



A reappraisal of the Jharol Formation in the context of stratigraphy of Aravalli Supergroup, Rajasthan, India

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The enormously thick sedimentary succession exposed between Rishabhdev Lineament and rocks of the Delhi Supergroup constitutes Jharol Formation of the Aravalli Supergroup in Udaipur region of Rajasthan. The whole sedimentary succession is named Jharol Formation and designated as deep water turbidites. A detailed field examination indicates presence of two distinctly different litho successions juxtaposed across a crustal level fault along which brecciated ultramafics are tectonically emplaced. The sedimentary successions exposed immediate west of the Rishabhdev Lineament are deep water sediments with distinct facies types characterizing inner to outer lobe stacked turbidites. These turbidites are similar to the turbidites of the Udaipur Formation and Tidi Formation exposed east of the Rishabhdev Lineament. However, the sedimentary succession exposed west of these deep water sediments across the aforesaid fault contains facies types that represent continental to shallow marine deposits. This basin marginal sediments continue up to the contact with rocks of the Delhi Supergroup. Such litho-association suggests that a separate formation status of the sediments lying west of the Rishabhdev Lineament should be dropped and the turbidites of the Udaipur Formation should be considered as the youngest formation of the Aravalli Supergroup.

Keywords. Aravalli Supergroup; Jharol Formation; turbidites; rift-basin; stratigraphy.

1. Introduction

The Paleoproterozoic Aravalli Supergroup represents a sedimentary succession that developed in a continental rift basin along the northwestern fringe of the Indian peninsula (Roy *et al.* 1988). The Aravalli succession is represented by unconformity bounded more or less similar sedimentary packages exposed between linear highs of Archean granitoid basement (figure 1A and regional map published in Roy 1988). Bhattacharya and Bull (2010) and Bhattacharya (2014a) recognized four sedimentary facies assemblages within the Aravalli Supergroup. The basal most facies assemblage-1, sandstones

with quartz pebble conglomerate and intercalated mafic volcanics, overlies basement rocks with a well developed unconformity. The basal volcano-sedimentary succession is overlain by stromatolitic carbonate–black shale–sandstone–mudstone (now phyllite) succession. Some of the carbonates contain stromatolitic rock-phosphate. Conglomerate–greywacke–mudstone (siliciclastic turbidites) of Zawar area constitutes the facies assemblage-2. Pb–Zn sulphide ore bearing conglomerate–sandstone–carbonate alternations with sulphidic black silty-shale (siliciclastic–carbonate turbidites) represent facies assemblage-3. The contact between cycle-2 and cycle-3 is sharp. These three facies

