The Cuyo Basin

Toward a more efficient model

by Daniel A. Dellapé
Astra CAPSA, Exploration and Production

and A.G. Hegedus
Enterra Oil Field Rental

La versión castellana de este trabajo puede consultarse en las Actas del XII Congreso Geológico Argentino y II Congreso de Exploración de Hidrocarburos 1993 (Tomo III), que se encuentra en la Biblioteca del Instituto.

Considering the incidence of the structural style in the oil accumulations in the Cuyo Basin of Mendoza, the following work "Structural reversion of the Cuyo Basin and its relationship with hydrocarbon accumulations" was prepared, in which the authors have considered some cases where the relationships between stratigraphy and structure are evident. The study is oriented toward the preparation of models that may allow a more efficient development in future exploration and production activities.

Daniel A. Dellapé
is a MSc in Geology, from the La Plata National University. He worked as Senior Geologist in Esso, and as Chief of the Geology Dept. in Bridas, and as Geologist for Pérez Companc at the Piedras Coloradas Field. Presently, he carries out his activities in ASTRA, in the operation that this company has in Venezuela.

Andrés G. Hegedus
is MSc in Geological Sciences from the Buenos Aires National University. He has followed post-grade studies in Reservoir Engineering in the Buenos Aires National University. He developed his professional activities in YPF, in Dowell Schlumberger, in Inei S.A. and in Astra CAPSA Exploration and Production. He is presently Manager of Enterra Oil Field Rental in Neuquén.

*The Cuyo basin in Mendoza covers a depressed area of some 30,000 square kilometers, located between the high blocks of the Andes foothills and the Pampean mountain range. The work carried out during the past 50 years has led to the delimitation of some 15 oilfields. In most of the cases, these fields are controlled by traps in which the structure is essential. It is a series of anticlines and half-anticlines with double dips and ridges with a tendency to a stepped arrangement following three main trends (fig. 1 and also Criado Roque **et al.**, 1959; Turic **et al.**, 1981; Pombo, 1986). Although it is accepted that the faults associated to the closures have also had an important role in the development of traps, there is no general agreement on the fundamental features of the dominant structural style.*

*The traditional interpretation (e.g. Padula, 1972) assumes that the productive structures are associated to large basement blocks, limited by faults with a high angle of eastern convergence. More recent studies, based on a better seismic control (e.g. Turic et al., 1981; Pombo, 1986) claim there is a structurization controlled by faults of a medium to low angle, that involve the basement. According to this model, the main faults would be of the reversed type with eastern vergence, and would present themselves associated with a conjunction of antithetic layovers and transverse conjugate faulting, possibly with a trend displacement. A more recent hypothesis (Legarreta **et al.,** in the printing press), stresses the presence of change in the structural polarity and the existence of a shift in the trajectory of the main faults, and based on these attributes some of the productive structures to a tectonic inversion effect of extension faults, active during the Triassic.*

The area analyzed covers from somewhat to the south of the city of Mendoza, up to the Southernmost portion of the Cacheuta Sub-basin, that is, within the ambit where the oilfields are found.

STRATIGRAPHIC RECORD

*The rocks that conform the substratum of the analyzed area, are sedimentites with a medium to low degree of metamorphism assigned to the **Villavicencio Formation** (Harrington, 1941) and the vulcanites and pyroclastites of the **Choiyoi Group** (Rolleri and Criado Roque, 1968). The latter are closely related to the basement units of the Triassic succession (Kokogian and Mancilla, 1989).*

*The Triassic sedimentites of the basin cover this Paleozoic substrata discordantly and are related to an episode of **rifting**, with block rotation, which allowed the development of pits limited by faults. These fills remained partially isolated during the initial sedimentation stage.*

*This package or **Lower Supersequence** (Kokogian and Mancilla, 1989) in proximal positions, is made up by conglomerates **(Río Mendoza Formation)** formed in the midst of alluvial fans. Toward distal and crest portions, the replacement of accumulated sediments for fluvial and lagoon systems was noted **(Las Cabras Fm.).** These deposits were initially controlled by the subsidence associated to the faulting of the **rift** stage and then by the transition conditions toward the phase of the regional sinking dominated by a thermal subsidence effect.*

*The sedimentation column continues with a succession of units that include the **Higher Supersequence** (Kokogian and Mancilla, 1989) and younger terms that involve layers of the **Potrerillos, Cacheuta, Río Blanco and Barrancas formations**. These units represent the period between the last transition* *stage and the regional sinking stage itself.*

