Gondwana Research (Gondwana Newsletter Section) V. 6, No. 4, pp. 931-934.

GNL

CORRESPONDENCE

$\delta^{13}C$ Variations in Late Jurassic Carbonates, Jaisalmer Formation, Western India

Anil Maheshwari [1*], A.N. Sial[2], S.C. Mathur[3] and R.P. Tripathi[4]

[1] *Department of Geology, University of Rajasthan, Jaipur - 4, India*
[2] *NEG-LABISE, Department of Geology, UFPE, Recife, Brazil*
[3] *Department of Geology, J.N.V. University, Jodhpur, India*
[4] *Department of Physics, University of Jodhpur, Jodhpur, India*
* *Corresponding author*

(Manuscript received April 22, 2003; accepted August 1, 2003)

Abstract

The carbon isotope measurements, carried out on subsurface carbonate samples from Oxfordian Jaisalmer Formation, western India, yield positive $\delta^{13}C$ values up to +3.17‰. The most positive Oxfordian C-isotope value corresponds to the carbon isotope excursion measured in samples from from other late Jurassic basins of world. The latest Oxfordian C-isotope values of Jaisalmer Basin fluctuate around 2‰ while the C-isotope values of 1.50‰ mark the base of Kimmeridgian. The Oxfordian C-isotope excursion appears to correspond to a time of overall increased organic carbon burial triggered by increased nutrient transfer from continents to oceans during a time of rising global sea level.

Key words: Carbon isotopes, Oxfordian Jaisalmer Formation, palaeoenvironment, carbonates, Ghotaru.

Introduction

The history of atmospheric CO_2 levels and of the global carbon cycle is mirrored in marine carbonate carbon isotope curves. Fluctuations in $\delta^{13}C$ can be explained by variable C_{org}/C_{carb} export ratios into the marine sedimentary carbon reservoir (Schidlowski, 1987). Times of intensified biological carbon pumping and of high C org burial rates are commonly linked to perturbations of the atmospheric carbon reservoir and to greenhouse climate. Positive $\delta^{13}C$-excursions may be regarded as response signals of perturbations of global climate linked to fluctuations in atmospheric carbon dioxide concentrations (Weissert, 1989).

The late Jurassic was not only a time of increased organic carbon burial but it was also a time which was favourable for reef growth and for increased accumulation of carbonate carbon (Budyko et al., 1987). The late Jurassic carbonate carbon isotope record mirrors the response of the marine organic and carbonate carbon pumps to changing climate. The excessive burial of organic carbon at times of high carbonate accumulation rates was triggered by a greenhouse climate combined with a monsoonal rainfall pattern controlled by the break-up of the pangea supercontinent during the late Jurassic (Parrish, 1993). Intensified seafloor spreading and volcanic activity impacted Jurassic climate through the increased flux of volcanic CO_2 to the atmosphere, as suggested by a number of GCM-paleoclimate models (Moore et al., 1992) and by geochemical models (Berner, 1994).

The Jaisalmer Formation in western India consists of a thick sequence of cream, buff and brown-coloured, commonly fossil-bearing limestone along with oolitic limestone and greyish brown sandstone. The formation occurs extensively on the surface and is also encountered in the subsurface. The thickness of the Jaisalmer Formation ranges between 120 m to 170 m. The subsurface data however, indicate more thickness. In the subsurface the formation has two distinct lithounits. The upper carbonate unit comprises grey to buff limestone, oolitic near top. The intercalation of shale and oolitic bands are frequent within this sequence. The lower unit mainly comprises calcareous sandstone and shale with thin limestone intercalation. The limestone beds are generally horizontal or nearly horizontal.

