subsurface of Europa. It is therefore unclear how subduction can physically occur on Europa. Kattenhorn and Prockter suggest a mechanism where the push supplied by extension at ridges is the driving force, instead of the plate being pulled by the subducting slab, which is thought to be the dominant driving force for plate tectonics on Earth. However, the stresses and rates of extension required for this mechanism to overwhelm buoyancy forces have not yet been quantified nor shown to be reasonable for Europa.

Furthermore, volcanism on Earth is generated because a subducting slab of oceanic crust is water-rich, which lowers the melting temperature of overriding rock. On Europa, the subducting slab of ice would be similarly heated by friction, but any meltwater would be denser than ice and expected to sink, rather than rise to the surface as cryovolcanism. Perhaps pressure squeezes pockets of meltwater up to the surface, but the plausibility of this mechanism has also yet to be assessed.

Of the hundreds of geologic features mapped in the study region, only about 30 crosscut the subsumption bands, indicating that these zones are perhaps less than five million years old. Whether a subduction-like process is responsible or not for the missing surface ice, the region has experienced extensive recent convergence. Subsumption bands may represent a diagnostic geomorphologic signature left behind at convergent zones on Europa.

Additional subduction zones would be required for the destruction of surface area through subsumption to balance the creation of the new ice at dilational bands, which are estimated to represent about 10–40% of the total surface area of Europa[6]. However, much of Europa's surface is not imaged at a resolution high enough for the tectonic reconstruction approach employed by Kattenhorn and Prockter. A potential future mission from NASA, the Europa Clipper, would acquire the data needed to identify subduction zones and constrain their surface and subsurface structure.

Kattenhorn and Prockter[1] suggest that subduction, and hence a plate tectonic system, is operating on Europa. Thus, icy Europa may be more tectonically similar to rocky Earth than any other planetary body we know of. Perhaps Europa and Earth are even more uniquely similar: It is tempting to note the correlation between the existence of both life and plate tectonics on Earth and wonder if the latter might not be a requirement of the former. ❐

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BIOGEOCHEMISTRY

Microbial flexibility

As an essential building block of amino acids, proteins and DNA, nitrogen is key to life on Earth. Nitrogen is also the main constituent of our atmosphere, but the main form it takes, N_2, is unusable by almost all living organisms but a few select microbes. Instead, most living creatures, from bacteria to primates, rely on nitrogen that has been bound in oxides, as ammonia or in organic compounds. Many microbes actually make a living by cycling nitrogen from one fixed state to another: they gain energy using various nitrogen species as electron donors and receptors.

One part of the nitrogen cycle is nitrification, in which bacteria and archaea oxidize ammonia, and nitrite-oxidizing bacteria convert nitrite to nitrate. One of the most widespread genera of these nitrite-oxidizing bacteria is *Nitrospira*, with species occurring in oxic oceans, soils, hot springs and even wastewater treatment plants. However, *Nitrospira* appears to alternatively be able to perform anaerobic respiration, with H_2 as an electron donor and nitrite as an electron acceptor. Culture experiments and genetic sequencing now suggest that *Nitrospira moscoviensis* can also use H_2 as an energy source for aerobic respiration when nitrite is not available (*Science* **345,** 1052–1054; 2014).

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Holger Daims and colleagues observed cultures of *N. moscoviensis* growing with no nitrite available, as long as H_2 and O_2 were present. The uptake of CO_2 by these microbes occurred even when H_2 concentrations were low, but no net growth occurred. This indicates that only a fraction of the cells in the culture were highly metabolically active under these conditions.

Genome sequencing of *N. moscoviensis* identified a series of genes associated with the hydrogen oxidizing enzyme hydrogenase, known as the *hup* locus. The best explanation for the appearance of these genes in *N. moscoviensis* is lateral gene transfer from a different phylum of bacteria. Intriguingly, the *hup* locus only appears in one of the phylogenetic lineages of *Nitrospira* (lineage II), suggesting that either only this lineage acquired the gene through lateral gene transfer or that the gene was later lost by lineage I.

The ability of *N. moscoviensis* to remain metabolically active without the continued presence of nitrite provides a strong ecological advantage, and probably explains why *Nitrospira* can be found in some low oxygen environments with available H_2, such as rice paddies, deep hydrothermal fields and hot springs.

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