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Barremian–Danian chemostratigraphic sequences of the Cauvery Basin, India: Implications on scales of stratigraphic correlation

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ABSTRACT

Chemostratigraphic concepts postulate that distinct chemozones could be recognized from rock records to help correlate geographically separated strata. Many studies have upheld this view, but were limited to classic boundaries such as Cenomanian–Turonian or Cretaceous–Tertiary. Only a few elements and isotopic compositions were made use in such studies. An attempt to recognize chemozones of Barremian–Danian strata of the Cauvery Basin, South India through whole-rock chemistry had revealed many complex signals and depositional events as expressed by bulk geochemical profiles. The signals indicate major shift in sedimentation pattern from dynamic depocenter to stable depositional conditions during Santonian. Varying sensitivities of different elements towards prevalent depositional conditions are also inferred. Trends of geochemical composition indicated domination of single depositional control all through the depositional history, basinal configuration that limited terrestrial sediment source and episodic influx of detrital materials. Presence of distinct change in whole-rock geochemistry across geochronological and lithostratigraphic boundaries is deciphered through a statistical tool ANOVA. These results demonstrate that visual delineation of chemozones in a long ranging rock record would be tenuous and has to be exercised with caution.

1. Introduction

During the last two decades, chemostratigraphy has emerged to be a potential tool for correlation of widely separated strata where other conventional stratigraphic methods fail or have limitations (Ramkumar and Sathish, 2006). Many recent studies have addressed the chemostratigraphic application (e.g., Sawaki et al., 2008; Ishikawa et al., 2008; Le Guerroue and Cozzi, 2010) and its potential as a vital tool for stratigraphic correlation, fixation of geological boundaries and petroleum exploration. These studies attempted solving selective boundary questions (for example: Saltzman, 2002; Schroeder et al., 2004; Bergstoerm et al., 2006; Kouchinsky et al., 2007; Marquillas et al., 2007; Schroeder and Grotzinger, 2007; Handley et al., 2008; Robinson et al., 2009; Elrick et al., 2009; Ruhl et al., 2009). Many of the publications have either documented geochemical and or isotopic compositional trends across a chronological boundary or geochemical trends of limited chronological span (for example: Brasier and Shields, 2000; Mutti and Bernoulli, 2003; Saylor et al., 2005; Mutti et al., 2006; Nedelec et al., 2007; Kakizaki and Kano, 2009) thus concentrating on presence/absence of similarity in geochemical profiles for a limited geologic time. Only selective elemental or isotopic data were employed in these studies.

As stratigraphic record is the outcome of an exogenic system consisting of geologic setting, changes in sea level, changes in geochemical reactions between the sea and earth, climate and processes of sediment formation (Srinivasan, 1989), the ensuing sedimentary record should show differences in bulk chemistry. As these changes produce different combinations of minerals, primary differences in the chemistry of their constituent minerals or in the proportions of accessory phases such as heavy minerals and clays, there might be distinctive major and trace elemental compositions of the sediments as well which in turn forms the basis of chemostratigraphic application in sub-dividing strata (Das, 1997). If this underlying concept of chemostratigraphy holds good, an ability to judge these differences, distinctness of chemical composition and its causative factor (local, regional or global), should enable recognize and correlate chemozones at appropriate scale (Ramkumar, 1999; Ramkumar and Sathish, 2006). Thus, applicability of chemostratigraphic technique as a potential tool for stratigraphic correlation could be tested only when its perceived capabilities are examined critically through analysis of whole-rock geochemical trends of strata representing considerable time span and also through demonstrating the ability of whole-rock chemistry to distinguish depositional units produced under varying conditions of sedimentation.

