

INTEGRATED BIO-CHRONO-TECTONOSTRATIGRAPHIC AND PALEOENVIRONMENTAL FRAMEWORK FOR HYDROCARBON EXPLORATION IN EAST-COAST BASINS OF INDIA: PRESENT STATUS

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Extended Abstract

The value of foraminifera in well to well correlation of hydrocarbons bearing deep wells was initially demonstrated in 1889 by Gryzbowsky in Poland. Besides foraminifera, nannofossils and dinoflagellates cysts, spore pollen, acritarchs and other microfossils are used day to day in exploration. Agglutinated forms become valuable in deep water exploration. Microfossils control towards accurate and precise high resolution bio-chrono-stratigraphy is available particularly in dating, correlation and paleoenvironmental /paleobathymetric determinations in case of several offshore wells along the east-coast basins of India.

In the Cretaceous of 80My duration, TS creator 2008 provides seventy dated foram datum's (41 FADs and 29 LADs), which means a resolution close to 1 My can be achieved.

In the Lower Miocene of 7.06My duration, about 30 dated datums are listed; meaning a resolution of less than 0.5My can be achieved.

In Pliocene of 3.52My, 36 dated datums are given, that is a possibility of achieving a resolution of 0.1My to 0.2My.

Main constraints in achieving such high resolution are: (i) quality of samples (ditch cuttings/cores), (ii) spacing of samples in context of the rate of sedimentation, (iii) expertise of micropaleontologist / palynologists. Tectonostratigraphy is a relatively new and actively developing field in the geology of sedimentary basins. The tectonostratigraphic trend is actively applied by petroleum companies, including British Petroleum, which is one of the leaders in the field (Nikishin and Kopaevich, 2009). Tectonostratigraphy means the identification of megasequences and their interpretation in terms of tectonic settings at the time of their accumulation (Watkinson et. al. 1977, see Nikishin and Kopaevich, 2009). Unconformity-bounded units became very popular at the time tectonic episodes were considered eventually synchronous worldwide, but did loose favours among geologists where synchronicity was found not to hold true (Selvador, 1987).

An attempt is made to introduce an informal tectonostratigraphic classification useful for east- coast basins of India. Abbreviation TS is used for tectonostratigraphy. Some of the TS units are equivalent to Supersequences of Ravi Shanker (1989) but it would be better to keep them independent / parallel.

TS Unit – 1

It is equivalent to super sequence V of Ravi Shanker (1989).

Duration: Early Ordovician to Late Carboniferous.

Bounding tectonic events: The lower event is Pan-African / Xingkin Orogeny (ca 500 Ma). The cycle terminates during late Carboniferous due to Tianshanian (Hercynian) orogenic uplift followed by global glaciation.

TS Unit – II

Duration: Permian.

The sediments of this unit were deposited during the transgression of marine waters over the vast Mid-Paleozoic peneplain.

TS Unit III

Duration : Triassic to earliest Jurassic (equivalent to major part of super sequence VII of Ravi Shanker et. al (2005). The basal event coincides with late Permian – early Triassic hiatus in KG Basin.

TS Unit IV

Duration: Early Jurassic. Equivalent to part of supersequence–VIII of Ravi Shanker et al. (2005). This event in KG Basin is represented by a major hiatus of duration of 48 My from Sinemurian to Middle Oxfordian based on dinoflagellate data (Aswal and Mehrotra, 2002).

TS Unit V

Duration: Oxfordian (Jurassic) to Berriasian (earliest Cretaceous). The lower event is a major one along the eastern margin of India representing a rifting and creation of south eastern arm of Tethys II

TS Unit VI

Duration: Late Valanginian to Aptian.

Bounding events: Lower event is close to plate tectonic event coinciding with final break up between Australia (Central Exmouth) and "greater India" and initiation of modern Indian Ocean.

TS Unit VII

Duration: Albian to Turonian.

This unit is characterized by rapid deepening of KG and Cauvery basins during late Aptian-Albian. Upper boundary event was close to separation of Madagascar from India

TS Unit VIII

Duration: Coniacian to Maastrichtian.

The event towards the top of this unit is Deccan volcanism, uplift along east coast basins and erosion at several areas.

TS Unit IX

Duration: Paleocene to Middle Eocene.

The upper limit is characterized by relative drop in sea level.

During later phase of this unit, Himalayan uplift (Himalayan orogenic movement–1) took place.

TS Unit X

Duration: Oligocene

Towards upper part of this unit a major hiatus was detected and dated (Raju et. al. 2005, Raju 2008). The duration and magnitude of hiatus along east coast basins, was documented.

TS Unit XI

Duration: Early-Middle Miocene.

The lower as well as upper limits are bound by regional unconformities. Chart ECB was published and shows the duration of bounding hiatuses and the preserved record in the east coast basins. The upper limit also coincides with uplift / drop in sea level.

TS Unit XII:

Duration: late Middle Miocene to base of Pliocene.

Near to lower limit of this unit, major tectonic events took place in Indian Ocean, Himalaya and beginning of monsoon system (around 12-11 Ma). Several slope fans as in full form structure were deposited.

TS Unit XIII

Duration: Base of Pliocene to Present

The base represents major transgression following Late Miocene unconformity and drop in sea level.

Most preferred environmental / cyclical settings of oil / gas source rocks are:

For Indian basins, paleoenvironmental settings and cycles of sea-level changes during the deposition of source, reservoir and seal rocks are fairly understood through the study of microfossil markers like foraminifera, dinoflagellate cysts, spore-pollen and geochemical isotopes. A few examples are: -

- (i) **Panna Formation:** of Late Paleocene-Early Eocene deposited in several cycles (up to 10) in a fluvial-marginal marine- shallow inner shelf syn-rift set up is the source rock for several reservoirs including giants like Mumbai High and Bassein along the Western offshore.
- (ii) **Cambay Shale:** of Late Paleocene-Early Eocene deposited in 6 to 10 cycles in a setting of lacustrine to marginal marine is the main source rock in Cambay intra-cratonic onshore basin.
- (iii) **Kommugudem Formation:** of Early Permian consists of coal-shale alternations comparable to cyclothems of fluvial-lacustrine set up with marine incursions in Krishna-Godavari Basin.
- (iv) **The main source rocks:** of Palakollu Shale of Late Paleocene and Vadaparru Formation deposited in middle outer shelf settings

The reservoirs of Mumbai High giant oil field are in a set-up of cyclical sediments of carbonate- shale. They represent 4th older cycles.

The reservoirs of Ravva oil / gas field are clastics deposited in 3rd older cycles.

What the audience will learn and or the problem addresses

The paper brings to / focuses the audience on the importance of foraminifera in hydrocarbon exploration with roots in 1889. Emphasis has been merits and limitations. More:

- Presently achievable resolution in classification and correlation-basinal and global and constraints imposed by quality of samples from exploratory wells.
- Tectonostratigraphic trend is relatively new and is applied by petroleum companies.
- It is considered timely to propose a tectonostratigraphic classification useful for east-coast basins and northern Indian Ocean as there is a vast virgin area for exploration.
- Case examples are given towards understanding the preferred paleoenvironmental settings of hydrocarbon source rocks from East-coast as well as west-coast basins of India.

What is new about the information or application presented

This article presents a lead to tectonostratigraphic classification/ framework which is basic for viewing tectonic evolution vs. mega sequences within a frame of geological time scale.