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POLYCYCLIC LANDSCAPE AND ITS RELATIONSHIPS WITH TECTONIC INSTABILITY AND PALAEOCLIMATE : (A BOWSPRITE)

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ABSTRACT : The present paper attempts a geomorphological study of polycyclic landscape by citing examples from different parts of the world. Two main reasons exist for investigating polycyclic landscapes : Firstly, due to the frequency with which they occur in the physical landscape and their significance in indicating tectonic instability; Secondly, because they are able to reflect the paleoclimates of the earth's surface.

INTRODUCTION

The earth is unstable. Its surface is changing (Bradshaw et al. 1979) by different constructional and distructional processes (Bloom, 1979) and lowering at the rate of 3 cm/thousand years (Stoddart, 1969). It has inferred that the peneplanation could take place between 10 to 110 thousand million years (Schumm, 1969). Such charac teristic conditions of our earth surface compel us to think about the questions such as: how this change is taking place? and what is the chronology behind this change etc. The credit goes to the geomorphologist rather than other earth surface scientists to advocate the above questions with the aid of his conceptual tool viz., the concept of polycyclic landscape. The polycyclic landscape is an assemblage of landforms – polygenetic in nature and keeps the records of all major and minor changes of the earth surface. Among such landorms which are polygenetic in nature may be included – alluvial terraces, strath-terraces, alluvial fans, debris cones, multicyclic valleys, intrenched and ingrown meanders, knick-points, interlooking spurs and slip of slopes etc. These polycyclic landforms are formed by the superimposition of aggradation by climatic changes and upheaval crustal movements of the area (Nakata, 1972, p. 167). Upheaval crustal movement or tectonic-controls are direct rather than indirect climatic controls (Leopold et al, 1964, p. 474).

POLYCYCLIC LANDSCAPE AND TECTONIC INSTABILITY

The landscape on the earth are mainly polycyclic unless it happens to be a coastal land newly emerged from the sea or an extensive alluvial basin of the Quaternary as the Ganga Plain, in which case the only evidence one may advance for a polycyclic landscape are the terraces (Dikshit, 1970, p. 240). The polycyclic landscape exhibits the uplift of the area while the monocyclic landscape – the subsidence. For instance, in northern India the boundary between the upheaval and subsidence are marked by tectonic line (viz., Himalayan Front Tectonic Line) both sides of which two structural units, i.e. the Himalayan ranges and the basements of the Indo-Gangetic Plain have reversed crustal movements that are distinctly reflected to the Quaternary tectonic movements; consequently, polycyclic landforms are frequently available in the Himalayan Zone and monocyclic in the Plains (Nakata, 1972, p. 167). Tectonic processes such as faulting, folding, warping and tilting, usually affect river systems through differential changes in gradient, uplift may in addition place the land in different climatic environment or produce change in the river system altering the delivery of sediments (Leopold, et al. 1964, p. 474) forming polycyclic landforms. Thus, polycyclic landscape played a significant role in understanding the tectonic instability. They exhibit – the regional uplift, tectonic displacement, successive stages of tectonic uplift, amount of uplift, differential uplift and morphotectonic and neo-tectonic relationships.

EXAMPLES

1. Regional uplift in the Post Siwalik times at least between 950 and 1250 feet has produced polycyclic fans and alluvial terraces in Dehra Dun valley. The valley floor of the alluvial fans are characterized by three levels of terraces which are caused by successive vertical movements (Nossin, 1971). These polycyclic piedmont alluvial fans of the Northern Dun valley are the result of differential uplift influencing later sedimentation and soil genesis (Rupke 1974). The terrace convergence and felescopic surfaces in this valley suggest that the greater amount of the upheaval movement is taking place in the northern portion of the Western Dun section (Nakata 1972).

2. Warping on the terrace surface of the Ventura River (California) as appears from Figure 4, is the product of uplift of the mountain area. Deformation of the longitudinal trace of the terrace profile is due to faulting subsequent to the formation of the terrace. Ventura River has intrenched the valley at a more rapid rate than the rate of uplift resulting in the warped terrace.

3. The Sikkim-Bhutan Sub-Himalayas, sub-recent and recent river terraces display the last tectonic displacements as indicated by warping and folding of the multi-tier terraces, forming an incipient anticline particularly discernible near Jaldhaka River.

4. The Central Bhutan Foothill block is turned as under by rivers which dissected originally one uplifted block into five blocks showing multi-erosional surfaces.

5. The polycyclic geomorphic surfaces lying at 150 m and 300 m in the left bank side of the Subarnrekha River (Southeast India) bear distinct evidences of uplift. The events of uplift in several stages during the tertiary period are well reflected in the different topographic forms in the basins of the Chota Nagpur Plateau (Mukhopadhyay 1980).

6. Several number of base-levels, exhibiting the polycyclic nature in Pennsylvania rest to some extent on the altitudes of windgaps.

These are the result of successive uplift. Following uplift and the growth of subsequent valleys, transverse streams were captured and the water-gap, became wind-gaps (Fenne man 1938).

