INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print), 2222-3045 (Online)
http://www.innspub.net
Vol. 6, No. 1, p. 633-641, 2015

RESEARCH PAPER OPEN ACCESS

Palynostratigraphy and palynofacies of the sanganeh formation in Qarah-Su section (NE, Iran)

Narges Shokri*, Ebrahim Ghasemi-Nejad[1], Ali-Reza Ashouri

Department of Geology, Faculty of Sciences, Ferdowsi University of Mashhad, Mashhad, Iran

[1]Department of Geology, University College of Sciences, University of Tehran, Tehran, Iran

Key words: Kopeh-Dagh Basin, Lower Cretaceous, Palynofacies, Palynostratigraphy, Dinoflagellate cysts, Iran.

Article published on January 31, 2015

Abstract

Palynomrphs extracted from rock samples of the Sanganeh Formation cropping out in the central Kopeh-Dagh Basin indicate a late Aptian-early Albian age for the formation. Eighty samples recovered from the shale and marl beds were processed and analysed for palynomorphs. Two palynological zones and tree types of Palynofacies have been identified. The Palynofacies and dinoflagellate assemblages indicate deposition in neritic to shallow marine environments.

***Corresponding Author:** Narges Shokri ✉ shokri_narges@yahoo.com

Introduction

The Kopeh-Dagh basin is located in northeast of Iran with WNW-ESE trend. This sedimentary basin contains a great gas field which is in common with Iran, Turkistan and Afghanistan. The recent topography and morphology has formed during the Alpine tectonic phase (Aghanabati, 2004).This basin is especially interesting for geologists because it is located between the two super continents of Aurasia and Gondowana.

Palynology is regularly been used in such fields as biostratigraphy, paleoclimatology and pale environmental reconstruction which has more recently been developed. Palynofacies analysis is an interdisciplinary approach. The entire organic content of the slides are assumed as sedimentology components that reflect original conditions of depositional environments (Tyson, 1995;Götz *et al.*, 2008). The use of Palynofacies analysis for environmental interpretation allows determination of depositional environments (e.g. salinity, oxygenation) (Tyson, 1993, 1995; Batten, 1996). We try to interpret paleoenvironment of the Sanganeh Formation via determining such parameters as distribution of dinocysts as littoral and neritic group, the Peridinioid to Gonyaulacoid ratio (P/G), and palynofacies types; Also determination of the relative age of the study beds based on dinoflagellate cyst assemblages.

The Sanganeh Formation is one of the lower Cretaceous rock units in the Kopeh-Dagh Basin in north eastern Iran and south eastern Turkmenistan. Its type section thickness is 770m at the Sanganeh village, north-east of Mashhad (Afshar-Harb, 1994). The thickness increases from east to west (200-2000m). This Formation is overlain by the Aitamir Formation Sandstones and underlain by the Sarcheshmeh Formation. Although, it is overlain unconformably by the Kalat Formation (Maasstrichtian) in the west part of the basin. Overally, the age of the Sanganeh Formation has been designated as Albian (Kalantari, 1969) based on planktonic foraminifera and Late Aptian age based on benthic foraminifera (Motamedalshariati *et al.*, 2010). Based on nannofossils, Mahanipour *et al.*, (2011) suggested an early Aptian for this Formation. On the other hand, Raisossadat (2006) attributed the Sanganeh Formation to the late Early Aptian to Early Albian age based on ammonite fossils recovered in different sections.

The studied section is located at the Qarah-Su village at N36° 58' 14.04″, E59° 40' 46″, north-east of Mashhad (Fig. 1). At the studied section, the Sanganeh Formation is composed of dark grey shale, marl, limestone and siltstone. Its thickness is 580 m which contains some structures such as concretion, *Septarian nodules* (sometimes with ammonite core) and cone-in-cone. The aim of this paper is study palyno stratigraphy and palyno facies of the Sanganeh formation in Qarah-Su section (NE Iran) and find types of Palynofacies and indicate deposition in neritic to shallow marine environments.