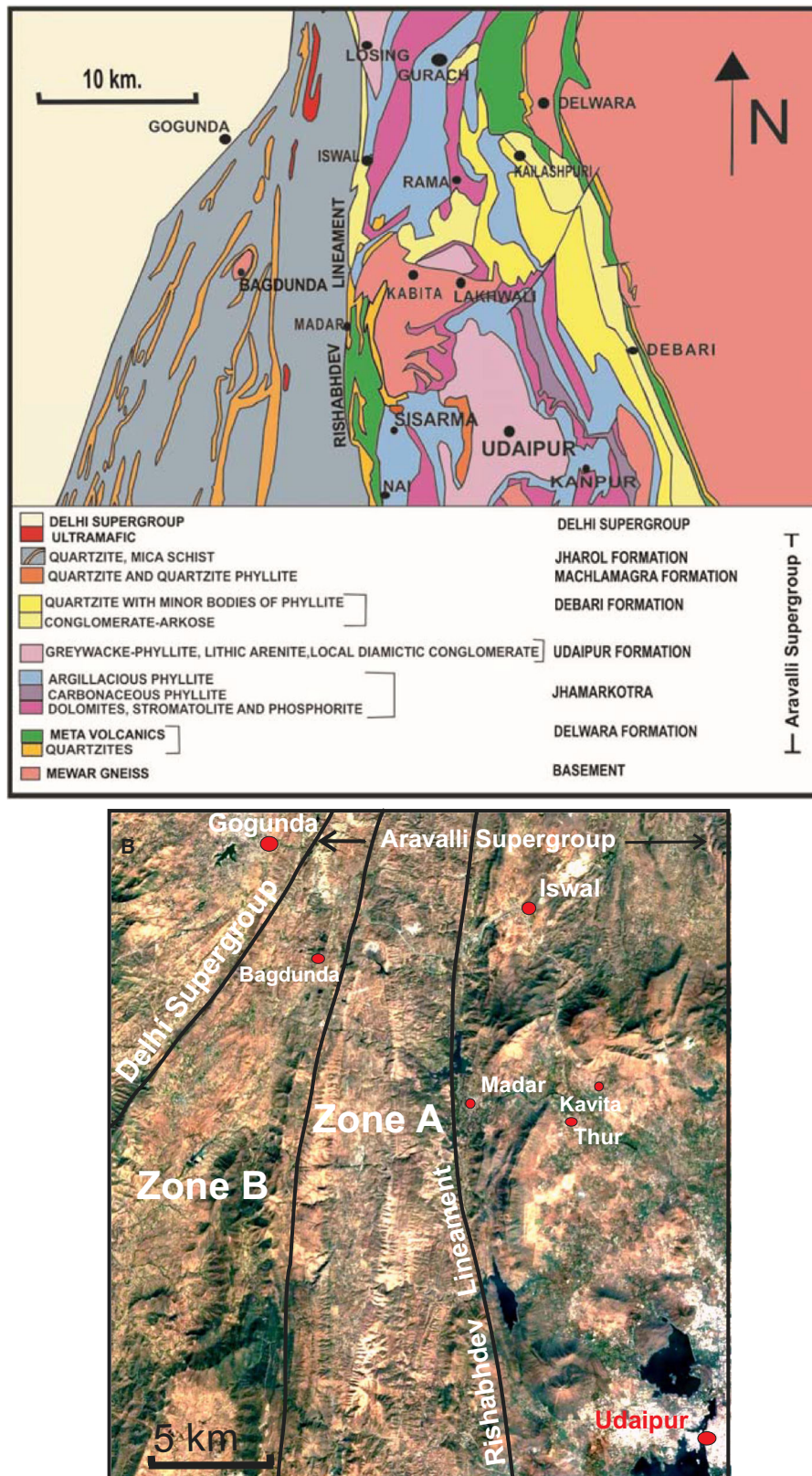


Figure 1. (A) Geological map of Udaipur region showing the Jharol Formation exposed in between the Rishabhdev Lineament and the rocks of Delhi Supergroup in the west. The map is a coloured version of a part of the map published by Roy (1988). (B) Satellite imagery of the western part of Udaipur region showing Zone A and Zone B with strong geomorphological contrast and distinguishable sedimentological contrast described in the text.

assemblages are unconformably overlain by a succession of polymictic conglomerate–sandstone–mudstone that gradually grades to an enormously thick succession (~2 km in some sections) of greywacke–mudstone alternations (turbidites), which constitutes facies assemblage-4. The facies assemblage-1 includes Delwara Formation and Jhamarkotra Formation; the facies assemblage-2 includes Kathalia Formation; the facies assemblage-3 includes Mochia Formation and the facies assemblage-4 includes Debari Formation and Udaipur Formation of Roy (1988) and Roy *et al.* (1993). However, controversies exist regarding inclusion of these formations in different groups under the Aravalli Supergroup (Roy 1988; Roy *et al.* 1993; Sinha-Roy 1993; Banerjee and Bhattacharya 1994; Roy and Purohit 2018).

In each scheme of stratigraphic classification (Roy and Paliwal 1981; Roy 1988; Roy *et al.* 1988, 1993; Sinha-Roy 1993; Banerjee and Bhattacharya 1994), the sediments exposed in the west of the Rishabhdev Lineament (figure 1A), are placed at the top of the stratigraphic column of the Aravalli Supergroup as Jharol Formation or Jharol Group (table 1). Poddar and Mathur (1965) and Poddar (1966), based on their studies on turbidites of the Udaipur valley, suggested that the ‘carbonate-free’ slate–phyllite–orthoquartzite litho-association exposed west of Udaipur represent a deeper part (axial zone) of the basin. This proposition was championed later by Roy and Paliwal (1981), Roy *et al.* (1988), Banerjee and Bhattacharya (1989, 1994), Roy and Jakhar (2002), and Sinha-Roy (2004). According to their paleogeographic model, the N–S running Rishabhdev Lineament (a ductile shear zone) separates eastern, ‘carbonate-bearing shallow water nearshore-shelf sediments’ of Udaipur region from the western ‘carbonate free deep-sea sediments’ of Jharol and neighbouring areas (figure 1A). Their deep-sea sediments, comprising dominantly of slate, phyllite, quartzite, mica-schist and amphibolite, are grouped under the Jharol Group (Banerjee and Bhattacharya 1989, 1994) or under the Jharol Formation (Roy *et al.* 1993). Gupta *et al.* (1997) designated the sediments of Jharol Group as deep water ‘shaley flysch’.

2. A critical appraisal of the Jharol sediments

Following points emerge from the detailed analysis of published literature on stratigraphy of the Aravalli Supergroup, database generated during field

investigations and geomorphologic analysis of the terrain on satellite imagery.

- (a) The geological maps published by Roy and Paliwal (1981), Roy *et al.* (1988), Banerjee and Bhattacharya (1989, 1994) and Sinha-Roy *et al.* (1993) show that the area between Rishabhdev Lineament and Delhi Supergroup is covered with deep-water Jharol sediments (figure 1A). However, present field investigation reveals that the aforesaid area exposes two distinguishable litho-packages. A heterolithic succession of sandstone–mudstone (now phyllite) alternations in centimetre scale is exposed in the immediate west of the Rishabhdev Lineament and covers approximately a 6 km wide zone that widens up southward. For the purpose of the present study, the zone is named as Zone A (figure 1B). The litho-succession of Zone A is shown in figure 2(A). A regionally continuous sedimentary succession, with folded quartzite bands (~10 m) intercalated with mica-schist and local amphibolites, is exposed further west of the aforesaid Zone A and continues up to the contact with rocks of the Delhi Supergroup. This zone is named as Zone B (figure 1B). This succession is developed unconformably on gneissic basement, known as Bagdunda Gneiss (figure 2A). This zone is nearly 5–20 km wide and widens up southerly. The contact between these two zones is a crustal level fault, across which two contrasting litho-succession are juxtaposed (figure 1B). The north–south running fault, dividing these two zones, passes through a point (lat. 24.43'52.5"; long. 73.33'11.8") on the highway joining Iswal with Gogunda (shown in figure 1B) and connects isolated lenses of serpentinised ultramafics showing textures supporting intense brecciation and shearing.
- (b) The entire Jharol sediments are designated as youngest Jharol Formation of deep water origin (Roy *et al.* 1993), without mentioning on which formation the deep-water Jharol Formation is developed.
- (c) On satellite imagery (figure 1B), these two zones show contrasting geomorphology. Zone A contains low-lying smooth dome shaped hills and valleys and Zone B contains long running rugged, frequently curved strike ridges with deep valleys in between.
- (d) Petrofacies analysis, carried out by Banerjee and Bhattacharya (1989), of Jharol quartzite

Table 1. Stratigraphic succession of Aravalli Supergroup of Udaipur region, Rajasthan (after Roy and Jakhar 2002).

