Cretaceous Napo U and Napo T Sandstone Channels Accommodation Space Created by Erosion and Tectonism, Exploration and Development Implications on Western Ecuadorian Oriente Basin*

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Abstract

A regional evaluation of Cretaceous Napo U and Napo T Sandstones channels petroleum reservoirs, in the central and western Ecuadorian Oriente Basin, based on sequence stratigraphy analysis, has been performed by integrating well logs, core descriptions and seismic data information. This regional evaluation has allowed the identification of main mechanisms that created accommodation spaces of Napo U Sandstone and Napo T Sandstone channels across the western and central Oriente Basin. Detail sequence stratigraphic analysis, depositional setting evaluations and facies analysis from different oilfields like Coca Payamino, Paraiso, Huachito, Inchi, MDC, Sacha, Shushufindi, Auca, Cononaco, etc., has helped to identify and explain that accommodation spaces were created by tectonic and erosive mechanisms working on the depositional timing over different areas on the western and central Ecuadorian Oriente Basin.

Petroleum producing reservoirs in the Ecuadorian Oriente Basin occur in the Lower to Middle Cretaceous Hollin Sandstone, the Middle to Upper Cretaceous Napo Formation and the Upper Cretaceous/Paleocene Basal Tena Sandstone. Significant differences in sandstone deposition and sand bodies geometries are quite evident between reservoirs within the Hollin Sandstone and those in the Napo Formation. The Cretaceous Napo Formation (Cenomanian to Campanian) in the Ecuadorian Oriente Basin consists of shales, sandstones and limestones, whose deposition and distribution were significantly controlled by relative sea level changes, and minor extensional tectonic activity. Cyclic Napo deposits have been subdivided on four sequence stratigraphic intervals separated by erosional sequences boundaries. Eustatic sea level drops are acknowledged to be responsible for the creation of those erosional surfaces within the Napo Formation.

The Cretaceous Napo T and Napo U Sandstone reservoirs cannot be image out of seismic data since channels sandstone thickness are below seismic vertical resolution. The Napo T and Napo U Sandstone reservoir stratigraphy unit starts up with an erosional base, locally having basal lag facies documented on core descriptions (Payamino, Oso, Auca, MDC). Estuarine channel sandstones grade upwards to tidal and to shallow marine facies, and all those facies are capped by carbonate deposits, which represent maximum flooding units. Each carbonate unit have a related seismic reflection which can be mapped out confidently across the Oriente Basin. There are three carbonate/seismic reflection marker

units, namely A Limestone, B Limestone and C Limestone. The Napo T reservoir Unit is encased between C and B Limestone, and Napo U reservoir Unit is encased between B and A Limestone seismic marker.

Stratigraphic well log correlations at oilfield scale, whenever flattened at A or B Limestone marker show that channel sandstone thickness varies laterally, from about 50 feet to none. The channel sand thickness development has a direct correlation to time interval increment between A and B seismic markers, which can be seen on both isochron maps of seismic events and stratigraphic well log correlations. The described seismic time interval increment related to sand channel thickening is indicative that the accommodation spaces to preserve the channel sand reservoir units were created by a minor extensional tectonic regime, working at reservoirs depositional timing. Additionally, erosion with residual basal lags has also been documented on core data from different oilfields.

Generally, southwards of present-day Napo River, erosion was the main mechanism working to create the required accommodation spaces to preserve the Napo U and Napo T Sandstone channels. As oppose to that event, to the north of Napo River, an extensional tectonic event was the main mechanism to develop the accommodation spaces for Napo U Sandstone channels. The geological models of different oilfields are compared against published models highlighting hard data that supports interpretations and conclusions. The regional evaluation and geological modelling of Napo U and Napo T Sandstone reservoirs depositional setting is a key tool on both exploration and development projects. Understanding the geological evolution and patterns that created accommodation spaces for sandy channels helped to develop indirect mapping technique of reservoir areal distributions, since those reservoirs cannot be reliable image from seismic data due to limited thickness and vertical seismic resolution. That indirect mapping technic approach has been successfully applied to both exploration and development projects, including secondary recovery by water flooding for some oilfields in the western Ecuadorian Oriente Basin.

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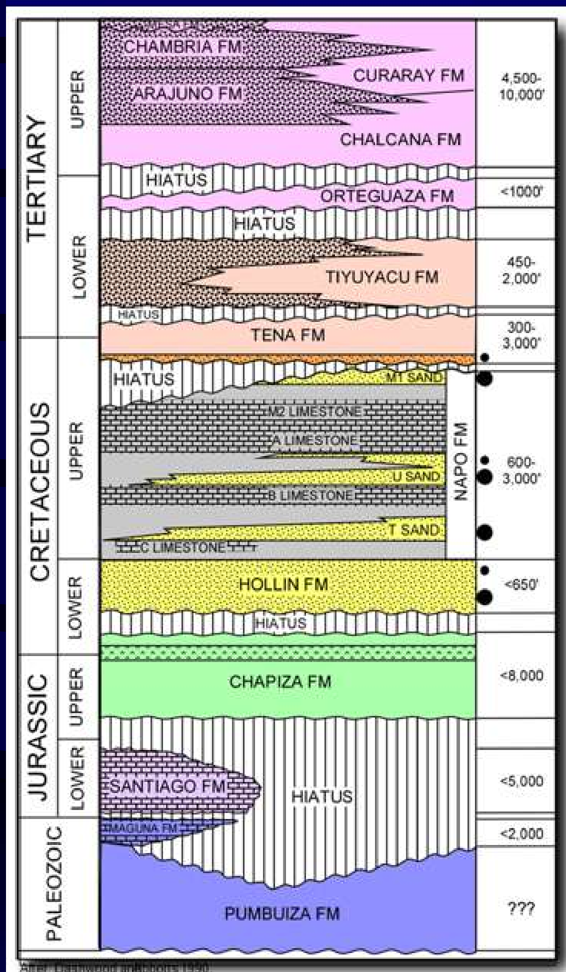
Cretaceous Napo U and Napo T Sandstone Channels Accommodation Space Created by Erosion and Tectonism, Exploration and Development Implications on Western Ecuadorian Oriente Basin

Felix A. Ramirez

Poster Session Theme 1: Siliciclastic Systems

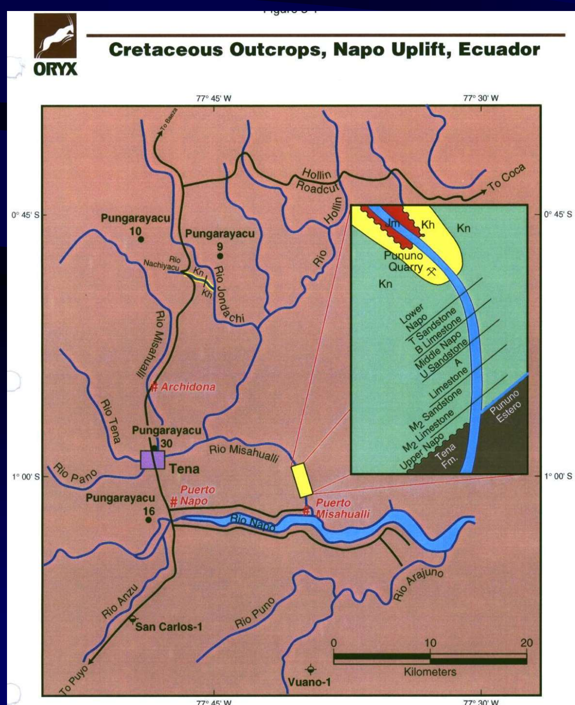
Putumayo-Oriente-Marañon Basin

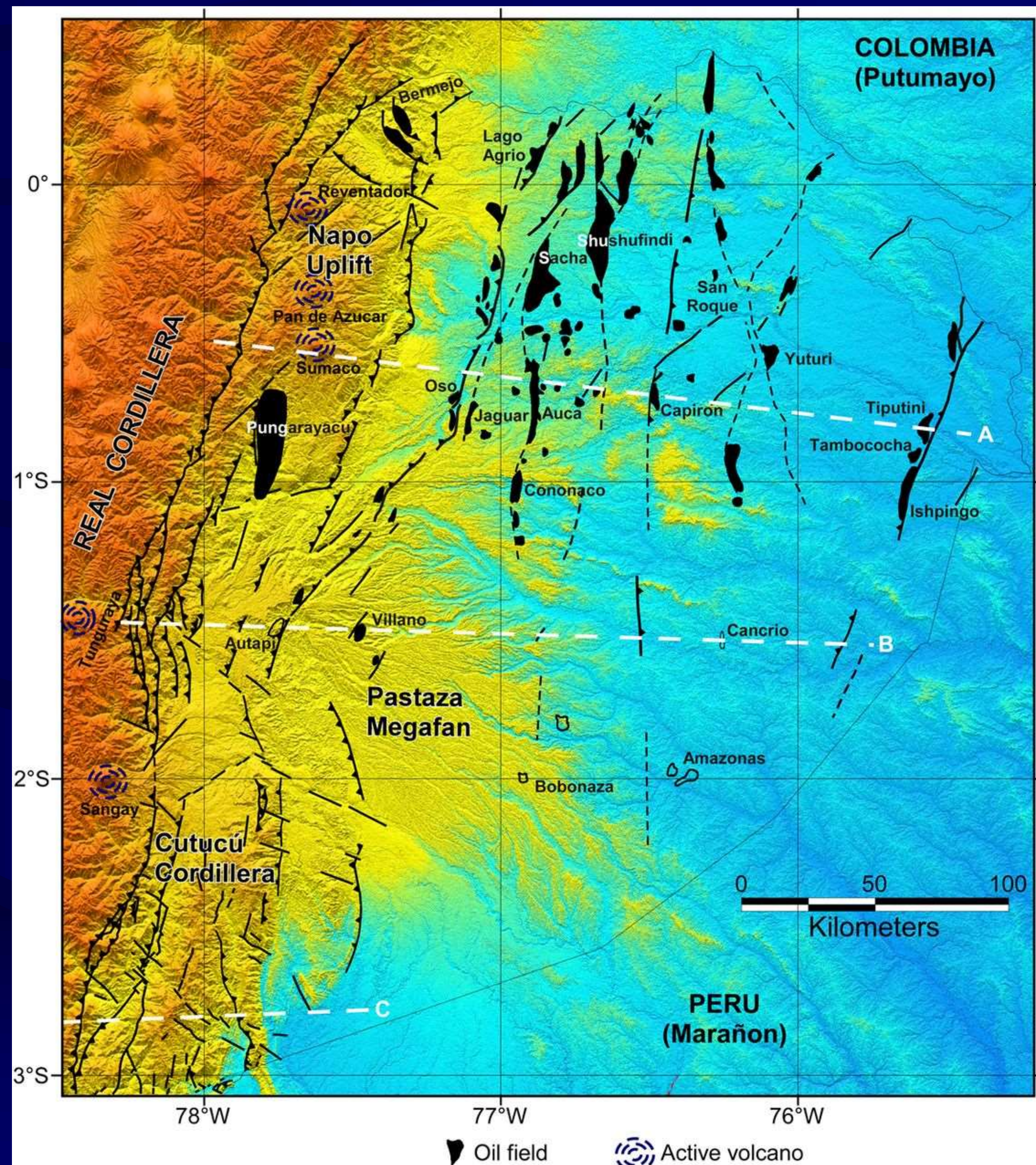


The Putumayo-Oriente-Marañon Basin encompasses about 320000 km2. First oil discovery was made in Putumayo on 1963, although exploration begun on 1920'. Ecuadorian Oriente Basin has produced over 6 billion barrels of oil from Cretaceous clastic reservoirs.

