Research reveals sources of carbon dioxide from Aleutian-Alaska Arc volcanoes

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Degassing is seen on Pavlof Volcano in July 2017. Credit: Taryn Lopez

Scientists have wondered what happens to the organic and inorganic carbon that Earth's Pacific Plate carries with it as it slides into the planet's interior along the volcano-studded Ring of Fire.

A new study suggests a notable amount of such subducted carbon returns to the atmosphere rather than traveling deep into Earth's mantle.

The finding can improve long-term projections about Earth's climate.

A study led by a University of Alaska Fairbanks Geophysical Institute scientist has shown that volcanoes of the Aleutian-Alaska Arc return more subducted slab carbon to the atmosphere as carbon dioxide than previously thought. This occurs through a process known as recycling.

Research associate professor Taryn Lopez is the lead author on research published today in the journal *Science Advances*. The 12 co-authors come from institutions in California, New Mexico, New York, Rhode Island, Washington state and Washington, D.C., as well as Italy and New Zealand.

"While we now have a fairly good idea of how much carbon is driven into Earth's interior through subduction and how much is released to the atmosphere by volcanoes, we still have a lot to learn about what happens to the carbon after it is subducted and what fraction is returned to the atmosphere," Lopez said.

The Aleutian-Alaska Arc, which stretches from Cook Inlet west across the Aleutian Islands, has fewer sources of carbon in its crust and subducted slab than most volcanic arcs around the world. This makes it possible to track carbon through the subduction cycle and get a better idea of how much subducted carbon volcanoes return to the atmosphere.

Carbon recycled to arc volcanoes—those located above an oceanic plate subduction zone—originates from three places: the subducted oceanic plate or slab, the mantle wedge overlying the descending slab, and the overriding crust.

Lopez sought to better define how much carbon is coming from the subducted slab.

Organic carbon settles atop the sea floor—the surface of the oceanic crust slab heading toward subduction. Organic carbon includes remains of marine plants and animals and of terrestrial plants and animals washed into the ocean.

Degassing is visible from a summit fracture on Kanaga Volcano in September

2015. Credit: Taryn Lopez

Inorganic carbon, derived from seawater, can precipitate as minerals onto the slab of oceanic crust.

The new research drew on gas samples Lopez and others collected from 17 volcanoes during this and previous research. They used data from ocean drill cores taken at four locations near the Aleutian Trench, where the Pacific Plate dives under the North American Plate.

With that information, the researchers used chemical modeling to track what fraction of organic and inorganic carbon returns to the atmosphere from the slab subducted at the Aleutian Trench. They tracked carbon from subduction to volcano outgassing.

The research focused on the Aleutian-Alaska Arc's central and western regions, which consist of oceanic crust.

"From the Alaska Peninsula west, we know that the overriding crust does not have a substantial amount of carbon," Lopez said. "So that means we can assume that the carbon degassing from volcanoes comes from either the mantle or the subducted slab."

Lopez and her colleagues began looking for the proportion of carbon 12 and 13 atoms in the gas coming from volcanoes. The carbon 12 isotope constitutes nearly 99% of Earth's carbon. The carbon 13 isotope, which has an additional neutron in its nucleus, makes up only about 1%. Inorganic carbon, organic carbon and mantle carbon all have somewhat distinct proportions of the two isotopes.

The team identified the average carbon isotopic composition of the volcanic gases, as well as the isotopic composition and total amount of carbon entering the trench from the subducted slab. Using that information, they calculated the quantity of subducted carbon released to the atmosphere through degassing of Aleutian-Alaska Arc volcanoes.

Previous studies concluded that minimal amounts of organic carbon in ocean floor sediments and inorganic carbon from the subducted slab crust returned to the atmosphere.

Lopez and colleagues instead found that approximately 43% to 61% of sediment-derived organic carbon is returned to the atmosphere through volcanic degassing in the central Aleutians and that approximately 6% to 9% of inorganic carbon from the slab crust is returned to the atmosphere by degassing of western Aleutian volcanoes.

The scientists also found that the proportions of organic carbon and inorganic carbon recycled through arc volcanoes seemed to be influenced by characteristics of the subduction zone such as subduction speed and slab temperature.

"These results indicate less carbon is returned to the deep mantle than we previously thought," Lopez said. "These results help clarify our understanding of the fate of subducted carbon and can help improve global climate models."

More information: Taryn Lopez et al, Tracking carbon from subduction to outgassing along the Aleutian-Alaska Volcanic Arc, *Science Advances* (2023). DOI: 10.1126/sciadv.adf3024

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