PS Porosity Preservation in the Lithic Carmópolis Reservoirs, Sergipe-Alagoas Basin, Brazil*

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Abstract

Aptian lithic sandstones and conglomerates of the Carmópolis Member, Muribeca Formation, constitute the reservoirs of the giant Carmópolis and adjacent oil fields of Sergipe-Alagoas Basin, northeast Brazil. The reservoirs were deposited by alluvial-deltaic systems in the margin of a "pre-salt" hypersaline lake, and are highly porous, despite being rich in ductile, low-grade metamorphic rock fragments. A systematic petrographic study of 135 thin sections prepared from core samples from 6 wells revealed that early partial cementation by Fe-dolomite, previously regarded as the main porosity preservation process through compaction inhibition, is clearly not the only factor responsible for the quality of these reservoirs. Several samples with little or no dolomite cementation still present unusually high porosity values. Therefore, other mechanisms of sustaining framework, including early oil saturation and overpressure, are being evaluated. The systematic study of the variation of depositional texture and composition, and of the distribution of dolomite cementation and other diagenetic processes in relation to facies and stratigraphic sequences and boundaries is revealing the controls on the quality of Carmópolis reservoirs. Understanding the distribution of these controls will contribute to improving production from these unconventional and complex reservoirs, as well as for identifying new potential prospects with similar characteristics.

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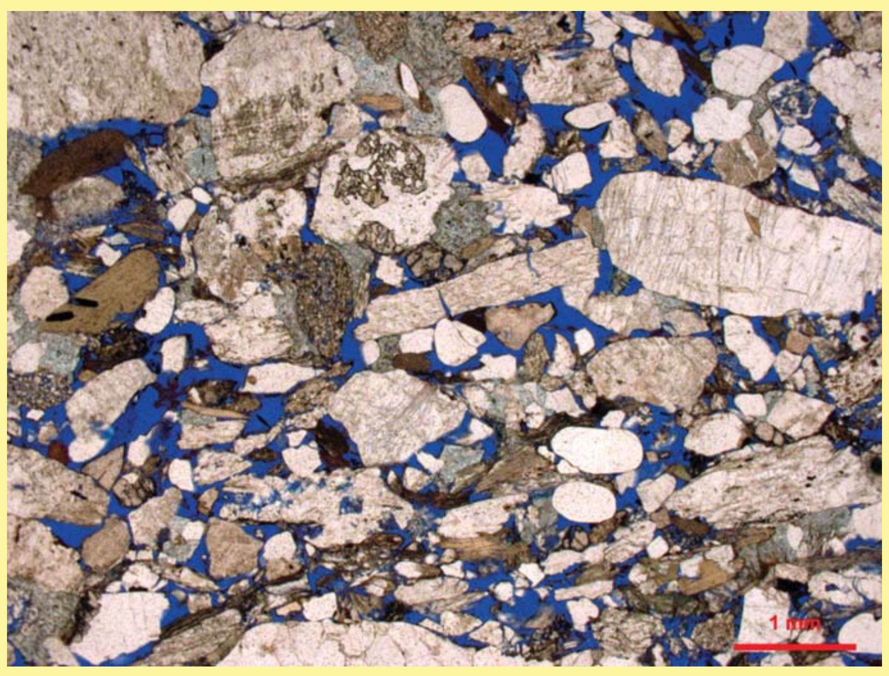
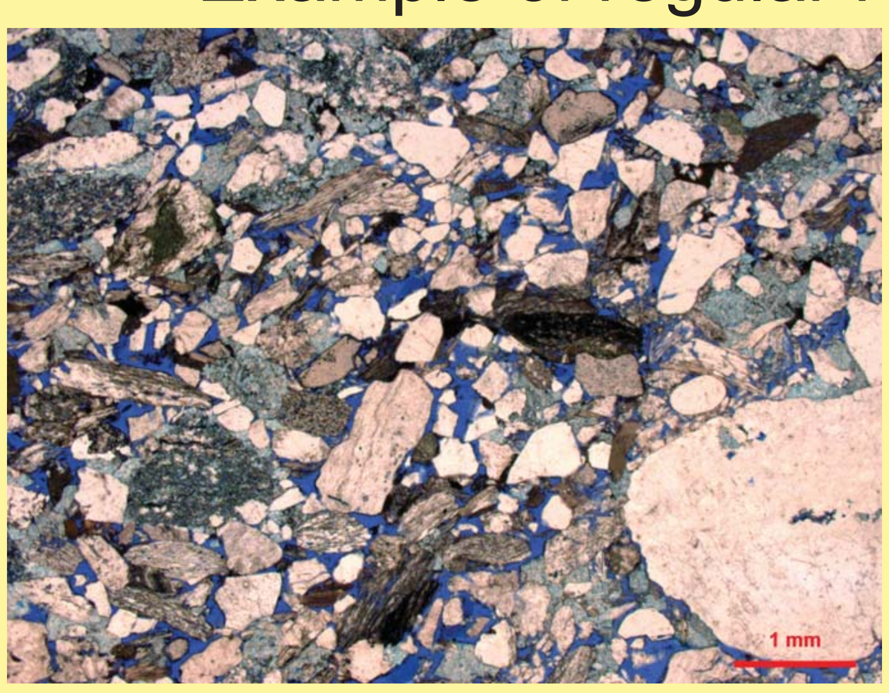
Twenty reservoir petrofacies were defined via the combination of main depositional structures, textures, primary composition and diagenetic processes that control porosity and permeability. Nine of these are volumetrically significant, being three exemplified here.

