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Cyclostratigraphy of the Upper Dalan Member by using Evolutionary Spectral Analysis with Fast Fourier Transform and Multitaper Methods in the Salman Gas Field

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Introduction

Salman gas field is one of the oil and gas fields of Iran, which is located in Hormozgan province, 144 km southern of Lavan Island, and has common hydrocarbon reservoirs with the Abu al-Bukhosh field in the United Arab Emirates (Fig. 1). Kangan and Dalan Formations together with Faraghan Formation are classified in the Dehram group. In particular, the hydrocarbon reservoirs of the upper part of the Dalan Formation along with the Kangan Formation In the direction of land and Iranian offshore includes the largest gas fields in the Middle East region [1]. Cyclostratigraphy is a sub-branch of stratigraphy that deals with the identification and interpretation of cyclicity variations in the stratigraphy record. Also, cyclostratigraphy by using the remaining Milankovitch cycles (eccentricity, obliquity and precession) signals in sedimentary successions helps to date the strata, interpret the sedimentary record, and estimate sediment accumulation rates [2]. Milankovitch cycles signals in the petroliferous systems of oil-rich basins around the world are based on a multiple of paleoclimate proxies including the lithological grayscales, petrophysical well logs (gamma-ray, density, sonic and etc.), geochemical parameters (total organic carbon, carbon and oxygen isotopes and etc.) and magnetic susceptibility have been traced [3]. In this study, the cyclostratigraphic investigation of the upper part of the Dalan Formation in 2SK-1 well in the Salman gas field has been performed by using spectral gamma-ray (SGR) log and evolutionary spectral analysis methods (Fast Fourier transform, multi-taper and evolutionary Correlation Coefficient).

Methodology

The intensity of gamma-ray in sediments is related to the content of uranium (U), thorium (Th), and potassium (K) in rocks, which reflects the clay and organic matter in sediments [4]. This log is often used as a paleoclimate indicator in cyclostratigraphic studies. In addition, in this study, time series analysis methods were carry outed using Acycle 1.2 [5] and QAnalySeries 1.4.1 software. In the first step with Acycle, the multitaper method (MTM) (along with red-noise models) power spectra of the SGR data was used to identify significant frequency peaks. In the next step with Acycle, the evolutive Fast Fourier transform (LAH) method was used to test variations in the main frequency patterns through the SGR series. Then the Gaussian bandpass-filtering function in the QAnalySeries software was used to extract Milankovitch cycles.

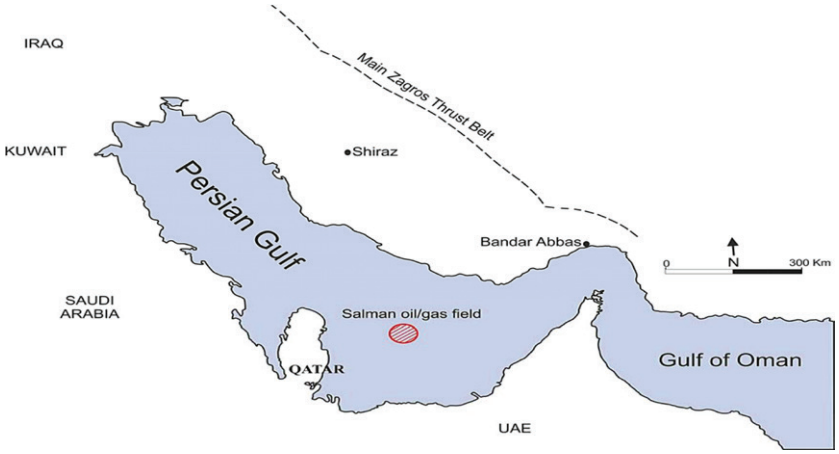

Fig. 1 Location of Salman gas/oil field in the Persian Gulf. Modified from [2].

Afterwards, by applying the evolutionary correlation coefficient (eCOCO) method and evolutionary H_0 significance level (H_0) for in Acycle, the sediment accumulation rate was estimated for the upper part of the Dalan Formation in 2SK-1 well of Salman gas field. In the last stage, the astronomical time scale were constructed through the cyclostratigraphic analysis.

