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RECENT SEISMICITY ALONG THE DAVIE RIDGE / FRACTURE ZONE.

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INTRODUCTION

The Davie Ridge/Fracture Zone has been considered as the seaward extension of eastern branch (Kenya Rift Valley) of the East African Rift System (EARS) (Chorowicz, 2005; Mougenot et al., 1986).

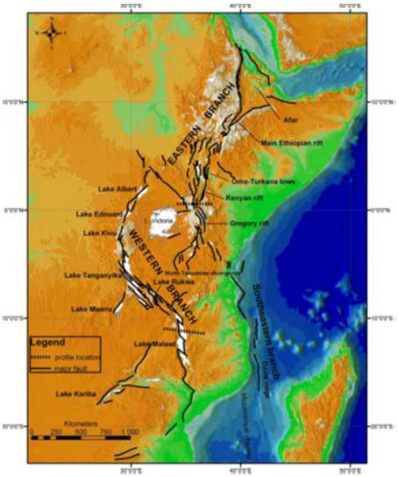

Figure 1: Southward extension of the Eastern branch (Kenya Rift Valley) of East African Rift system.

It is a 2200 km-long prominent relic fracture zone cutting across the West Somali Basin (Coffin and Rabinowitz, 1987, 1988; Grimison and Chen, 1988). It ranges between 30 and 120 km wide, with a west-facing scarp along the lower half of its length, that rises as much as 2300 meters above the sea floor (Scrutton, 1978; Mougenot et al., 1986).

Earthquakes as deep as 40 km have been recorded along Davie Ridge (Grimison and Chen, 1988). However, evaluation of recent seismic data for the purpose of this study shows that M_W 5.0 earthquakes at relatively shallow depths of 10 - 30 km are a common occurrence along Davie Ridge and Mozambique channel. The earthquake focal mechanism indicates that the Davie ridge is characterized by normal faulting with occasional obligue slip faulting.

Seismic reflection, gravity and magnetic data from offshore East Africa allow the Davie Ridge/ Fracture Zone to be traced from 11°S to its intersection with the Kenyan coast at 2°S (Figure 2), constraining the relative motion of Madagascar and Africa (Coffin and Rabinowitz, 1987).

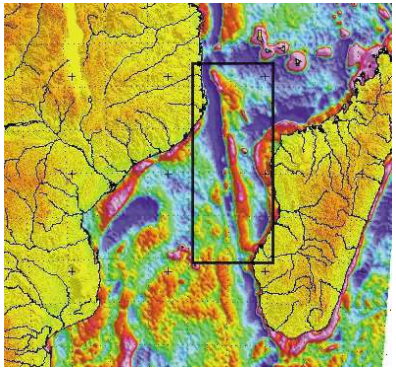

Figure 2: Satellite derived free-air gravity anomaly of the Davie Ridge/Fracture Zone enclosed in box (After Bird, 2001).

Faults and fractures, probably associated with Davie ridge/Fracture zone, have been mapped using gravity and magnetic data between latitudes 2°21'S and 3°03'S and longitudes 40°08'E and 40°45'E by Gippsland Offshore Petroleum Limited (2009).

SEISMICITY AND SEISMIC HAZARDS

The Kenya rift and Davie ridge are characterized by moderate level of seismicity. Small magnitude ($M \leq 3$) earthquakes described as earthquake swarms (Ibs-von Seht et al. (2008) are common on eastern branch (Kenya rift) of EARS. In comparison to EARS, the Kenya rift shows a low seismicity. Significant earthquakes in Kenya include the 1928 M_s 6.9 in central Kenya rift valley, an aftershock M_s 6.0, as well as the 1913 M_s 6.0 Turkana region earthquake (Ambraseys and Adams, 1991).

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Mulwa and Kimata (2014) have assessed tsunami hazard potential along the Davie ridge using three earthquake scenarios of M_W 7.2, 8.0 and 9.0 and fault parameters (rupture length, width, and surface displacement/fault dislocation) for normal faulting from Wells and Coppersmith (1994). Table 1 summarizes fault parameters as well as the associated sea floor displacement and tsunami heights for the three earthquake scenarios.

Table 1: Fault parameters and associated sea floor displacement (m) and tsunami wave height (m) due to three earthquake scenarios along the Davie Ridge.

M (M_w)	Strike*	Dip* (West)	Slip (m)	Length (km)	Width (km)	Sea floor displacement (m)	Maximum tsunami wave height (m)
7.2	0° (360°)	70°	3.5	60	35	≤ 0.5	1.0
8.0	0° (360°)	70°	7.6	200	50	≤ 3.0	5.0
9.0	0° (360°)	70°	20	1200	200	≤ 10	10

*Values of strike and dip are adopted from continental studies of the Kenya rift valley e.g. Omenda, 1994; Nyambok, 2001)

METHODOLOGY

Subscription of IDC SEL1 and REB products as well as supplementary earthquake data from International Seismological agencies/sources e.g. ISC, GFZ, USGS, NEIC e.t.c. has allowed continuous monitoring of the seismicity along the Davie ridge. Since early 2018 through 2019, the Davie ridge has been characterized by high frequency of earthquakes occurrence. Figure 3 shows the seismicity of the eastern part of Africa including the Davie Ridge and the Mozambique channel from 1900-May 2019, while Figure 4 shows earthquake epicenters for the period January 2018 to May 2019 for $M_W \geq 3.5$.

