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Petrography and geochemistry of Permian Strata in Tabas and Kalmard regions, Eastern-Central Iran

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Introduction.

Permian strata in Eastern-Central Iran have been distributed in two regions named Tabas and Kalmard. In the first, Permian sediments are composed entirely of pure carbonate successions named Jamal Formation whereas those of the second are represented by predominantly siliciclastic and rare carbonate or mixed carbonate-siliciclastic sequences.

The objectives of this study are: **1)** to summarize the stratigraphy, facies analysis and reconstruction of the depositional environment of Permian strata in the Jamal and Khan Formations **2)** to recognize primary mineralogy of Jamal and Khan Formations carbonates on the basis of Sr contents and petrographic evidence **3)** to report δ18O and δ13C compositions in order to distinguish diagenetic trends during Permian time.

For petrographic studies and microfacies controls over 950 samples from 9 stratigraphic sections spanning Permian strata were taken in Kalmard and Tabas regions. For geochemical analyses and determinations of stable isotopes values (δ18O and δ13C) and Sr compositions of calcite and dolomite we chose and analyzed 90 samples. Detailed petrographic investigations have led to the recognition of several microfacies and microfacies groups which constitute four facies belts in the Jamal Formation (including tidal flat, lagoon, bar and open marine) and three paleoenvironment associations in the Khan Formation (including tidal flat, lagoon and bar). Most of the Jamal Formation sediments were deposited on a ramp setting and those of the Khan Formation show a setting near shore. The Permian limestone of the Jamal and Khan Formations was originally composed of aragonite, as indicated by the recrystallized nature of limestone, oomoldic porosity, dropped nuclei in oolites, and high Sr compositions (800-2050 ppm). Bulk rock δ18O compositions of the Jamal Formation range from -9‰ PDB to -4‰ PDB but the carbonates δ13C values show minor fluctuations (2-3.5‰ PDB). Increasingly light δ18O and invariant contents of δ13C in Jamal formation carbonates suggest a burial diagenetic trend. δ18O values of Khan formation dolomites and limestone range from -6‰ PDB to -4‰ PDB and δ13C show changes between 2.7‰ PDB to about -1‰ PDB. We suggest that both δ18O and δ13C observed in the Khan Formation are compatible with meteoric diagenetic regime because δ13C compositions usually do not change during diagenesis except when carbonates are exposed to subaerial processes.

Stocklin et al. (1965) were the first to describe Permian sediments named Jamal Formation in Tabas region. Afterwards, Upper Paleozoic biostratigraphy of Tabas basin were presented by Ruttner et al. (1968), Kahler (1974), Kahler and Kahler (1979), Jenny-Deshusses (1983), Partoazar (1992, 1995), Taheri (2002), Leven and Taheri (2003). Aghanabati (1979) was the first to distinguish Permian sequences of the Kalmard region as a separate unit and named it Khan Formation. Most of these studies have been conducted on general stratigraphy and biostratigraphy of the Jamal and Khan Formations, but no detailed petrographic or geochemical analyses have been carried out. The existence of conspicuous differences of Permian sediments between the Kalmard and Tabas regions encouraged us to study 9 stratigraphic sections within these two areas. This was done in order to report petrographic characteristics and geochemical compositions (δ18O, δ13C and Sr) of Permian rock and better understanding of diagenetic trends during this time interval.

Geoloical setting.

Iran can be divided into different tectonic domains, each with its own discrete characteristics and structural and tectonic evolution. Eight geological provinces can be recognized in Iran. Precambrian to Carboniferous sediments of most these provinces were lithologically similar, confirming that they once formed a united block on the north-eastern margin of Gondwana (Stocklin, 1968). During the Middle-Late Permian and Early Triassic time, the Iran block rifted northward to form the Neo-Tethys basins and later collided with Eurasia during Middle-Late Triassic time. The area under study compromises the part of a central Iran province considered to be a microcontinent. Alavi (1991) in recognition of long strike-slip dextral faults (Nayband, Kalmard, Kuhbanan, and Posht-e-Badam), divided Central Iran province into four sub-blocks Lut (LB), Posht-e-Badam (PBB), Yazd (YB) and Tabas (TB). The latter is separated from the Yazd block by the Kalmard fault. The Kalmard area is situated within the Yazd block, west of the Tabas region. The location of the Kalmard area between two very active faults named Kalmard and Naeini formed a mobile zone throughout the Paleozoic so that lithostratigraphic units show considerably contrasting facies in comparison with other Central Iran areas.

Material and analytical methods.

A total of 950 samples were taken from the Jamal Formation for petrographic studies and among those collected samples the number of 90 and 33 samples singled out for geochemical and isotopic analyses, respectively. All thin sections were stained with potassium ferrocyanide and alizarin-red solutions (Dickson, 1965). To determine Sr contet about 0.25 gramm of whole-rock powders of 90 samples of limestone and dolomites were dissolved in 1 N HCL and analyzed by an atomic absorption spectrometer at the Department of Geology, Shahid Beheshti University, Tehran, Iran. The precision of the analysis is $\pm$ 1 ppm. For stable isotopes analyses about 15 mg of whole-rock powders of 33 representative limestone and dolomites were analyzed with mass spectrometry (Micromass, 602D) at the Geology Department, University of Tasmania, Australia. The relative precision for both of δ18O and δ13C is $\pm$ 0.1%¸.

Stratigraphy and depositional environments; Jamal Formation in Tabas region.

