Evaluation of the Paleocene-Eocene deposits, Jahrum Formation, base on 2-D seismic data, Central Persian Gulf

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Abstract

The Persian Gulf is part of an asymmetric foreland basin related to the Zagros Orogen. It has been episodically flooded for much of its history which are reflected in sedimentary successions. The evaluation of this succession from depositional trend view, in central Persian Gulf during Paleocene-Eocene, is the aim of this article. The sedimentary rocks physical characteristics effects on seismic data, gives an appearance to the data, which can be a key factor for their evaluation. The reflectors geometry and terminations have been used for their interpretation. The current study the uses seismic data beside drilling wells data, including cutting description and logs. The study result shows progradation toward northeast, the direction in which the accommodation space is increasing. The sedimentary environments changes to lagoon, platform and basin which affect the deposits. These environments demonstrate suitable condition for carbonates and evaporites precipitation, in Jahrum Formation, which are approved by cutting description. The sediments extension and its trend show high thickness of Paleocene-Eocene deposits in north west of the study area, where the basin is deeper. In some intervals the thickness of sediments is decreased in deep basin, due to sediment starvation.

Keywords: *Accommodation space, Jahrum Formation, Sediments thickness.*

1. Introduction

The geometries of the reflections configurations are the most varied aspects of seismic data, including parallel, prograding, mounded, onlap, and onlap fill. Each geometry suggests different depositional processes that can occur in different depositional environments; a lack of continuity is often characteristics of carbonates buildups. The appearance of carbonate rocks in seismic data contains information about their original depositional environments, lithofacies, source rock and reservoir potential [1].

A depositional facies might be altered by postdepositional processes, potentially resulting in a nonunique acoustic character of a depositional environment. This is especially true in carbonates where impedance is the combined product of sedimentation and diagenesis [2]. The area under study is located in the Persian Gulf (Fig. 1), which is situated next to Zagros Frontal Fault and is part of an asymmetric foreland basin related to the Zagros Orogen [3].

The Paleocene-Eocene deposits of study area, includes Pabdeh- Jahrum Formations, which are apply for deep and shallow marine sediments respectively. The equivalent formations in Arabian countries are three formations as Umm Er Radhuma, Rus and Dammam formations, which apply for the same sediments from the paleocene to Eocene. For more details in Jahrum formation, the Rus Formation equivalent sediments were extracted from, and have been analyzed.

Geological Setting

The Persian Gulf is part of an asymmetric foreland basin related to the Zagros Orogen [3]. It is situated between the Arabian trend in the south western and the Zagros fault and folded belt in the north. The Persian Gulf forms part of the Mesopotamian Basin, the foreland basin to the Zagros Orogenic Belt, which is a segment of the central Tethyan deformation belt. The basin is located on the Arabian plate and is currently partly covered by an epicontinental sea. It has been episodically flooded for much of its history [4, 5].

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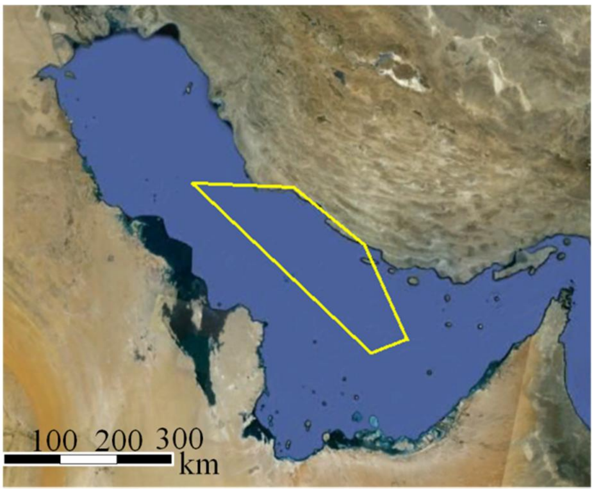

Fig.1. Geographical and geological setting of the Study Area, situated between main Zagros trust belt and Zagros Deformation Front (ZDF) line (dotted line). The line source is from [5].

