

Review

History of river channel modifications - A review

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Many river basins have witnessed episodes of modifications and shifts in its courses in the geological past. The study of these aspects can be regarded as part of a trend towards the understanding and explanation rather than depiction of how rivers adjust, under varied terrains of landform behaviour. The methodological appraisals that arise from such intensive research are illustrated in this paper using a detailed investigation of river reach with a special emphasis on palaeochannels and channel modification. The proper evaluation of the past works on channel modifications is expected to provide more insight into not only the theoretical concepts of channel metamorphosis but also to the realistic development of natural resources. For successful planning and management of the water resources, it is essential to evaluate the actual surface and subsurface signatures of the dynamic river systems.

Key words: Channel modification, river, palaeochannel.

INTRODUCTION

Palaeochannels are the elongate, lobate or sinuous fluvial landforms representing the drainage path in the geologic past; with an expected aerial extent from a fraction of a kilometer to many kilometers in length. Large rivers are arteries which are critical to the life of diversified landscapes they pass through.

The rivers are largely instrumental in shaping the landforms both by means of erosion and deposition. Although rivers are mere narrow ribbons across the continents, their network direct and regulate one of the most significant activities of nature. Rivers form the vital components of the hydrological cycle. The increasing number of settlements and population necessitated the suitable methods of exploitation of water resources very significantly. This also needs a comprehensive hydrogeological analysis. An appraisal of the existing groundwater conditions in any fluvial system helps the supplementary development of resources in order to meet the projected demand. Since the advent of modern techniques in the field of earth science, it has become obvious that any shift in the present river course or distribution of abandoned channels is considered to be the topics of wide discussion. A trend has also been set

in the search of old channel courses which can be used to find the promising sites for groundwater exploration.

Many features can be attributed to successfully recognize the existence of palaeochannels. Features of meanderplains like, old channel scars, point bar deposits, meander scrolls, meander loops, ox-bow lakes, and water filled abandoned channels; variously dissected fluvial deposits; elongate, low sinuous ribbons of sediment deposits, characteristic narrow mosaic of sedimentary deposits and type and texture of vegetation can provide reliable information about the nature of palaeochannels. Since the groundwater potentialities of such zones are remarkably excellent, anomalous growth of healthy plants in high density is also expected.

SCOPE AND OBJECTIVES

The continuing channel modifications and change in river courses have got a greater implication on the potentiality of water resources. For successful planning and management of these resources, it is important to assess the actual surface and subsurface signatures of the dynamic river systems. The scope of the present study is to assess the development in the field of channel modifications and palaeochannels, which form one of the important hydrogeological domains. This study involves

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the analysis of the function played by geology and structural characteristics in the channel shifts, palaeochannels and their hydrogeological aspects and evaluation of the mechanism of drainage metamorphosis. In the recent past, proper attention has been paid particularly in many parts of the world to characterize the palaeochannels or the old courses of the major rivers. An assessment of the existing sources of earlier studies has been made and presented in this paper.

DISCUSSION

Historical developments

A clear description of river channel adjustment was given by Clemmens (1883) (was probably the first?). The suspected changes inferred before 1900 were not investigated in the subsequent years. After 1900 the Davisian explanation prevailed and dominated the geomorphological thinking about rivers. This interpretation involved the assumed changes which occurred during the cyclic evolution of landscape development. Remarkable beginning was given by Sonderreger (1935). The concept further was oriented towards the measurement of change. One of the greatest and outstanding problems for a geomorphologist is to differentiate between the evolutionary sequences of chance and adjustments inspired by direct and indirect human activities. Collections of papers on river morphology (Schumm, 1972a) and on environmental geomorphology demonstrate that some research was completed during the past century which is pertinent to river channel change.

A number of methods are available for the identification of channel changes and these are clear from the (1) empirical measurements, (2) historical methods, (3) dating techniques, and (4) Space-time substitution.

CHANNEL MODIFICATIONS

Any adjustment in the channel forms and processes will lead to a typical hydrogeological and hydrogeomorphological set-up. The earliest work on river change and morphology were carried out by Schumm (1968), followed by Dawson and Tilley (1972); Hickin and Nanson (1975) and Lewin and Weir (1977). Gregory (1977) was probably the first to review the context of river channel changes by summarizing the results of various studies. Studies on channel modifications induced by natural phenomena like floods, tectonism and high meandering are a few. Alluvial rivers react to valley slope deformation caused by these factors in various ways depending on the rate of amount of surficial deformation and on the nature of river. Significant among them could be seen in Ritter Dale (1979), Malcolm Anderson and

Ann Calver (1980), Carson (1986) and Shunji Ouchi (1985). Changes in the channel geometry caused by human intervention with fluvial processes have received considerable attention (Gregory, 1977). Richards and Greenhalgh (1984) discussed the limitations of the spatial interpolation method of identifying and interpreting the channel modification. Kesel Richard and Yodi's Elaine (1992) studied the effects of human modifications on sand-bed channels in south western Mississippi.

