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Cenozoic evolution of Socotra Island in relation with the stages of opening of the Gulf of Aden

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A complete stratigraphic and geological map revision of the Tertiary of Socotra Island is undertaken in order to better characterize the geometry and the tecto-sedimentary evolution of this portion of the southern margin of the Gulf of Aden, and compare them with those of the conjugate northern margin in Oman.

The Paleocene to Middle Eocene pre-rift sequence corresponds to carbonate platform systems similar to those of the Arabian and Somalian plates. They record the two important transgressive phases of the Thanetian-Early Eocene (Umm Er Rhaduma Fm.) and of the Middle Eocene (Dammam Fm.), separated by a regressive interval Late Cuisian – base Lutetian in age (Rus Fm.). A significant discontinuity marked by a stratigraphic gap of the Lower Ilerdian separates two first depositional sequences.

An increase of the rate of subsidence is recorded during the Late Eocene and is associated with a transgressive peak within carbonate platform deposits (Aydim Fm.). At the scale of the Arabian plate, the extent of this platform is reduced to the future rift area. This evolution of the platform system shows a modification of the sedimentary profiles, controlled by the beginning of the rifting. At the Eocene-Oligocene boundary, the siliciclastic influx from the western part of the Gulf of Aden under a phase of surrection (Afars uplift) doesn't reach the Socotra area. The syn-rift deposits of the Early Oligocene correspond to sub-reef carbonate platform facies (Ashawq Fm.). First, the throw of synsedimentary faults and the movements linked with differential subsidence are widely compensated by carbonate production which manages to maintain a platform profile. These movements are recorded by thickness variations, significant lateral variations in the platform facies and by a local inversion of sedimentary polarities controlled by the tilting of faulted blocks. Like on the northern margin, an acceleration of the extension process leads, during the Late Oligocene, to a collapse of the platform and to the creation of deep sub-basins with carbonate gravity-flow sedimentation. Marginal reef platforms keep growing at this stage on the structural highs and feed gravity-flow sedimentary systems. The sedimentation rate stays then relatively low in the basin, forming a complex topography of the margin, marked by a segmentation into numerous sub-basins more or less connected and separated by submarine escarpments marked by wedges of breccia deposits along active normal faults. In different points, these faults are sealed by sedimentary deposits characterized by progressive unconformities and onlap geometries on the fault escarpments. These geometries show the relatively short length of the phase of « stretching » of the continental crust.

Around the end of the Early Miocene, the progradation of conglomerate fan-delta deposits locally results in the fill of the basins and shows a major phase of uplift. It is very rapidly followed by a new phase of subsidence which allows the preservation of thick fan-delta and equivalent reef platform complex unconformably overlying different units of the syn-rift and pre-rift sequences, or even the exhumed Proterozoic basement. This tectonic-sedimentary phase is interpreted as synchronous to the continental breakup and the onset of the T.O.C. at the foot of the margin. The analogy with the phase of development of « sag basins » on the Atlantic margins has to be analyzed. This major « uplift » at the transition syn-rift / post-rift seems to be expressed symmetrically on both margins. These « syn-TOC » deposits are then uplifted and affected by late tilting events. However, the most recent deposits, probably Late Miocene to plio-Quaternary in age, have only been affected by small uplifts, unlike

those of the Dhofar on the northern margin. The general uplift of plio-quaternary deposits on the northern margin (up to the Oman Mountains) appears therefore like a phenomenon linked with the movements and deformation of the Arabian plate only (ex : collision of the Zagros) and could thus be independent of the mechanisms associated with the opening of the Gulf of Aden.