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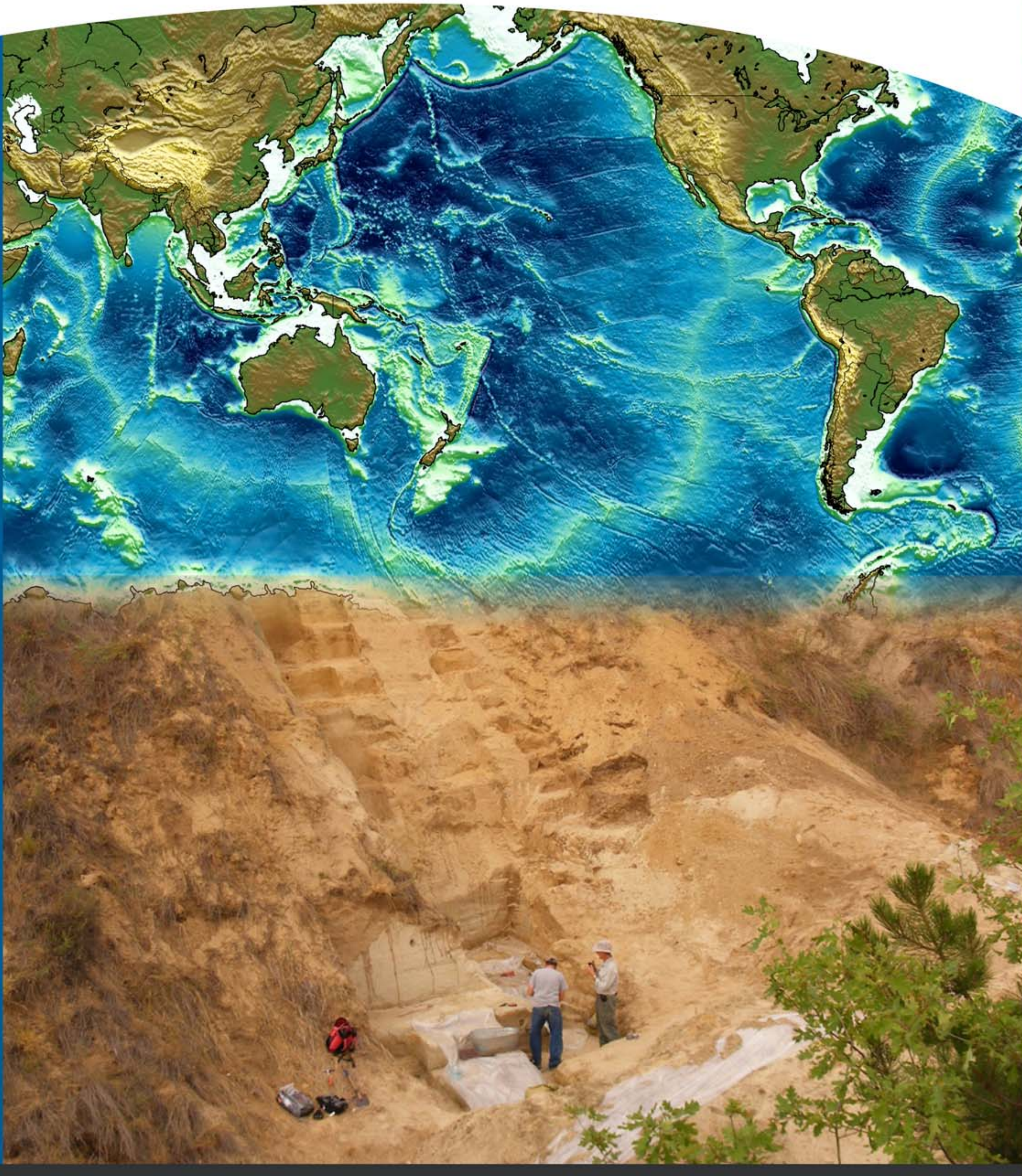

