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Hiatus Mapping of Late Cretaceous sediments in Cauvery Basin, India

Abstract

Hiatus mapping has been attempted for the first time in Cauvery Basin at three distinct levels in Late Cretaceous i.e. Turionian, Coniacian and Maastrichtian tops utilizing biostratigraphic and isochronopach data. Three unconformities have been identified earlier in the basin, the first in the time span of Late Turonian to Early Santonian, the second during Maastrichtian to Danian and the third in the later part of Eocene. A total number of 65 wells covering the five sub - basins viz. Ariyalur - Pondicherry, Tranquebar, Tanjore, Nagapattinam, Palk Bay - Ramnad and the Mannar have been taken into consideration for mapping of hiatus in the basin. Contouring of hiatus values has been done at an interval of 1My. At top of Turonian, hiatus span ranges from 1.38 - 3.96My, at Coniacian top, duration of hiatus is ranging from 0.08 - 5My and at Maastrichtian top, hiatus values ranging from 0.1 - 5.85My have been recorded. The duration of hiatus has been calculated by taking a uniform sedimentation rate at the top of each age boundary. Hiatus will give an evidence of variable relative movements/upheavals that basin has undergone through geological time. Hiatus trends shall be helpful in better understanding of the basin configuration and the temporal and spatial relationship of the reservoirs.

Introduction

Hiatuses pervade stratigraphic record at all scales from grain boundaries to inter regional unconformities. They represent the time lapse that may indicate surface of erosion and/or non - deposition which play a significant role in hydrocarbon exploration. During the time interval in which a surface of hiatus is generated, deposition may simply have ceased or erosion may have removed some of the previously deposited sediment. Consequently, three distinctly different components of the accumulation history may all be condensed into a single surface of hiatus: episodes of non-deposition; episodes of erosion; and time intervals occupied by the accumulation of sediment that is subsequently eroded. The subsurface biostratigraphic data is an evidence to indicate a gap or break in the geological record. However, records of such data were hitherto depicted as point data across the stratigraphic succession and their utility was not recognised on a regional scale. Representation of hiatus on a map and subsequently their contouring has been attempted for the first time in Cauvery basin at top of Turonian, Coniacian and Maastrichtian levels taking into account the biostratigraphic data generated in sixty five wells.

Geology of Cauvery Basin

Cauvery Basin came into existence as a pericratonic rift basin (Rangaraju *et al*. 1993) in Mesozoic with the disintegration of Gondwanaland (Prabhakar and Zutshi, 1993) and comes under Category-I . The basin covers an area of 1.5 lakh sq.kms. comprising 25,000 sq.kms of onland, 30,000 sq. kms of shallow offshore and 95,000 sq. km. of deep-water offshore (Fig 1). The basin is endowed with five to six kilometres of sediments ranging in age from Late Jurassic to Recent (mainly thick shale, sandstone & minor limestone). Block faulting along dominant NE-SW Eastern Ghat trends led to the formation of depressions and ridges (Sastri *et al*. 1977). From north to south, the grabens are designated as Ariyalur - Pondicherry, Tranquebar, Tanjore, Nagapattinam, Palk Bay - Ramnad and the Mannar sub-basins. The horsts adjoining these sub-basins are Kumbakonam - Madanam, Karaikal, Pattukotai, Vedaranniyam and Mandapeta - Delft horsts. North and north eastern parts of Cauvery basin show continuity as compared to the other areas where either the sediments of Late Maastrichtian or Middle - Late Maastrichtian or even Middle Campanian - Maastrichtian are absent due to erosion/non-deposition. The Mesozoics of Cauvery basin are divided into two Groups viz. Uttatur Group and Ariyalur Group (Fig 2). Uttatur Group consists of Andimadam formation, Sattapadi

Shale, Bhuvanagiri Formation and Palk Bay Formation. Ariyalur Group comprises Kudavasal Shale, Nannilam formation, Portnovo Shale and Komarakshi Shale.

