Research Journal of Environmental and Earth Sciences 4(9): 838-843, 2012
ISSN: 2041-0492

Submitted: June 28, 2012 Accepted: July 28, 2012 Published: September 20, 2012

Using 2-D Seismic Data for Reconstruction of Paleocene-Eocene Sedimentary Environment in Central Persian Gulf, Iran

[1]Naser Abdi, [2]Hossain Rahimpour-Bonab, [3]Sayyed Reza Moussavi-Harami and [4]Davood Jahani
[1]Department of Geology, Science and Research Branch, Islamic Azad University, Tehran, Iran
[2]Department of Geology, Science Faculty, Tehran University, Tehran, Iran
[3]Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran
[4]Department of Geology, North Tehran Branch, Islamic Azad University, Tehran, Iran

Abstract: The sedimentary depositional environments are more important for reservoir evaluation. The Paleocene-Eocene sedimentology and ancient sedimentary environments study in Central Persian Gulf is the subject of the study under the light of 2-D seismic data, as a key data for geological study. The sedimentary rocks physical characteristics effects on seismic data, gives an appearance to the data, which can be a key factor for their evaluation and sedimentary environment reconstruction. These data are useful in any area, for which less data have been collected by drilling, as well as they can be traced for a vast area. For the current study the seismic data are used beside drilling wells data, including cutting description and logs. The study result shows progradation toward northeast, the direction in which there is increase in accommodation space and the sedimentary environments also migrated toward. Based on sediments thickness achieved by 2-D seismic data interpretation, beside seismic profiles, the deposits are precipitated in shelf, slope and basin environments. Also in some horizons, the sedimentary environments changes to lagoon, platform and basin. 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 were revealed as well.

Keywords: Accommodation space, jahrum formation, sediments thickness

INTRODUCTION

The appearance of carbonate rocks in seismic data contains information about their original depositional environments, lithofacies, source rock and reservoir potential (Palaz and Marfurt, 1997). The geometries of the reflections configurations are the most varied aspects of seismic data, including parallel, prograding, mounded, on lap and on lap fill. Each geometry suggests different depositional processes that can occur in different depositional environments; a lack of continuity is often characteristics of carbonates buildups. Carbonate platforms, platform margins, slope environments and basinal deposits have characteristics combinations of seismic facies that aid in their recognition and in the evaluation of their hydrocarbon potential (Palaz and Marfurt, 1997).

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 (Anselmetti and Eberli, 1993).

The area under study is situated 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 (Buerberry *et al*., 2011).

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 3 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 (Buerberry *et al*., 2011). 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

Corresponding Author: Naser Abdi, Department of Geology, Science and Research Branch, Islamic Azad University, Tehran, Iran

