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The paleoenvironmental and thermal histories of the Permian Irati Formation shale in the Paraná Basin, Brazil: An integrated approach based on mineralogical and organic imprints

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ABSTRACT

Mineralogical assemblages and organofacies are important sources of information to recover the paleoenvironmental and thermal histories of shale deposits. In this study, a detailed qualitative and quantitative characterization of the Permian Irati Formation (Assistência Member) shale is based on mineralogical (XRD and SEM-EDS) and organic components (TOC, Rock-Eval pyrolysis, organofacies, TAI, fluorescence and vitrinite reflectance measurements) and provides integrated data about sediment provenance, depositional environment, diagenesis, and thermal history, while supporting interpretations on the Paraná Basin (PB), Brazil, paleogeography and its correlation to the southwest Gondwana. The results revealed a prevailing type I/II kerogen, with type III kerogen being also present but mainly confined along the paleoshoreline of the PB. The dominance of fluorescent amorphous organic matter (AOM) combined with framboidal pyrite suggests microbial activity in an anoxic-dysoxic neritic-marine paleoenvironment. Additionally, common to abundant well-preserved phytoclasts, as well as the occurrence of *Botryococcus braunii*, indicates freshwater influx in a brackish marine depositional setting. Immature to early-oil window thermal maturities prevail across the PB, according to the organic maturation indicators. The combined analysis between the organic matter evolution with clay mineralogy, such as the occurrence of interstratified clays (e.g., I/S) and its positive correlation with depth suggest that burial diagenesis reached the transition to early catagenesis on the north, southeast, and south of the basin, attributing a shale oil potential for the Irati Formation on a regional scale. Local scale imprints of the Early Cretaceous Paraná-Etendeka Large Igneous Province (LIP), and its thermal effect in the Irati Formation shale components, are recorded as clay authigenesis (e.g., smectite webby texture and clay coating development), crystallization of minerals by low to high-grade of thermal alteration (e.g., corrensite, talc, lizardite and diopside), and by local scale gas-window maturities. Such thermal alteration, identified in the proximity to intruded sills and dykes, led to a heterogeneous organic maturation pattern with implications on shale gas and shale oil potential of the Irati Formation shale, demonstrating that these subjects in the Paraná Basin should be assessed locally.