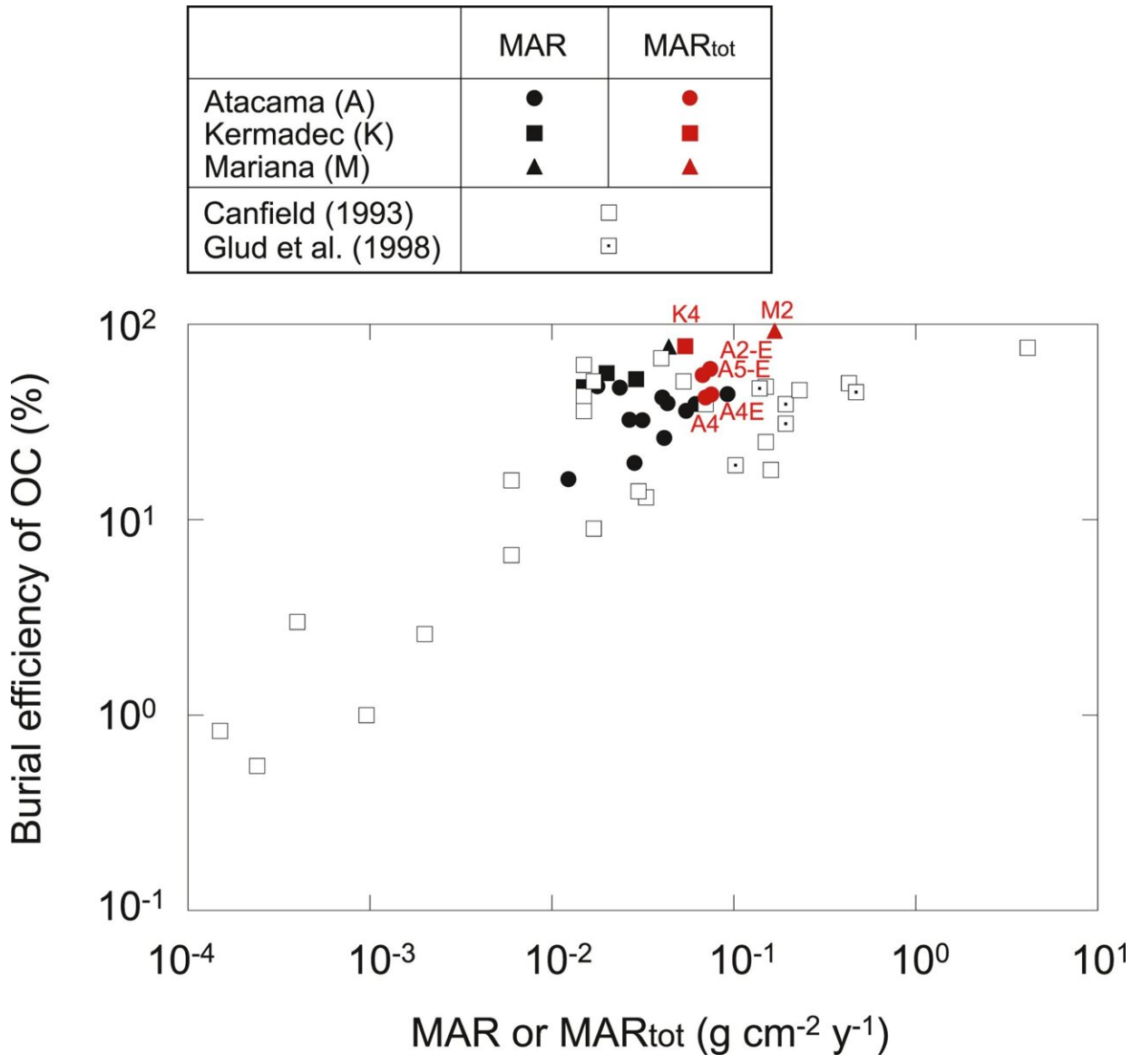
Disproportionately large amounts of carbon accumulate at the bottom of deep-sea trenches, research shows

December 21 2022, by Birgitte Svennevig



The burial efficiency of organic carbon as derived from deposition and mineralization rates versus the Mass Accumulation Rate (MAR) or total MAR (MAR_{tot}) quantified for a range of marine settings. The hadal data of the current study are plotted along with previous values collected at a depth range from 10 to 5,330 m compiled in Canfield (1993) and Glud et al. (1998). Credit: *Journal of Geophysical Research: Biogeosciences* (2022). DOI: 10.1029/2022JG006814

The Earth's deep-sea trenches are some of the least explored places on Earth—as they are very difficult to access, are pitch black and the pressure is extremely high. Collecting samples and making reliable measurements of the processes that regulate the turnover of organic material in the deep is therefore difficult.

