MULTIDISCIPLINARY STRATIGRAPHIC ANALYSIS OF THE APTIAN MEGASEQUENCE IN CAMPOS AND ESPIRITO SANTO BASINS, BRAZIL

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Summary

A thick (up to 450 meters) package of siliciclastic rocks and carbonates composes the pre-evaporitic Aptian megasequence in Campos and Espirito Santo basins. This megasequence is characterized by a poor resolution of biostratigraphic and seismic methods.

In order to obtain a more detailed stratigraphy, an integrated sedimentological and stratigraphic study was carried out based on data from 7 wells drilled in distal portions of these basins. Conventional and no conventional (mainly chemostratigraphy) stratigraphic approach were used to recognize four depositional sequences and many stratigraphic surfaces.

Introduction

The Aptian Stage, along the Eastern Brazilian Margin, can be subdivided into two sections. The lower one is composed of siliciclastic rocks and carbonates and the upper one, of evaporites.

The pre-evaporitic megasequence in Campos and Espirito Santo basins may reach 450 meters in thickness and it is characterized by a poor resolution of biostratigraphic and seismic methods. A relative tectonic quiescence had predominated during the deposition of the Aptian sediments in these two basins. Siliciclastic alluvial sediments prevail in the proximal areas where it is very difficult to make a consistent stratigraphic analysis. A more detailed stratigraphic framework is possible to obtain only in more distal areas where shallow marine environments has been interpreted.

Data from 7 wells drilled by Petrobras in these distal areas (Fig.1) were used to carry out an integrated sedimentological and stratigraphic study of this pre-evaporitic Aptian megasequence.

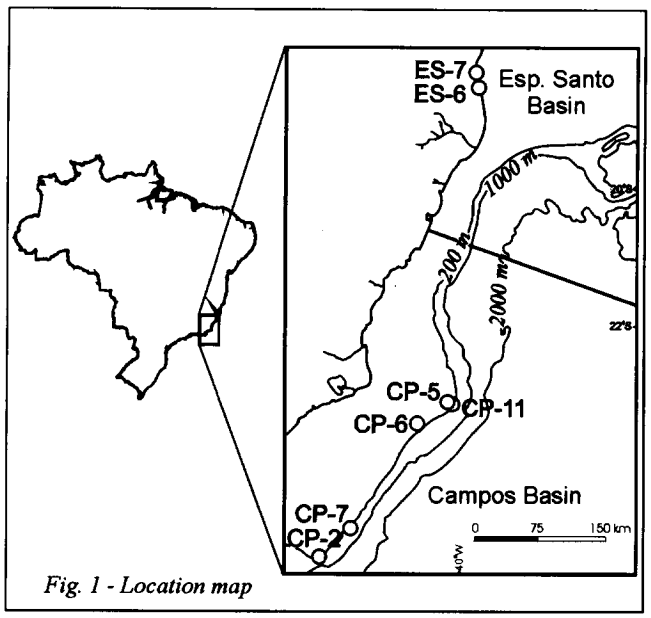

Fig. 1 - Location map

Espírito Santo Basin

The pre-evaporitic megasequence in the Espirito Santo Basin is composed of a relative thick (up to 350 meters) package of conglomerates, sandstones, shales and thin beds of anhydrite usually interpreted as continental deposits. The biostratigraphic analyses based on palinological and ostracode methods have not been effective to subdivide this package. The seismic resolution is also inappropriated to identify consistent reflectors with stratigraphic significance and regional widespread distribution.

More than 300 meters of almost continuous coring were recovered in ES-6 and ES-7 wells. Using these data, detailed sedimentologic and stratigraphic analysis were made allowing to carry out a consistent paleoenvironmental interpretation. Many facies were interpreted to be deposited in shallow marine environment.

A remarkable cyclic facies succession was identified in these wells, allowing to recognize four depositional sequences (ASS-1 to ASS-4 sequences). The basal portion of each sequence is composed of conglomerates and coarse-grained sandstones deposited by alluvial fans and braided fluvial depositional systems. These beds are covered by a package composed mainly of sandstones and, subordinately, by siltstones, shales and anhydrite beds. Lenticular and wavy bedding described in the sandstones suggest an influence of tides during deposition. The interpretation of a marine environment was confirmed by the $^{87}Sr/^{86}Sr$ analyses of anhydrite. The Sr isotope ratios obtained from two samples are 0,7088 ± 0,0008 and 0,7089 ± 0,0001 (PDB). They are lower than that ones related to mineral precipitation exclusively from continental waters, always over than 0,711 (Elderfield, 1986). These thin beds of anhydrite were deposited in *sabkha* and coastal saline subenvironments.

