Statement of Dr. Geoffrey S. Ellis
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before the
Senate Committee Energy and Natural Resources
on
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Good morning, Chairman Manchin, Ranking Member Barrasso, and Members of the Committee. Thank you for the opportunity to testify before you today on the potential for geologic hydrogen resources. My name is Geoffrey Ellis and I lead the U.S. Geological Survey's (USGS) research on geologic hydrogen resources.

Introduction

The USGS is the science arm of the Department of the Interior and brings impartial, actionable science to an array of stakeholders and partners, including decision-makers such as Congress, resource managers, and the public.

Congress passed the USGS Organic Act in 1879, in part to gain greater understanding of our Nation's energy and mineral resources. That goal remains central to our mission 145 years later. We provide science and data on the occurrence and distribution of national and global energy resources and on the potential environmental and socioeconomic effects associated with resource occurrence and use.

The USGS's research addresses the full life cycle of energy resources, from how and where resources form and accumulate, through resource extraction, to disposal, recycling, reclamation, and the potential to reuse waste as a resource. We study widely-used energy commodities such as petroleum, coal, geothermal energy, and uranium, as well as the use of subsurface pore space for disposal of energy waste, including geothermal and hydraulic fracturing fluids and carbon dioxide. We also study emerging energy resources such as gas hydrates and geologic hydrogen.

Hydrogen as an energy resource

Hydrogen is the most abundant element in the visible universe. In its molecular form (H_2), it contains more energy per unit of weight than any other fuel. Hydrogen is currently an important feedstock for a variety of industrial processes, including petroleum upgrading, steel manufacturing, and fertilizer production. Hydrogen is also viewed as an important emerging medium for storing and transporting energy.

Today, most commercially-available hydrogen is produced from natural gas. This "grey" hydrogen is relatively energy-intensive and releases about 10 tons of carbon dioxide to the atmosphere for every ton of hydrogen gas generated. Until recently, additional hydrogen was projected to come from a combination of hydrogen derived from natural gas, coal, or biomass coupled with carbon capture and sequestration ("blue" hydrogen), and hydrogen generated by electrolysis of water using renewable sources of electricity ("green" hydrogen). Today, my testimony will focus on a previously overlooked source of hydrogen: naturally occurring geologic hydrogen accumulations in the Earth's subsurface ("white" or "gold" hydrogen).

Why the recent interest in geologic hydrogen?

The existence of naturally occurring hydrogen is well documented in many geologic environments. Nevertheless, out of the millions of oil and gas wells that have been drilled to date, only a few dozen oilfields have been documented to contain more than trace levels of hydrogen. This has led many geoscientists to conclude that economic accumulations of hydrogen in the subsurface are non-existent. However, recent evidence indicates that we have simply not looked for geologic hydrogen resources in the right places with the right tools.

In 1987, a shallow water well drilled in Mali, West Africa, produced an unexpected gas explosion and was quickly abandoned. Nearly 25 years later, an oil and gas company returned to the site and discovered that the gas was more than 97 percent hydrogen. Subsequent exploration identified five geologic reservoirs containing nearly pure hydrogen gas. This hydrogen has been in production for more than 10 years and is used to provide electricity to a local village.

This discovery was first described in the scientific literature in 2018 and stimulated new interest in the resource potential of naturally occurring or 'geologic' hydrogen. Several countries are actively working toward a hydrogen economy through investments in geoscience, technology, infrastructure, and by readying utilities and the manufacturing industry. Researchers in France have investigated geologic hydrogen resource potential for more than a decade. Australian research has expanded in recent years. Active exploration campaigns are ongoing in Brazil, Colombia, and elsewhere.

In the United States, the first well ever drilled specifically to target a geologic hydrogen accumulation was in Nebraska by Natural Hydrogen Energy LLC in 2019. The USGS began investigating geologic hydrogen resources in 2021. Several more hydrogen exploration wells have been drilled in the United States in the last two years and more are planned for 2024.