In this case there are fluvial, deltaic-lacunar and lacustrine sedimentites (Kokogian and Mancilla, 1989). These were deposited mostly during the regional sinking stage, where the differential sedimentation had some effect, allowing a large areal distribution and a localized development of the largest sedimentary layers. This aspect had particular relevance on the depositional pattern of the facies rich in organic matter ***(Cacheuta Formation)****, as well as on the distribution of the sandy sediments with reservoir quality* ***(Potrerillos, Río Blanco and Barrancas Formations).*** *During this stage the volcanic activity was sporadic, and restricted in the area. During the Jurassic and the early Cretaceous periods, pours of olivinic basalts were situated locally, and were called* ***Punta de las Bardas Formation*** *(Rolleri and Criado Roque, 1968).*

Finally, during the Miocene-Pliocene, some 1500 to 2200 meters of sediments were deposited, all of continental nature, which include fine clayey deposits, sandstones and conglomerate sandstones, conglomerates and tobaceous intercalations, which correspond to the ***Mariño, La Pilona, Tobas Grises and Mogotes Formations.*** *For this period forced subsidence conditions are assumed due to tectonic load, related to the concurrent lifting and deformation of the folded and faulty strip of the Andes foothills and the deformed part of the foreland located in the Pampean mountain range.*

REGIONAL STRUCTURE

The structural features visible in the area considered are anticline folds, elongated and well defined although irregularly spaced, and limited in their flanks by reverse faults, with a vergence of their axial planes both to the East and to the West.

Such as it was suggested in a previous paper (Legarreta, Kokogian and Dellapé, being printed), it is estimated that the present structure of the basin is a result of the Cenozoic tectonics, although the main features appeared when the Triassic basin started to be developed.

The anticlines follow three main axes with a NNW-SSE trend (fig. 1). The one farthest west includes the Cacheuta, La Pilona, Estructura Intermedia, Tupungato, Piedras Coloradas, Chañares Herrados and Alto Verde culminations. The central axis includes the positive structures of Cruz de Piedra, Lunlunta, Barrancas, Carrizal, Río Tunuyán, La Ventana, Vacas Muertas, Punta de las Bardas and El Quemado. The eastern alignment is more atenuated than the previous ones, both on the surface and in the subsurface, and includes the structures of Rivadavia, Zampal and Vizcacheras.

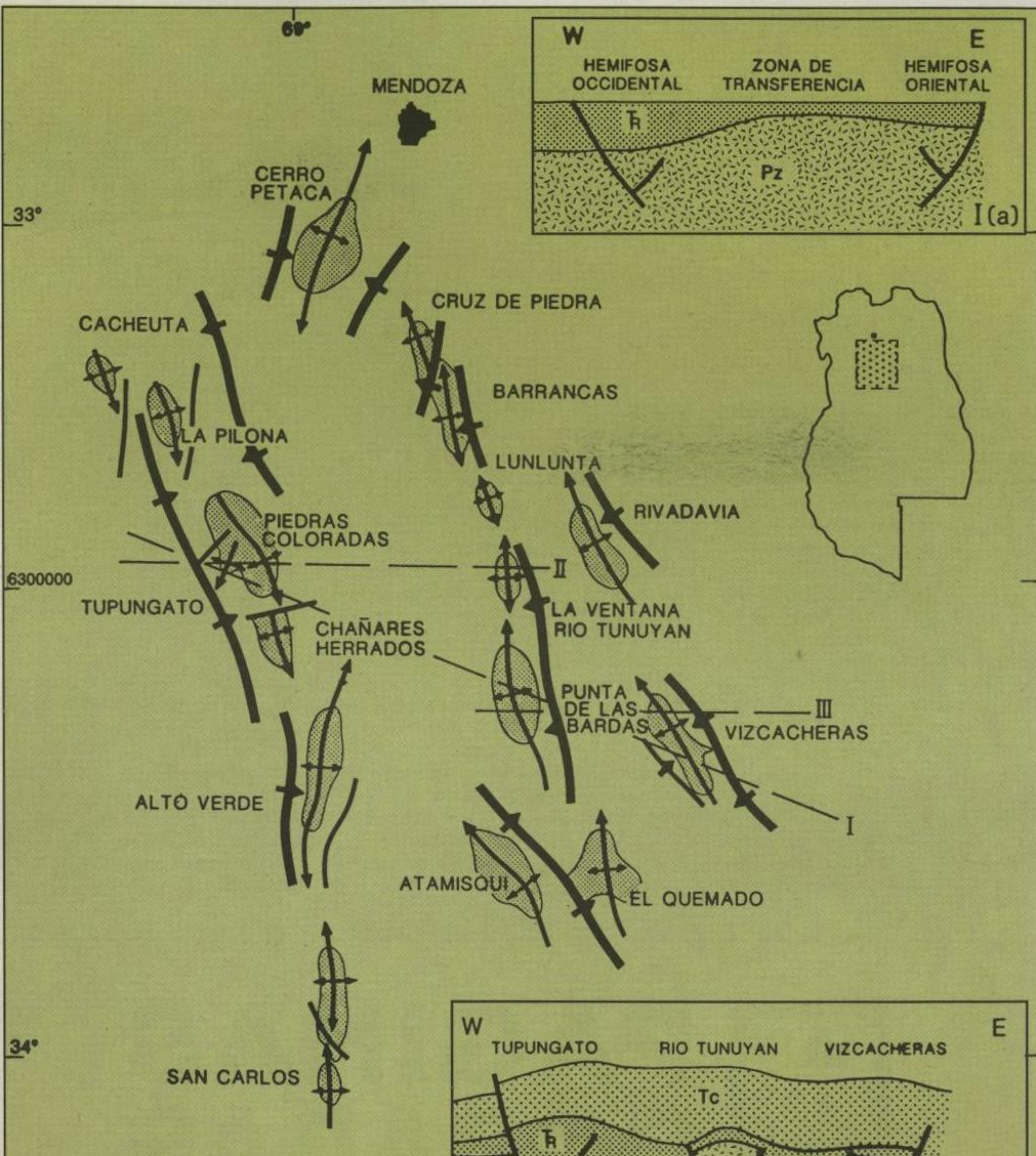
These anticline axes and structural noses are associated to reverse main faults in the western flank in some cases, and to the eastern one in others, marking an asymmetry of folds, with one smooth flank, and the other one steep. The different culminations are separated mostly by structural chairs.

