Groundwater, not ice sheets, is the largest source of water on land and most of it is ancient

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Credit: AI-generated image (disclaimer)

Outside of the world's oceans, groundwater is one of the largest stores of water on Earth. While it might appear that the planet is covered in vast lakes and river systems, they make up only 0.01 percent of the Earth's water. In fact, we now know there is 100 times as much groundwater on this planet as there is freshwater on its surface.

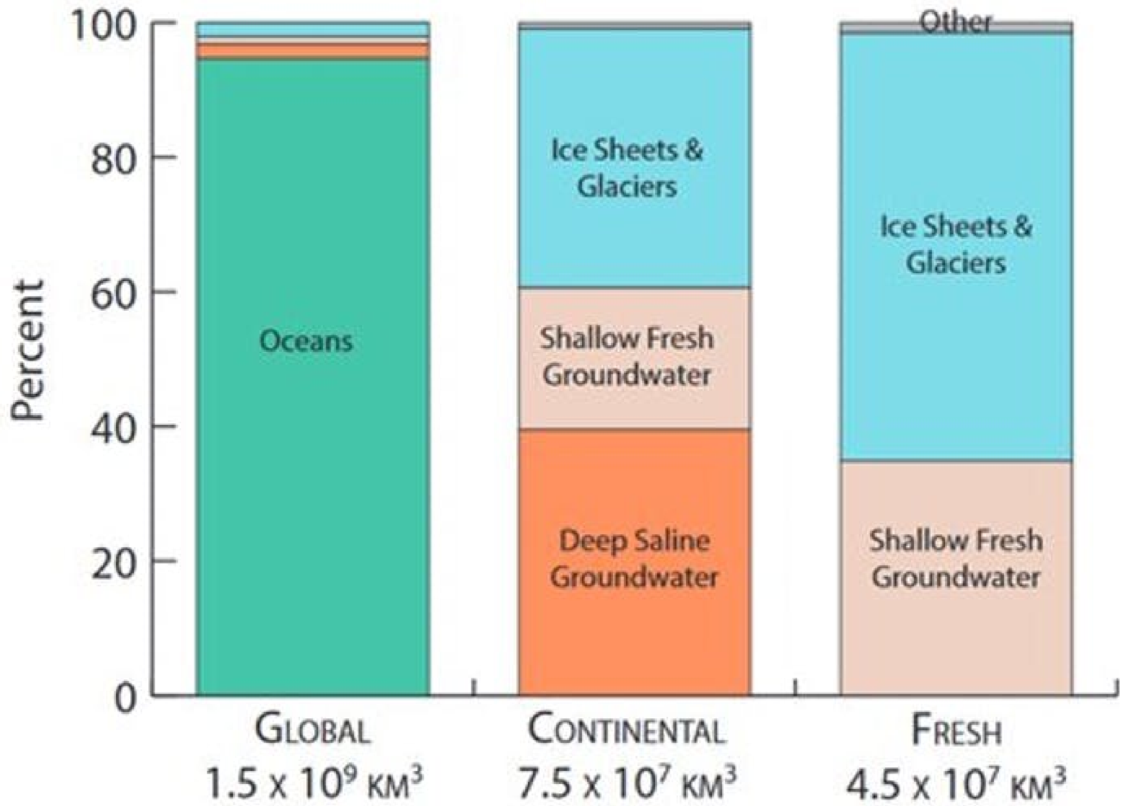
Groundwater is the water contained beneath the Earth's surface. It's stored in the tiny cracks found within rock and the spaces between soil particles. It can extend deep into the subsurface, at least as much as 10 kilometers.

As groundwater researchers, we're interested in how governments and industries might use these extensive groundwater reservoirs, such as for storing liquid waste and carbon dioxide. But groundwater may also have environmental functions that have not yet been revealed—this body of water remains hidden, with very few windows available for us to explore it.

One of Earth's largest stores of water

While scientists have known for at least five decades that groundwater makes up a large fraction of the world's water, estimated volumes of groundwater had focused on the upper two kilometers of the Earth's crust.

A recent analysis that looked 10 kilometers beneath the surface found that the true volume is likely twice as large. These new estimates mean that groundwater is the largest continental reservoir of water—even more than all the water contained in the continental ice sheets in Antarctica and Greenland, which were long thought to be the Earth's second-largest stores of water.



The relative sizes of the Earth's water reservoirs. Groundwater makes up about 60 per cent of the water on land. Credit: AGU/Geophysical Research Letters

Previous groundwater estimates arrived at lower volumes because they only considered groundwaters at shallower depths. But permeable rocks are found down to at least 10 kilometers below the Earth's surface and can hold water in cracks and pores. While these spaces only account for a small volume of the rock mass, they add up to nearly 44 million cubic kilometers of water in the upper 10 kilometers of rock, enough to fill more than 10,000 Grand Canyons.

Groundwater matters because it can provide reliable water for homes, irrigation and industry. But these wells tend to be less than 100 meters deep and they rarely approach one kilometer. Most of the groundwater contained in the rock below that is saline, sometimes several times saltier than seawater, and unusable for drinking water or irrigation.

Scientists know much less about the groundwater stored more than one kilometer deep. Yet they have determined that rain and snow falling in North America can circulate to depths of one to four kilometers. Beneath these depths there is only ancient water with other origins, last in contact with the atmosphere more than tens of thousands of years ago, but sometimes in excess of a billion years ago.

The circulation of this deep groundwater is controlled by the forces that drive flow, such as topography, and the permeability of the rock. For example, rainwater and snowmelt circulate more deeply in mountainous areas than flatter regions. Groundwater can flow at speeds of meters per year in sandstones and limestones, or nanometres per year in intact igneous and metamorphic rocks, due to extreme variations in the permeability of different rocks.

Environmental functions of deep groundwater

All of this has helped contribute to the treatment of deeper groundwater as being separate from shallow groundwater resources. For example, oil and gas producing regions often only protect groundwater to a certain depth, without consideration of the strength of the connections between shallow and deep groundwaters.

This assumed disconnect is also the basis for a number of waste isolation projects, including the geologic sequestration of carbon dioxide, also called carbon capture and storage, and of nuclear waste repositories in Canada, Finland and elsewhere.

Onkalo was built to house high-level radioactive waste for at least 500 years. The storage facilities are set 500 metres deep in 1.9-billion-year-old rock on the coast of Finland. Credit: Teemu Väisänen/Wikimedia

Deep groundwaters may only be weakly connected to the rest of the hydrologic cycle but this does not mean they are unimportant to the functioning of our planet. Microbes have been found in most subsurface environments with temperatures below 80 C, typical for depths of three to four kilometers. This subsurface life likely accounts for more than 10 percent of the Earth's total biomass, and yet the links between deep groundwater circulation and subsurface life are largely unexplored at this time.

There's clearly still much to learn about deep groundwater. Our windows into the deep subsurface are limited to deep mines, oil and gas wells and a handful of research sites.

New approaches are required to understand deep groundwater, its environmental functions and interactions with the rest of the hydrologic cycle over deep time, both in the past and into the future.

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