Example of good reservoirs



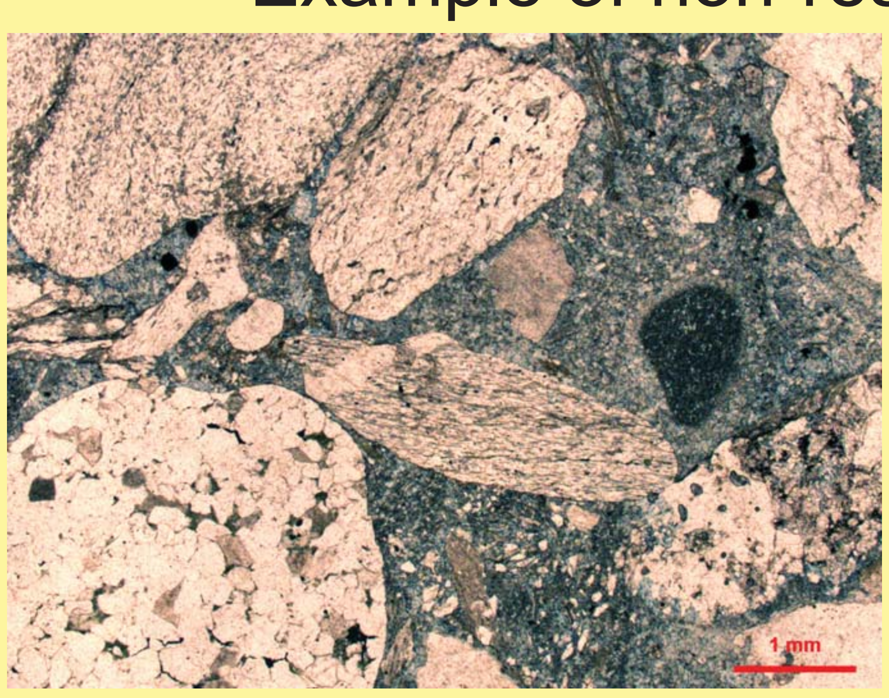
PorCongs: Conglomerates with >8% intergranular porosity. Dolomite cementation range between 3 and 11% and dissolution is <6%.

