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Paleogene dinoflagellate cysts and thermal maturity from Pabdeh Formation (Zagros basin, west of Iran)

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***KEYWORD*:** Pabdeh Formation, Dinoflagellate cysts, Paleogene, Palynostratigraphy, Thermal maturity

ABSTRACT: Palynological investigation on 132 samples from the 428m thick outcrop section of Late Paleocene to Early Oligocene of the Pabdeh Formation in southwestern Iran yielded 55 species of dinoflagellate cysts and allowed establishment of seven biozones. Quantity of marine palynomorph elements indicate an open marine environment at that time interval but, a slight increase in number of spore and pollen grains in some samples indicate suitable conditions for forest development as a consequence of increase in climate humidity. The species are common in various latitudes and most of them are cosmopolitan. Thermal maturity index measurement indicates oil prone nature for majority of the samples. ©JASEM

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Introduction

Fifty-five dinoflagellate cyst species were identified from Late Paleocene to Early Oligoce of Pabdeh Formation in west of Iran. The Formation is known as the source rock for the eminent reservoir, Asmari Formation, which is extended through Zagros basin from southwest to southeast of Iran. The Pabdeh Formation beginning from Paleogene, shows different age ranges up to Oligocene in different parts of Zagros basin. In Fars and Khuzestan provinces the Formation has been dated as Paleocene to Oligocene while it is dated as Paleocene to Early Miocene in Lurestan province.

There was a trough in Paleogene and Neogene covering today's highlands to the Arabian shield in which strata were countinuously deposited. This sea was separated by Fars platform in Southern Jahrom city. With some lithological differences such as the Rus anhydrite Formation in UAE, Qatar, Eastern Iraq, Kuwait and Hejaz, this trough extends to Arabia and Iraq. Equivallent strata to the Pabdeh Formation consists of Dammam Formation on top, Rus anhydrite in the middle and Ommolradhome Formation at the base in countries to the south of Persian Gulf. The present study is focused on marine palynomorphs and palynostratigraphy of a sections of the Pabdeh Formation in Zagros basin in southwest of Iran.

Previous Research: No study has been done on dinoflagellate cysts from the Pabdeh Formation though vast and precise studies have been carried out on foraminifera contents of the formation by the National Iranian Oil Company (NIOC)which led to differentiation of 14 foraminifeal biozones dating in age from Paleocene to Late Oligocene (Motiei, 2003). A Recent investigation on calcareous nannofossils extracted from subsurface samples indicated a Danian to Chattian age (Gholami,1386). General researches in Zagros basin suggest a Paleocene to Miocene age for the Pabdeh Formation but, this age range varies in different areas (Aghanabati, 2004). This Formation is a known source rock for the Asmari Formation, a huge reservoir rock in the Middle East and also the olargest Carbonate reservoirs rocks discovered in the world (Ashkan, 1983). For this reason, most studies on Pabdeh Formation are associated to petroleum industries.

Geological Setting: The area selected for the present study is located in Southwest Iran, Zagros basin, Kohgiliyeh va Boyeramad province. One of the three sections studied for this article is located between Gachsaran and Yasuj city in this province as shown in Figure1.

MATERIAL AND METHOD

A total of 132 samples were processed with mineral acids in several steps taken according to palynological standard methods (Traverse 1988). The processed amount depends on the lithology: for shale, mudstone and siltstone 20-25 grams; for limestone and calcareous shale30 -35grams, and for siltstone and mudstones 25-30 grams are common. For this study approximately 20-30 grams of rock samples were crushed and soaked in 30% Hydrochloric acid (HCl) for at least a day to remove calcareous cements

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and particles. The residue was then washed with distilled water for 10 times to neutralize the acid. Then it was placed in Hydrofloric acid (30%) for 48 hours to remove Silicate compounds. Then, they were boiled for 20 minutes with Hydrochloric acid (10%) to remove the gel formed. To remove palynomorphs from heavy minerals and other wastes based on their specific weight, heavy zinc chloride solution ($Zncl_2$) was used and the residue was centrifuged. When the samples were passed through the 20 micron sieve, palynological slides were mounted from the residues remaining on the sieve. To analyze the palynological elements, the prepared slides were investigated with a binocular transmitted light microscope equipped with objectives of 10X and 40X and the index dinocysts were photographed and presented (Plates 1 and 2).

