Cretaceous Research 56 (2015) 702–715

Contents lists available at ScienceDirect

Cretaceous Research

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

Sea level changes in the upper Aptian-lower/middle(?) Turonian sequence of Cauvery Basin, India – An ichnological perspective

Amruta R. Paranjape [a, *], Kantimati G. Kulkarni [a], Anand S. Kale [b]

[a] Geology & Palaeontology Group, Agharkar Research Institute, G.G. Agarkar Road, Pune 411004, Maharashtra, India
[b] Bharat Petro Resources Ltd., Maker Towers, Cuffe Parade, Mumbai 400005, Maharashtra, India

ARTICLE INFO

Article history:
Received 3 June 2014
Accepted in revised form 13 November 2014
Available online 4 December 2014

Keywords:
Sea level changes
Ichnology
Karai Formation
Cauvery Basin
Sequence stratigraphy
Upper Aptian-lower/middle(?) Turonian

ABSTRACT

Cauvery Basin, a pericratonic rift basin along the Eastern Continental Margin of India, evolved during the breakup of the Eastern Gondwanaland. It exposes both syn-rift and later post-rift passive margin deposits ranging from Barremian to Miocene. The Karai Formation, upper Aptian-lower/middle (?) Turonian represents the oldest passive margin in the Cauvery Basin. It is bounded at both contacts by major sequence boundaries viz. the break-up unconformity and the Turonian tilt event. The present communication deals with the ichnology of the Karai Formation and its integration with sedimentary facies and biostratigraphy to interpret the sea level changes during deposition. A traverse between the villages Karai and Kulakkalnattam was studied in detail for this purpose. Based on the lithological position, characters and internal grain size trends, the Karai Formation is sub-divided into four informal lithologic units; the lower three units, constitute a lithostratigraphic unit known in literature as the Gypsiferous Clay Member, while the uppermost, corresponds to the Sandy Clay Member. At the base, clays of the Karai Formation unconformably onlap onto the Precambrian basement or the fluvial syn-rift deposits across the break-up unconformity. Upper Aptian to middle Cenomanian, units I and II showing the distal *Cruziana* ichnofacies, deepening of the basin and a retrogradational stacking pattern represent a transgressive system tract (TST). This long phase of transgression is attributed to continuous accommodation created by the post-breakup thermal subsidence. The upper part of unit II (middle Cenomanian) shows condensation, with its top representing the maximum flooding surface (MFS). Upper Cenomanian to lower/middle (?) Turonian, units III and IV characterised by a shift from the distal *Cruziana* to the *Skolithos* ichnofacies, an initial aggradational and later deltaic, progradational stacking pattern resulting from a fall in the relative sea level and filling up of accommodation space represent the highstand system tract (HST). A further fall in the relative sea level led to the exposure, incision and erosion of the Karai Formation over which the younger transgressive sequence of the Trichinopoly Group was deposited with an angular unconformity.

1. Introduction

The Cauvery Basin is a pericratonic rift basin along the south-eastern part of the Eastern Continental Margin of India. The basin preserves a record of events related to the rifting, subsequent break-up of Eastern Gondwanaland and evolution of the Indian Ocean (Fig. 1A). In the basin, marine passive margin sedimentary sequences from upper Aptian to Miocene are deposited which overlie the crystalline basement (Precambrian) or Early Cretaceous fluvial syn-rift deposits (Yesudian et al., 2009; Sinha et al., 2010). The deposits consist of a wide range of shallow marine to deep marine facies.

The earliest discussion on sea-level changes in the Cauvery Basin dates back to Blanford (1862), who recognized their role in development of several unconformities within the Cretaceous times. In the subsequent century most of the work focused on establishing the macro- and microfossil biostratigraphy and lithostratigraphy. In the past two decades, a few interpretations on sea level changes of the entire Cretaceous succession of the Cauvery Basin have been carried out taking into account the transgressive–regressive cycles deduced from lithological and mega- and micro-fossil data (Tewari et al., 1996a; Sundaram et al., 2001; Ramkumar et al., 2004; Raju et al., 2005; Watkinson et al., 2007; Nagendra et al., 2011).

* Corresponding author. Tel.: +91 20 25653680, +91 9890136282.
E-mail addresses: amrita.paranjpe@gmail.com (A.R. Paranjape), kgkulkarni@aripune.org (K.G. Kulkarni), anand.kale@bharatpetroresources.in (A.S. Kale).

