



Eocene sea retreat out of Asia: paleogeography, controlling mechanisms and environmental impacts

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The sediments of the Central Asian basins include the remnants of the easternmost extent of a large epicontinental sea. Before it retreated westward and eventually separated as the Paratethys Sea following the Eocene-Oligocene transition (EOT), this shallow marine sea extended across the Eurasian continent from the Mediterranean Tethys in the west to the Tarim Basin in western China in the east. However, the paleogeography and the timing of the westward retreat of the proto-Paratethys Sea are too poorly constrained to identify its proposed controlling mechanisms and paleoenvironmental impacts. The sea supposedly entered Central Asia in the Cretaceous and five third-order marine incursions have been recognized from the Cretaceous-Paleogene sedimentary record, of which the last two transgressions are documented here. We studied the sea retreat in the Tarim Basin in western China, the Alai Valley and Ferghana Basin in southern Kyrgyzstan and the Afghan-Tajik Basin in south-western Tajikistan. Integrated bio-magnetostratigraphic dating shows that the sea retreated westward from the Tarim Basin in stepwise fashion. The major fourth transgression occurred during the Lutetian, after which the sea retreated from the southwest Tarim Basin paleodepocenter at ~41 Ma (base C18r). The last and fifth transgression was restricted to the westernmost margin of the Tarim basin and occurred during latest Bartonian-early Priabonian (base C17n.3n-base C16n.1n). At the level of precision of our dating, each of these marine incursions is apparently synchronous across the Tarim Basin suggesting rapid regional transgression/regression cycles in these shallow epicontinental basins with limited diachroneity. The shallow marine near-shore sediments of these last two transgressions can be convincingly correlated by litho- and biostratigraphy across Central Asia, showing for the first time that the sea may have largely retreated from Central Asia in the late Eocene.

The lack of apparent diachroneity of the two last regressions and their concomitancy with the closure of the Turgai Strait in the late Lutetian, with short-term cooling events recognized in contemporary marine records, important late Eocene regressions documented in European basins (e.g. Paris Basin, Ebro Basin, and Transylvanian Basin) and with minor drops in global sea-level, suggest that the individual marine incursions may have been controlled by short-term global fluctuations in sea-level. On the other hand, the gradual continuous character of the marine-continental transitions and the westward paleogeographic step between the fourth and fifth incursions, separated by several millions of years, rather are typical of long-term tectonic control. Tectonism is likely related to the Eocene India-Asia collision and Pamir initiation to the south in agreement with the infilling with northward paleoflow directions observed in the investigated sections. This is confirmed here by paleomagnetic data from the southwest Tarim Basin showing that clockwise rotation initiated after the fourth marine incursion, probably in response to initial symmetric radial thrusting of the Pamir Mountains. However, the presence of a major disconformity in the southwest Tarim Basin at the EOT, associated with a major global sea-level fall, confirms that the Tarim Basin remained hydrologically connected to the Mediterranean Tethys in the Eocene and had not yet been isolated by tectonic uplift of the surrounding mountains. This is in agreement with previously reported late Oligocene-early Miocene exhumation ages of the Pamir-Kunlun orogenic system and proposed kinematic models suggesting that after late Oligocene-early Miocene initiation of slip along the Kashgar-Yecheng Transfer System along the Eastern Pamir. This is consistent with the paleomagnetic data presented here showing that after the Oligocene deformation became asymmetric with ceased clockwise rotation in the Tarim Basin and continued anticlockwise rotation on the western side in the Afghan-Tajik Basin.

The stepwise sea retreat and disconformity are concurrent with the documented aridification steps in the North-

eastern Tibetan Plateau (Xining Basin) at ~ 41 Ma (C19n-C18r), ~ 37.1 Ma (top C17.1n) and the EOT at ~ 33.9 Ma (top C13r), suggesting that the sea retreat and aridification in Asia were indirectly paced by global climate deterioration in the Eocene through eustatic level changes affecting the Proto-Paratethys sea. In line with climate modelling results, the sea retreat may have amplified the aridification of the Asian interior. Hence, future studies of Asian paleoenvironmental change during Eocene times also have to be interpreted in terms of fluctuations in moisture supply by the changing paleogeography of the proto-Paratethys Sea in Central Asia.