in the middle part of all the three stratigraphic sections (Amiruh, Darwaza-Charpani and Hissartang).

Thickness at type section is 105.97m, at Darwaza-Charpani 42.51m and at Amiruh 53.55m.

The lower contact of the Hissartang Formation with Darwaza Formation is covered by alluvium in Hissartang, Darwaza-Charpani and Amiruh sections. The upper contact with Inzari Formation is gradational and conformable.

The formation is correlated with Silurian-Devonian Quartzite of Missribanda (Hussain, 1984). As the formation is nonfossiliferous, so the age assigned to the formation is Silurian-Devonian on the basis of lithologic correlation.

DETAILED LITHOLOGICAL DESCRIPTION OF THE HISSARTANG FORMATION AT HISSARTANG TYPE SECTION. (MEASURED FROM BOTTOM TO TOP)

	Thickness	
	m	cm
Agrillites, thinly bedded, showing grey colour at fresh surface but brown at exposed surface, at places minor folds also found, highly fractured and laminated.	42	37

Argillites, medium bedded, light to dark grey at fresh surface and light brown to reddish-brown at exposed surface; laminated and fractured.	16	63
Argillites, thin to medium bedded, medium beds are interlayered by thin beds, grey at fresh and exposed surface but at some places brown appearance at exposed surface, fractured and laminated.	40	12
Fine grained quartzite, medium bedded, interlayered by thin beds of argillites, grey coloured and fractured.	4	63
Argillites, thin bedded greyish at fresh surface and brown at exposed surface, laminated, fractured.	1	45
Fine grained Quartzite, medium bedded, grey (light to dark) coloured, brown exposure negligible, specks are found and is fractured.	12	43
Fine grained, quartzite, thin bedded, grey coloured, specked, fractured. At certain places brown exposure (from light to dark reddish-brown).	21	11
Quartzite, thin to medium bedded, fine grained, light grey to greenish-gray, specked but specks are less concentrated than previous unit.	19	83
Quartzite, fine grained, thin bedded, grey coloured, laminated.	1	85
Clayey unit, thin bedded, grey to greenish-grey colour.	1	23
Quartzite, medium bedded, dark grey, laminated and specked. Whitish material found along the laminations.	2	64
Quartzite, thin to medium bedded, light to dark grey laminated, specked.	5	90
Fine grained, quartzite, thin bedded, grey coloured, no specks found, laminated.	0	39
Quartzite, thin bedded to medium bedded, light grey colour, with no specks, laminated.	0	92
Fine grained quartzite, thick bedded, light, whitish-green colour at fresh surface but light whitish-brown on exposed surface, specked.	17	00
Argillites, variegated colour, finely laminated, thin to medium bedded, highly fractured, showing reddish-brown colour at most of places due to iron leaching.	23	73
Grey coloured quartzite, fine grained, thin bedded, laminated.	4	48
Clayey unit, greenish grey, highly fractured, and laminated.	0	62
Quartzite, thick bedded, reddish-brown to brown at exposed surface but greyish-brown at fresh surface.	2	42

Argillites, variegated colour, fine grained, thin bedded, laminated, exposed surface reddish-green and show minor folding.	10	72
Quartzite, fine grained, medium bedded, whitish-brown to brown.	5	73
Quartzite, fine grained, medium to thin bedded, highly fractured, dark grey coloured, laminated.	3	60
Quartzite, fine grained, medium bedded, dark grey coloured.	5	10
Argillites, variegated colour, thinly bedded, laminated and highly fractured.	8	50
Quartzite, fine grained, medium to thick bedded, whitish-brown to brown in colour, specked, at some places cross beds are noted. At some places colour becomes greenish-grey at fresh surface but it is mostly whitish-brown to light brown at fresh surface.	27	80
Clayey unit, thin bedded, fractured, greenish-grey colour.	0	36
Quartzite, fine grained, brownish-grey to grey coloured, specked.	2	56
Clayey unit, thin bedded, highly fractured, greenish-grey to grey in colour.	0	32
Quartzite, medium bedded, light brown to reddish-brown colour, fractured and specked.	8	73
Quartzite, thin to medium bedded, light grey to light greenish-grey in colour and specked. At places laminae and cross beds found.	12	48
Quartzite, thin bedded, grey to dark grey in colour and fractured.	10	87
Argillites, variegated colour, laminated and fractured.	0	86
Quartzite, thick bedded, specked, brownish-grey coloured.	3	35
Quartzite, medium to thick bedded, specked, light brownish-grey to grey coloured.	4	11
Quartzite, thin to medium bedded, light reddish-brown to reddish-brown at exposed surface. At some places colour becomes light brownish grey to greyish-brown at exposed surface but at fresh surface it is light grey to grey and laminated.	9	36