What do we know about the resource potential?

The geologic setting of the hydrogen accumulation in Mali is not unique, which suggests that geologic-hydrogen accumulations could be widespread. In fact, researchers have begun reviewing historical industry records and unpublished data and have uncovered historical discoveries of natural hydrogen that had gone unnoticed in numerous places around the world.

The USGS has recently developed a model of global hydrogen resource potential.[1] The model is based on known properties of hydrogen and well-understood accumulations of other geologic resources, including petroleum, geothermal energy, and noble gases such as helium. These factors provide some constraints on the possible magnitude of the global geologic hydrogen

[1] Ellis, G.S. and Gelman, S.E., 2022. A preliminary model of global subsurface natural hydrogen resource potential. Geological Society of America Annual Meeting, Denver, Colorado, October 9-12, 2022. Geological Society of America Abstracts with Programs, v. 54, no. 5. https://doi.org/10.1130/abs/2022AM-380270

resource in the Earth's crust. Estimated in-place[2] global geologic hydrogen resources range from thousands to billions of metric tons (Mt), with an approximate mean value in the tens of millions of Mt. The model does not predict the spatial distribution of hydrogen in the subsurface.

Based on historical data on other geologic energy resources, the vast majority of the in-place hydrogen resource is likely to be in accumulations that are too deep, too far offshore, or too small to be economically recovered. However, the remainder could constitute a significant resource.

What more needs to be done?

More geoscience research and data collection is needed to better understand where natural accumulations of hydrogen might be found. Fortunately, we have extensive experience from petroleum, geothermal, and hydrothermal mineral-resource exploration that can be applied to understand geologic hydrogen resources. Building on that experience, the USGS is developing a conceptual geologic model for evaluating the potential for hydrogen accumulation in the subsurface.

The USGS model will initially be applied to mapping the likelihood of finding geologic hydrogen resources in the lower 48 states of the U.S. To better understand the global potential for geologic hydrogen resources, we are partnering with geological surveys of other nations to share data and refine our model. We are working with the Colorado School of Mines and several industry partners to advance the geoscience and exploration methods needed to mature our understanding of geologic hydrogen resource potential.

Another significant advance in our understanding of global geologic hydrogen resource potential would be the incorporation of better data on the potential to stimulate hydrogen generation. We are partnering with the U.S. Department of Energy to identify the geologic conditions under which these technologies may be applied, in ways that are effective, safe, and protective of local communities' health and the environment.[3] Advancement of stimulation technologies could significantly add to our current estimate of the global potential for economically recoverable geologic hydrogen.

Summary

In summary, our current understanding suggests that the amount of naturally occurring hydrogen in the Earth's interior is likely to be large. However, the potential for this hydrogen to be present in accumulations that could be economically, safely, and responsibly recovered is unknown. Research is currently underway at the USGS to improve our understanding of the potential for economic accumulations of hydrogen and to develop exploration tools for this potential low-carbon primary energy resource.

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[2] In-place resources are the total volume occurring in accumulations regardless of technological or economical ability to recover them.

[3] U.S. Department of Energy Announces $20 Million to Explore Potential of Geologic Hydrogen, September 7, 2023, https://arpa-e.energy.gov/news-and-media/press-releases/us-department-energy-announces-20-million-explore-potential-geologic

Thank you for the opportunity to testify today. I look forward to your questions.

