De-risking hydrocarbon charge in the Namibe Basin (southern Angola) using combined 2-D and 3-D petroleum systems modelling techniques

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We combine 2-D and 3-D (map-based) basin and petroleum system modelling techniques to de-risk hydrocarbon charge in the Namibe Basin, a largely underexplored deepwater rift margin off southern Angola. This is a timely study, following the recent announcement of license rounds by the Agencia Nacional de Petroleo, Gas e Biocombustiveis (ANPG), including most of the offshore Namibe basin blocks (Figure 1a).

The models use the 2D and 3D PGS GeoStreamer® seismic data acquired in 2011, where the critical elements to the petroleum systems in the prolific conjugate Santos-Campos margin and the Kwanza basin to the north have been identified, namely (Figure 1b): (1) thick syn- and post-rift sediment packages; (2) alternating reservoir and seal facies in both the syn- and post-rift sequences; (3) the deposition of thick Aptian salt; and (4) large 4-way dip closures and multiple syn- and post-rift stratigraphic traps. The presence of several good-excellent source rock horizons, both in the syn-rift and sag sections, can also be extrapolated into the Namibe Basin from previous studies and published (or open access) geochemistry data along the West Africa and South America margins.

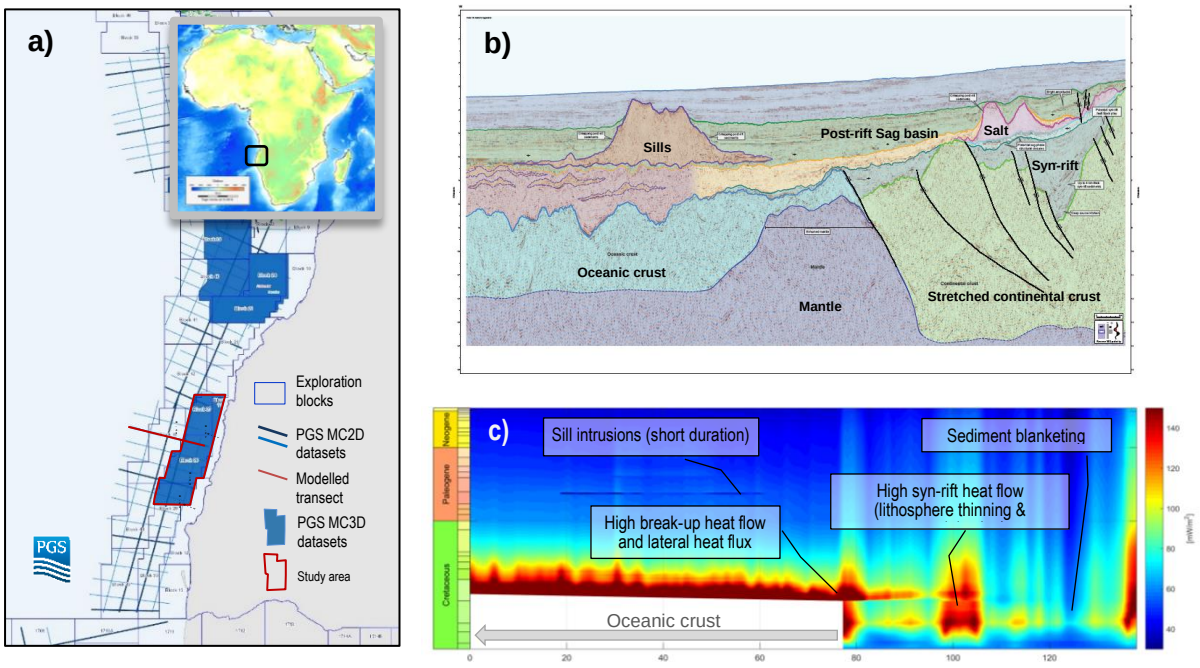

Figure 1. a) Location map showing the explor ation blocks offshore Angola (dark blue polygons) and the PGS GeoStreamer® datasets in the Benguela and Namibe basins (blue shadded polygons). The area modelled in this study, and the deep seismic transect used for 2-D modelling are highlighted by the red polygon and line, respectively, and the location of the Namibe Basin is depicted in the inset Africa map (thick black polygon); b) Modelled seismic transect across the northerm Namibe Basin, between stretched continental and oceanic crust; c) Predicted base sediments heat flow through time across the basin, assuming an Early Cretaceous rift event and continental break-up.

For the 2-D modelling we use TecMod-2D (GeoModelling Solutions, GmbH), along high quality deep seismic transects (Figure 1b). TecMod-2D combines forward modelling of basin-scale (e.g. sedimentation, compaction, maturation) and lithosphere-scale (e.g. crust/lithosphere thinning, break-up, flexure, serpentinization) processes, to an inverse scheme of iterative stratigraphy fitting. The modelling therefore provides the thermal structure of the basin along a transect, which is determined by an evolving lithosphere rift geometry, and is consistent with the burial history constrained from the seismic data (Figure 1c). This is particularly valuable in frontier basins, where there is only scarce information on the present and past thermal regimes.