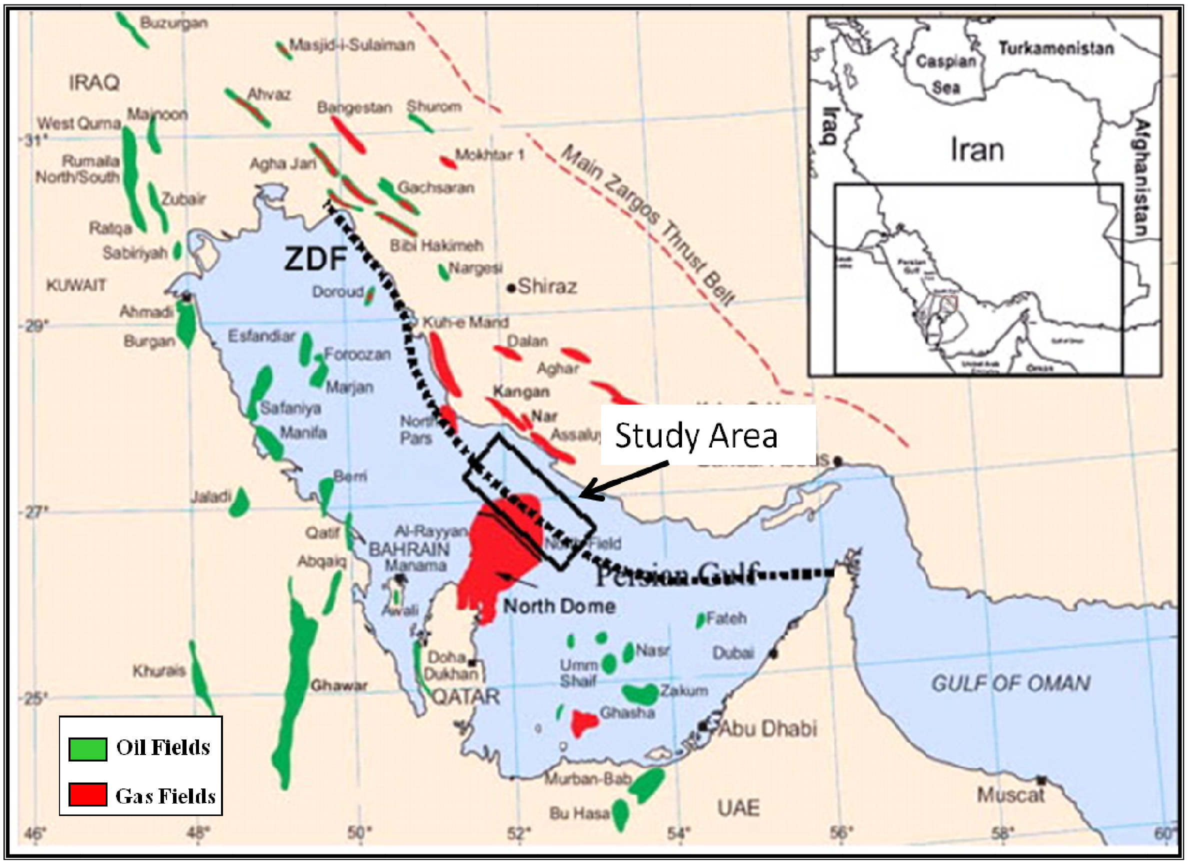

Fig. 1: Geographical and geological setting of the study area, situated between main Zagros trust belt and Zagros Deformation Front (ZDF) line (dotted line). The line source is from Alavi (2004)

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 (Sharland *et al*., 2001; Alavi, 2004).

Stratigraphy: 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 (Paleocene-Eocene) is part of the lower Tertiary deposits. The upper Tertiary deposits record a regression from lower Miocene to Pliocene Fars Group (Motiee, 1993).

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. Numerous shallow marine water benthonic microfauna are also present in the Jahrum Formation (Kalantary, 1986; Jalali, 1971).

Paleocene-eocene climate: The Paleocene-Eocene climate has been investigated by several researchers (Scheibner *et al*., 2005; Scheibner and Speijer, 2008; Gingerich, 2006; Hall, 2001; Murphy *et al*., 2010; Soleimani, 2009, Zachos *et al*., 2001; Hottinger, 1998). 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 (Soleimani, 2009). 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) (Scheibner and Speijer, 2008). 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

