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Petroleum Provinces of the Tarija Basin, Southern Bolivia and Northwestern Argentina.

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Three petroleum provinces were identified in the Tarija Basin: a) *Santa Cruz*, where the Early Devonian (Lochkovian) section is probably the main source rock in a context of low thermal heat flow; b) *Pilcomayo*, extending up to northern Argentina, where the Middle Devonian (Eifelian) section is a proven source rock; c) *South Subandean Thrust Belt*, where there is a considerable Tertiary overburden and the Eifelian section is the source for oil and gas. Additionally two intervals are considered: the Silurian as a potential contributor to the oldest reservoirs and the Givetian (Middle Devonian), as a source related to deep (kitchen) positions.

Almost 1000 rock samples data (TOC, Rock-Eval pyrolysis and kerogen microscopy) from the typically recognized Silurian and Devonian sequence sets were evaluated for source rock typing and maturity assessment. The samples were collected from several wells and outcrops from a broad area comprising the Thrust Belt, Foothills, Chaco Plains and Izozog High, between the Santa Cruz Elbow (Latitude 17°15' S) and the Ramos gas field in Northwestern Argentina (Latitude 22°45' S). Poor to moderate, and occasionally good source rock qualities have been recorded in most of the evaluated samples. Typical TOC contents are lower than 1%, although peak values attain 2%. Variations from thermal immaturity to overmaturity are dependent on stratigraphic position and geologic setting. Kerogen, although predominantly unstructured, shows as type II/III to type III by pyrolysis Rock-Eval, with primary capacity for mixed (gas/oil) generation. Due to the limited organic contents and partly refractory character of the kerogen, effective expulsion of hydrocarbons is believed to begin at relatively high levels of thermal stress (VRE>0.9-1.0%), with prevalence of gassy hydrocarbons. The fair/moderate-TOC-bearing Givetian and Eifelian sections (*Iquiri* and *Los Monos*) contain the richest hydrocarbon-prone organic facies in most of the evaluated areas. However, the Givetian beds are disfavored as effective generating sources due to the overall low thermal maturity. The Emsian section (*Los Monos-Huamampampa*) has poor organic content in Bolivia but is an essentially gas source in Northwestern Argentina. The Lochkovian section (*Icla-Santa Rosa*) recorded the highest organic contents in the Santa Cruz influence area and Izozog High and is probably an active source rock in that zone. Scattered information on the Silurian in the thrust belt indicates low residual organic richness with an advanced overmaturity, but it could have had higher TOC values previously.

Hydrocarbon occurrences are restricted to light oil, condensate and gas. Gas chromatography and biomarker data of 10 oil/condensate samples along with isotope data of 18 gas samples from different reservoirs and fields were evaluated. The predominance of condensate accumulations precluded assessing definite oil-source correlation patterns. Nevertheless, genetic relations were proved for Givetian and, particularly, the Eifelian sources that have generated oils carrying a typical mixed marine-terrestrial signature. In detail, the Givetian section sourced an early oil seeping at the Taputá Creek, in the emergent thrust front at the Charagua Hill. Molecular data supports the genetic link of the Monteagudo oil with Eifelian source rocks in the thrust belt. In the Santa Cruz area, an oil of Rio Grande Field has been generated close to the peak oil phase, at a maturity level comparable to that of the Lochkovian section. Gas accumulations are attributed to multiple sources. Isotope data arranged by reservoir and geographic location, point to significant variations in thermal maturity, allowing for distinct kitchens of a same source rock and/or co-sourcing. The hydrocarbons discovered in a recent Pluspetrol exploratory well, TacoboX-1001, fit this general pattern.

Modeling of hydrocarbon generation of the Devonian source rocks demonstrates that the main episodes of expulsion and charge occurred coupled to the Andean tectonics. A generally low thermal heat flow linked to the Tertiary foreland deposits constrained the maturation process. In the Santa Cruz influence area the Tertiary thickness (less than 2500 m) is not enough to induce maturation of the Eifelian (*Los Monos*) section, but the Lochkovian interval reaches the maturity required for effective hydrocarbon expulsion (0.9-1.1% Ro). Southwards, in the Río Pilcomayo-Villamontes influence area, an increase of the thermal heat flow is recorded and consequently the Eifelian section becomes an effective source rock. Towards northern Argentina, the Tertiary column is thicker and the thermal heat flow is probably higher. In the thrust belt, the mild thermal regime is counterbalanced by thick orogenic columns up to 6000 m. The Eifelian beds are proven source rocks for oil and gas, while the Givetian (*Iquiri*) section could be an active source if adequately buried. Overburden during Carboniferous times is viewed to be significant in terms of source rock maturation for the Silurian deposits.