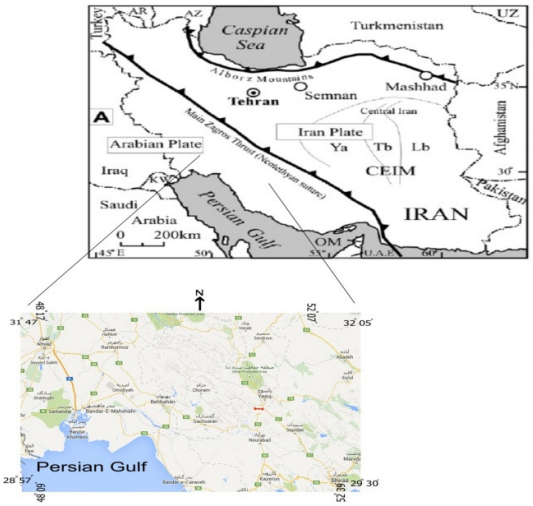


Fig1.Location map of the studied section.

*Biostratigraphy***:** Biostratigraphic data is used to answer many stratigraphic queries. Biostratigraphic investigation of the Tertiary outcrop, located in the main oil basin in Iran are mostly based on foraminifera and calcareous nanoplanktons. In this study, the authors try to focuse on dinoflagellate cysts to establish a biozonation. Microscope studies of the prepared slides let to identification of 55 species which are used for this purpose (Figure 2.). Dinoflagellate cysts are an important group of microfossils in petroleum exploration due to their potential to resolve questions on age dating and correlation. The remarkable morphological diversity displayed by dinoflagellate cysts facilitates their identification. Most of them are short-lived and, geographically widespread in marine sediments due to their planktonic nature. Several zonation schemes based on dinocysts have been proposed for Eocene age, but almost all of them have been established in high and middle latitudes, whereas data from tropical areas are scarce or even lacking. Zonal schemes established in the Northern Hemisphere (Northwestern Europe) can't be applied to the Middle East without modifications. This is probably due to the following reasons: Water temperature and oceanic circulation patterns seem to constitute the two principal factors in the determination of provincialism in dinoflagellate cysts (Ramirez 1990). Today, some species of dinoflagellate cysts are confined to the tropical/subtropical regions, while others are found exclusively in high latitudes. During the Middle to Late Early Eocene, the oceans and seas are characterized by a rather uniform warm global climate andwarm marine conditions are indicated by oxygen isotope ratios of planktonic and benthic foraminifera recovered worldwide from many locations. Within the Middle Eocene, the climate started to deteriorate, leading to a steeper temperature gradient from lower to higher latitudes. This climatic change was perhaps more pronounced in tropical regions (Sloan e.g. & Rea 1995) and lead to an increase in the differences between low latitude and middle to high-latitude assemblages.

Biozone 1*: Palaeoperidinium pyrophorum* interval zone
Age: Late Paleocene (Thanetian), Occurrence: from 5.14m to 10. 28m, Definition: The base of *Palaeoperidinium pyrophorum* interval zone defined by FAD of *P. pyrophorum* and the top defined by LAD of *Apectodinium paniculatus*. The taxa companions whose events concord to this biozone are *Hystrichokolpoma denticulate, wilsonidinium* cf. *echinusuturatum, Apectodinium homomorphum* (Fig.3,4) Biozone 2*:Phelodinium magnificurn* interval zone . Age: Early Eocene (Ypresian) Occurrence: from 10. 28m to 109. 61m. Definition: The base of *Phelodinium magnificum* interval zone is defined by FAD of *Enneadocysta arcuatum* and the top by LAD of *Phelodinium magnificurn.*The taxa companions whose events concord to this biozone are *Cordosphaeridium fibrospinosum, Costacysta bucina, Cribroperidinium* sp. ، *Deflandrea foveolata Lejeunecysta hyaline*، *Phthanoperidinium* sp. (Fig.2-5) Biozone3*:Deflandrea phosphoritica* interval zone
Age: Early Eocene (Ypersian) Occurrence: from 109.61m to 175.4m
Definition: The base of *Deflandrea phosphoritica* interval zone is defined by LAD of *Deflandrea phosphoritica* and the top by LAD of *Lejeunecysta hyaline*. The taxa companion whose events concord to this biozone are *Phelodinium kozlowskii, Selenopemphix septum.* (Fig.2-5)

