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QUATERNARY MORPHO-STRATIGRAPHY OF THE ZIRO VALLEY, ARUNACHAL HIMALAYA : A FIELD MUSEUM OF QUATERNARY LANDFORM ELEMENTS

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ABSTRACT

The tiny Ziro valley in the Kale river sub-basin of the Subansiri River of Arunachal Himalaya, presents a unique display of various landforms of glacial, fluvio- glacial, laustrine and fluvial environments. The valley is situated at a low altitude of 1520 a.m.s.l. being encircled by hills rising up to 2684 m. Evidences of four different environments have been identified. Nature and the geomorphology of the typical landforms have been recorded, and their mutual field relationships, lithological assemblages and inherent sedimentary structures have been taken as the prime factors for establishing the morpho-stratigraphy and litho-stratigraphy and litho-stratigraphy of the Quaternary sequence. Slope character, relief, drainage density, channel morphology pedological character, degree of dissection, oxidation pattern of the sediment and existing land use pattern have also been given due significance while attempting classification of mopho-stratigraphic units.

Keywords: Ziro valley, Quaternary sedimentation, Glaciofluvial, Laustrine and Fluvial environment, Arunachal Himalaya.

INTRODUCTION

The Quaternaries of the Ziro valley have been classified into five mopho-stratigraphic units. The oldest, Hapoli unit, includes the erosional landforms sculptured by the glacial and fluvio-glacial agencies. The specific landform elements identified within this unit are rock-cut terraces or strath-surface at the fringes of the valley, roche-moutonnees, inselbergs in valley and some small cirque-like features. The inselbergs jut out abruptly from the alluvial cover. Rock constituents are prophyritic granite gneiss, quartzite and pink mica schist. Next younger unit is the Ziro Formation, comprising angular to sub-angular heterogeneous rock fragments of more than a metre to grit size, in sandy/clayey matrix. Boulders, cobbles, pebbles in the glacial till comprise porphyritic granite gneiss, biotite gneiss, bedded quartzite, ink mica schist, biotite schist, chlorite schist and vein quartz etc. Prominent landforms are the drumlins, crag and tail etc. Next younger unit, the Hang Formation, comprises peat, lacustrine carbonaceous and varved clays, generally occurring below the ground and water level. Fluvial terraces of Bre formation, forming highly dissected table l and overlying the lacustrine sediments. These river terraces are essentially capped by thin, dark spongy humus layer and highly oxidized red - yellow soil. The Bre Formation consists of unconsolidated gravel, sand, silt and clay in different admixtures and also in respective fashion. Occasional boulder beds are also seen on the fringes of the valley. The youngest Soro Formation constitutes the present-day flood plain of the Kale Nadi.

A few grains of quartz, collected from various lithological sections of different mopho-stratigraphic units, were subjected to Scanning Electron Microscope study which yielded positive signatures of glacial, fluvio-glacial and fluvial sedimentation. Radio carbon dating of the peat collected from the lacustrine

sediments of Hang Formation near Hang and Chiya villages, gave its age more than 40,000 years B.P. which suggests Late Pleistocene age for the geomorphological processes leading to the geomorphic evolution of the Ziro valley.

The Ziro valley occupies an important place in the Apatani plateau in north-eastern Himalayas. It has a catchment area of about 155 sq km and is situated at the height of about 1520 m above mean sea level in Lower Subansiri district, Arunachal Pradesh (fig.1). The valley is surrounded on all sides by rugged mountains with individual peaks rising up to 2684 m a.m.s.l. and with steeply sloping flanks. In the central part, however, it consists of a flat alluvial plain, the monotony of which is broken by occasional inselbergs and mounds. The entire catchment is dominated by centripetal drainage. The Kale Nadi, which winds its way longitudinally through the central part, finds a narrow outlet at the southern tip of the valley and then cascades down over a few hundred metres before finally debouching into the Ranga River. Like many other similar valleys within the Himalayas, the Ziro valley too exhibits certain erosional and depositional landforms indicative of diverse palace-climatic and environmental conditions. Unique landforms recorded here, find their linkage to four different geological environments namely, glacial, fluvio-glacial, lacustrine and fluvial.