Example of regular reservoirs

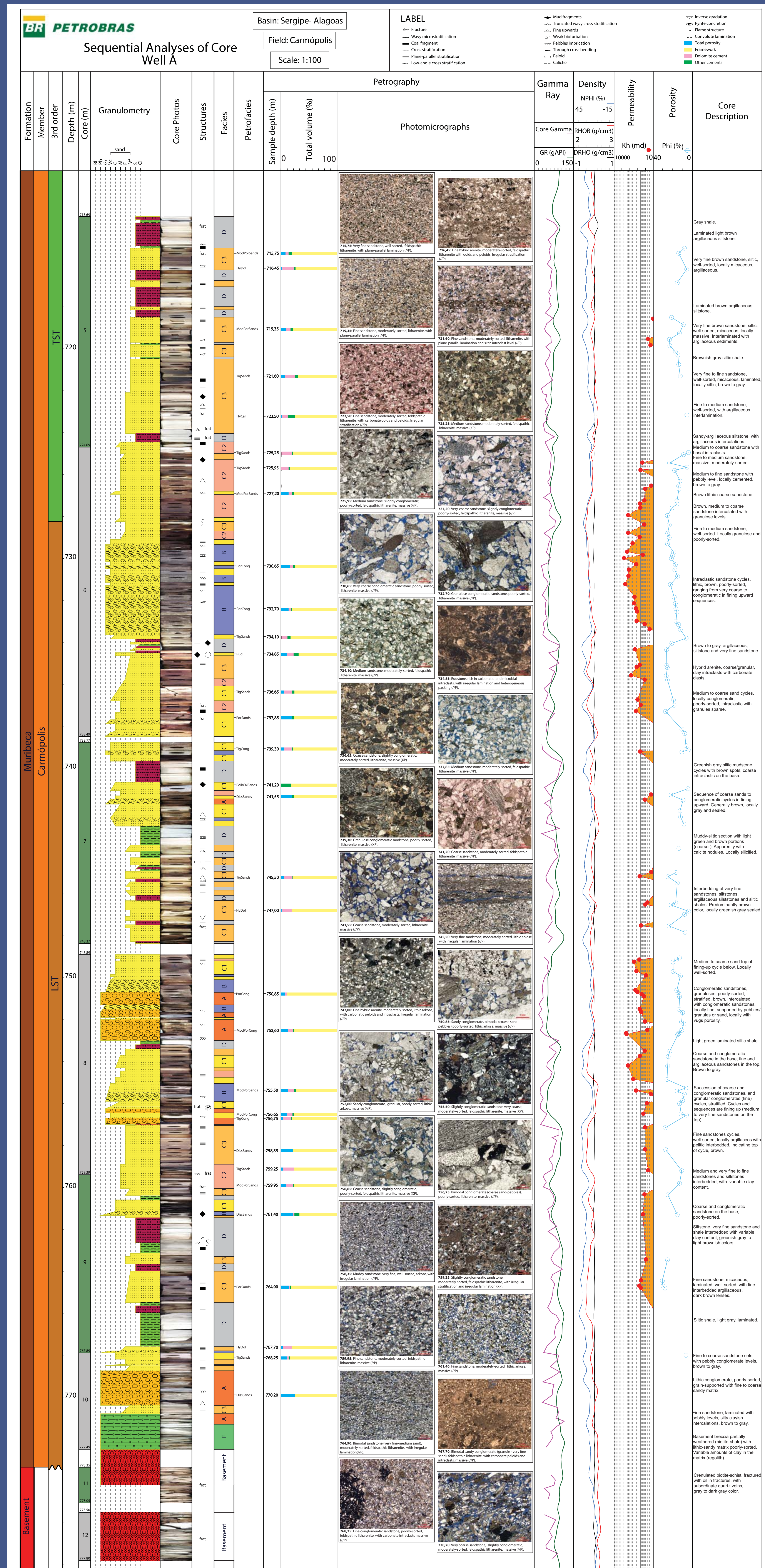


ModPorCon: Conglomerates with >5% and <8% intergranular porosity. Dolomite cementation is variable (4-9%).

Example of non-reservoirs



TigCongs: Conglomerates completely cemented by Fe-dolomite. Total porosity is extremely low (<2%).



The distribution patterns of quality and heterogeneities of the reservoirs were defined through the integration of wireline