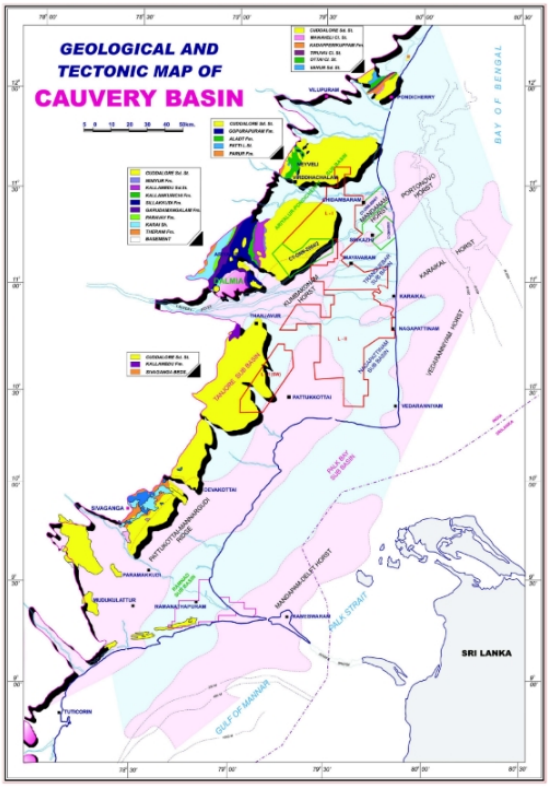

Fig 1. Location Map of Cauvery Basin (After DGH)

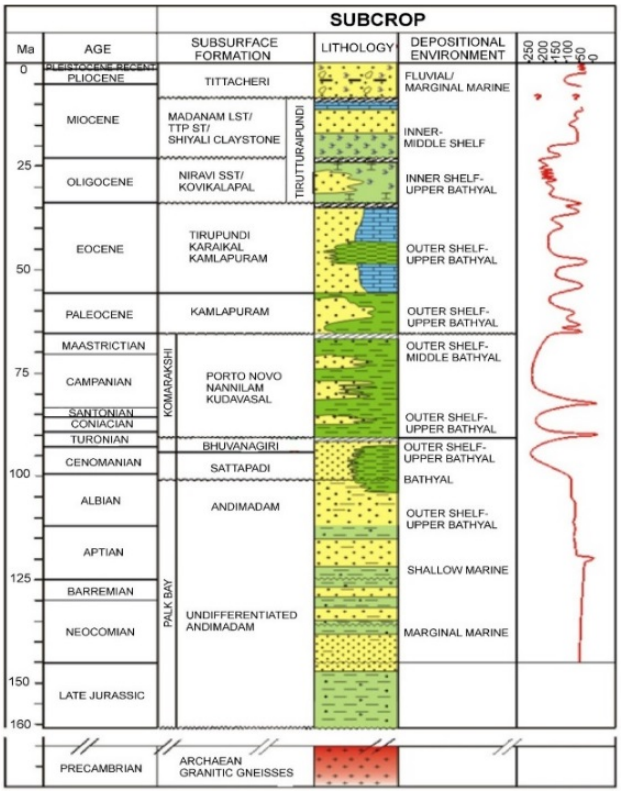

Fig 2. Generalised Stratigraphy of Cauvery Basin (after Venkatarengan et al., 1993)

Fig 3. Rate of Sedimentation for different Sedimentary basins of India (After Raju and Prabhakaran, 2005)

Methodology

The hiatus maps were prepared by collating the biostratigraphic and isochronopach data. Sedimentary thicknesses were calculated using biostratigraphic boundaries. Average rate of sedimentation (Fig 3) is taken after the work of Raju and Prabhakaran (2005). The sedimentation time was calculated by taking the ratio of sedimentary thickness and average sedimentation rate. Hiatus value was obtained on taking a difference of sedimentation time from the respective standard epoch time as per Geological Time Scale 2017/02. The hiatus value obtained in million years has been plotted in form of contours on the maps at various age/stage levels in the Cauvery basin considering the available isochronopach data.

For the present study, a uniform rate of sedimentation has been assumed for each age/stage for the calculation of hiatus span as available for Cauvery basin (Raju *et al*. 2005). However, the nature of deposition of sediments in a basin may not be uniform in space as well as time and the value of estimated hiatus, which is a function of sedimentation time would thus have a latitude to that extent. However, the mapping of hiatus trends has been helpful to reveal the depositional history and basin configuration during the Late Cretaceous in Cauvery Basin.

Hiatus Maps

In the present study, hiatuses have been mapped for Turonian top, Coniacian top and Maastrichtian top. Biostratigraphic boundaries for 26 wells for Turonian, 32 wells for Coniacian and 45 wells for Maastrichtian have been considered for the preparation of hiatus maps. Contouring for hiatus maps has been done at an interval of 1My for all the three levels.

