AAPG Annual Convention
Salt Lake City, Utah
May 11-14, 2003

Enhanced reservoir characterisation of the Triassic Argilo Greseux-Inferieur, Algeria using high resolution chemostratigraphy

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The Triassic Argilo Greseux-Inferieur (TAG-I), which is one of the principal hydrocarbon reservoirs in the Berkine Basin (Algeria), comprises continental fluvio-lacustrine deposits that form a 25 to 80m thick reservoir section in the Burlington Operated Block 405a. Poor biostratigraphic control, lateral facies variations and sandstone units of sub seismic thickness, makes reservoir correlation and therefore reservoir management problematic. Chemostratigraphy has been carried out on over 800 conventional core samples, providing the basis for both regional and high-resolution chemostratigraphic-based correlation.

The regional framework recognises a three-fold division of the TAG-I over a wide geographic area. Changing palaeoclimate and a major change in sediment provenance control the geochemical variations that define this framework. The framework provides the basis around which the high-resolution chemostratigraphic reservoir characterisation is built. When integrated with sedimentology, high-resolution chemostratigraphy carried out on the TAG-I of the MLN Field allows an almost bed for bed correlation that highlights lateral continuity of reservoir sandstones and claystone barriers. Predictability of this analytical tool also enabled correlations to be made even where lateral facies variations were marked. Chemostratigraphy is now routinely conducted on development wells prior to formation testing. This allows the well test engineer to formulate correct testing procedures to obtain maximum information on sandstone unit correlation, horizontal and vertical connectivity and thus ultimately connected hydrocarbon volumes.

Introduction

The TAG-I sequences being investigated here are of Triassic Carnian age and form an important hydrocarbon reservoir in the Berkine Basin of Algeria (Figure 1). The TAG-I in the Burlington Resources operated Block 405a comprises sandstones and claystones deposited in a semi-arid fluvial system that occupied a NE-SW trending valley system. The reservoir complex varies in total thickness in the study wells from 25 to 80 meters. In Block 405a, the TAG-I unconformably overlies Viséan Carboniferous sequences and is in turn overlain by limestone and evaporite sequences of the Triassic Carbonaté, a shallow water claystone, limestone and evaporite sequence. The upward change in sedimentary facies documented from the TAG-I regionally, indicates an overall raise in base level. Initial paleotopography-fill sandstones pass upward into coalesced, laterally extensive sandstone sheets and ultimately into channel-fill sandstones isolated within claystone overbank deposits. Changes in palaeosol type suggest that during deposition, the palaeoclimate became progressively more humid.

Chemostratigraphy, (a correlation tool), involves the application of elemental geochemistry to the characterisation and correlation of sedimentary sequences. The technique relies upon the fact that the geochemistry of sediments is highly variable and is sensitive to subtle changes in composition. Even, apparently uniform successions may show subtle differences in accessory phases (e.g. heavy minerals and clay minerals) that can be modeled using geochemical data. For this study, geochemical data for 47 elements have been acquired for approximately 800 samples from thirteen well well penetrations from Block 405a. In addition to the elemental data displayed and discussed here, supporting XRD, petrographic and heavy mineral data are used to supplement the interpretations below.

Geochemical correlation

Wells from the MLW, MLNW, MLN, MLC and MLSE fields are included within this study (Figures 1 and 2). Within the TAG-I, three geochemical units can be defined and regionally recognised (Units T1, T2 and T3). Within this broad and laterally extensive framework, more detailed, but localised, correlation is provided by the chemostratigraphic data (Figure 2). Although the geochemical units T1-T3 are laterally extensive, this does not imply that the sandstones are continuous sheets over several tens of kilometers. Rather, it indicates that, for example, sandstones from Unit 1 were deposited from the same source area, which is different to that for Unit 2 sandstones, and are approximately coeval. The regional framework therefore allows for a better understanding of sandstone distributions over the study area.

Key elements used in this study are Al_2O_3, TiO_2, K_2O, P_2O_5, Zr, Hf, Rb, Cs, Nb, Ta and La. The mineralogical controls on these elements are determined using graphical and statistical techniques and then by using the geochemical data to model mineralogical changes it is demonstrated that:

A marked change in sediment provenance is recorded at the Unit 1/Unit 2 boundary. Unit 1 sandstones are derived from a sedimentary source area, with some localised volcanic input, whereas sediments in Unit 2 and 3 are mostly derived from an acid igneous source area.