Results and Discussion

Cyclostratigraphy Results

The 2π MTM power spectrum of the SGR series in 2SK-1 well shows significant peaks at cycles of 23/79 m, 12/0 m, 4/9 m, and 1/97 m (Figure 2). The confidence levels for these peaks are higher than 95%. These cycles are approximately equal to 20:5:2:1 and close to the Milankovitch cycle ratio for the Permian system, calculated by Berger et al. [6]. Moreover, the main frequency patterns related to Milankovitch cycles were shown at different depths in the evolutionary Fast Fourier transform scalogram, as seen in Figure 2. The detected Milankovitch cycles were extracted by using the filtering method from the SGR log. Thus, 18 long term eccentricity cycles, 72 short term eccentricity cycles, 162 long term obliquity cycles and 342 long term precession cycles were identified for the upper part of Dalan Formation in the study well. It was also revealed by using the eCOCO method that the sediment accumulation rates of the upper part of Dalan Formation in the 2SKD-1 well are variable in the ranges of 2/2 cm/kyr to ~ 7 cm/kyr.

Then, the astronomical time scale created was compared with the duration of the Paradagmarita monodi, Paradagmarita flabeliformis, Hemigordiopsis renzi range, and Dagmarita Chanakcheinsis biozones for the upper part of the Dalan Formation. That way the lithostratigraphy units in 2SK-1 wells of Salman gas field were compared in terms of geological time scale and astronomical time scale, as a result of which the effects of Milankovitch cycles in these units and the dispersal of microfaunas containing them were determined.

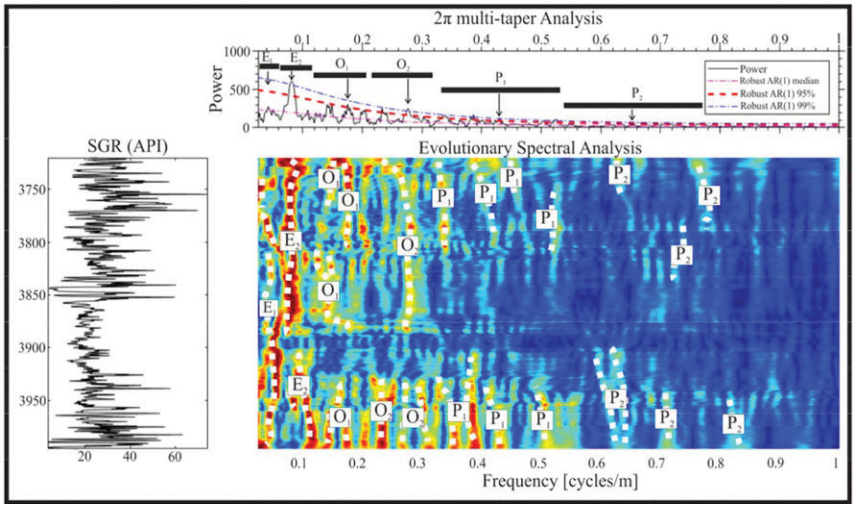

Fig. 2 2π MTM spectral analysis and evolutionary Fast Fourier transform scalogram of the upper part of the Dalan Formation in 2SK-1 well of Salman gas field.

Conclusions

The cyclostratigraphy analysis based on evolutionary spectral analysis was performed by MTM and Fast Fourier transform methods in the upper part of the Dalan Formation in 2SK-1 well of the Salman gas field. During these analyses, the SGR series showed strong astronomical cycle signals in the Upper Dalan Member, revealing that the sediments of the upper part of the Dalan Formation in 2SK-1 well of Salman gas field were affected by Milankovitch cycles. Also, by applying the eCOCO and H0 methods, the maximum sediment accumulation rates of 65 m/myr or 6.5 cm/kyr are estimated. In addition, the average rate of sediment accumulation in this well for the upper part of the Dalan Formation is 40 m/myr or 4 cm/kyr. Minimum sediment accumulation rates are estimated at 22 m/myr or 2.2 cm/kyr. Finally, the astronomical time scale created in this study was approximately equal to the duration of the biozones.

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