	SHELF SEQUENCE	DEEP- WATER SEQUENCE
UPPER ARAVALLI GROUP	Ultramafic Intrusive	Jharol Formation Mica schist, phyllite thin bands of quartzites, ultramafic
	Lakhwali Phyllite Kabita Dolomite Debari Formation Conglomerate, arkose and quartzite	
UNCONFORMITY		
MIDDLE ARAVALLI GROUP	Tidi Formation Slate/phyllite with thin beds of dolomite & quartzite	
	Bowa Formation Quartzite and phyllite	
	Mochia Formation Dolomite with facies variants, including carbonaceous phyllite with Pb, Zn, Ag	
	Udaipur Formation greywacke-phyllite	
UNCONFORMITY		
LOWER ARAVALLI GROUP	Jhamarkotra Formation Dolomite, quartzite, carbon phyllite, phyllite, thin local bands of stromatolitic phosphorite, copper and uranium deposits	
	Delwara Formation Metavolcanics with thin beds of meta-sediments	
UNCONFORMITY		
MEWAR GNEISS	Gneisses, granites, amphibolites, mica schist	

indicates presence of 95% of quartz with 5% feldspar and lithic fragments as framework components, which does not match with gross quartz–feldspar–lithic fragment rich mineralogical composition of deep basinal siliclastic turbidite sediments (Fetter *et al.* 2009).

- (e) Except cross-bedding, no other primary sedimentary features have been reported from these sedimentary units.

The above observations on the Jharol sediments pose serious doubts about their inclusion under one formation entirely, and their paleogeographic interpretation as deep-water sediments as a whole. The internal diversity and contrast of sedimentary attributes of the Jharol sediments instigated the present authors to study the sediments through analysis of unequivocal outcrop scale data, which are available in Iswal–Gogunda and Madar–Bagdunda sections (figure 1A). The outcome of the present detailed facies analysis of the Jharol sediments will help the reconstruction of a more

comprehensive paleogeographic model of the Aravalli Basin.

3. Facies analysis of Zone A sediments

Interbedded and rhythmic sandstone, siltstone and mudstone succession in centimetre scale, a typical heterolithic association, is the main essence of this Zone A. The beds are vertical and the succession is thickened due to repetition because of development of upright folds. The actual thickness of the succession is approximately more than 2 km. Close examination of the sediments reveals important primary sedimentary features, hitherto unreported, which helps to classify the sediments into five distinct sedimentary facies types, namely thick lenticular sandstone facies, thick sandstone–thin mudstone interbedded facies, thin sandstone–thin mudstone interbedded facies, thin sandstone–thick mudstone alternation facies and mudstone facies. A comprehensive litho-log of Zone A showing vertical

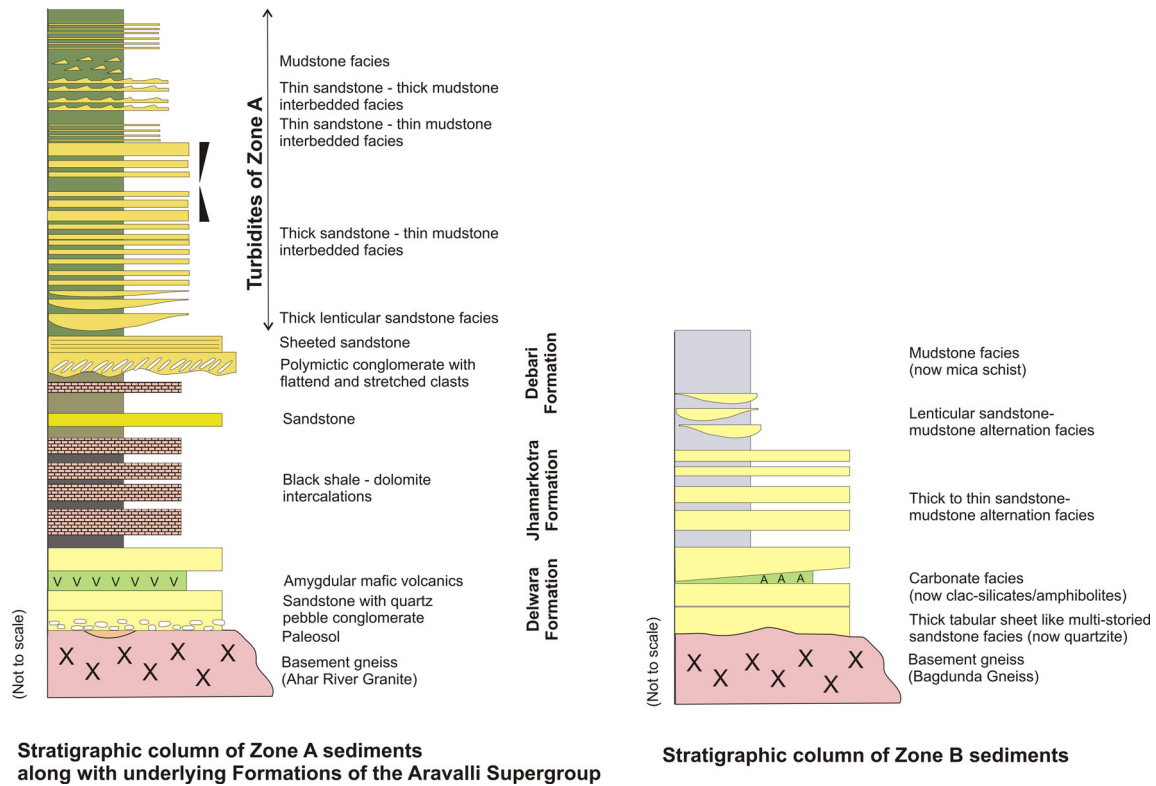


Figure 2. Tentative stratigraphic columns of Zone A and Zone B shown in figure 1(B). Column A shows the facies distribution of turbidite sediments that constitute the Zone A and cover the upper part of the column above the older sediments of the Aravalli Supergroup exposed in the studied section. Column B shows the facies architecture of the Zone B sediments.

