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The secrets of rock tides

Did you know that the water in a well drops when there is a high tide at sea and rises at low tide? Nor did I until recently. The phenomenon has been known since about 100 BC when Poseidonios noticed it on the Atlantic coast of Spain.

The Greek philosopher's original observations are lost. However, the Greek geographer Strabon reports them in his *Geographika*: "There is a spring at the [temple of] Heracleium at Gades [Cadiz], with a descent of only a few steps to the water (which is good to drink), and the spring behaves inversely to the flux and reflux of the sea, since it fails at the time of the flood-tides and fills up at the time of the ebb-tides."

Incredibly, Poseidonios' mystery was not solved until 1940. The American geophysicist Chaim Leib Pekeris realised it was a consequence of the fact that the Moon creates tides not only in the Earth's oceans but in its rocks as well (To be precise, the tides are caused by both the Moon and the Sun, with those of the Moon being twice as big as those of the Sun).

As Isaac Newton first realised, tides are a distortion in the shape of the Earth caused by the pull of the Moon being stronger on parts of the Earth closer to the Moon than those further away. Imagine the ocean immediately beneath the Moon. The pull on water at the surface is greater than the pull on water at the seabed. The difference causes the sea to bulge upwards towards Moon. A similar effect causes a second tidal bulge on the opposite side of the Earth to the Moon. And, as the Earth rotates through the two bulges, any location gets two tides a day, as the ocean is pulled upwards and slumps back down again.

But the Moon causes a tidal bulge in the solid Earth too. It is just that it less noticeable since rock is a lot stiffer than water. The explanation of Poseidonios' observation is as follows. The ground around a well is, not surprisingly, waterlogged. Think of it as a wet sponge. When the sponge is stretched upwards at high tide, it sucks water out of the well, lowering its level; and, when the sponge is scrunched back down at high tide, it squeezes water back into the well, raising its level.

A more contemporary example of rock tides comes from the 26.7 kilometre subatomic racetrack of the Large Hadron Collider near Geneva. It is around this ring that counter-rotating beams of protons are smashed together at 99.9999991 per cent of the speed of light. In July 2012, they created the fabled Higgs particle, "quantum" of the Higgs field, which endows all other subatomic particles with mass. The LHC occupies the same tunnel as an earlier accelerator known as the Large Electron-Positron collider. And, in 1992, physicists at LEP noticed a peculiar thing. Twice a day, they had to adjust the energy of the circulating electrons and positrons to keep them in the tunnel. After scratching their heads a while, they finally realised why: the ring was being stretched and squeezed twice a day by the Moon. Although the circumpherence was changing by only about 1 millimetre, it explained perfectly the anomalous behaviour of the electron-positron beams.

Perhaps the most extreme manifestation of rock tides, however, can be found on Jupiter's pizza-like moon, Io. In March 1979, NASA's Voyager 1 space probe streaked through the Jupiter system faster than a speeding bullet. Looking back, its camera snapped a last image of Io. Spouting from the crescent moon, silhouetted against the starry backdrop of space, was a phosphorescent plume of gas. Voyager had discovered the volcanoes of Io.

Io is the most geologically active world in the Solar System, with more than 400 active volcanoes. The explanation is that the moon is periodically stretched and squeezed by the combined effect of Jupiter – 318 times as massive as the Earth - and two nearby moons, Ganymede and Europa. The repeated squeezing, just like the repeated squeezing of a squash ball, makes it hot. In fact, the body in our Solar system that generates the most heat, pound for pound, is not the Sun. It is Io.

We now know of hundreds of Jupiter-mass planets orbiting other stars. And there is no reason to believe they are not accompanied by giant moons just like Jupiter's Io. Such "exomoons" will have their own central heating, courtesy of rock tides. This means liquid water, the prerequisite of terrestrial biology, may be present on their surfaces even though they may be far from the warmth of their parent sun. Who knows, exomoons, not planets like the Earth, could be the most likely locations in our Galaxy to find life. ●