The Unit 1/Unit 2 boundary is a regional hiatal surface at which subaireal weathering took place.

The claystones of Units 2 and 3 record an upward change in base level and/or palaeoclimate, with conditions becoming increasingly wetter.

The sandstones of Units 2 and 3 display upward increase in feldspar content, reaching a maximum in the lower parts of Unit 3.

In the uppermost parts of Unit 3 in several wells (e.g. MLN-1 and MLC-1 on Figure 2) a blocky sandstone is present that appears to have no lateral equivalent in adjacent wells. This sandstone is geochemically distinct from other Unit 3 sandstones and is discussed in more detail below.

The geochemistry of this uppermost sandstone strongly indicates the primary source of sediment is local, more specifically the underlying TAG-I sediments.

The top of the TAG-I is geochemically well defined, allowing clear definition of the TAG-I/Triassic Carbonate contact, even when this contact is one of claystone on claystone (e.g. MLN-5 on Figure 2).

Within this regional framework an almost bed for bed correlation can be made between closely spaced wells (Figure 2), which can then be used for helping with reservoir management issues by predicting lateral continuity of sandstones and claystones. This is highlighted by consideration of the data from MLN-10 and is discussed below.

Increased confidence in reservoir management

Once the regional framework has been constructed and the enhanced detail of each field determined, it is possible to use sidewall core and cuttings samples to place appraisal and development wells within the chemostratigraphic correlation scheme. When well MLN-10 was completed, an unexpectedly thick, blocky sandstone (Sst A on Figure 3) was encountered at the top of the TAG-I. It is important to determine whether this "sandstone A" was likely to be related to a sheet-like sandstone, or if it was more likely to be an isolated channel sandstone similar to that seen in MLN-1 and MLC-1 (Figure 2). Geochemical analyses of cuttings samples indicate that the sandstone in question has geochemical attributes that are similar to the "isolated" sandstone unit in MLN-1 (Figure 3). Confident characterisation of this sandstone results in a modified and improved production program since its presence in a well effectively increases the oil column.

Figure 1. Location map. Approximate location of the Berkine Basin within Algeria is displayed on the inset. Only the locations of wells mentioned in the text are displayed.