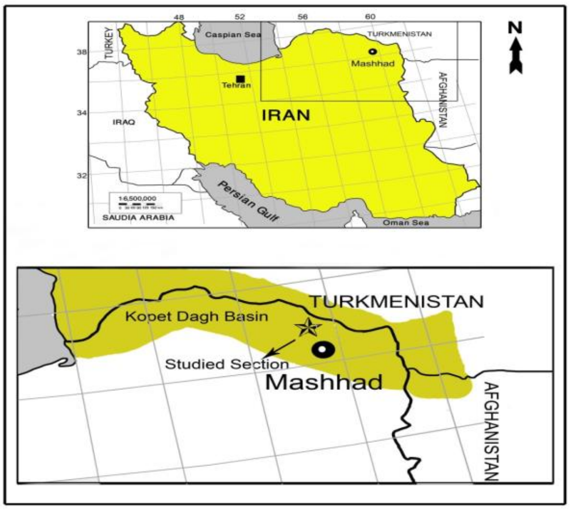

Fig. 1. Location map of the Qarah-Su village (Studied section).

Materials and methods

Sampling method

A total of 80 rock samples were collected from the shale and marl beds of the Sanganeh Formation in the Qarah-Su village, central Kopeh-Dagh basin, Iran (Fig. 1). The samples were processed for palynomorphs. The precise location of each sample is given in Fig.2.

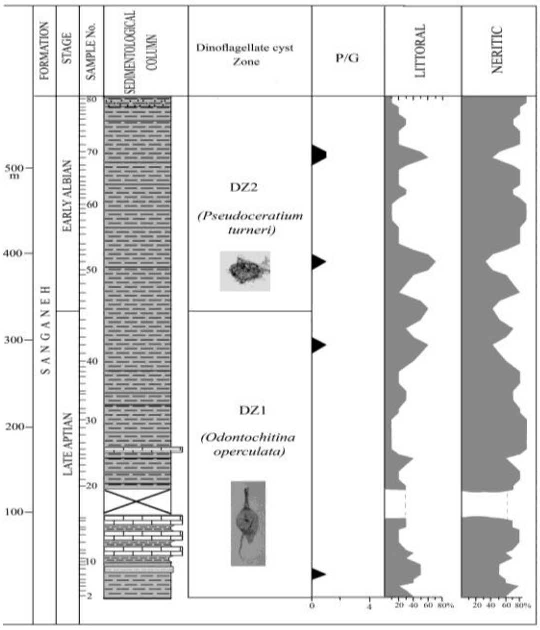

Fig. 2. Relative abundance of dinoflagellate cyst paleoenvironmental groups at Qarah-Su section. P/G-ratio of abundance of peridinioid/ gonyaulacoiddino flagellates.

Analytical techniques

After washing and drying, the sediment samples were prepared for palynological analysis following standard extraction techniques (Poulsen *et al*., 1990; Travers, 2007) involving hydrochloric (HCl) and hydrofluoric acid (HF) treatment in order to dissolve carbonate and siliceous contents. The concentration of palynomorphs was filtered by decantation over a 10μm nylon mesh sieve, and the samples were centrifuged to concentrate the residues. The residues were not oxidized or stained. Three to five slides were prepared from each sample. The slides were investigated under a light microscope with magnifications of 200× -1000×, to identify and count the palynomorphs. All slides and residues are stored in the paleontology group, Department of Geology, Faculty of Sciences, Ferdowsi University of Mashhad, Iran.

Results and discussions

Palynostratigraphy and Dinoflagellate assemblages: The Qarah-Su section has shown a moderate density and diversity of dinoflagellate cysts with more than 37dinoflagellate cyst species belonging to 19 genera recorded.

Two bio zones have been identified based on the stratigraphic ranges of dinoflagellate cysts recorded.

DZ1: This dinozone corresponds to the total-range occurrence of the dino flagellate cyst species Odontochitinao perculata, which is considered to be diagnostic of it (Evans, 1966). It encompasses the interval from the base to 330 m with and is also marked with presence of *Cribroperidinium*, *Cyclonephelium distinctum*, *Oligosphaeridium pulcherrimum*, *Paleoperidinium cretaceum*, *Spinifer itesramosus*, *Subtilisphaera* and *Coroniferaoceanica*; however *Oligosphaeridium* is the dominated genus (Fig. 3). *O. operculata*is reported from Aptianstrata in New Zealand (Wilson, 1984) and Australia (Helby *et al*.,1987, 2004;Helby and Mcminn,1992, Oosting *et al*, 2006).