The seismic sections showed that the folded structures at shallow levels are replaced in the deep part by dislocated and rotated blocks, in which there is a lower degree of folding. This is due to the difference in the thickness of the different units and to a deformation history that records the change from conditions with a regional extension effort to a compressive type regime (figs. 2 and 3). The fact that the units of the Tertiary are laid in a parallel habit without angular disconformity, and the fact that the Pliocene participates in the deformation, suggests a very young structure (Padula, 1972, Jordan and Ortiz, 1987).

DEFORMATION SEQUENCE

The seismic lines that cross the Cuyo Basin in its north section, show an asymmetric structure during the sedimentation

FIGURE 1


69°
MENDOZA
CERRO PETACA
33°
CACHEUTA
CRUZ DE PIEDRA
BARRANCAS
LA PILONA
LUNLUNTA
RIVADAVIA
PIEDRAS COLORADAS
II
6300000
TUPUNGATO
LA VENTANA
RIO TUNUYAN
CHAÑARES HERRADOS
PUNTA DE LAS BARDAS
III
VIZCACHERAS
ALTO VERDE
I
ATAMISQUI
EL QUEMADO
34°
SAN CARLOS
20km
R.G.
2500000
W
E
HEMIFOSA OCCIDENTAL
ZONA DE TRANSFERENCIA
HEMIFOSA ORIENTAL
Tr
Pz
I (a)
W
E
TUPUNGATO
RIO TUNUYAN
VIZCACHERAS
Tc
Tr
Pz
I (b)

stage of the sequences of the lower Triassic, and even, although to a lesser extent, in the upper Triassic. The main faults are those that controlled the sedimentary thickening in the morphotectonic depressions of the half-graben type (figs. 2 and 3).

The deformation sequence includes the following stages (Table I):

Stage of extension, block rotation and filling of half-grabens.

During this stage the sequences dated between 245 and 232 million years were deposited, levels A and B in figures 2 and 3. During this period, the geodynamic control is attributed to the extensional collapse of the later Paleozoic orogenic, formed as a consequence of the compressive deformation and of the cortical thickening that took place during this period (Mpodozis and Kay, 1990; Legarreta, et al. in the printing press).

This extension phase is registered by the development of listric faults with maximum displacements of 3,500 to 4,000 meters, which controlled the depocenters of the lower Triassic in the area of Tupungato and Piedras Coloradas, on one side, and of Vizcacheras, Zampal and Rivadavia on the other (fig. 1). The location of these depocenters coincides in space with the western and eastern structural axes. The central axis was developed in correspondence with a higher area and with the zone of transfer between the two linked systems of half-grabens. This situation is reflected in an attenuated development of all the Triassic column.

