Diagenetic Characterization of the Riachuelo Formation, Cretaceous of Sergipe Basin - Brazil, Using Isotopes Data ($\delta^{18}O$ and $\delta^{13}C$)*

Mary Luz Raigosa Diaz[1], Egberto Pereira[2], and René Rodrigues[2]

Search and Discovery Article #50251 (2009)
Posted March 13, 2010

*Adapted from expanded abstract prepared for poster presentation at AAPG International Conference and Exhibition, Rio de Janeiro, Brazil, November 15-18, 2009

[1]Departamento de Estratigrafia e Paleontologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil (mary.raigosa@gmail.com)
[2]Departamento de Estratigrafia e Paleontologia, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

Abstract

Due to the importance of Albian carbonates as a reservoir in offshore Brazilian basins, an isotopic analysis of carbonates in the Riachuelo Formation was carried out to identify the diagenetic environment that enhanced or inhibited the porosity of these carbonates. The isotopic analysis was performed on whole-rock samples collected in the Inhumas and Carapeba quarries. Most of the section described in Inhumas Quarry is composed of rudstone with oncoids, pellets and intraclasts. The carbon and oxygen isotope signature shows a very homogeneous behavior in this facies. The $\delta^{18}O$ values range from -5 ‰ to -4 ‰, indicating that the cementation took place in warmer water. The dolomite levels have more positive $\delta^{18}O$ signatures, suggesting dolomitization linked to a marine environment with higher salinity. In the dolomite microfacies, $\delta^{13}C$ values present positive signatures, which confirm that the dolomitization took place in a marine environment with high salinity.

In the Carapeba Quarry, when the matrix is composed of sparry calcite, the $\delta^{18}O$ values are more negative, ranging from -5 ‰ to -3.5 ‰, showing the same range as the Inhumas Quarry. The $\delta^{13}C$ values in the whole Carapeba section present a range from -2 ‰ to +2 ‰; this suggests initial cementation in the marine environment. In some microfacies, the matrix dolomitization is the most important diagenetic product, and it shows a negative $\delta^{18}O$ signature (-3 ‰), indicating that the dolomitization process was associated with a meteoric environment. The $\delta^{13}C$ average values are between +1 ‰ and +3 ‰ in those samples. This signature indicates that the precursor cement of the dolomitized matrix was deposited in a marine environment.

The isotopic and diagenetic study carried out in the Cretaceous carbonates of Sergipe-Alagoas Basin point to the dolomite facies of Inhumas Quarry as the interval with the best characteristics of porosity. Its origin is probably linked to the enrichment of Mg in a stronger saline marine environment. In Carapeba Quarry, the absence of permeability and porosity is due to the strong process of compaction to which the sediments were submitted after deposition.

Copyright © AAPG. Serial rights given by author. For all other rights contact author directly.

Methodology

The studied samples were obtained from two quarries: Inhumas Quarry and Carapeba Quarry (Figure 1) located in Sergipe–Alagoas Basin.

Petrographic Analysis

The parameters that were most relevant in describing the thin sections are the type and size of the grains, the percentage of matrix, the percentage of cement, the type of porosity and the type of contact between grains. Typical diagenetic processes, such as cementation, compaction, dolomitization, dissolution and recrystallization, were also identified.

Isotopic Analysis

This study applied the concepts of isotopic stratigraphy in the study of carbonate rocks, based on isotopic analysis of carbon and oxygen in whole rock samples. The combined study of isotopes of carbon and oxygen in carbonate rocks is used to determine diagenetic environments. The isotopic composition is represented in accordance with the international standard Vienna Pee Dee Belmnite (V-PDB), and the results are expressed in parts per thousand (‰). The study of oxygen isotopes in carbonates can be used to determine the origin of fluids in equilibrium with carbonates and, at the same time, to estimate the temperature during their formation. The determination of temperature can indicate the original temperature of the water or the temperature of diagenesis (Rollinson, 1995).

Results

Inhumas Quarry

In the Inhumas Quarry four microfacies were identified, distributed from the base to the top: rudstone with oncoids, pellets and intraclasts; rudstone with oncoids and dolomitized matrix; grainstone with oncoids and dolomitized matrix; and dolomite. Most of the section shows strong compression features. The carbon and oxygen isotope curves have a very homogeneous behavior in rudstone with oncoids-pellets-intraclasts, with values ranging between -5 ‰ and -4 ‰ (Figure 2). The negative signatures in $\delta^{18}O$ indicate that the cementation observed occurred due to burial, because of the high temperatures involved in this environment.