Stratigraphy

There was a sedimentary deposition during early transgression from Hormuz Strait to wide areas of the Zagros basin, including, northeast-southeast part of this basin. The Jahrum Formation is part of the shallow marine sedimentation of such a transgression. The Jahrum Formation (Paleocene-Eocene) is part of the lower Tertiary deposits. The upper Tertiary deposits record a regression from lower Miocene to Pliocene Fars Group [6]. The Tertiary deposits in the Zagros basin are divided in to the Lower Tertiary (Paleocene-lower Miocene) and upper Tertiary (lower Miocene-Pliocene and younger).

The Jahrum Formation is part of the shallow marine sedimentation of such a transgression. Numerous shallow marine water benthonic microfauna are also present in the Jahrum Formation [7, 8].

Paleocene – Eocene climate

The Paleocene- Eocene climate has been investigated by several researchers [9-16]. The clay minerals study in Pabdeh formation, located in Bangestan Anticline, southwest of Iran, demonstrate transition of humid climate to dry and warm climate, with nonmarine sedimentary environment for its containing sediments, during paleocene - Eocene [14]. The early Paleogene experienced the most pronounced long-term warming trend of the Cenozoic, superimposed by transient warming events such as the Paleocene–Eocene Thermal Maximum (PETM) [10]. The modern orders of mammals, Artiodactyla, Perissodactyla and Primates (APP taxa), first appear in the fossil record at the Paleocene–Eocene boundary, c. 55 million years ago. Their appearance on all three northern continents has been linked to diversification and dispersal in response to rapid environmental change at the beginning of a worldwide 100 000–200 000-year Paleocene–Eocene thermal maximum (PETM) and carbon isotope excursion [11].

In the deep-sea, the Paleocene–Eocene Thermal Maximum (PETM) is often marked by clay-rich condensed intervals caused by dissolution of carbonate sediments, capped by a carbonate-rich interval [13]. The changes in paleocene- Eocene climate has been reported in south of Iran, based on large Nomolite fossils [6]. Such changes in climate is an indication of suitable condition for evaporate precipitation, based on which, the sedimentary environment could be reconstructed.

Methodology

The paper uses 2-D seismic for sedimentary interpretation, for which three different horizons have been tracked on seismic data, all over the study area. The horizons determination is based on stratigraphic column of at least 10 wells, sparsely but suitably situated all around the study area. First the horizons detected on all the wells and were correlated together to find precise depth for the horizons, on which the seismic data are interpreted and used for sedimentary environment reconstruction. We used wells checkshot for plotting the wells on 2-D seismic data. These wells checkshot also have been used for synthetic seismogram, together with wells logging data, from which the sonic log has been selected for. The comparison between constructed synthetic seismogram and seismic data trace, shows good and reliable matching between them, in seismic peaks and troughs (Fig.2). the similarity enables us, to use the seismic time to metric unit, the method which we used for sediments thickness calculation.

Discussion

This paper uses a 2D seismic dataset from the Persian Carpet 2000 survey, which has a line length of c. 7000 km. The Persian Carpet 2000 survey covers the entire Iranian part of the Persian Gulf and is a dense network of lines designed to provide high-quality 2D data as a basis for all exploration companies applying for Iranian license blocks. A seismic-stratigraphic approach is used to investigate the location and timing of sequence boundaries within the Persian Gulf, offshore Iran. The quality of these data allows clear reflection events to be assigned across the entire study area and, by tying these to sparse but nearby well data, allows ages and depth to be assigned to these reflections and the seismic unit they bound.

Analysis of the stratigraphic relationships between the mapped units allows both formations and layers to be identified and traced to follow the definite surfaces all over the study area.

For this study three horizons including Top of Jahrum Formation, Top of the sediments, which are equal to Rus Formation and base of Jahrum Formation, have been selected and interpreted for ancient sedimentary environment reconstruction (fig. 3). So the horizons include, Top of Jahrum Formation (TJF), Top of Middle Jahrum Formation (TMJF) and base of Jahrum Formation (BJF).