Turonian Top

At top of Turonian, hiatus ranges from 1.38-3.96My in the Basin (Fig 4). In Ariyalur - Pondicherry sub-basin, well PND-1-A recorded the maximum span of hiatus i.e. 2.84My followed by Ariyalur-A having hiatus duration of 2.7My. At Kumbakonam ridge, well Bhuvanagiri-B shows a hiatus span of 2.7My. On Pattukotai - Mannargudi ridge, maximum hiatus span recorded is 3.96My in well Vadatheru-A. Hiatus duration is increasing towards Nagapattinam sub - basin. Shortest span of recorded hiatus is 1.52My in well North Kovilkalappal-C. At Vedarinniyam ridge recorded hiatus span is 3.37My in well Vedarinniyam-A. In Ramnad sub- basin, well Kanjirangudai-E shows a maximum span of 3.23My hiatus. Hiatus values are comparatively more on the highs as seen in well Vadatheru-A while basinwards in well Orathanadu-A, a lower value of 1.96My has been estimated. The Turonian subsurface section in well Vadatheru-A, has been inferred to have been deposited in inner to middle shelf regime and in well Orathanadu-A, outer shelf to upper bathyal depositional environment is interpreted.

Coniacian Top

At Coniacian top, duration of hiatus ranges from 0.08 – 4.64My in the basin (Fig 5). Hiatus trends in Coniacian are similar to that of Turonian however, there is a decrease in magnitude of hiatus along eastern side of the basin during Coniacian as compared to Turonian which could be seen in wells Vedaraniyam-A and Kanjirangudai-E. In Ariyalur - Pondicherry sub - basin, well PND-1-A has recorded maximum duration of hiatus i.e. 3.25My, where the sedimentary succession has been dated as of undifferentiated Turonian - Coniacian age. In Tranquebar sub- basin, well Vanagiri-A has recorded a hiatus span of 5.84My with undifferentiated sediments of Coniacian - Santonian age. In Nagapattinam sub basin, the maximum hiatus value 4.64My has been recorded in well Kamalapuram-A. At Vedarinniyam ridge a hiatus span of 2.46My is recorded is in well Vedarinniyam-A. In Ramnad - Palk Bay sub basin, PH series wells have recorded an undifferentiated Coniacian - Santonian sediments, thereby showing a hiatus span of 1.5My to 6.07My. In Madanam Delft Ridge area, well Perungulam-A and H recorded a hiatus span of 2.14My. Well PP-A, C, D recorded hiatus duration of 2.66My. Well Kanjirangudai-E has a minimum hiatus span of 1.84My in the area.

Maastrichtian Top

At Maastrichtian top, hiatus values range from 0.1-5.85My in Cauvery Basin (Fig 6). In Ariyalur - Pondicherry sub-basin, well Ariyalur-A recorded maximum hiatus span of 4.09Ma while well Panrutti-C showed a minimum span of 0.16My. Well Bhuvanagiri-B recorded a hiatus span of 2.6My. In Tranquebar sub - basin, whereas the highest value of hiatus recorded is 5.86My in well PY-1-H followed by well Madanam-F showing a span of 5.46My. At Karaikal Ridge, well Narimanam-X recorded hiatus span of 5.47My and Well North Kovilakappal-C in Nagapattinam sub-basin recorded 5.47My of hiatus. In Ramnad Palk Bay sub-basin, well Ramanavalasai-A has lowest hiatus value i.e. 0.1My and the highest value recorded is 5.01My in well PP-A. There has been a sea level fall at Maastrichtian top resulting in an increase in magnitude of hiatus observed in the subsurface section. During KTB the basin experienced upliftment which resulted in sea level fall and basinward movement of coastline (Gilbert *et al.*2017).

Discussion

Work on estimation of magnitude of hiatus in Cauvery basin was initiated by Raju *et al.* (1994). They have determined the hiatus values by planktonic foraminiferal events across KTB by calibrating them with geological time scale. In the present work, rate of sedimentation and sedimentary thickness are used as indices for calculation of hiatus. In work of Raju et al. (1994), the magnitude of hiatus varies from 2My to 30My across KTB. They have estimated the magnitude of hiatus in well Vedaranniyam-A as 18.6My across KTB while the present study shows a hiatus of 1.32My at Maastrichtian top. Similarly for well PH-31-A, they have reported hiatus of 12.5My whereas present work has recorded 4.57My of hiatus. The variation in estimation of hiatuses across KTB/Maastrichtian top may be due to the fact that in the work of Raju *et al.* (1994), the period of hiatus includes Campanian, Maastrichtian as well as part of Paleocene as they have calculated hiatus across KTB while in the present work it is limited only to Maastrichtian. Cauvery basin underwent regression with the entire episode of positive tectonism getting initiated during Late Maastrichtian (Sastri *et al.* 1977). The Cretaceous sediments were uplifted and subjected to erosion thus resulting into hiatus towards the close of Cretaceous.