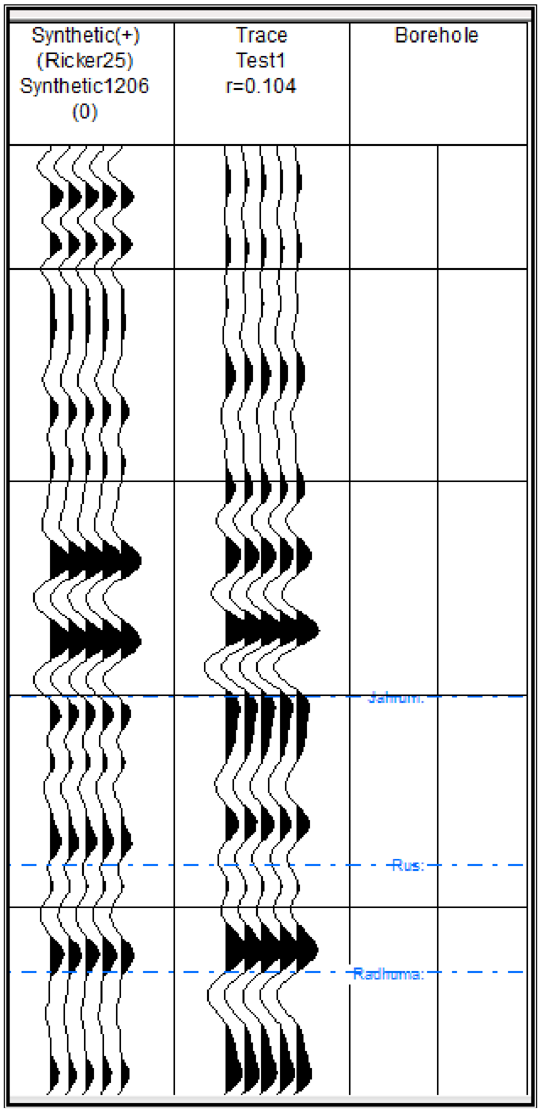

Fig. 2: The synthetic seismogram and 2-D seismic data peaks and troughs matching, shows reliable accuracy in study interval

ago. Their appearance on all 3 northern continents has been linked to diversification and dispersal in response to rapid environmental change at the beginning of a worldwide 100000-200000 year Paleocene-Eocene Thermal Maximum (PETM) and carbon isotope excursion (Gingerich, 2006). 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 (Murphy *et al*., 2010). The changes in paleocene-Eocene climate has been reported in south of Iran, based on large Nomolite fossils (Motiee, 1993). Such change in climate is an indication of suitable condition for evaporate precipitation, based on which, the sedimentary environment could be reconstructed.

METHODOLOGY

The study uses 2-D seismic for sedimentary interpretation, for which 3 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 check shot for plotting the wells on 2-D seismic data. These wells check shot 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 study 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 3 horizons including top of Jahrum Formation, top of the sediments, which are equal to Rus Formation (Hereinafter also referred to as top of Middle Jahrum 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

