

Stratigraphic discriminatory potential of Heavy Minerals: an evaluation in Cauvery and Palar Basins, India

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Abstract

Heavy mineral assemblages characterizing sedimentary sequences offer a potential for correlation and delineation of sand units within a formation as well as across the formations. Evaluation of stratigraphic delineation of heavy minerals characterizing the reservoir formations is crucial to deploy as an additional tool for delineation and correlation. Seven wells viz. 6 wells from Cauvery basin and 1 well from Palar basin have been studied. Heavy minerals characterizing sedimentary sequences of different formations have been extracted and identified using megascopy, petrography, SEM-EDS, XRD and EPMA analyses. Various heavy minerals identified are majorly diopside, barite, garnet (almandine, spessartine and grossular), hornblende and epidote while accessory minerals are rutile, pyrite and zircon. In the Periyakudi wells (wells PD#AA, AC and AD), garnet, diopside, hornblende are the main heavy minerals found along with pyritized lithic fragments. Diopside is characterized only in Jurassic sediments of all three wells. Hence, it is an indexing mineral for Jurassic sediments in that area. Vertical variation and lateral correlation of heavy mineral suites in this area are moderate and poor respectively. In the correlatable wells of Tulsapattinam and Melapperumalai area (wells TA#AD, AE and MPM#AA), garnet, barite, hornblende and pyritized lithic fragments are the main constituents of the heavy fraction. Vertical variation and lateral correlation of heavy mineral suites in this area are poor and good respectively. Garnet is the prominent mineral in Cauvery basin whereas Epidote is the dominant mineral in Palar basin. Conclusively the stratigraphic discriminatory potential of heavy minerals is moderate to poor in the studied areas.

Introduction

High-density accessory mineral constituents of siliciclastic sediments are called heavy minerals (Maria A. Mange and Heinz F.W. Maurer, 1992). Economic applications of heavy mineral analysis in conjunction to petroleum industry include correlation of reservoir sandstones, geosteering of high angle wells, mapping sediment dispersal pattern etc. Heavy minerals can be used as a stratigraphic tool when they are laterally wide spread and vertically narrow distribution in rock formations. Hence, stratigraphic discriminatory potential of the heavy minerals needs to be evaluated before using it as a correlation tool.

The Cauvery Basin is a passive margin rift basin comprising of horst-graben Basement architecture situated at the south eastern edge of Indian peninsula. The structural grain of the basin is dominated by the Jurassic–Early Cretaceous pattern of normal faults that control the system of NE–SW trending horsts and grabens characteristic of rift