The present paper describes the various geomorphic features mapped in the area and attempts a palaeo-climatic environmental reconstruction of the valley's geomorphic evolution during the Late Pleistocene.

METHODOLOGY

In the courses of Quaternary geological and geomorphological studies, forming part of the integrated geological investigation of the Ziro valley, the different erosional and depositional landforms have been mapped in detail on 150,000 scale, making use of aerial photographs, through extensive field traverses. Lithological and sedimentological details

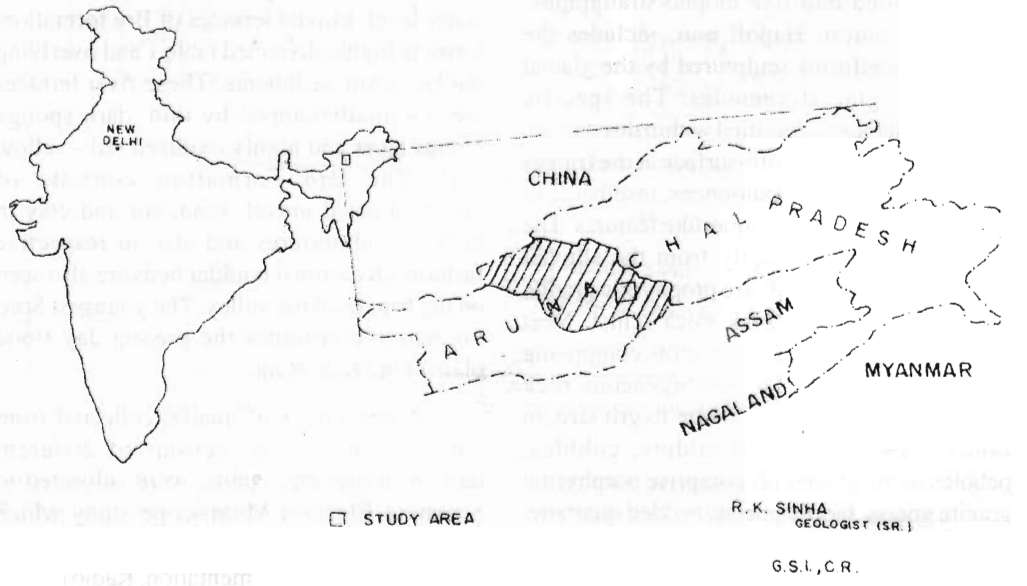

Fig. 1. Location map of the area

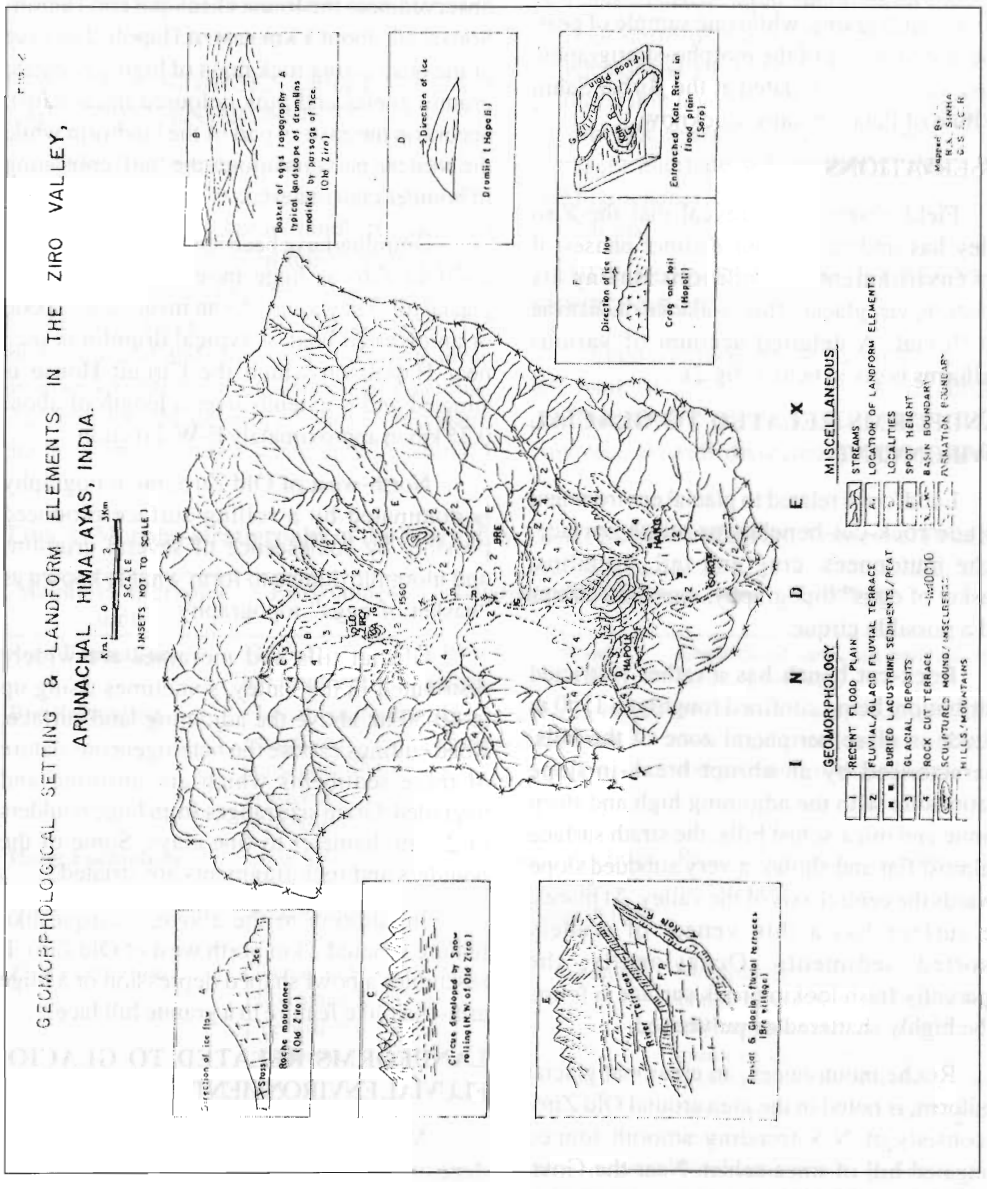

Fig. 2. Geomorphological setting and landform elements in the Ziro valley, Arunachal Himalaya, India

systematically recorded from exposed vertical sections of the different morpho-stratigraphic units. Some samples, collected from various units, studied under the Scanning Election Microscope for diagnostic surface textures of quartz (sand) grains, while one sample of peat, collected from one of the morpho-stratigraphic units, was also been dated at the Birbal Sahni Institute of Palaeobotany, Lucknow.

OBSERVATIONS

Field observations reveal that the Ziro valley has undergone four distinct phases of geo-environmental conditions during its evolution, viz. glacial, fluvio-glacial, lacustrine and fluvial. A detailed account of various landforms is given below (fig.2).

LANDFORMS RELATED TO GLACIAL ENVIRONMENT

Landforms related to glacial environment include rock-cut benches or strath surface, roche mutonnees, crag and tail, drumlins, "basket of eggs" topography, morainic dumps and a possible cirque.

Rock-cut bench has a rather restricted distribution, being confined roughly to 1560 m altitude in close peripheral zone of the hills. Characterised by an abrupt break-in-slope relationship with the adjoining high and steep granite and mica-schist hills, the strath surface is almost fiat and shows a very subdued slope towards the central axis of the valley. At places, the surface has a thin veneer of crudely assorted sediments. Occasionally, the apparently fresh looking rock surface is found to be highly shattered or pulverised.

