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## Global correlation of Late Cenozoic Fluvial Deposits: Focus on India

Rivers play a dominant role on the continents as agents of denudation, sediment and water transport, and floodplain development. The activities of human societies are centred around rivers, more particularly so in the case of agricultural communities. Fluvial basins are studied intensively by earth scientists, agriculturists, environmentalists, hydrologists and flood engineers. Rivers constitute dynamic elements of a landscape, and may change their form and behaviour with time. Depending upon the tectonic and geomorphic settings of river basins, variable thicknesses of sediments may accumulate in them. In areas of major subsidence on the continents, such as foreland and rift regions, thick kilometre scale sediment sequences may be found. For example, the Himalayan Foreland has accumulated more than 5 km thick fluvial deposits in the last 20 m.y. Fluvial records can therefore be potentially exploited for understanding palaeoclimate and palaeoenvironment, and thereby for understanding land responses to global climate change.

In the past decade, there has been a sustained focus on understanding the Quaternary fluvial systems from various river basins around the globe. Integrated approaches using geomorphology, sedimentology and stratigraphy, palaeohydrology, palaeontology and archaeology are being emphasized. Such approaches help in using fluvial archives for understanding a variety of subjects – faunal evolution, human occupation and migration, Quaternary environmental change(s), and the responses of fluvial systems to various forcing mechanisms such as climate, tectonics, sea level, and their linkages.

Comprehensive information from the oceanic basins is available based on detailed studies of oxygen isotopic records of Late Cenozoic oceanic sediments. A well-established oxygen isotope stratigraphic framework has been developed for the Late Cenozoic from the world's oceans. Fluvial archives, particularly long fluvial records representative of various tectonic, climatic, and geomorphic settings of the globe must be synthesized and benchmarked against the oxygen isotope stratigraphy (OIS) record of the oceans, in order to understand the inter-relationship of land–ocean system with respect to global climate change. In addition to several other objectives, the former is a major goal of the International Geological Correlation Project (IGCP) 449 (Global Correlation of Late Cenozoic Fluvial Deposits). The main objectives of IGCP-449 are as follows:

- to promote studies, compile and disseminate data of long fluviatile records,
- to develop an agreed methodology for the study and recording of fluvial sequences,
- compilation of database of well-dated Late Cenozoic fluvial sequences,
- correlation of fluvial sequences with the global marine record, by whatever means possible and with emphasis on a multi-proxy approach.

It must be emphasized that the eventual scope of the project is global with emphasis on temperate, tropical, and equatorial fluvial basins. The time interval of interest to the project is the Late Cenozoic, but the emphasis of the project is on the past 1 Ma as much of the available dating evidence falls in this time scale.

Annual meetings are an important element of the activities of IGCP-449; three meetings – the inaugural meeting at Praha (April 2001), a second meeting at the Indian Institute of Technology, Kanpur (December 2001) and a third meeting at Marrakesh, Morrocco (December 2002) have been held. The purpose of the second meeting held at Kanpur was to mainly compile and disseminate data on the fluvial records from the South Asian region, and from India in particular. This meeting was well attended by active groups of workers from India as well as international participants from Australia, Malaysia, Russia, Turkey, Ukraine, and the United Kingdom.

In comparison to the enormity of the Late Cenozoic records from India, the existing data is meagre. Nevertheless, considering the needs and goals of IGCP-449 for global correlation, it was agreed at the end of the Kanpur meeting that a compilation of the work done on Late Cenozoc fluvial sequences of the Indian region should be attempted. We have, therefore, compiled a thematic set of papers on this important subject for *Current Science*, and hope that it will serve as a catalyst for more work on the Late Cenozoic fluvial records of India.

The thematic set consists of fourteen papers that deal with various aspects of Late Cenozoic fluvial deposits. Ten of these papers deal with fluvial deposits occurring in northern and western India. Two papers presented at the IIT, Kanpur meeting deal with terrace staircase systems from Syria and Turkey. Although the main focus of the present thematic set is on Indian fluvial deposits, these papers have been included in order to provide coverage to the subtheme of terrace systems. Similar detailed descriptions from such systems occurring in the Himalayan region would be valuable. The last two papers deal with special aspects such as the arsenic cycle in fluvial deposits, and a suggestion regarding using the effects of changes in the Earth's moment of inertia during glaciation for Quaternary chronology.