The diagenetic environment of burial has been interpreted on the basis of features of chemical dissolution-compaction (stylolites) observed in the petrographic analysis. Cementation observed is represented by the presence of sparry cement in the nucleus of some oncoids and the presence of microspar.

The facies composed of dolomite has more positive carbon and oxygen isotopic signatures. The dolomite, in turn, has intercrystalline secondary porosity by dissolution (Figure 3). More positive $\delta^{18}O$ levels in dolomite are associated with hypersalinity conditions. The dolomite facies is on top, in the facies succession described.

Therefore, the exposure conditions and evaporation facilitated the hypersalinity conditions in depositional setting and the process of replacement of carbonate by dolomite. The ^{13}C isotope signatures in the dolomite microfacies, which are more positive, ranging between -1 ‰ and +0 ‰, correlate with the positive trend of $\delta^{18}O$ observed in the same facies. These signatures confirm that the process of dolomitization probably occurred in a marine environment with hypersalinity conditions.

Carapeba Quarry

The heterogeneity in the ^{13}C and ^{18}O isotopic curves observed in this quarry coincides with the relatively high number of microfacies observed. It indicates that different environmental conditions prevailed in each cycle of carbonate deposition (Figure 4).

In samples where the cement is composed of microspar, the isotopic signatures show very negative values of $\delta^{18}O$, ranging between -5 ‰ and -3.5 ‰. These negative values indicate high temperatures in the pore water. This process would occur in a burial diagenetic environment, and the rock shows evidence of compression, according to observations in thin sections. In the same facies, the ^{13}C isotope signatures show a positive trend, ranging between -2 ‰ and +2 ‰, indicating that the initial cementation probably occurred in a marine environment.

In other microfacies, the dolomitization of the matrix is one of the most important diagenetic products, and the $\delta^{18}O$ signature shows an average of -3 ‰, which indicates the influence of meteoric water in the dolomitization process. ^{13}C values are on average between +1 ‰ and +3 ‰, indicating that the diagenetic product (cement), precursor of the dolomitized matrix, was deposited in a marine environment.

Conclusions

The dolomites of the Inhumas Quarry exhibit the best porosity features. The origin of the dolomitization process is associated with hypersalinity conditions. The porosity developed is of the secondary type, and would be caused by the dissolution of dolomite crystals, creating vuggy porosity.

In Carapeba Quarry, the isotopic analysis show that the origin of dolomite is associated with an environment under the influence of meteoric water, and the lack of porosity is due to a strong compression process affecting the sediment.

Enhanced porosity is more common in dolomitized units that have larger crystals, such as in the Inhumas Quarry. Fine-grained dolomite, such as in Carapeba Quarry, does not develop more significant porosity, mainly due to the intense compression to which it was subjected.

References

Berthou, P.I., and P. Bengtson, 1988, Stratigraphic correlation by microfacies of the Cenomanian-Coniacian of the Sergipe basin, Brazil: Fossils and Strata, v. 21, p. 1-88.

Rollinson, H.R., 1993, Using Geochemical Data: Evaluation, Presentation, Interpretation: New York, Longman Scientific and Technical, 352 p.

Rollinson, H.R., 1995, Using Geochemical Data: Evaluation, Presentation, Interpretation:, Harlow: Longman Scientific & Technical (reprint), 352 p.