distribution of the facies types is shown in figure 2(A). Details of each facies types and their interpretations are given below.

3.1 Thick lenticular sandstone facies

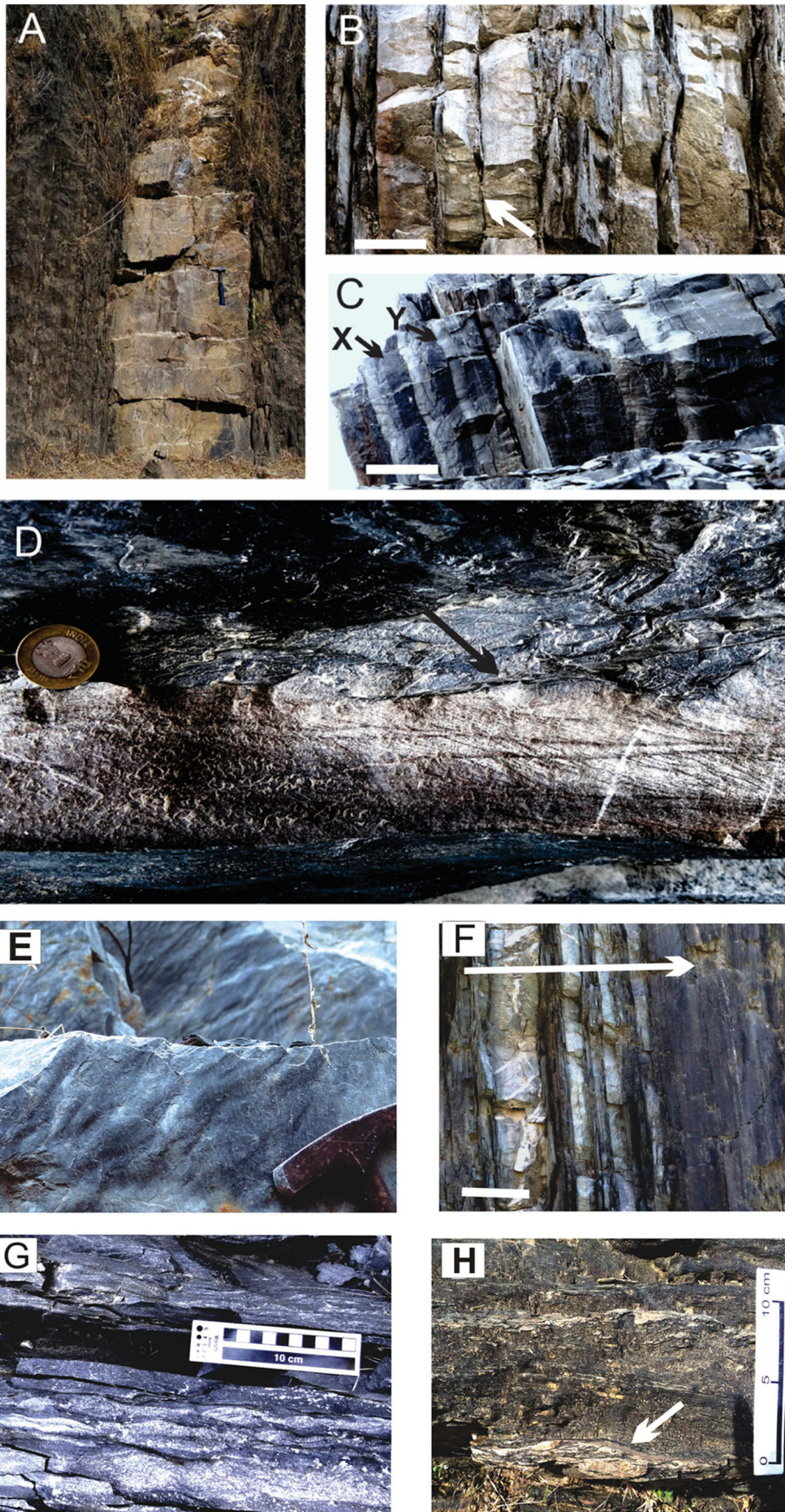
This facies is represented by 60–180 cm thick lenticular sandstone bodies with scoured base and diffused top contact with overlying wispy laminated mudstone (figure 3A). Lower part of the sandstone is massive and the upper part is plane to ripple laminated, distinguishable only where the sediment escaped strong recrystallization.

This facies is a product of rapid deposition from bipartite turbidity current (see Hogdson 2009; Talling *et al.* 2012), high-density near base and low-density in the upper part. Plane laminated part marks the boundary between high-density and low-density turbidity currents. Top rippled part of the sandy interval represents deposition from traction carpet. Lenticular shape indicates their development within channel confines in mid- to outer-lobe area (Starek and Fuksi 2017). Overlying mudstone, showing graded contact with underlying sandstone, represents deposition from slow moving tail mud cloud (Starek and Fuksi 2017).

