View of one of the peaks of the Southern Alps. (Credit: Frédéric Herman)

Eighteen thousand rock ages were used in the project – a huge job. "The course of one PhD usually identifies around 30 rock ages so we benefited from a large number of people's work," says Herman.

"A global signal requires a global cause, and the strong correlation found with global climate change shows that cooling is a very good candidate for the causing mechanism," says Pedersen. "This study gives persuasive evidence for a strong link between highly variable cold climates and erosion rate, especially linked to glacial and periglacial proceses."

Pointing to glaciers as a cause of the erosion makes sense: glaciers can scour relatively flat topography into a rugged, jigsaw-like landscape within several thousand years. The rock currently on the surface of the fjords in the New Zealand Southern Alps, for example, used to lie two kilometres deep just 2.5 million years ago – a rapid change in geological terms. However it's not just glaciers that can have an influence. These Southern orogens – belts of the Earth's mountainous crust – receive high amounts of rainfall, which can trigger landslides and add to the erosive action.

Missing years

But the climate versus tectonic debate does not stop here. Thermochronometry is based on the idea that a rock's age can be converted into an erosion rate. The rocks must have been moved a couple of kilometres through the Earth before a rock age can be taken, a process that only occurs in areas where there is enough tectonic activity, such as the Alps, Patagonia and Himalaya.

Philippe Steer, who used a different method, found erosion increased by a factor of 20 during the past five million years. Even with such a huge increase, the total erosion remains too small to be detected by the technique used by Herman and his colleagues, so this study was restricted to certain parts of the world only.

"We don't know every cycle and are only seeing one part of the signal. Therefore this study is just the tip of the iceberg," says Herman. "We are now developing techniques to isolate shorter timescales to, say, 100,000 years."

Becky Summers
Freelance Science Writer, London, UK

References

Herman, F. et al.: Worldwide acceleration of mountain erosion under a cooling climate, Nature, 504, 423–426, 2013
Molnar P. and England P.: Late Cenozoic uplift of mountain ranges and global climate change: chicken or egg?, Nature 346, 29–34, 1990
Steer, P. et al.: Bimodal Plio-Quaternary glacial erosion of fjords and low-relief surfaces in Scandinavia, Nature Geosci. 5, 635–639, 2012

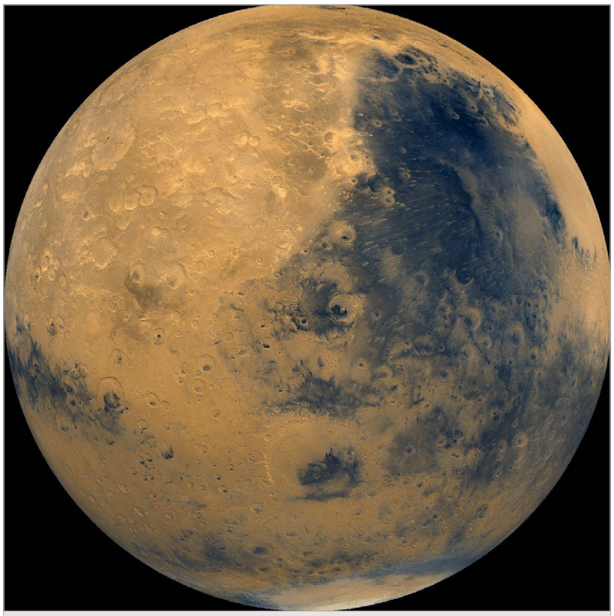
A glimpse of Mars' early history

Space and the Earth

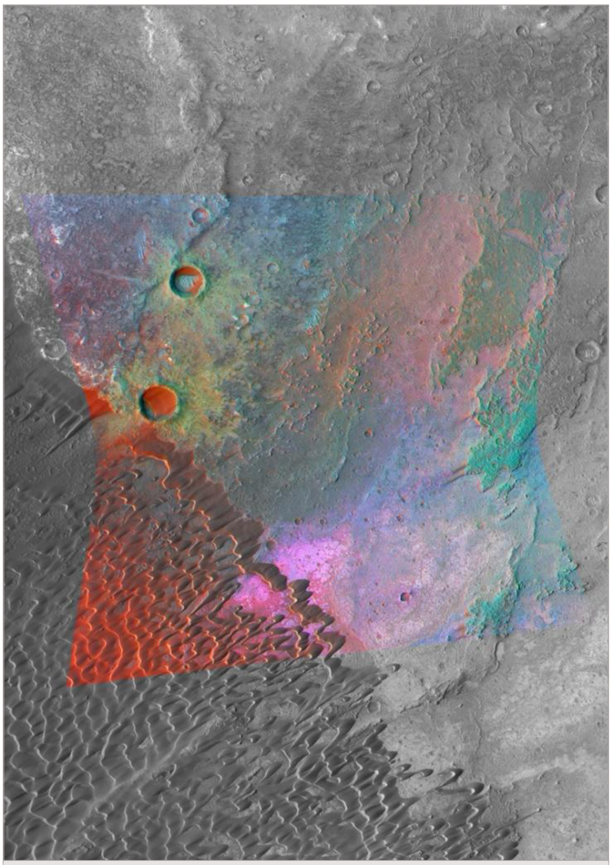
Finding increasing evidence of rocks previously thought to be non-existent on Mars sheds new light on the composition and early evolution of the planet.

