Dinoflagellate cysts from the Upper Triassic (Rhaetian) strata of the Tabas Block, East - Central Iran

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Abstract
Rhaetian strata from the Nayband Formation of the Tabas block, East- Central Iran, were studied palynologically. The material examined contained moderately diverse and well-preserved dinoflagellate cyst assemblages which lead to the identification of Rhaetogonyaulax rhaetica Zone. The assigned age of this dinozone (Rhaetian) is justified by plant fossils such as Equisetites arenaceus, Scytophyllum persicum, Pterophyllum bavieri, Pterophyllum aequale and Nilssoniopteris musafolia recorded from these strata. The dinoflagellate cysts show close similarities with assemblages reported from Australia, Northwest Europe, Arctic Canada and Northern Iran. Furthermore, the associated marine palynomorphs (dinoflagellate cysts), accompanied by spores grain indicate a nearshore depositional environment for the Late Triassic (Rhaetian) deposits in Tabas Block of Iran.

Keywords: Late Triassic, Dinoflagellate cysts, Palaeobiogeography, Tabas block, Iran.

Introduction
The Upper Triassic Nayband Formation in Tabas Block, of East-Central Iran has been divided into the Gelkan, Bidestan, Howz-e-Sheikh and Howz-e-Khan members. The Gelkan Member contains shales and sandstones with an age of Early Norian; the Bidestan Member containing sandstones, shales and reefal limestones with common Heterastridium has been assigned an age of middle-late Norian, while the Howz-e-Sheikh Member containing shales and sandstones and the Howz-e-Khan Member with shales, sandstones and reefal limestones containing algae, calcareous sponges and corals have both been assigned a Rhaetian age (Seyed-Emami, 2003; Cirilli et al., 2005). The Nayband Formation at the type section has a 2195 m thickness (Seyed-Emami, 2003) but this formation at the section studied here, is different in terms of lithology and thickness such that lithologically it consists mainly of shales and sandstones interbedded with thin bedded limestone, marl and coal and its thickness reduced to 1847 m. Furthermore, the upper carbonate member (the Howz-e-Khan Member) is partly or entirely replaced by a thick, siliciclastic sequence with prominent coal-measures informally named by the geologists of the National Iranian Steel Company Qadir Member (Bragin et al., 1981). The Qadir Member, studied palynologically, has a thickness of 435 m, and is composed of alternations of shales and sandstones interbedded with thin bedded limestone and coal seams (Fig. 2). This study shows that the lower part of the Qadir Member is rich in marine (dinoflagellate cysts) and terrestrial (spores and pollen grains) palynomorphs. The marine elements used in this study were for palynostratigraphy, palaeogeography and palaeoenvironmental interpretations.

Geological setting
Upper Triassic strata of the Nayband Formation are well developed at Southwest Tabas, Parvadeh mine, East-Central Iran. The studied section of the Nayband Formation is situated within a tectonic unit called the Tabas Block in Central-East Iranian Microcontinent (Takin, 1972) and together with the Alborz Mountains and Central Iran, forms the Iran Plate (Wilmsen et al., 2009). The Parvadeh section located 75 km south of Tabas City, center of the Tabas Block together with the Yazd Block in the west and Lut Block in the east, forms the so-called Central and East Iranian Microcontinent ((CEIM), (Fig. 1)).

Materials and Methods
In this study, 116 rock samples were collected from the Qadir Member of the Nayband Formation at Parvadeh section, North Tabas block and prepared in the palynology laboratory of the Exploration Directorate of the National Iranian Oil Company (NIOC). The preparation method of Traverse
(2007) was used. Cold hydrochloric (20%) and hydrofluoric (50%) acids were used to dissolve carbonates and silicates. The residue was neutralized and centrifuged in ZnCl₂ (specific gravity 1.9), then sieved with a 15 μm nylon mesh, and mounted on microscopic slides using liquid Canada balsam. The samples were designated with the National Iranian Oil Company code number with the prefix MZY. The microscopic slides were examined with a Zeiss optical microscope equipped with a Delta Pix (DP 450) Camera by which the index species were photographed and the photomicrographs of the selected dinoflagellate cyst specimens have been compiled and presented in Plates I and II. The slides were housed at the Department of Geology and Geochemistry of the Exploration Directorate of the NIOC.

Previous studies
The Nayband Formation is the extensive and predominantly marine facies development of the Upper Triassic in eastern parts of Central Iran (Douglas, 1929; Stöcklin, 1961; Brönnimann et al., 1971; Kluyver et al., 1983a). The thickness of the formation decreases from 2195 m at the type section in East-Central Iran to only 80 m in Southern Iran (Senowbari-Daryan, 1996). The Qadir Member being studied here, introduced in an unpublished report of the National Iranian Steel Company by Bragin et al. (1976), has never been formalized. The member corresponds to member 5 of the Nayband Formation of Kluyver et al. (1983b). The Upper Triassic successions of the Central Iran and Alborz basins have previously been investigated palynologically by Arjang (1975), Achilles et al. (1984), Ghasemi-Nejad et al. (2004) and Cirilli et al. (2005). Arjang (1975) sampled the coal-bearing deposits of Kerman area through several stratigraphic sections dated as Rhaetian, Liassic, and Dogger. Achilles et al. (1984) has also described miospores from the Mesozoic (upper Triassic-Jurassic) strata of the Kerman Basin (Central Iran), Zangerud (Western Alborz Mountains), Zirab (North Central Alborz) and Tazareh (Eastern Alborz) and introduced several miospore zones. Mannani and Yazdi (2009) sampled Qadir Member in the Bagher Abad area (North of Esfahan), recorded *Indopecten glabra* (bivalve) and assigned a Rhaetian age to this member. Fürsich et al. (2005) assigned a marginal marine environment to lower part of the Qadir Member at Parvadeh area. Vaez-Javadi (2012) and Jalali-fard et al. (2011) recorded plant macrofossils from the Qadir Member of the same section being studied and assigned a Rhaetian age to this member.

