Carbon- isotope stratigraphy; a correlation tool for Cenomanian–Turonian carbonates in Southern Iran

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Introduction:

The Cenomanian-Turonian Sarvak Formation forms one of the main hydrocarbon reservoirs in southern Iran and the Persian Gulf. Surface and subsurface sections from this heterogeneous carbonate reservoir were examined to define the chemical conditions of the Mid- Cretaceous basin. The obtained data were compared to previously published data of the Tethyan region for stratigraphic correlation. This was carried out using detailed petrography, stable carbon, and oxygen and strontium isotope analysis.

Results:

The $\delta^{13}C$ values (range from -6.4‰ to 4.1‰, VPDB) for Sarvak carbonate matrix fall well within the Mid-Cretaceous marine values. Superimposing of these data on the Cenomanian-Turonian $\delta^{13}C$ curve shows a good global correlation, including similar $\delta^{13}C$ excursions. These positive excursions in $\delta^{13}C$ values reflect the Cenomanian-Turonian Oceanic Anoxic Event (OAE). The occurrence of thinly laminated Ahmadi shales and Khatiyah bituminous shaly limestone (members of the Sarvak Formation) confirms the anoxic condition and corresponding OAE of Mid-Cretaceous basin in the studied area. These shales could be considered as a potential source for the Upper Sarvak Formation and also the other important reservoirs of the younger ages.

There is a positive shift in $\delta^{13}C$ values within the strata with values of between +3.3 and +4.1 ‰ which corresponds to the well-defined Mid-Cenomanian Event (MCE). This positive excursion is detected both in surface and subsurface sections.

Negative values (e.g. -6.4‰) were obtained from samples collected along the paleoexposure surfaces on top of the Sarvak Formation which reflect the effect of meteoric diagenesis on these carbonates.

The $^{87}Sr/^{86}Sr$ ratios from surface and subsurface samples plotted on the Cenomanian-Turonian portion of the secular seawater curve of Burke et al. (1982) [1] show that the majority of the obtained values fallow the Cenomanian portion of the curve and confirm the validity of present carbon-isotope data.

Conclusions:

Carbon- isotope stratigraphy could be used as a regional and global correlation tool in Cenomanian-Turonian carbonates even in heterogeneous Formations (i.e. Sarvak Formation).

The results of this study added new data to the isotopic composition records and confirmed the occurrence of OAE in the eastern margin of the Neo-Tethys Ocean.

[1]Burke, W.H., Denison, R.E., Hetherington, E.A., Koepnick, R.B., Nelson, H.F. and Otto, J.B. (1982). Variation of seawater $^{87}Sr/^{86}Sr$ throughout Phanerozoic time. Geology, 10, 516-519.

Stratigraphic constraints on critical fluxes in the Phanerozoic sulfur cycle

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Understanding the influence of sulfur cycle processes on the evolving oxidation state of the oceans and atmosphere, on the chemical composition of seawater and on the respiration of sedimentary organic matter requires knowledge about the removal of sulfur from the oceans as pyrite and as sulfate evaporites. Most approaches have attempted to constrain the magnitude and isotopic composition of influxes to the ocean and have used measurements of isotopic ratios in sedimentary pyrite and sulfates to constrain the relative magnitude and isotopic composition of the outfluxes in the context of isotope mass balance models [1-4]. These studies suggest an average Phanerozoic fractional pyrite burial rate (f_{pyr}) of approximately 0.4 [1-4], with the notion that variation in f_{pyr} values reflects changes in the rates of sulfate reduction.

Taking an inverse approach, we attempted to constrain the burial flux of sulfate evaporites and then test various sulfur cycle models for consistency with independent physical understanding of the sulfur cycle. Our data were derived from a comprehensive stratigraphic database [5], with unprecedented spatial and lithological resolution in North America and the Caribbean (NAC). Using constraints on deposit age, we converted evaporite volumes into burial rates. On long timescales, the burial rates correlate with the area of continental shelf at latitudes of net evaporation (±10–50°), whereas short-timescale variability in sulfate deposition corresponds to variability in the rate of sea level change. We used these relationships to scale the NAC data globally and to generate a synthetic record of global Phanerozoic sulfate burial rates. The average Phanerozoic sulfate evaporite burial rate is ~3.3×10^{11} mol yr^{-1}. Sulfur entering the ocean in excess of this amount must exit as pyrite and given estimates of riverine sulfate influxes to the ocean ($1.5–3.5\times10^{12}$ mol yr^{-1} [3,6]), the implication is that f_{pyr} has had a value of ~0.7–0.9 over Phanerozoic time.

The results describe a marine sulfur cycle where the majority of net outputs and inputs are burial and oxidative weathering of sedimentary pyrite, respectively. While perturbations to the pyrite burial rate have likely occurred over short timescales, models of constant or slowly varying pyrite burial yield results that are consistent both internally and with existing observations of seawater sulfate concentration and $\delta^{34}S$. Over the time intervals resolved by the data, the long-term value we estimate for f_{pyr} is generally high, and large downward excursions in its value are associated with high rates of sulfate evaporite burial, rather than times of less pyrite burial. High values of f_{pyr} also imply a larger than previously thought role for the sulfur cycle in stabilizing atmospheric oxygen levels.

[1] Berner (1987) *Am J Sci* **287**, 177. [2] Garrels & Lerman (1984) *Am J Sci* **284**, 989. [3] Canfield (2004) *Am J Sci* **304**, 839. [4] Kampshulte & Strauss (2004) *Chem Geol* **204**, 255. [5] Peters & Heim (2010) *Paleobiology* **36**, 61. [6] Kump & Garrels (1986) *Am J Sci* **286**, 337.