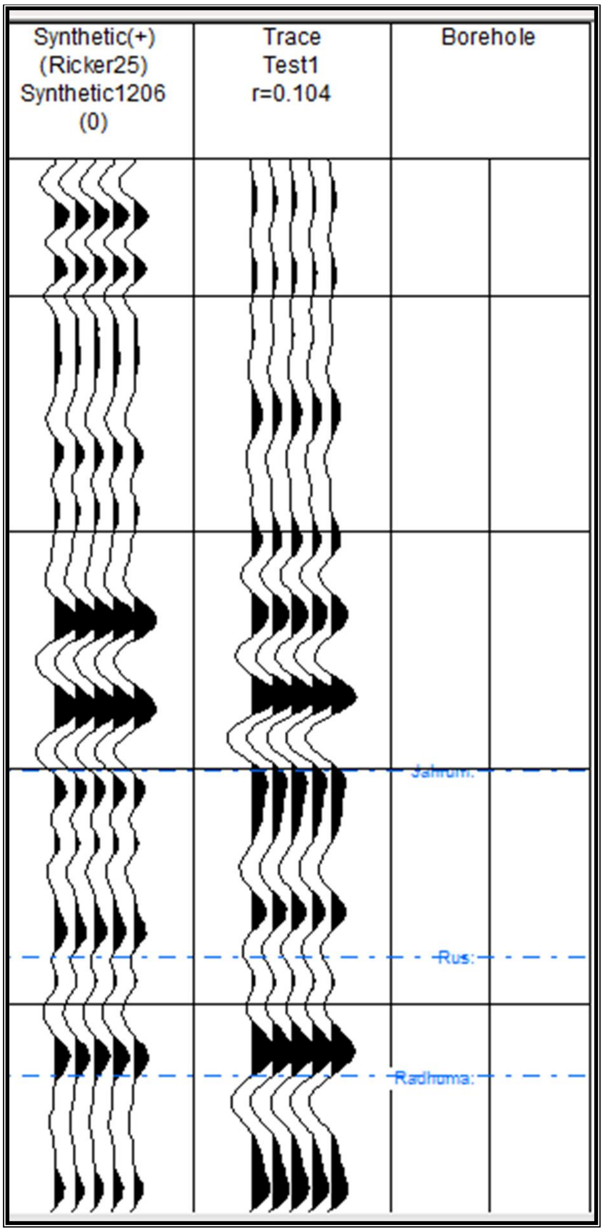

Fig. 2. The synthetic seismogram and 2-D seismic data peaks and troughs matching, shows reliable accuracy in study interval.

Seismic profile (fig. 3) shows a high thickness of sediments in lower Jahrum Formation in southwest of study area , which decrease towards deep marine, due to sediment starvation. In upper Jahrum Formation the situation is changed with a progradation in southwest – northeast direction, and the sediment thickness is increasing towards to northeast. By this way the shallow marine Jahrum deposits overlays the deep marine Pabdeh sediments. This seismic profile shows that the sediments have been affected by a salt diapir as secondary factor.

Seismic interpretation of each horizon, shows its current morphology, which also can be data for original sedimentary environment, if the sediments are not affected by digenesis processes. For solve the problem, after horizons interpretation, the time based thickness have been calculated for any two selected horizons. The time thickness map gives useful information about the basin depositional system, as the sediment thickness is affected by accommodation space, and the accommodation space fluctuates in basin, in connection with any sedimentary environment. The deposits of Base Jahrum-Top Middle Jahrum horizons interval, are composed of dolomite with anhydrite interlayers, which the anhydrite value, ascends upwards. This interval is equivalent to Umm Er Radhuma and Rus Formation, which are composed of dolomite with anhydrite interlayers and Anhydrite, respectively.

