Titan's impacts

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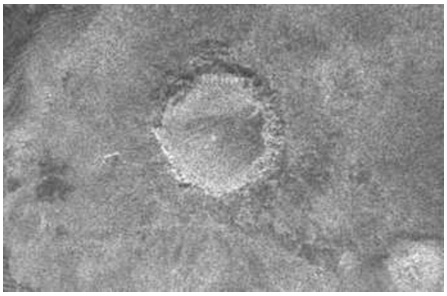

NASA / JPL

Radar images show that Saturn's moon Titan is marked by relatively few impact craters, all of which appear to have been modified by surface processes. The relative paucity of craters provides evidence of the vigorous reshaping of Titan's surface.

The Cassini spacecraft has obtained radar data covering about 22% of the surface of Titan. Charles Wood of the Planetary Science Institute, Arizona, and colleagues used these images to search for potential impact craters, identifying only 49 definitive or probable craters. Furthermore, all the crater-like features were modified by subsequent surface processes; many show evidence of erosion by rivers, and others are covered by dunes or lakes that developed after the impacts.

Assuming these results can be extrapolated to the rest of Titan, it would seem that its surface is less scarred than many other planetary satellites, such as the Moon. The researchers conclude that the youthful appearance of Titan's surface is a reflection of high rates of geological activity, which removes evidence of previous impacts.

Displaced arc

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The subduction of an old fault could be to blame for an embayment within the volcanic arc that stretches across central Mexico, according to geochemical data. Fluids produced by the subduction of the Pacific plate under North America fuel this volcanic activity.

Dawnika Blatter, of the Berkeley Geochronological Center, and Lisa Hammersley from California State University in Sacramento analyzed the geochemistry of volcanic rocks along the arc. The presence of a slab fluid signature in the rocks behind the embayment led the researchers to suggest that the Pacific slab is not dipping uniformly along the arc. Instead, the angle of the slab must be shallower beneath this bend.

The area of shallow dip occurs along the landward projection of an inactive fault on the Pacific plate. Subduction of this fault — made buoyant by prolonged and extensive chemical alteration by sea water — could have reduced the slab's dip and pushed volcanic activity further inland.

Appetite for iron

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Unique iron-rich stromatolites are a prevalent feature of the 1.9-billion-year-old rock formations that surround Lake Superior. According to new geochemical data, these particular stromatolites were built by early iron-oxidizing bacteria.

Noah Planavsky, of the Woods Hole Oceanographic Institution, and colleagues reconstructed the depositional environment of the stromatolites using various geochemical techniques. Analyses of cerium and other rare-earth elements suggest that deposition occurred in deeper ocean waters that were low in oxygen. In the modern ocean, such settings are conducive to the proliferation of iron-reducing bacteria. Furthermore, iron isotope values are consistent with the activity of iron-oxidizing microbes, and the abundant microfossils bear a strong resemblance to modern iron-oxidizing bacteria.

The field of iron-rich stromatolites stretches for over 100 km, but the growth of the stromatolites was temporally quite limited. The authors suggest that evolving ocean chemistry led to a narrow window during which the continental shelves were periodically flooded by low-oxygen iron-rich waters, which promoted widespread colonization of the sea floor by iron-oxidizing bacteria.

Into the ocean

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The world's oceans take up substantial amounts of ozone from the atmosphere, but it isn't clear just how the ozone is removed. New model simulations indicate that chemical reactions of atmospheric ozone with the chemical constituents of the ocean, and turbulence at the air–sea interface, are integral to ozone uptake.

Laurens Ganzeveld, of Wageningen University and Research Centre in The Netherlands, and colleagues examined the mechanisms of ozone uptake using an atmospheric chemistry climate model, with a special mechanistic representation of atmosphere–ocean ozone exchange. According to the simulations, ozone removal in the tropical and subtropical oceans is mainly driven by biochemical processes, specifically the breakdown of ozone through reactions with iodide and chlorophyll. In contrast, in the mid- and high-latitude oceans, ozone deposition is primarily controlled by turbulence in the lower atmosphere and upper layer of the ocean.

The incorporation of these ozone uptake mechanisms into model simulations reduced the overall sensitivity of atmospheric ozone concentrations to oceanic uptake, resulting in lower simulated sensitivity of ozone concentrations to climate variabilty .

Warming and wobbling

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As atmospheric temperatures increase, the oceans warm and expand, leading to rising sea levels. According to simulations with a general circulation model, and calculations of seafloor pressure, this ocean expansion changes the way mass is distributed on shallow continental shelves, resulting in small but quantifiable changes in the tilt of the Earth's rotation axis.

Felix Landerer, of the Max Planck Institute for Meteorology in Germany, and colleagues simulated the thermal expansion of the oceans in response to a doubling of atmospheric carbon dioxide by 2100. They found that the expansion causes water masses to exert further pressure on shallow regions of the ocean floor, with an unanticipated effect on the planet's rotational axis: in the simulations, the pole shifted towards western Alaska at a rate of about 1.5 cm yr^{-1}.

In addition to the effects of thermal sea-level rise, melting of the polar ice sheets could have an even stronger effect on the orientation of the pole, though the direction of polar motion would vary depending on the source of the melt water.