Oriente Basin and Main Oil Producing Fields

The regional study includes well log correlation of more than 300 well representing most of oilfields, core data from 40 wells from western and central Oriente, and field study on the Subandean Foothills

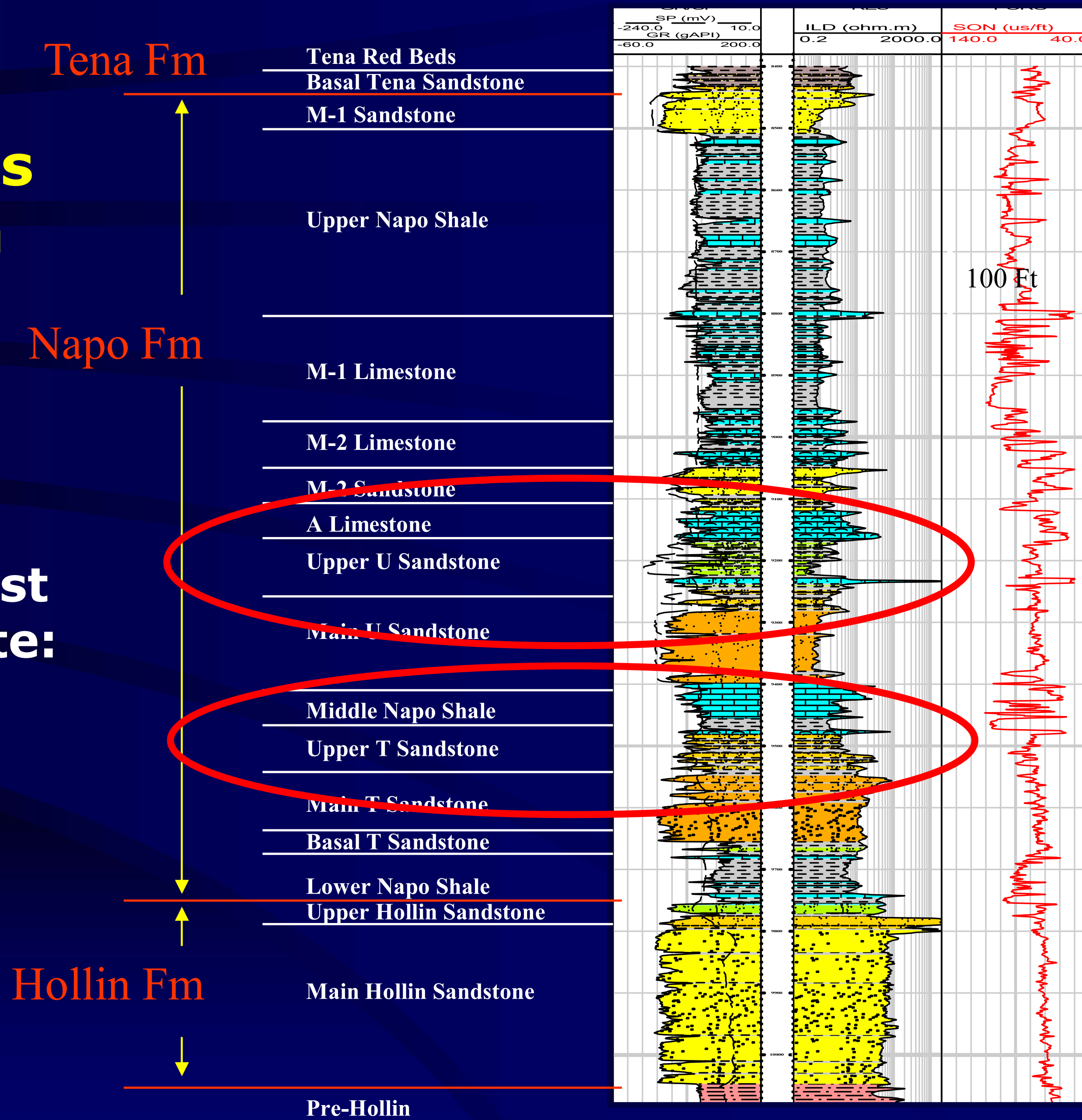




The Cretaceous Oriente Basin Stratigraphy

Exploration & Development Targets in the West and Central Oriente:

Hollin Fm
Napo T
Napo U
Basal Tena



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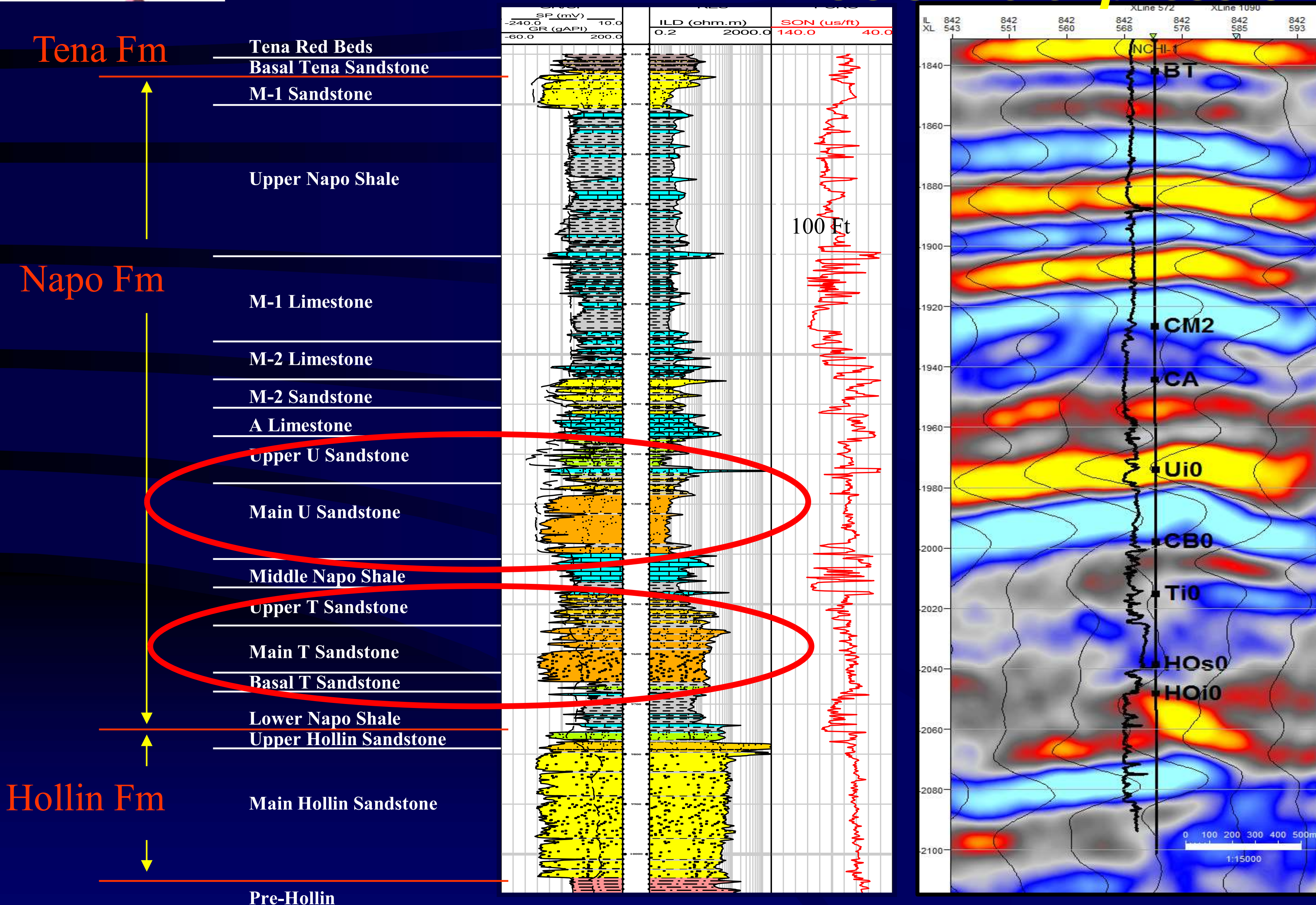
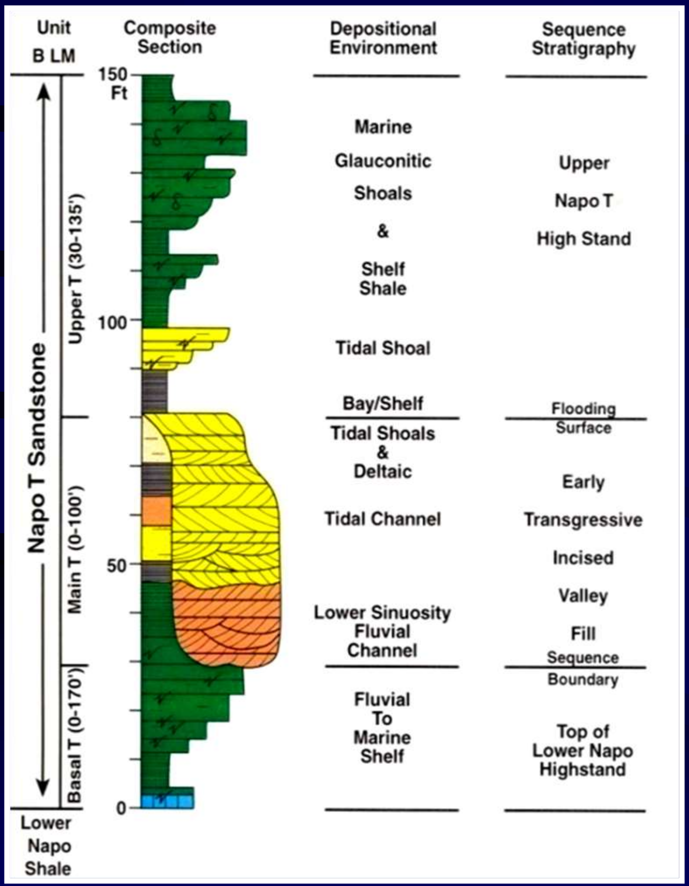
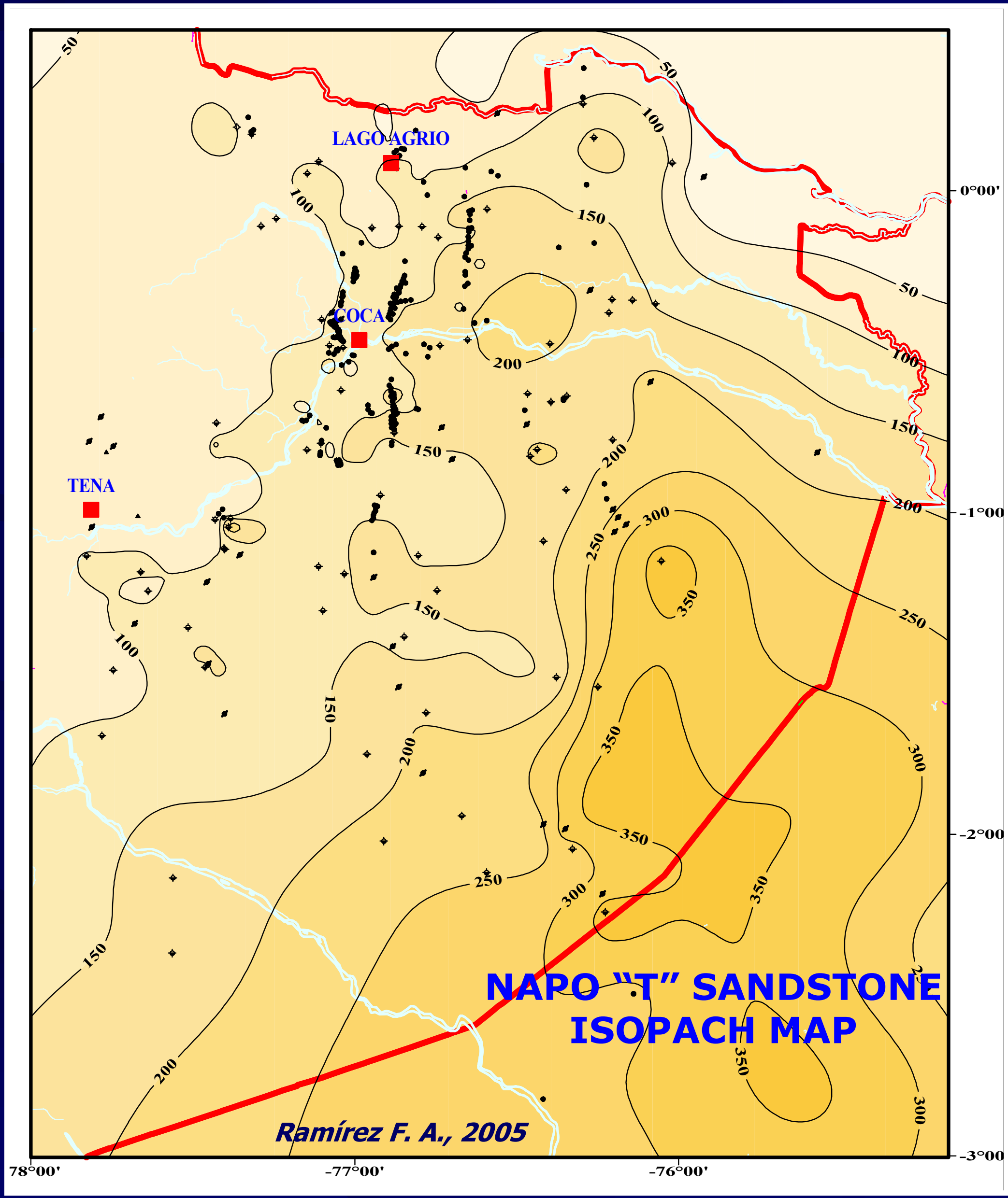
Cretaceous Stratigraphy and Seismic expression