Phase of Regional Sinking and Local Variations in the Sedimentation Effect

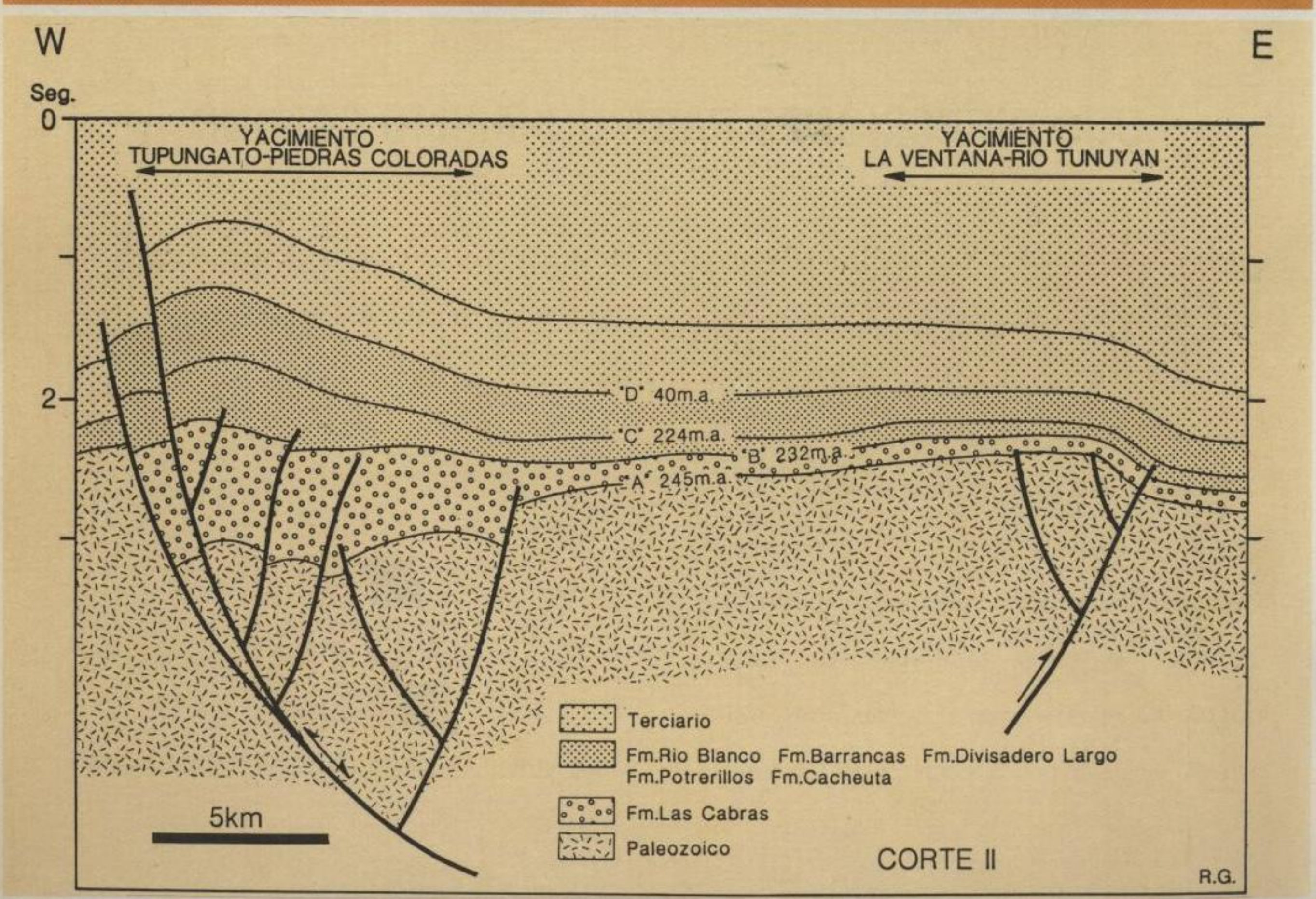
*In the attenuation phase of the rifting and regional sinking, sedimentary sections dated between 232 and 40 million years were deposited, levels C and D of figs. 2 and 3. The regional mapping of the thicknesses and the seismic lines (figs. 2 and 3) reveal that the depressed blocks of the half-grabens were subjected to a higher relative subsidence during the Triassic, Jurassic, Cretaceous and early Tertiary, although somewhat more attenuated in their relative magnitude. Even so, there are important variations in the thickness of the sedimentary column: 3000 m in Tupungato correspond with 500 m in Río Tunuyán and with 1000 m in Vizcacheras. On the other hand, the Jurassic, Cretaceous and lower Tertiary sequences **(Barrancas, Punta de las Bardas and Divisadero Largo formations)**, are only very locally affected by the extensional faults, and show a much more regular variation of thickness.*

The differential subsidence during this period is evidenced by the most representative facies of each formation unit. Therefore, the distribution of the sandy and clayey bodies accumulated in a continental regime keep a relationship with the original depressed and elevated positions.

Phase of contraction and reversion of the Mesozoic structures

During the later Tertiary, the compressive stress of the Andean deformation produced the tectonic reversion and the differential lifting of some of the originally

FIGURE 2



depressed zones, which formed the main depocenters during the sedimentation of the Triassic. Some of these areas took structurally high positions.