The constrained thermal regime is then extrapolated to the area covered by the 3D PGS GeoStreamer® seismic data, taking into account the lateral variations in the structure and burial history of the margin and (tentatively) halokinesis. We use the map-based 3-D modelling Trinity software (Zetaware, Inc.), which allows rapid parameterization and low running times of model experiments, and thus efficient testing of multiple scenarios varying key input parameters to de-risk source rock maturity and charge of mapped structures. The modelling results suggest, for example (Figure 2): (1) recent maturity and oil-gas expulsion from an Albian source rock horizon (Pinda Fm. equivalent) in the southern Namibe basin, and low charge risk at a number of Late Cretaceous and younger structures; (2) maturity of a top syn-rift SR (Bucomazi Fm. equivalent) over an extensive area of the Namibe basin and significant oil and gas (localized) expulsion, charging mainly syn-rift and/or base salt structures; and (3) voluminous oil and gas generation and expulsion from mid-lower syn-rift source rock horizons (Lower Cuvo Fm. equivalent) along the basin axis early in the basin's burial history, charging numerous syn-rift and post-rift structures (depending on seal competence) along the basin axis and in the deeper SW sector of the margin.

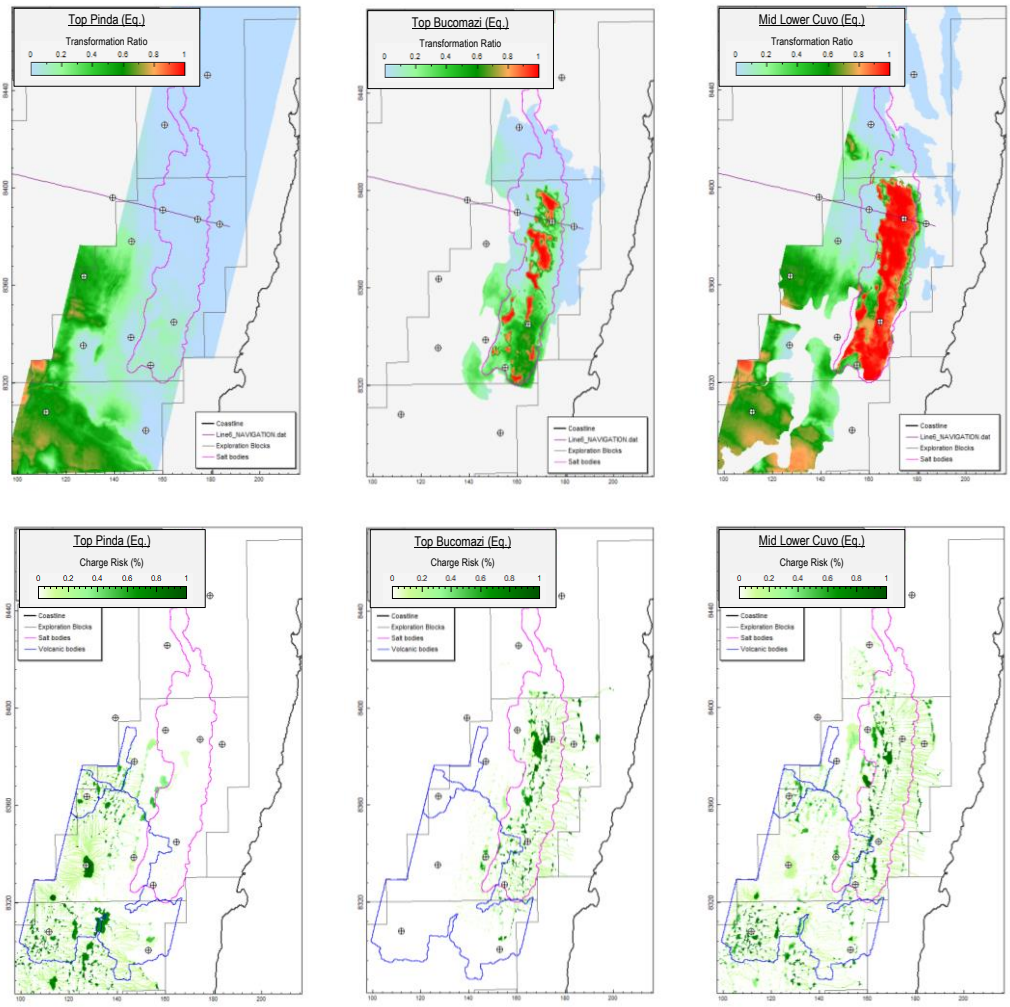

Figure 2. Predicted hydrocarbon generation (kerogen transformation ratio; top) and charge risk maps (bottom) for three source rock (SR) horizons, stratigraphically equivalent (Eq.) to the Pinda (left), Bucomazi (centre) and Lower Cuvo formations in the Kwanza Basin. The charge risk maps are compiled from numerous migration experiments varying top seal capacity, source rock potential, migration losses (generated hydrcarbons volumes not available for charge), and the timing of oil & gas expulsion. The maps show the coast line (thick black line), the exploration blocks (grey polygons), and the limits of the salt (pink polygons) and volcanic intrusions (blue polygons).