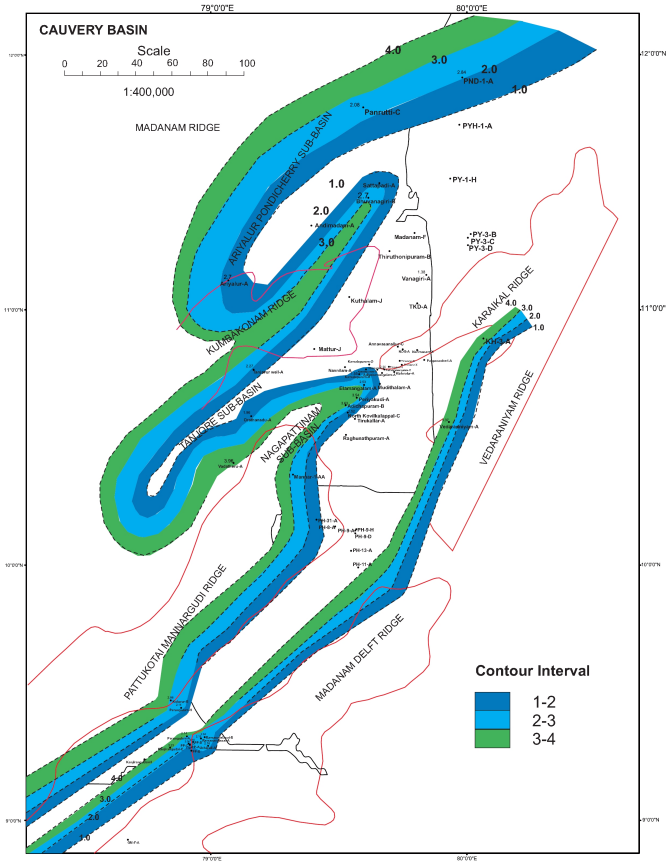

Fig 4. Hiatus Map at Turonian top showing magnitude of hiatus in My, Cauvery Basin

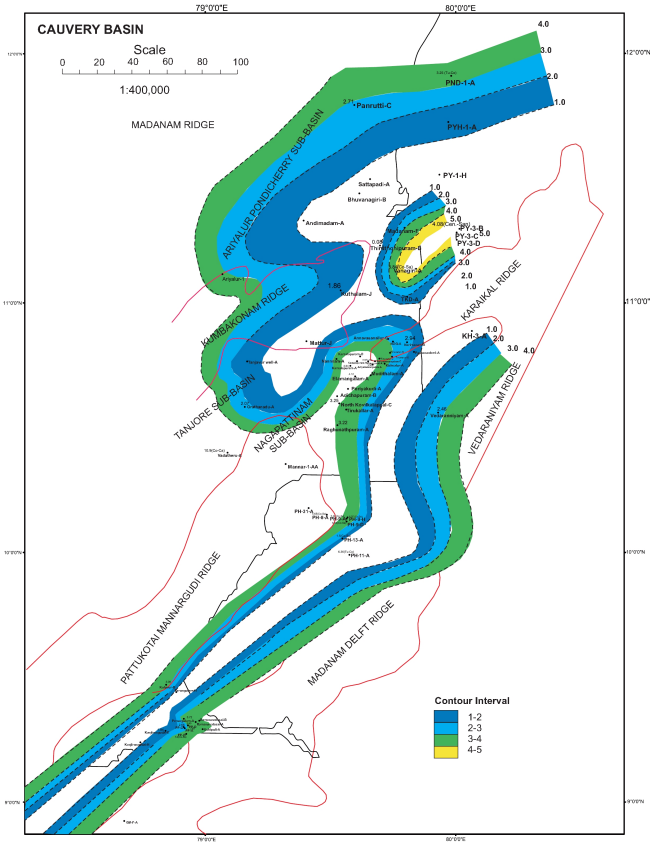

Fig 5. Hiatus Map at Coniacian top showing magnitude of hiatus in My, Cauvery Basin

Fig 6. Hiatus Map at Maastrichtian top showing magnitude of hiatus in My, Cauvery Basin

Conclusion

1. It has been observed that the range of hiatus from depocentre to the basin margin is comparable during Turonian and Maastrichtian, while it is of shorter time span during Coniacian as the basin was uplifted during Turonian and Maastrichtian while further deepening of the basin occurred in Coniacian resulting into a higher magnitude of hiatus.
2. At top of Turonian, magnitude of hiatus is decreasing on moving from North to South. Maximum span is recorded in well Vadatheru-A.
3. At top of Coniacian, hiatus magnitude is decreasing on the eastern side of the basin as compared to Turonian.
4. Hiatus trends are observed in Turonian and Coniacian at Madanam and Karaikal ridge however at Maastrichtian due to submergence of basin, hiatus trend is not recorded at these ridges.

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