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Characterization of Hydrocarbon Leakage Indicators in the Malvinas Basin, Offshore Argentine Continental Margin

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The Malvinas Basin is located in the south of the wide offshore Argentine continental margin. Despite the lack of a commercial discovery, evidence of an active petroleum system and gas leakage have been documented for the western and eastern margin of the basin (Galeazzi, 1998, Richards et al., 2006). The goal of this work is to characterize the hydrocarbon leakage indicators based on their abundance, distribution, seismic pattern, and their relationship to the post-rift evolution of the Malvinas Basin in order to address potential hydrocarbon migration pathways in the basin.

We have interpreted over 1000 2D industrial seismic-reflection profiles, which cover the shelf and the upper-slope, as well as 25 exploration wells that were tied to the seismic grid. This allowed establishing a long term seismo-stratigraphic framework for the basin. Thus, five major seismic units were identified and correlated with the main tectonic phases of the margin: U1 (Pre-168 Ma) pre-rift/ seismic basement, U2 (168-150.5 Ma) syn-rift phase, U3 (150.5-68 Ma) sag phase, U4 (68-42.5 Ma) transtensional foredeep phase and U5a (42.5∼5.5 Ma) / U5b (5.5∼0 Ma) transpressional foreland phase.

Several seismic features, probably linked to active or paleo- migration of fluids and gaseous hydrocarbons, were identified and interpreted as gas chimneys, seabed and buried pockmarks, and carbonate-mounded structures. They were separated into three populations, CP1 to CP3, and based upon their likely controlling factors, classified as structurally- or stratigraphically-controlled. The thermogenic origin of the present gas has been proven from isotopic analysis on gravity cores taken on the basin.

CP1 is located in the western margin of the basin, flanking the regional Rio Chico basement high. It consists mostly of seismic anomalies located above basement highs, often associated with basement normal faults that terminate in U3 crossing the uppermost Jurassic to Barremian Springhill Fm reservoir. The seismic anomalies are located beneath mounded structures rooted within the Eocene sequences. Additionally, some mounds are also found within U5.

CP2 is located at the eastern margin of the basin. The seismic anomalies originate from basal pinch outs or from the deltaic-fan front and are stratigraphically-controlled gas chimneys. They either reach the seafloor or terminate nearby the seafloor and some might be associated with seafloor mud-volcano-like structures.

CP3 is located in the center of the basin. Most of the seismic anomalies are structurally-controlled gas chimneys. They are controlled either by basement normal faults or by faults and mud diapirs from a nearby deformation front. Additionally, several buried and some seabed pockmarks can be associated to bright spots, suggesting the presence of gas. They are also often associated with an underlying highly vertically-faulted interval, which could represent a polygonal fault system in a 3D view. Both gas chimneys and pockmarks terminate within the youngest Pliocene to Pleistocene U5b.

The gas source for CP1 and CP3 is most likely leakage from the uppermost Jurassic to Barremian Springhill Fm. Additionally, pockmarks of CP3 could be fed by the dewatering processes of the underlying polygonally faulted interval. CP2 is possibly sourced by gas of Mid-Cretaceous sediments from the Middle Inoceramus Fm. They occur within the progradational wedge-shaped deltaic-fan of U3. The deeper located Springhill Fm reservoir could tentatively also source CP2, albeit the distribution of Springhill sands is poorly constrained. Migration paths are most likely guided along basement normal faults crossing the Springhill Fm reservoir in U3, whilst in CP2 leakage at a stratigraphic pinch-outs is more likely.