Roche moutonnees, an erosional glacial landform, is noted in the area around Old Ziro. It consists of N-S trending smooth topped elongated hill of mica-schist. Near the Govt. Primary School at Old Ziro, there is yet another such feature, trending WNW-ESE. It is an elongated, asymmetrical mount with a steep slope of the lee-side towards the east and a gentler stoss-side slope towards the western end.

A typical 'crag and tail' feature has been observed near the forest check post on Hapoli-Soro road, about 1 km east of Hapoli. The crag or the obstructing rock mass of highly resistant granite gneiss and pink coloured mica-schist, occurs on the eastern part of the landform while the western part constitutes the 'tail' consisting of boulder clay material.

Drumlins have been identified near Hapoli and Old Ziro as huge mounds comprised of glacial till. They loom like an inverted tea spoon or an inverted boat. A typical drumlin is seen near Hapoli on which the Circuit House is situated and it extends over a length of about 0.75 km in approximately E-W direction.

North-west of Old Ziro, the topography is dominated by a rolling surface produced possibly by coalescence of several drumlins and morainic dumps to form what is known as "basket of eggs" topography.

Glacial tills and moraines are widely distributed in the valley, sometimes rising up to 40-50 m. above the adjoining land surface. Road cuttings expose the heterogeneous nature of these sediments which are unsorted and ungraded. Grain size ranges from huge boulders of 2-3 m diameter to fine clays. Some of the boulders and rock fragments are striated.

In addition to the above, a cirque like feature is noted 2 km north west of Old Ziro. It resembles a bowl shaped depression or a huge arm-chair like feature in a granite hill face.

LANDFORMS RELATED TO GLACIO-FLUVIAL ENVIRONMENT

Mounds and terraces comprising Sandur deposits have been observed to the south of Ziro and east and south-east of Hapoli. These are made up of horizontally disposed layers alternating with cross-bedded layers of planar

and trough types. Appreciable variation in grain-size of adjoining bed sets is noticed. The sediments are poorly to moderately sorted and range in grain size from fine grained sand to gravel. The Sandur or outwash plain deposits suggest glacio-fluvial environment.

FEATURES / SEDIMENTS RELATED TO LACUSTRINE ENVIRONMENT

The sediments related to lacustrine environment do not form any separate, characteristic geomorphic/ landform unit. On the contrary, they occur in sub-crop near water level or beneath in exposed vertical sections. However, because of their specific environmental and climatic significance these deserve special mention. Peat, carbonaceous clay and locally developed varves represent the lacustrine features/ sediments. A nearly 4 m thick sequence of carbonaceous clay and peat is exposed from Hang to Soro in the left bank of the Kale Nadi. Two horizons of peat beds have been noticed in the exposed sections. Varves have been observed in a section, north of the Schist hill near Hapoli, which consist of alternating dark and light coloured thin layers comprising clay, very fine silt and fine to coarse silt, respectively. These represent alternate sedimentation during low and high energy currents of different climatic conditions.

LANDFORMS RELATED TO FLUVIAL ENVIRONMENT

Fluvial terraces are well developed on the left bank of the Kale River. This landform, confined usually between 1520 m and 1620 m contours, is well dissected and it comprises

Table 1: Morpho-stratigrpahy of the Ziro valley, Lower Subansiri district, Arunachal Pradesh.

Mopho-stratigraphic units	Environment	Landform Elements	Lithology
Soro Formation	Fluvial environment.	Present-day flood plain.	Unoxidised sand, silt with rolled pebbles, cobbles.
Bre Formation	Fluvial landforms sculptured subsequently by erosional processes.	Fluvial terraces, highly dissected tableland	Think dark, spongy humus layer over highly oxidized red-yellow soil and sand-silt-clay layers.
Hang Formation	Lacustrine depositional features	Varve beds, clay beds, peat (below ground level) exposed in river bed.	Peat, carbonaceous clay and varved clays.
Ziro Formation	Glacial and Fluvioglacial Depositional landforms.	Drumlins, crag and tail.	Morainic landforms (such as boulders, cobbles, pebbles in the till) comprising of porphyritic granite gneiss, biotite gneiss, bedded quartzite, pink mica schist, biotite schist, chlorite schist and vein quartz, etc.
Hapoli unit	Glacial and Fluvioglacial - Primarily erosional landforms.	Rock-cut terraces or strath-surface, roche-moutonnees, inselbergs, small cirques	Porphyritic granite gneiss, quartzite and pink mica-schist.