Mohammed-Aslam et al. (2006) applied Linear Mixture Model for studying alluvial plain that contains palaeochannels. Petts (1980) has suggested a few analytical methods for the river channel changes. Saini et al. (1980) have mapped out the abandoned channels of Mendha River in Orissa using LANDSAT MSS data. They have attributed that the sand movement towards the northeast has forced the river to change its course.

The other notable work done on river changes could be seen in Antczak (1981) and Ferguson and Werrity (1983). The morphology and hydrology of ancient meandering fluvial systems have been assessed by means of the physical parameters by Gardner-Thomas (1983). Dury (1984) explained the abrupt variation in the channel width along a river and proposed a functional relationship of channel properties. Watkins and Simmons Clyde (1984) compared the hydrological conditions of the Chicod Creek basin, before and during channel changes.

Rajaguru and Kale (1985) used the geomorphological, archaeological, palaeontological and C_{14} dating information in deriving the buried and exposed alluvial deposits of upper parts of Krishna, Bhima, and Godavari Rivers of Western Maharashtra. Ramasamy et al. (1992) pointed out the river migration in northern Tamil Nadu with the evidences from satellite data, archaeology and Tamil Literature. The sinuous nature of river meanders and their complexities with fractal dimensions of alluvial and non-alluvial channels have been conceptually analyzed by Keith Montgomery (1996). Recent studies on channel modifications are seen in Hasegawa Kazuyoshi (1989), Mason Robert et.al.(1990), Singh et.al.(1990), Ramasamy et.al.(1991), Fried Alan (1993), Xue-Chunting (1993), Mohammed-Aslam and Balasubramanian (2001, 2002), Mohammed-Aslam (2003), Mohammed-Aslam et al. (2002, 2003, 2006) and Carolyn et al. (2009).

PALAEOCHANNELS

Well-preserved palaeodrainage systems in the major rivers have dragged the attention of enthusiastic workers mainly because of the valuable economic deposits resulted from the hydrochemical response with sediments and enriched groundwater resources. The general features of palaeochannels were brought into the limelight by Schumm (1972). Later in the year 1979, Wynn had explained the applications of electromagnetic methods in locating the buried palaeochannels. Bachman and Wilson

(1982) published a report on the palaeochannels discovered over the Delmarva Peninsula in USA. Gregory (1983) has illustrated the different sections come under palaeohydrology. The geometrical aspects of palaeochannels and their flow patterns have been analyzed by Marc B Edwards et.al (1983) using the vertical sections of channels and their floodplains. Narasimhan (1990) and Absar-Ahsan et al. (1991) have investigated the palaeochannels of Palar river and concluded that the uplift of the terrain have occurred during the Quaternary periods. A few pioneering works have been done on palaeochannels and their impact on Mine Stability. Such studies are seen in Guion Paul (1987), Ingram David and Chase Frank (1987). Glacial palaeochannels of Susquehanna River in the Chesapeake Bay area were studied by Colman et al. (1988). Dimichele William and Philips Tom (1988) pointed out the palaeoecology of Herrin coal swamp adjacent to the Walshville palaeochannel. Other remarkable work done on palaeochannels was found in Qin-Yunshan et al. (1988) ; Brazier and Balantyne (1989); Willis (1989, 1993); Mohammed-Aslam and Balasubramanian (2001, 2002); Mohammed-Aslam (2003); McLaren et al. (2004); Mohammed-Aslam et al. (2002, 2003, 2006) and Robert (2009).

Castaldini (1990) has brought out the Palaeochannel network of Po river, Italy, using remote sensing, archaeological, historical and prehistorical data. He has also dated the Roman settlements aligned along its old courses, archaeological remains of Bronze age, Iron age etc. and concluded that the Po river has wandered almost widely during 4000 - 5000 years ahead of the present.

David et al. (1991) used the transient electromagnetic soundings and terrain conductivity meter measurements for mapping the palaeochannels geometry in the Al Jaww plain in eastern Abu Dhabi Emirate. Du-Xiaodi et al. (1991) made an effort on palaeochannel reconstruction based on sedimentary characteristics of the fluvial facies. There are a few examples in the literature for palaeochannels and further notable observations are seen in Li- Huanchun (1991); Richard et al. (1992); Shevchenko (1992) and Smith et al. (1993).

A few authors have attempted to identify the major palaeochannels in different river basins of Indian sub continent. The lost courses of River Saraswati were mapped by Ghose et al. (1979). Remote sensing techniques have been successfully utilized in studying the palaeochannels (Philip et al., 1991; Ramasamy, 1991; Sarma, 1993; Mohammed-Aslam and Balasubramanian, 2001; Mohammed-Aslam et al., 2006). Tiwari (1992) estimated the groundwater potential zones in a part of the Thar desert by demarcating the palaeochannels.