7. The erosive trend in the valley of Epirus was directed by tectonic activity in Lower Pleistocene times which was continued until Late Pleistocene (Mac Leod and Vita-Finzi 1982) by which the deposition by streams was followed by two episodes of the valley aggradation inducing polycyclic landforms.

POLYCYCLIC LANDSCAPE AND PALAEOCLIMATES

The palaeoclimatic studies through polycyclic landscape specially composed of Quaternary sediments have drawn some meaningful results which indicate the past glacial invasions, rise and fall in rainfall, temperature and moisture conditions. Temperature changes on the earth influences the retreat and advancement of the icesheets which produces negative and positive changes in sea-level, resultant are the polycyclic landscapes.

EXAMPLES

1. The polycyclic landscape in the form of river terraces in the Eastern Coastal Plain of U.S.A., ranging from 8 to 82 m in height are the product of different interglacial epoch (Table 1).

2. Polycyclic fluvial terraces of the Chandigarh Siwalik Hills Punjab are climatic in genesis which emerged at different interglacial epoch (Table 1). The higher level erosional bed rock terrace was formed during the Mindal-Riss Interglacial, the depositional abandonal middle level terrace was formed by the continuous aggradation from Mindal-Riss Interglacial upto Wurm glacial, the depositional-erosional lower level terrace was emerged during the Later Holocene.

Thus, the emergence of above polycyclic terraces Sketch briefly the climatic responses to glacial climatic changes. Detail structural and sedimentological studies of the polycyclic terraces warrant the rainfall, temperature and moisture canditions.

EXAMPLES

1. The darker and more dense laminae deposited particularly between 1920 and 1930 in the Santa Barbara basin, is the product of winter rains which is considered to be density flow deposits while the less dense and lighter laminae are the product of drier conditions (Soutar and Crill, 1977).

2. The boulder in the fluvial terraces of the Chandigarh Siwalik Hills, emerged in Mindal-Riss Interglacial epoch indicates the increase in rainfall in this period while changes in the texture material to silty-clay in the short advent of Riss-Glacial period indicates the reduction in rainfall and water discharge; the small size of gravels in the horizon of Riss-Warm Interglacial period sediments have been considered as the product of less moist condition than Mindal-Riss Interglacial (Mukerji 1978).

Apart from the geomorphological implications of climatic changes (Schumm 1969) the exhaustive sedimentological studies of the polycyclic deposits present numerous other palaeoenvironmental chronology such as palaeobotany, palaeoarcheology and palaeoeconomy etc. Palaeobotanic environment studied through polycyclic deposits appears from the works of Glock (1955), Schulmam (1956), Phipps (1961), Martin et al. (1961), Fritts (1965), Fritts et al. (1971) and numerous others, Leopold and Miller (1954), Miller and Wendorf (1958), Dakaris et al. (1964), Higgs and Vita-Finzi (1966), Higgs et al. (1967); and Bintliff (1976) have investigated palaeoarcheological methods through the sedimentological studies of Quaternary deposits. The problem i.e. related territories and alluvial sediments attempted by Vita-Finzi (1974) provides geomorphic implications of palaeoeconomy.

Eighty five pages in the proceeding of the Prehistoric Society contributed by Dakaris et al. (1964), Higgs and Vita – Finzi (1966); and Higgs et al. (1967), present a noble attempt on the geomorphological implications of palaeoenvironment including the climate, environment and industries of the stone age.

TABLE 1 : PLEISTOCENE TERRACES SHOWING THE POLYCYCLIC LAND FORMS

The Eastern Coastal Plain, U.S.A.*			Siwalik Hills India*+		
Height in 'm'	Name	Tentative Age	Height in 'm'	Name	Tentative Age
82	Brandywine	Aftonian Interglacial stage	16	Higher Terrace	Mindal-Riss Interglacial
66	Coharine	Yarmouth Inter glacial stage	5	Middle Terrace	Early Holocene
52	Sundarland	Yarmouth Interglacial stage	4	Lower Terrace	Later Holocene
30	Wicomico	Sangamon Interglacial stage			
21	Penholoway	- do -			
13	Talbot	- do -			
18	Pamlico	Peorian Interglacial stage			

* After Cooke (1931)

*+ After Mukerji (1978)

REFERENCES

BintLiff, J.L. (1976). Sediments and Settlement in Southern Greece, in *Geoarchaedology*, Davidson, D. and Shackley, N. (Eds.), London, Dukwarth, pp. 267-275.

Bloom, A.L. (1979). *Geomorphology, A Systematic Analysis of Late Cemozoic Landforms*, New Delhi.

Bradshaw, M.J., Abbott, A.J. and Gelsthorpe, A.P. (1979). *The Earth's Changing Surface*, Tanfield, Edinburgh EH 3, 5JT, Great Britain.

Cook, C.W. (1931). Tentative Ages of Pleistocene Shore Lines, *Jour. Wash. Acad. Sci.*, **Vol. 25**, p. 333.

Dakaris, S.I., Higgs, E.S. and Hey, R.W. (1964). The Climate, Environment and Industries of Stone Age Greece, Proceeding of the *Prehistoric Society*, **Vol. 30**, pp. 199–244.