During this episode, the sedimentation centers associated to the presence of normal faults that allowed the development of thick columns in the lower lip, were locally transformed into highs by a combination of compression and lateral displacement, generating anticlines in correspondence with the greater sedimentary thickness.

Seismic control reveals that some structural highs, such as Tupungato, Piedras Coloradas and Vizcacheras, coincide with areas of greater thickness in the sedimentary columns, which means that as a result of the reversion process (Bally, 1984; Biddle and Rudolph, 1988) zones that were originally low were transformed into positive elements. As it happens in these cases, the root of the structural highs involves greater stratigraphic thicknesses and the high angle faults show normal displacement in the deep levels, reverse separation at intermediate levels, and they disappear towards the young levels of the sedimentary sequence.

Various examples of reversed half-grabens and grabens have been illustrated in figs. 2 and 3. These present different polarities. This means that while those located to the West, in coincidence with the western trend of productive structures, present the main faults and the greatest sedimentary thicknesses towards the west; those located in the eastern trend present themselves as a specular image, which means that the main faults and the greatest sedimentary thicknesses are located in the East.

The zone that corresponds to the central structural trend shows an old high, with development of small half-grabens towards one side and the other, depending on the position of these within the maximum. This zone presents a smaller sedimentary thickness, specially for the Triassic terms, and is interpreted as the zone of transfer between the half-grabens located to both sides.

The degree of inversion varies areally in different parts of the basin, and manifests itself vertically with different characteristics at the level of the successive members of the sedimentary column. Thus, it may happen that for certain basement levels there is no inversion, or that the inversion may be smaller for the levels of the base of the Tertiary, which means that the sections of the upper Triassic and of the Tertiary are deformed by compression, while the basement could have responded rigidly, that is to say, without visible arching.

In the zones where the inversion was relatively smaller, the cretaceous deposits (sag)

TABLE 1

TIEMPO	CONTROL GEOTECTONICO	EVOLUCION ESTRUCTURAL SISTEMAS DEPOSICIONALES	SISTEMA PETROLIFERO
	RECIENTE		
PLEISTOCENO PLIOCENO	ALZAMIENTO COMPRESION OESTE–ESTE 14 MA	Inversion compresiva por reactivacion de las fallas normales que delimitaban las hemifosas.	MIGRACION GENERACION DE TRAMPAS.
MIOCENO	SUBSIDENCIA FORZADA Y SOBRECARGA TECTONICA 40 MA	Enterramiento regional. Acumulacion sedimentaria proveniente de areas circundantes a la cuenca.	MADURACION
EOCENO CRETACICO JURASICO TRIASICO TARDIO	HUNDIMIENTO REGIONAL SUBSIDENCIA DIFERENCIAL 224 MA	Distribucion areal y espesores localizados de los sedimentos. Distribucion selectiva de los principales reservorios.	DESARROLLO DE LOS PRINCIPALES NIVELES PERMO-POROSOS
TRIASICO MEDIO A TARDIO	TRANSICION DE "RIFT" A HUNDIMIENTO REGIONAL 232 MA	Disminuye la tasa de subsidencia y se delimitan las areas donde continuara la sedimentacion. Desarrollo de las facies ricas en materia organica.	ACUMULACION DE MATERIA ORGANICA
TRIASICO TEMPRANO A MEDIO	ESTADIO DE "RIFT" 245 MA	Rellenos parcialmente conectados. Rotacion de bloques. Desarrollo de fosas y hemifosas limitadas por fallas.	HABILITACION DE LA CUENCA
PALEOZOICO	ACRECION CONTINENTAL	Eventos metamorficos y volcanicos	

were locally shortened by folding without faults (fig. 3). Where there is more deformation, the nucleus of the folds started to be penetrated by faults, and wedges appeared with reverse faults in the flanks (pop-up structures).

The main faults reactivated as reverse sometimes develop antithetic faults (converging backthrusts). These faults are important in the delimitation of some of the structures, an even in the hydrocarbon trapping in others. The presence and development of these depend on the local degree reached by the compression effect.

The most obvious oil traps are folds of the most superficial levels, characterized by the decrease of the deep structural closures. The blocks with preserved (not reversed) extensional faults, provide large unexplored prospects, the potential of which appears to be conditioned by the depth and quality of the reservoirs.

STRUCTURAL STYLE IN THE VIZCACHERAS BLOCK

The sedimentary column in the zone of the Vizcacheras Block is thinner than in the western sector. However, its evolution in time has been comparable to that of the other sectors, with a remarkable development of thick sandy levels in the lower portions of the half-grabens for some of the units (fig. 3) corresponding to the stage of thermal sinking (dipping) ***(Barrancas and Papagayos Formations).***

Seismic analysis has allowed to sketch a structural scheme regarding the temporal variations in the behavior of the faults.

