An Integrated 1-D Basin Modelling of the Petroleum Systems Offshore Sierra Leone

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Abstract

The Equatorial West African Transform Margin has now become an established world class petroleum province, with exploration interest grown over the last 20 years, in Ghana and more recently in the offshore basins of Benin, Senegal, Cote d'Ivoire, Liberia and Sierra Leone. Exploration in Sierra Leone began in the 1980s focusing on the shallow waters with 2D seismic, gravity surveys and two exploration wells drilled. Followed by a deepwater drilling campaign between 2009-13. Most of the wells encountered oil and gas shows, proving a working petroleum system. The most outstanding of these discoveries is Mercury-1 having a net pay of 41 m. However, a limited understanding of the basin has not led to any commercial discoveries. The Sierra Leone offshore basin is approximately 330 km and bounded to the NE and SW by the Guinea and Monrovia transform faults respectively. This region developed in two phases. Firstly, with initial extension during the separation of Gondwana and development of the South Atlantic, forming the continental-marine syn-rift sediments from the Aptian until Mid Albian, followed by the propagation of the passive margin, which was dominated by widespread marine sedimentation until recent.Sierra Leone contains two main source rocks: (i) Aptian to Early Cenomanian lacustrine shales with a TOC range of 4-20% and HI of 795-482. Geochemical analysis has confirmed the good quality and high potential of this source zone. (ii) Late Cretaceous, Cenomanian-Turonian shales (TOC ~5% and HI~560). Both source rocks are currently mature within the oil/gas window (0.8-1.2 R_o%). The quality of these source rocks generally increase with depth, and it is believed the main source rock is yet to have been penetrated. The reservoirs consist of fluvial sands in structural Aptian-Albian tilted fault block traps, whilst above the Mid Cretaceous break up

unconformity, there is an abundance of deep water fan lobe/channel sands that are stratigraphically trapped. Based on current well and seismic data, a total net sand thickness of 1500-2000m is expected in the deep water with average porosities of 15%. Substantial thick intervals of overlying and interbedded hemi-pelagic shales are present throughout the basin providing an effective seal unit across the basin. As part of an integrated study of the offshore waters of Sierra Leone, a series of 1D basin models were performed using Petro Mod on existing wells to get a regional understanding of the source rock in terms of maturity and hydrocarbon phase. In addition to this, several pseudo wells were created to give an understanding of the source rock maturity within the inner shelf shallow water areas (~500m), and outer shelf deep water zones/areas (~2500m). Results of this study show that the outer shelf is likely to be oil-prone (at 5000m TVDSS), and gas prone at (7000m TVDSS) whilst the inner shelf is likely to be oil prone at depths of around 2500-35000m.