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Sequence stratigraphic controls of clastic diagenesis: Preliminary studies of analogue reservoirs from the Salton Trough, San Joaquin Basin, California

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***Abstract* – Preliminary Studies reveal the clastic reservoirs of the Salton Trough are arkosic to lithic arkossic arenites, but that there is variation in textural maturity as well as petrophysical properties. Quantitative statistical data revealed total porosity for the Alverson (average 13.3%), Elephant Trees (average 16.3%) and Latrania sandstones (average 10.4%) with total porosity showing a slightly increasing trend with textural maturity. The sandstones have undergone early to intermediate stages of diagenesis with authigenic cementation being the more important agent of porosity destruction than compaction. Diagenetic processes, together with depositional factors, are responsible for variation in petrophysical properties and reservoir quality.**

INTRODUCTION

Until recently, sequence stratigraphic and diagenetic techniques have been employed independently to study clastic reservoirs. While sequence stratigraphy is a useful tool for predicting the distribution of facies away from control points (Catuneanu et al., 2011), it cannot provide direct information about the diagenetic evolution of reservoir quality (Morad et al., 2012). Recent work by Ketzer (2002) has shown that the integration of diagenetic alterations within a sequence stratigraphic framework can improve predictions of the petrophysical properties of sandstone petroleum reservoirs. However, this approach has not yet been widely applied and therefore the validity of this approach needs to be tested in other settings. The current research will answer the questions: How might sequence stratigraphic controls of clastic diagenesis vary from one geological setting to another? How does this affect their reservoir quality distribution? How does reservoir compartmentalization by diagenetic baffles differ in these environments?

However, in this study, we present data for reservoir-analogues from the Salton Trough located at the Southern end of the Great San Joaquin Forearc Basin of California with a focus on petrographic description and reconstruct the paragenetic sequence.

METHODOLOGY

A set of nine (9) samples from the Alverson, Elephant Trees, and Latrania Formations of the clastic sequences of the Salton Trough was evaluated by petrographic analyses. Values were obtained for mean grain size, sorting term and thin section porosity. This data was integrated to extract permeability. The values for porosity were plotted against those of permeability and thereafter constrained by statistical analysis using Spearman's rank correlation. Finally, the values obtained for intergranular volume (IGV) were plotted against volume of cement (%) to determine porosity loss.

RESULTS AND ANALYSIS

Reservoir Lithologies

Petrographic investigation of these clastic reservoirs shows that the reservoirs of the Alverson Formation consist of detrital quartz (average 33.5%), feldspars (average 47.4%) and rock fragments (average 19.1%). The Elephant Tree Formation is composed of detrital quartz (average 29.3%), feldspars (average 57.8%) and rock fragments (12.9%). The Latrania Formation comprises detrital quartz (average 35.2%), feldspars (average 43.2%) and rock fragments (average 21.6%). The composition of these clastic reservoirs is, therefore, arkosic to lithic arkosic arenites (Fig. 1). The detrital quartz grains are monocrystalline while detrital feldspars are mostly plagioclase with minor K-feldspars. The reservoirs of both

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the Alverson and Elephant Trees Formation are fine to very coarse grained sandstones with some pebbles and are poorly sorted. The reservoirs of the Latrania Formation, on the other hand, are very fine to coarse-grained sandstones with high detrital illite matrix and biotite but also very poorly sorted. Regarding textural maturity, Elephant Trees has relatively higher textural maturity whereas, Latrania with the highest matrix content, has the least.

Diagenetic mineralogy and paragenetic sequence

The clastic reservoirs have undergone early to intermediate stages of diagenetic modification comprising compaction, authigenic cementation consisting of quartz, feldspar, calcite and montmorillonite cementation, micro-fracturing, and detrital grain dissolution and alteration (Figs. 2 & 3). Calcite is the dominant authigenic cement. Quantitative statistical data revealed total authigenic cement for Alverson (average 25.4%), Elephant Trees (average 18.5%) and Latrania (average 27.5%). Total cement shows a slight increasing trend with grain size.