Normal Faults

These faults have limited the sedimentary fills of the lower Triassic. These sequences accumulated in the blocks sunk in the fractures, whilst in the higher lips they remained above the sedimentation base level. These normal faults originally presented throws of more than 1,000 m.

During the sedimentation of the sequences of the later and younger Triassic, the differential movement of the blocks continued, although at a far lower speed, originating the sequences with variations in thickness, depending on whether it is located in the low or in the high block. In some units of the Triassic and Jurassic, as the ***Río Blanco and Barrancas Formations****, it is possible to observe the above mentioned differences in thickness. The greater sandy thicknesses were developed in correspondence with the most depressed areas, near the main faults.*

This situation did not persist during the Tertiary sedimentation, which reached a column of 1900 m, and where no notable differences in thickness are observed.

Reversed normal faults

During the compressive stresses that took place during the Tertiary, the main extension fault was reactivated (fig. 3) inducing the development of antithetic faults (backthrusts) and the arching and lifting of the area where the field is located. These compressive stresses caused a reverse separation for the intermediate and upper levels of the column.

In this zone of the basin further away from the mountains, the compressive stresses were of a lower magnitude, and therefore the tectonic inversion is attenuated. The culmination of the structures is developed in relation to the antithetic faults, maintaining in the lower structural positions the most depressed portion of the half-graben. The correlation of the deep reflectors shows that the low block maintained a high sinking rate until the deposition of the D horizon ***(Barrancas Formation).***

The geological interpretation of this section and the ties with well, show that the stratigraphic succession becomes thinner from East to West, reaching its greatest thickness near the main fault, that it shows normal displacements for the sections of the lower Triassic, and becomes thinner towards higher positions, where the thickness of the sandy levels with reservoir capacity become thinner (fig. 3).

INFLUENCE OF THE FAULTS ON THE PETROLEUM HABITAT

Since the main faults controlled the structural evolution and the final geometry of the hydrocarbon traps, we must stress that they also played an important role regarding the distribution of the source rock and the reservoir rock (Graph I).

Normal Faulting and Distribution of Source Rock

The main hydrocarbon source rock is located in the ***Cacheuta Formation****. There are also sections with organic matter, of less thickness, in the* ***Las Cabras, Potrerillos and***

Río Blanco Formations. This means that through time the development of lacustrine systems was maintained, allowing the accumulation and preservation of organic matter.

The main hydrocarbon source zone is the zone of La Pilona - Tupungato - Piedras Coloradas - Chañares Herrados, where the largest thicknesses of lacustrine sediments are found. The Rivadavia - Vizcacheras area was the least favored, because of its limited thickness, a smaller amount of organic matter and a lower level of thermal maturity.

The analysis of the stratigraphy and the fault systems involved indicates that the relationship between the subsidence rate and detrital supply allowed the accumulation of lacustrine deposits with abundant organic matter preserved in a reducing environment in the deepest parts of the half-grabens, close to the historic faults. After burial under Terciary Sediments, they originated the hydrocarbons in the basin (Chebli et al, 1984; Jordan and Ortiz, 1987; Rosso et al, 1987).

Normal Faulting and Content of the Reservoirs

Oil reservoirs consist of sandy deposits, the accumulation of which was governed by fluvial dispersion systems. Being nearly exclusively fluvial systems, it is natural that these reservoirs be developed mostly in the most depressed parts of the basin, and parallel to the elongation of the half-grabens. Different distributaries converged to these main channels, but contributed less to the development of sandy levels. In the season of floods and therefore of expansion of the deposits, sands remained away from the borders of the system, where only fine sediments were deposited. It is stressed that the high zones show a condensed stratigraphic development, with a minimum participation of layers capable of storing fluids.

For this reason, as we move out of the more depressed zones of the half-grabens and towards those places where the column is thinner, the development of reservoirs is reduced. This situation happens mostly in the **Potrerillos, Río Blanco, Barrancas and Papagayos Formations**, which are the levels with the highest proportion of sands and the highest cumulative production of hydrocarbons.

Faults and Trapping

On the basis of the analysis performed, it is observed that all the traps that have hydrocarbons are, to a certain extent, related to the listric principal and secondary faults, which allowed the most important accumulations of sediments.

The original architecture of the basin, controlled by a system of chained extensional faults, had a strong influence on the orientation of the regional stress during the development of the reversion and on the configuration of the reverse faults and closures associated with it.