The Jaisalmer Formation is divided into five members, which are named after the localities of their best development namely Kuldhar, Badabagh, Fort, Hamira and Joyan Members. Rich fossil assemblage has been reported from the top most Kuldhar Member which includes *Reineckeria sp., Indosphinctes sp.* and *Dhosaites aff. D. otoibides,* etc. Dave and Chatterjee (1996) have recognised three foraminiferal and five Ammonoite zones suggesting Callovian to Oxfordian age. The Jaisalmer Formation is the most fossiliferous Jurassic formation in the region. A shallow marine environment of deposition of the Jaisalmer formation is indicated by the development of fossil bearing limestone-arenaceous limestone sequence without shale beds (Singh, 1996). Marine depositional environment is also indicated by the fair distribution of conifer pollens and the presence of Hystrochosphaeridium within the formation.

Isotopic Data and Discussion

Bulk subsurface samples were chosen from Ghotaru bore hole section (Fig. 1) for the establishment of a C isotope stratigraphy of the late Jurassic Jaisalmer Formation. A total of 12 carbonate samples were selected. CO_2 was extracted from carbonates in a high vacuum line after reaction with phosphoric acid at 25°C, and cryogenically cleaned, according to the method described by Craig (1957). CO_2 gas released by this method was analyzed for O and C isotopes in a double inlet, triple collector V.G. ISOTECH mass spectrometer, using the reference gas BSC (Borborema Skarn Calcite) that is calibrated against NBS-18, NBS-19 and NBS-20, has a $\delta^{18}O$ value of –11.28±0.004‰ PDB and $\delta^{13}C$ = –8.58±0.02‰ PDB. The results are expressed in the δ-notation in parts per thousand in relation to international PDB scale.

The C isotope data are provided in Table 1. The isotope data are graphically summarized in figure 2. The sedimentary rocks carrying the Oxfordian C-isotope signal are preserved in the Jaisalmer Formation of western India. The measured carbon isotope record starts with a positive shift starting within the Oxfordian. The most positive Oxfordian values fall within a range of +2.9‰ to +3.1‰ which corresponds to a synchronous carbon isotope excursion measured in samples from the Swiss Jura Mountains (Bill et al., 1995). The oxygen isotope values fluctuate between –3.0‰ and –4.23‰ in the carbonates from the Jaisalmer Formation. Heydari et al. (1993) analysed late Oxfordian sediments from the Smackover Formation and they report C-isotope compositions reaching values of up to $\delta^{13}C$ = +3‰ to 6‰. Jenkyns (1995) identified a prominent C-isotope excursion falling within the *transversarium* zone and reaching carbon isotope values of more than +3‰ in sections from the southern Tethyan margin. The observed variations in the late Jurassic carbonate carbon isotope record may reflect changes in Jurassic marine carbon cycle. Times marked with more positive C-isotope compositions should correspond to times of a higher organic carbonate/carbon burial ratio (Schidlowski, 1987). The long-term oceanic carbon isotope budget should reach a balance if average river carbon input is balanced by carbon and carbonate export into the sedimentary sink. The measured carbon isotope values fluctuates around 2‰ in the latest Oxfordian and the early Kimmeridgian represented by Baisakhi Shales in Jaisalmer Basin is represented by lower C-isotope values ~1.5‰.

Globally, the major organic carbon-rich deposits show major peaks in the late Oxfordian, the Kimmeridgian and in the early Tithonian. Major sinks for organic-rich sediments were the cratonic Siberian basin (Oxfordian and Volgian/ Tithonian age, Nesterov et al., 1990), the North American Gulf Coast (Smackover Formation, late Oxfordian; Fails, 1990) and the Arabian shield. The widespread occurrence of organic carbon-rich sediments can be explained as a result of high productivity and/or limited deep water renewal and widespread low oxygen conditions and/or elevated sedimentation rates with improved preservation of marine and terrestrial organic carbon.

