

The character and habitat of natural hydrogen resources

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Commercial hydrogen gas, H₂, is produced directly from hydrocarbons contributing ~2.4% of global CO₂ emissions. H₂ is mostly used as a chemical feedstock, producing ammonia used in fertiliser production amongst other hard to abate uses. Extending to provide a future clean energy vector, H₂ demand could increase from ca 95 Mt H₂ today, to 540 Mt H₂ by 2050. Clean, low carbon sources of hydrogen are essential for this energy transition.

Hydrogen is produced naturally in the continental crust through water-rock reactions with mafic or ultramafic rocks and the radiolysis of water from the radioactive decay of U and Th. The mass of H₂ generated, little associated with carbon, has the potential to be a significant clean societal H₂ resource. Other putative terrestrial sources of H₂, such as the Earth's mantle, are not substantiated. The timescales and environments that enable significant hydrogen generation occur in geological different continental terrane. These vary from dominantly Phanerozoic ophiolite/mantle wedge complexes, Proterozoic-Phanerozoic alkaline granite complexes, Mesoproterozoic-Phanerozoic large igneous provinces (LIP), to dominantly Archean TTG and greenstone belts. The capacity to form traps in all systems is required alongside the porosity and permeability history that exposes the rock to water, both associated with the tectonic evolution in each setting. To form a commercial reserve, an environment that produces and preserves a free gas phase from the ubiquitous water over the timescale of the system is also required. Helium (⁴He) provides an important analogue for natural hydrogen behaviour and the processes that control both deep-seated flux to the near surface and gas phase formation. Loss due to microbial utilisation remains a high preservation risk. Exploration strategies consider the full hydrogen system. Accumulation and preservation of only a small portion of the natural hydrogen generated is technically interesting. Identification of accessible parts of the continental crust containing a gas phase that are close to markets is required to form a commercial viable natural resource.

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