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## Potential shale plays in sub-andean basins of Peru

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### SUMMARY

The growing importance of U.S. shale gas resources is reflected in the worldwide extension of unconventional shale plays market. This fact has motivated its exploration and exploitation in South America; where the extensive exploitation of conventional hydrocarbons on the Sub-Andean, belt added to the proven occurrence of shale plays in Argentina (Jurassic Vaca Muerta and Los Molles Fms.) and positive early exploratory assessments in Bolivia (Devonian Tomachi Fm.), Brazil (Devonian Jandiatura Fm.) Colombia and Venezuela (Cretaceous La Luna Fm.) increase the exploration chances in the Sub-Andean Basins of Peru.

The sub-Andean foreland basins span the length of the Andes from Venezuela in the north to the southernmost tip of South America. All the major basins and many of the smaller basins are hydrocarbon bearing. The Marañon, Ucayali, and Madre de Dios are the principal Peruvian Foreland Basins. Each has subsidiary basins, such as the Ene, Huallaga, and Santiago basins, where they have been deformed and partitioned in the foothills of the Andean fold and thrust belt. Up to date the Marañon Basin has a cumulative production over 1 billion bbl of oil, likewise Ucayali Basin has cumulated a production over 32 million bbl of oil, 201 million bbl of condensate and 1.7 tcf of gas. On the other hand, several wells in the Peruvian Madre de Dios Basin have important oil test and shows; the most relevant is the Candamo-1X well,

which after several DSTs (cumulate production test of 10.5 x 10<sup>6</sup> cfg/d) revealed a significant gas discovery. In addition, 32.4° API oil was recovered at the Pando Field in Bolivia (20 million bbl of oil as potential resources).

The purpose of this study is to discuss Peru's potential for shale plays exploration based on geological and geochemical keys: the organic content and type, thermal maturity, thickness, areal distribution, and present-day depth; other properties such as mineralogy, permeability, rock mechanics, and adsorption capacity are excluded from this presentation since their public knowledge is very limited or nonexistent. Preliminary results suggest very favorable potential for eight shale units within the Peruvian sub-Andean Basins.

### RESULTS

Marañon Basin is characterized by the presence of five organic-rich shales.

- Devonian Cabanillas shales in the SE part of the basin contain fair to very good organic-rich (TOC: 0.79–4.70 wt%) and kerogen types II and III, its samples are within condensate–wet gas window (Ro: 1.11–1.35) and reach some high values of thermal maturity (2.16 %Ro), and have variable thickness (185–430 m).
- Carboniferous Tarma shales in the southern basin contain good organic-rich (TOC: 1.05–1.65 wt%) and kerogen type II/III, its samples range from late oil window to main gas win-

dow (Ro: 1.1–1.45%), and its thickness range from 18 to 254 m.

- Triassic-Jurassic Aramachay<sup>1</sup> shales bear very good to excellent organic rich (TOC: 2–14 wt%) and kerogen type II, its samples range from early to main oil window (Ro: 0.67–0.89%), and its thickness range from 350 to 600 m.
- Cretaceous Chonta shales show good to excellent organic-rich (TOC: 0.98–6.00 wt%) and kerogen types II and II/III, its samples range from immature to main oil window (Ro: 0.45–0.95%) and have variable thickness.
- The Oligocene Pozo shales contain poor to very good organic rich (TOC: 0.5–3.5 wt%) and kerogen types I and II, its samples range from early to main oil window, have a widespread areal distribution, and variable thickness (50–200 m).

Ucayali Basin is characterized by the presence of five (5) organic-rich shales.

- Ordovician Contaya shales contain fair to very

good organic-rich (TOC: 0.46–2.65 wt%) and kerogen type II/III?, its samples range from early oil window to dry gas window (Ro: 0.78–3.7%), it has variable thickness, and its areal distribution is evidenced by wells in the northern part of the basin while in the southern part is interpreted within isolated depocenters.

- Devonian Cabanillas shales bear fair to very good organic-rich (TOC: 0.65–2.34 wt%), its original kerogen types was likely type II and II/III, its thermal maturity range from main oil window to dry gas window (Ro: 0.84–2.18%), have variable thickness (200–1000 m), and widespread distribution evidenced by wells and also mapped by seismic.
- Carboniferous Ambo shales show fair to excellent organic-rich (TOC: 0.6–9.0 wt%) and kerogen types II/III and III, its samples range from early oil window to dry gas window (Ro: 0.77–1.96%), have variable thickness (25–515 m), and widespread and patchy areal distribution in southern and northern basin respectively.
- Permian Ene shales (Shinai Member) contain