PETROGRAPHY

Mineral composition of argillites and quartzose sandstone has been determined by petrographic techniques. The percentage composition of various minerals is evaluated by comparing the visual charts of Compton (1962) and Chilinger, Bissel and Fairbridge (1967). Various minerals can be categorized as following, in order of their decreasing abundance.

Argillites

Major Minerals : Clay (Kaoline?)

Accessory Minerals : Quartz, ore mineral, muscovite, biotite, alkali feldspar, sericite, chlorite.

Cementing Material : Calcareous.

Quartzose sandstone

Major Minerals : Quartz.

Accessory Minerals : Ore minerals, muscovite, epidote.

Cementing Material : Siliceous.

TEXTURE

Argillite

These are very fine grained with plenty of quartz veins developed along fractures. Argillites also contain few quartz particles of silt and very fine sand size embedded in clay matrix and appear as floating in it. Alteration of clay is important textural feature at some stratigraphic levels. The alteration products are chlorite, sericite and show crinkled laminae. Iron is present along fractures showing the effects of oxidation.

Quartzose sandstone

These are characterized by specks of iron.The grains are of fine to medium sand size. The quartz particles are subangular to subrounded, showing long, concavo-convex contacts. Ore minerals, among which ilmenite is the most important are scattered throughout as isolated grains among quartz particles. Sorting in quartzose sandstone is well to moderate (based on visual observations). Quartz particles are subrounded and indicate that quartzose sandstone of the Hissartang Formation are mature.

ENVIRONMENTS OF DEPOSITION

On the basis of lithological, textural and structural studies, two distinct facies are recognized. These include :

1. Argillite facies
   a. Lower Argillites
   b. Upper Argillites
2. Quartzose Sandstone facies
   a. Lower Quartzose Sandstone
   b. Upper Quartzose Sandstone

1. Argillite facies

This facies can be divided into two units, which alternate with quartzose sandstone facies. Both units represent similar mineralogical as well as textural features, indicating same source and similar environmental parameters. This facies is typically characterized by fine laminae (mm scale), formed due to vertical textural variation. The dominant constituent of the facies are clay minerals with subordinate very fine quartz silt imparting laminae (mm scale).

This facies is devoid of any depositional and organic structures which would have provided a strong basis for environmental diagnosis.

Mud facies have been reported from various environments including deeper pelagic (Davies and Gorsline, 1976; Windom, 1076), Shelf (Kulm *et al.*, 1977) and tidal flats (Renieck and Singh, 1973).

Mud facies of the pelagic environments are open sea deposits and contain less than 20% terrigenous sediments of fine silt size (Renieck and Singh, 1973; Friedman and Sanders, 1978; Ramsay, 1973; Burger and Winterer, 1974; Winterer, 1973; Davies and Gorsline, 1976; Window, 1976) and include

a) Skeletal remains of micro-organisms that live in seawater e.g. Planktonic forams, siliceous sponges and oozes.

b) Nodular chert derived from either volcanic emanations or disolution and precipitation of siliceous tests of bottom communities.

c) The alteration of clay minerals.

d) Any chemical precipitate.

But the argillites of Hissartang Formation neither contain skeletal material and oozes nor show any sign of chert.

The mud deposits of shelf are characterized by strong bioturbation, patches of faecal particles and burrows, intercalation of storm silt layers, laminated and weakly graded, and are dark in colour. Whereas the muds of Hissartang Formation are laminated and dark coloured only.

The argillites are also deposited in the upper part of high tidal flat at the time of flood slack below which quartz arenite is deposited. According to Renieck and Singh (1975), these argillites are (1) composed of mud and rarely fine sand, and (2) are thin bedded and with fine laminae. Similar is case with Hissartang argillites which are also composed of mud, contain fine sand size particles of quartz embedded in mud, and thin bedded to finely laminated.

The similarity of Hissartang argillites with those of high tidal flats (Fig. 2) shows that Hissartang argillites were deposited on high tidal flat when suspension load settled down at the time of low energy.

