Textural and Compositional Controls on Diagenetic Mineralogy Variability in a Shale Play: An example from the Vaca Muerta Formation, Neuquen Basin, Argentina

Viviana Meissinger[1] and Gabriela Lo Forte[2]

[1]YPF S.A., Buenos Aires, Argentina
[2]YPF Tecnologia, Ensenada, Buenos Aires, Argentina

ABSTRACT

Controls on diagenetic mineralogy are critical considerations to evaluate unconventional shale oil/gas reservoir as a target, because they influence on the physical properties of the rock. In the Vaca Muerta Formation, a world class unconventional shale oil and gas play, the variability of diagenetic mineralogy is strongly controlled by texture and composition of the original sediments. These controls deeply imprinted the final composition of the rock since early diagenesis.

The sediments of the Vaca Muerta Formation comprise a thick sequence of fine grained marine deposits, accumulated in a back-arc basin located at the eastern side of an active subduction related magmatic arc during late Jurassic - early Cretaceous times. As a result of this paleogeographic position, they recorded an important volume of volcanic derived products, as background material and also as discrete layers of variable thickness.

The influence of texture on diagenetic mineralogy variability is related to the specific surface (surface/volume ratio) of volcanic particles, mainly volcanic ashes, that play an important role in eodiagenetic events, in which clay alteration and calcite replacement of volcanic glass both generate most of the volume of diagenetic products. Clay alteration starts immediately after deposition, and calcite replacement seems to begin after some burial. This paragenesis is evident from detailed thin sections and SEM petrographic analysis. As a consequence of this paragenesis, in millimeters thick layers of very fine grained volcanic glass clay alteration has been completed before calcite replacement started. In these layers actual composition is 100% illite/smectite, with no or negligible carbonate replacement. On the contrary, in coarser grained ash layers mainly composed of glass shards, the sequence of events is represented by a clay coating of illite/smectite delineating glass shard ghosts with variable thickness, and calcite replacement which developed after clay alteration. It is assumed that similar processes were operating in the background material, although this is not so clear from petrographic evidence. Initial composition of the sediments has also a strong influence in early diagenetic mineralogy variability, as volcanic derived basandesitic materials are chemically unstable. This condition favors a strong rock-fluid interaction in volcanic ash rich layers, in which clay and carbonates develop during eodiagenesis.

We propose that texture, specific surface of volcanic particles, mainly volcanic ashes, and the initial composition of sediments, relative abundance of unstable volcanic derived particles, are the main controls responsible for the final diagenetic mineralogy variability. Specially, they are responsible for the lateral and vertical distribution of diagenetic clay and carbonate. These are the most volumetrically significant diagenetic products in this formation through the entire basin. Furthermore, at the light of these controls, it is necessary to evaluate the importance of diagenetic mineralogy variability about clay/calcite distribution in the Vaca Muerta Formation previous to other considerations,

e.g. stratigraphical and sedimentological. The timing of events demonstrated that these controls operated mainly during early diagenesis. As a consequence, physical properties of the rock are impacted since the beginning of burial, and may strongly vary along diagenetic evolution.