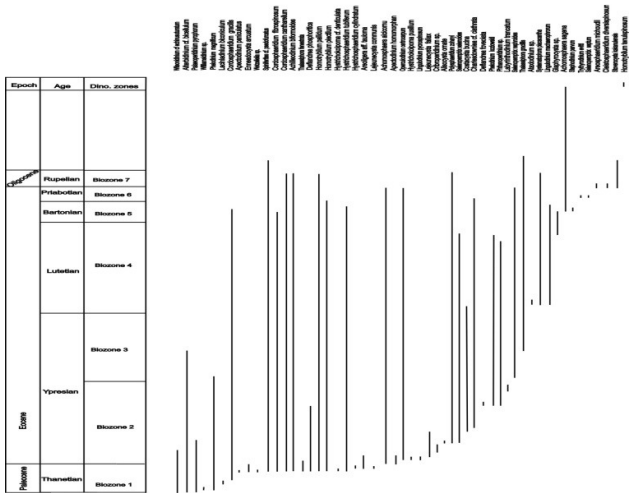


Fig 2. Distribution of dinoflagellate cysts in the Darishk section of Pabdeh Formation.

Biozone 4*: Systematophora placacantha* interval zone. Age: Middle Eocene (Lutetian)

Occurrence: from 175.4m to 261.24m, Definition: The base of *Systematophora placacantha* interval zone is defined by LAD of *Systematophora placacantha* and the top by the upper biozone.

The taxa companions whose events concord to this biozone are *Systematophora placacantha, Stephodinium* sp*., Lejeunecysta communis, Moratodinium fimbriatum.*(Fig.3,4). Biozone 5*: Cordosphaeridium cantharellus* interval zone. Age: Middle Eocene(Bartonian) Occurrence: from 261. 24m to 283m

Definition: The base of *Cordosphaeridium cantharellus* Interval zone is defined by LAD of *Cordosphaeridium cantharellus* and the top by LAD of *Cleistosphaeridium placacanthum.*

The taxa companion whose events concord to this biozone are *Arepligera sp., Cleistosphaeridium diversis, Trythyrodinium cf. evitti.* (Fig.3,4)

Biozone 6*: Operculodinium centrocarpum* interval zone. Age: Late Eocene (Priabotian)

Occurrence: from 283m to 299.3m. Definition: The base of *Operculodinium centrocarpum* interval zone is defined by LAD of *Operculodinium centrocarpum* and the top by LAD of *Achomosphaera alcicornu*.

The taxa companion whose events concord to this biozone are *Cleistosphaeridium diversis, Glaphyrocysta vicina, Opercculodinium centrocarpum.*(Fig.3,4), Biozone 7*: Polyshaeridium zoharys* interval zone

Age: Early Oligocene (Ruppelian). Occurrence: from 299.3m to 310.5m. Definition: The base of *Polyshaeridium zoharys interval zone* defined by LAD *Polyshaeridium zoharys* and the top defined by LAD of *Thalassiphora pelagica.*

The taxa companions whose events concord to this biozone are *Polysphaeridiunzohary, Selenopemphix armaeddonsis , Stoverocysta* sp.*,Homotrybliumpallidum.*(Fig.3,4)

Thermal Maturity: Pabdeh Formation is a source rock in Zagros basin and the abundance of palynological elements in this Formation provided a suitable condition to study thermal maturity. About 21 samples containing spores and pollen were acquired. Color range was from pale yellow to dark brown. Thus, the yellow color indicated the immature organic matter, and the brown color range indicated petroleum prone stages. Most of the samples are in brown color range. Therefore, the thermal maturity condition is in petroleum generation range. (Table 1)

Table1. Thermal maturity index, based upon spore and pollen colors that indicate oil prone for most of the samples