The time thickness map and also thickness map resulted from seismic data interpretation, reveals two low thickness with parallel with two high thickness deposits area (Fig. 4). The left low thickness can be interpreted as a shelf platform, but the next one is a open marine , and the low thickness is due to sediment starvation, as the downlap geometry is clearly seen in the seismic profile (Fig. 3). The left high thickness area can be interpreted as a lagoon, and the right one as a low angle slope, which is dipping gently. Some areas with low sediments in platform area, shows the irregular pattern for the ancient platform.

The next interval covers the sediments, which precipitated between top of Middle Jahrum and top of Jahrum horizons. This interval is equivalent to Dammam Formation in Arabian countries nomenclature. The Dammam Formation and its equivalent in Jahrum Formation, are composed of dolomite with rare anhydrite interlayers.

After interpretation of the top and bottom of this interval, the time thickness map has been calculated (Fig. 5). The result map shows, two different area of precipitation, on which there are two clearly recognizable thickness of sediments. The first one with low sediments, located in northwest of the study area, and the second one containing high rate of sediment precipitation in southeast. Detail review shows two other very high thickness of sediments in east and southeast, which have rather low expansion.

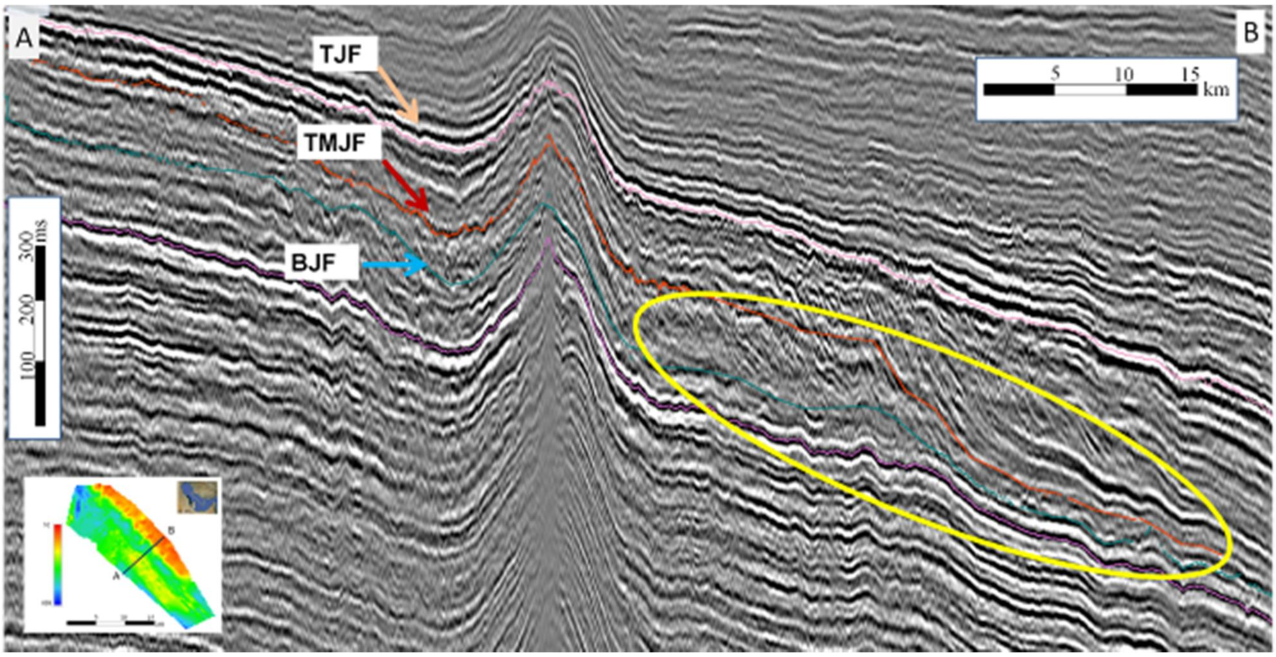

Fig. 3. Different layers on applied 2-D seismic data. Downlap geometry is clearly seen in yellow colored bounded area (TJF: Top Jahrum Formation, TMJF: Top Middle Jahrum Formation, BJF: Base Jahrum Formation).