Palynology and palynostratigraphy
The aim of this study is to summarize the stratigraphic range of the dinoflagellate cyst assemblages recorded in the Qadir Member of the Tabas Block (Central Iran) and to erect a cyst
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Figure 2. Biozone and stratigraphic distribution of dinoflagellate cysts throughout the Qadir Member.

Palynologically productive samples were generally confined to the lower part of the Qadir Member at the studied section which is made up of shale, sandstone and thin bedded coal with a thickness of 200 m.

Twenty one out of the 116 rock samples prepared yielded dinoflagellate cysts. The assemblages recorded, though not well-preserved a yield of 8 species including taxa such as: *Heibergella asymmetrica*, *Heibergella* sp., *H.*
kendelbachia, H. salebrosacea, Hebecysta brevicornata, Sverdrupiella cf. mutabilis, Dapcodinium priscum, Rhaetogonyaulax sp., Rhaetogonyaulax rhaetica, and Noricysta pannucea (Plates I & II). Based on the first and last appearances of the R. rhaetica, the Rr Zone of Woollam and Riding (1983) has been recognized which is being discussed as follows:

**Rhaetogonyaulax rhaetica Interval Biozone**

This biozone is defined as the interval between the FAD and the LAD of *R. rhaetica* and is given an age of Rhaetian (Woollam & Riding, 1983). The index specis, *R. rhaetica* has been recorded abundantly through the zone. The zone ranges from sample MZY 7629 to sample MZY 7687 and encompasses 200 m of the base of the Qadir Member. The zone corresponds to the *R. rhaetica* (Rr) Zone of Woollam and Riding (1983) for Great Britain and the DSTr of Poulsen and Riding (2003) for Subboreal Northwest Europe (Fig. 3). This zone has also been used by Helby *et al.* (1987) for lower Rhaetian strata in Australia. Nicoll and Foster (1994) and Haq *et al.* (1987) reported and dated this zone as early Rhaetian. Ghasemi-Nejad *et al.* (2004) recorded this zone in Alborz Mountains of North Iran and dated it as Rhaetian (Fig. 3).

![Figure 3. Comparison and correlation of the Rhaetian dinoflagellate cyst zonation erected for the Qadir Member of Nayband Formation, with those of Northwest Europe (Poulsen and Riding, 2003; Woollam & Riding, 1983), Australia (Nicoll & Foster, 1994) and the North Iran (Ghasemi-Nejad *et al.*, 2004). Time in Ma taken from Haq *et al.* (1987).](image-url)
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Plate II
Qadir Member of the Nayband Formation at this locality. The records and differentiated zones mentioned are presented and compared in Figure 3.

**Palaeobiogeography and Palaeoenvironment**

The Upper Triassic (Norian-Rhaetian) siliciclastic-carbonatic deposits of the Nayband Formation crops out in the Central-East Iranian microcontinent as a part of the Cimmerian Continent (Seyed-Emami, 2003). The Cimmerian continent divided the Tethys into the northern Palaeotethys and the southern Neotethys ([Nützel & Senowbari-Daryan, 1999]). According to Fürsich et al. (2005), the Nayband Formation was deposited after the early Cimmerian tectonic event. Palaeogeographic maps show that the Tabas block of Central-East Iranian microcontinent occupied the southern margin of Eurasia and northern margin of Neotethys during the Late Triassic (Wilmsen et al., 2009). The dinoflagellate cyst assemblages show close similarities with assemblages reported from Australia, Northwest Europe, Arctic Canada and Northern Iran.

The relative abundances of dinoflagellate cysts recorded in the lower part of the Qadir Member indicate that it was deposited in a marine environment though, the accompanying spores and pollen grains indicate a nearshore depositional environment for this Late Triassic (Rhaetian) member in the Tabas Block. This is in accordance with Kluvyer et al. (1983) and Fürsich et al. (2005), (2005), who believe that the first four members of the type section of the Nayband Formation including the Qadir Member, accumulated in shallow to marginal marine environments. Vaez-Javadi (2012) who sampled the Qadir Member of the same section reported diverse plant fossils from this rock succession and suggested a moist and warm climate for the Rhaetian in this area.

**Conclusion**

The Qadir Member of the Nayband Formation in the Parvadeh area of the Tabas block, East – Central Iran yielded moderately diverse dinoflagellate cyst assemblages indicative of a Late Triassic (Rhaetian) age in comparison with northwest Europe, Australia and Northern Iran. Association of marine palynomorphs (dinoflagellate cysts) with spores and pollen grains indicate a nearshore depositional environment for these Late Triassic deposits in the Tabas Block of Iran.

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**References**