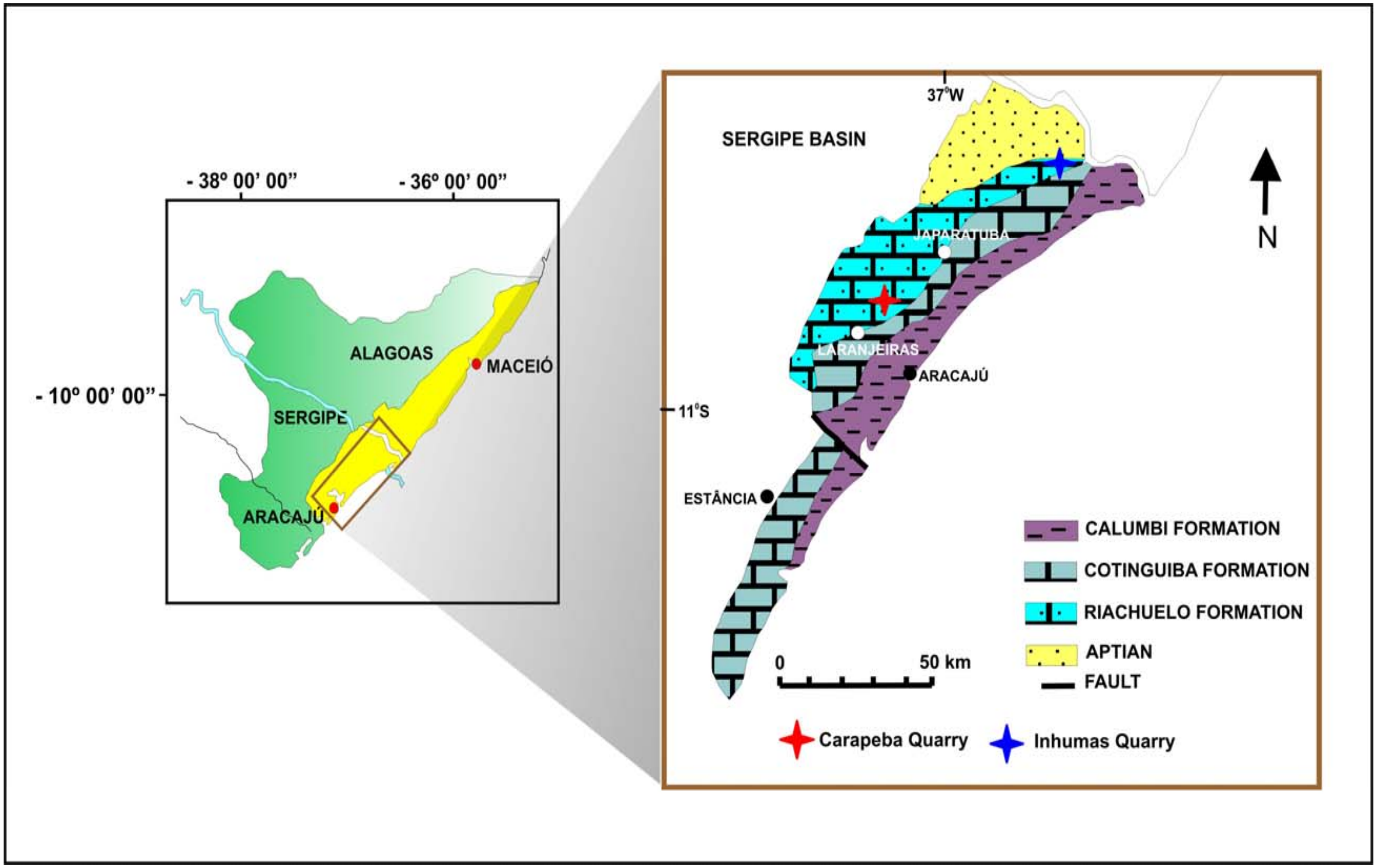

Figure 1. Location map of the area of study (modified from Berthou and Bengtson, 1988).