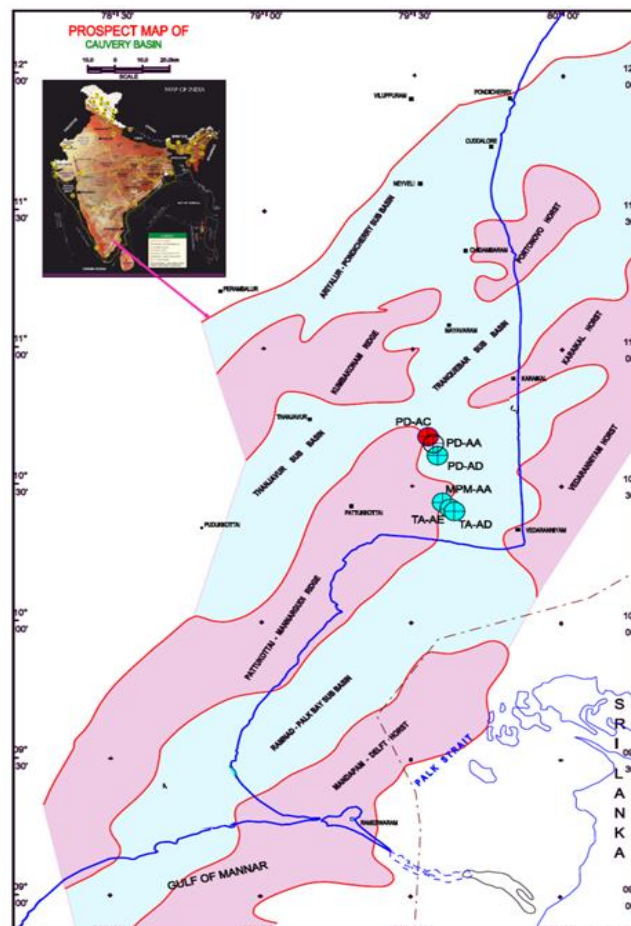


Figure 1: Location map of the selected wells for study in Cauvery Basin

extension. Western margin of the Cauvery basin is demarcated by steep down to basin faults separating the shield crust from the Cretaceous and Tertiary sediments. The location map of the selected wells in the background of tectonic framework is shown in Figure 1.

The Palar Basin is a pull apart basin got initiated during the Permo-Triassic rifting of eastern Gondwanaland (Radhakrishna M. and Bastia R., 2012) Later, it formed a part of a peri-cratonic rift system of the Indian peninsula as the Indian plate broke apart from the Antarctica during Early Cretaceous (Lal et al., 2009; Bastia et al., 2010). It lies in the eastern coast of southern part of India and encompasses both on land and offshore up to 200m isobath. Its axis trends NNE-SSW. The location map of the selected well is shown in Figure 2.

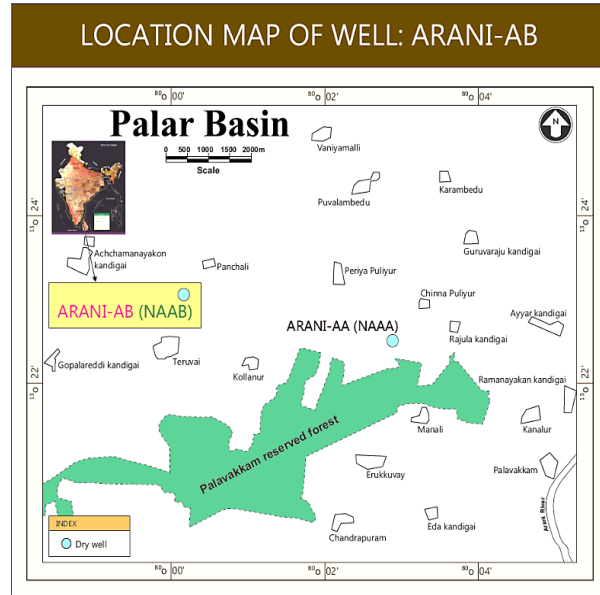


Figure 2: Location map of the selected well for study in Palar Basin

Present Study

The present study focuses on identification and characterization of heavy minerals in various sedimentary sequences of Kamalapuram, Nannilam, Bhuvanagiri and Andimadam Formations and correlation of these sequences in light of their heavy mineral assemblages.

Methodology: Cutting samples of 6 wells from Cauvery basin and 1 well from Palar basin have been studied (Table 1). Sampling was done for every 10m in various sedimentary sequences identified using electro logs and in correlation with the available age data. The heavy mineral fraction was separated using bromoform (specific gravity 2.89) from the processed cutting samples of very fine to fine sand fraction (Sergio Ando, 2020). The separated heavy fraction was then studied for identification of various heavy minerals using laboratory techniques like megascopy, petrography, SEM-EDS, XRD and EPMA. Details of the wells, formations considered and objective taken up for the study are tabulated in Table 1.