3.2 Thick sandstone–thin mudstone interbedded facies

This facies is represented by 4–46 cm thick sandstone and 2–30 cm thick mudstone (figure 3B). This interbedded facies is laterally continuous for more than 150 m. The sandstone beds are sharp based and show graded top contact with overlying silty-mudstone. The couplets at places share a dark mudstone cap or there are individual couplets, with a dark mudstone cap. At places amalgamation of sandstone beds is common (figure 3B). Near the base, the sandstone is massive and followed upward by plane or ripple cross-laminations (figure 3C). Few sandstone beds are normally graded (figure 3C). At places the entire sandstone bed is ripple cross-laminated (figure 3D). Flutes on the sole of the sandstone beds are common (figure 3E). Locally this interbedded facies form thinning upward succession (figure 3F).

Lateral continuity, internal organization of primary structures, flutes on sole of sandstones of this facies strongly advocate in favour of deposition from low density turbidity currents (see Lowe 1982). Such attributes also suggest their deposition as lobes beyond the confines of channels (see Mutti



et al. 2009; Starek and Fuksi 2017). Amalgamation of sandstone beds, sandstone–mudstone couplets with shared dark mudstone cap signify synchronously triggered amalgamated turbidites, whereas presence of dark mudstone cap on certain couplets represents non-synchronously triggered turbidite stack (see Daele *et al.* 2017). Development of thinning upward successions in the turbidite stack suggests lateral shift of the lobe axis with landward stacking of successive pulses or individual flows of low density turbidity currents (see Starek and Fuksi 2017).

3.3 Thin sandstone–thin mudstone interbedded facies

This facies is represented by one ripple thick (0.8–3 cm) sharp-based sandstone interbedded with 0.5–4 cm thick mudstone (figure 3G). Some of the sandstone beds are plane laminated in the lower part, which is followed upward by ripple cross-laminations or climbing ripple cross-lamination with uniform flow direction. Normal grading of grains from fine sand to silt to mud is present.

Thin laterally extensive couplets with non-erosive base and structures indicative of surge-like waning flows are the characteristics of external levee deposits, deposited from decelerating low-density turbidity current that overflows the levee crests of the channels in mid- to outer-fan domain (also see Kane and Hodgson 2011; Hansen *et al.* 2017). Dominance of ripples in the sandstones indicates bed-load transport during the initial phase of the deposition followed by higher rate of suspended load fallout.

3.4 Thin sandstone–thick mudstone interbedded facies

Digitated starved ripples with amplitude less than 1–2 cm forming fine grained sandstone lenses

within thick sand streaked mudstone represents this facies (figure 3H).

Starved ripples and sandstone streaks in thick mudstone represents deposition of suspended load from extremely low-density turbidity current with intermittent bed load transport of fine sand. This facies represent distal lobe fringe or outer levee deposit (Kane and Hodgson 2011).

3.5 Mudstone facies

Massive mudstone (now foliated) with rare 0.2–0.5 mm thick very fine sandstone or siltstone layers constitutes this facies. At places, 3–20 cm thick dark and massive mudstone are interbedded with gray mudstone.

This facies represents final suspension fall-out from slow moving diluted tail mud in outer or beyond lobe areas (Daele *et al.* 2017) or in distal external levee (Hansen *et al.* 2017). Dark mudstone interbeds may represent hemipelagic mud deposited during pauses between low-density gravity flows.

Petrography of the sandstone and siltstone beds (figure 4A and B) of the sandstone-dominated facies types reveals their quartzo-feldspathic wacke character. The coarse sandstones contain chert and carbonate fragments along with monocrystalline quartz, polycrystalline quartz and feldspar grains (figure 4A). Thin siltstones layers (<1 cm) alternate with thin mudstone layers (figure 4B) in fine-grained turbidites. Grain composition of the sandstone beds in the turbidites indicates granitoid basement source with intrabasinal component indicating possible exhumation of the early formed sediments.

The sandstone dominated facies types constitute the lower half of the facies architecture and the mudstone dominated facies types cover the upper half (figure 2A). Such a fining up facies architecture suggests a faster basin subsidence rate than the rate of sediment supply. Thus the basin was

Figure 3. (A) Field photograph of thick lenticular sandstone facies. Figures B–D represent field photograph of thick sandstone–thin mudstone interbedded facies. (B) Showing amalgamation of the sandstone beds of this facies (arrow marked). The white bar in the lower left corner of the photograph is 20 cm long. (C) In sections, the sandstone parts of this facies are massive near base and plane or ripple cross-laminated near the top (marked X), and some sandstone parts are normally graded (marked Y). The white bar in the lower left corner of the photograph is 10 cm long. (D) Some of the sandstone beds of this facies is entirely ripple cross-laminated with preserved mud-draped ripple bed-form on the top of the bed (arrow marked). Diameter of the coin for scale is 2.57 cm. Figure (E and F) are field photograph of thick sandstone–thin mudstone interbedded facies. (E) Flute casts on the sole of the sandstone beds. (F) Locally the interbedded facies form thinning upward succession (arrow marked). The white bar in the lower left corner of the photograph is 20 cm long. (G) Field photograph of thin sandstone–thin mudstone interbedded facies. Note gradual thinning of sandstone beds towards top of the succession. (H) Field photograph of thin sandstone–thick mudstone interbedded facies. Arrow marks a starved ripple draped by thick mud.