logs, petrophysical and petrographic data, interpreted stratigraphic intervals, lithofacies and petrofacies.

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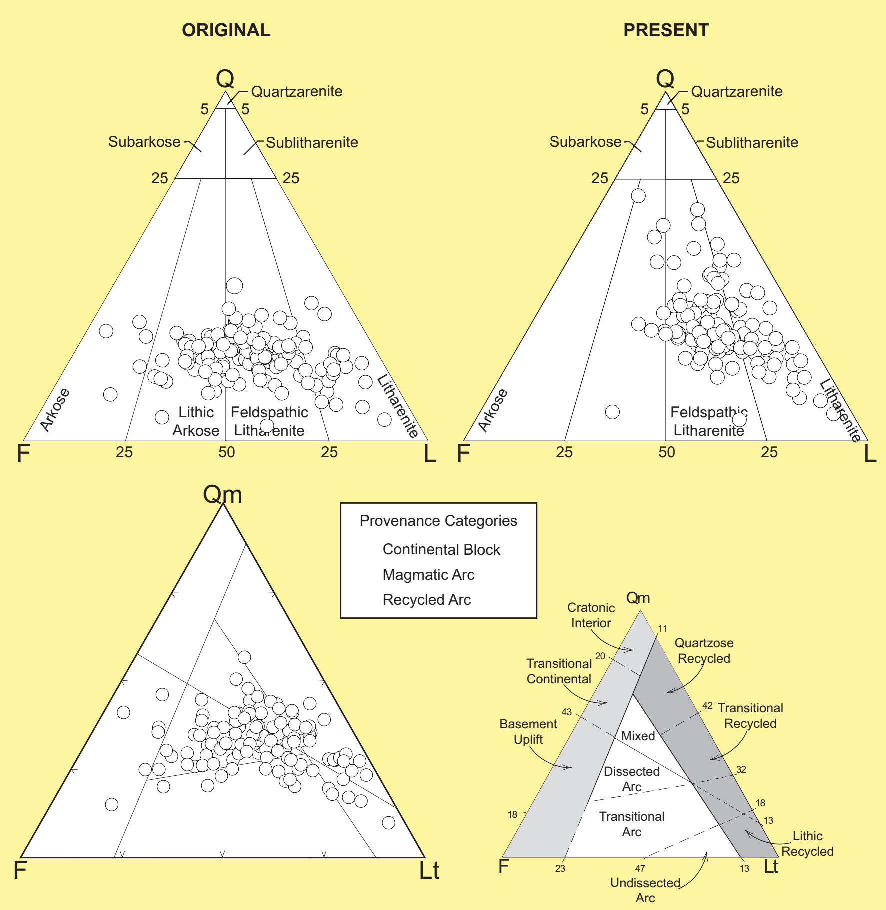
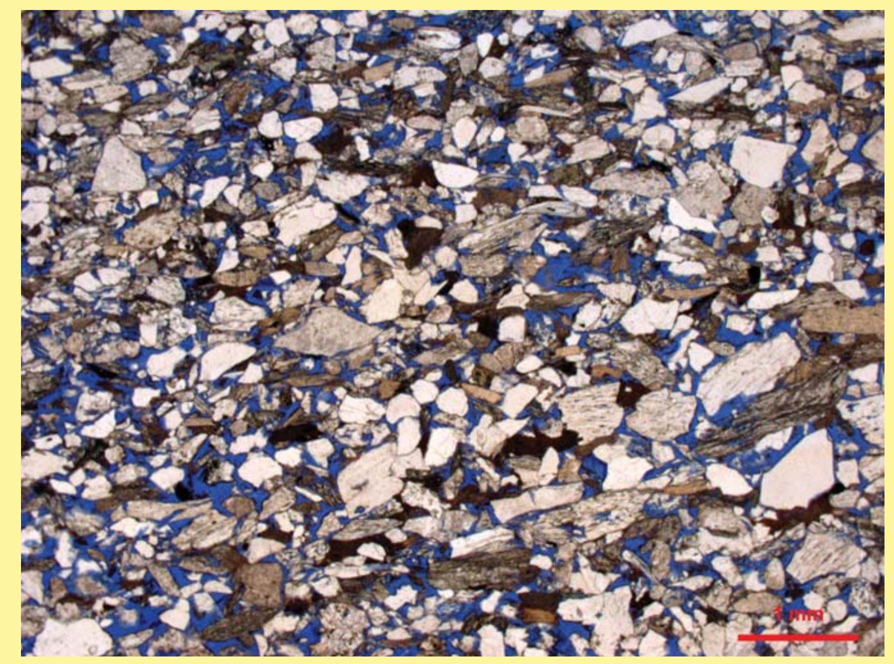
Quantitative petrography of 135 thin sections revealed that the sandstones and conglomerates are rich in low-grade meta-sedimentary rock fragments, derived from the uplifted metamorphic basement.

