Oil Prospects in the Mozambique Channel: Where Incipient Subduction meets Passive Margin

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Abstract

Davie Ridge Overview
The Davie Ridge has been observed as a prominent morphological feature in the Mozambique Channel. It shows a relative gravity low bounded to the east by a gravity high striking across the continental margin of Madagascar and Mozambique. The ridge was discovered by Heirtzler and Burroughs (1971)\textsuperscript{1} noticing a bathymetric elevation in the Mozambique Channel; they proposed that the Davie Ridge represents the expression of a transform fault resulting from the relative southward motion of Madagascar with respect to Africa. The entire feature was subsequently termed the ‘Davie Fracture Zone’ by Scrutton (1978)\textsuperscript{2}, even though there is no evidence of sea floor spreading in the East African Ocean.

It has long been widely understood that Madagascar was first disconnected from the Kenya-Somalia part of the African continent during the Middle to Late Jurassic, by dextral transcurrent movement along the Davie Ridge\textsuperscript{3, 4, 5, 6}, after the Gondwana breakup in the Late Liassic\textsuperscript{6}. However, most of plate tectonic reconstructions have assumed an inactive transform fault of the Davie Ridge.\textsuperscript{3, 7, 8}

A continuation of the Davie Ridge as a transform fault has been interpreted to extend northwards to the Karimbas Graben in northern Mozambique and Walu Ridge in Kenya by Rabinowitz (1971)\textsuperscript{9} based on an observed gravity high running along the graben and ridge until its intersection with the continental margin of Kenya.\textsuperscript{1} Recent contrary studies by Klimke and Franke (2016)\textsuperscript{10, 11}, and Klimke et al. (2018)\textsuperscript{11} show no geological evidence of the existence of a major transform fault in the Karimbas Graben and Walu Ridge based on field and reflection seismic data. The Karimbas Graben and Walu Ridge were subsequently interpreted to be tectonically unrelated to the Davie Ridge and to the southward motion of Madagascar.\textsuperscript{10} Consequently, the Davie Ridge has been proposed to be a conjugate transform margin to the Gunnerus Ridge offshore Antarctica\textsuperscript{11}, with a much more southerly pre-break-up position of Madagascar within Gondwana than most published plate reconstruction\textsuperscript{10}.

Incipient Subduction Davie Ridge
Recently acquired and public domain 2D reflection seismic data covering offshore central Mozambique Channel, south of the Rovuma Basin and northeast of the Zambezi Delta (Angoche Basin), are used to understand the crustal nature, to identify basin architectures, and to assess potential hydrocarbon prospects within this area.

The northeast Zambezi Delta region demonstrates a volcanic rifted margin style with deformation of Seaward Dipping Reflectors (SDRs) identified between the inboard uplifted continental crust and outboard oceanic crust representing a passive margin. The margin shows a narrow area of SDRs comparing to other volcanic rifted margins, for instance the South Atlantic margin of Namibia and South Africa. The crustal architecture consequently appears to be faulted semi-stratified volcanic layers which are interpreted to be oceanic crust in the outboard.

The Davie Ridge is clearly related to neotectonics. The ridge is composed of more than one ridge making ‘the Davie Zone’ a better term, based on its display on gravity and reflection seismic data. This zone comprises sedimentary ridges and trenches, and it is made up of thick sedimentary layers, younger well stratified and older compressed sediments (Fig 1). The compressed sediments have been observed by Klimke et al. (2018)\textsuperscript{7} and this study all the way along the gravity minimum of the Davie Zone (Fig 1 and 2), and we have interpreted this to be a crustal thickening accretionary wedge front of a forearc basin which stratigraphically continues
in to the Morondava Basin of Madagascar. We believe that these features were developed during an early stage of subduction where the passive margin of the African plate moves underneath the compressed continental crust of the Madagascar-Seychelles-Mascarene microplate.

Fig 1. Dip reflection seismic sections across the Davie Ridge demonstrating compressed sedimentary features interpreted to be accretionary wedge of an incipient subduction zone. Seismic data line A courtesy of WesternGeco and Spectrum.

**Oil slicks in the Davie Subduction Zone**

Several sea surface oil slicks have been identified on Optical Satellite Imagery above the thickening accretionary wedge and a relative position of the forearc basin to the Davie Subduction Zone (Fig 2), some comprising of clusters re-occurring over time. A very prominent cluster of slicks classified as high confidence oil slicks are observed from a single image, grouped together over a 10 km area and away from shipping routes. This unusual distribution of oil slicks appears in correlation with the Grandidier Seamount which we interpret to be a ridge associated to the Davie Subduction Zone (location B on Fig 2). Two similar groups of slicks are also observed within the region of the subduction zone (location A and C on Fig 2). These oil slicks provide a direct indication of source rock presence.

Other direct hydrocarbon indicators (DHIs) have been identified within the modern 2D reflection seismic data such as Bottom Simulating Reflectors (BSRs), pock marks, fluid escape features and shallow high amplitude reflectors. Some of the oil slicks appear to have a strong correlation to pock marks, fluid escape features and shallow high amplitude reflectors, and are supported by geological features such as fault and erosional surface for oil slick’s escape route.
Conclusions
The Davie Ridge is a plate boundary. We propose that from possibly Early Cretaceous the Davie Ridge has been an incipient subduction zone where the African plate moves underneath the Madagascar-Seychelles-Mascarene microplate until Turonian, which coincides with volcanism in Madagascar, and subsequently propose the term ‘Davie Subduction Zone’ based on our findings.

Numerous sea surface oil slicks and DHIs found within the subduction zone point to a new prospective oil province offshore Mozambique.
References


10 Klimke, J., and Franke, D., 2016, Gondwana breakup: No evidence for a Davie Fracture Zone offshore northern Mozambique, Tanzania and Kenya, Terra Nova 28 (4), n/a-n/a. In press.

Presenter Biography

Dr. Anongporn (Yen) Intawong is a geoscientist at Spectrum Geo Ltd. Anongporn received a PhD in Geology focusing on structural style and evolution of rift and strike-slip basins from Royal Holloway, University of London in 2006. She has more than fifteen years’ experience in the resource industry, including six years at consultancy companies, RPS Energy and Novas Consulting Ltd. After joining Spectrum in 2013 with a passion for geology in Africa, Anongporn has undertaken various geological and geophysical studies in Morocco, MSGBC, Gabon, Namibia, South Africa, Madagascar and Mozambique.