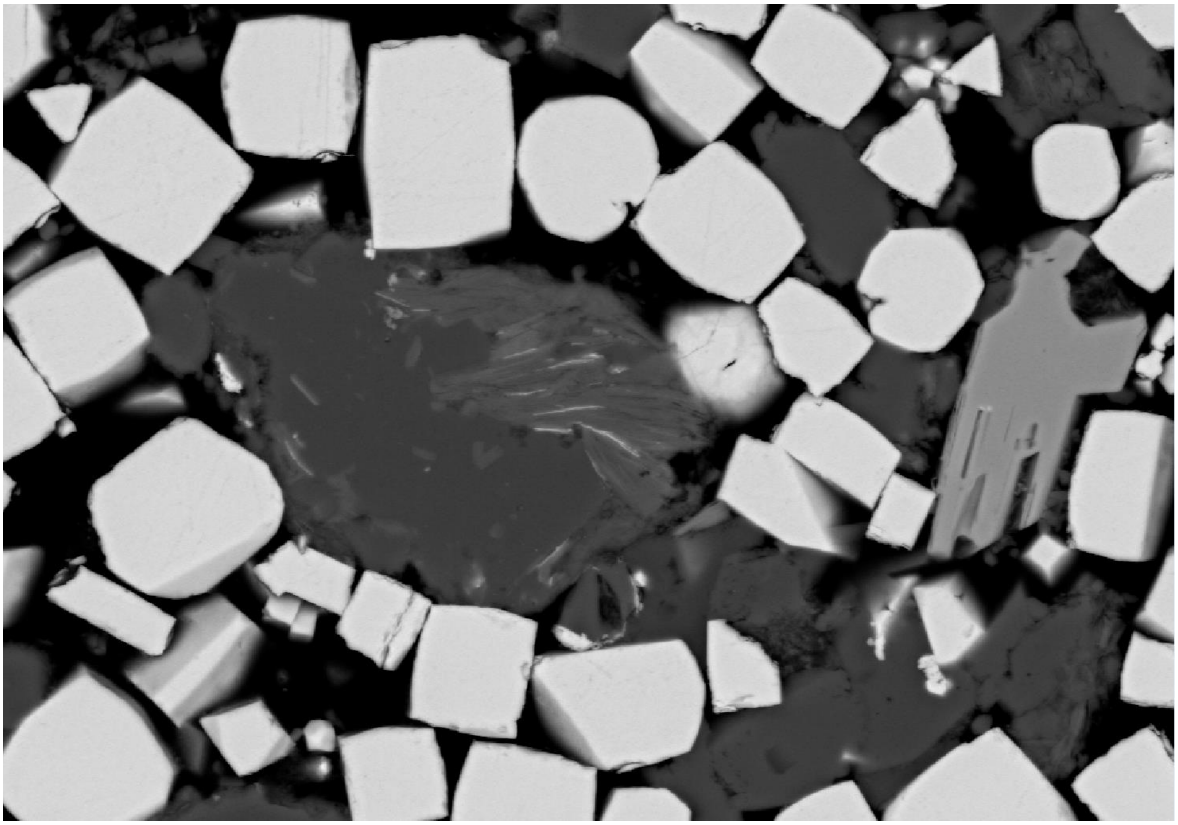
The Irati shales of Brazil: a hidden gem?

(a puzzle piece of the Irati Shale - Whitehill Fm. system in Brazil and South Africa to Namibia)

-Literature review-



BSE image of a TOC-rich shale of the Assistencia Member (eastern margin of the Paraná Basin). Length is 1.2 mm.

Hans-Martin Schulz

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Executive summary

In this comprehensive literature review we critically assess the factors controlling the distribution and composition of the Early Permian Irati-Whitehill source rock of southern Gondwana as well as the prime drivers leading to petroleum generation and migration. We synthesise the results into a prognosis of conventional and unconventional resource potentials.

The organic-rich shale deposits of the Irati Formation in Brazil are 40 m thick on average, and 70 m in the depocenter. The upper part of the Irati Fm., the Assistência Member, consists of organic-rich shale, locally intercalated by carbonate beds, reaching up to > 25 wt.% TOC. The organic matter is composed of a kerogen type I-II (with Type III and lower TOC content mainly at the northern basin margin). Hence, these intervals have a moderate to high HC potential and can be classified as exceptionally good source rocks.

Maximum present-day burial depth of the Irati Fm. in the basin center is > 2,300 m, and subsidence rates were highest during the Permian-Triassic transition and during the early Cretaceous (related to the intrusion of sills and dikes of the Serra Geral Formation being up to 1,700 m in thickness). Thermal OM maturity across the Paraná Basin is predominantly (immature to) early oil window maturity due to burial in general.

HC fluid inclusions in veins formed simultaneously with the Paraná LIP during the Early Cretaceous are black oil with homogenization temperatures in the 60-80 °C range, but lack gas (e.g., CH_4 or CO_2). PVT modelling for trapped fluid inclusions indicates the formation of shallow hydrocarbon petroleum systems (ca. 2.5 km depth) during the Early Cretaceous with medium to light hydrocarbons of different API gravity, corresponding to medium and low density oils.

HC generation in the Irati shales and migration occurred during: (i) Late Permian to Triassic, (ii) Early Cretaceous (renewed high geothermal gradient due to multiphase emplacement of intrusions), and (iii) with cooling of intrusions. In regions containing igneous intrusive rocks in the Irati shales, the OM transformation rates are dependent on the thickness and number of intrusions, reaching 100%.

Irati-sourced oil accumulations in the Upper Permian strata was controlled by structural highs where NS–NE trending diabase dykes acted as barriers to horizontal migration from the W. Such shale is exploited for shale oil since 1972.

Currently there is just one potentially commercial gas field probably co-sourced from the Irati shales, the Barra Bonita Field (Paraná state), located at depth of 3,500m in sandstones of the Itararé Group. Today, the Irati shales are also investigated for CO_2 storage potential in areas with higher thermal maturity.

In summary, a higher potential as shale oil reservoirs exists in the eastern and southern Paraná Basin whereas a potential for shale gas and CO_2 storage is attributed to the northern basin. The western part of the state of Paraná was investigated to test the necessity for fracking and whether economic shale gas extraction is feasible.

Though regionally heterogeneous, the mineralogy of the TOC-rich Irati shales roughly resembles that of the Barnett and Fayetteville shales of the USA.

Content