Dikshit, K.R. (1970). Polycyclic Landscape and the Surfaces of Erosion in the Deccan Trap Country with Special Reference to Unpland Maharashtra, *The National Geog. Jour. of India*, **Vol. XVI**, Parts 3 & 4, pp. 236–252.

Fennemen, N.M. (1938). *Physiography of Eastern United States*, McGraw Hill Book Company, Inc., New York and London.

Fritts, H.C. (1965). Tree Ring Evidence for Climate Changes in Western North America, *Mon. Weather Rev.*, **Vol. 93**, pp. 421–443.

Fritts, H.C., Blasing, T.J., Hayden, B.P., and Kutzbach, J.E. (1971). Multivariate Techniques for Specifying Tree-Growth and Climate Relationships and for Reconstructing Anomalies in Palaeoclimate, **Jour. Appl.** *Meteorology*, **Vol. 10**, pp. 854–864.

Glock, W.S. (1955). Tree Growth and Rainfall, *Am. Geophys. Union Trans.*, **Vol. 36**, No. 2, pp. 315–318.

Heim, A., and Gansser, A. (1939). *Central Himalaya, Geological Observations of the Swiss Expeditibn, 1936*, Mem. Soc. Helv. Sci. Nat., **Vol. 73(i)**, pp. 1–245.

Higgs, E.S., and Vita-Finzi, C. (1966). The Climate, Environment and Industries of Stone Age Greece, Part II, Proceedings of the *Prehistoric Society*, **Vol. 27**, pp. 144–145.

Higgs, E.S., Fagg, A.E., Vita–Finzi, C. and Harris, D.R. (1967). The Climate, Environment and Industries of Stone Age Greece, Part III, Proceedings of the *Prehistoric Society*, **Vol. 28**, pp. 1–29.

Leopold, L.B. and Miller, J.P. (1954). A Post-Glacial Chronology for Some Alluvial Valleys in Wyoming, *U.S. Geol. Survey Water Supply Paper*, 1261. p. 90.

Leopold, L.B., Wolman, M.G. and Miller, J.P. (1964). *Fluvial Processes in Geomorphology*, Eurasia Publishing House (Pvt.) Ltd., Ram Nagar, New Delhi 55.

MacLeod, D.A. and Vita–Finzi, C. (1982). Environment and Provence in the Development of Recent Alluvial Deposits in Epirus, NW Greece, *Earth Surface Processes and Landforms*, **Vol. 7**, pp. 29–43.

Martin, P.S., et al. (1961). *The Last 10,000 Years, Geochronology Laboratories*, Univ. of Arizona, Tucson, p. 119.

Miller, J.P. and Wendorf, F. (1958). Alluvial Chronology of the Tesuque Valley, New Mexico, *Jour. Geol.*, **Vol. 66**, No. 2, pp. 177–194.

Mukerji, A.B. (1978). Choe Terraces of the Chandigarh Siwalik Hills, **T. XXV**, pp. 1–16.

Mukhopadhyay, S.C. (1980). *Geomorphology of the Subarnarekha Basin*, The University of Burdwan.

Nakata, T. (1972). *Geomorphic History of the Cristal Movements of the Foot-Hills of the Himalayas*, Institute of Geography, Faculty of Science, Tohoku University.

Nossin, J.J. (1971). Outline of the Geomorphology of the Doon Valley, Northern U.P., India, *Z. Gemorph. N.F.*, Suppl. Bd. 12, Berlin – Stuttgart, pp. 18–50.

Phipps, R.L. (1961). Analysis of 5 Years Dendrometer Data Obtained with 3 Deciduous Forest Communities of Neotomo, Neotomo Ecological and Bioclimatic Lab, *Research Cirl.* 105, Ohio Agric. Exp. Sta.

Putnam, W.C. (1942). Geomorphology of the Ventura Region, California, *Geol. Soc. Am. Bull.*, **Vol. 53**, pp. 691–754.

Rupke, J. (1974). Stratigraphic and Structural Evolution of the Kumaun Lesser Hima7aya, Sedimentary Geology, Vol. 11, Netherlands, pp. 81–265.

Schulman, E. (1956). *Dendroclimatic Changes in Semi-Arid America*, Univ. of Ariz Press, Tucson, p. 142.

Schumm, S.A. (1969). Geomorphic Implications of Climatic Changes, in Chorley, R.J. (Ed.), *Water, Earth and Man*, London, Methuen and Co., pp. 525–534.

Soutar, A. and Crill, P.A. (1977). Sedimentation and Climatic Patterns in the Santa Barbara Basin During the 19th and 20th Centuries, *Geol. Soc. Amer. Bull.*, **Vol. 88**, No. 8, pp. 1161–1172.

Stoddart, D.R. (1969). World Erosion and Sedimentation, in R.J. Chorley (Ed.), *Water Earth and Man*, London, pp. 43–64.

Vita–Finzi, C. (1974). Related Territories and Alluvial Sediments, in *Palaeoeconomy*, Higgs, E.S. (Ed.), Cambridge University Press, pp. 225–231.

Vita–Finzi, C. (1978). *Archaeological Sites and their Setting*, London, Thames and Hudson.

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