In the Tabas region, we have chosen 4 stratigraphic sections located in the Shotori and Shirgesht area. Our selected sections in Shotori are situated 5 and 8 km east of the type-section of the Jamal Formation (approximately 52 km southeast of the Tabas town, central Iran). In this area the Jamal Formation is underlain by the Sardar Formation without visible angular unconformity, but there is a significant hiatus between these formations. The uppermost unit of the Sardar Formation includes white medium- to thick-bedded sandstone interbedded with shale. The basal beds of Jamal are shell fragment-bearing sandy limestone. The major part of the Jamal Formation is composed of gray medium- to thick-bedded grainstone-packstone interbedded with wackstone, micritic limestone and oolithic limestone; Previous data (Jenny-Deshusses, 1983) and our preliminary analysis of samples suggest Kubergandian-Dorashamian age for formation. The Jamal formation is overlain by Lower Triassic yellow platy micritic limestone of the Sorkh Shale Formation, which in the type-section has fault contact.

In the Shotori area, we studied Bagh-e-Vang and Shesh Angosht sections. In both sections the Jamal Formation is unconformably underlain by red to brown thin-bedded fine sandstone of the Sardar Formation. Partoazar (1995) introduced the basal parts of the Jamal Formation at Bagh-e-Vang as separate Bagh-e-Vang Member comprising very coarse fusulinid-bearing grainstone with pebbles of silty limestone and micritic limestone. The upper two-thirds of the Bagh-e-Vang Member contains medium-bedded fusulinid grainstone interbedded with black shale. The Jamal Formation starts with black massive coarse grainstone with fusulinids and a conglomerate bed with matrix of very coarse grainstone and sharp clasts. The main part of the Jamal Formation consists of dark or gray thick- to medium-bedded cherty micritic limestone with thin wackstone-packstone at the base of some beds containing smaller foraminifera and radiolarians. The thickness of the wackstone-packstone horizons decrease upwards and is finally replaced by massive, reefoidal limestone in the upper portion of the middle Jamal Formation and terminates with oolithic limestone and dolomites; it is overlain by platy micritic of Sorkh Shale Formation. Detailed petrographic investigations led to the recognition of several microfacies which contain four environmental belts, including tidal flat, lagoon, bar and open marine. Obtained data from interpretation of these facies suggest that carbonate sediments in Jamal Formation were deposited in a ramp setting. It is worthy notice that the sedimentary environment in Shotori area was relatively shallower than that of Shirgesht area.

Khan Formation in Kalmard region.

We have measured, described and sampled 5 stratigraphic sections in the Kalmard region located West of Tabas Town. The Khan Formation rests unconformably on Lower Carboniferous limestone of the Gachal Formation and is overlain by Lower Triassic yellow vermiculate limestone of the Sorkh Shale Formation. There is a disconformity between the Khan and Sorkh Shale Formations indicated by a bauxite horizone. Lithologic features of the Khan are generally stable in all chosen sections Formation. The Khan Formation is represented mainly by red to brown cyclic sequences that start with gravel to cobble conglomerate or with very coarse to coarse sandstone. The clastic sediments decrease upwards and the top portion of each cycle represent shallow water thick- to medium-bedded packstone to grainstone. Our preliminary identification of fusulinids suggests Asselian-Sakmarian age for middle-upper parts of the Khan Formation. Petrographic studies show several microfacies within the Khan Formation that constitute three environmental belts including tidal flat/beach, lagoon and bar suggesting its deposition near shore.

Geochemistry.

In order to determine original mineralogy both petrographic studies and geochemical analyses are very necessary. One of the characteristics of Jamal and Khan Formation carbonates is recrystallization, particularly the presence of oomold in oolites. Oomoldic porosity and dropped nuclei have observed to support a former aragonite mineralogy (Sandberg, 1983; Wilkinson et al, 1985). Marine calcite contains about 1000 ppm Sr whereas aragonite has about 10,000 ppm Sr. Brand and Veizer (1980) demonstrated that recrystallization of aragonite results in lack of Sr. Sr contents of Khan and Jamal Formations range from 800-2054 ppm. The recrystallization nature of the limestone of these two Formations and their high Sr compositions are consistent with an original aragonite mineralogy. Bulk carbonates δ18O compositions range from -9‰ PDB to -4‰ PDB whereas their δ13C values have minor changes from 2-3.8‰ PDB. Since during burial diagenesis with increasing temperature δ18O compositions decrease and δ13C values nearly remain without change, we suggest a burial diagenesis trend for Jamal Formation carbonates. δ18O values of Khan formation dolomites and limestone range from -6‰ PDB to -4‰ PDB and δ13C compositions show fluctuations between 2.7‰ PDB to -1‰ PDB. With regard to isotope carbon values there is usually no change during diagenesis except when carbonates are exposed to subaerial processes (Heydari et al, 2001), we can thus suggest a meteoric diagenesis regime for Khan Formation dolomites and carbonates.

Conclusion

1. The results of petrographic studies indicate that Jamal formation within Tabas region was deposited in a ramp setting with a shallower situation in Shotori area and Khan Formation within Kalmard region was deposited in a situation near shore during Permian time.

2. As function of important Precambrian fault, the Kalmard area has been tectonically active and this has influenced its geological history.

3. The Permian carbonates of Khan and Jamal Formation were originally composed of aragonite, as indicated by coarse calcite and high Sr contents.

4. The changes of δ18O and δ13C values in Jamal and Khan Formation suggest burial and meteoric diagenesis trends, respectively.

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