The Napo T Sandstone Regional Model

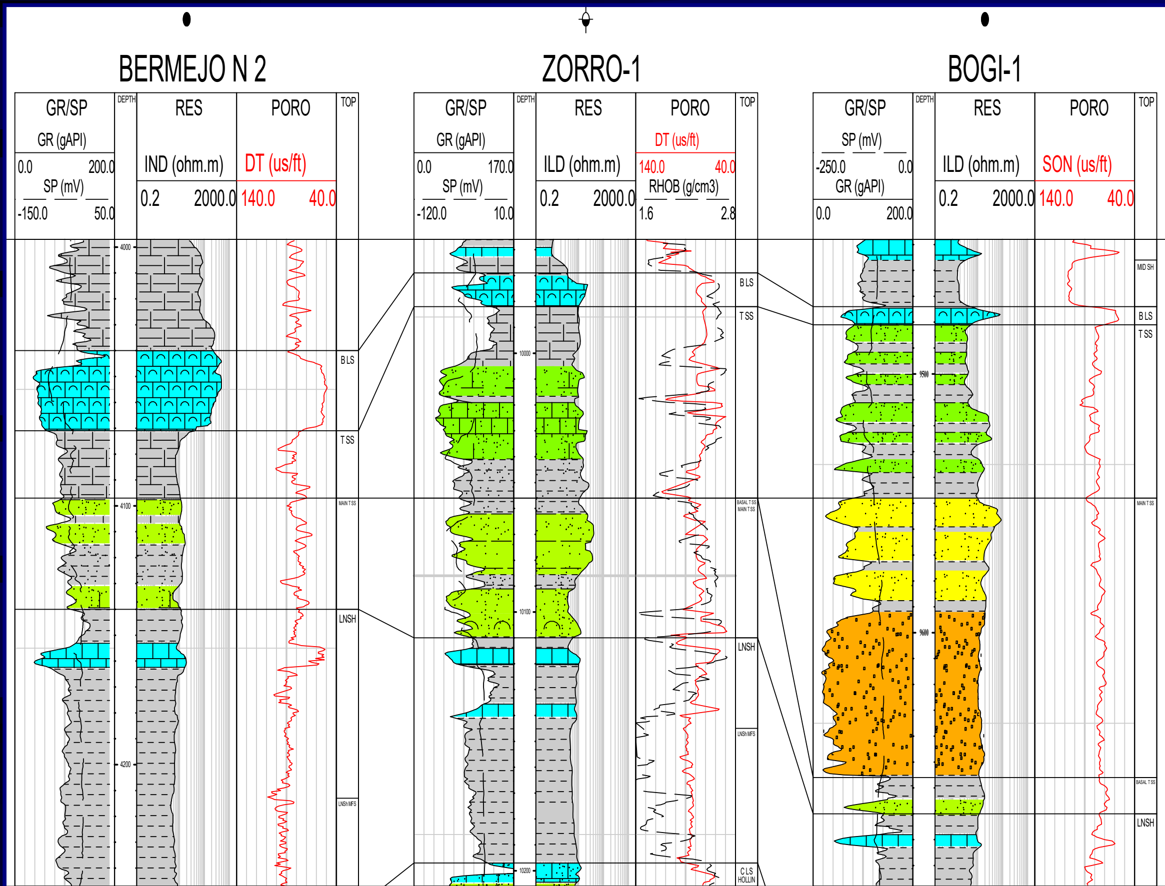


White H & Barragan R., 1997



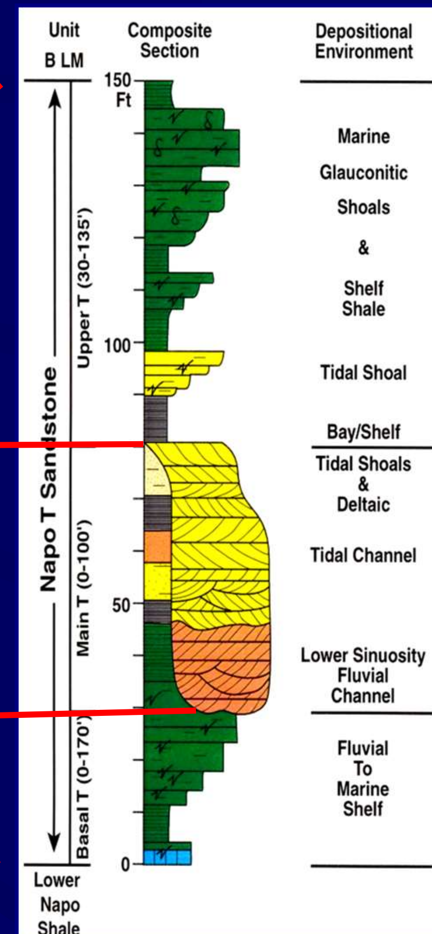
Ramírez F. A., 2005

The Napo T Sandstone Reservoir Model



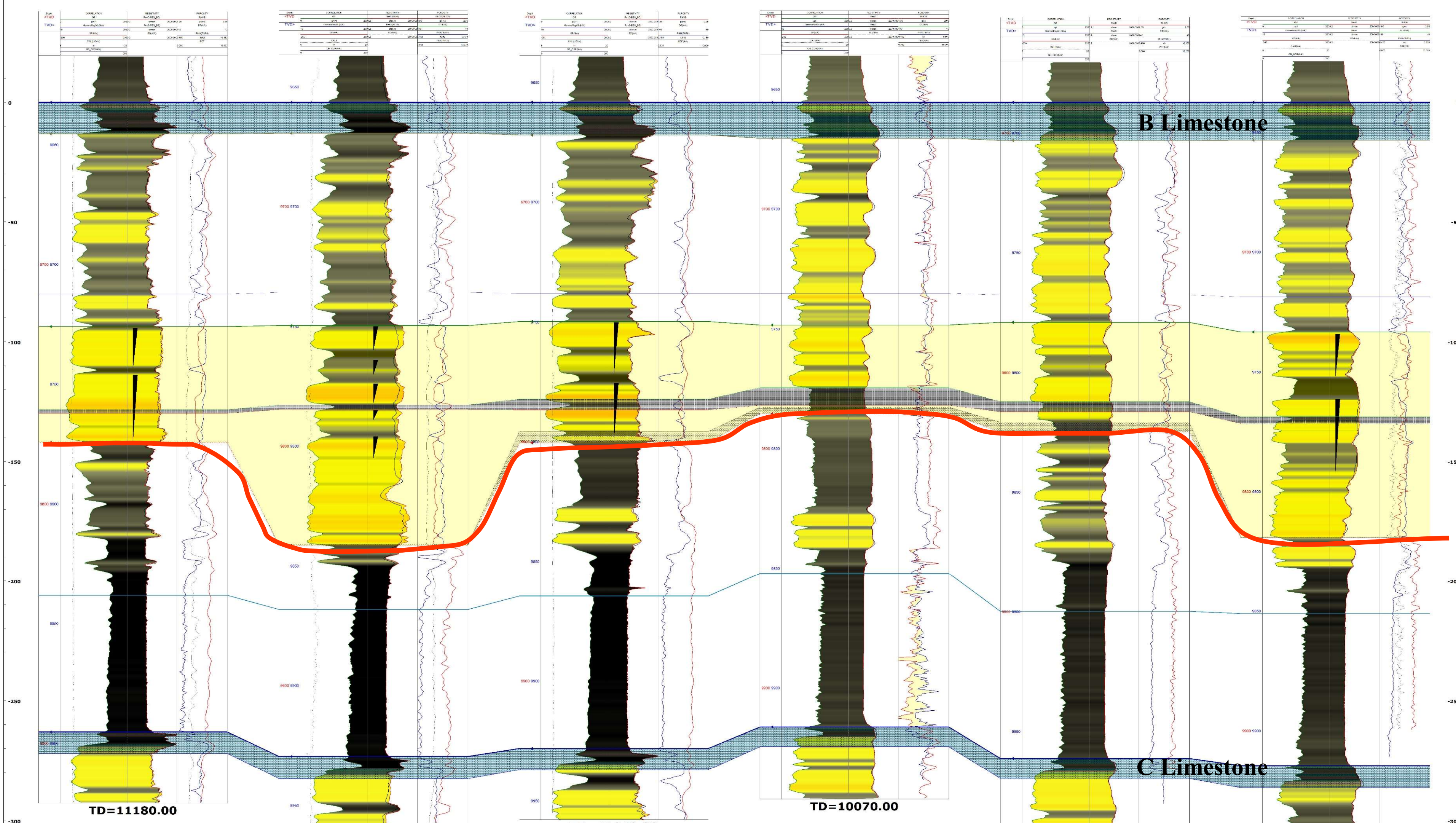
Ramírez F. A. et al , 2005

White H & Barragan R., 1997



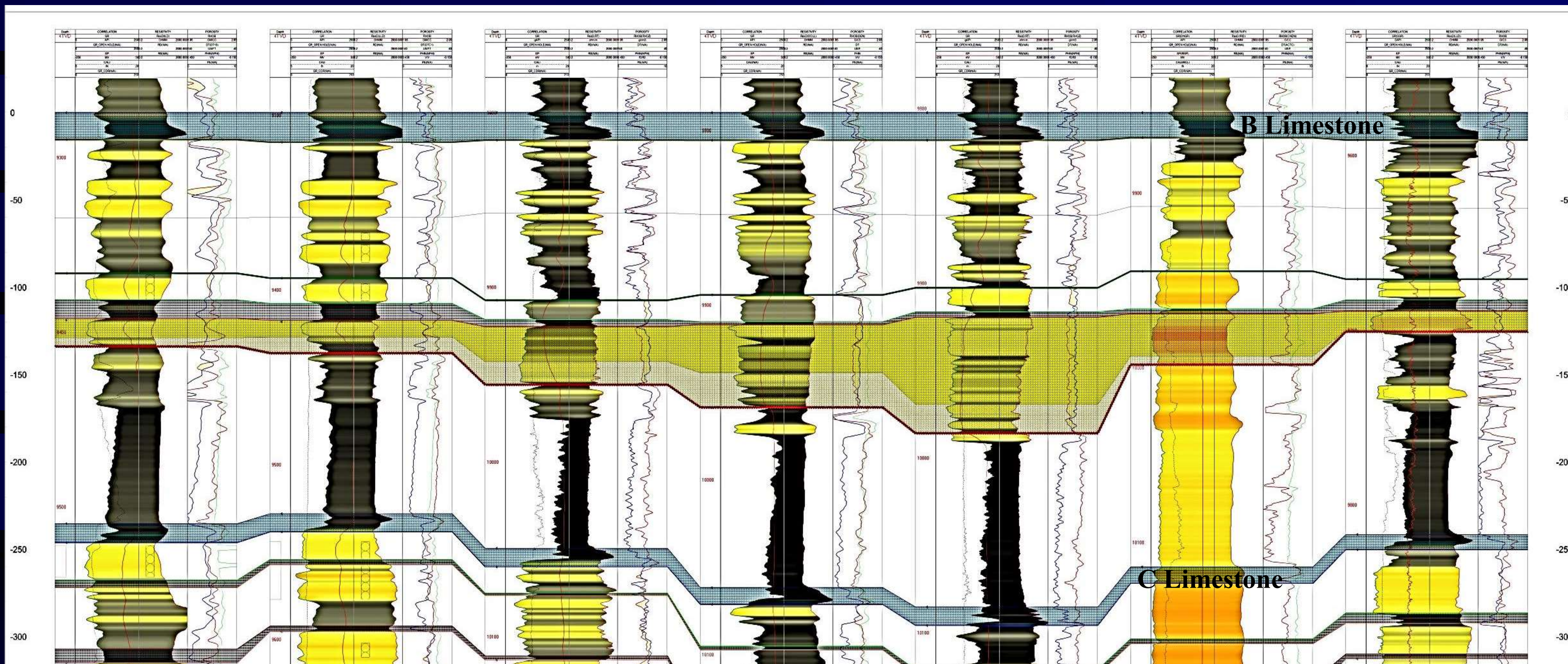
Regional well log correlations, core descriptions and field geology, has allowed to identify three units in the T Sandstone Unit: Basal T, Main or Lower T and Upper T. Each unit show specific facies and lithologies that can be recognized across the Oriente Basin.

The Napo T Sandstone Reservoir in MDC Field



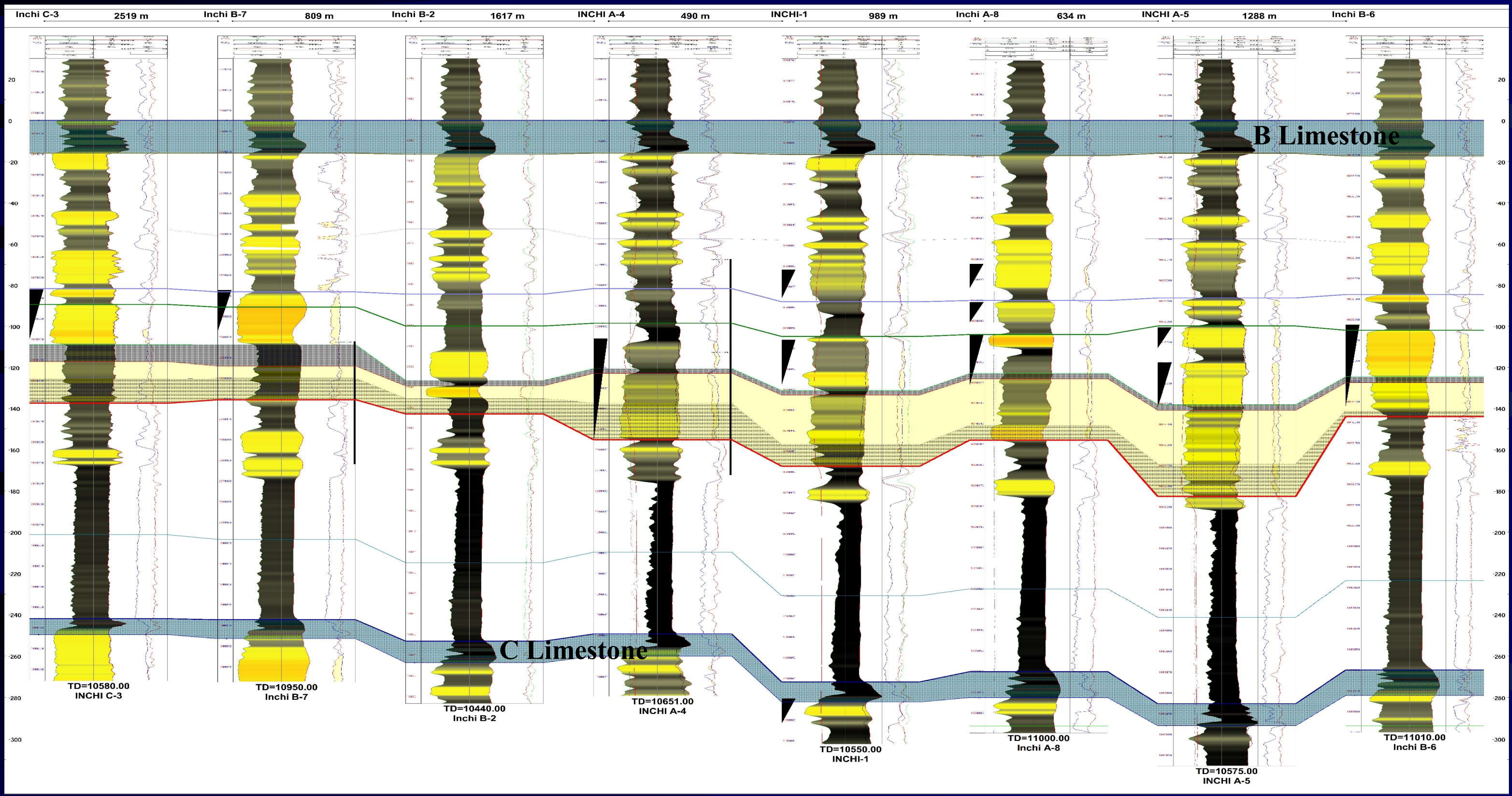
In the Central Oriente Basin, a North-South Napo T Sandstone stratigraphic well log correlation shows that channel development was created by erosion and partial subsidence. Upper T Sandstone shows quartz-glauconitic bars.