Babu (1975, 1986) has divided the Cauvery basin into four main physiographic zones and made a detailed study about the past and present characteristics of Cauvery Delta. Rao (1982) discussed the morphology and evolution of modern Cauvery Delta. Ramasamy (1991) employed remote sensing techniques for studying the river delta in Tamil Nadu. Radhakrishna (1992) described the

geological past of Cauvery Basin and observed its drainage architecture and fluvial anomalies.

Recent investigations on palaeochannels have diversified approach. Seismic-Reflection Identification of Susquehanna River Paleochannels on the Mid-Atlantic Coastal Plain was attempted by Robert et al. (1994). Jean-Christophe et al. (2003) used three classical geophysical methods (electromagnetic profiling supplemented by electrical soundings, electrical resistivity tomography and ground penetrating radar [GPR]) to define alluvial bodies and palaeochannels.

The paper by David (2003) discussed the properties of the buried flood- plain at six sites in the Loup River basin, to consider why the properties of buried flood-plain vary from site to site, and to evaluate possible reasons why the Loup River flood-plains stabilized 5500 years ago. Extensive works on Palaeochannels of NCP (North China Plain) are seen in works of Wu Chen et al. (1996a, 1996b, 1996c) and Xu Qinghai et al. (1996a, 1996b).

Ellis and Brown (1998) illustrated how archaeomagnetic dating can be used for palaeochannel fills within floodplain sequences. The sites investigated are palaeochannels associated with the mediaeval braided/anastomosing channels of an unstable reach of the River Trent at Hemington, North-west Leicestershire.

The paper from Ogbaghebriel et al. (1998) presented a geomorphologic–stratigraphic analysis of a travertine dammed lacustrine–swampy sedimentary sequence, composed of clay, peaty layers and phytoclastic travertine sands, deeply incised by the Mai Maikden River, on the Highlands of Tigray (Northern Ethiopia) where a few palaeochannels were identified. Dates for sediment deposition have been obtained for a number of abandoned channels with modern features on the Upper Murray, Kiewa, Ovens and Goulburn Rivers, and from palaeochannel deposits on the Upper Murray River just west of Albury by Ralph et al. (2001). A research paper from Mauro (2002) discussed the changes in fluvial dynamics that started from Late Pleistocene and Early Holocene due to distinct climatic changes. Imaging of a large palaeochannel by Fielding et al. (2003) on the northeastern Australian continental shelf by a series of shallow seismic reflection profiles preserves a rare insight into the stratigraphic record of falling sea level during the last glacial period. Abandoned channel belts, ponds and point bar deposits of palaeochannels in the interfluvial regions of central Ganga Plain and the changes in the morphohydrologic conditions during the Latest Pleistocene–Holocene were carried out by Pradeep et al. (2003). David and Andy (2004) used a method using Coleoptera remains recovered from a palaeochannel fill at Spalford Meadows in the Lower Trent Valley, for the reconstruction of river histories of Trent basin, UK, a key factor in understanding the distribution of valley floor archaeological settlement patterns. Lewin et al. (2005) classified Holocene alluvial archive of Great Britain by sedimentation unit (channel sediments, palaeochannel fills, floodplain surface sediments, floodbasins and colluvial

deposits) and alluvial ensemble (fans and cones, upland gullies and streams, braided systems and active/inactive meandering and anastomosing systems).

Based on the observation from high-resolution 3D seismic data sets, Gay et al. (2006) documented the subsurface reservoir architecture and organization of a portion of the Oligocene–Miocene stratigraphy within the Congo Basin, offshore southwestern Africa, and identified four levels of turbiditic palaeochannels, which are separated by low-amplitude continuous reflectors interpreted as hemipelagic sediments. Recently, Olga et al. (2006) made use of the morphological, geological, geochronological and palynological methods and showed that the landscape, climate and hydrological history of the Seim River basin. Vincent et al. (2006) employed the archaeological analysis and dendrochronological dating to discuss the four palaeo-flooding events occurred during a short time period between AD 20 and AD 145/146. These geoarchaeological observations focus on floods that do not seem to have considerably affected human occupation in the Rhine floodplain.

CONCLUSIONS

The application potential of geological, geophysical, remote sensing and related techniques in characterizing the palaeochannels and channel modifications has been attempted and demonstrated in this work.

The proper appraisal of the past works on palaeochannels and channel modifications expected to provide more insight into not only the theoretical concepts of channel metamorphosis but also to the practical development of natural resources.

Micro-level and sector based investigations of natural resources are now given much emphasis that are related with channel shifting and palaeochannels. Integrated studies are encouraged in order to assess and evaluate the quantitative and qualitative aspects of palaeochannels.

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