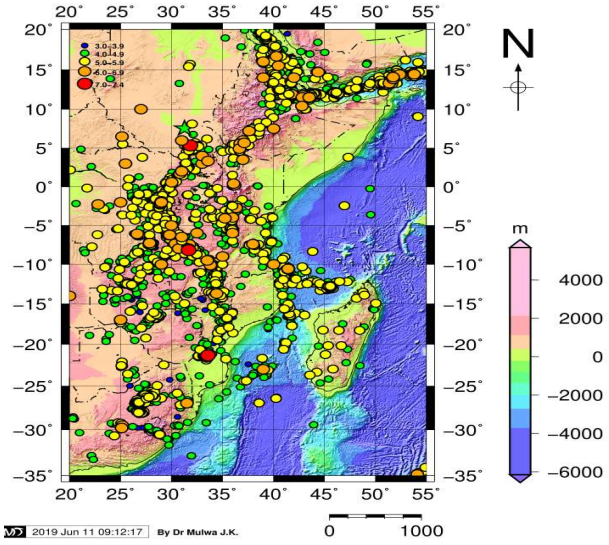

Figure 3: Seismicity of the eastern Africa from 1900 – May 2019 ($M_w \geq 3.5$).

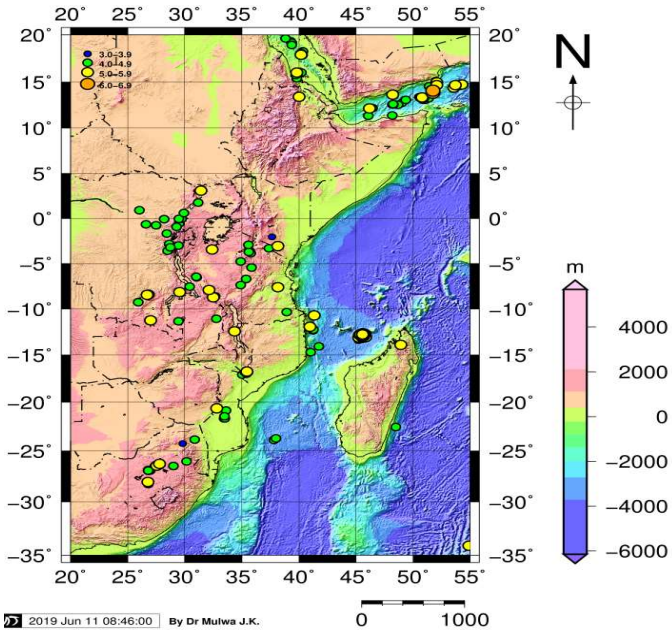

Figure 4: Seismicity of the eastern Africa for the period 2018 – May 2019 ($M_w \geq 3.5$).

To assess stress drop along the Davie Ridge, moment magnitudes (M_w) from various seismological agencies, in addition to fault parameters for normal faulting have been used. Seismic moment M_o (Nm) required for stress drop computation has been calculated from the standard relation $\mathbf{M_w=2/3[\log_{10}M_o-9.1]}$. The stress drop has been estimated based on equation $\mathbf{\Delta\sigma=2.5M_o/S^{1.5}}$ (Fukao and Kikuchi, 1987).

RESULTS AND DISCUSSION

Distribution of earthquake epicenters in figure 4 shows that, out of a total of 364 events during the period 2018 to May 2019, 222 events (61%) have occurred along the Davie Ridge (7) and Northwest of Madagascar (215). The magnitude (M_w) ranges between 4.4-5.4 and 4.4-5.9 respectively. Along the Davie Ridge, the estimated fault (rupture) area ranges between 10.9-49.1 km^2 and the corresponding stress drop ranges between 0.39-1.02 MPa. The results from this study have been compared with previous works (e.g. Mulwa, 2011; Mulwa and Kimata, 2014; Hussein, 1999) and found to underestimate rupture area and therefore overestimate the stress drop by ≅0.3 MPa.

CONCLUSION AND RECOMMENDATION

Stress drop based on fault parameters obtained using empirical relationships, regression curves and coefficients e.g. Wells and Coppersmith (1994); Papazachos et al., 2004; Vakov, 1996 e.t.c. are overestimated. Nevertheless, the relationships, curves and coefficients offer rapid estimate of fault parameters and stress drop. Waveform modeling/inversion (e.g. Mulwa, 2011; Mulwa and Kimata, 2014; Tsuboi et al., 2000; Hussein, 1999; Pinar and Türkelli, 1997; Thio and Kanamori, 1996; Giardini and Beranzoli, 1992; Fukao and Kikuchi, 1987; Kanamori and Given, 1981 e.t.c to retrieve source (fault) parameters is herein recommended.