In recent years, however, researchers from the Danish Center for Hadal Research (HADAL) at University of Southern Denmark have carried out a number of expeditions to deep-sea trenches.

They have developed and applied sophisticated underwater robots, and they have demonstrated in several published studies that the steep deep-sea trenches accumulate various material including organic carbon that ends up at the bottom of the trenches.

The bottom of a deep-sea trench can therefore be a veritable deposition hotspot for microbial life forms that converts the material.

Carbon accumulates in the trenches

In three recent studies, the researchers report that hard-to-decompose organic carbon, including so-called black carbon, accumulates in large quantities at the bottom of the trenches.

Black carbon consists of particles formed during burning of fossil fuels, wood and forests; activities that also lead to the release of CO_2. The occurrence of black carbon is thus an indicator of the extent of fossil burning. The particles themselves can also contribute to warming, as they are carried by wind and weather to ice-covered areas, e.g. polar regions, where they settle on ice and snow, increasing heat absorption and thus the melting.

"And now we see that large amounts of black carbon end up at the bottom of deep-sea trenches," says Ronnie N. Glud, professor and head of the Danish Center for Hadal Research.

Samples from more than six kilometers depth

More concretely, the research team has calculated that every year, somewhere between 500,000 and 1,500,000 metric tons of black carbon is stored in the hadal deep-sea; that is the part of the seabed that lies at a depth of more than six kilometers.

In comparison, 6,600,000—7,200,000 metric tons of black carbon are emitted annually from the burning of fossil fuels.

The researchers base their calculations on sediment samples that they have retrieved from various deep-sea trenches, exceeding six km deep and thus part of the hadal realm. The hadal zone covers 1% of the seabed.

Not only are disproportionately large amounts of black carbon being deposited in the deep; the same happens for other resilient, hard-to-decompose carbons. In fact, the studies show that every square meter in the central parts of a deep-sea trench buries 70 times more resilient carbon compared to the deep sea in general.

"Although the hadal zone only makes up a very small part of the seabed, disproportionately more carbon is stored here than in the deep sea in general," says Ronnie N. Glud. "So, despite the fact that the deep trenches have a relatively high microbial turnover, the hadal zone and the deep-sea trenches are overlooked reservoirs of stored carbon and thus represent a piece of the global carbon cycle and counteract the rate at which CO^2 accumulates in the atmosphere."

The researchers cannot say with certainty where the deep-sea trenches' content of deposited carbon comes from; this work is still going on.

The sea as a landfill

But the black carbon can be the result from burning fossil fuels in nearby countries such as New Zealand, Australia and Chile, which sends black carbon out to sea with the wind.

This hypothesis aligns with the fact that the black carbon content is highest in trenches that are close to industrialized countries, while trenches that are close to less industrialized countries such as Papua New Guinea have a lower content of black carbon. However, factors such as wind direction, ocean currents are forest fires may confound such relations.

According to Ronnie N. Glud the deep-sea trenches act as deposit zones for organic material. The process is facilitated by frequent earthquakes, which are characteristic of the hadal systems.

The earthquakes carry large amounts of material down into the deepest parts of the trenches and bury it in oxygen-free sediments. Here, the material will accumulate over centuries and millennia.

Thus, one may want to ask whether the deep-sea trenches are suitable for

carbon storage?

"Man has always used the sea and the deep sea as a dumping ground in the pretense of being 'out of sight out of mind'. But today we know this is not true. The ocean, rich in life, and its biological and biogeochemical processes are important for the function of the globe—this also applies to the hadal trenches," says Ronnie N. Glud.

Other materials end up in the deep-sea trenches

The fact that man-made, resilient, hard-to-decompose organic material (partly from our burning of fossil fuels), reaches the bottom of our deepest deep-sea trenches, does not surprise Ronnie N. Glud.

"In the past, it was believed that the deep-sea trenches were deserted and devoid of life, and that they were unaffected by what happened at the surface. Hence the name 'hadal', which is derived from the name of the realm of Death in Greek mythology (HADES)," he says.

"Today we know that the hadal trenches have a rich and diverse life, are dynamic and very diverse, and that material from land and the surface finds its way all the way to their interior—unfortunately this also includes plastic and pollutants. For example, we have previously demonstrated that hadal sediments contain surprisingly high levels of mercury."

The studies are published in the *Journal of Geophysical Research: Biogeosciences*, *Communications Earth & Environment*, and *Geochemistry, Geophysics, Geosystems*.

More information: Kazumasa Oguri et al, Sediment Accumulation and Carbon Burial in Four Hadal Trench Systems, *Journal of Geophysical Research: Biogeosciences* (2022). DOI:

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Provided by University of Southern Denmark