# Distribution and source rock potential assessment of Paleozoic source rocks of Punjab platform (Middle Indus basin) Pakistan

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The study was initiated to evaluate the source potential and distribution of Paleozoic source rocks in the eastern part of Middle Indus basin (Punjab platform). The Indus basin of Pakistan from west to east is comprised of the Sulaiman fold and thrust belt, Sulaiman Depression and Punjab platform. The Punjab platform extends eastwards from Pakistan into Rajasthan, India. Only 20 exploratory wells have been drilled in the area.

The objective of the study was to increase the geological understanding of the Punjab platform and improve the prospectivity of the area for encouraging further exploration and discovery of new oil and gas reserves. The study is based on geochemical and organic Petrographic analysis of 134 ditch cuttings/cores and 01 gas sample collected from 9 wells.

The geochemical studies demonstrated that Cambrian / Infra Cambrian shales are potential source rocks in the Punjab platform. The Infra Cambrian salt range formation has adequate organic richness but its distribution is not thick and wide enough and suffers from lack of maturity due to insufficient depth of burial. However it is possible and even likely that these rocks might have attained adequate maturity in Paleo lows. In Karampur well the oil was discovered, but it was too viscous to produce. In contrast with Bikaner Nagaur basin in India, significant reserves of oil have been discovered in the Baghanwala area close to the border with Pakistan. On Pakistani side commercial accumulation of gas at Panjpir and Nandpur were discovered. The gas has high Nitrogen and Carbon dioxide contents.

Geochemical studies indicate that Infra Cambrian / Cambrian are the principal source rocks in the area. It has been postulated that significant amount of hydrocarbons could be generated, if these are buried to a sufficient depth.

# How primitive is the “primitive” mantle?

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A recurrent question in planetary sciences is: what is the nature of the “late veneer”? Indeed this late extra-terrestrial addition to the Earth is seen as the carrier of water and possibly the life seeds on earth. However as recently summarized [1] the nature of this late component remains elusive and constraints from various geochemical systems seem at first glance contradictory. Especially, the primitive upper mantle Os composition rules out carbonaceous chondrites – the only wet chondrites - as the source of the `late veneer'. However, one may wonder about the robustness and significance of the PUM estimate wich is heavily based on 2 mantle suites: The Pyreneans lherzolites and the Kilbourne Hole xenoliths.

Recent work has unfold a unique set of convergent structural and geochemical arguments showing that the Lherz’ lherzolites are secondary rocks formed at the expense of the harzburgites via a refertilization reaction involving precipitation of pyroxene (±spinel) and sulfide [2]. Chalcophile and highly siderophile elements (HSE) strongly support this scenario. *In situ* measurement of the Os isotopic composition of sulfides in the harzburgites yield a constant unradiogenic composition indicating a Re depletion age $\approx 2$ Ga. While the lherzolites sulfides show a large spread of Os compositions, with two sulfide populations, one residual similar to the one found in harzburgite; and a second one showing (extremely) radiogenic compositions probably related to the pyroxenite suites.

Kilbourne hole xenoliths - as almost all alkali-hosted xenoliths [3] - show two sulfides population (residual and metasomatic) characterised by drastically different HSE and $^{187}Os/^{188}Os$ composition.

These suggest that HSE-Os “resetting” mechanism via sulfide enrichment promoted by melt-rock reaction occur worldwide, casting thus strong doubt on the relevance and significance of the PUM concept itself at least for the absolute and relative HSE abundances and $^{187}Os/^{188}Os$ composition of the Earth’primitive mantle.

[1] Drake & Righter (2002) *Nature* **416**, 39-43. [2] Le Roux *et al.* (2007) *EPSL* **259**, 599-612.. [3] Alard *et al.* (2002) *EPSL* **203**, 651-663.