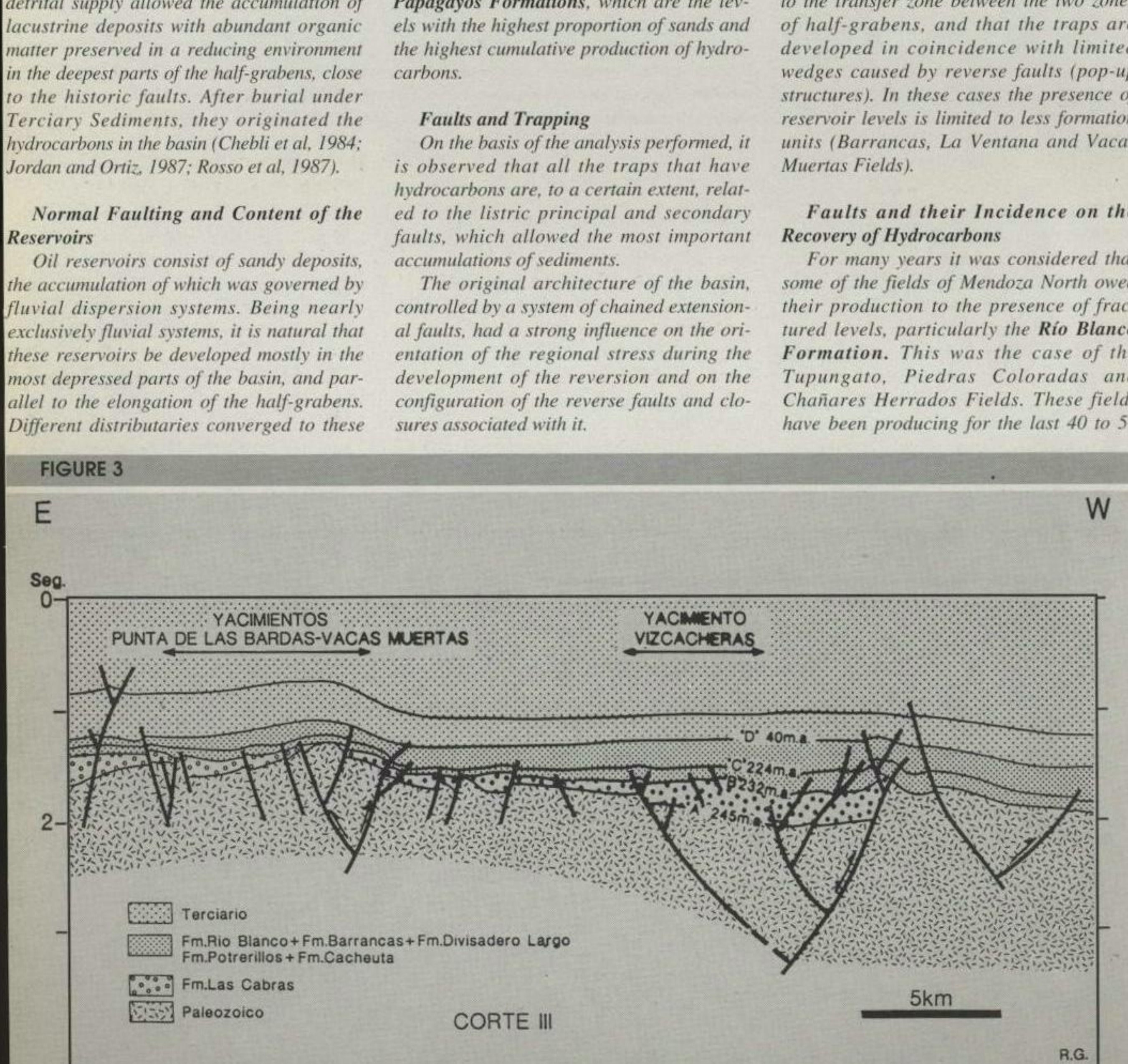
The present productive structures are directly related to the tectonic inversion processes which originated anticlines and ridges coincidentally with zones that have preferential developments of sands in stratigraphic positions near to the source rocks (e.g. Tupungato, Piedras Coloradas, Chañares Herrados).

In other cases the fields are related to a wider range of displacement of the antithetic faults, and in correspondence with frames of stratigraphic condensation and wedging of sands towards originally higher positions (e.g. Vizcacheras). A third possibility is that the productive traps are related to the transfer zone between the two zones of half-grabens, and that the traps are developed in coincidence with limited wedges caused by reverse faults (pop-up structures). In these cases the presence of reservoir levels is limited to less formation units (Barrancas, La Ventana and Vacas Muertas Fields).

Faults and their Incidence on the Recovery of Hydrocarbons

For many years it was considered that some of the fields of Mendoza North owed their production to the presence of fractured levels, particularly the **Río Blanco Formation.** This was the case of the Tupungato, Piedras Coloradas and Chañares Herrados Fields. These fields have been producing for the last 40 to 50

FIGURE 3



years. Presently with the detailed analysis of cores and the drilling of horizontal wells, it has been proved that the presence of fractures is nearly nil and has a very small incidence on oil recovery. The most important factor, apart from the original presence of the sandy levels, is the magnitude of the diagenesis that took effect on those levels.

