Journal of Asian Earth Sciences 77 (2013) 45–58

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Holocene vegetation and climatic variations in Central India: A study based on multiproxy evidences

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ARTICLE INFO

Article history:
Received 7 June 2012
Received in revised form 1 August 2013
Accepted 5 August 2013
Available online 21 August 2013

Keywords:
Holocene
Palaeoclimate
Palaeovegetation
Multiproxy data
Pollen analysis
Central India

ABSTRACT

Palynology, texture, mineralogy, geochemistry, and magnetic susceptibility analysis of a 2 m deep sediment core from Padauna Swamp, southeastern Madhya Pradesh infers that between 8600 and 7500 cal yr BP a warm and relatively less-humid climate prevailed with open tree-savannahs dominated by grasses followed by sedges, *Artemisia* and members of Chenopodiaceae/Amaranthaceae with scanty trees viz., *Schrebera*, *Aegle marmelos* and *Sterculia urens*. This is well supported by lower organic to carbonate carbon ratio, coarser texture having relatively low CIA and magnetic susceptibility values and presence of some primary minerals. Between 7500 and 6250 cal yr BP the tree-savannahs were succeeded by open mixed deciduous forests with the invasion of a few more trees viz., *Madhuca indica*, *Holoptelea*, *Emblica officinalis*, *Mitragyna parvifolia* and members of Anacardiaceae in response to onset of a warm and humid climate. A considerable rise in organic carbon generated from the degradation of plentiful biomass along with increase in clay content with signs of kaolinite and increase in immobile over mobile elements with slightly higher CIA and magnetic susceptibility values also suggest climatic amelioration. The presence of ruderal plants such as *Artemisia*, *Cannabis sativa* and Cheno/Am further infers initiation of human activities in the region. Between 6250 and 2800 cal yr BP, the mixed deciduous forests became more diverse and dense, subduing grasses and other herbaceous elements. Sporadic incursion of *Shorea robusta* (Sal) in forest floristic was recorded around 5000 cal yr BP. The overall change in the vegetation mosaic reflects that a warm and more-humid climate prevailed in the region, probably on account of invigoration of southwest monsoon. This observation is further corroborated by other proxy data showing a spurt in organic/inorganic carbon ratio, increase in clay content with matured mineralogy, significantly higher CIA and magnetic susceptibility values. Since 2800 cal yr BP onwards, the modern Sal dominated deciduous forests were established indicating continuation of warm and more-humid climate including timely arrival of SW monsoon coinciding with the shedding of Sal seeds as they are viable for a very short period.

1. Introduction

The southwest (SW) monsoon system covers a large region spreading from Africa to southeast Asia including India (Overpeck et al., 1996). In Indian subcontinent, SW monsoon provides ~80% of the total rainfall (Gadgil, 2003) and is influenced by El Nino, La Nina, Indian Ocean dipole and Walker circulation in the equatorial Pacific (Kumar et al., 1999; Krishnamurthy and Goswami, 2000). Since the instrumental records are meagre and available for the last century or so, there is a need to look for alternate palaeoclimatic proxy records such as sediments of continental and marine origin. Palaeoclimatic studies indicate strong SW monsoon during early Holocene which gradually weakened with increased aridity by mid-Holocene (Steig, 2000). Global palaeoclimatic records show weakening of the SW monsoon during 5000–3500 cal yr BP including increased aridity in the NW India, Arabia and Sahara regions (Petit-Maire et al., 1995). Although several marine and continental records from eastern Arabian sea and NW India respectively indicate a dry climatic phase during the mid-late Holocene (Caratini et al., 1991, 1994; Sukumar et al., 1993; Sarkar et al., 2000; Prasad et al., 2007), but the spatial variation of different basins and their deposits show variance in timing of this phase (Kale and Singhvi, 2003).

Palaeoecological studies, particularly based on pollen evidence from the sedimentary deposits, in the tropical regions of India (Vishnu-Mittre and Gupta, 1968, 1971; Singh et al., 1972, 1974; Gupta, 1973; Van Campo et al., 1982; Tissot, 1986, 1990; Van Campo, 1986; Vasanthy, 1988; Gupta and Bera, 1998; Farooqui and Sekar, 2002; Farooqui and Achyuthan, 2006; Shaw et al., 2007; Chauhan and Quamar, 2010, 2012; Quamar and Chauhan, 2012; Trivedi et al., 2012) provide good account of palaeovegetation and palaeomonsoon distribution, however, the antiquity of the tropical deciduous Sal (*Shorea robusta*) forests, particularly its

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http://dx.doi.org/10.1016/j.jseaes.2013.08.005