The first five papers of this thematic set are on the fluvial deposits of the Himalayan foreland. S. B. Bhatia (**page 1002**) presents a correlation of the Late Miocene (7.9 to 5.1 Ma) fluvial sequences of the Siwalik Group (Chuaria Group) in Nepal over a distance of 700 km on the basis of molluscan, ostracode, and charophyte assemblages. Kumar *et al.* (**page 1006**) recognize two major events of sedimentation patterns and drainage organization at 10 Ma and 5 Ma in the Panjab sub-Himalaya. In a related study, Sangode and Kumar (**page 1014**) have compiled the data on the magnetic polarity of the Siwalik Group from the Indian part of the Himalayan foreland. In addition to a discussion of the use of magnetic fabrics and rock magnetic ratios of pedogenic horizons as correlation tools, Sangode and Kumar discuss the stratigraphic utility of the polarity data for identifying tectonic and climatic events in the Himalayan hinterland. Jain and Sinha (**page 1025**) have emphasized the geomorphic diversity of the river systems and sedimentation patterns in the Gangetic Plains and explore the utility of this data for understanding the sedimentary environments of ancient fluvial sequences in foreland basins. Shukla and Bora (**page 1034**) highlight yet another diversity of the Gangetic plains and describe a sedimentary sequence from the Piedmont zone in the northern Gangetic plains. The Piedmont fan deposits are characteristically made up of both fluvial and debris flow facies and which distinguish them from the (alluvial) megafan deposits. Wasson (**page 1041**) has used published data on sediment load to propose a sediment budget for the Ganges–Brahmaputra catchment. The computations based on Nd/Sr tracers show that 80 ± 10% of the total contribution from the Ganges tributaries comes from the High Himalaya and 20 ± 10% from the Lesser Himalaya. The actual contributions from the Siwaliks, Plains, and Peninsular region are unknown but each of these is likely to be less than 10 per cent.

The next set of four papers deal with the fluvial deposits of western India. Jain and Tandon (**page 1048**) have used the clay mineral ratios of smectite/chlorite and smectite/illite from the alluvial palaeosols of the Sabarmati sequence at Mahudi as proxy indicators of climate change. Wet phases are recognized during OIS 5 and OIS 1 in these sequences. Maurya *et al.* (**page 1056**) have shown from the less-studied area of southern mainland Kachchh that the Late Quaternary fluvial sequences form three distinct geomorphic surfaces – a featureless alluvial plain (S1 surface), the extremely dissected S2 surface characterized by deep ravines, and the low flat S3 terrace surface. Deposition of the successions associated with the S1 and S2 surfaces took place in ephemeral rivers in a semi-arid to arid climate. Bhatt and Bhonde (**page 1065**) have shown the influence of marine flooding in the river valleys of south Saurashtra, and suggest that the marine flooding can be linked to OIS 5. Kale *et al.* (**page 1072**) have used slack water deposits of bedrock gorges to assemble a 2000-year chronology of large floods on Narmada and a less than 500-year chronology of floods for the Tapi. They have noted clustering of flood events, and a possible link between palaeofloods and Holocene climatic changes.

Terrace staircase sequences are important for modelling the relationships between regional-scale surface uplift and large scale fluvial incision over long time-scales. Bridgland and coworkers (**page 1080**) have presented the records of a long Quaternary terrace sequence in the Orontes river valley, Syria with reference to uplift and human occupation. Similarly, the terrace sequences of western Turkey have been used by Westaway *et al.* (**page 1090**) to investigate Pliocene and Quaternary surface uplift.

The paper by Raymahashay and Khare (**page 1102**) on the arsenic cycle in fluvial sediments, though not in line with the main theme of this compilation of papers, touches upon a very important geo-environmental problem of the delta region of the Ganges in India and Bangladesh. Finally, the thematic set includes a suggestion by Westaway (**page 1105**) regarding the use of the effect in the earth's moment of inertia during glaciation on geomagnetic polarity excursions and reversals for Quaternary chronology.

R. Sinha
S. K. Tandon