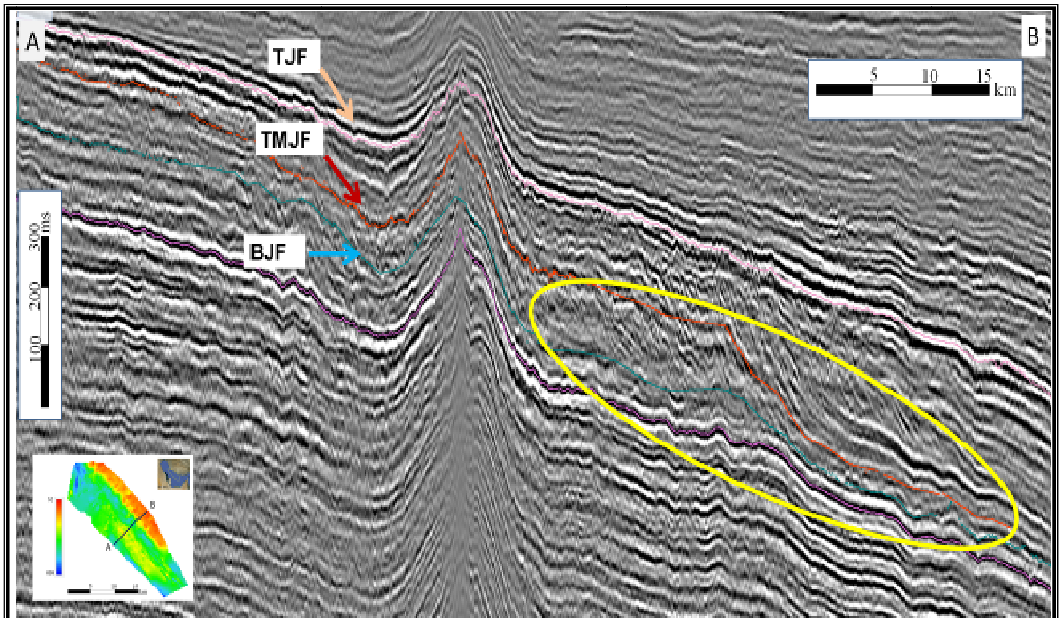

Fig. 3: Different layers on applied 2-D seismic data. Down lap geometry is clearly seen in yellow colored bounded area TJF: Top Jahrum Formation; TMJF: Top Middle Jahrum Formation; BJF: Base Jahrum Formation

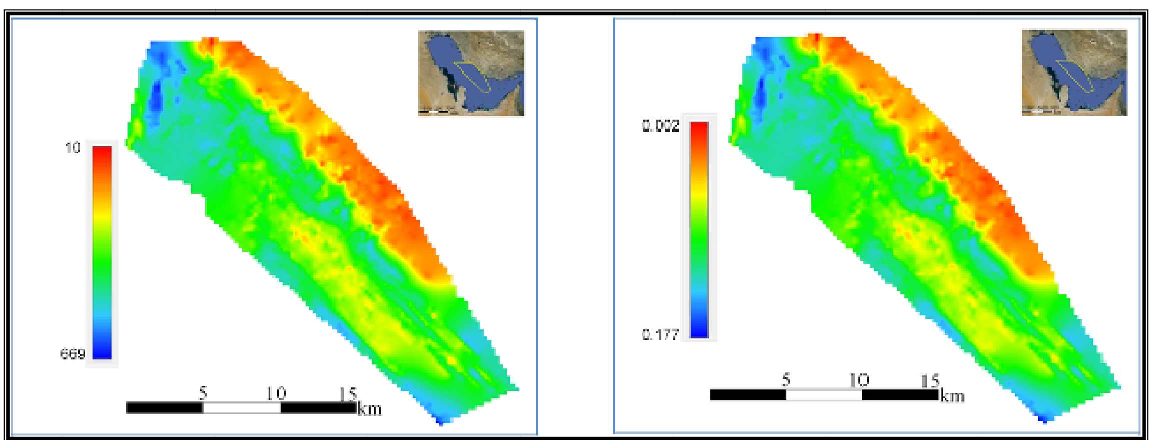

Fig. 4: Time thickness (right) and metric thickness (left) for base jahrum-top of middle jahrum interval sediments

of Middle Jahrum Formation (TMJF) and Base of Jahrum Formation (BJF). Further investigation on the Fig. 3, illustrate at least 3 different sedimentary environments, including, shelf, slope and deep marine, which have been moved rightward by the time, due to progradation. This seismic profile shows that the sediments have been affected by a salt diapir as well. 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 2 selected horizons. The time thickness map gives useful information of the ancient sedimentary environment, 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 for this interval which have been resulted from seismic data interpretation, reveals 2 low thickness parallel with 2 high thickness deposits area (Fig. 4). The left low