Sample No	Color of spore and pollen	TAI	maturity	Hydrocarbon
1	*Pale brown*	3 -	*Mature*	*Liquid petroleum*
3	*Pale brown*	3	*Mature*	*Liquid petroleum*
4	*Dark brown*	3+	*Mature*	*Liquid petroleum*
6	*Light brown*	2+	*Mature*	*Liquid petroleum*
7	*Pale brown*	3	*Mature*	*Liquid petroleum*
8	*Dark brown*	3-	*Mature*	*Liquid petroleum*
11	*Pale brown*	3-	*Mature*	*Liquid petroleum*
12	*Light brown*	2+	*Mature*	*Liquid petroleum*
22	*Pale brown*	3-	*Mature*	*Liquid petroleum*
28	*Dark yellow*	2	*Immature*	-
36	*Dark yellow*	2	*Immature*	-
42	*Pale brown*	3	*Mature*	*Liquid petroleum*
47	*Pale brown*	3	*Mature*	*Liquid petroleum*
48	*Light brown*	2+	*Mature*	*Liquid petroleum*
66	*Dark brown*	3+	*Overmature*	*Dry gas or barren*
70	*Very Dark brown*	4	*Ovarmature*	*Dry gas or barren*
74	*pale brown*	3-	*Mature*	*Liquid petroleum*
81	*Dark brown*	3+	*Mature*	*Liquid petroleum*
88	*pale brown*	3-	*Mature*	*Liquid petroleum*
91	*pale brown*	3	*Mature*	*Liquid petroleum*
127	*Dark brown*	3+	*Mature*	*Liquid petroleum*

RESULT AND DISCUSSION

Of the 132 samples processed from the Paleogene of Pabdeh Formation, mostly, except for a few, were unproductive. Marine palynomorphs dominate most samples. Preservation of dinoflagellates in most productive samples is in moderate to good state. Eight samplesfrom the top of the formation were barren of palynomorphs. A total of 55 marine palynomorph species (mostly dinocysts) were recorded in this study and are listed in figures 1 and 2. Their stratigraphic distribution in the Paleocene to Early Oligocene of this section is presented in figures 3and 4. In this study,using the recovered species and the defined boizones, Late Paleocene to Early Oligocene age was defined forthe section. The thermal maturity index of most samples indicate a petroleum generation range. Hence, many wells in the region are drilled to exploit petroleum and gas.

Of those species that are considered to be stratigraphically useful, many occur sporadically in this section, or well within their established ranges. The index species for biostratigraphy that exist in Europe, Canada and Americas were not found here but rare species in other regions such as *Lejeunecysta* spp., *Phelodinium* spp., *Selenopemphix* spp., *Deflandrea* spp., were frequently found throughout this section. For this reason, no formal zonation is proposed here and local biozones were defined. Nevertheles,the events of many species of other regions provide clues to define local biozones. The recognition of cosmopolitan and endemic species in Tertiary is complicated because of the increasing provincialism observed in dinoflagellate cysts (Stover et al., 1996). This affects the definition of biozone boundaries and other significant events as well as the chronostratigraphic correlation with Eocene and Oligocene zonations established in NW Europe, Canada and Australia. These events are mainly based on representatives of the species *Palaeoperidinium pyrophorum* , *Phelodinium magnificurn*, *Alterbidinium bicellulum*, *Lejeunecysta* spp., *Selenopephix* spp., *Deflandrea heterophlycta*, *Polysphaeridium zohary*, *Areoligera gippingensis*. All these species, are index-fossils of Paleogene of Zagros basin, but, they are absent in some basins in the world.

Conclusion: A new Paleocene – Oligocene palynostratigraphy has been established based on the study of 132 samples. Stratigraphical studies based on palynological events resulted in definition of seven interval zones. These palynological interval zones have been correlated with the foraminifera biozones of West Zagros basin in Iran.The dinoflagellate cyst correlation shows the Late Paleocene to Early Oligocene age that also occurs in the Darisk section of Pabdeh Formation.