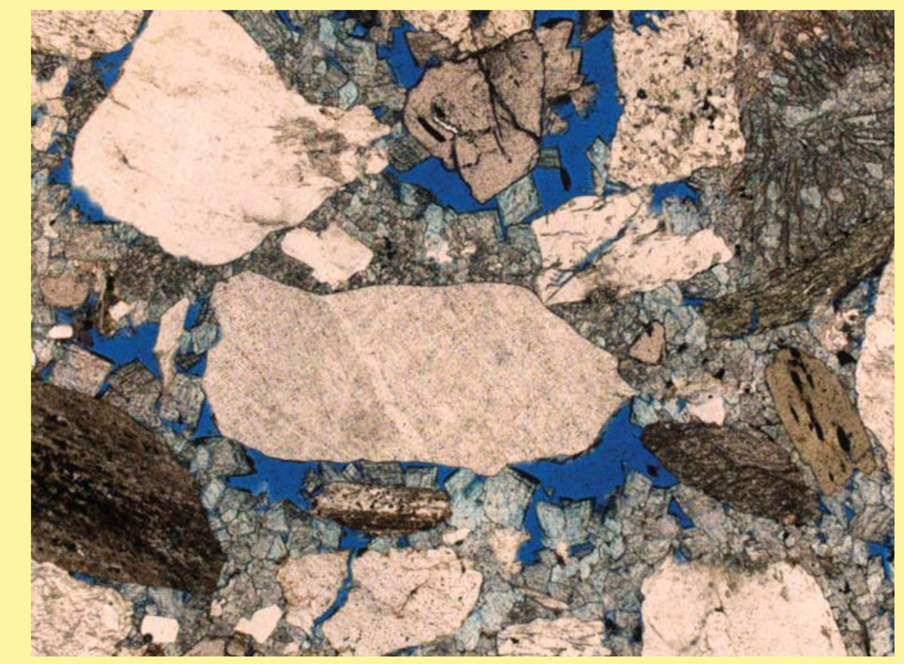


Original and present major composition of the analyzed samples, plotted on Folk (1968) and Dickinson (1985) diagrams.

However, several samples with relatively large intergranular porosity have very little or no dolomite, suggesting that another mechanism must also be contributing for porosity preservation.

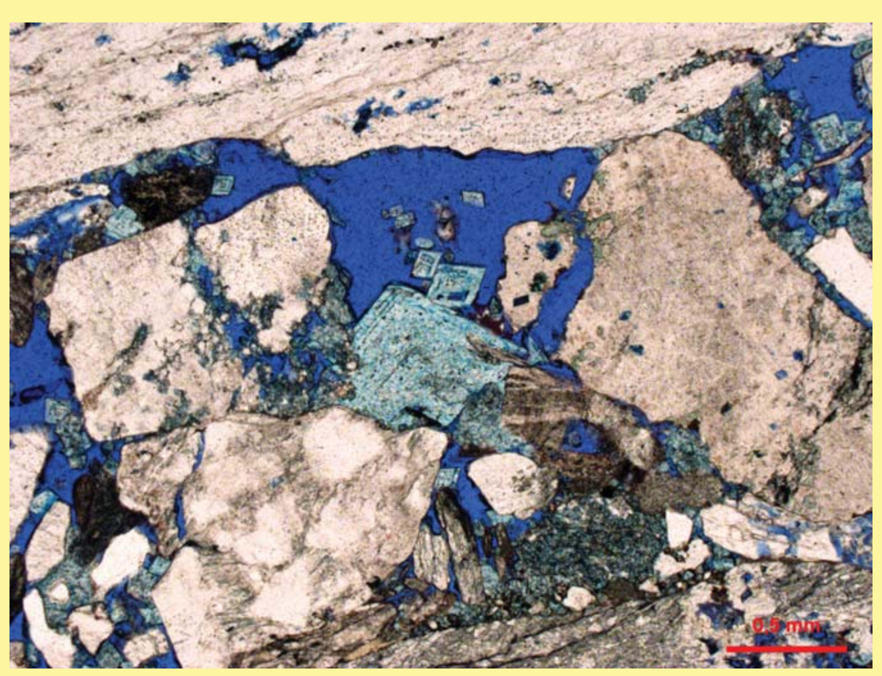


Porous sandstone with <2% dolomite cement. (//P)

