Mercury mineral evolution

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Mineral evolution posits that Earth's near-surface mineral diversity gradually increased through an array of chemical and biological processes. A dozen different species in interstellar dust particles that formed the solar system have evolved to more than 4500 species today.

Previous work from Carnegie's Bob Hazen demonstrated that up to two thirds of the known types of minerals on Earth can be directly or indirectly linked to biological activity. Now Hazen has turned his focus specifically on minerals containing the element mercury and their evolution on our planet as a result of geological and biological activity. His work, published in *American Mineralogist*, demonstrates that the creation of most minerals containing mercury is fundamentally linked to several episodes of supercontinent assembly over the last 3 billion years.

Mineral evolution is an approach to understanding Earth's changing near-surface geochemistry. All chemical elements were present from the start of our Solar System, but at first they formed comparatively few minerals--perhaps no more than 500 different species in the first billion years. As time passed on the planet, novel combinations of elements led to new minerals. Although as much as 50% of the mercury that contributed to Earth's accretion was lost to volatile chemical processing, 4.5 billion years of mineral evolution has led to at least 90 different mercury-containing minerals now found on Earth.

Hazen and his team examined the first-documented appearances of these 90 different mercury-containing minerals on Earth. They were able to correlate much of this new mineral creation with episodes of supercontinent formation--periods when most of Earth's dry land converged into single landmasses. They found that of the 60 mercury-containing minerals that first appeared on Earth between 2.8 billion and 65 million years ago, 50 were created during three periods of supercontinent assembly. Their analysis suggests that the evolution of new mercury-containing minerals followed periods of continental collision and mineralization associated with mountain formation.

By contrast, far fewer types of mercury-containing minerals formed during periods when these supercontinents were stable, or when they were breaking apart. And in one striking exception to this trend, the billion-year-long interval that included the assembly of the Rodinian supercontinent (approximately 1.8 to 0.8 billion years ago) saw no mercury mineralization anywhere on Earth. Hazen and his colleagues speculate that this hiatus could have been due to a sulfide-rich ocean, which quickly reacted with any available mercury and thus prevented mercury from interacting chemically with other elements.

The role of biology is also critical in understanding the mineral evolution of mercury. Although mercury is rarely directly involved in biological processe--except in some rare bacteria--its interactions with oxygen came about entirely due to the appearance of the photosynthetic process, which plants and certain bacteria use to convert sunlight into chemical energy. Mercury also has a strong affinity for carbon-based compounds that come from biological material, such as coal, shale, petroleum, and natural gas products.

"Our work shows that in the case of mercury, evolution seems to have been driven by hydrothermal activity associated with continents colliding and forming mountain ranges, as well as by the drastic increase in oxygen caused by the rise of life on Earth," Hazen said. "Future work will have to correlate specific mineral occurrences to specific tectonic events."

Future work will also focus on the minerals of other elements to see how they differ and correlate with mercury's mineral evolution, and to new strategies for locating as yet undiscovered deposits of critical resources.

"It's important to keep honing in on the ways that minerals have evolved on our planet from their simple elemental origins to the vast array in existence today," Hazen said.

Provided by Carnegie Institution for Science

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