The cyclic facies succession and the detailed sedimentological interpretation allowed to place the sequence boundaries at the base of alluvial sediments. The cyclic facies succession indicates that the wells ES-6 and ES-7 are located in a region where the continental deposits were periodically buried by shallow marine deposits during the Aptian. Moreover, the progressively thinning of the intertidal facies from Sequence ASS-1 to Sequence ASS-4 indicates that the influence of tidal currents was reduced during the geological evolution of this region. It was interpreted the presence in this area of a fluvial and estuarine incised valley. This kind of incised valley is usually characterized by the progressively minor influence of the topographic restrictions along the coast line leading to a decrease or disappearance of tidal currents (Dalrymple *et al.*, 1992).

In areas of relative tectonic quiescence, like had predominated in the Espirito Santo Basin, the early infilling of an incised valley usually is made by continental deposits of the late LST and early TST. The estuarine phase is related to TST and HST. In the defined depositional sequences some surfaces with stratigraphic significance could be interpreted. The transgressive surface was placed at the top of the alluvial sediments. The maximum flooding surfaces have been interpreted more properly in sequences ASS-1 and ASS-3 corresponding to a thin bed of bioturbated shales.

Campos Basin

The pre-evaporitic megasequence in Campos Basin is composed by siliciclastic rocks in proximal areas and by a thick package of carbonates (up to 450 m) in distal areas. Like in the Espirito Santo Basin the biostratigraphic methods are not effective to break this package into allostratigraphic units. The high velocity carbonates also difficulties the seismic resolution. In Campos Basin a continuous coring is not available in any well like in the Espirito Santo Basin. Sedimentological analysis of carbonates and associated facies was made using few cores from 5 wells.

Detailed petrographic description of these cores shows that carbonates are mainly microbiolites (stromatolites and microbial laminites) and subordinately mudstones, bioclastic packstones and wackstones. The microbiolites have been interpreted to be deposited mainly in intertidal environments. Silicified birds-eye mudstones have been related to supratidal environments and the packstones and wackstones to lower intertidal to subtidal environments. Each facies has a specific signature in Gamma Ray log. The proximal facies (supra and upper intertidal facies) correspond to the lowest values of GR, while the distal facies (lower intertidal and subtidal facies) correspond to the highest values of GR.

These characteristics were useful to interpret the facies succession in the well CP-5 where the megasequence is 430 meters thick. This well was chosen to make a detailed stratigraphic analysis due its more distal position in Campos Basin. The facies characterization in this well was based in one core, in GR log and in petrographic description of 26 selected thin sections of cuttings.

Moreover, a detailed organic and inorganic geochemistry analysis was carried out using samples from cuttings at 6 meters intervals. The anylisis included carbon and oxigen isotope ratios of the whole-rock samples, the TOC content and Hydrogen Index of the organic matter. Some petrographic analyses of the organic fragments were made in order to identify the primary types of organic matter.

The $\delta^{13}C$ and $\delta^{18}O$ profiles show a good parallelism suggesting that both ratios have been affected by the same geologic factors. Diagenesis is especially important in some intervals. The $\delta^{13}C$ range between -0,5 and 2,8 $^{o}/_{oo}$ (PDB), usually lower than values (2 to 4 $^{o}/_{oo}$) of fully marine sediments drilled in the southern South Atlantic (Dias, 1998). The $\delta^{18}O$ profile shows a progressively increase values from ASC-1 to ASC-4 sequences. This behavior could be the result of crystallization temperature fall or due to a salinity rise (Holser *et al.*, 1996). However, the presence of a thick package of microbiolites suggests that the main influence was the environmental stress due to a salinity increase that reached its maximum during the evaporite precipitation at the very late Aptian.

Four depositional sequences (ASC-1 to ASC-4) have been recognized. Each sequence is composed, at the base, of proximal facies (supra and upper intertidal facies) that grades upward to more distal facies (lower intertidal and subtidal facies), all probably representing the TST and HST system tracks.

The sequence boundaries were placed at the base of proximal facies just above the highest values of TOC and HI, and relative low values of $\delta^{18}O$. These levels of TOC enrichment correspond to an exclusively amorphous organic matter content. All this data suggest that these levels correspond to maximum flooding surfaces, characterized by an input of normal marine waters with high content of algal material.

The sequences defined in the CP-5 well have been identified in other wells where the carbonates predominate. Nevertheless, they may not be precisely identified in the proximal areas where the continental siliciclastic sediments are predominant.

Conclusions

The sedimentological and stratigraphic analysis of the pre-evaporitic Aptian megasequence in Espirito Santo and Campos basins show that a reasonable stratigraphic framework can be obtained using conventional and no conventional (mainly chemostratigraphy) stratigraphic approach. These results have special significance to areas where the biostratigraphic and seismic resolutions are inadequate. The stratigraphic framework obtained could be useful in mineral exploration like in Espirito Santo Basin where the petroleum reservoirs are positioned in specific stratigraphic levels at each sequence.

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