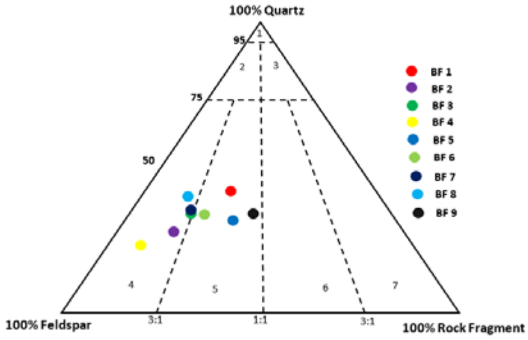

Figure 1. Folk (1980) ternary classification plot for BF1 and BF2 sandstones. 1 = Quartz Arenite, 2 = Subarkose, 3 = Sub-litharenite, 4 = Arkose, 5 = Lithic arkose, 6 = Feldspathic litharenite, 7 = Litharenite (BF 1-2 = Alverson Fm.; BF3 - 4=Elephant Trees Fm; BF5-9 = Latrania Fm)

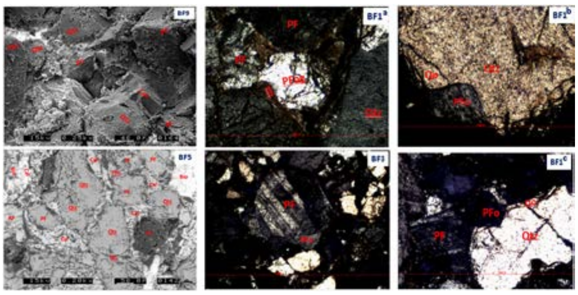

Figure 2. Diagenetic features: BF9 shows authigenic calcite (Cal) and montmorillonite (Sm) cement on grains and pores; BF5 shows calcite (Cal) cement in pores and predates quartz cement (Qo); BF3 shows feldspar (PF) overgrowth (PFo); BF1ª shows feldspar outgrowth (PFog) predating montmorillonite (Sm) and reducing pores; BF1ᵇ shows feldspar cement predating quartz cement; and BF1ᶜ shows micro-fracturing postdating quartz cement (Qo)

Porosity evolution and reservoir implications

Quantitative statistical data also revealed total porosity for Alverson (average 13.3%), Elephant Trees (average 16.3%) and Latrania (average 10.4%). Total Porosity shows a slight increasing trend with textural maturity. The plot of intergranular volume (IGV) versus volume of cement (Fig. 4[A]) reveal that cementation was a much more important agent of porosity destruction than compaction. Further plot of porosity versus permeability (Fig. 4[B]) shows that reservoir quality varies with the Elephant Trees Formation having the highest reservoir quality whereas the Latrania Formation has the least. Variation in reservoir quality in these reservoirs is not only due to varied compaction and authigenic cementation but also to variations in detrital clay and mica.

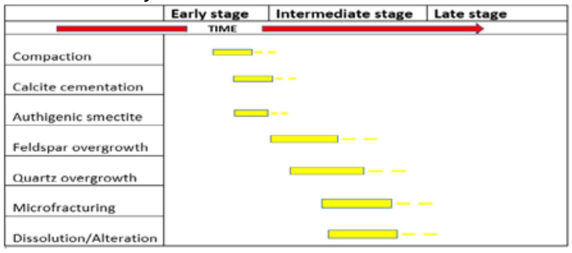

Figure 3. Paragenetic sequence of diagenesis

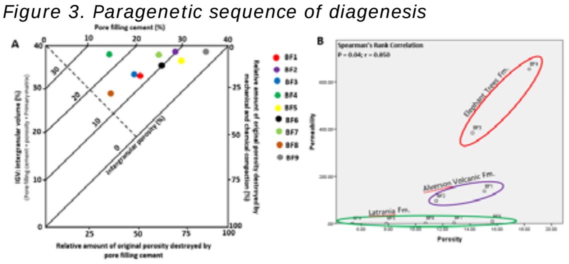

Figure 4. Plot of intergranular volume Vs. volume of cement (A) and Plot of Porosity Vs. Permeability (B)

Summary of Preliminary Study

The study classifies the clastic reservoirs of the study area as arkosic to lithic arkosic. These reservoirs have different petrophysical properties and reservoir quality and have undergone early to intermediate stages of diagenetic evolution. Authentic cementation played more of a role in destroying primary porosity than compaction. Both depositional and diagenetic processes therefore control potential reservoir quality.

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