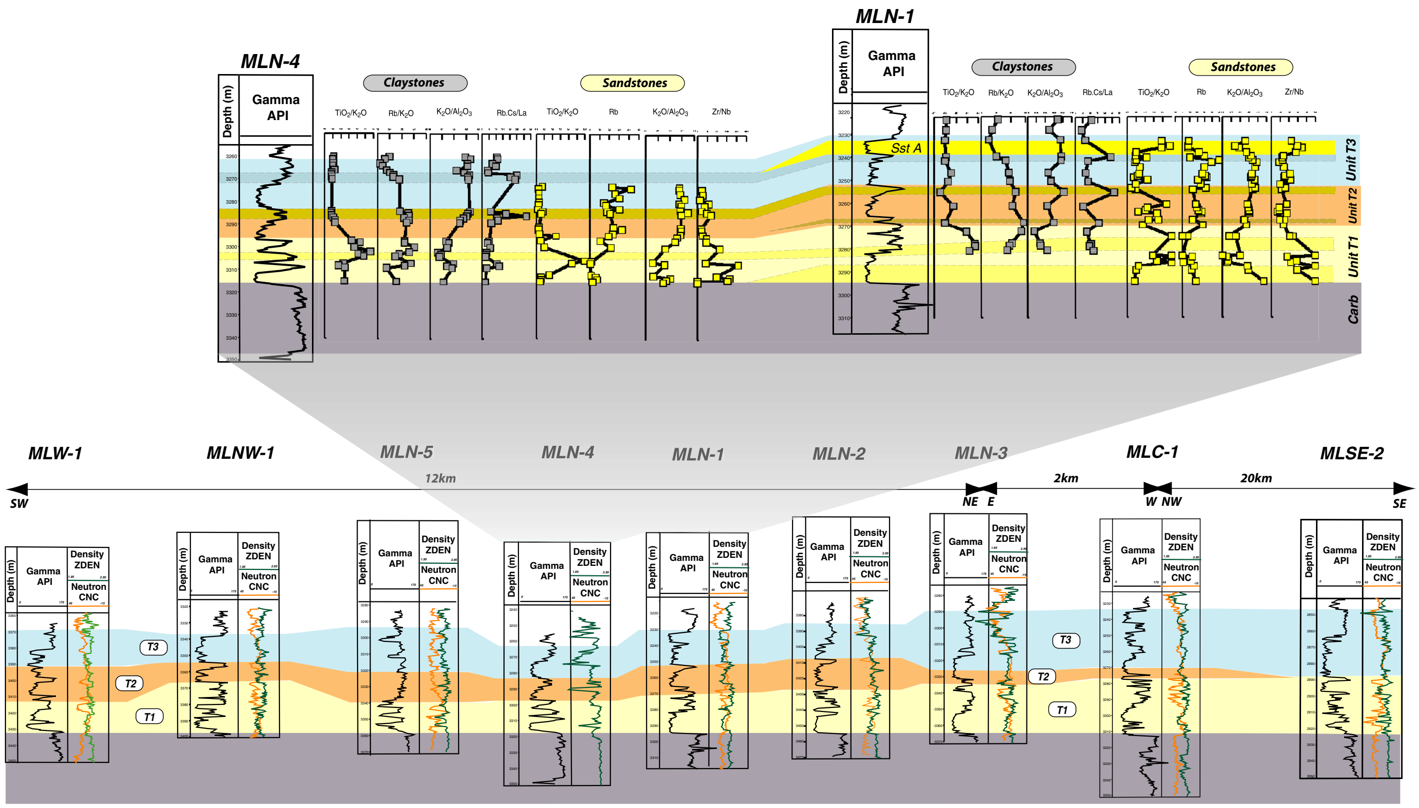

Figure 2. Geochemical correlation. The lower panel shows the regional three-fold correlation and the upper displays the detailed correlation available from closely spaced wells.

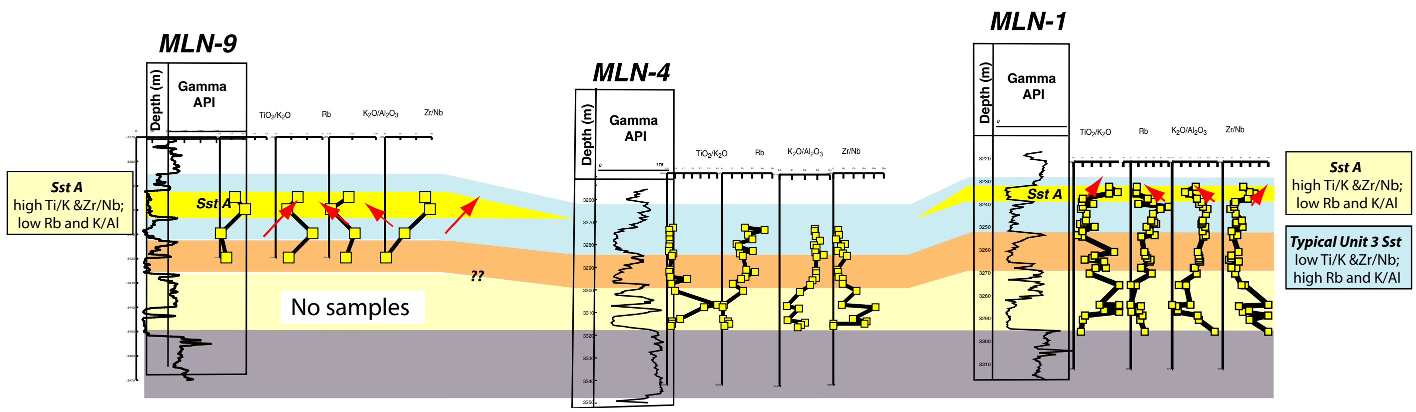

Figure 3. Sandstone geochemical data for selected MLN wells chosen to display the distinctive geochemical character of Sandstone A in well MLN-1 and the similarity of the blocky sandstone encountered at the top of the TAG-I in well MLN-9.