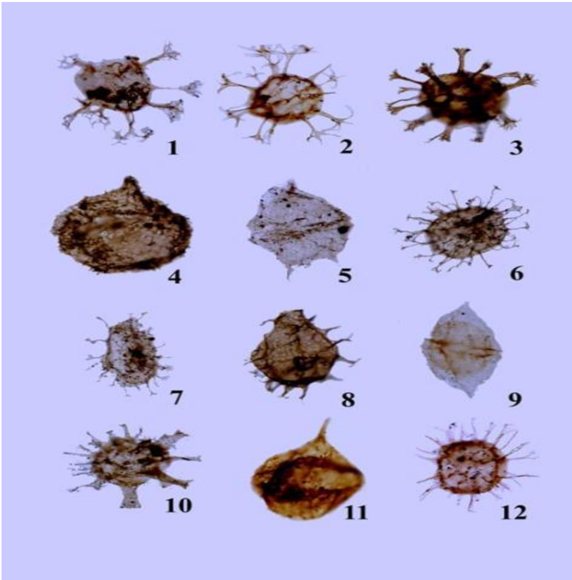

Fig. 3. *Oligosphaeridium pulcherrimum* (Deflandre and Cookson, 1955) Davey and Williams 1966. X500; 2, *Oligosphaeridium complex* (White, 842), Davey and Willams, 1966. X500;3, *Kleithria* s, *Haeridium* sp., 4, *Cyclonephelium* sp., X500; 5, *Paleoperidinium cretaceum* Pocock 1962. X 500; 6, *Surcolosphaeridium longifurcatum* (Firtion, 1952) Davey *et al*, 1966b. X 500;, 7, *Cleistosphaeridium* sp., X500;8, *Spiniferites* sp., X500;9, *Subtilisphaera* sp., X 500;10, *Florentinia daenei* (Davey and Williams, 1966) Davey and Verdier 1973. X 500; 11, *Cribroperidinium orthoceras* (Eisenack, 1958) Davey, 1969 Emend. Sarjeant, 1958. X500; 12, *Systematophora* sp., X500.

Although, some authors considered this species as index form for *Huterivian baremian* (Haq *et al*, 1987; Costa and Davey, 1992) and for upper Baremian (Harding, 1990). The other taxa were recorded from different point associated with this zone are: *Subtilisphaera* and *Achomosphaera* from late Aptian (Davey and Verdier, 1974; Skupien, 2003); *Kiokansiumpolypes, Cyclonepheliumdistictum* and *Oligosphaeridium complex* in Canada (Kimyai, 2000); *Oligosphaeridium complex* and *Cassiculosphaeridium reticulate* with early Aptian in age from Australia, South eastern France and south of Italy (Stover, 1996) andAlbian from Egypt (Omran *et al.*, 1990). The dinocyst*o. complex* has a stratigraphic range of Valanginian to upper Albian for Tethys region (Williams and Bujak, 1985).

DZ2. This dinozonecorre sponds to the total-range occurrence of the dinoflagellate cyst species *Pseudoceratiumturneri* with an early Albian age (Morgan, 1980).

This biozone also recognized with *Cassiculosphaeridium reticulata*, *Achomosphaera*, *Florentiniamantellii* and *Cyclonephelium*; dominated genera are *Systematophora* and *Cribroperidinium*. This biozones encompassed the interval from 330m to the top of the formation.

Some species such as *Paleoperidinium cretaceum*, *Spiniferitesramosus* and *Coroniferaoceanica* were recorded from late Aptian strata and *Florentiniamantellii* from Albianof northern Western Desert of Egypt (Omran *et al.*, 1990).

Dinoflagellate cysts are useful indicators for original paleoproductivity in surface water and oxygen changes in the bottom waters (Pross, 2001). Diversity of living dinoflagellate assemblages are controlled basically by the availability of nutrients, temperature, vertical stratification, water salinity and environmental stress (Pross and Brinkhuis, 2005; Wall *et al.*, 1977).

The Peridinioid to Gonyaulacoid ratio (P/G) is used to determine paleosalinity variations and proximity to shorelines. Peridinioid-dominated assemblages reflect low salinity and nutrient-rich conditions (Jaminski, 1995) related to near shore environments (Lagoonal, Brackish water). In contrast, low values of the ratio, i.e. gonyaulacoid-dominated assemblages indicate open marine environments and are resistant to oxic conditions (Sluijs *et al*, 2005).

In addition, cavate cysts are adapted to high-energy conditions and shallow marine environments; in contrast, chorate cysts are often inhabitant of low-energy and deep waters (Ghasemi-Nejad*etal*, 1999). Therefore, the genera *Spiniferites*, *Florentinia*, *Achomosphaera*, *Oligosphaeridium* are cyst types with relatively long processes that are considered to be typical for outer neritic to open marine mid-shelf environments (Oosting *et al*, 2006). Genus *Cleistosphaeridium* reflects shallow marine and some genera such as *Cyclonephelium*, *Subtilisphaera* and *Systematophora* are associated with marginal marine (brackish, coastal) (Omran *et al.*, 1990). *Spiniferites* with high percentage of phytoclasts indicate regressive conditions.