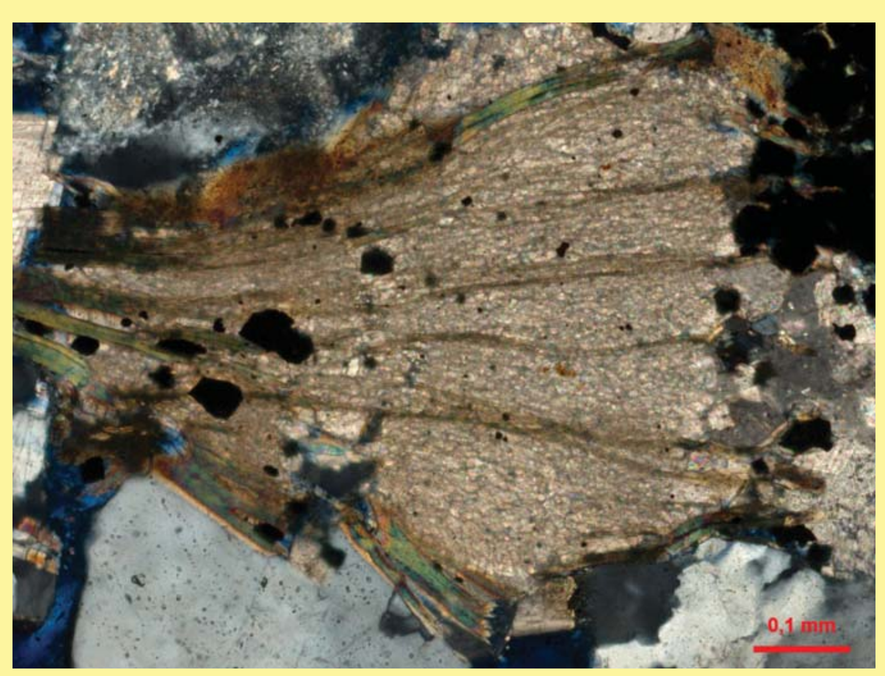


Fe-dolomite as blocky cement. (//P)

The early onset of dolomite cementation was an important process for the stabilization of the framework and, therefore, for porosity preservation in many samples.

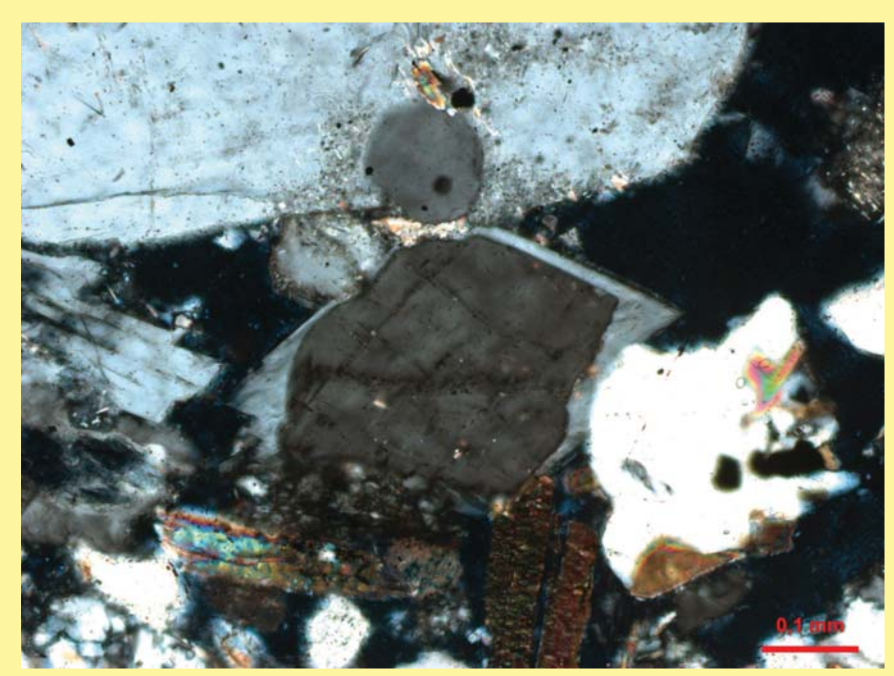


Discrete Fe-dolomite rhombohedra in intergranular pores. (uncrossed polarizers; //P)



Fe-dolomite expanding biotite flake. (crossed polarizers; XP)

Feldspar dissolution was important for porosity enhancement. Pre-dissolution, K-feldspar overgrowths are common, but not significant for porosity modification.



K-feldspar overgrowth surrounding a microcline grain. (XP)

Dissolved feldspar grain with remaining diagenetic K-feldspar overgrowths and ingrowths. (//P)