http://dx.doi.org/10.1016/j.cretres.2014.11.005
0195-6671/

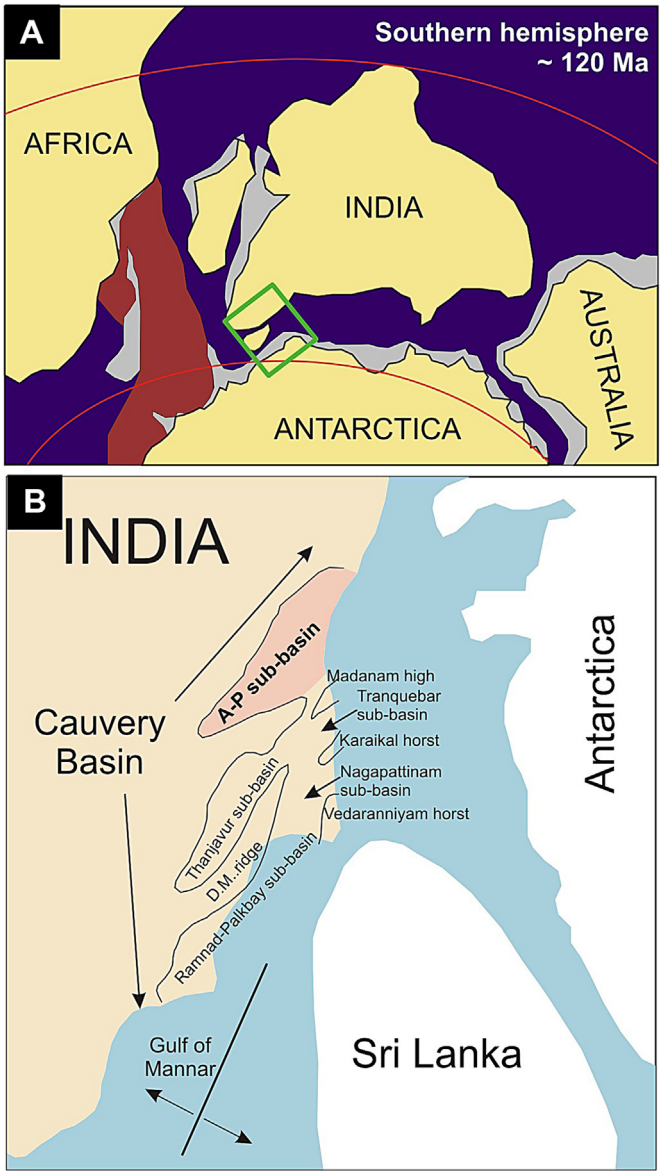

Fig. 1. Location maps for the study area. (A) Position of the Cauvery Basin with respect to the eastern Gondwanaland at around 120 Ma (modified after Reeves and Wit, 2000). Inset: (B) Tectonic map of the Cauvery Basin at the time of rifting (modified after Lal et al., 2009; Sastry et al., 1981).

Trace fossils and their ichnofacies are considered to be excellent indicators in interpreting the environments of deposition and palaeo-bathymetry of sediments; and that the interpretation of sedimentary facies can be largely improved by integrating ichnofacies, sedimentological characters and the stratigraphic context of different lithologies (Buatois and Mángano, 2011). Studying an ichnological succession in association with sedimentological data helps in determination of sequence stratigraphic surfaces and system tracts. Trace fossils from surface exposures are reported from the Kulakkalnattam Sandstone (Nagendra et al., 2010), Trichinopoly Sandstone (Hart et al., 1996). Tewari et al. (1996a) and Ramkumar et al. (2004) record presence of a few ichnogenera in different stratigraphic units. However, detailed ichnological studies of the Cretaceous deposits were lacking. Sequence stratigraphic studies in the basin are also rare and deal with broad aspects (Kale, 2011; Nagendra et al., 2011).

The present communication attempts to decipher the sea level changes of the upper Aptian-lower/middle (?) Turonian Karai Formation, Cauvery Basin by integrating analysis of its lithofacies and ichnofacies with the available biostratigraphic data. The main aims of the present study include:

1. Record of ichnological features and sedimentary characters of the Karai Formation and its integration with other records of biota.
2. Interpretation of ichnofacies and sedimentary environments to understand their spatial and temporal variations.
3. Interpretation of the sequence stratigraphy and sea-level changes during deposition of the Karai Formation.

2. Geology and tectonics

The Cauvery Basin initiated during the Late Jurassic – Early Cretaceous rifting between India and Antarctica and the subsequent breakup of Eastern Gondwanaland. It is the southern-most basin along the Eastern Continental Margin of India (ECMI) and exposes the most widespread outcrops of marine Cretaceous in Peninsular India.

Major tectonic events affecting the Indian plate have defined distinct sequences along the ECMI. The tectonic events began with initial syn-rift sedimentation during the Early Cretaceous break-up of India and Antarctica, followed by marine sedimentation during the post rift sag and passive margin stage, during the remaining part of Cretaceous. The syn-rift and the post-rift deposits represent two first order sequences, separated by the break-up unconformity. Along the ECMI, during the passive margin stage, two major second order sequences are recognized, separated by major unconformities, formed by events which affected the drifting Indian Plate viz. near the K/Pg boundary, related to the Deccan Trap eruption and the mid-Miocene, during which the Indian plate tilts due to its collision with the Asian plate and consequent rise of the Himalayas. During the Turonian (mid Turonian in Cauvery Basin) erosional unconformities are observed in the surface and subsurface in all the ECMI basins which represent third order sequence boundaries (Rao et al., 2010). While the cause for the same remains to be understood, there is an increase in the basinal gradient across the unconformity due to uplift of the peninsula and a minor northeastward plate scale tilt (Moulik et al., 2006; Lal et al., 2009). The event is called as the 'Turonian tilt event' (Yesudian et al., 2009; Paranjape et al., 2013).

The Cauvery Basin after its formation was block faulted into a number of grabens separated by sub-surface ridges (Sastri et al., 1981). The present study area lies in the Ariyalur–Pondicherry Sub-basin, northernmost amongst them with exposures of a more or less a complete Valanginian–Maastrichtian sequence (Fig. 1B).

Within the Cretaceous deposits of the Ariyalur-Pondicherry Sub-basin, the deposition began with the first order syn-rift sequence of the fluvio-deltaic sediments of the Sivaganga Formation. Unconformably overlying them are the marine post-rift deposits of the passive margin phase which are classified into Uttatur, Trichinopoly an Ariyalur groups. The syn-rift and post-rift sequences are separated by the breakup unconformity (of the first order) with a variable time gap from Valanginian to Aptian. The Uttatur Group is a third order sequence deposited between the breakup unconformity and the Turonian tilt event i.e. between upper Aptian to lower early mid(?) Turonian.

The Uttatur Group is sub-divided into the Karai and Dalmiapuram formations. The Karai Formation is widely developed and covers the same age period as the Uttatur Group itself (Fig. 2B). It dominantly consists of sandy clays. Basal sandy clays or clayey