Table 1: Details of the wells, formations considered and objective taken up for the study

Well Name	Formation	Objective
Periyakudi-AA (PD#AA)	Andimadam, Bhuvanagiri and Nannilam	Characterize & Correlate
Periyakudi-AC (PD#AC)	Andimadam, Bhuvanagiri and Nannilam	
Periyakudi-AD (PD#AD)	Andimadam, Bhuvanagiri and Nannilam	
Tulasipatinam-AD (TA#AD)	Andimadam, Bhuvanagiri, Nannilam & Kamalapuram	Characterize & Correlate
Tulasipatinam-AE (TA#AE)	Andimadam, Bhuvanagiri, Nannilam & Kamalapuram	
Melaperumalai-AA (MPM#AA)	Andimadam, Bhuvanagiri and Nannilam	Characterize
Arani-AB (AI#AB)	Andimadam	

Periyakudi Field, Nagapattinam Sub-basin: Three wells PD-AA, PD-AC & PD-AD from the Periyakudi field of Nagapattinam sub-basin had been studied and were correlated based on their heavy mineral assemblages. Studies have been carried out in the above wells for seven sedimentary sequences identified using electro logs and lithology (Fig.5) viz. one each in Nannilam Formation and Bhuvanagiri Formation and five sequences in Andimadam Formation corresponding to Albian-Aptian, Barremian, Neocomian, Tithonian and Kimmeridgian respectively (age data taken from unpublished laboratory reports, ONGC).

In the area, garnet, diopside and hornblende are the main heavy minerals found along with pyritized lithic fragments. Garnet was found to be the most dominant mineral in Nannilam and in the post Jurassic sediments of Andimadam Formation in all the three wells. Diopside (Ca-Mg rich Pyroxene) was found present only in the Jurassic sediments of these wells across the Periyakudi field and hence turns out to be an indexing mineral for Jurassic sediments of this area. Na-rich amphiboles are identified only in well PD-AC in Nannilam and Early Cretaceous sediments. High percentages of Fe-Mg minerals, mainly Hornblende characterizes Nannilam Formation in general across the field. Details of identified heavy mineral assemblages of these sequences are represented in figure 3.