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*Review Article*

# EVOLUTIONARY HISTORY OF THE PROTEROZOIC KOLHAN BASIN: A REVIEW

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The sedimentation pattern in the Kolhans reflects a change from braided fluvial-ephemeral pattern to a fan delta lacustrine type. Repeated fault controlled uplift of the source followed by subsidence and forced regression, generated multiple sediment cyclicity that led to the fluvial-fan delta sedimentation pattern. Intermittent uplift of the faulted blocks exposed fresh bedrock to mechanical weathering that generated a large amount of detritus and resulted to forced regressions, repeatedly disrupting the cycles which may reflect a stratigraphic response of marine-connected rift basins at the early stage of extension. The marked variations in thickness of the fan delta succession and the stacking pattern in different measured profiles reflect the overriding tectonic controls on fan-delta evolution. The accumulated fault displacement created higher accommodation and thicker delta sequences. Intermittent uplift of fault blocks exposed fresh bedrock to mechanical weathering, generated a large amount of detritus, and resulted in forced closure of the land locked basin, repeatedly disrupting the fining upward pattern. The controls of source rock lithology or climate were of secondary importance to tectonic effects. Such a retrograding fan delta could be a stratigraphic response of connected rift basins at the early stage of extension.

***Keywords:*** subsidence, fan delta, lacustrine, forced regression

## INTRODUCTION

The 2.2-2.1 Ga pear shaped Kolhan basin (Figure 1) is a time transgressive shale dominated supracrustal succession (shallow epicontinental) set in a passive continental rift setting, and caused due to the fragmentation of the Columbia supercontinent. The succession is a sequence of subarkose-quartz arenite with lenses of conglomerate overlain by extensive thick shale-limestone package and show a non-cyclicity in the sedimentation history. The Kolhans were deposited in an intracratonic basin that had a westward slope and were subsequently deformed into a synclinal structure (Figure 2). A strong asymmetry in the vertical basin architecture and the linearity in the outcrop pattern of the preserved sedimentary sequence are presumed to have developed in an elongated trough during the initial basinal rifting stage, while the later stage is marked by the progressive overlaps and coalesce of the facies builtup. The fining upward sequence, the vertical (Figure 5b)

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**Figure 1: Geological Map of Singhbhum Crustal Province (Bose 1994)**