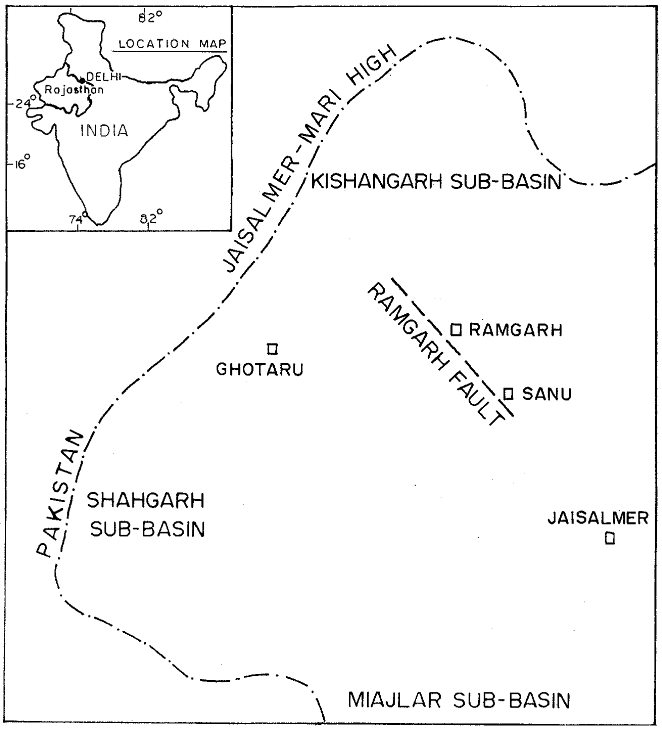

Fig. 1. Location of the investigated area, western India.

Table 1. Stable isotope data for carbonates from Jaisalmer Formation, western India.

S.No.	Depth(m)	δ^{13}CPDB	δ^{18}O PDB
1	2313-44	1.501	-3.004
2	2416-19	2.294	-3.46
3	2521-24	2.032	-3.53
4	2579-82	2.309	-3.936
5	2584-87	2.013	-3.83
6	2646-49	2.257	-3.458
7	2691-94	2.807	-3.25
8	2757-60	2.608	-3.7
9	2820-23	3.137	-3.707
10	2830-83	3.179	-3.725
11	2943-46	2.603	-4.238
12	2985-88	2.677	-4.176

It may be inferred that the paleoceanographic and paleoenvironmental conditions favoured the accelerated burial of organic carbon during the Oxfordian and Kimmeridgian times. Gygi (1986) studied the sedimentology and late Jurassic facies pattern of the Jura mountains and found evidence for a major mid-Oxfordian transgression starting within the *Transversarium* ammonite zone and peaking during late Oxfordian. Transgressive conditions for the Oxfordian are reported from Tethys Ocean; Siberian Basin (Nesterov and Ushatinsky, 1991) and Jurassic Gulf coast environment. On comparison of the late Jurassic sea level curve with the carbonate carbon isotope record, it is observed that the onset of the late Jurassic carbon isotope excursion coincides with a marine transgression.

In conclusion it may be reiterated that carbon isotope measurements, carried out on subsurface carbonate samples from Oxfordian Jaisalmer Formation, western India, yield positive δ^{13}C values up to +3.17‰. The most positive Oxfordian C-isotope value corresponds to the carbon isotope excursion measured in samples from from other late Jurassic basins of world. The latest Oxfordian C-isotope values of Jaisalmer Basin fluctuate around 2‰ while the C-isotope values of 1.50‰ mark the base of Kimmeridgian. The Oxfordian C-isotope excursion appears to correspond to a time of overall increased organic carbon burial triggered by increased nutrient transfer from continents to oceans during a time of rising global sea level.

