The complicated birth of a volcano: Researchers unravel the origin of Antarctic seamounts

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A full chain bag dredge of samples obtained from the Marie Byrd Seamounts is emptied on board of POLARSTERN. Credit: F. Hauff, GEOMAR

They are difficult to reach, have hardly been studied scientifically, and their existence does not fit into current geological models: the Marie Byrd Seamounts off the coast of Antarctica present many riddles to volcanologists. In the international journal "Gondwana Research", scientists from GEOMAR Helmholtz Centre for Ocean Research Kiel in cooperation with colleagues from the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research just published possible explanations for the origin of these former volcanoes and thus contributed to the decryption of complex processes in the Earth's interior.

Snow storms, ice and glaciers—these are the usual images we associate with the Antarctic. But at the same time it is also a region of fire: the Antarctic continent and surrounding waters are dotted with volcanoes - some of them still active and others extinct for quite some time. The Marie Byrd Seamounts in the Amundsen Sea are in the latter group. Their summit plateaus are today at depths of 2400-1600 meters. Because they are very difficult to reach with conventional research vessels, they have hardly been explored, even though the Marie Byrd Seamounts are fascinating formations. They do not fit any of the usual models for the formation of volcanoes. Now geologists from GEOMAR Helmholtz Centre for Ocean Research Kiel were able to find a possible explanation for the existence of these seamounts on the basis of rare specimens. The study is published in the international journal *Gondwana Research*.

Classic volcanologists differentiate between two types of fire mountains. One type is generated where tectonic plates meet, so the earth's crust is already cracked to begin with. The other type is formed within the earth's plates. "The latter are called intraplate volcanoes. They are often found above a so-called mantle plume. Hot material rises from the deep mantle, collects under the earth's crust, makes its way to the surface and forms a volcano," said Dr. Reinhard Werner, one of the authors of the current paper. One example are the Hawaiian Islands. But neither of the above models fits the Marie Byrd Seamounts. "There are no plate boundary in the vicinity and no plume underground," says graduate geologist Andrea Kipf from GEOMAR, first author of the study.

To clarify the origin of the Marie Byrd Seamounts, in 2006 the Kiel scientists participated in an expedition of the research vessel POLARSTEN in the Amundsen Sea. They salvaged rock samples from the seamounts and subjected these to thorough geological, volcanological and geochemical investigations after returning to the home labs. "Interestingly enough, we found chemical signatures that are typical of plume volcanoes. And they are very similar to volcanoes in New Zealand and the Antarctic continent," says geochemist Dr. Folkmar Hauff, second author of the paper.

Based on this finding, the researchers sought an explanation. They found it in the history of tectonic plates in the southern hemisphere. Around 100 million years ago, remains of the former supercontinent Gondwana were located in the area of present Antarctica. A mantle plume melted through this continental plate and cracked it open. Two new continents were born: the Antarctic and "Zealandia", with the islands of New Zealand still in evidence today. When the young continents drifted in different directions away from the mantle plume, large quantities of hot plume material were attached to their undersides. These formed reservoirs for future volcanic eruptions on the two continents. "This process explains why we find signatures of plume material at volcanoes that are not on top of plumes," says Dr. Hauff.

But that still does not explain the Marie Byrd Seamounts because they are not located on the Antarctic continent, but on the adjacent oceanic crust instead. "Continental tectonic plates are thicker than the oceanic ones. This ensures, among other things, differences in temperature in the underground," says volcanologist Dr. Werner. And just as air masses of different temperatures create winds, the temperature differences under the earth's crust generate flows and movements as well. Thus the plume material, that once lay beneath the continent, was able to shift under the oceanic plate. With disruptions due to other tectonic processes, there were cracks and crevices which allowed the hot material to rise, turn into magma and then- about 60 million years ago - allowed the Marie Byrd Seamounts to grow. "This created islands are comparable to the Canary Islands today," explains Andrea Kipf. "Some day the volcanoes became extinct again, wind and weather eroded the cone down to sea level, and other geological processes further eroded the seamounts. Finally, the summit plateaus arrived at the level that we know today," the PhD student describes the last step of the development.

Based on the previously little investigated Marie Byrd Seamounts, the researchers were able to show another example of how diverse and complex the processes are, that can cause volcanism. "We are still far from understanding all of these processes. But with the current study, we can contribute a small piece to the overall picture," says Dr. Werner.

More information: Kipf, A. , F. Hauff, R. Werner, K. Gohl, P. van den Bogaard, K. Hoernle, D. Maicher, Klügel A. (2013, in press): Seamounts off the West Antarctic margin: A case for non-hotspot driven intra-plate volcanism. *Gondwana Research*; dx.doi.org/10.1016/j.gr.2013.1006.1013

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