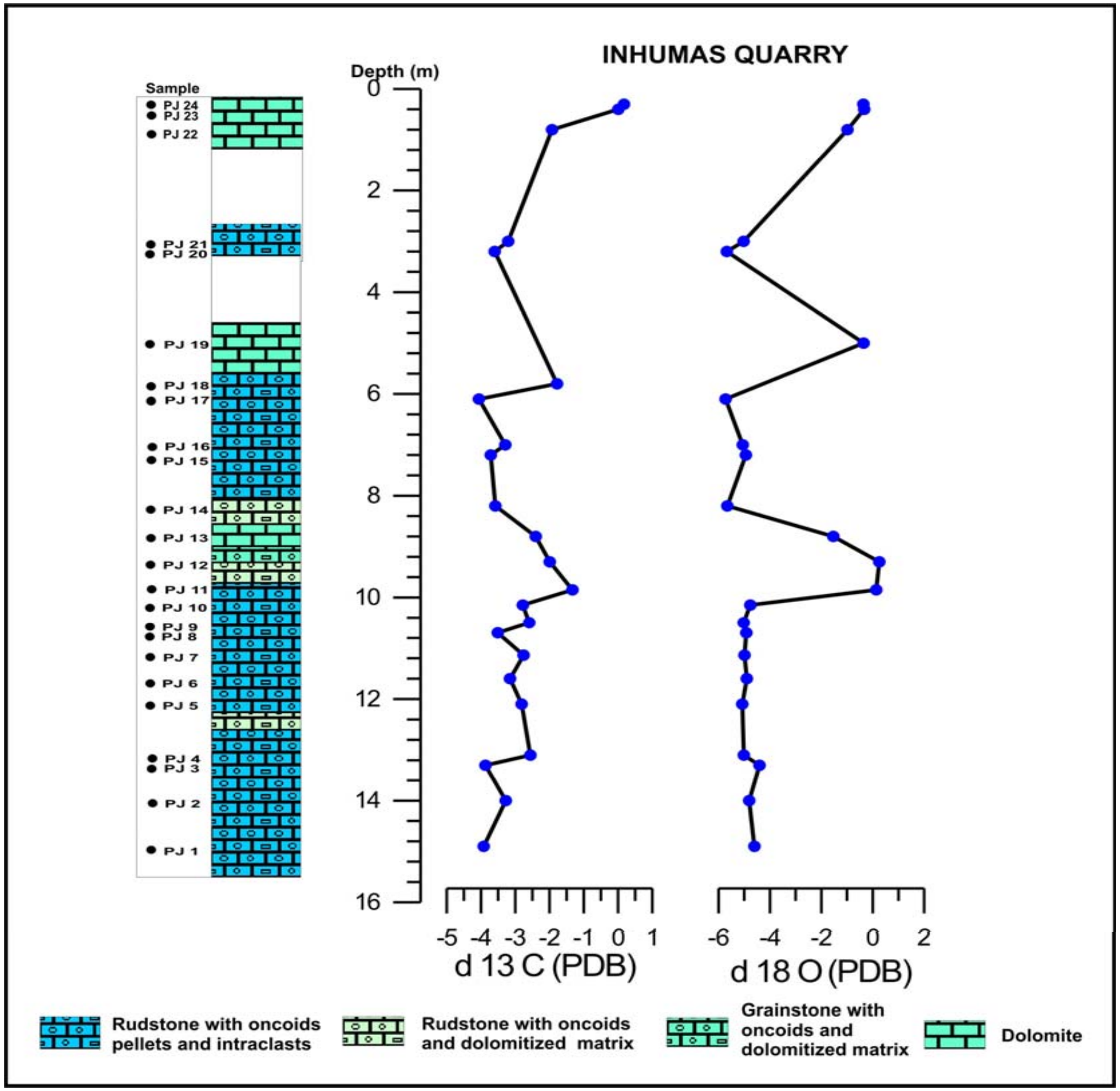

Figure 2. Microfacies of Inhumas Quarry, with carbon and oxygen isotope curves (modified from Diaz and Pereira, 2009).

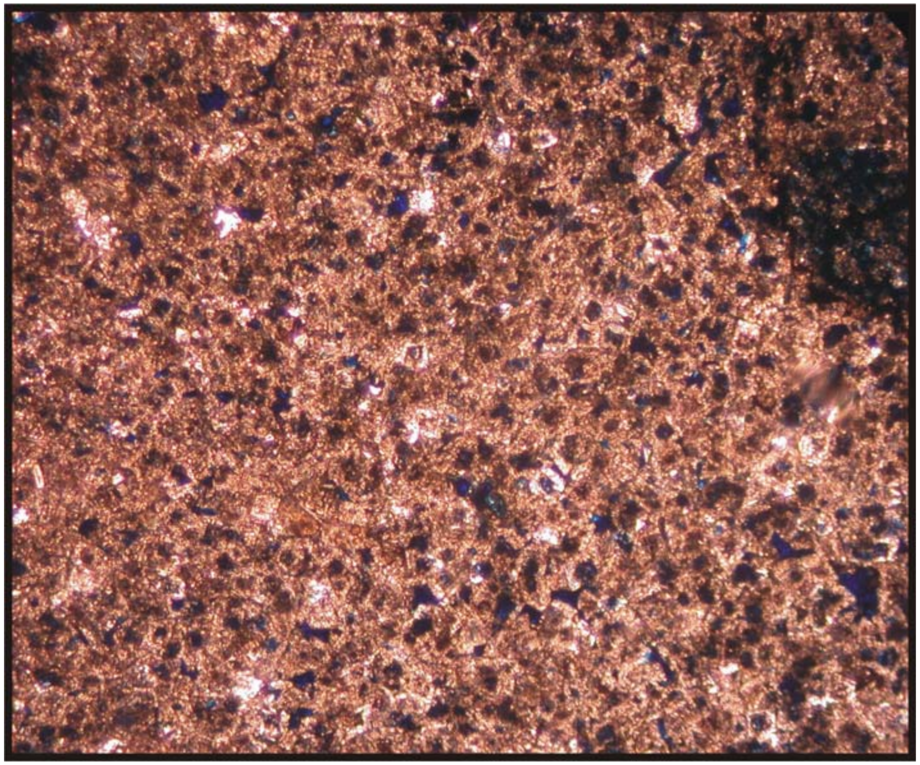

Figure 3. Secondary porosity due to dolomite dissolution.