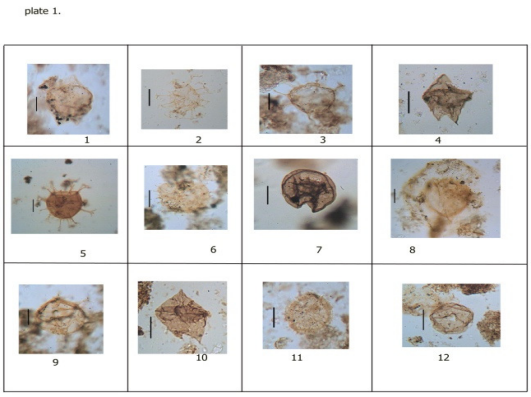
PLATE 1. scale bar = 30 micron

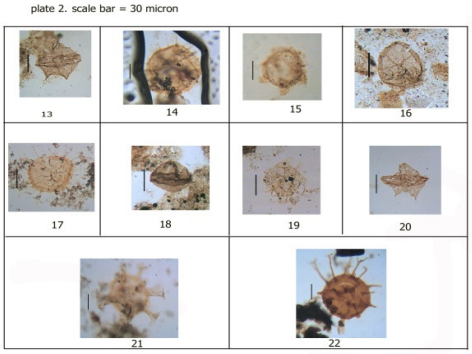
1-*Deflandrea phosphoritica Eisenack*, 1938, 2-*Enneadocysta arcuata* (Eaton, 1971) Stover and Williams, 1995, 3-*Homotryblium pallidum* Davey and Williams, 1966, 4-*Lejeunecysta communis* Biffi and Grignani, 1983

5-*Achomosphaera alcicornu* (Eisenack,) Davey and Williams, 1966, 6- *Cleistosphaeridium placacanthum* (Deflandre and Cookso,) Eaton et al., 2001, 7-*Selenopemphix selenoides* Benedek, 1972
8-*Thalassiphora pelagica* (Eisenack, 1954) Eisenack and Gocht, 1960, 9-*Spiniferites pseudofurcatus* (Klumpp, 1953) Sarjeant, 1970, 10-*Phelodinium magnificum* (Stanley, 1965) Stover and Evitt, 11- *Operculodinium centrocarpum* (Deflandre and Cookson, 1955) Wall, 1967, 12-*Selenopemphix nephroides* Benedek, 1972

PLATE 2. scale bar = 30 micron

13- *Palaeoperidinium pyrophorum*(Ehrenberg, 1838) Sarjeant, 1967
14-*Lingoulodinium machaerophorum*(Deflandre and Cookson, 1955) Wall, 1967
15-*Hystrichokolpoma pusillum* Biffi and Manum, 1988
16-*Selenopemphix septum* Benedek, 1972
17- *Cleistosphaeridium placacanthum* (Deflandre and Cookson, 1955) Eaton et al., 2001
18-*Trithyrodinium cf.evitti* Drugg, 1967
19-*Apectodinium paniculatum* (Costa and Downie, 1976) Lentin and Williams, 1977
20-*Lejeunecysta fallax* Artzner and Dörhöfer, 1978
21-*Cordosphaeridium cantharellus* (Brosius, 1963) Gocht, 1969
22- *Melitasphaeridium pseudorcuvatum*(Morgenroth 1966a) Bujak et al. 1980





REFERENCES

Aghanabati, A. (2004). Geology of Iran.Ministry of Industry & Mine. Iran: Geological Survey of Iran, 350pp, in Persian.

Ashkan, S. A. M.(1383). Fundamentals of geochemical studies of hydrocarbon source rocks and oils. National Iranian Oil Company, 279pp, in Persian.

Biffi,U. and Grignani, D. (1988).On the Eocene - Oligocene boundary in Alam El-Bueib IX, Western Desert, Egypt. Revista Española de Micropaleontología, 20(1):59-70.

Biffi,U., Manum, S. B.(1988). Late Eocene- Early Miocene dinoflagellate cyst stratigraphy from the Marche Region(CentralItaly). Bollettino della Società Paleontologica Italiana, 27(2):163-212.

Bujak,J.P, Downie, C, Eaton,G.L, and Williams, G. L.(1980). Dinoflagellates cyst and acritarchs from the Eocene of Southern England.ThePalaeontological Association London.Specialpaperinpalaeontology, 24:96

Bujak, J. P., &Mudge, D. (1994). A high-resolution North Sea Eocene dinocystzonation.Journal of the Geological Society of London, 151,449–462.

Bujak,J.P. 1984. Cenozoic dinoflagellate cysts and acritarchs from the Bering Sea and northern
North Pacific, DSDP leg 19. Micropaleontology, 30:180-212.

Cookson, I . C. and Eisenack,A. (1967). Some Early Tertiary microplankton and pollen grains froma deposit near Straha, western Victoria. Proccedings of the Royal Society of Victoria, 80:131-140.

Drugg, W. S. and Stover, L. E.(1975). Stratigraphic ranges charts of selected Cenozoic dinoflagellates. In: Evitt, W.R.(Ed.).,Americam Association of Stratigraphic Palinologists Foundation, Contribution Series No.4:73-76.

