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Basalt-CO_2 Interaction at 50°C and 62 Bar: Mineral Carbonation Potential in Kula Volcanic Field (Manisa, Turkey)

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The concept of geological storage for climate mitigation has advanced significantly over the last three decades, over the last three decades, with notable advancements demonstrated by the CarbFix project, which successfully sequestered CO_2 from geothermal plants in unaltered basaltic reservoirs via mineral carbonation. Mineral carbonation is widely regarded as the safest and most sustainable CO_2 storage method; however, its effectiveness depends largely on local geology.

The Kula Volcanic Field (KVF), located in western Anatolia is a monogenetic volcanic field characterized by alkali basaltic lava flows and scoria deposits, with an estimated total volume of ~5.5 km^3. This study experimentally investigates the carbonation potential of KVF basaltic rocks under subsurface conditions, to evaluate their potential for long-term CO_2 storage.

Three distinct lithologies derived from KVF were selected for this study: i) massive basalt derived from columnar lava flow, ii) vesicular basalt derived from flow breccia deposits, and iii) basaltic scoria from a cinder cone. Rock samples, including block-sized specimens (1 cm^3) and clasts (2–3 mm), were subjected to detailed mineralogical, petrographical, chemical, and physical characterization using polarizing microscopy, XRD, FE-SEM, and Micro-CT. Fluid-rock interaction experiments were conducted at 50°C and 62 bar using carbonic acid (pH: ~3.1) over 15 days to simulate CO_2-rich subsurface conditions. Post-experimental analysis confirmed the formation of secondary carbonate minerals, predominantly aragonite and calcite, occurring as microcrystalline aggregates, amorphous coatings, and crust-like growths within fractures and pore spaces. Micro-CT analysis revealed 1–2% changes in pore structure due to successive dissolution and precipitation of minerals.

The preliminary findings suggest that KVF basalts have the capacity to undergo mineral carbonation, which indicates their potential for sustainable CO2 sequestration, rather than continued exploitation as a low-cost construction material. As a UNESCO Global Geopark, KVF should be repurposed as a natural CO_2 trap contributing to climate mitigation efforts.