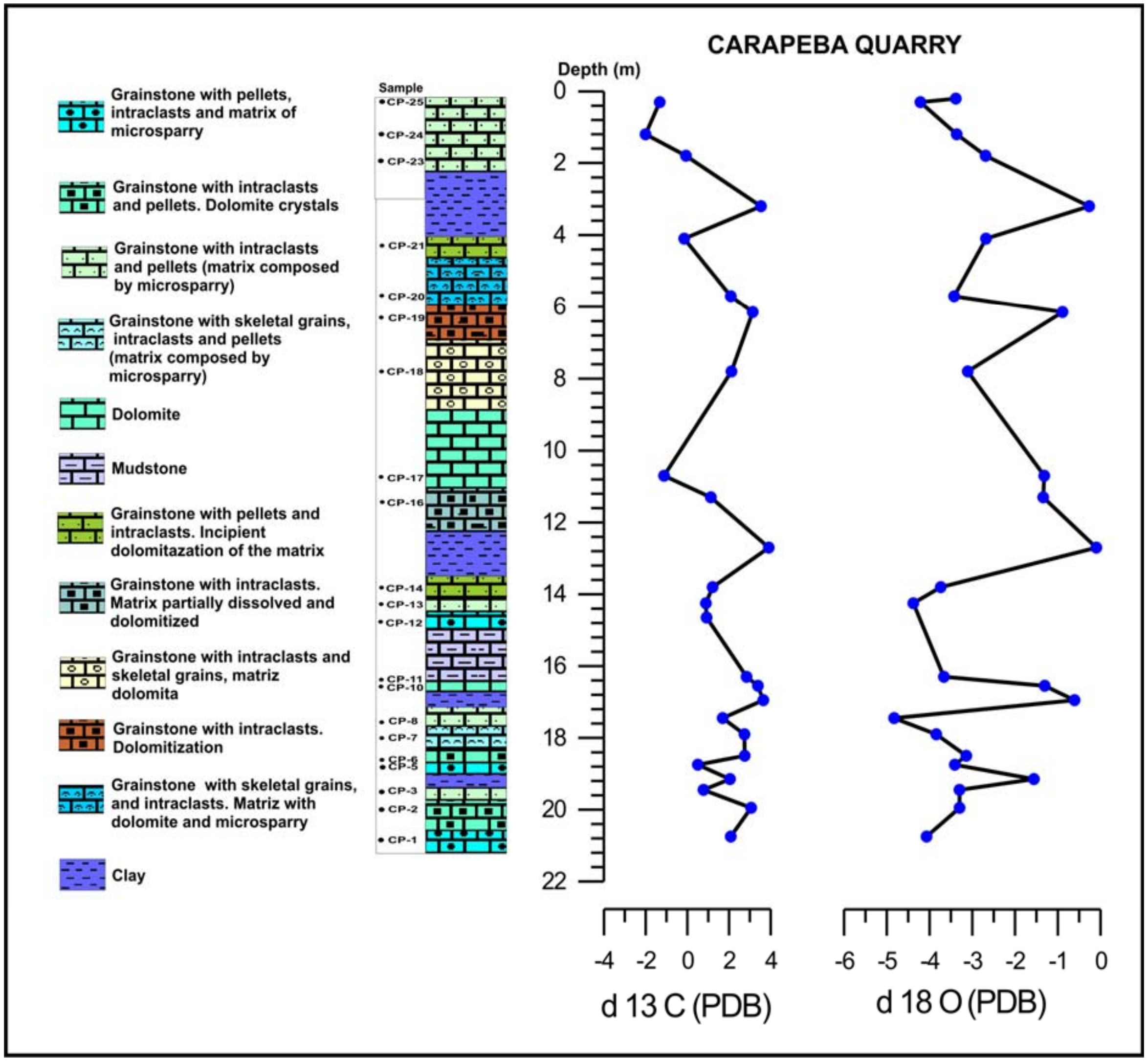

Figure 4. Isotope curves for carbon and oxygen, Carapeba Quarry (modified from Diaz and Pereira, 2009).