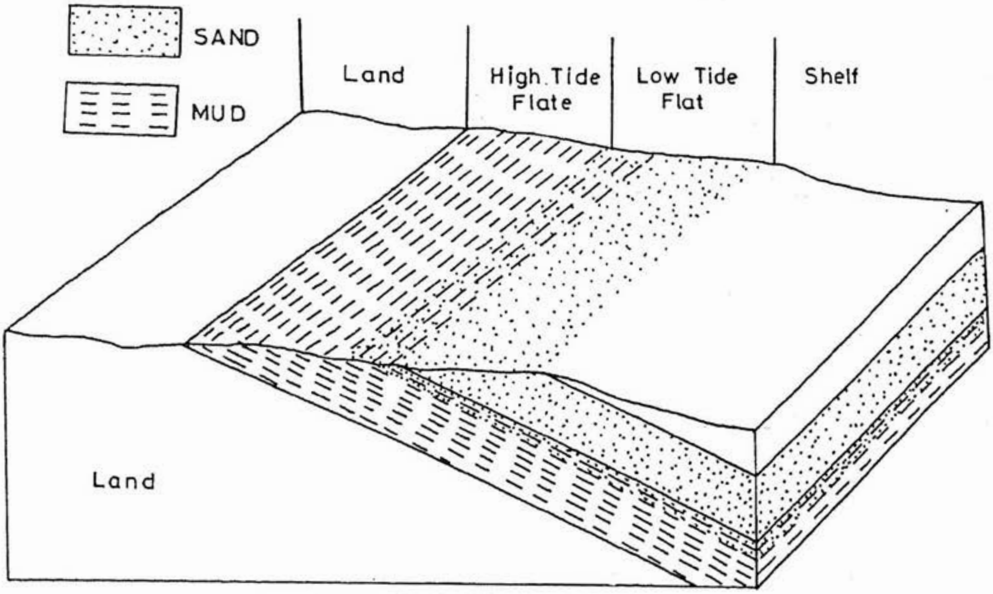

Fig. 2. Schematic cross section across the tidal flats.

2. *Quartzose sandstone facies*

The quartzose sandstones are interbedded with carbonate sediments which are most probably of intertidal and supratidal in orgin (Laporte, 1968; Halley, 1975; Tissue, 1977). This field association with carbonate implies that quartzose sandstones are of shallow water origin. Several depositional models were proposed and documented including fluvial (Mc Dowell, 1957); eolian dune (McKee, 1966; Folk, 1968), beach and barrier island (Fraser, 1976), and tidal flats and tidal sand bodies (Klein, 1970a, 1970b; Swett *et al.,* 1971; Singh, 1969, Barnas and Klein, 1975; Erickson, 1977; Button and Voss, 1977; Tankard and Hobday, 1977; Beukes, 1977) (Fig. 3).

The fluvial environments sand is deposited as point bars which are characterized by the presence of cross strata and gradation of grain size and structures. But in case of Hissartang quartzose sandstone no such evidence is found.

Beach sands are unimodal and contain heavy minerals. But Hissartang quartzose sandstones are neither unimodal nor contain so much heavy minerals like that in beaches.

The eolian dunes are characteristically unimodal and along its steeper side large scale cross strata are formed. But Hissartang quartzose sandstones are