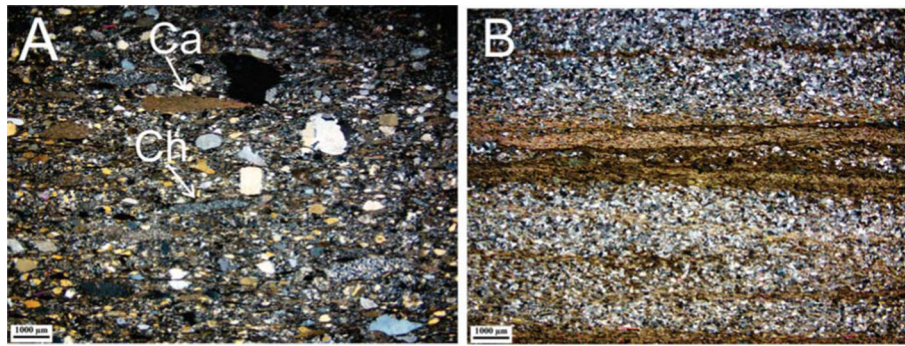


Figure 4. Photomicrograph of (A) sandstone and (B) siltstone of the turbidite beds. Photomicrograph of the turbidite sandstone containing chert (Ch) and carbonate (Ca) clasts along with a polycrystalline and monocrystalline quartz and feldspar grains. Note poor textural and mineralogical maturity of the sandstone.

tectonically active during the entire phase of sedimentation with an incremental rate of basin floor foundering.

4. Facies analysis of Zone B sediments

Very thick (~10 m) to thin (~0.3 m) sandstone beds (now quartzite) alternating with 0.1–12 m thick mudstone (now mica schist) characterize the sedimentary succession of the Zone B (figure 2B). The sandstones and mudstones are now represented by quartzite and mica schist. Local intercalations of calc-silicate bands (meta-carbonates?) are common. This succession is developed on a granitoid basement known as Bagdunda Gneiss (see Sharma *et al.* 1988), exposed near Bagdunda village. The sediments are intensely deformed, with development of large regional folds on quartzite bands, and the mudstone is transformed to mica schist, where large muscovite flakes define the schistosity. The sandstones are extremely recrystallized and are represented by coarse quartz grains with sutured contacts. However, in two locales, cross-stratified sandstones are located. Four sedimentary facies types have been identified in this succession, mainly depending on the three-dimensional aspects of the sandstones bodies (now quartzite) and mudstones (now mica schist) intercalations. The facies types are: (a) thick tabular sheet like sandstone–mudstone alternation facies, (b) lenticular sandstone–mudstone alternation facies, (c) carbonate facies, and (d) mudstone facies, respectively. Intense deformation and upper greenschist to lower amphibolite facies metamorphism have erased most of the pristine sedimentary attributes except the geometry of the sedimentary

bodies. However, available details of each facies types and their interpretations are given below.

4.1 Thick tabular sheet like multi-storeyed sandstone facies

Very thick (2–20 m) laterally continuous for more than a kilometre, multi-storeyed sandstones characterize this facies (figure 5A). The base of this sandstone bodies are sharp and at places wavy. The upper contact with mudstone is sharp or gradational. Locally amalgamated lenticular sandstone bodies constitute this facies. The sandstones are plane laminated. At places plane laminations grade to trough cross-stratifications (figure 5B). Remarkable lateral extent, great thickness with plane and trough cross-stratification and absence of mudstone partings advocate in favour of upper shore-face depositional environment (Einsele 2000).

4.2 Thick to thin sandstone–mudstone alternation facies

20–80 cm thick and laterally continuous for 60–140 m sandstones alternating with mudstones represent this facies (figure 5C). The sandstones are sharp-based and grades upward into 0.4–1.2 m thick mudstone that contains < 1 to 4 cm thick sandstone partings. It appears that this interbedded facies constitutes a thinning upward succession and there is cyclic repetition of sandstone–mudstone couplets. Except plane laminations grading to trough cross-stratification (figure 5D), exposed in a few locales, no other primary structures are preserved.

An overall fining and thinning upward succession from mud-free sandstone to sandstone–mudstone alternations points to a regressive subtidal to