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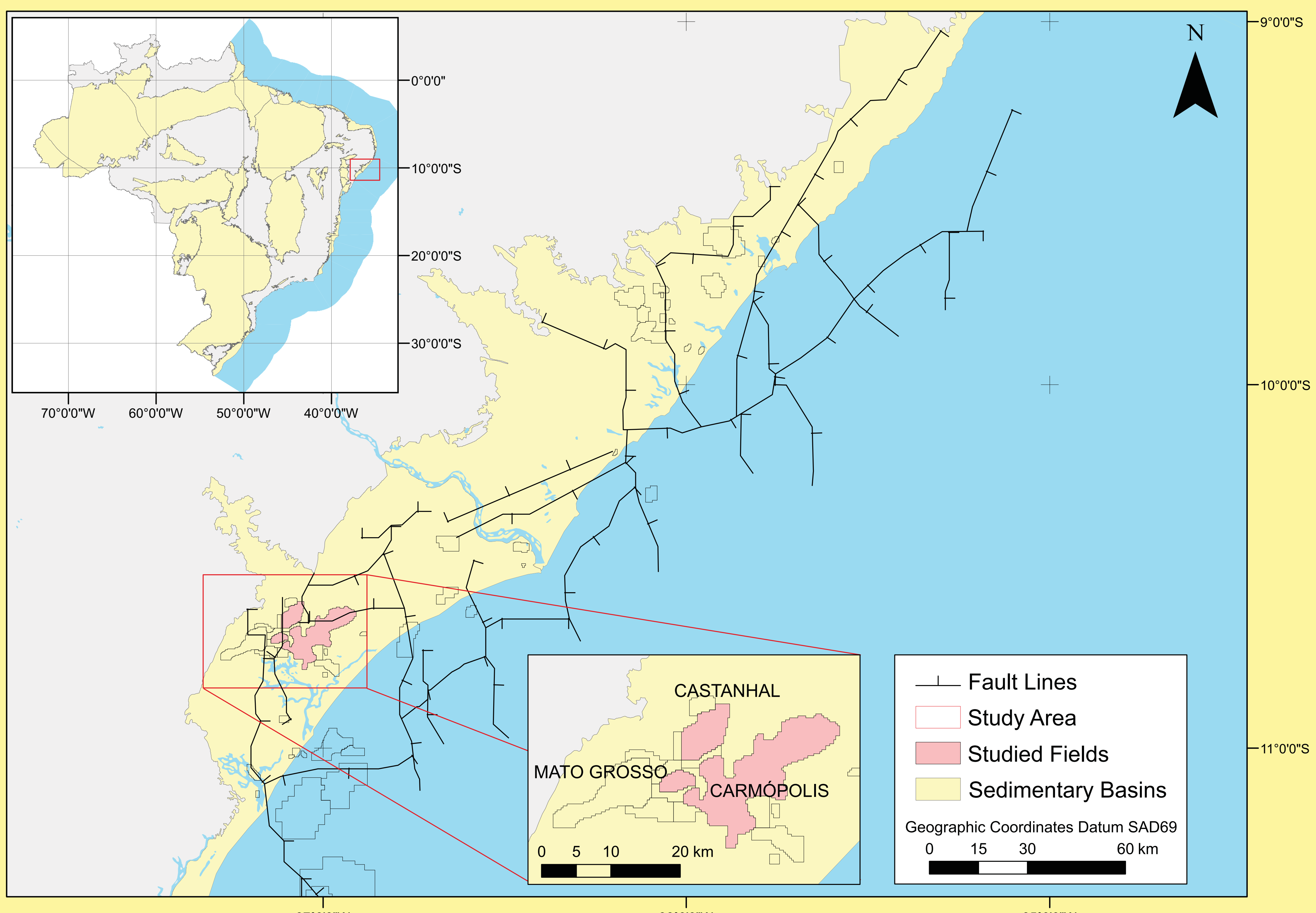
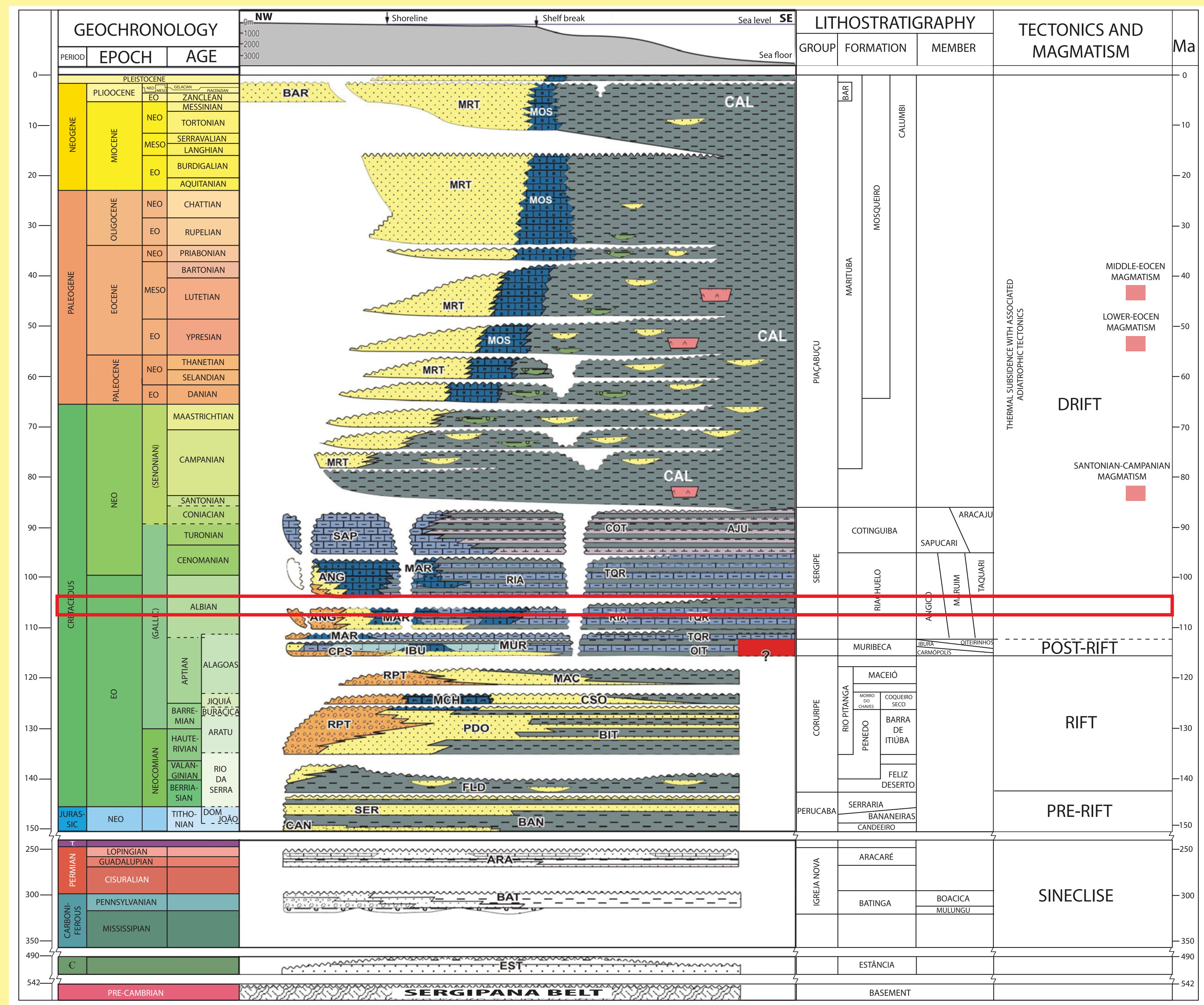
The Sergipe-Alagoas Basin is one of the most productive basins of Brazil, with 256M proved barrels of oil and 7Mm3 of gas (ANP, 2015). About 2/3 of its production are from onshore fields.



