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The Potential of Helium Production from Geothermal Fluids – Field Observations, Lab and Pilot Scale Extraction Studies

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Helium is classified as a critical raw material due to its strategic importance in key industrial sectors, including medical diagnostics (e.g., MRI systems), aerospace engineering, electronics manufacturing, semiconductor processing, and fibre optics production. Currently, economically viable helium production is almost exclusively linked to natural gas reservoirs, where it is recovered as a by-product using cryogenic distillation. Given the limited number of helium-producing fields worldwide and increasing supply risks, alternative and sustainable sources are of growing interest.

Within the framework of the EU-funded project “CRM-geothermal,” we evaluate the potential of geothermal systems as an alternative source of helium. Geothermal fluids typically contain dissolved and free gases, including helium of crustal and mantle origin, which may be co-produced during geothermal energy exploitation. This study examines gas samples from diverse geothermal locations in Europe and East Africa. Geochemical and isotopic analyses reveal highly variable helium concentrations ranging from as low as 6 ppm up to 6 vol%. The isotopic signatures of $^{3}He/^{4}He$ indicate contributions from both crustal sources and mantle reservoirs, which highlight the geological controls on helium enrichment.

We conducted experimental investigations using various polymeric membrane materials under simulated geothermal conditions, to assess the technical feasibility of membrane-based gas extraction efficiencies from geothermal fluids. Tubular membranes composed of polydimethylsiloxane (PDMS) and polytetrafluoroethylene (PTFE) proved to be robust and suitable for continuous, online gas extraction from geothermal fluids. For subsequent helium enrichment, activated molecular sieves were tested and successfully achieved helium enrichment by an order of magnitude, demonstrating the potential for scalable concentration steps following primary extraction.

The technical concept was validated as part of a production test at a geothermal drilling site in Cornwall (UK). The results confirm the operational feasibility of membrane-based gas extraction and downstream enrichment under real field conditions.

Our findings provide new insights into helium prospection, monitoring, extraction, and enrichment in geothermal environments and demonstrate that geothermal systems may represent a promising complementary source to conventional natural gas-based helium production.