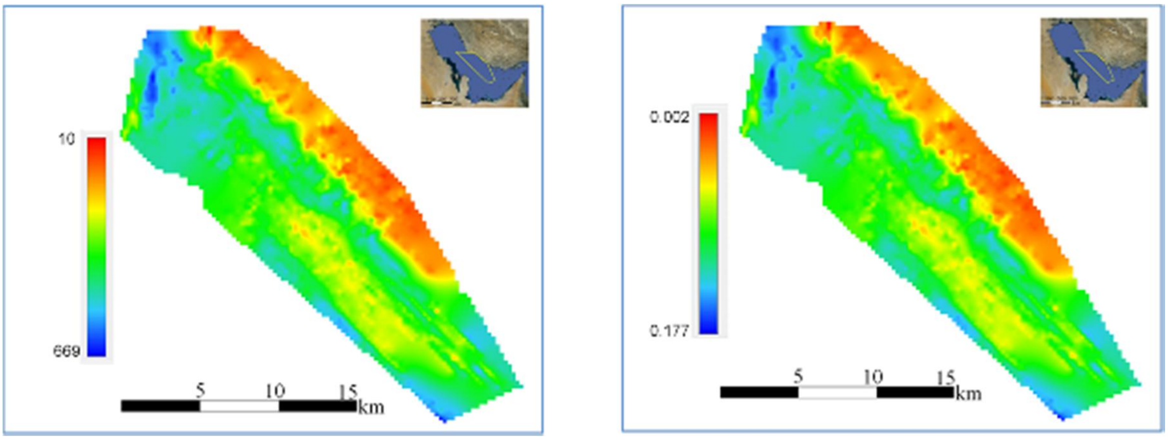

Fig. 4. Time thickness (Right), and metric thickness (Left) for Base Jahrum-Top of Middle Jahrum interval sediments.

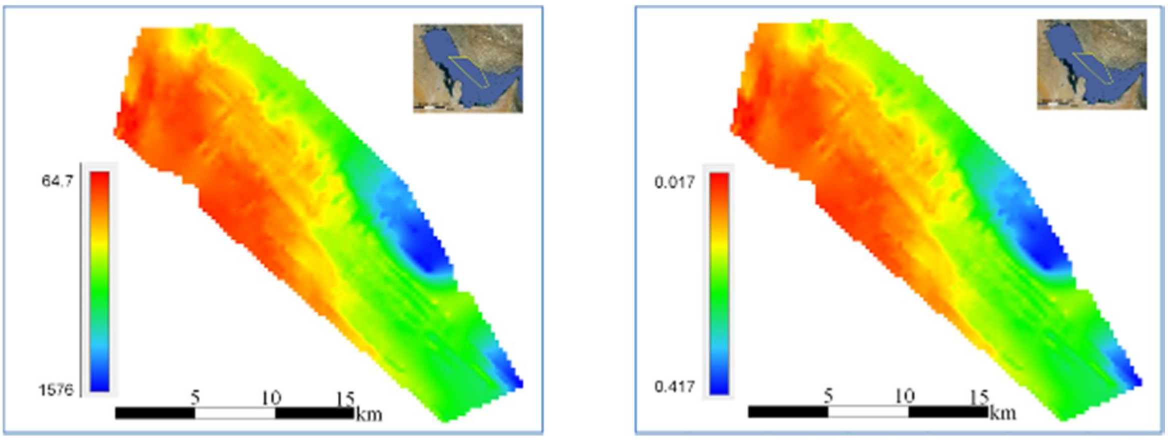

Fig. 5. Time thickness (Right), and metric thickness (Left) for Top of Middle Jahrum-Top Jahrum interval sediments.