Napo T Sandstone Reservoir along Paraiso, Inchi and Sacha Fields



A regional West-East Napo T Sandstone stratigraphic well log correlation running west to east across Paraiso, Inchi and Sacha Fields clearly shows the lateral thickness variation. The A to B Limestones thickness increases related to the Main T Sand channel development, indicating that tectonic subsidence was the main mechanism to create the accommodation space to preserve sand channels.

Napo T Sandstone Reservoir in Inchi Field



Inchi Field, a stratigraphic play, since no structural closure can be identified (structural nose) shows that the sand channel development is related to mainly tectonic subsidence.

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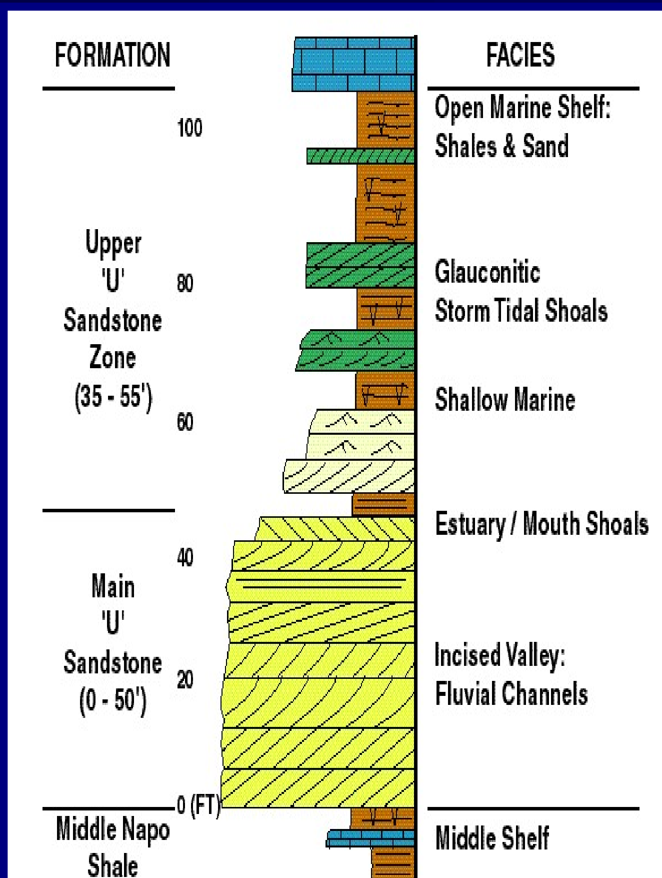
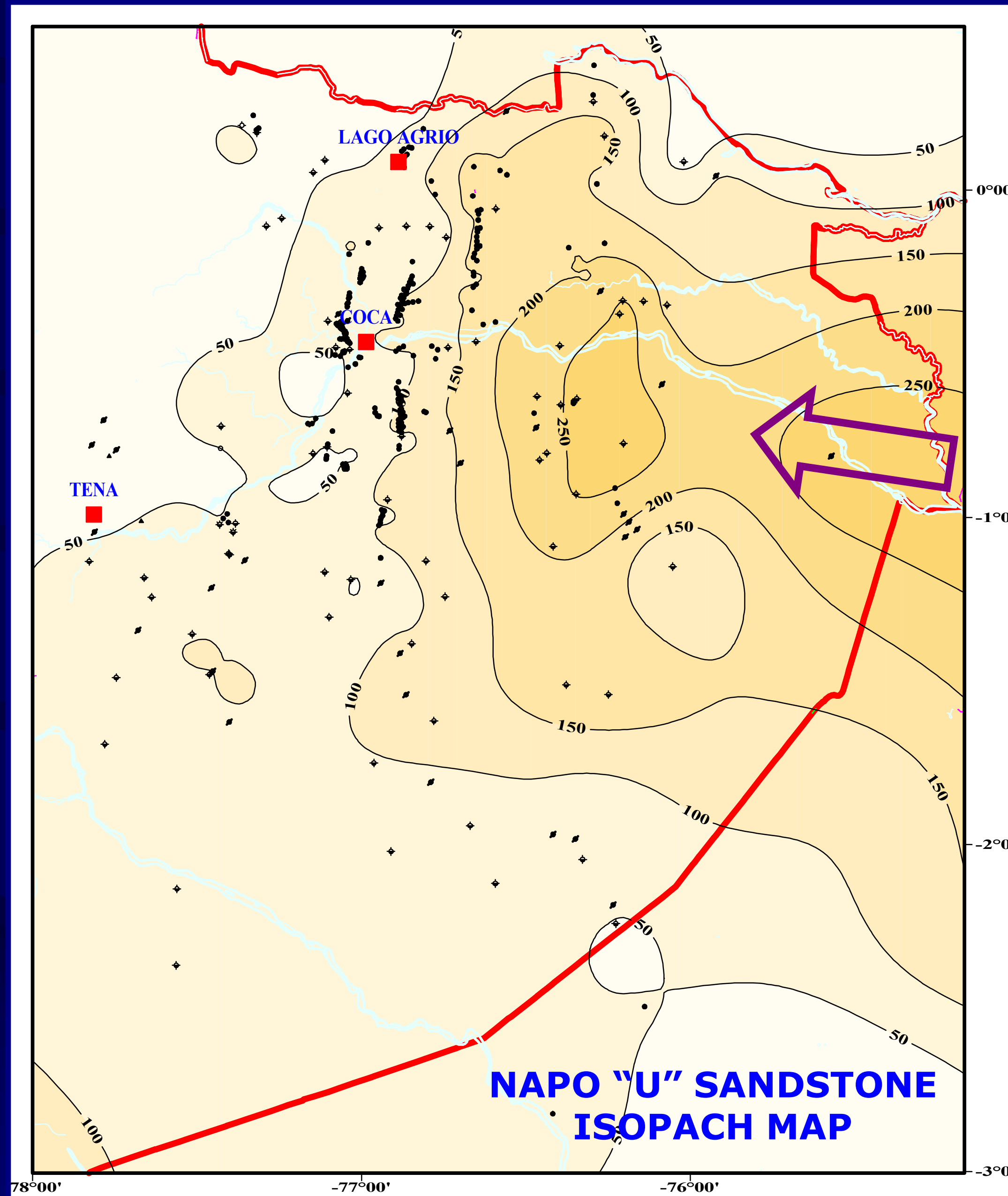
The Napo U Sandstone Reservoir Model



