Unraveling the Dolomitization Puzzle: Insights from the Cambrian Ambar Formation, Peshawar Basin

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The Ambar Formation, a Cambrian carbonate sequence within the Peshawar basin, is characterized by extensive dolomitization. Tabular bodies of dolomite- cemented breccias and networks of dolomite veins accompany dolomitized bodies of varying sizes and shapes. Field observations and petrography reveal three distinct types of matrix dolomite. Dolomite-1 is stromatolitic, Dolomite-2 is oncoidal and bedded, and Dolomite-3 is replacive saddle dolomite. Analysis indicates that dolomitization occurred through a complex process involving hydrofracturing, dissolution of the host rock, and subsequent dolomite precipitation. The dolomites exhibit distinct stable oxygen isotopic signatures, with Stromatolitic Dolomite and Oncoidal Dolomite showing similar signatures to the Cambrian carbonates, while Replacive Saddle Dolomite displays depleted oxygen isotopic signatures. Strontium isotopic signatures reveal similarities between Dolomite-1, Dolomite-2, and the Cambrian carbonates, while Dolomite-3 and cement dolomite exhibit more radiogenic signatures. Fluid inclusion analysis suggests elevated temperatures (135 to 215°C) for the dolomitizing fluids, indicating a fossil hydrothermal system. This process is likely driven by the episodic expulsion of over-pressured fluids through fault and fracture systems. Dolomite-1 and Dolomite-2 are thought to have formed in shallow burial or near- surface settings, while Dolomite-3 and dolomite cement are seen as having a hydrothermal origin. This hydrothermal system is likely linked to deep-seated faults, suggesting considerable fault activity during the Cambrian Ambar Formation. This study offers valuable insights into the complex processes of dolomitization and their geological implications in similar contexts.