Mars: A Rosetta Stone for Understanding the Early Earth

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Just a few traces of Earth's geologic record are preserved from the time of life's emergence, over 3800 million years ago. Consequently, what little we understand about abiogenesis on Earth is based primarily on laboratory experiment and theory. The best geological window into early Earth might actually be Mars' crust, which is more ancient than our own, and contains clear evidence for past hydrothermal environments analogous to those where chemosynthetic life may have first taken hold on Earth.

Mars, a planet without plate tectonics through most or potentially all of its history, contains an older and better-preserved geologic record than the Earth. At only ~10% of Earth's mass, Mars began with far less primordial and radiogenic heat. By about 4000 Mya, Mars had cooled sufficiently to cause cessation of the magnetic dynamo. The loss of the martian magnetic field marked exposed the surface to solar wind, which ultimately stripped away much the planet's atmosphere. Erosion rates decreased by orders of magnitude. As one result, the early geologic record of Mars from >3500 million years ago is relatively well preserved.

The last 15 years of exploration of Mars have revealed that the ancient crust (>3500 million years old) contains many hydrothermal deposits, dating roughly to the end of the period of intense impact bombardment on Earth and Mars. Many of these hydrothermal deposits include Fe and Mg-rich smectite clays, Fe-micas, and serpentine-bearing deposis. In fact, the conditions thought by some to be linked to abiogenesis on Earth – serpentinzation reactions in ultramafic crust – also occurred on Mars at the same time when life might have formed on Earth.

Hydrothermally altered terranes have been exhhumed from the martian subsurface by meteor impacts and other processes. In addition, rare examples of hydrothermal seafloor deposits also exist. The Eridania basin was filled with 1-2 km depth of water >3800 million years ago. Ancient basin floor deposits contain saponite, Mg-rich nontronite, talc-saponite, serpentine, carbonate and probably sulphide deposits that likely formed in a deep-water hydrothermal seafloor-type setting. Unlike analogous deposits on Earth, these materials have seemingly not been metamorphosed and metasomatized. A focused analysis of well-reserved hydrothermal deposits on Mars, including exhumed crust and ancient deep-water hydrothermal sediments could reveal clues to how abiogenesis occurred on Earth.