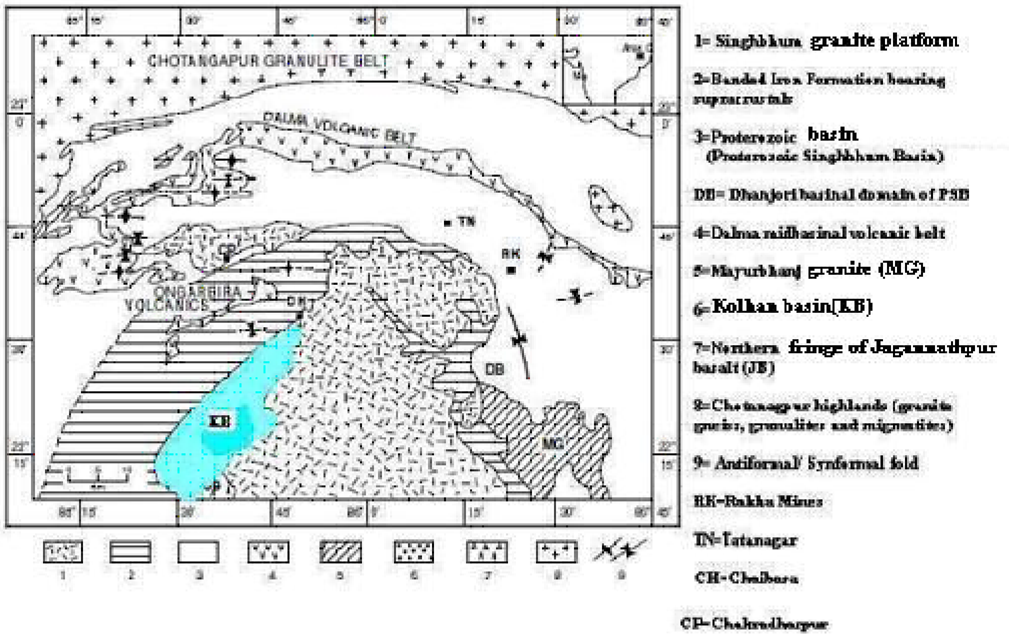
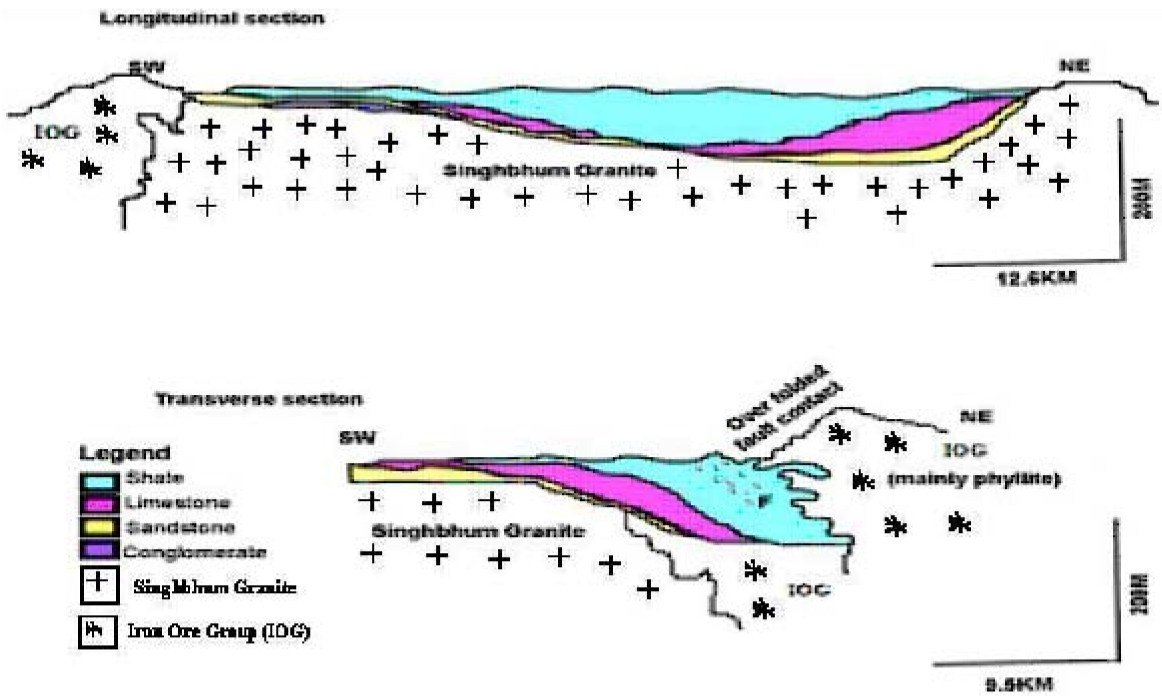



**Figure 2: Longitudinal and Transverse Section of Kolhan Basin (Chatterjee and Bhattacharya, 1969)**



and lateral facies (Figure 4) variation in the Kolhan implies superimposition of retrograding fan delta complex (Chaibasa basin) on an earlier prograding alluvial fan sand complex (Keonjhar basin).

