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Palaeoenvironmental and tectonic significance of Miocene lacustrine and palustrine carbonates (Ait Kandoula Formation, Ouarzazate Foreland Basin, Morocco): insights into the development of the High Atlas Mountains.

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The Ouarzazate Basin is the southern foreland basin to the High Atlas Mountains in Morocco, bounded to the north by the Southern Atlas Fault and associated fold-and-thrust belt, and to the south by the Anti-Atlas Mountains. The sedimentary fill of the Ouarzazate basin preserves a sequence from the Eocene to Pleistocene that records the interplay between tectonics, climate and surface processes allowing insights into Cenozoic palaeoenvironmental change and the development of the adjacent High Atlas Mountains. In this study, we present the first stable isotope and facies analyses of the Middle to Late Miocene Aït Ibrirn lacustrine Member (Aït Kandoula Formation), a well exposed member with good existing chronological constraints. Five sedimentary facies of lacustrine and palustrine limestones are interbeddded with extensive sequences of palaeosols and fluvial sandstones and conglomerates, often associated with evaporite (gypsum) development. These facies can be divided into two facies associations related to water depth and sub-aerial exposure within the basin. Sediments dating to the Serravalian and early Tortonian are dominated by shallow water successions, typical of underfilled foreland basin settings. Furthermore, carbonate δ18O and δ13C isotopes from the sections show strong covariance confirming that these carbonates were deposited within a hydrologically closed basin. However, late Tortonian to Messinian carbonates do not demonstrate the covariance typical of endorheic basins. Additionally, the facies association of these younger sediments indicates the presence of deeper water lake systems. These two lines of evidence demonstrate that the basin was externally draining at this time and had transitioned to a balanced-fill lacustrine system. This evolution in the palaeogeography of the basin questions the established view of tectonic stagnation in the development of the High Atlas Mountains in the Late Miocene. Additionally, this work demonstrates that the Cenozoic sediments of the Ouarzazate Basin contain a rich record of climate change and tectonic evolution on the edge of the Sahara desert.