Abundance of *Cribroperidinium* in the more dysoxic intervals in the Votorantim section in Brazil indicates shallower environments (Santos *et al.*, 2013). This genus has been identified in strata deposited in inner neritic environments in southeast France (Wilpshaar and Leerveld, 1994), north-central Spain (Peyrot *et al.*, 2011; 2012), the Neuquén Basin in Argentina (Guler *et al*, 2013) and the Sergipe Basin in Brazil (Santos *et al.*, 2013).

The few reported dinocysts are represented mainly by *Subtilisphaera* and *Oligosphaeridium*. These reflect marginal (Brackish) marine environments (Harding, 1986).

In the study section, the dinoflagellate assemblage composition dominated by *Oligospharidium* specis indicates inner neritic environment. In some parts of the section (Fig. 2), littoral group such as *Systematophora, Subtilisphaera* and *pseudoceratium* show a regressive phase.

According to the distribution of dinoflagellate cysts as presented above, *Oligosphaeridium*that reflects the inner neritic environment is the dominated species. Distribution patterns of paleoenvironmentally important dinoflagellate cysts are displayed in Fig. 2. Additionally, the proportion of genus *Spiniferites* increases upwards. This trend reflects a deepening upwards sedimentation trend. Increase in the P/G ratio (especially *Subtilisphaera*) indicates increase in nutrient content.

Palynofacies analysis and sedimentary environments

In palynofacies analysis the entire organic content of the slides are investigated. Palynofacies studies are used to understand paleoenvironment and hydrocarbon potential of the Sanganeh Formation. The main particles that were used for determination of the sedimentary environment were divided into three main groups: structured debris and phytoclasts, palynomorphs, and amorphous organic matter (AOM).

According to Tyson (1995), the AOM group consists of structureless particles that were observed under light microscopy. AOM quantity directly depends on the relative sea level changes. Their preservation increases in reducting conditions. The phytoclast group consists of structured particles that have terrestrial sources such as plant debris, cuticle, spore and pollen. This group is subdivided into two major subgroups: opaque and translucent. In spite of their high density (Van der Zwan, 1990), they display a high portability and can undergo long distance transport (Bombardiere and Gorin, 2000).

Marine palynomorphs such as dinoflagellate cysts, acritarchs and foraminiferal test linings; show ecological and environmental conditions.

Depositional paleoenvironments and paleoecology factors such as sea level changes, oxygen rate and proximity to the source of terrigenous material can be figured out even in carbonate systems (Götz *et al*., 2008; Santos *et al*., 2013) by using these groups, their percentage, and contribution on the slides.

Therefore, at least 300 particles are counted for each slide. The palynofacies composition and relative abundance in the samples are presented (Fig. 4).The AOM -palynomorphs- phytoclasts ternary plot (Fig. 5) show the presence of three palynofacies types in the Sanganeh Formation at the study area.

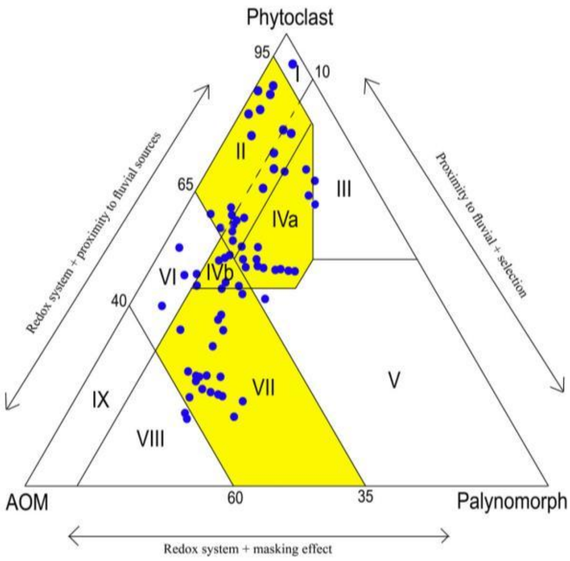

Fig. 4. Ternary diagram plot forQarah-Su (late Aptian-early Albian) section. Key to paleoenvironmental fields (Tyson, 1995): I- Highly proximal shelf or basin; II- Marginal dysoxic-anoxic basin; III-Heterolithicoxic shelf (proximal shelf); IV-Shelf to basin transition; V- Mud-dominated oxic shelf (distal shelf); VI- Proximal suboxic-anoxic shelf; VII- Distal dysoxic-anoxic shelf; VIII-Distal dysoxic-oxic shelf; IX-Proximal suboxic-anoxic basin.