Ramírez F. A. et al, 2005



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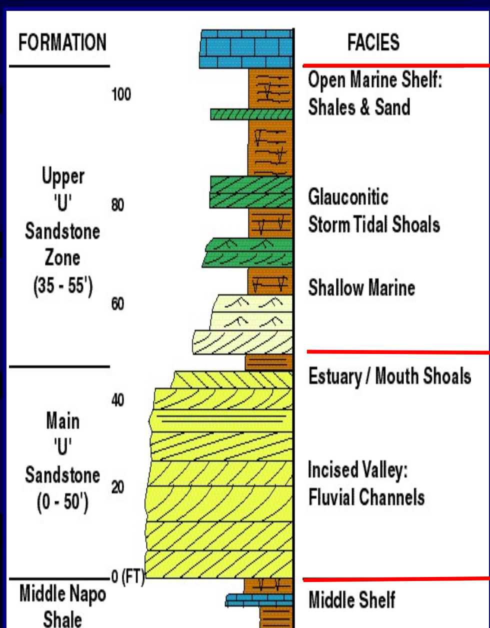
The Napo U Sandstone Reservoir Model



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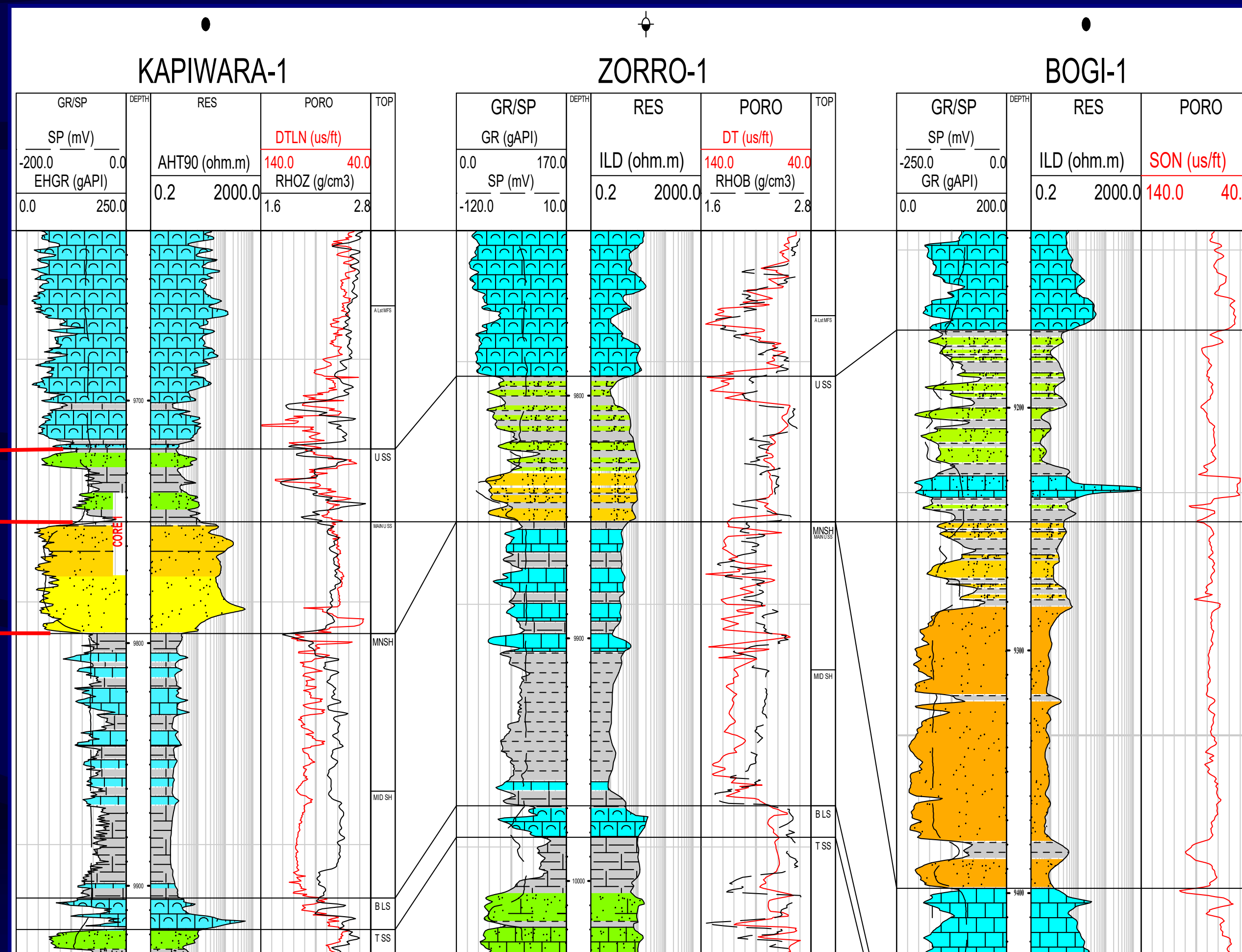
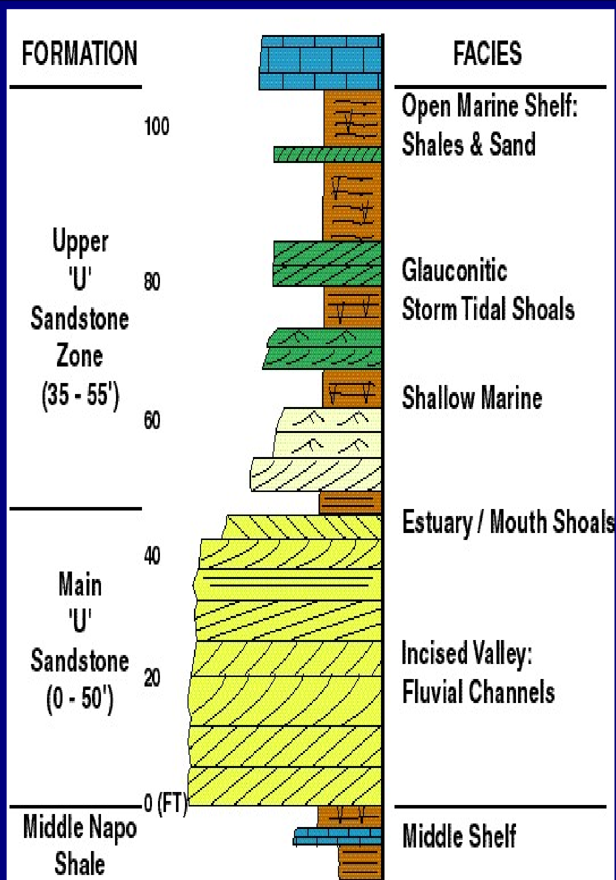


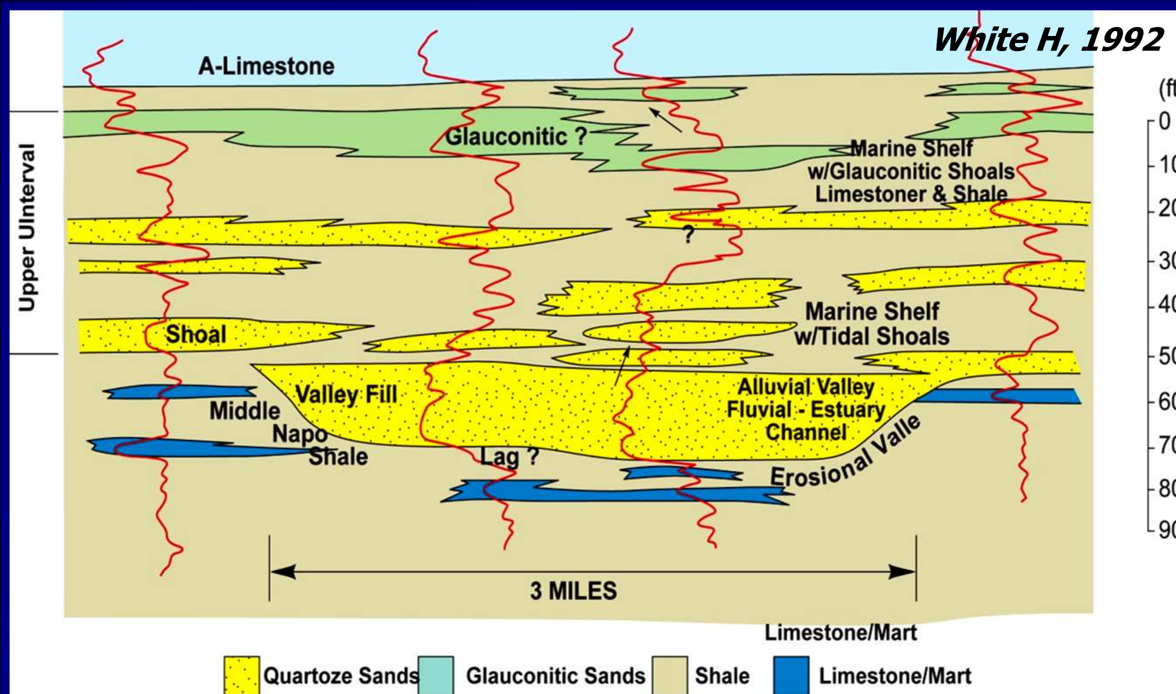
The model presented applies mainly to the western Oriente Basin since to the east the Napo Main U Sandstone consist mainly of alluvial plain facies (Ramírez F. A. et al, 2005).