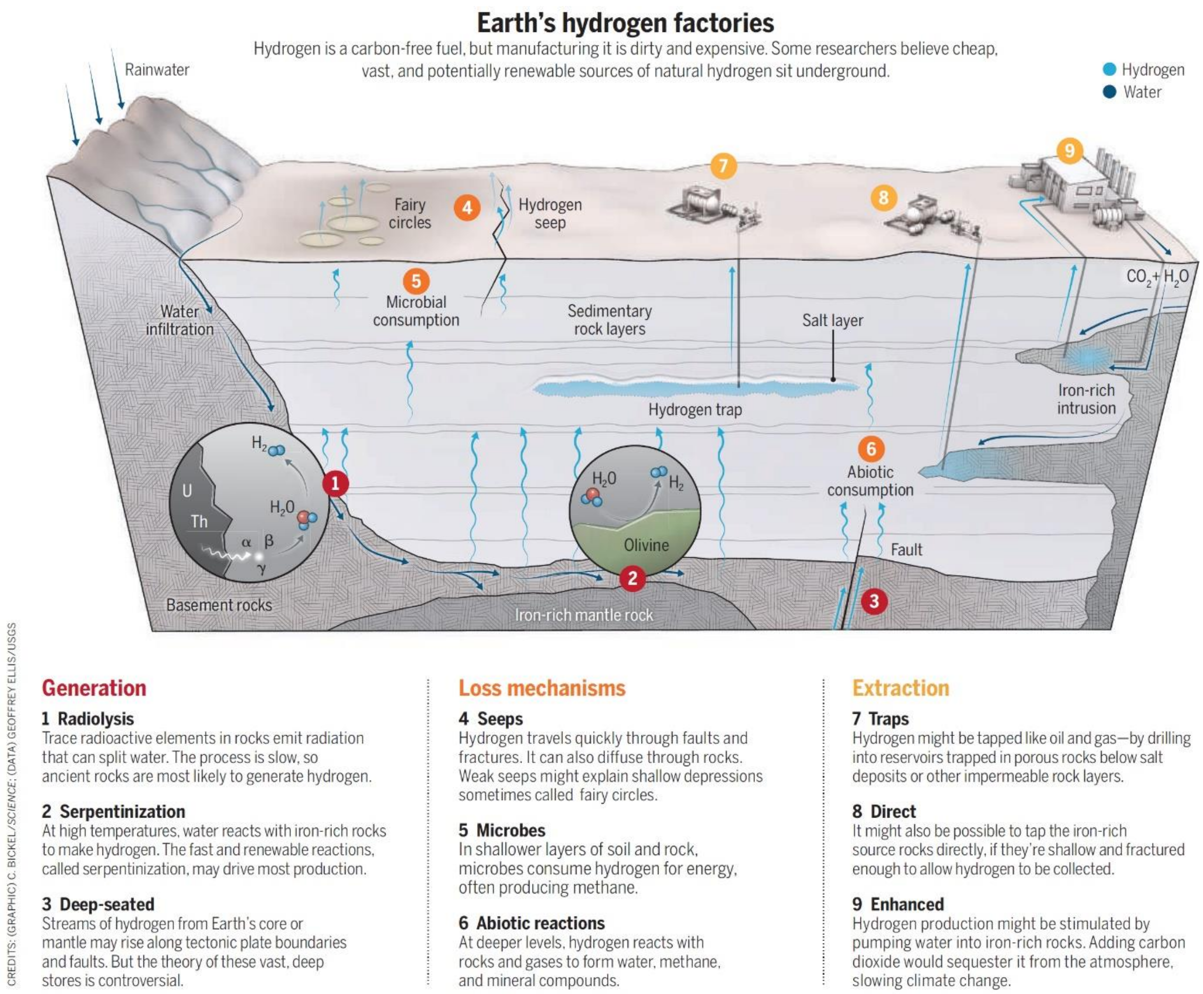

Figure 1. Schematic diagram showing potential mechanisms for generation (1-3) and consumption (4-5) of hydrogen in the subsurface as well as potential approaches for resource recovery (7-9). Three conceptual types of exploitable hydrogen include natural accumulations (7), natural generation (8) and stimulated generation (9). (Source: Hand, E. 2023, Hidden Hydrogen – Does Earth hold vast stores of a renewable carbon-free fuel?: Science 379:6633, p. 631-636, https://doi.org/10.3133/ofr20211045.)