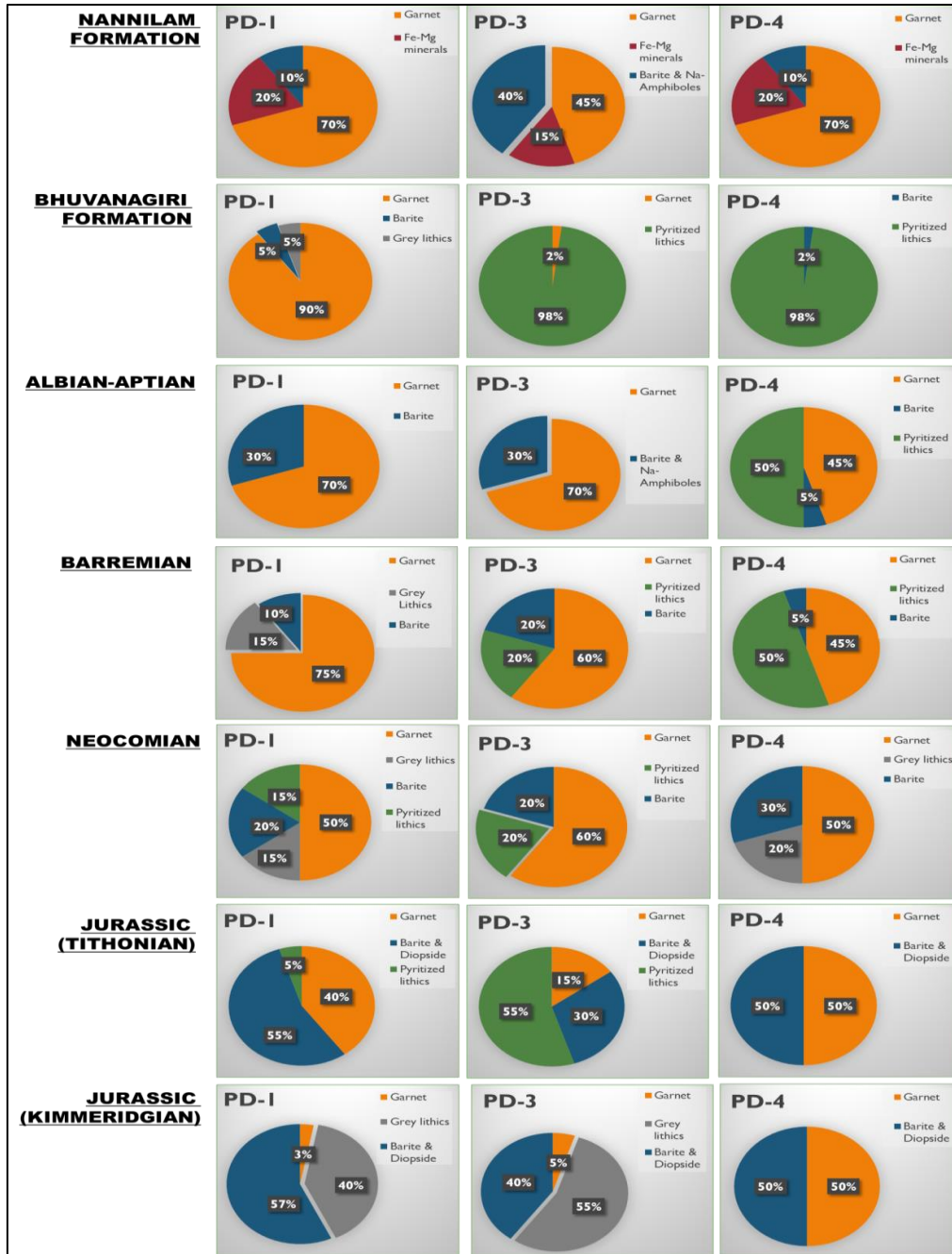


Figure 3: Heavy Mineral assemblages identified within various sedimentary sequences of Periyakudi area

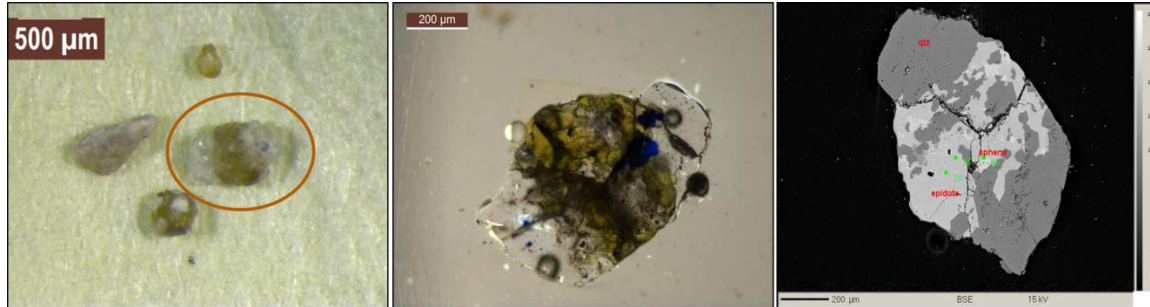


Figure 4: Megascopic, Petrographic and EPMA images of Epidote from Jurassic sequence of the well PD-AD

Based on the detailed analysis of heavy mineral assemblages, the vertical variation and lateral correlation of heavy mineral suites in this area is found to be moderate to poor respectively (Figure 5) indicating that the stratigraphic discriminatory potential of heavy minerals is moderate in the studied area.