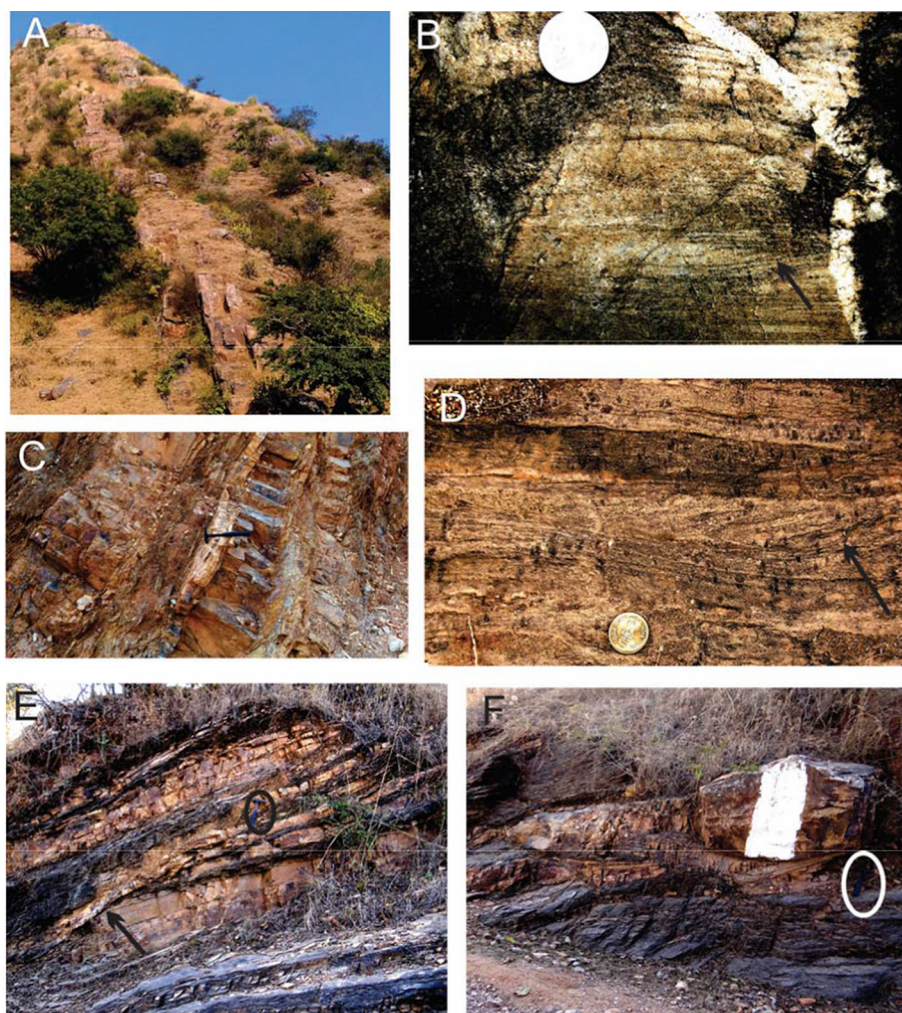


Figure 5. (A) Field photograph of thick tabular sheet like multi-storeyed sandstone facies forming high ridge. In this facies, plane laminations grade to trough cross-laminations (arrow marked in B). Diameter of the coin for scale is 2.57 cm. (C) Field photograph of thick to thin sandstone–mudstone alternation facies. This sandstone of this facies is trough cross-stratified (arrow marked in D). Diameter of the coin for scale is 2.57 cm. (E) Field photograph of lenticular sandstone–mudstone alternation facies. Hammer for scale is marked in the photograph. Superposed channel fill sandstones with intervening flood plain mudstone. Note the erosional base of the channel fill sandstones (arrow marked). (F) Erosional base and flat top contact of the channel fill sandstone with overlying mudstone. Hammer for scale is marked in the photograph.

intertidal sedimentary environment. Each sandstone–mudstone couplet records deposition under a regressive phase of basinal sedimentation. Further, cyclic stacking of this facies also suggests recurrent sharp transgression and later regression under the influence of basinal tectonics (see Bhattacharya 1991).

4.3 Lenticular sandstone–mudstone alternation facies

Lenticular sandstone bodies, 4–20 m wide and 6 cm to 1.4 m thick, in mudstone represent this facies (figure 5E). Longitudinal sections reveal shoe-string like shape of the sandstone bodies. The base

of the sandstone lenses are sharp, erosional and concave upward and the top contact with mudstone is more or less flat (figure 5F). The sandstone lenses are plane-laminated in the lower part and trough cross-stratified in the upper part. The top surface of the sandstone lenses, at places, is current rippled.

These shoe-strings like sandstones in mudstone reveal low gradient, well-defined channel deposits separated by muddy interfluvies. Lenticular shape in transverse sections suggests lack of migration and vertical aggradation of sinuous and branching channels (Einsele 2000). Vertical stacking of channel deposits with intercalated mudstone reveals tectonic instability and rapid sagging.

4.4 Carbonate facies

This facies occurs as laterally continuous, 5–20 m thick bands in close association with thick tabular sheet-like multi-storeyed sandstone facies. Since sediments of this facies are subjected to upper greenschist to lower amphibolite facies metamorphism, pristine sedimentary attributes are totally obliterated and now represented by actinolite–calcite–albite–quartz assemblage (figure 6A).

Lateral variation from calc-silicate to amphibolite present within this facies indicates impure carbonate sediments as their precursor. Close association with shore-face sediments indicates that the carbonates may represent platformal deposits.

4.5 Mudstone facies

Thick (4–20 m) mudstone represents this facies. Rarely this facies contains 2–4 cm thick sandstone partings. This facies occurs in alternation with thick tabular sheet-like multi-storeyed sandstone facies.

This facies may represent outer shoreface or shelf mud deposit.

The overall facies architecture suggests shallow marine to deltaic depositional setting for the Zone B sediments. Frequent change in facies architecture also reveals tectonic instability of the basin. Mineralogical maturity of the sandstones with 90–98% quartz (figure 6B) reveals derivation of the sediments from a distant quartzo-feldspathic, i.e., granite-gneissic provenance.

5. Discussion

The present study, with plenty of field evidences clearly depicts juxtaposition of two sedimentary successions of widely varying depositional settings

and environments across a north–south line lying east of Gogunda village (shown in map 1B). The sediments in the eastern Zone A represents essentially deep water sediments deposited by sediment gravity flows on a sedimentary succession of conglomerate and sandstone, an equivalent of Debari Formation, deposited in continental to shallow marine environments (Roy and Paliwal 1981). This change-over records a gradual deepening of a shallow basin, a situation very much similar to a collapsed passive margin (see Bhattacharya 2014b). In contrast, the sediments of western Zone B are basin marginal shallow water deposits developed on basement gneiss. Clubbing of these two contrasting sedimentary successions under one formation (Jharol Formation) and designating them as deep-water sediments as a whole is not only wrong, but also misleading for the constructions of stratigraphy and paleogeography of the Aravalli Basin.