The Napo U Sandstone Reservoir Model

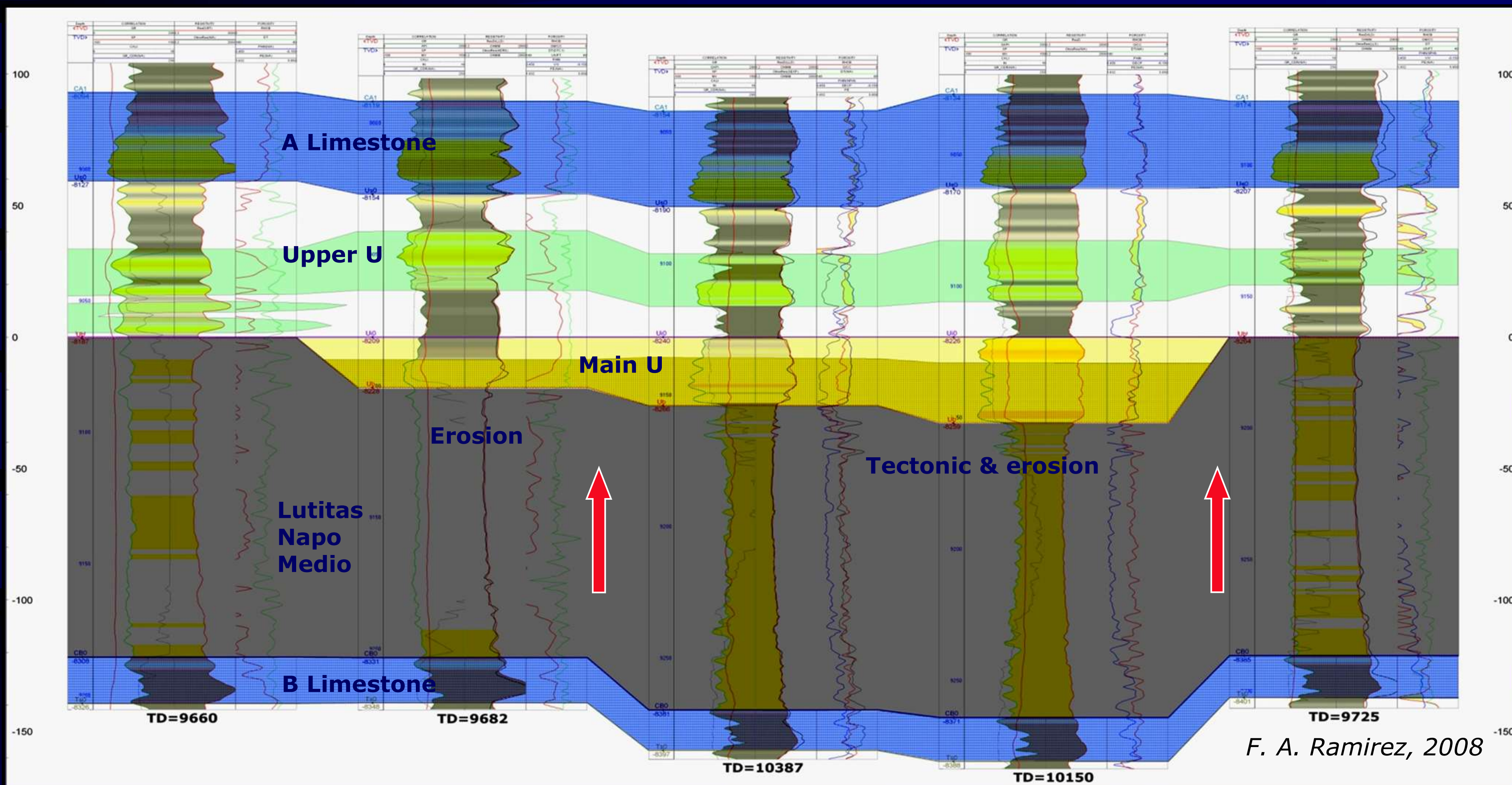
The display model mainly applies to the western Oriente Basin since to the east the Main U Sandstone consists of alluvial plain facies



Ramírez F. A. et al, 2005



The Napo U Sandstone Reservoir Model in Coca, Huachito and Paraiso wells



Similar models were later generated for other fields like Huachito, where erosion was combined with tectonic subsidence to generate the space to accommodate the sand channels. The stratigraphic well log correlation shows that sand channel development is related to thickness incremental between the two flooding markers, A and B Limestone.

The Napo U Sandstone Reservoir Core Description

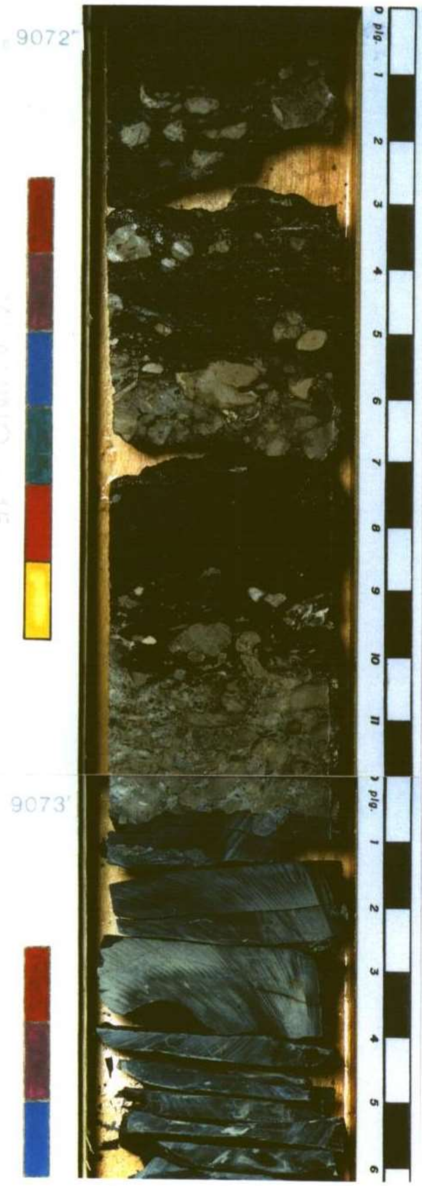


Plate 5-6.

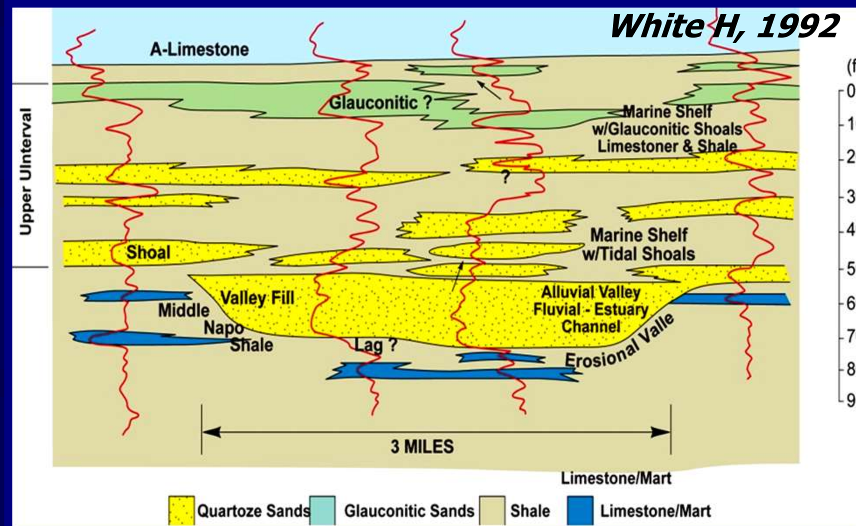
Payamino-15
Napo U Sandstone
Core Photo: 9072' - 9073.5'

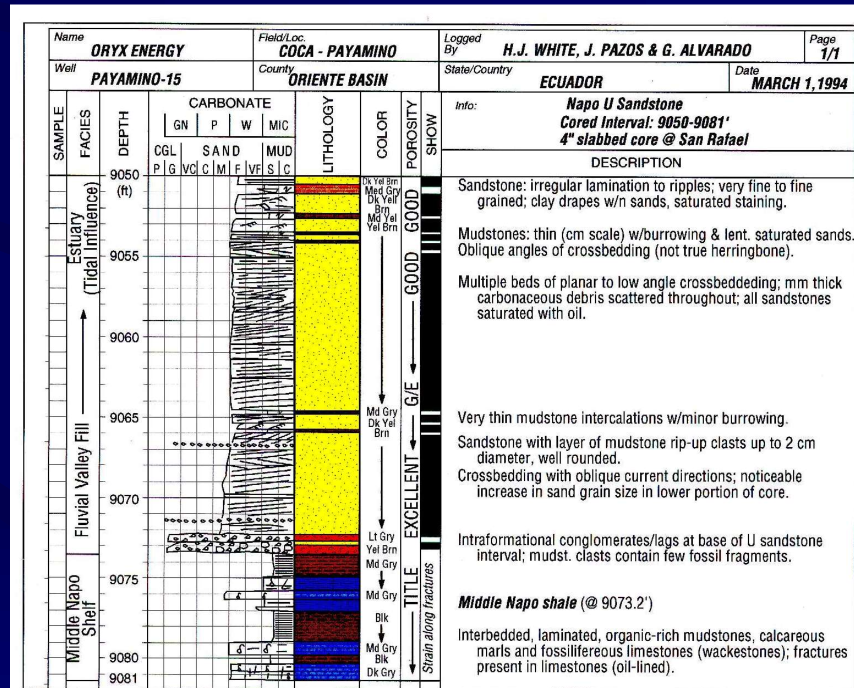
Selected core photographs of the Payamino-15 cored interval (courtesy of Petroecuador's Core Analysis Group) are shown here and on the following three pages. The photos were taken of the slabbed core at Petroecuador's facility in San Rafel.

This view exhibits the basal contact of the Lower U Sandstone overlying the Middle Napo Shale. The Middle Napo consists of laminated, calcareous mudstone and thin to thick interbeds of fossiliferous limestone (wackestone). The contact with the U Sandstone is erosional as is evidenced by the presence of basal, rip-up clast lag at the base of the U Sandstone. These clasts, up to three centimeters in diameter, were derived from updip erosion of the Middle Napo Shale. The rounded clasts are generally calcareous mudstone which occasionally contain fossil (mollusk) debris. Note that the basal foot of the U Sandstone, shown here, contains several thin layers of the lag conglomerate suggesting episodic deposition above the erosional contact.