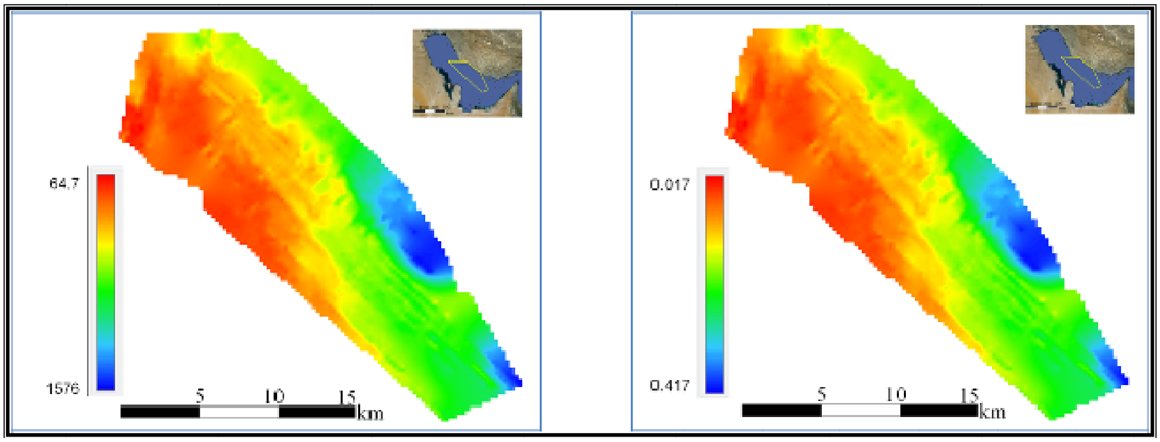

Fig. 5: Time thickness (right) and metric thickness (left) for top of middle jahrum-top jahrum interval sediments

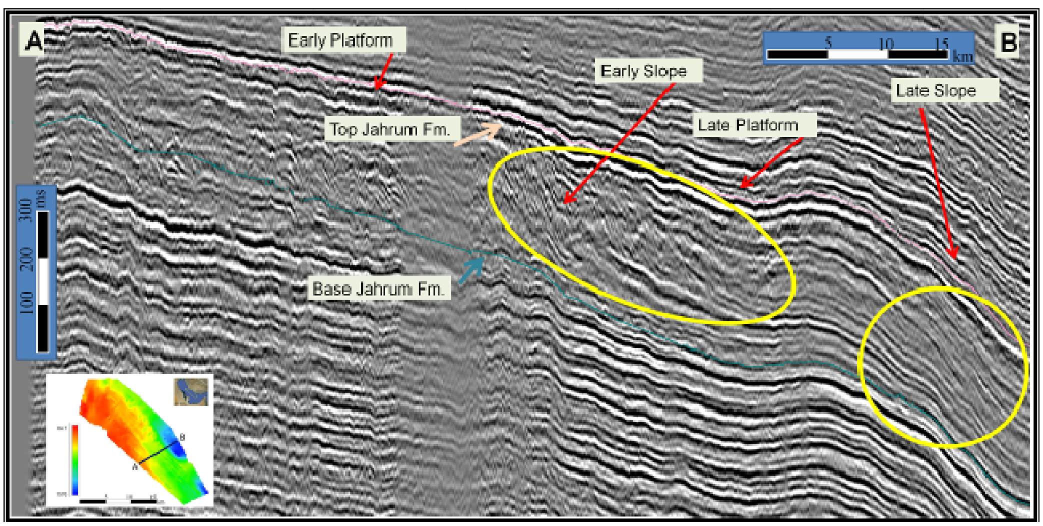

Fig. 6: Environments transition due to sediment progradation and deep marine's location

thickness can be interpreted as a shelf platform, but the next 1 is an open marine. The low thickness is due to sediment starvation, based on the down lap geometry which is clearly seen on the seismic profile (Fig. 3). The left high thickness area can be interpreted as a lagoon and the right 1 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, 2 different area of precipitation, on which there are 2 clearly recognizable thicknesses of sediments. The first 1 with low sediments, located in northwest of the study area and the 2nd one containing high rate of sediment precipitation in southeast. Detail review shows 2 other very high thicknesses of sediments in east and southeast, which have rather low expansion. 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 is shown in Fig. 6. The deep marine is located in the right end.

CONCLUSION

The sediment time thickness and metric thickness could be used for ancient sedimentary environment construction.

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

The Paleogene deposits ancient sedimentary environments should be discussed at least in 2 different intervals, separating by top of middle Jahrum Formation.

The ancient sedimentary environments for Paleogene deposits, include shelf, slope, lagoon and deep marine, which had transited southeastward during the time, due to accommodation space change, resulted by increase in worldwide sea level and local factors effects like salt diapirs. Seismic profiles of the study area show good indication for sediment starvation by down lap geometry. Hard grounds can be extended in these circumstances.