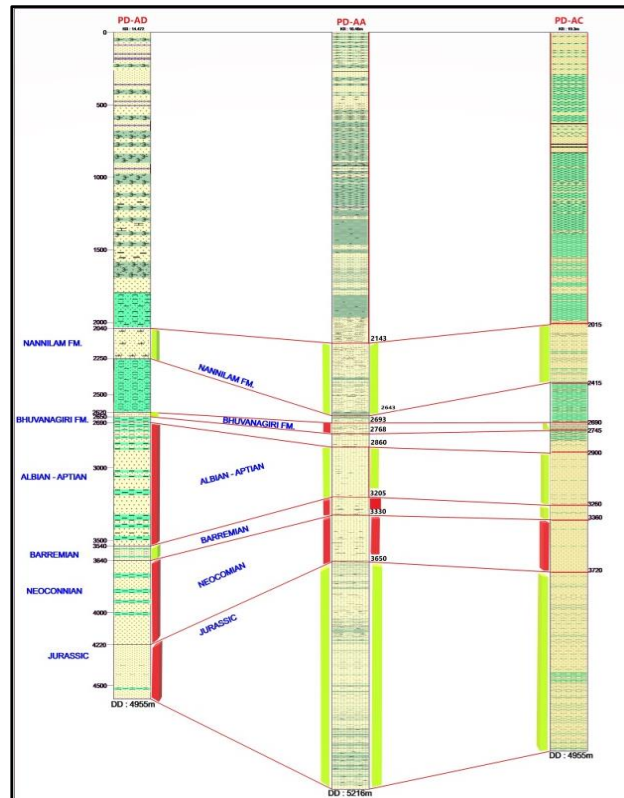


Figure 5: Poor Lateral co-relation of heavy mineral suites in Periyakudi area (wells PD-AA, AC & AD).

Tulsapattinam and Melaperumalai Field, Nagapattinam Sub-basin: Two wells from the Tulsapattinam field i.e. TA-AD, TA-AE and well MPM-AA from the Melaperumalai field of Nagapattinam sub-basin were studied and correlated based on their heavy mineral assemblages. The studies are made in the frame work of ages (Figure 6) for Andimadam, Bhuvanagiri, Nannilam and Kamalapuram Formations.