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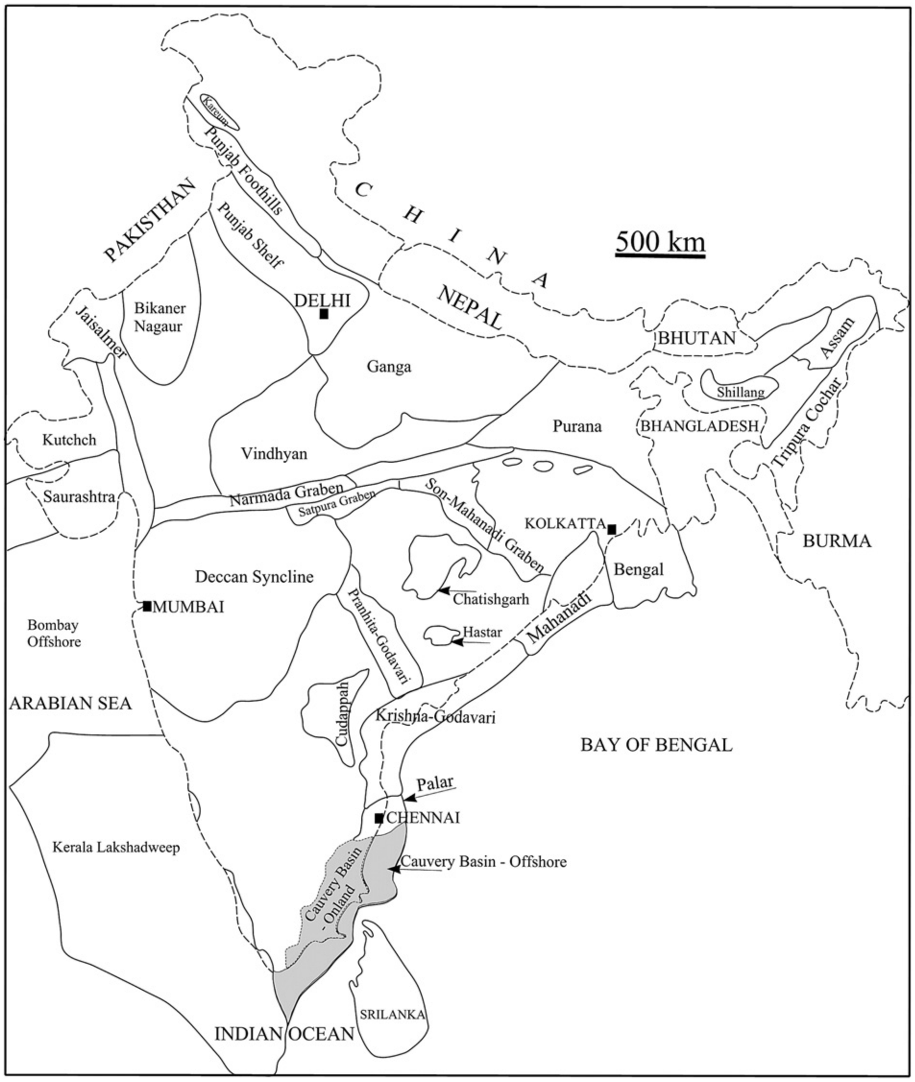

Fig. 1. Sedimentary basins of India and location of the Cauvery Basin.

The exposed part of the Cauvery Basin, south India (Fig. 1) contains a more or less complete sedimentary record of the Upper Cretaceous–Lower Tertiary periods (Yadagiri and Govindan, 2000). The basin comprises many commercially exploitable oil reserves accumulated under "stratigraphic traps", and warrants a high-resolution stratigraphic model (Raju and Misra, 1996). On the other hand, presence of barren rock sequences, patchy occurrence of fossils and occurrence of exotic blocks (older rocks in younger sequences — Ramkumar, 2008a) have thwarted successful stratigraphic correlation and exploration through conventional methods in this basin (Ramkumar et al., 2004a).

To meet these two requirements namely, testing the potential of chemostratigraphic modeling in long ranging strata and the need for high-resolution stratigraphic setup, we have examined geochemical properties of the Cauvery Basin, South India (Fig. 1).

2. Geology of the area

The Cauvery Basin formed as a result of fragmentation of Gondwanaland during Lower Cretaceous. It continued evolving till the end of Tertiary through rift, pull-apart, shelf sag and tilt phases (Prabhakar and Zutshi, 1993), during which many episodes of transgression, regression, erosion and deposition took place to fill the basin. Comprehensive lithostratigraphy of onland part this basin was presented by Tewari et al. (1996) and revised (Table 1; Fig. 2) by Ramkumar et al. (2004a). Fig. 3 depicts the lateral and vertical variation of these members in the exposed area as observed in ten traverses shown in Fig. 2.

2.1. Facies characteristics of the Barremian–Danian strata

Sedimentation in the Cauvery Basin commenced with fluviatile and coastal marine deposition during Barremian. Deposition continued until Danian. The depositional environments varied from fluviatile, lacustrine, coastal marine to deep marine and continental regimes during this period. These environmental changes have impacted the lithofacies association and succession. These are briefly presented in the Table 2 (Figs. 4, 5, and 6).

2.2. Depositional history and sea level changes

The depositional history in terms of depositional units, depositional breaks and major geological events is presented in the Table 3. This table shows that depositional history of this basin was controlled predominantly by sea level changes. Raju and Ravindran (1990) and Raju et al. (1993) presented sea level curve for this basin based on foraminiferal data that documented the presence of six 3rd order cycles caused by glacio-eustatic fluctuations. Ramkumar et al. (2004a) constructed sea level curve for this basin based on lithofacies data, which is similar to the curves presented by Raju et al. (1993) except that it additionally