ACKNOWLEDGMENT

The contribution of a large number of previous workers as mentioned in the text and the references is the basis for this study.

We are indebted to the management and staff members of the IOOC research and development section, who did not spare efforts in their assistance and provision with seismic and well data.

The author is grateful for the support provided by the Petrokav Energy Company. Gratitude is especially expressed to Dr. Mokhtari, Rasoulzadeh and Sharafkhani.

The management and staff members of Tarh Abriz Company is gratefully acknowledged for their supports. The study was reviewed by anonymous reviewer. Their comments to the manuscript are acknowledged with thanks.

REFERENCES

Alavi, M., 2004. Regional stratigraphy of the Zagros fold-thrust belt of Iran and its proforeland evolution. Am. J. Sci., 304(1): 1-20.

Anselmetti, F.S. and G.P. Eberli, 1993. Controls on Sonic Velocity in Carbonate Rocks. In: Liebermann, R.C. (Ed.), Pure Appl. Geophys., 141(2-3): 287-323.

Buerberry, C.M., C.A.L. Jackson and J.W. Cosgrove, 2011. Late Cretaceous to Recent Deformation Related to Inherited Structures and Subsequent Compression within the Persian Gulf: A 2D Seismic Case Study. University of Nebraska, Lincoln, pp: 485-498.

Gingerich, P.D., 2006. Environment and evolution through the paleocene-eocene thermal maximum. Trends Ecol. Evolut., 21(5): 246-253.

Hall, M.A., 2001. Warm tropical sea surface temperatures in the late cretaceous and eocene Epochs. Nature, 413: 481-487.

Hottinger, L., 1998. Shallow Benthic Foraminifera at the Paleocene-Eocene Boundary. S.l., pp: 4.

Jalali, M.R., 1971. Stratigraphy of Zagros Basin. National Iranian Oil Company. Exploration and Production Division Report Nos, 1249(1072): 34-36.

Kalantary, A., 1986. Microfacies of Carbonate Rocks of Iran. National Iranian Oil Company, Geological Laboratory Publication, Tehran, pp: 410.

Motiee, H., 1993. Zagros Stratigraphy. Iranian Geological Survey, Tehran, Iran, pp: 536, (In Persian).

Murphy, B.H., K.A. Farley and J.C. Zachos 2010. An extraterrestrial 3He-based timescale for the Paleocene-Eocene Thermal Maximum (PETM) from walvis ridge, IODP Site 1266. Geochim. et Cosmochimical Acta, 74(17): 5098-5108.

Palaz, E. and K.J. Marfurt, 1997. Carbonate Seismology. SEG Books, Tulsa, OK, pp: 443, ISBN: 1560800380.

Scheibner, C., R.P. Speijer and A.M. Marzouk, 2005. Turnover of larger foraminifera during the Paleocene- Eocene Thermal Maximum and paleoclimatic control on the evolution of platform ecosystems. Geology, 33(6): 493-496.

Scheibner, C. and R.P. Speijer, 2008. Late Paleocene-early Eocene Tethyan carbonate platform evolution- A response to long- and short-term paleoclimatic change. Earth-Sci. Rev., 90(3-4): 71-102.

Sharland, P.R., R. Archer, D.M. Casey, R.B. Davies, S.H. Hall, A.P. Heward, A.D. Horbury and M.D. Simmon, 2001. Arabian Plate Sequence Stratigraphy. Gulf Petro Link, Manama, pp: 371.

Soleimani, B., 2009. Paleoclimate reconstruction during pabdeh, gurpi, kazhdumi and gadvan formations (cretaceous-tertiary) based on clay mineral distribution. Int. J. Environ. Sci. Eng., 1(2): 59-63.

Zachos, J.C., M. Pagani, L.C. Sloan, E. Thomas and K. Billups, 2001. Trends, rhythms and aberrations in global climate 65 Ma to present. Science, 292(5517): 686-693.