multi-cyclic, fining upward sequence of fluvial sediments represented by sand of various size grade together with pebbles and boulders. It is capped by a yellow, oxidised silty-clay horizon (1) m in thickness with 30 cm thick humus rich layer at the top. Cross beddings are common in the grit-sand layers. This has been named as Bre surface.

The youngest geomorphic unit in the valley constitutes the present flood-plain comprising clay, silt and sand. This has been named as Soro surface.

LABORATORY ANALYSIS

One samples of peat collected from Kale river near Soro locality, has been dated (by radio carbon method) 40,000 + Years BP.

Palynological study of peat and carbonaceous clay indicates presence of pollens of Upper Pleistocene affinity and suggests a vegetation complex of sub-tropical hill forest type.

Scanning Electron Microscope studies of some quartz (sand) grains collected from natural sections of different landforms, also suggest glacial environment for some landforms and fluvial for some others.

Correlation of major morpho-stratigraphic units, landforms, lithology and geologic environments

Based on field criteria of geomorphic expression, lithology, oxidation and pedogenic character, processes and dominant environmental conditions, amongst a morpho-stratigraphic map of the area has been prepared (fig.2). Broad correlation morpho-stratigraphic units, landform elements, dominant lithology and depositional environment has been attempted and shown in Table 1 below :

DISCUSSION

The present study brings out the role of glacial, glacio-fluvial, lacustrine and fluvial processes in shaping the landscape of the Ziro valley. It also suggests a basis for making a tentative model for climatic-environmental reconstruction during the later part of the Quaternary. Evolution of the extant geomorphic expression of the valley presumably commenced with the Apatani plateau gaining its present elevation during the end phases of the Himalayan orogeny. The origin of the original basin is not fully understood. It could e an erosional basin or could be a structurally and tectonically controlled one as indicated by linearity of the drainage pattern. Global cooling during the Late Pleistocene glaciation caused probably the general lowering of the snow-line and the resultant debouching of the glaciers into the Ziro valley. With the amelioration of climatic condition, the glacial ice melted and Sandur or outwash plain deposits were formed during the glacio-fluvial phase. Further betterment or the warming of the climate must have resulted in greater volume or sediment load carried by the melt water which ultimately chocked the narrow outlet of the valley in the south and a lake must have been formed. Wile coarser sediments were deposited along the lake-fringes, the finer clastics settled in the central, deeper part of the lake. The luxuriant vegetation on the hill slopes contributed lavishly to the deposition of organic matter in the lake thus forming the carbonaceous peat and clay sequence under anaerobic conditions. The peat samples yield an age of 40,000 + years B.P. which corroborates with the last phase of the Pleistocene glaciation. Subsequently the lake water appears to have found an opening by out bursting the dammed outlet and the lake was drained out. A regular phase of fluvial cycle of erosion, deposition and valley alluviation may thus have set in. It is likely that there were episodic breaks in sedimentation during this end phase resulting in the oxidation and pedogenesis of the cover sediments followed by the valley trenching and alluviation that is continuing till date.

CONCLUSION

The Ziro valley, tough tiny in size, presents a fascinating record of the gradual transition in the climatic conditions beginning with the initiation of glacial activity during the last Pleistocene glaciation caused by global cooling to the ultimate present-day alluviation by fluvial agencies. By and large, there has been a continuous amelioration in the climatic conditions since the last glaciation around 40,000 + years B.P. There exists a close correlation between the palaeo-climate, palaeo-environmental conditions, the sediment characters and the resulting landforms in Ziro-valley.

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