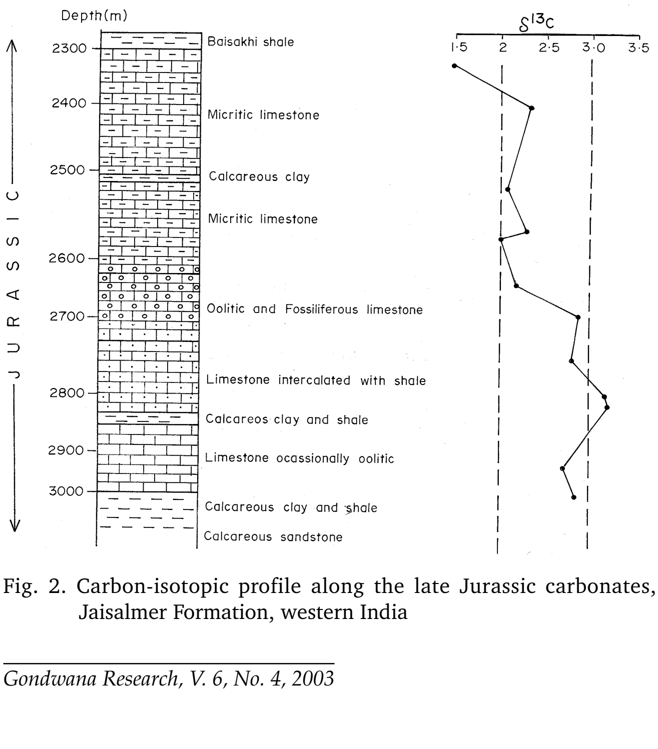

Fig. 2. Carbon-isotopic profile along the late Jurassic carbonates, Jaisalmer Formation, western India

Acknowledgment

AM and ANS wish to express their gratitude to Gilsa M.de Santana and Vilma S. Bezerra for the assistance with the carbon isotope analyses at the LABISE, Federal University of Pernambuco, Brazil. RPT wish to thank ONGC, India, for permission to use subsurface samples. This is NEG-LABISE contribution No. 204.

References

Berner, R.A. (1994) Geocarb II: A revised model of the atmospheric CO_2 over Phanerozoic time. Amer. J. Sci., v. 294: pp. 56-91.

Bill, M., Baumgartner, P.O., Hunziker, J.C. and Sharp, Z.D. (1995) Carbon isotope stratigraphy of the Liesberg Beds Member Oxfordian, Swiss Jura using echinoids and crinoids. Eclogae Geol. Helv., v. 88, pp. 135-156.

Budyko, M.I., Ronov, A.B. and Yanshin, A.L. (1987) History of the Earths atmosphere. Springer, Heidelberg, 139p.

Claypool, G.E. and Mancini, E.A. (1989) Geochemical relationships of petroleum source rocks of Jurassic Smackover Formation, southwestern Alabama. Amer. Assoc. Petrol. Geol. Bull., v. 73, pp. 904-924.

Craig, H. (1957) Isotope standard for carbon and oxygen and correction factors for mass spectrometry analysis of carbon dioxide. Geochim. Cosmochim. Acta., v. 12, pp. 133-149.

Dave, A. and Chatterjee, T.K. (1996) Integrated foraminiferal and ammonoid biostratigraphy of Jurassic sediments in Jaisalmer Basin, Rajasthan. Geol. Surv. India, v. 47, pp. 477-490.

Fails, T.G. (1990) The northern Gulf Coast Basin: a classic petroleum province. In: J. Brooks (Ed.), Classic petroleum provinces. Geol. Soc. Spl. Publ., v. 50, pp. 221-248.

Gygi, R.A. (1986) Eustatic sealevel changes of the Oxfordian (late Jurassic) and their effect documented in sediments and fossil assemblages of an epicontinental sea. Eclogae Geol. Helv., v. 79, pp. 455-491.

Heydari, E. and Wade, W.J. (1993) Sedimentology and geochemistry of the Lower Mudstone member of the Smackover formation, U.S. Gulf coast: Implications for late Jurassic seawater composition, paleoceanography, and anpxic events. Annu. Conv. Can. Soc. Pet. Geol. Progr. Abst., p. 138.

Jenkyns, H.C. (1995) Relative sea-level change and carbon isotopes: data from the upper Jurassic (Oxfordian) of central and southern Europe. Terra Nova, v. 7, pp. 57-71.