Termed the Goldilocks Planet because of its ideal distance from the sun, which allows the planet to have liquid water on its surface, the Earth is also the perfect size to have maintained plate tectonics over the past 4,600 million years. Mars was likely too small to develop plate tectonics in its early years, cooling too quickly to maintain the hot core needed to power large-scale motions on the surface of the planet. Tectonics are the key to the variety of rocks we have on Earth: the tectonic system works as a giant conveyor belt that transports elements from deep within the planet up to the surface and back again. Mars, without the ability to maintain a tectonic cycle, was left with a largely basaltic composition. So, recent articles by Wray et al. (2013) and Carter and Poulet (2013) describing Martian rocks containing large amounts of iron-rich feldspar (a group of aluminium silicate minerals not commonly found in basaltic rocks) are unexpected and exciting.

In both studies, the researchers used data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on the Mars Reconnaissance Orbiter to identify the feldspars. Usually, feldspar is undetectable by CRISM, unless there are small amounts of metal such as iron within the mineral structure. CRISM detected very weak absorptions in the wavelength range typically associated with iron, but not strong enough to indicate the presence of iron-rich minerals like olivine and pyroxene common in basalt. Because of



Mars (Credit: NASA)



Mars surface as imaged by the Mars Reconnaissance Orbiter. Magenta coloured areas are high in feldspar. (Credit: NASA Jet Propulsion Laboratory)

the weak absorptions, both teams have associated the findings with extremely high levels of feldspar in the rocks, specifically iron-bearing plagioclase feldspar. Where the studies begin to differ, however, is on the identification of the host rock.

Carter and Poulet argue that the feldspar is indicative of a rock called anorthosite. The absorption spectra show an electronic transition band at 1.25 μm, which is characteristic of iron-bearing feldspar. The same band has also been detected when spectrally imaging the Earth and the Moon. The Moon has widespread occurrences of anorthosite, and the rock is also present on Earth, but in general, it is rare in the Solar System. Wray et al., although acknowledging the possibility of anorthosite on Mars, do not rule out the possibility that the presence of the feldspars could indicate rocks that contain quartz (pure silica), such as granite or dacite, or even selective hydrological weathering of other iron-rich rocks. In either case, these rocks have a significantly different (more silica rich) composition than other, typically basaltic rocks, such as those erupted by the Martian super-volcano Olympus Mons.

In the case that the feldspars do represent either anorthosite or granite, both studies are in agreement about the implications for altering our understanding of Mars' early evolution. Many silica-rich rocks on Earth, such as granite and dacite, are formed at subduction zones, or 'hotspots' (where super-hot magma from the mantle rises up below a plate and forms volcanoes, like Yellowstone) and some formed very early in the Earth's past, in the Archean, where the hot primordial Earth melted the plates at shallow depths. In all of these processes partial melting or fractional crystallisation is likely to occur, leading to the formation of silicate rocks. In fractional crystallisation of magma, minerals such as olivine and pyroxene crystallise first (forming basaltic rocks), leaving behind a silica-rich 'evolved' residue. Partial melting melts silica-rich rocks first, as these have low melting temperatures. Until now, these types of prolonged magmatic processes were not thought to have been present on Mars, but the presence of feldspar leaves open new avenues of investigation for planetary and space scientists.

In addition to needing slow magma crystallisation, the formation of granitic rocks requires the presence of water. Granitic rocks are also the core of many continents, their relative density to basalts being lighter. The possible presence of granitic rocks on Mars indicates that maybe it was not always so different from Earth: there was water present and even the possibility of a brief magnetic field.

As most of Mars is swept by winds and battered by meteorites, it is rare to get a glimpse of past processes in its early history. Currently, the quest for water on Mars tends to make the headlines, but maybe knowing more about the planet's geochemistry can help us answer this question and begin to ask some more: is Mars a 'failed' Earth and if so, what could this teach us about our own planet's future?

Jane Robb
EGU Educational Fellow

References

Carter, F. and Poulet, J.: Ancient plutonic processes on Mars inferred from the detection of possible anorthositic terrains, Nature Geosci., 6, 1008–1012, 2013

Wray, J. J. et al.: Prolonged magmatic activity on Mars inferred from the detection of felsic rocks, Nature Geosci., 6, 1013–1017, 2013