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One Type of Carbon So Resilient It Skews Carbon Cycle Calculations

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One Type of Carbon So Resilient It Skews Carbon Cycle Calculations

Scientists interested in the Earth's carbon cycle — something that must be understood to assess the ongoing effects of carbon dioxide created by human actions, such as driving cars — have a new problem. They need to adjust various calculations because one component, graphitic black carbon, similar to the material found in pencil lead, turns out to be so tough.

In a letter in today's issue of Nature, researchers say that graphitic black carbon is created as sedimentary rocks undergo metamorphism — unlike forms of combustion-derived black carbon such as soot, charcoal and other debris that's left when biomass such as forests or fossil fuels don't burn completely. Eroding from rocks on land, graphitic black carbon appears to be one of the only kinds of carbon that resists conversion to other forms of carbon, such as combining with oxygen to form carbon dioxide, as it cycles between land, atmosphere and oceans.

"Carbon is generally considered to pass fairly freely between reservoirs, or 'boxes,' of the carbon cycle," says lead author Angela Dickens, a doctoral student in chemistry and oceanography at the University of Washington. "The carbon stays in one box for a variable amount of time — for hundreds of years in trees, a few days in a bug, thousands of years as organic carbon dissolved in the world's oceans and such, but not generally staying more than a few thousand years in any one form before being converted into a different form.

"Of course carbon in rocks cycles on a much longer time scale — millions of years — but it has been assumed that once that carbon weathers out of rocks it will enter a different box, perhaps becoming atmospheric carbon dioxide or part of the biomass. This isn't the case for graphitic black carbon," Dickens says. "It's tough stuff."

This gives it a chance to become so old its exact age can't even be determined using radiocarbon dating methods, meaning it's at least 50,000 years old and, Dickens suspects, much, much older.

This really old graphitic black carbon, referred to as fossil graphitic black carbon, was inseparable from combustion-derived black carbon in marine sediments until co-author Yves G□linas of Concordia University in Montreal developed a new technique in recent years. One implication of this latest work is that where fossil graphitic black carbon is present with combustion-derived black carbon or other organic carbon, it skews the radiocarbon data scientists have been using to understand the carbon cycle.

Although fossil graphitic black carbon makes up only roughly 0.5 percent of the total organic carbon and perhaps 10 percent of the total black carbon buried in most marine sediments, the "widespread presence of fossil graphitic black carbon in sediments has therefore probably led to significant overestimates of burial of combustion-derived black carbon in marine sediments," the scientists write in the letter to Nature.

For example, in the equatorial Pacific Ocean the scientists estimate that, of published results, somewhere between 20 percent and 60 percent of the open-ocean black carbon fluxes might actually consist of fossil graphitic black carbon.

The authors also say their results imply that a significant fraction of sedimentary organic carbon in marine sediments is fossil graphitic black carbon. That changes, for example, the age of organic carbon from Washington coastal sediments by 75 to 530 years and makes scientists believe organic carbon stays longer than it actually does in intermediate reservoirs, such as soil.

"These interpretations are important for understanding the time scales of carbon cycling in the environment. For example, for understanding whether carbon in a watershed is very rapidly eroded, carried to the oceans and buried — implying that this system is a carbon sink — or if it sits around in soils for a very long time so that presumably most of it is oxidized back to carbon dioxide before what little remains erodes away," Dickens says.

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