Since the generation of oil is very recent, it is possible that some of the main faults may have acted as hydrocarbon migration means.

CONCLUSIONS

The study of the stratigraphic and structural characteristics of the hydrocarbon fields in the Cuyo Basin, has allowed to determine that the arrangement of the systems of reverse faults that are presently prominent in the area is genetically related to a previous system of chained extensional fractures (Gibbs, 1988), dominated by reverse pits and relief zones.

During the extension phase, the main faults allowed the differential subsidence and the accumulation of sedimentary wedges with thicknesses of up to 4,000 meters, the localized development of levels with source rock characteristics and the preferential distribution of reservoir rocks.

The inversion of this system of Triassic extensional faults, resulted in asymmetric structural configurations with development of flank antithetic faults (backthrusts) configuring structures with a well defined closure.

The structural axis of the Cuyo Basin present axial planes with eastern and western vergence. The seismic sections show that the folds in shallow and intermediate levels are pronounced, and are replaced at deep levels by faulted structures that show a geometric conformation that preserves features of the original style of extensional blocks. The nucleus of the anticlines involve greater thicknesses of sediments than at the flanks, deposited during the phase of extension (rift) and regional sinking.

During the late Cenozoic, with the climax of the Andean orogeny, the compression of these extensional structures originated in the Mesozoic took place, with the resulting tectonic inversion, originating anticline structures and ridges where presently oilfields are being produced, with a total recovery estimated in approx. 200,000,000 cu.m.

REFERENCES

BALLY, A.W., 1984. Tectogenese et sismique réflexion. Societé Géologique de France, Bulletin 7 (XXVI): 279-285. Paris.

BIDDLE, K.T. & RUDOLPH, 1988. Early Tertiary structural inversion in the Stord Basin, Norwegian North Sea, Journal Geological Society 145: 603-611. London.

CHEBLI, G.A.; LABAYÉN; G. LAFFITE; and M.R. ROSSO, 1984. Organic matter, depositional ambient and oleogenetic evaluation of the Cuyo Basin. Ninth Argentine Geological Congress, Records VII: 68-85. Buenos Aires.

CRIADO ROQUE, P.; E.O. ROLLERI; C. DE FERRARIS; I. SIMONATO; A. MINGRAMM; AND T. SUERO, 1960. Sedimentary Basins of Argentina. Boletin Informaciones Petroleras, 320: 62-95. Buenos Aires.

GIBBS, A., 1988. Balancing geoseismic cross-sections. Canadian Society Petroleum Geology, Short Course: 1-88. Calgary.

HARRINGTON, H.J., 1941. Geological investigation in the Villavicencio and Mal País Mountains. Mining and Geology Dept., Bulletin 49: 1-38. Buenos Aires.

JORDAN, T.; and A. ORTIZ, 1987. Time of generation of petroleum in North Mendoza. Tenth Argentine Geological Congress, Records II: 271-276. Tucumán.

KOKOGIAN, D. and O. MANCILLA, 1987. Sequential stratigraphic analysis of the Cuyo Basin. In print at G.A. Chebli and L.A. Spalletti (Editors): Argentine Sedimentary Basins, Tenth Argentine Geological Congress, Simposium: 169-210. Tucumán.

LEGARRETA, L.; D. KOKOGIAN and D. DELLAPÉ (In print). Tertiary structure of the Cuyo Basin: How much tectonic reversion? Argentine Geological Association Magazine XLVII (1): 83-86

MPODOZIS, C. and S.M. KAY, 1990. Acid magmatic provinces and evolution of Gondwana: Chilean Andes (28-31 S). Chilean Geological Magazine, 17 (2): 153-180.

PADULA, E., 1972. The oil producing sedimentary basins in Argentina. Their results. Series G.1. National Cuyo University, School of Petroleum Engineering, 1-30. Mendoza.

POMBO, R., 1986. Areas tendered in the Cuyo Basin. In Oil and Gas in Argentina, I:151-163. Buenos Aires.

ROLLERI, E.O.; and P. CRIADO ROQUE, 1968. The Triassic Basin of the North of Mendoza. Third Argentine Geological Congress: I:1-76. Buenos Aires.

ROSSO, M.R.,; LABAYÉN; G. LAFFITTE, and M. ARGUIJO, 1987. Hydrocarbon generation in the Cuyo Basin. Tenth Argentine Geological Congress, Records II: 267-270. Tucumán.

TURIC,M.; C. FERNÁNDEZ GARRASINO; R. POMBO; J.L. BIANCHI; and H. DI BENEDETTO, 1981. Sedimentary Basins in Argentina. Communications: 14-18. Buenos Aires