Moore, G.T., Hayashida, D.N., Ross, C.A. and Jacobson, S.R., (1992) Paleoclimate of the Kimmeridgian/Tithonian (late Jurassic) world: results using a general circulation model. Palaeogeogr. Palaeoclimatol. Palaeoecol., v. 93, pp. 47-72.
Nesterov, I.I. and Ushatinsky, I.N. (1991) Black shales strata of Western Siberia. Int. Symp. Black shale basins and related mineral deposits, IGCP Project 254, Novosibirsk, pp. 298-300.
Nesterov, I.I., Salvamanov, F.K., Kontorovich, A.E., Kulakhmetov, N.K., Surkov, V.S., Trofimuk, A.A. and Shpilman, V.I. (1990) West Siberian oil and gas superprovince. In: J. Brooks (Ed.), Classic petroleum provinces. Geol. Soc. Spl. Publ., v. 50, pp. 491-502.
Parrish, J.T. (1993) Climate of the supercontinent pangea. J. Geol., v. 101, pp. 215-233.
Schidlowski, M., (1987) Application of stable carbon isotopes to early biochemical evolution on earth. Amer. Rev. Earth Planet. Sci., v. 15, pp. 47-72.
Singh, N.P., (1996) Mesozoic-tertiary biostratigraphy and biogeochronological datum planes in Jaisalmer Basin, Rajasthan. Cont. XV Ind. Colloq. Micropal. Strat. Dehradun, 63-89 KDMIPE and WIHG publ.
Weissert, H. (1989) C-isotope stratigraphy, a monitor of paleoenvironmental change: a case study from the early Cretaceous. Surv. Geophys., v. 10, pp. 1-61.

Gondwana Research (Gondwana Newsletter Section) V. 6, No. 4, pp. 934-935.

GNL

DISCUSSION

Structural Framework of Deolapar Area, Central India and its Implications for Proterozoic Nappe Tectonics: Comment*

S. Mohanty

Department of Applied Geology, Indian School of Mines, Dhanbad - 826004, India, E-mail: mohantysp@yahoo.com

Deolapar area has attracted attention of Precambrian geologists of India for report of a nappe structure by West (1936), mainly on the basis of stratigraphic omissions and inversions in the Sausar Group. In a recently published paper, Chattopadhyay et al. (2003) have tried to solve the problem of nappe controversy by remapping the area around Deolapar. However, when we compare the map published by West (1936) on a scale larger than that of Chattopadhyay et al. (2003), it becomes clear that some of the metasedimentary units (Chorbaoli Formation and Junewani Formation) mapped by West (1936) show westward closures between Kadbikhera and Khapa, but these have been regrouped as Tirodi Gneiss by Chattopadhyay et al. (2003) without any closures. No explanation is available for this change. In addition, the paper by Chattopadhyay et al. (2003) has the following lacunae, which require clarification.

Evidence of Thrusting

The authors have stated that the basement block shows evidence of shearing (p. 109, col. 2, 5th line from the bottom), but neither attempt was made to decipher the sense of shearing from the foliated fabric nor the orientation of any lineation related to shearing is reported. Subsequently the authors have stated that typical fault shear zone rocks are absent in the area (p. 115, col. 2, line 1-4). The only evidence of thrusting is mentioned to be a 'fibrolite-biotite schist', mapped at the contact of the Tirodi Gneiss (basement block) and the adjacent supracrustal rocks (Sausar Group). The authors considered that the granitic rocks of the basement were considerably modified by fluid flow during thrusting to give rise to aluminum-rich protoliths, which were modified to give the fibrolite biotite schists. However, alternative explanation (cf. Mohanty, 1993) for the development of such aluminum-rich protoliths by weathering and leaching of the granitic basement rocks (development of palaeosol) before the deposition of the Sausar Group is possible. This alternative explanation would explain the absence of any shear zone rocks along the contact of the basement and cover rocks. The authors have not given any reason against such a possibility.

Evidence for Unconformable Relation

Chattopadhyay et al. (2003a) state that "Typical

**See Anupam Chattopadhyay et al. (2003) Gondwana Research, v. 6, pp. 107-117*