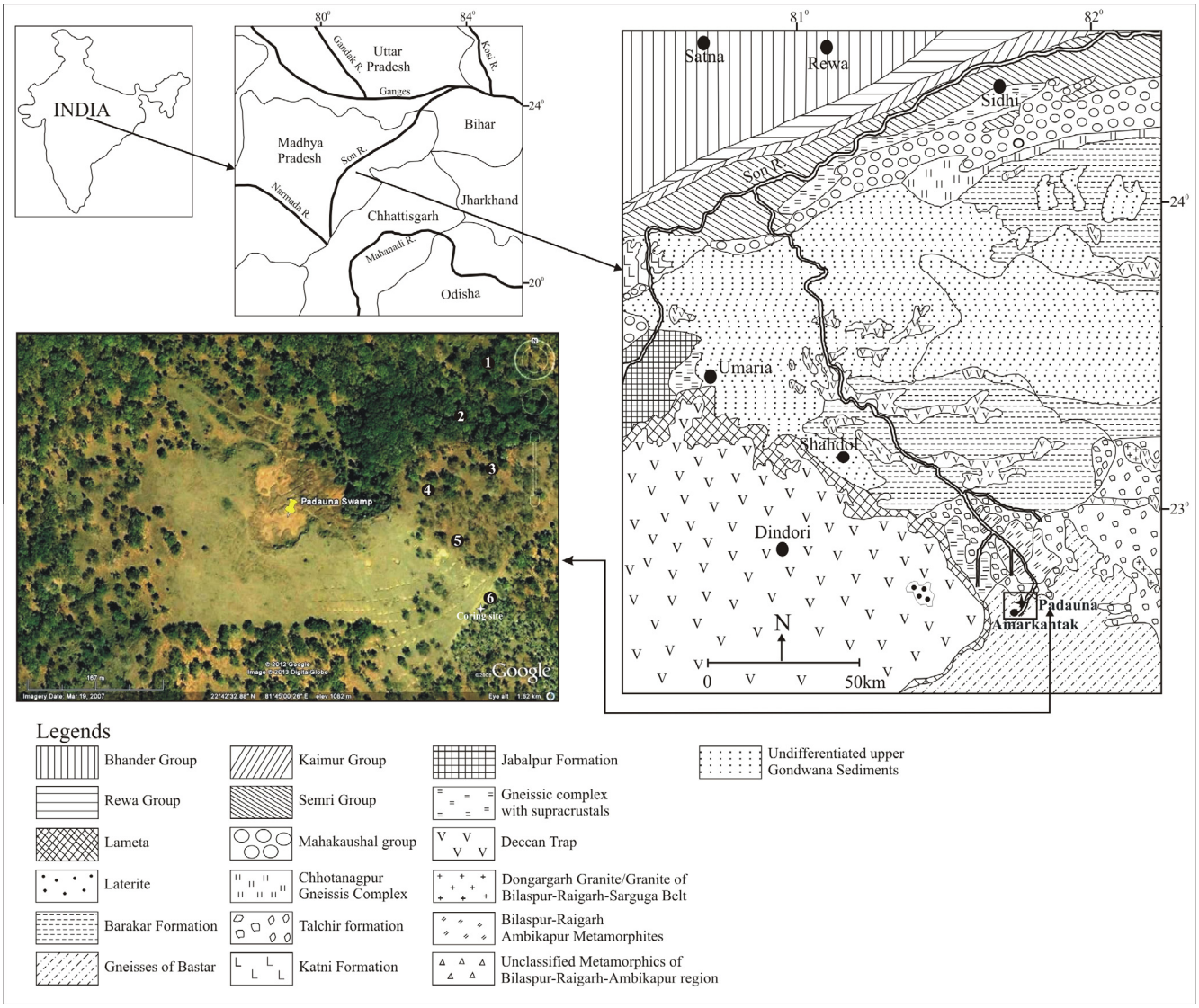

Fig. 1. Location map, Google image (showing surface samples and coring site) and geological map of the study area.

significance in determining the arrival and strength of monsoon is not well understood. It is interesting to note here that the germination of *Shorea robusta* (Sal) seeds needs timely advent of SW monsoon and require ~1200 mm of rainfall, a decisive factor for the regeneration of Sal (Meher-Homji, 2000). Such studies have not yet been pursued adequately from Central India, which is one of the biggest phytogeographical provinces of the country. This region also abounds with diversified tropical deciduous Sal forests and their propagation and distribution is entirely influenced by the SW monsoon. Therefore, a concerted approach involving pollen and other proxies is imperative so that the precise floristic dynamics and concurrent monsoon fluctuations could be reconstructed. Hitherto, some information is available on this aspect from the northeastern Madhya Pradesh (Chauhan, 1995, 2000, 2004, 2005; Yadav et al., 2006; Chauhan and Quamar, 2010), however, the southeastern region with more diversified tropical deciduous Sal (*Shorea robusta*) forests has not yet received much attention, except for some sporadic data retrieved through the pollen analytical investigation of sediment deposit (Chauhan, 2002). Hence, in order to decipher the various seral stages involved in the formation of the present climax forests, their temporal and spatial phytogeographical extent with special reference to prominent forest ingredients, more particularly *Shorea robusta* (Sal) and the climatic fluctuations they have experienced during the Holocene, a 2 m deep sediment core was analyzed from the Padauna Swamp (Amarkantak), Anuppur District (Fig. 1) for multiproxy study. The present work also discusses the palaeogeographic distribution of Sal forests as a function of climatic shift and their westward migration.

1.1. Study site

Padauna Swamp lies ~14 km north of Amarkantak township in Anuppur District, Madhya Pradesh. The swamp is located in a valley, measuring ~500 m × 300 m in dimension and is encircled with gentle as well as steep sloped hills. Presently, the swamp is perennial, highly waterlogged and overgrown with reed-swamp grasses. A natural spring is the source of perpetual water supply to the swamp. The eastern flank of the swamp (Lat. 22°41″E and Long 81°46″N) was cored to collect the material for the present investigation (Fig. 1).

1.2. Geomorphology and geology

Geomorphologically, the study region is characterized by hilly to undulating topography with altitudes ranging between 470 m