Geophysical Research Abstracts, Vol. 9, 11471, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-11471

Sedimentology and lithostratigraphy of the Mesozoic successions of Mekelle Basin of Ethiopia, Northeastern Africa

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Mesozoic sedimentary successions of Mekelle basin, about 3km thick, are produced by a second order cycle of sedimentation on a gently sloping ramp during Triassic to Early Cretaceous. Sedimentation in this basin started with the marine transgression in Triassic from southeastern side of Ethiopia. Due to eustatic sea-level rise in the Mesozoic, Indian Ocean transgressed over gently sloping platform (Somalia, Ethiopia and part of Sudan). There was an abundant clastic supply in Triassic, when sea-level was rising, as well as in Early Cretaceous, when sea-level was falling, which produced two sandy successions, basal retrogradational and upper progradational. Whereas during Jurassic, when sea-level was at its acme, clastic supply became negligible (as it was restricted in coastal area), a carbonate dominating aggradational succession, sandwiched between two sandy successions, formed. Therefore, in Mekelle basin, Mesozoic transgression and regression has produced a thick succession of clastic (at the base), carbonate, carbonate and evaporites (in the middle) and again a clastic (at the top). These successions unconformably overlie either directly on Upper Proterozoic Basement or on patchy Palaeozoic rocks. Lithologically, Proterozoic Basement of Mekelle basin represents low to medium grade metamorphic rocks, with syn- to post-tectonic granitic bodies, dykes and quartz veins. The Palaeozoic successions have Enticho Sandstone Formation (ESF) and Adaga Arbi Tillites Formation (ATF). Though, the ESF seems older, at places these two Paleozoic units show inter-fingering relationships. Mesozoic sedmentary successions are represented by four different lithostratigraphic units i.e. Adigrat Sandstone Formation (ASF), Antalo Limestone Formation (ALF), Agula Shale/Mudstone Formation (AMF) and Ambaradom/Upper Sandstone Formation (USF) in ascending order.

Middle Jurassic transgression, from southeast, deposited ASF at the base due to high rate of clastic supply in high energy environment, as evidenced by the presence of thick, cross-bedded sand bodies. However, a typical ASF shows two types of cyclically repeating lithologies. One is characterized by thick, coarse, cross-bedded, iron cemented, multi-storied sand bodies and devoid of body and trace fossils at the bottom produced by high rate of sedimentation and the other by thin, iron-rich mud-drapes of laminated mudstone, with petrified wood and occasionally vertical traces of Skolithos association (reported for the first time) at the top, resulting from low rate of sedimentation. ASF is a mappable unit (maximum thickness 1000m), diachronous in age if traced laterally, deposited in coastal beach environment with abundant tidal signatures. Therefore, it is assigned a lithostratigraphic rank of Formation. Further rise in sea-level has facilitated the deposition of carbonate succession by restricting the clastic supply to coastal area, which is referred as ALF. This is characterized by thick (more than 1000m), bedded, micritic limestone with plenty of invertebrate fossils, öolites and marly bands. ALF is also a mappable unit and hence referred as Formation. After deposition of ALF, the declining sea-level has resulted in the high rate of clastic supply of fine-grained terrigenous influx depositing AMF. This mud dominated unit, though very thin as compared to ASF and ALF, is also mappable, and hence is referred as Formation. It consists of variegated shale, mudstone, siltstone, claystone, fossiliferous limestone (coquina) and evaporites deposited in an arid-evaporatic environment. Presence of mud cracks in AMF indicates subaerial exposure and shallow depth of deposition. Continued regression in Early Cretaceous caused fluvial deposition of coarse, conglomeratic, iron cemented sandstone on the top, referred as USF. Thus, the Mesozoic sedimentary basin of Ethiopia is a repository of almost a complete cycle of sedimentation which started in Triassic and ended in Lower Cretaceous. Although, Lower Cretaceous is a time of global sea level rise, in Mekelle basin it resulted in the deposition of progradational succession due to forced regression produced by basinal tectonics. Sedimentary successions of Mekelle basin are later intruded and overlain by doleritic dykes of Oligocene age (31-26 Ma), popularly known as Mekelle dykes. Lithostratigraphic terminology suggested here will provide uniformity in usage and avoid ambiguity and confusion that exists in literature.