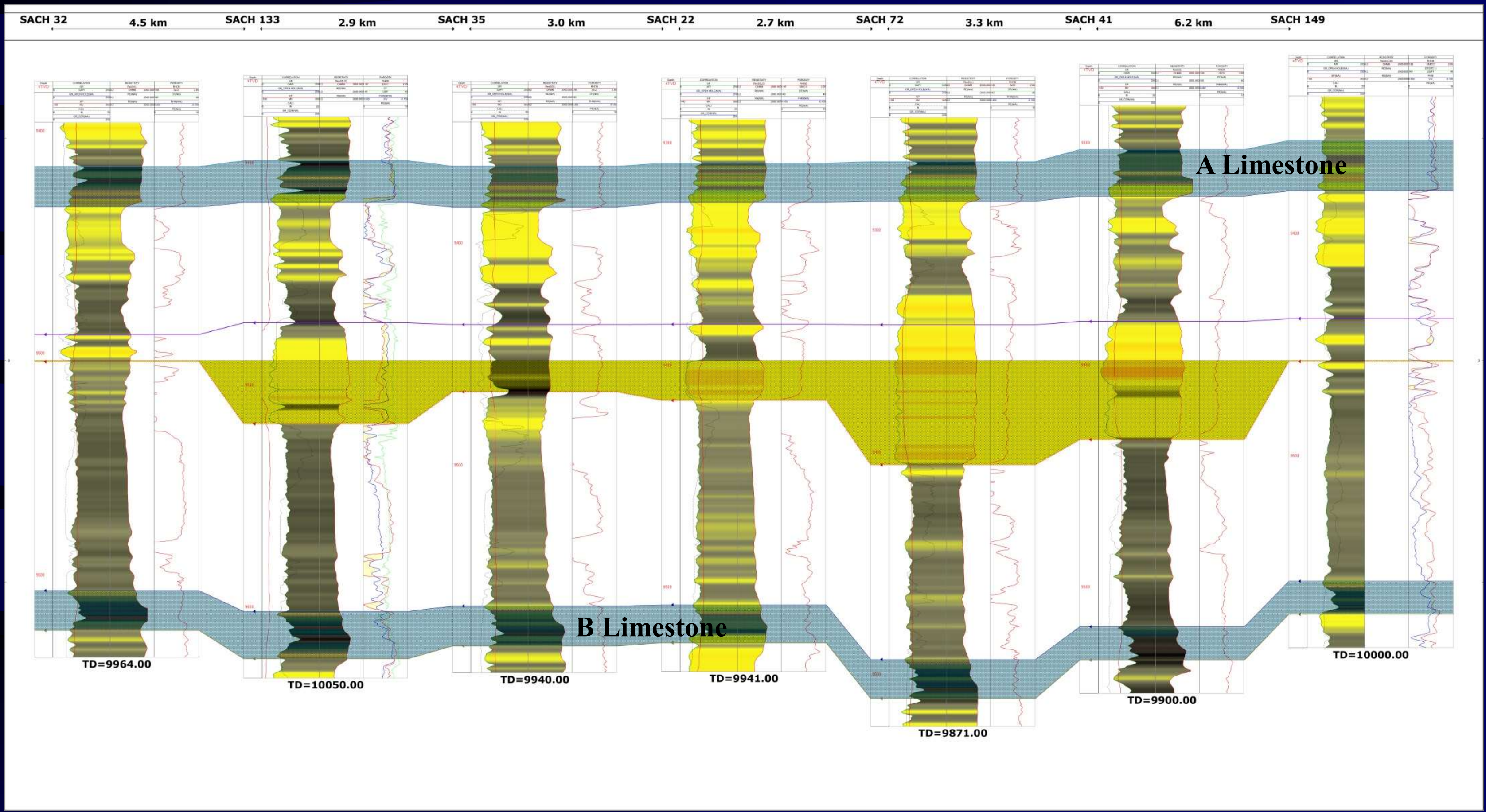
The saturated sandstone hosting the conglomeratic lags is medium to fine grained quartz. These beds in the basal portion of the cored interval show planar to trough cross-bedding and frequent erosional cut and fill contacts. This low degree of bedforms preservation is commonly associated with sand-rich estuary deposits such as are present in the Payamino area of northern Block 7.

Ramírez F. A. et al, 2005



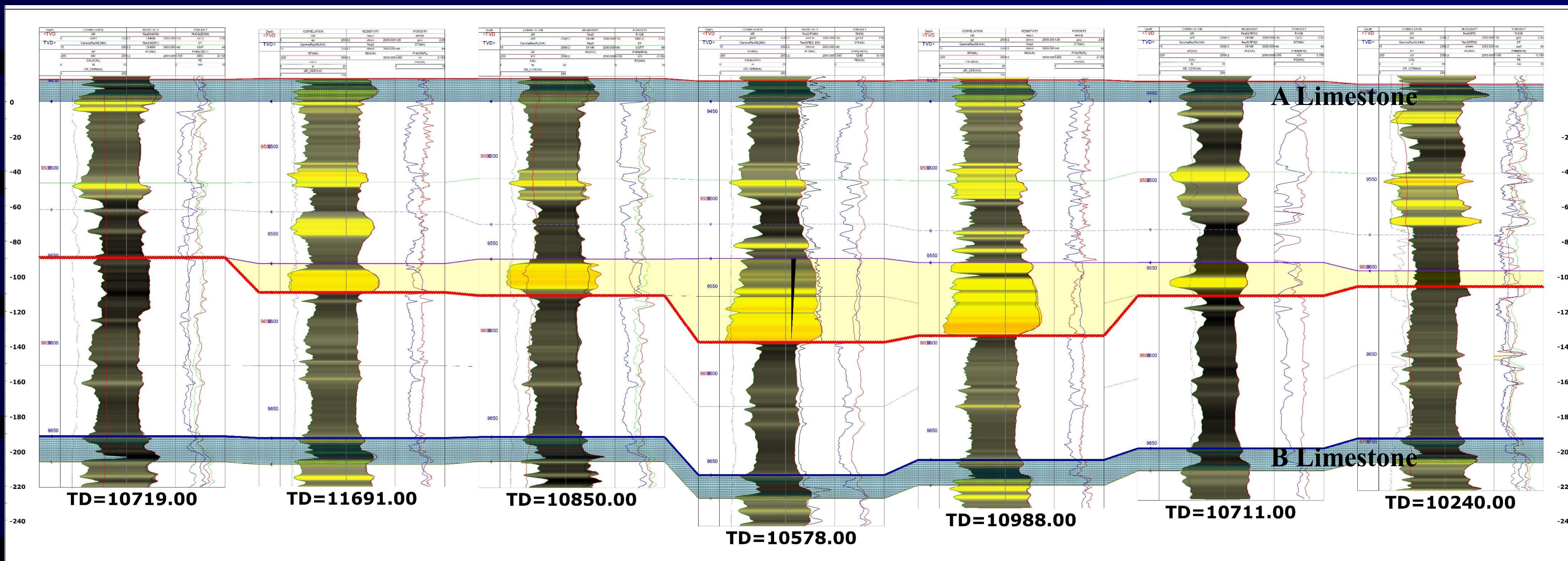


The Napo U Sandstone Reservoir in Sacha Field



Another example is presented in a North – South stratigraphic well log correlation along Sacha Field, which shows that channel development was created by a combination of tectonic subsidence and partial erosion. A NW-SE fault system generated the accommodation space which preserved sandy facies of Napo U channels.

The Napo U Sandstone Reservoir in Sacha, MDC and Paka Norte Field



Further to the east, a regional West – East stratigraphic well log correlation across Sacha-MDC-Paka Norte Fields shows that channel development was created by a combination of tectonic subsidence and partial erosion. A NW-SE fault system generated the accommodation space which preserved sandy facies of Napo U channels. Upper U Sandstone shows quartz-glauconitic bars.

