

Structural and Lithological Controls on Brine and Hydrocarbon Flow in the Giant Dzhezkazgan Sediment-Hosted Copper Deposit, Chu Sarysu Basin, Kazakhstan

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The late-Paleozoic Chu Sarysu Basin, Central Kazakhstan, contains one of the world's largest redbed ('Revette-type') sediment-hosted stratiform Cu (SHSC) systems. Deposits occur in three clusters at Dzhezkazgan (22 Mt contained Cu), Zhaman-Aibat (2.7 Mt) and the Zhilandy trend (2.9 Mt). The aim of this study is to understand the timing and migration pathways of hydrocarbons and brine. A new geological interpretation of the northern part of the basin sheds light on (i) the aquifer properties of Pennsylvanian redbeds, and (ii) the formation of hydrocarbon traps. In addition, source rock maturation modelling elucidates the timing of hydrocarbon generation. Pennsylvanian redbeds were deposited in a fluvial meanderbelt setting; an environment that typically produces mud-rich sediments. However, a dry climate, limited bank-stabilising vegetation, and third order (c. 1-2 Myr) sea-level fluctuations combined to produce laterally extensive and interconnected sand sheets. Residual brines from the Permian salt provided salinity. Volcanic lithic fragments within the Pennsylvanian redbeds, derived from the Balkhash-Yili arc, were the source of Cu. Hydrocarbon traps formed via extension, not compression, due to uplift and rebound in the foot walls of large-scale normal fault systems. Hydrocarbons, predominantly oil, filled traps during maximum burial at c. 275 Ma. Only around the largest faults did hydrocarbon columns breach local seals and invade the Pennsylvanian redbeds. Oxidised brines remained in the Pennsylvanian redbed aquifer, trapped beneath the salt at lithostatic pressure, until the basin was uplifted during Uralian orogenesis. Erosion of the salt seal in the northern part of the basin eventually uncorked the aquifer. Brine swept northwards through the Pennsylvanian redbeds driven by pore collapse under the weight of the overlying rock. Brines deposited Cu minerals where they intersected hydrocarbon traps. Sinuous patterns in ore grade maps at Dzhezkazgan are a hallmark of the fluvial meander necks that baffled fluid flow at the deposit-scale.