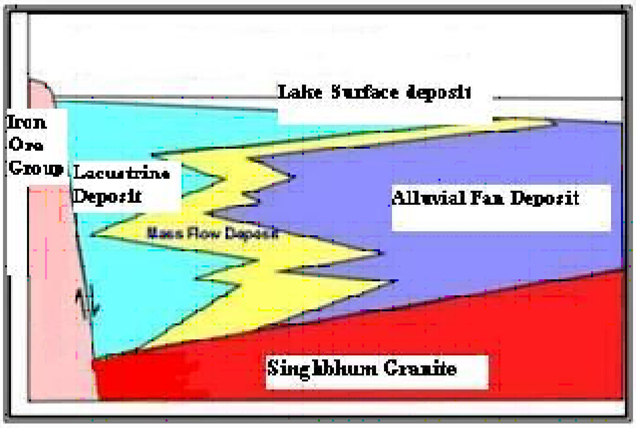
The regional stratigraphic framework (Figure 3) and the gradational facies relationships (Figure 4) between the clastic-carbonate members, compels one to interpret the entire Kolhan sequence as non-marine. The pattern of sedimentation associated with the basin floor reflects a sequence of emergence, submergence and re-emergence of the land surface related to the development of an extensive ephemeral lake. The early emergence of the Kolhan land surface, led to the development of the erosional topography and also involved considerable lowering of the local base level of at least few metres. This suggests a tectonic uplift of rather limited areal extent because of the apparent restriction of marked palaeotopography.

The flanking sandstones and conglomerates are possibly the products of subaerial erosion. The larger blocks of sandstone on flanking conglomerates were probably not transported far and may be delta fed material. The sandstone

**Figure 3: Lithostratigraphy of Entire Kolhan Basin (Saha, 1994)**

| | |
|---|---|
| 2.2 Ga | Newer Dolerite |
| | Kolhan shale (slightly phyllitic) |
| | Kolhan limestone (phyllitic in upper part) ......22 m |
| | Kolhan sandstone......8 m |
| Proterozoic | Kolhan conglomerate ......0.3 m |
| Unconformity | |
| Archaean | Singhbhum granite (3.0Ga) |

**Figure 4: Composite Lateral Sequential Facies Growth Of The Fan Delta Sequence**



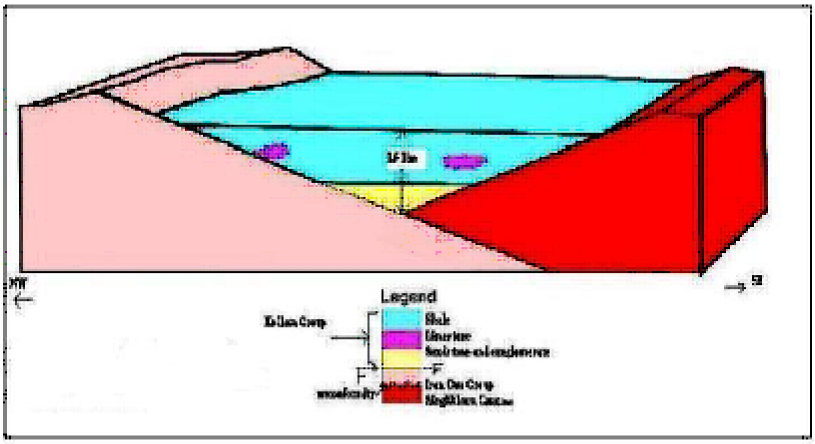
matrix of the conglomerates and the generally sandy nature of the flanking beds suggest that the early lithification was not particularly strong or complete and that disaggregation was fairly readily achieved. Some of the flanking beds are clearly subaqueous in origin, showing evidence of fluvio-lacustrine reworking. The subaqueous reworking probably resulted from the earliest phase of submergence as a lake developed in the area. The lake appeared to have been relatively starved of clastic input in its earliest stages when a thin layer of carbonate sediment was deposited as a drape over the topography. Such an early carbonate phase is not uncommon in other ancient lake-margin settings. It probably results from a combination of carbonate precipitated due to change in water chemistry caused by eruption of basic lavas (Jaganathpur lava). The fact that these deposits drape palaeotopography argues for considerable fluctuations in lake level even during the (relatively) submerged phase. Given such conditions, it is tempting to speculate upon the thicker development of carbonates in deeper parts of the lake (south western part of the basin).