Ghasemi-Nejad, E., Hobbi,M. H., Schiøler, P.(2006). Dinoflagellate and foraminiferal biostratigraphy of the Gurpi Formation (upper Santonian - upperMaastrichtian), Zagros Mountains, Iran. Cretaceous Research, 27 , 828-835

Gholami, A. (1386). Nanostratigraghy of Pabdeh Formation in Gachsaran field. Master of Science, Shahid Beheshty university.

Ghosh,S.andZambrano, E.(1996).The Eocene turbidites of the Trujillo Formation,Venezuela Andes. Program, Caracas! IIAAPG/SVGInternational Congress and Exhibition, A18.

Gradstein, F.M., Kristiansen, I.L., Loemo, L., Kaminski, M.A.(1992). Cenozoic foraminiferal and dinoflagellate biostratigraphy of the Central North Sea. Micropaleontology 38, 101-137.

Heilmann-Clausen, C. (1988).The Danish Subbasin, Paleogenedinoflagellates. In: Vinken, R. (ed.), The north west European Tertiary basin: results of the International Geological Correlation Programme, Project No. 124. GeologischesJahrbuch, A 100: 339–343.

Heilmann-Clausen,C., Simaeys, S. V.,(2005). Dinoflagellate cysts from the central danish basin 143 dinoflagellate cysts from the middle eoceneto ?lowermostoligocene succession in the kysing research borehole, central Danish basin palynology, 29, 143–204.

Holl, C, KarinA. F. Zonneveld, Helmut Willems.(2000). Organic-walled dinoflagellate cyst assemblages in the tropical Atlantic Ocean and oceanographical changes over the last 140 ka.Palaeogeography, Palaeoclimatology, Palaeoecology160, 69–90.

Iakovleva,A. I.,Rousseau,D. D.(2000). Paleocene–Eocene dinoflagellates cysts and continental palynomorphs from borehole no. 4 (vasugan basin, central western siberia). Palynology, 24 , 187–200.

Jaramillo, A. C. (1999). Sequence stratigraphic in terpretations from palynofacies, dinocyst and lithological data of Upper Eocene–Lower Oligocene strata in southern Mississippi and Alabama,U. S. Gulf Coast. Palaeogeography, Palaeoclimatology, Palaeoecology145 , 259–302.

Köthe, A. (1990). PaleogeneDinoflagellates from North west Germany- Biostratigraphy and Paleoenvironment. GeologischesJahrbuch, A118: 3-111.

Morgans, H.E.G., Beu,G., Cooper, R.A, Crouch, E.M., Hollis,C.J., Jones, C.M., Raine, J.I., Strong, C.P., Wilson, G.J., Wilson, G.S., (2004).Paleogene.In: Cooper Ra ed. (2004). The New Zealand geological timescale. Institute of Geological and Nuclear Sciences Monograph 22

Motiei,H.(2003). Geology of Iran: Stratigraphy of Zagros. Geological survey of Iran.343-363pp, in Persian.

Nøhr-Hansen, H.(2003). Dinoflagellate cyst stratigraphy of the Palaeogene strata from the Hellefisk-1, Ikermiut-1, Kangaˆmiut-1,Nukik-1, Nukik-2 and Qulleq-1 wells, offshore West Greenland Marine and Petroleum Geology, 20, 987–1016.

Norris, G. and Velásquez, M.(1994).Senonian through Pliocene zonation based on dinoflagellate and other organic walledalgal microfossils with catalog of dinoflagellate species with description supported by photomicrographs, Western Venezuela. MaravenExploración y Producción Caracas.Informetécnico EPC-13435: 51 p.

Rabbani, J. ,Ghasemi-Nejad, E. ,Ashori, A., Vahidinia, M.(2013).Quantitative palynostratigraphy and palaeoecology of Tethyan Paleocene–Eocene red beds in north of Zagros sedimentary basin, Iran. Arabian Journal of Geosciences DOI 10.1007/s12517-013-1164-2

Sluijs, A., Pross, J., Brinkhuis, H. (2005). From green house to icehouse; organic-walled dinoflagellate cysts as paleoenvironmental indicators in the Paleogene.Earth-Science Reviews,68, 281–315.