Palynofacies I (PF-1): Opaque phytoclasts

This facies is characterized by a predominance of phytoclasts (up to 60% of the total particulate organic matter). The phytoclasts are mainly opaque and well preserved. The high values of opaque phytoclasts indicate oxidizing conditions and proximity to terrestrial sources or redeposition of terrestrial organic matter (Tyson, 1989). This facies is classified palynofacies type II as deduced from the AOM-Phytoclast-Palynomorph ternary plot of Tyson (1993) shown in Fig. 5.

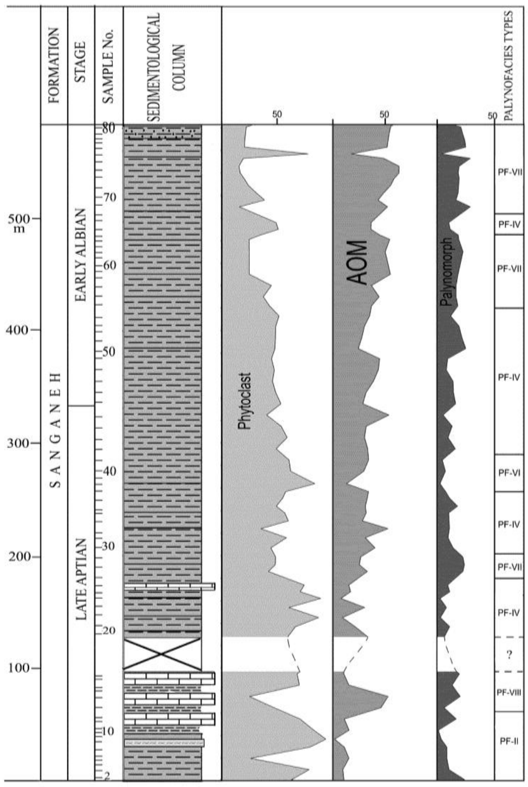

Fig. 5. Stratigraphic distribution of the tree main groups (phytoclast, AOM and palynomorph through theQarah-Susectiion.

Palynofacies II (PF-2): opaque phytoclasts, marine palynomorphs and amorphous organic matter.

This facies is distinguished by the commonness (up to 30%) of marine palynomorphs (specially dinocysts), common AOM (20-32%) and low frequency of opaque phytoclasts (Fig. 4). Dinocysts have good density and preservation but some of them reformed to AOM. This facies is classified as type IV of Tyson (1993).

Palynofacies III (PF-3): marine palynomorphs and amorphous organic matter.

This facies mainly was observed in upper part of the formation. It is characterized by high AOM (45- 65%) and common palynomorphs (about 35%). The high AOM preservation is due to reducing basin conditions (Tyson, 1995).It could be caused by higher freshwater runoff (Aksu *et al.*, 1995b, 1999; Abrajano *et al.*, 2002, Kholeif and Ibrahim, 2010). Generally, the high percentage of AOM indicates reducing conditions, dysoxic-anoxic environment (Batten, 1983; Tyson, 1993).

This facie is classified as palynofacies type VII of Tyson (1993), and it just exposed in the middle part of the formation.

Conclusion

Palynomorph and palynofacies analyses of 80 rock samples from the Sanganeh Formation at Qarah-Su section in the Kopeh-Dagh basin, north eastern Iran, revealed that the marine palynomorphs predominated over the continental palynomorphs with a moderate diversity and abundance. The age of the formation was determined on the basis of twopalynological zones were identified the based on dinoflagellate cysts distribution. *Odontochitin-aoperculata* zone indicated the late Aptianan dearly Albian age by *Pseudoceratiumturneri*dino zone.

Based on the distribution of three main palynological groups on the slides, three types of Palynofacies were differentiated. These Palynofacies are based on the classification of Tyson (1993,1995) that show This formation was deposited in a neritic to shallow marine pale environment under dysoxic to suboxic conditions. The percentage of neritic, littoral and P/G group of dinoflagellate cysts also indicate that a distal shelf with some regressive phase.

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