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An Integrated Tectono-Stratigraphic Framework for Kachchh Basin and its Conjugate Areas*

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Abstract

The widespread Pan African Orogeny of Neo-Proterozoic to Lower Palaeozoic Era has resulted in the formation of Gondwana Supercontinent by accretion and collision of continental blocks along major orogenic belts (Kröner and Stern, 2004). These orogenic belts are the weak zones along which intracratonic or passive margin rifting takes place. The East Gondwana continental fragments comprising Madagascar, Seychelles and India were attached to East Africa margin until the Middle Jurassic (Gieger, 2004). Subsequent rifting episodes at different time periods lead to continental breakup and development of a passive margin. In this present study, we have created a composite tectono-stratigraphic chart of Tanzania, Kenya, southern Somalia, Diego Basin of Madagascar, Seychelles and Kachchh Basin of India with an objective of identifying the rifting episodes and their influence on the sedimentary and structural geometry of the basins.

Before initiation of passive margin rifting, the study area had been affected by an episode of intra-cratonic rifting starting from Upper Carboniferous (Catuneanu et al., 2005). In Somalia, Kenya, Tanzania and Madagascar these rifts are collectively known as Karoo intracratonic rifts recording a sedimentary fill from Upper Carboniferous to Middle-Upper Triassic (Catuneanu et al., 2005). In East Africa and Madagascar these rifts dominantly follow NE-SW Precambrian structural trend known as South Trans-African shear system “STASS” (Key and Reeves, 2012). Presence of Triassic sediments in Seychelles (Plummer and Belle, 1994; Kaye, 1985) and onland Kachchh (Koshal, 1984) also hints the possibility of rifting in this region. Passive margin rifting started between East Africa and India-Madagascar-Seychelles during Early Jurassic (Reeves and de Wit, 2000; Gieger, 2004) with continental breakup occurring during Middle Jurassic (Gieger, 2004; Klimke and Franke, 2016). Post breakup, India-Madagascar-Seychelles drifted southward along the Davie Fracture Zone and by 120 Ma, Madagascar reached a position to the east of Mozambique (Bastia et al., 2010). The complete separation between India-Seychelles and Madagascar was achieved by 88 Ma (Rathesh-Kumar et al., 2014), after which India begins its northward drift (Bastia et al., 2010). Finally, last major phase of Gondwana rifting in the study area occurred, when Seychelles separated from India during 63.4 Ma (Collier et al., 2008).

Geologic History of Indian Ocean Study Area

In the study area (Figure 1), it has been observed that the initiation of rifting period or continental breakup is marked by change in depositional environment; modification in basement structural trend or by the emplacement of volcanics. The Permo-Carboniferous intracratonic rifts (Rift 1) are common across Tanzania, Kenya and in Madagascar and are proven by well data (Coffin and Rabinowitz, 1988; Catuneanu et al., 2005). In case of Kachchh, the presence of Triassic sediments is confirmed by a rich assemblage of bisaccate striate pollens, which are diagnostic of Triassic age (Koshal, 1984; Traverse A, 2007). However, the Permo-Carboniferous sediments corresponding to Rift 1, which were recorded in East Africa and Diego, are not found in Kachchh and Seychelles. The boundary between intra-cratonic rifts (Rift 1) and first passive margin rifting (Rift 2) is well demarcated by the presence of basin scale Late Triassic unconformity in East Africa and Madagascar (Catuneanu et al., 2005). In addition to that, change in structural trend of basement faults related to two different rifts is identified in Tanzania (present study).

In the Selous Basin of onland Tanzania, seismic interpretation indicates that the intracratonic faults of Rift 1 age follow NE-SW structural trend, whereas in offshore Tanzania, the basement faults of Rift 2 follow NNW-SSE to N-S structural trend (this work). The change in structural trend from older NE-SW to younger N-S is due to the difference in pre-existing basement anisotropy used by two different rifting events. Continental breakup between East Africa and Madagascar-Seychelles-India during Bajocian-Bathonian (Gieger, 2004; Klimke and Franke, 2016) is marked by basin scale deposition of marine carbonates and shale (Biswas, 1977, 1978; Coffin and Rabinowitz 1988; Plummer and Belle, 1995; Brownfield and Schenk, 2016) across the study area (Figure 2). However, the breakup timing varies across the study area. In Diego, Seychelles and Kachchh the lower part of Early Cretaceous is marked by marine sedimentation dominated by shale, marl and sandstone (Biswas, 1977, 1978; Coffin and Rabinowitz, 1988; Plummer and Belle, 1995; Brownfield and Schenk, 2016).

