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Earthquake swarms at divergent plate boundaries in the Southern Red Sea, Afar and Gulf of Aden region from 1960 to 2016

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Earthquake swarms observed at inland rift zones (e.g. Afar region, Iceland) and in a few offshore cases show an unambiguous relation with magmatic intrusions, when not located along transform fault zones. These swarms typically last for a few days to a few weeks and lack a clear mainshock-aftershock decay pattern. They are also systematically linked with rifting events or episodes, consisting of magmatic intrusions, surface faulting, and sometimes volcanic eruptions. Here we present a study of earthquake swarms in three areas: the southern Red Sea, Afar and Gulf of Aden, hereafter called the SAGA region. We compiled and analyzed an earthquake swarm catalogue integrating reexamined global and local earthquake catalogues from 1960 to 2016. We found that swarm sequences in the SAGA region have been re-occurring several times at the same locations at time intervals of a few years to a few decades (e.g. at Bada in Eritrea and off Port Sudan in the southern Red Sea in 1967 and 1993; Western Gulf of Aden in 1979, 1997, 2004 and 2010-2011). This suggests the existence of previously unrecognized active spreading centers in the region. The swarms show different families of magnitudes, with clusters of M3 and M5 events, and in rare cases earthquakes greater than M6 have been recorded, such as in the central Afar region (e.g., Serdo, 1969, Dobî graben, 1989). Of the three areas, Gulf of Aden shows the highest swarm concentration and activity, followed by Afar and the southern Red Sea. Despite seeing the least amount of activity and lower magnitudes, the southern Red Sea has experienced multiple earthquake swarms and three volcanic eruptions (two of which resulted in new volcanic islands) during the past 15 years. Together, our results reveal new details about the activity at the boundaries separating the Somalian, Nubian and Arabian plates during the last 50 years and suggest that magma is likely responsible for most of the observed seismic swarm activity. We also show that the three areas have been subject to an almost simultaneous increase of earthquake swarm activity during the period from 2005-2013 with three rifting episodes and several eruptions, suggesting a transient increase of magmatic activity in the entire SAGA region.