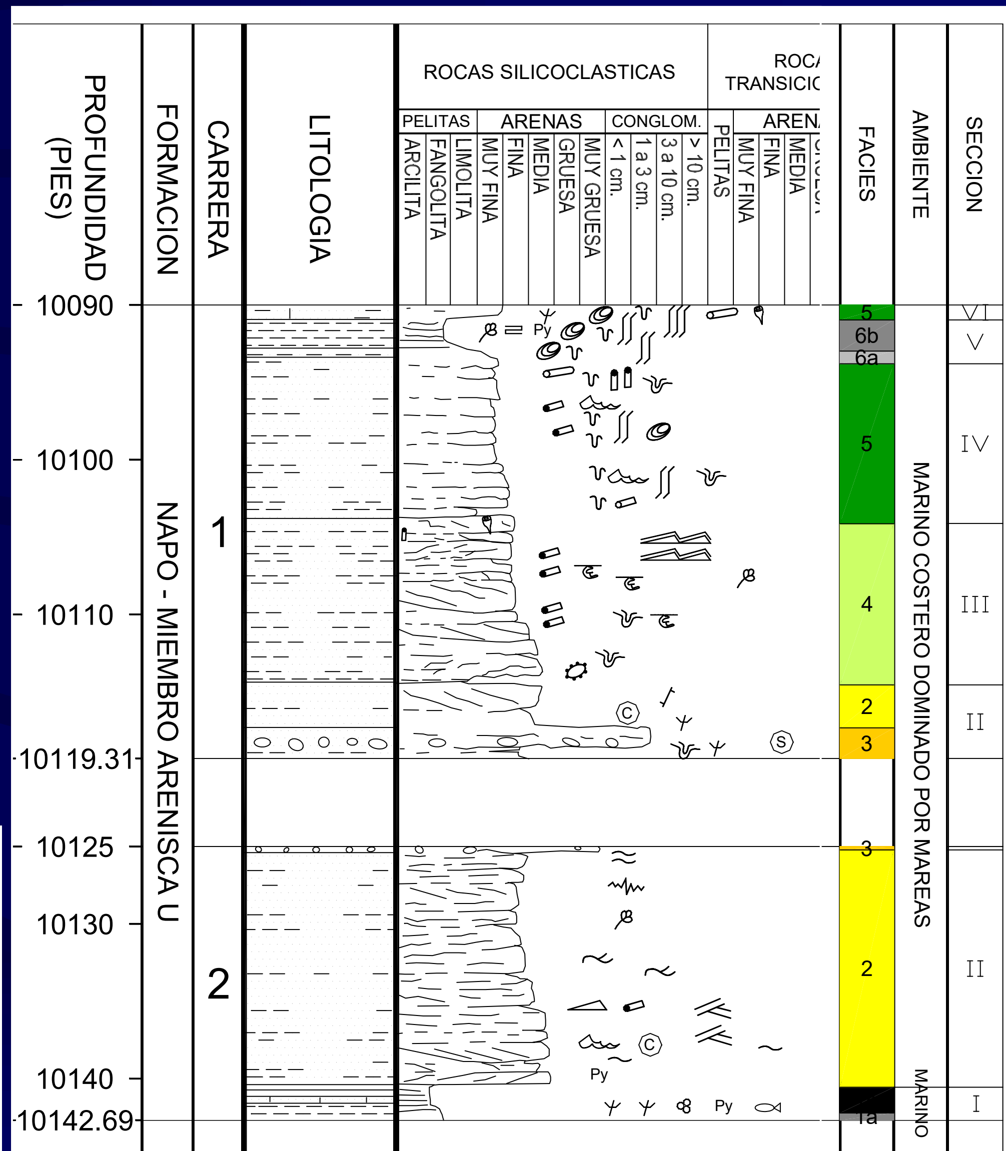
L C V

The Napo U Sandstone Reservoir Core description from MDC Well

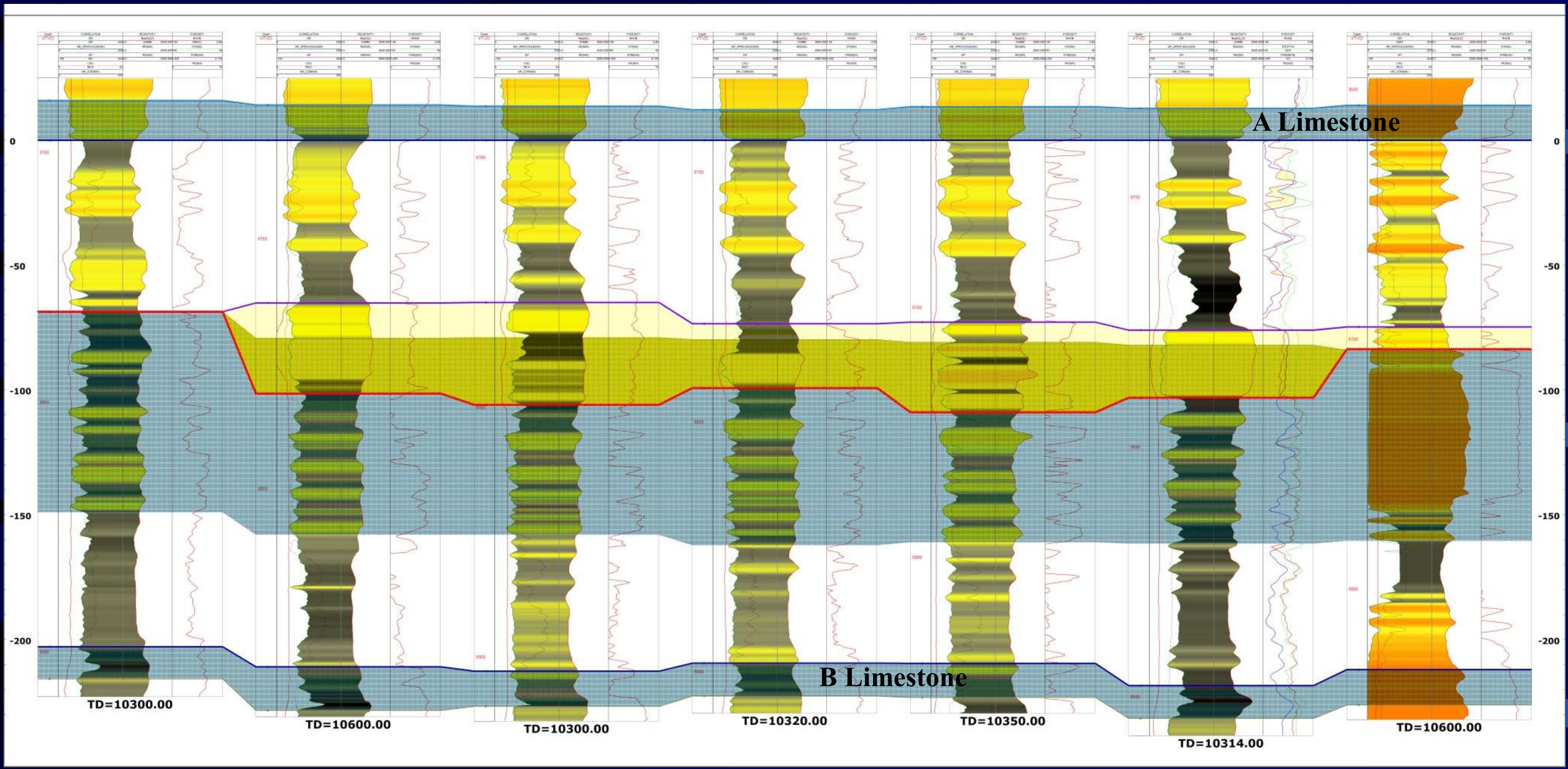
MDC Cores #1 y 2 U Sandstone

FACIES	DESCRIPCION
facies 1a	Pelitas con bioclastos
facies 1b	Pelitas negras
facies 2	Areniscas entrecruzadas con escasas intercalaciones pelíticas
facies 3	Areniscas con clastos de siderita
facies 4	Areniscas con intercalaciones heterolíticas
facies 5	Areniscas finas y pelitas bioturbadas
facies 6a	Pelitas y areniscas bioturbadas
facies 6b	Pelitas laminadas

LCV

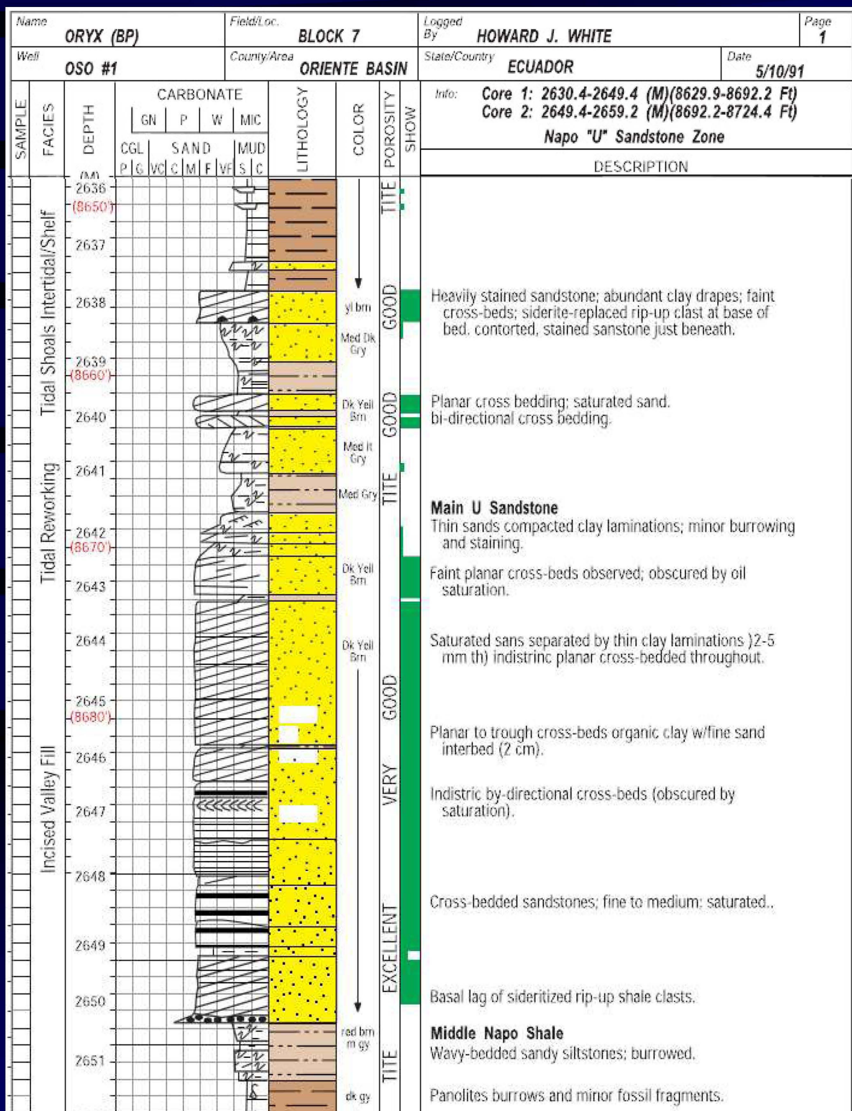


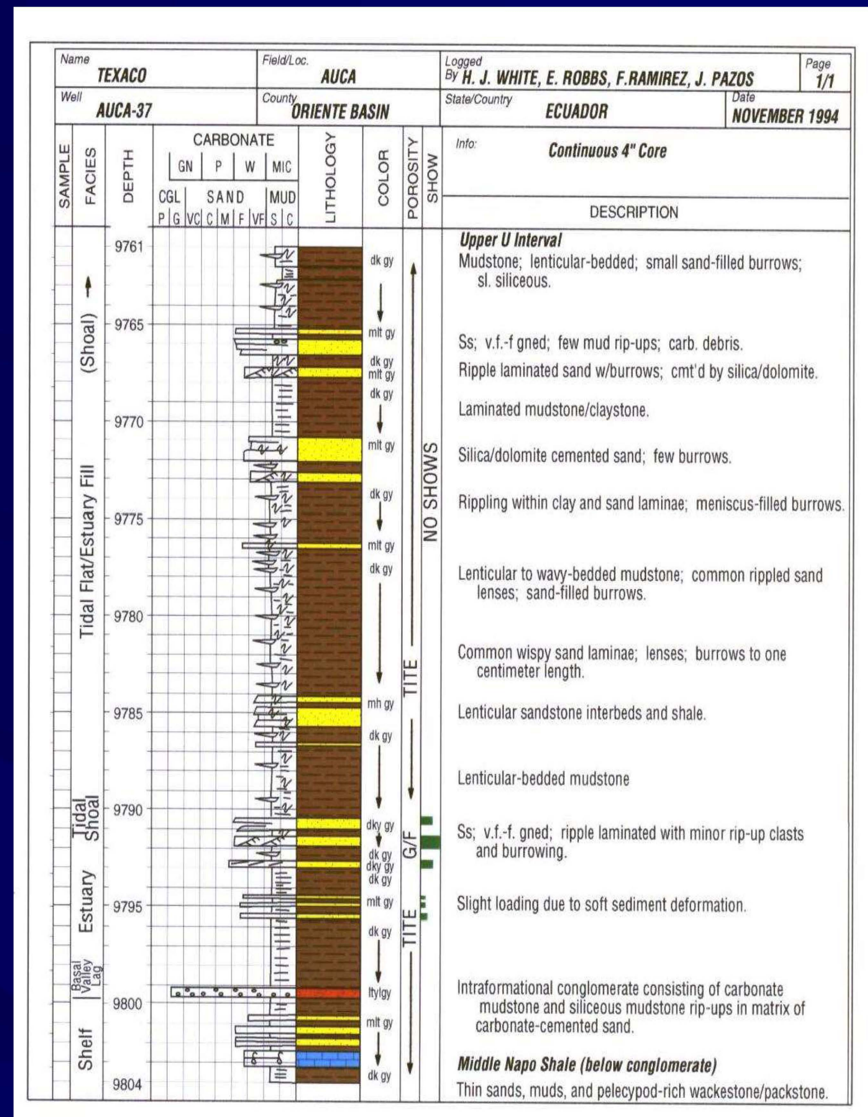
The Napo U Sandstone Reservoir in Auca Field



Southwards from present day Napo River, a North – South stratigraphic well log correlation along Auca Field shows that channel development was created by erosion and minor subsidence. A NW-SE fault system generated the accommodation space which preserved sandy facies of Napo U channels. Upper U Sandstone shows quartz-glauconitic shoals.

The Napo U Sandstone Reservoir Core description from Oso and Auca Wells





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Speaker/FELIX A. RAMIREZ

Petroleum Geologist - Universidad de Guayaquil – Ecuador, with many years managing both exploration and development projects. Those include planning, contract negotiations, acquisition, processing, and interpretation of 2D and 3D seismic data. Regional geosciences evaluations to prospect generation, prospect ranking; exploration and appraisal well locations to development plan generation.

Geosciences evaluations of exploration and development projects in the Putumayo-Oriente-Marañon Basin; Tumbes-Progreso Basins; Ecuadorian Coastal Basins (Manabi and Esmeraldas-Borbon); Western Desert, Gulf of Suez, and Northeast Nile Delta Basins - Egypt and Anadarko Basin–USA.
Technical training in BP Petroleum Development Ltd, “Field Trips” on England, Black Hills (Dakota, Wyoming-USA), Appalachian Range (USA), Bolivian Andes, Caribbean Coastal Basins (Venezuela and Colombia), Spanish French Pyrenees, etc.
Management training in the School of Business at the Southern Methodist University in Dallas, USA. Project management training in the School of Business at Universidad de San Francisco (Quito) and in the School of Administration at “Pontificia Universidad Catholica de Chile”.