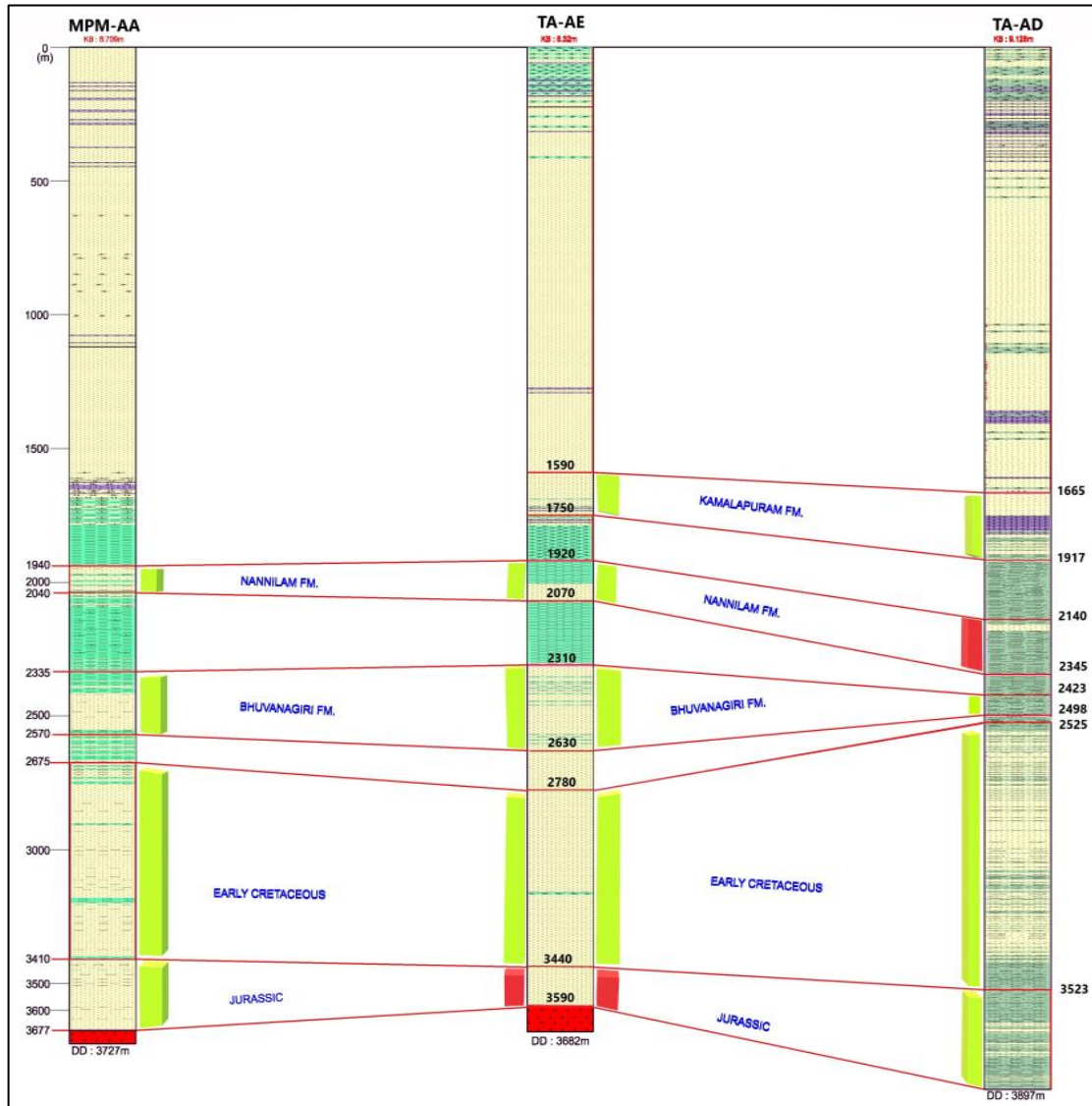


Figure 6: Lateral co-relation based on the heavy mineral assemblages shown amongst wells MPM-AA, TA-AE & TA-AD through various formations/ sedimentary sequences. Laterally correlatable sequences are marked with Green while non-correlatable sequences are marked as red.



Garnet, diopside, hornblende are the main heavy minerals found in this area along with pyritized lithic fragments. High percentage of Fe-Mg minerals mainly Hornblende characterizes the post Albian sequences in all the three wells unlike the Periyakudi field where it was restricted only to Nannilam Formation. . Promoted precipitation of pyrite indicating pronounced reducing conditions have been observed in the Jurassic sediments of wells MPM-AA and TA-AD and in the Early Cretaceous levels of all the three wells.

Detailed analysis of heavy mineral assemblages of the wells TA-AD, TA-AE and MPM-AA shows that these are well correlatable laterally with respect to their heavy mineral signatures particularly in the Early Cretaceous, Bhuvanagiri, and Kamalapuram sequences. Similar volumetric dominance of heavy mineral species has been observed in these areas indicating similar sediment province. However vertical variation of heavy mineral assemblages is poor in the Tulsapattinam-Melaperumalai area.

Conclusions

The study evaluated the stratigraphic delineating potential of heavy minerals as it may provide an additional argument for the stratigraphic definition of sedimentary sequences/formations. It is found that the potential is moderate in Periyakudi area, while it is poor in Tulsapattinam-Melaperumalai area. Lateral correlation is good in Tulsapattinam-Melaperumalai area, while it is poor in wells of Periyakudi area. Diopside (Ca-Mg rich Pyroxene) acts as an index mineral for Jurassic sediments of the wells in Periyakudi field. Stratigraphic delineating potential of heavy minerals in the well AI#AB is moderate to good. Garnet is the prominent heavy mineral in Cauvery basin whereas Epidote is the dominant mineral in Palar basin.

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Statement: Views expressed in this paper are purely of authors only and does not represent organization.

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