### TOC, Thermal maturity, Kerogen type, Thickness

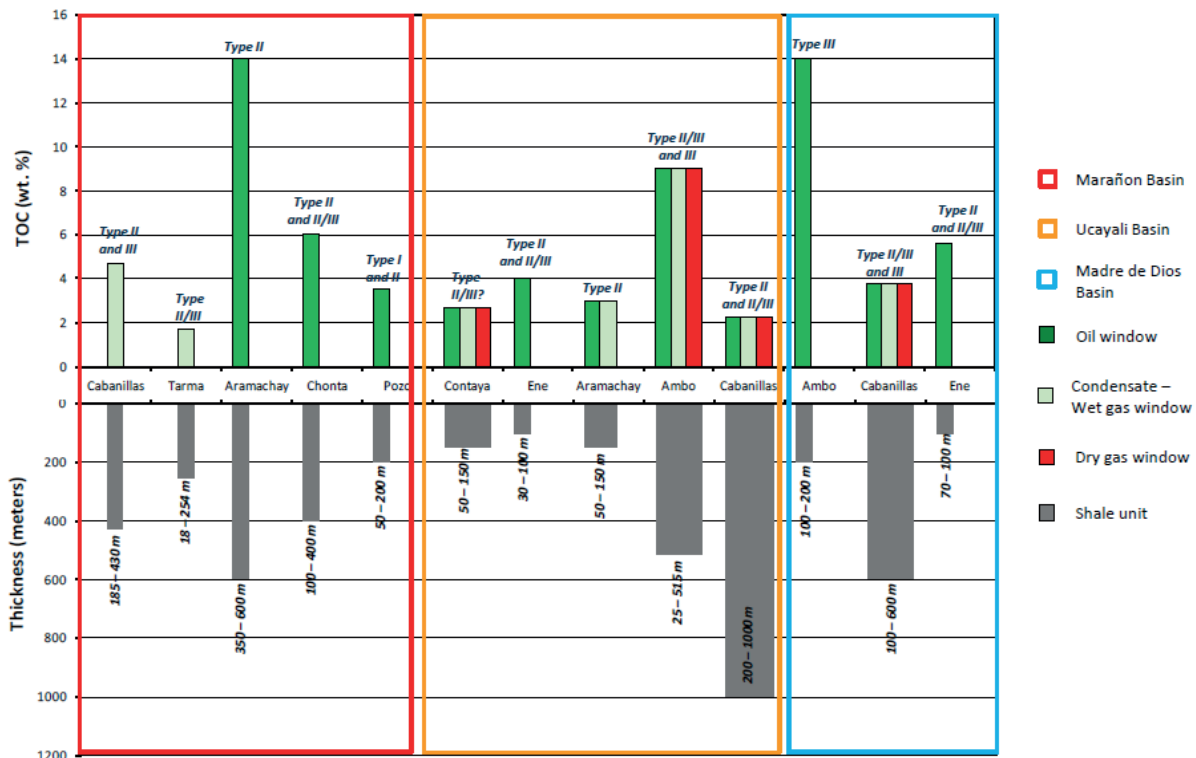


Figure 1. Potential Shale Plays in Peruvian basins.

good to excellent organic-rich (TOC: 1.5–4.0 wt%) and kerogen types I/II, II and II/III, its thermal maturity range from early to late oil window (Ro: 0.56–1.05%), have variable thickness (70–100 m), and are predominantly preserved in depocenters of the southern basin.

- Triassic-Jurassic Aramachay shales contain fair to very good organic-rich (TOC: 0.53–2.96 wt%) and original kerogen was type II, its samples range from early oil window to condensate-wet gas window (Ro: 0.58–1.40%), have an important thickness (50–150 m), and it extends in the northern part of the basin.

Madre de Dios Basin is characterized by the presence of three organic-rich shales.

- Cabanillas shales contain good to very good organic-rich (TOC: 1.6–3.8 wt%) and kerogen types II/III and III, moderate to very high thermal maturity (Ro: 0.64–3.8%) and have variable areal distribution and thickness (100–600 m).
- The Ambo shales bear very good to excellent organic-rich (TOC: 2.3–25 wt%), moderate thermal maturity (Ro: 0.4–0.76%), kerogen type III, and have variable thickness (100–200 m).
- Ene shales (Shinai Member) show good to very good organic-rich (TOC: 2.5–5.6 wt%), kerogen types II and II/III, and variable areal distribution and thickness (70–100 m).

These preliminary results predominantly suggest very favorable shale gas potential for five shale units within the Ucayali Basin and shale oil/gas potential for three shale units within the Madre de Dios Basin. In the same way within the Marañon Basin has three shale units with very favorable shale oil potential and two shale units with shale gas potential.

## CONCLUSIONS

Preliminary list of potential shale plays in Peruvian Sub-Andean basins is composed of eight shale units: Contaya (Ordovician), Cabanillas (Devonian), Ambo (Carboniferous), Tarma (Carboniferous), Shinai (Permian), Aramachay (Triassic-Jurassic), Chonta (Cretaceous) and Pozo (Oligocene).

Continuous developments of knowledge from po-

tential shale plays in Peru will allow re-evaluate the current limited economic viability.

Peruvian Sub-Andean basins have a sufficient amount of geologic and geophysical data for unconventional resource analysis.

It is necessary to compile information corresponding to reservoir parameters: clay mineralogical composition, permeability, pressure, and adsorption capacity to thereby generate a more robust integrated interpretation of potential unconventional reservoirs type shale plays.

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