Mount Etna's exceptional carbon dioxide emissions are triggered by deep reservoirs of the gas

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The transport of carbon dioxide stored in the Earth's lithospheric mantle beneath the Hyblean Plateau in southern Italy at a depth of approximately 50 to 150 kilometers is responsible for the exceptionally large CO_2 emission of Mount Etna. That is the result of research conducted by an international team of geologists, including researchers from the Universities of Florence (Italy) and Cologne (Germany), and from the Istituto di Geologia Ambientale e Geoingegneria of the Italian National Research Council (CNR). To reach this conclusion, the team determined the ratios of a particular set of elements in the magmas emitted by the volcanoes using cutting-edge, high-precision measurement methods. The results have been published in the article "A carbon-rich lithospheric mantle as a source for the large CO_2 emissions of Etna volcano (Italy)' in the journal *Geology*.

Over the geological times, variations in atmospheric CO_2 depended mainly on volcanic emissions, which are difficult to estimate because they are not directly related to the volume of the magmas erupted. Indeed, some volcanoes show exceptionally large emission of CO_2 when compared to the amount that can be dissolved in their magmas. Etna is perhaps the most striking example, contributing to 10 per cent (9000 tons/day) of the present global volcanic CO_2 emission. That is three times more CO_2 than a volcano like Kilauea (Hawaii) emits, which erupts four times more magma.

The team investigated magmas from four volcanoes in the region (Etna, Vulture, Stromboli, and Pantelleria), using the two rare elements Niobium (Nb) and Tantalum (Ta) as tracers. Ratios of Nb/Ta are very constant in many rocks and are only modified by few geological processes—like the infiltration of carbonate-rich melts in Earth's mantle. The study revealed that magmas from Mount Etna and Mount Vulture are characterized by extremely high Nb/Ta ratios, higher than any other active intraplate volcano. This means that the magma compositions testify to the presence of lithospheric mantle domains beneath southern Italy that are extremely enriched in carbon. This carbon is 'tapped' during the melting of the magmas.

The process is directly related to the region's complex geodynamic setting: The carbon-rich lithospheric mantle domains are located beneath the Hyblean Plateau in southern Sicily. These domains are transported towards the region beneath Etna by means of tectonic activity, specifically the rollback of the Ionian subduction plate. A symmetric mechanism is likely occurring on the other side of the Ionian plate, beneath Mount Vulture.

"The data also allow us to infer the contribution of such carbon-rich domains to the Earth's atmosphere in the past, suggesting that the CO_2 emissions of Mount Etna during its ancient activity might have been even higher than at present," Professor Dr. Carsten Münker from the University of Cologne's Institute of Geology and Mineralogy commented. He and his team were responsible for the high precision measurements including the two critical elements Nb and Ta.

Lead author Dr. Alessandro Bragagni, former postdoc at Cologne and now at the University of Florence, added that "similar carbon-rich domains might be hidden beneath other volcanoes worldwide, hence contributing to their CO_2 emissions. The innovative trace element approach used in this study represents a promising way to better estimate the contribution of carbon-enriched lithosphere to overall volcanic CO_2 emissions, both at present and in the past, which may have played a key role in changing the climate of our planet."

More information: Alessandro Bragagni et al, A carbon-rich lithospheric mantle as a source for the large CO2 emissions of Etna volcano (Italy), *Geology* (2022). DOI: 10.1130/G49510.1

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