The facies attributes of the deep water turbidites of Zone A is very much similar with the turbidites of Udaipur Formation (see Poddar 1966), exposed east of Rishabhdev Lineament around Udaipur city. However, the sediments of Zone B have no known equivalents in the east of Rishabhdev Lineament. This implies that the sediments of Zone A are a part of the type Aravalli Basin, whereas the sediments of Zone B most possibly represent sediments deposited along the western margin of the pre-deformation Aravalli Basin. A regional tectonic transport has juxtaposed the basin marginal sediments of Zone B against the deep water sediments of the Aravalli Supergroup across a crustal scale thrust, which is the north–south line in the present study separating Zone A from Zone B. Intensely brecciated and sheared ultramafic bodies occurring along this juncture might represent

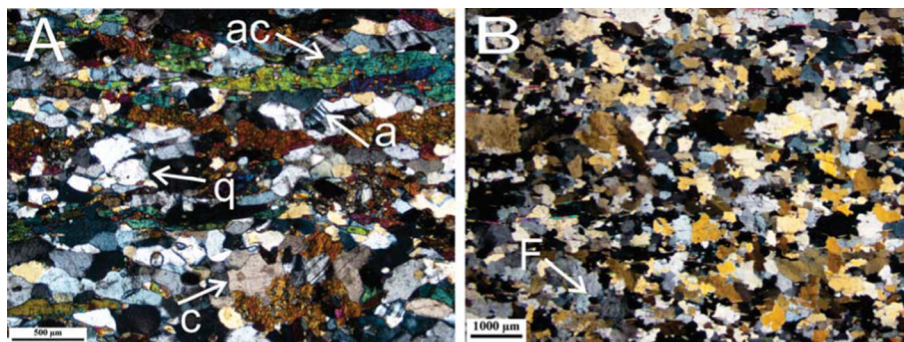


Figure 6. Photomicrograph of Zone B sediments. (A) Photomicrograph of calc-silicates, showing actinolite (ac)–calcite (c)–albite (a)–quartz (q) assemblage with well developed schistosity. (B) Photomicrograph of sandstone of Zone B sedimentary succession, showing quartz rich mineralogy with a few feldspar grains (F). The original texture is lost due to strong recrystallization and higher degree of pressure solution along grain boundaries.

upper mantle slices emplaced in solid state along this juncture.

Thur–Iswal–Gogunda section (figure 1A) exposes a continuous stratigraphy of the Aravalli Supergroup (figure 2A). The Ahar River granite, a basement complex for Aravalli Supergroup, is overlain in the west by volcano-sedimentary succession of the Delwara Formation and then by carbonate–black shale–sandstone succession of the Jhamarkotra Formation (Roy *et al.* 1988). Both these formations constitute riftogenic phase of the Aravalli Basin. A regional top-rift unconformity marks the end of this riftogenic phase. Polymictic conglomerate and sandstone of the Debari Formation drapes the unconformity represents the base of a post-rift succession (see Bhattacharya 2014a, b). Conglomerate and sandstone of the Debari Formation grades to the deep water sedimentary succession of Zone A in the west, representing quick foundering of the basin floor or collapse of a passive margin (see Pindell *et al.* 2014). Similar change from siliciclastic or siliciclastic–carbonate bearing riftogenic sediments to deep basinal turbidite–debrite deposits is a common phenomena in the Aravalli Basin (Bhattacharya and Bhattacharya 2005; Bhattacharya and Bull 2010). Such a syn-rift phase and post-rift collapse phase sedimentation pattern is well exposed in different sections of the Aravalli Basin, for example, across Baroi ridge of Zawar area; in Debari–Udaipur road section; across Machlamagra hill to Fathe Sagar section, Udaipur and in Eklingaji bypass highway road section. In these sections, black chert, quartzite phyllite and vein quartz clasts rich polymictic Debari conglomerate drapes a top-rift unconformity (also see Bhattacharya and Bhattacharya 2005; Bhattacharya and Bull 2010; Bhattacharya 2014a, b) that developed over volcano-sedimentary Delwara Formation and/or stromatolitic carbonate–black shale–quartzite–mudstone bearing Jhamarkotra Formation representing early riftogenic sediments.

Therefore, the deep water sedimentary succession of Zone A, lying immediate west of the so-called Rishabhdev Lineament, is an equivalent of the Udaipur Formation of Udaipur valley (figure 1A). The fluvial Debari Conglomerate and other shallow marine mature siliciclastic sedimentary associates represent the cover on an unconformity (top-rift) over riftogenic Jhamarkotra and Delwara Formations (Bhattacharya and Bhattacharya 2005; Bhattacharya 2014b). The quick foundering of the basin floor and formation of

deeper half-grabens/grabens as a consequence of collapse along a rifted passive margin ushered in deep marine turbidite sediments over fluvial to shallow marine sediments of the Debari Formation. Such a shallow to deep basinal sedimentation pattern is developed in different sedimentary troughs (lows) in between raised basement highs or rift shoulders in the east of Rishabhdev Lineament (Bhattacharya 2014b). The shallow platformal sediments of Zone B have a separate paleogeographic and stratigraphic status, and are juxtaposed against deep water Aravalli sediments along a crustal level fault.

6. Conclusion

In the present study, it can be concluded that the deep water Jharol Group/Formation is a superfluous stratigraphic entity and should be dropped from the stratigraphy of the Aravalli Supergroup. Additionally, the deep water turbidites exposed west of the Rishabhdev Lineament may be considered as stratigraphic equivalent of the turbidites of the Udaipur Formation. So, it will be meaningful if the Udaipur Formation is considered as the youngest formation of the Aravalli Supergroup.

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