Rich Ore Deposits Linked to Ancient Atmosphere

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(PhysOrg.com) -- Much of our planet's mineral wealth was deposited billions of years ago when Earth's chemical cycles were different from today's. Using geochemical clues from rocks nearly 3 billion years old, a group of scientists including Andrey Bekker and Doug Rumble from the Carnegie Institution have made the surprising discovery that the creation of economically important nickel ore deposits was linked to sulfur in the ancient oxygen-poor atmosphere.

These ancient ores -- specifically iron-nickel sulfide deposits -- yield 10% of the world's annual nickel production. They formed for the most part between two and three billion years ago when hot magmas erupted on the ocean floor. Yet scientists have puzzled over the origin of the rich deposits. The ore minerals require sulfur to form, but neither seawater nor the magmas hosting the ores were thought to be rich enough in sulfur for this to happen.

"These nickel deposits have sulfur in them arising from an atmospheric cycle in ancient times. The isotopic signal is of an anoxic atmosphere," says Rumble of Carnegie's Geophysical Laboratory, a co-author of the paper appearing in the November 20 issue of *Science*.

Rumble, with lead author Andrey Bekker (formerly Carnegie Fellow and now at the University of Manitoba), and four other colleagues used advanced geochemical techniques to analyze rock samples from major ore deposits in Australia and Canada. They found that to help produce the ancient deposits, sulfur atoms made a complicated journey from volcanic eruptions, to the atmosphere, to seawater, to hot springs on the ocean floor, and finally to molten, ore-producing magmas.

The key evidence came from a form of sulfur known as sulfur-33, an isotope in which atoms contain one more neutron than "normal" sulfur (sulfur-32). Both isotopes act the same in most chemical reactions, but reactions in the atmosphere in which sulfur dioxide gas molecules are split by ultraviolet light (UV) rays cause the isotopes to be sorted or "fractionated" into different reaction products, creating isotopic anomalies.

"If there is too much oxygen in the atmosphere then not enough UV gets through and these reactions can't happen," says Rumble. "So if you find these sulfur isotope anomalies in rocks of a certain age, you have information about the oxygen level in the atmosphere."

By linking the rich nickel ores with the ancient atmosphere, the anomalies in the rock samples also answer the long-standing question regarding the source of the sulfur in the ore minerals. Knowing this will help geologists track down new ore deposits, says Rumble, because the presence of sulfur and other chemical factors determine whether or not a deposit will form.

"Ore deposits are a tiny fraction of a percent of the Earth's surface, yet economically they are incredibly important. Modern society cannot exist without specialized metals and alloys," he says. "But it's all a matter of local geological circumstance whether you have a bonanza -- or a bust."

Source: Carnegie Institution

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