The shift in sedimentary facies, from shale-marl dominated sediments to Middle Cretaceous clastic dominated sediments is observed in Diego Basin and Seychelles (Coffin and Rabinowitz, 1988; Plummer and Belle, 1995; Brownfield and Schenk, 2016). At the same time, Kachchh Basin is also filled by fluvio-deltaic sediments (Biswas 1977, 1978). In offshore Kachchh, faults of NNW-SSE are interpreted affecting Upper Bhuj and Lower Bhuj section (present studies). This change in sedimentary facies and the presence of NNW-SSE trending faults sets in kachchh offshore possibly indicates the initiation of third episode of rifting (Rift 3) between India-Seychelles and Madagascar. In addition to that, volcanics of Late Cretaceous age (93-85 Ma) are recorded from Seychelles (?), Madagascar (Diego, Morondova and Majunga Basin) and India (St Mary's Island, Kerala and Karnataka) (Fisher et al., 1968; Torsvik et al., 1998 Pande et al., 2001; Bardtinzeff et al., 2009). This volcanic event is due to the activity of Marion hotspot (Torsvik et al., 1998; Kumar et al., 2001) situated at the south east part of Madagascar (Torsvik et al., 1998) and is coeval with continental breakup between India-Seychelles and Madagascar (88 Ma) (Rathesh-Kumar et al., 2014). Post breakup, India along with Seychelles started to drift toward the north (Bastia et al., 2010). The final episode of Gondwana rifting in this margin occurred between Seychelles and India. The rifting was fast with continental breakup occurring at 63.4 Ma (Collier et al., 2008). This episode of rifting is synchronous with the occurrence of Deccan volcanics in India and in Seychelles (Collier et al., 2008). In offshore kachchh, possible evidence of strike-slip fault reactivation at the top of Deccan volcanics is due to Rift 4, as observed in seismic data (present study).

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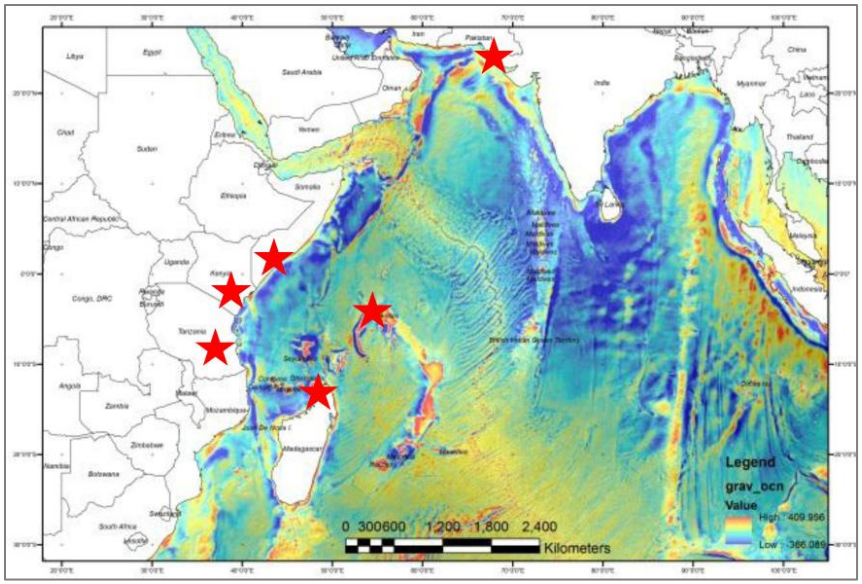

Figure 1. Free air gravity map of Indian Ocean. The red stars indicate the location of the study area.

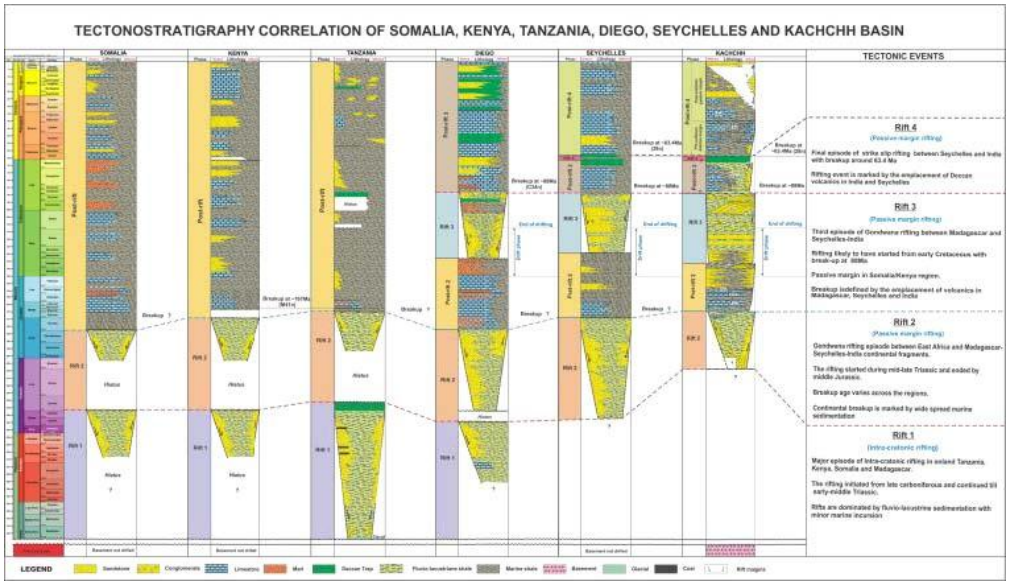

Figure 2. Composite tectono-stratigraphic chart of Somalia, Kenya, Tanzania, Diego, Seychelles and Kachchh.