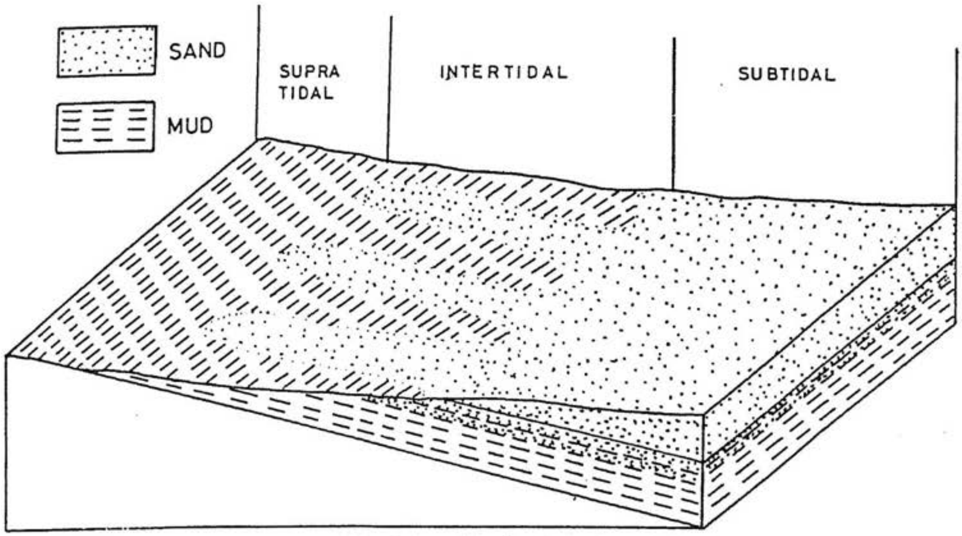

Fig. 3. Tidal flat facies model (modified after Klein, 1970b).

neither unimodal nor contain such large scale cross strata. Thus the idea about these quartzose sandstones to be of eoline dune is inappropriate.

The sand in barrier complex form basal horizontal laminated beds, gently seaward dipping beds, steeply landward dipping beds and washover fans and deltas. No such sequence is found in quartzose sandstone of the Hissartang Formation. Therefore, it is not plausible to say that Hissartang quartzose sandstones were deposited in barrier complex environments.

Quartzose sandstone of subtidal zone are massive, structureless and show biogenic structures when studied in detail. These also show low angle cross beds due to reversing tidal current bed load.

Like the quartzose sandstone of subtidal zone, the quartzose sandstone of the Hissartang Formation are massive and devoid of any depositional structures except low angle cross beds in the middle part of upper quartzose sandstone.

There are many reasons for these quartzose sandstone to be of tidal flat origin: Both intertidal and shallow subtidal (Figs. 2 and 3). Sand bodies are characterized by grain transport due to alternate flood and ebb currents. Such a sand transport mechanism provides means for a long distance grain transport and abrasion. This long transport causes :

i. removal of less resistant components
ii. higher roundness of resistant components.

Maturity and roundness are the characteristics of intertidal and subtidal sand bodies. Mineralogical maturity and higher roundness of quartzose sandstone of the Hissartang Formation suggest deposition in intertidal and subtidal environments.

Keeping in view the above discussion, it is concluded that the pattern of intertidal and shallow subtidal sand bodies favour the development of quartzose sandstone. It is, therefore, very likely that the dominant quartzose sandstone is of shallow subtidal origin.

SUMMARY

The Hissartang Formation forms the middle part of Silurian-Devonian stratigraphic sequence exposed in the Attock-Cherat Range, Peshawar District.

Lithologically, the Hissartang Formation is composed of argillites and quartzose sandstones as described below:

Name of unit	Description	Thickness (m) (type Section)
Upper Quartzose Sandstone	Medium to thick bedded white to light grey at fresh surface and rusty brown on weathered surface.	105.97
Upper Argillites	Thin bedded, variegated in colour on weathered surface but light grey on fresh surface.	27.73
Lower Quartzose Sandstone	Thin to thick bedded, white to light grey on fresh surface and light brown to reddish-brown on the weathered surface.	88.80
Lower Argillites	Thin bedded, variegated colour on weathered surface and light grey to dark grey on fresh surface.	99.12

Iron specks are present in both the units of quartzose sandstone which are more distinct on the weathered surfaces as compared to that on fresh surfaces. Only a few stratigraphic horizons of the upper quartzose sandstone have cross-beds whereas thin to thick strata and fine laminae are common in both argillites and quartzose sandstones.

Petrographic study reveals that the argillites are mainly composed of clay with subordinate quartz, micas, alkali feldspar and ore minerals whereas the quartzose sandstones mainly consists of quartz with muscovite, epidote and ore minerals as accessories.

Texturally, argillites are very fine silt/clay sized, poorly sorted and show crinkled laminae. The quartzose sandstones are fine to medium sand sized, moderate to well sorted and have subrounded to rounded grains.

The maturity and roundness of grains of quartzose sandstone indicate long distance transport before final deposition.

On the basis of maturity, roundness, absence of various sedimentary and biogenic structures, fine grained sand size of quartzose sandstones and association of argillites suggest the supratidal environments, whereas thin alternating sequence of argillites and quartzose sandstones represent the intertidal environments.

Fine sand size of quartz particles and absence of barrier ridge sandstone suggest long distance of transport of quartz particles and less amount of terrigenous material available on the shelf.

The environments of deposition are supratidal to subtidal but the sequence is thick which indicates that the basin was consistantly subsiding at the time of deposition.

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