

Is there a signature of life?

The life that a planet supports is a strong extra influence on the planet's shape and structure, says S. Ananthanarayanan.

Recent studies of *biotic* effects on erosion and movements of land masses suggest that the topography of a planet may bear a *signature of life*, if there is any.

Ridges and valleys

A glance at the topography of our own earth, say from an aircraft window, shows that the shape consists largely of ridges and valleys, smaller valleys draining into larger ones. The ridges seem to be caused by abrupt rising or descent of landmass, while the valleys, if they are sloping, appear to be the result of erosion and lateral movement of the matter of the earth.

Scientists have developed mathematical models of how every point on the surface, or even within the surface of the earth, should behave. A simple relation is like this:

$$\text{Speed of movement} = \text{rising tendency} - \text{settling tendency} - \text{spreading tendency}$$

Different mathematical forms for each of these terms result in specific shapes, like convex up, concave up, which, in turn, affect drainage or landmass pressure, which affect change, and so on. The ridge and valley pattern emerges from most models, and one of the factors that affect both the settling and the spreading tendency is the rate of erosion.

Biotic effects

Large rocky masses must break down into smaller fragments before they can be eroded and transported, be it by wind, by water or by landslips. Chemical weathering, cracking of rocks due to temperature changes, freezing of water inside cracks, landslides are the non-biotic or *abiotic* processes. But studies in the field have progressively shown that in many soil-mantled landscapes, the creation of loose, transportable soil material from bedrock is mainly caused by biogenic disturbance. Root growth and animal burrowing disrupt bedrock, creating a loose material free to move downslope.

The bionic effect on bedrock should reduce if there is much soil cover. This is in fact the way it is, as studies using radioactive dating have shown. When soil production is rapid, the soil cover increases and slows the process down. And if soil erosion speeds up, the soil cover reduces and soil creation gets faster. The rate at which both processes happen, in soil covered landscapes, is found to be highly bionic-influenced, by the effect of animal burrowing, soil binding by roots of plants and trees, microbial activity.

Rainfall and weather

Biotic processes tend to fall in step with seasonal temperature variations and to reduce harsh extremes. Thus green cover would follow a pattern of growth that would have an annual cycle and its affect on the atmosphere would attain balance with the forces that the atmosphere exerts. Animal species would sustain the ecology and the topography would be conservative. It would be a case of energy use to maintain structure.

In an abiotic world, on the other hand, there would be unidirectional erosion and compaction, leading to near absence of features. The solid mass may slowly erode and deposit below the liquid cover, leaving a world covered by liquid and enveloped by atmosphere showing little activity.

A world without life

The first effect, then, if life on the earth were to disappear, would be soil erosion and the emergence of bare, rocky surfaces. Weathering of rocks also would be limited to abiotic effects and the deep weathering profiles would be absent. Could we then say that smooth, rounded, soil mantled hilltops are the signature of a world that supports life?

This simple conclusion unfortunately is not valid, as even abiotic processes do create smooth and soil covered terrain. In the Atacama Desert of Chile there is a hyper arid portion called the Central Depression, where biotic processes are completely absent. But salt weathering does break down bedrock and the rock surfaces receive input of wind-blown soil sediment. And the landscape is rounded and soil-mantled!

A second effect of the disappearance of life would be coarser sediments in rivers and water channels, leading to deeper channels with sharper hillsides. The abiotic world would then have deep, rocky channels and high mountains. Yes, this may be a characteristic of the abiotic world, but this is not unique and may not constitute a distinctive signature!

A third feature that has been proposed is the meandering of rivers. Biotic effects are shown to strongly influence selective erosion that leads rivers to *meander* or *braid*. While this has been extensively documented, there are other factors that can lead to the same effect. Meandering bedrock canyons are observed both on earth and on Mars. This too, then, may not be a signature of life.