Location of the studied fields and main basement structures of Sergipe-Alagoas Basin.

The main reservoirs of this basin are coarse alluvial sandstones and conglomerates from the Carmópolis Member of the Muribeca Formation, deposited during the Aptian transitional or post-rift phase.



Stratigraphic column of the Sergipe Sub-Basin. The Muribeca Formation is highlighted in red (modified from Campos Neto, et al. 2007).

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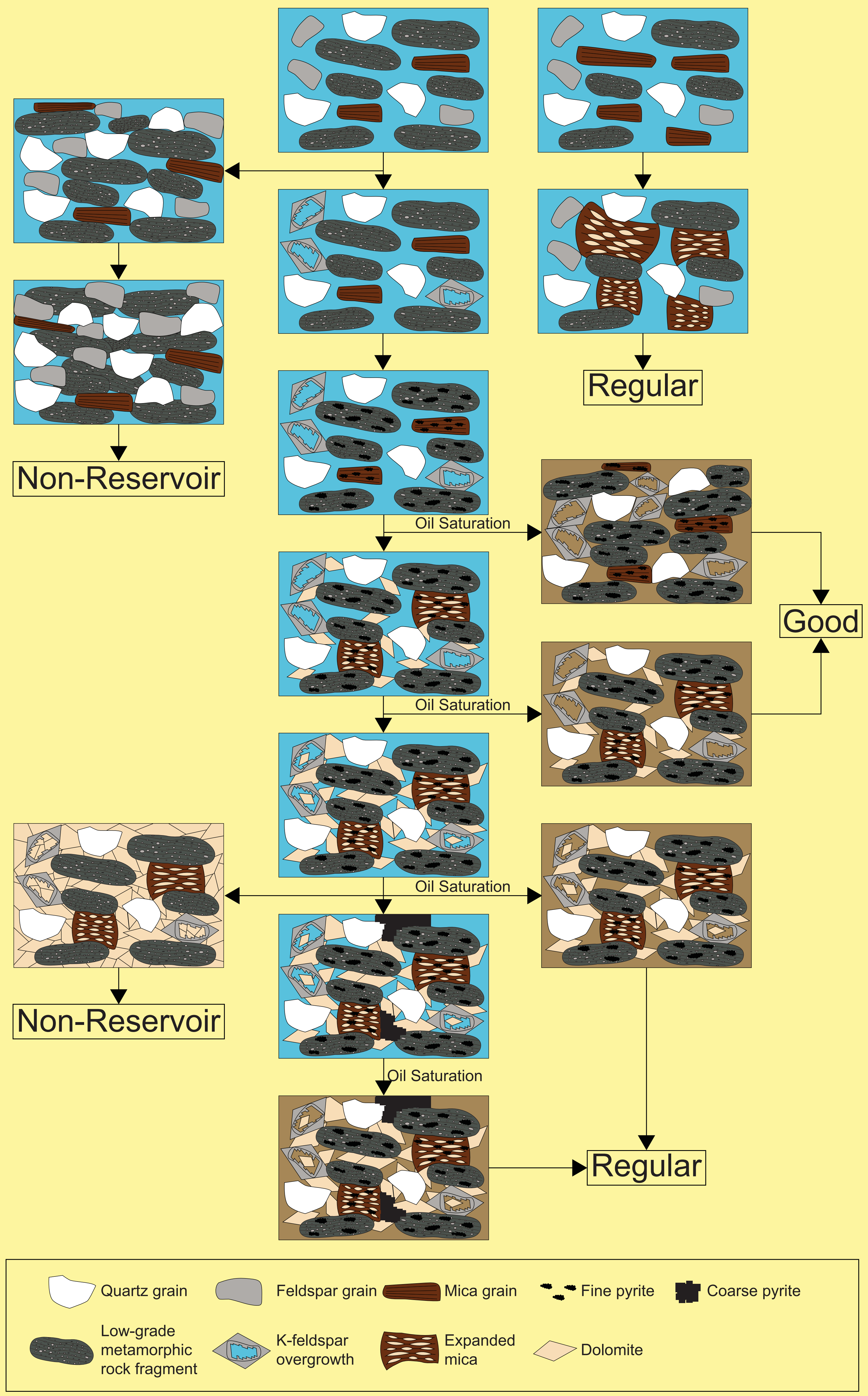
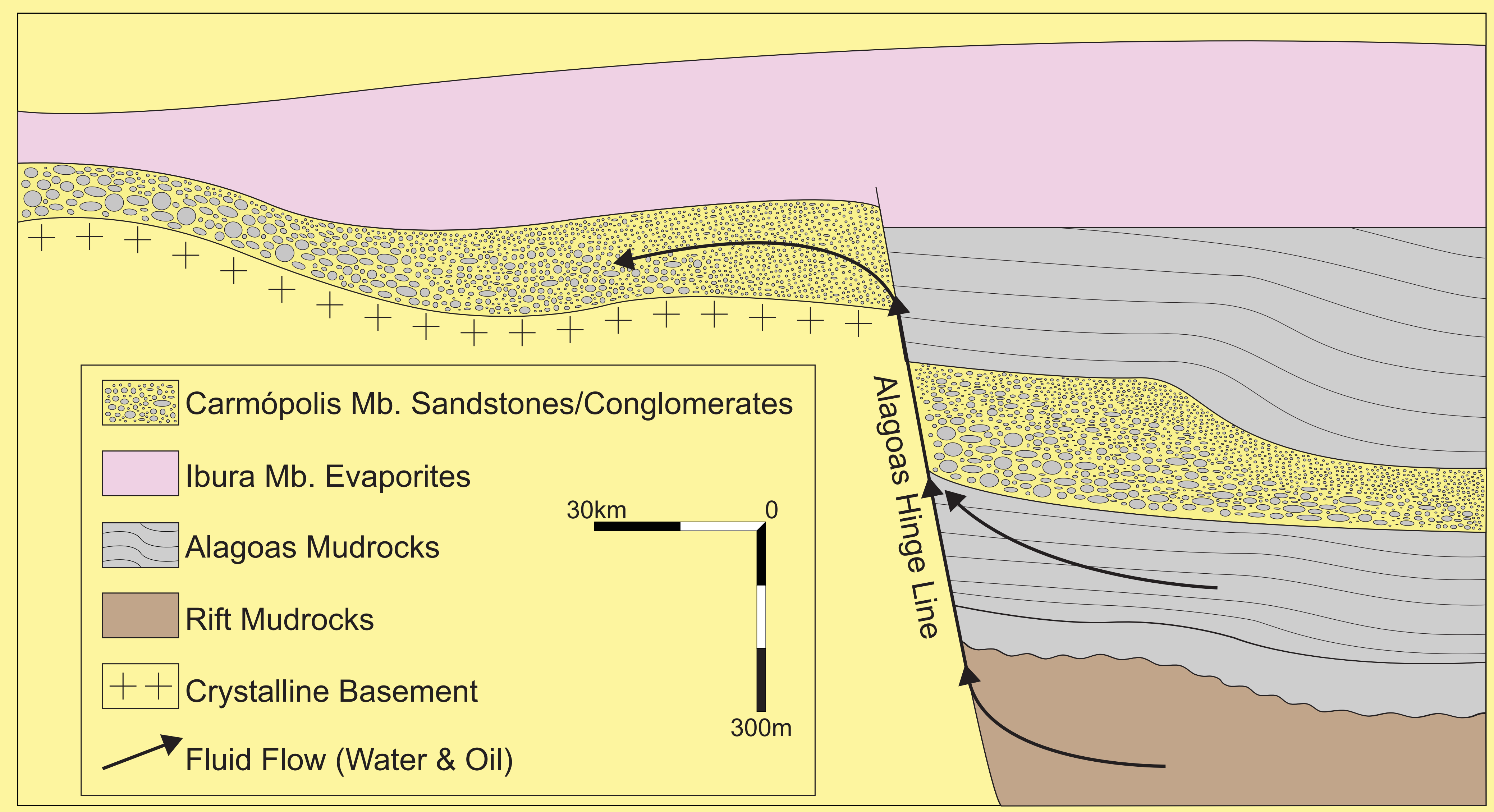


Diagenetic evolution pathways of the main petrofacies.

The diagenetic pathways of the main petrofacies were represented as flow diagrams. Partial dolomite cementation was clearly not enough to explain all the porosity preserved in the reservoirs. Early oil saturation is considered as a mechanism for the observed inhibited compaction and cementation, and preservation of porosity.

Oil and diagenetic fluids migrated through major faults from the low block into the sandstones and conglomerates of the Carmópolis Member before significant burial.



Schematic geological section of the Carmópolis field, showing major structural and stratigraphic features, and interpreted fluid flow.

Final Remarks

The mechanisms that controlled the distribution of quality in the Carmópolis Member reservoirs were recognized. This understanding and the characterization of the distribution patterns of heterogeneities and quality within the reservoirs will contribute for increasing the efficiency of oil recovery from producing reservoirs, as well as to reduce the risks in the exploration for similar reservoirs.

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