They are interpreted to be in connection with trenches, resulted from salt diapirs activity. This trench formation and sediment progradation are occurred simultaneously, which it is possible to be as a result of positive eustasy or worldwide sea level rise and increase in accommodation space, but we shouldn't ignore the local factors, like salt diapirs, as they are present in seismic profile, with clear effects. The sediments progradation and sedimentary environments transition are shown in fig. 6. The deep marine is located in the right end.

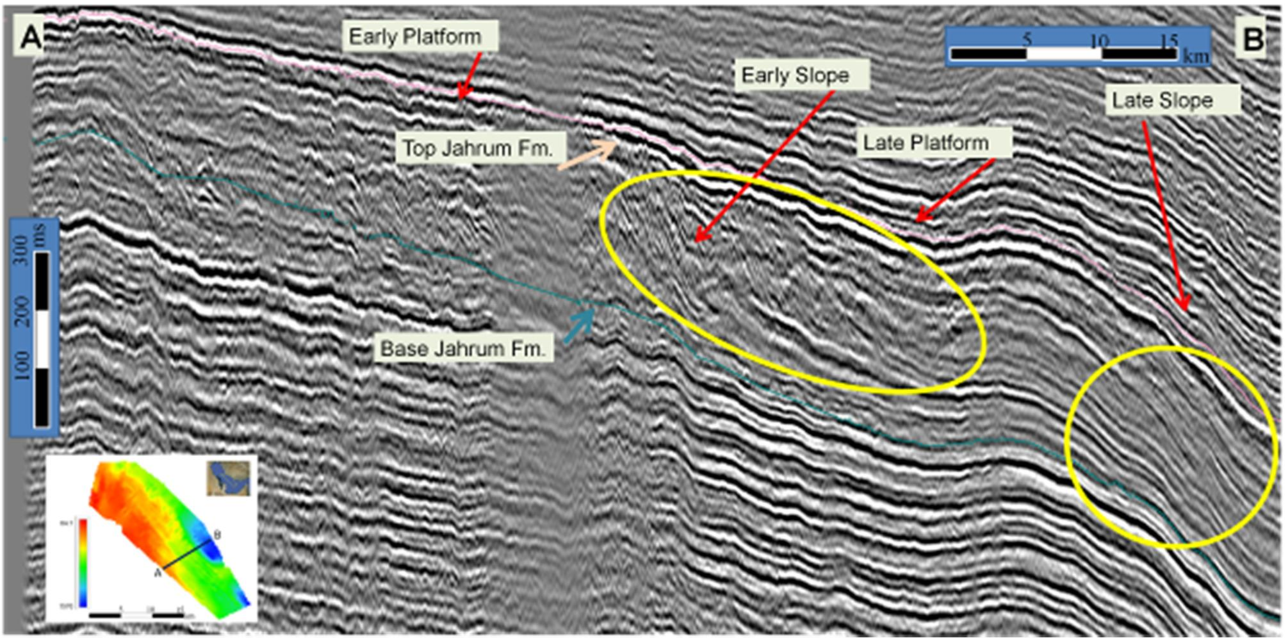

Fig. 6. Environments transition due to sediment progradation and deep marines location.

Conclusion

There is a high thickness of lower Jahrum Formation sediments in southwest which is overlays by low thickness of sediments Upper Jahrum Formation.

In northeast of the study area the Upper Jahrum Formation has more thickness than Lower Jahrum Formation, which shows a progradation from southeast to northwest direction.

The Paleocene- Eocene evaporites have been deposited in shallow platforms, which had enough extension during the time.

The Paleogene deposits of Jahrum Formation is affected by Rus Formation evaporites, and need to be classified to at least two parts as upper and lower Jahrum Formation.

The ancient sedimentary environments of Paleogene deposits, including shelf, slope, lagoon and deep marine, which had transited southeastward during the time, due to accommodation space change, are main factors which controls the sediments.

Seismic profiles of the study area show good indication for sediment starvation by downlap geometry. Hard grounds can be extended in these circumstances.

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