Deposition of shale-siltstone above the carbonate layer records the onset of clastic supply from the distant source area rather than from local reworking of the underlying sandstone. The silts were deposited primarily from suspension so that the topography was gradually draped. The lake was episodically inundated by floods some of which introduced sand sheets, and others brought silt clasts. This led to the gradual burial and elimination of the palaeotopography. The upwards passage into progressively silt rich sediments is thought to record the building out of a sandy alluvial system across the featureless ephemeral lake.

The origin, characteristics, distribution and spatial arrangement of the various lithofacies, the predominance of stream flow over debris-flow deposits, the semi-radial, fan-like dispersion pattern of the paleocurrents, the associated subaerial and subaqueous depositional settings are indicative of a lacustrine alluvial-fan/fan-delta environment, or a fan-delta system. An interplay between several intrabasinal and extrabasinal controls probably determined the fan evolution. This is suggested by the occurrence of traction deposits, tectono-depositional intervals and their textural characteristics, and by the evidence of synsedimentary extensional tectonism. The shallow water settings are highly sensitive to subsidence, and the presence of fine-grained sedimentation above coarse-grained deposits in a tectonically controlled sedimentary succession is the best indicator of renewed tectonic activity. As the rifting processes compartmentalized the basin into fault blocks (Figure 5a), and grabens were consequently separated, subsidence lowered the floor of these grabens below base level, and lakes were formed as an immediate response to tectonics. A large volume of sediment was then available for erosion due to the differential relief between the uplifted source area and the subsided basin, and the fan-delta systems began to prograde into the lakes. In some compartments of the basin, where the lakes were probably relatively deeper due to a greater subsidence rate, the initial clastic progradation took place through sandy flows, formed when heavily sediment-laden, sandy gravity flows or stream flows were introduced into the lakes.

Paleocurrent data suggest that the position of the fault blocks strongly influenced the deposition of the fan bodies. Subsidence pulses probably controlled the successive major progradational phases, leading to the development of the

**Figure 5: (a) Depositional model of the Upper Kolhans...Fan Delta Model...at Chaibasa-Noamundi and (b) Composite Stratigraphic section of the fan delta model**




superposed coarser and finer units. Clockwise block tilting associated with subsidence during graben evolution is indicated by the spatial relationships between the fan-delta progradational phases, where a new delta fan segment developed basinward at the toe of an older fan segment. This also suggests an asymmetric-graben geometry (Figure 5a) for the basin at this time. The textural and compositional characteristics of the fan-delta deposits attest to the reworking of a sandstone- and conglomerate-bearing sequence in the source area, probably the proximal deposits of the underlying Kolhan braided plain, exposed as the result of the basinward migration of the IOG fault system.

Therefore, the sedimentation of the lacustrine fandelta lithofacies association of the Kolhans probably took place in a NE-SW elongated, continental rift basin, compartmentalized by NW-SE and E-W trending normal faults. The basin-fill architecture was probably determined by episodic subsidence, clockwise block tilting and asymmetric-graben evolution, as well as by inherited characteristics of the source area.

Recurrent seismic/tectonic triggering of the basin is also indicated by soft sediment deformation structures in different stratigraphic units. The fluvial system was marked by a remarkably persistent northernly paleocurrent and sediment dispersal attesting to a northerly paleoslope throughout the Kolhan sedimentation phase. The loci of deposition were delimited by an NE-SW trending basin margin fault system farther north of the present limit of the outcrop.

Repeated fault-controlled uplift of the source, followed by subsidence, generated multiple fining-upward cycles and a retrograding fan-delta system. The marked variations in thickness of the delta succession and the stacking pattern in different measured profiles reflect the overriding tectonic controls on fan-delta evolution. The accumulated fault displacement in active sectors created higher accommodation and thicker delta sequences. Intermittent uplift of fault blocks exposed fresh bedrock to mechanical weathering, generated a large amount of detritus, and resulted in forced closure of the land locked basin, repeatedly disrupting the fining upward pattern. The controls of source rock lithology or climate were of secondary importance to tectonic effects. Such a retrograding fan delta are rarely reported and may be a stratigraphic response of connected rift basins at the early stage of extension.

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