Methane hydrological cycle on Titan

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Saturn's largest moon Titan is covered by a dense nitrogen atmosphere mixed with a few % of methane. Titan's atmospheric condition allows the existence of methane in gaseous, liquid and solid phase analogously to water on Earth. Detection of several types of clouds in the lower atmosphere (e.g. Brown *et al*., 2002), dendritic features on the surface presumably carved by flowing liquid methane (Tomasko *et al*., 2005) and evidence of methane drizzle at the landing site of Huygens (Tokano *et al*., 2006) indicate that an active hydrological cycle of methane exists on present Titan. Methane in Titan's atmosphere may play a similar role as water in Earth's atmosphere in that it causes greenhouse effect, clouds, precipitation and geological features. However, several important differences to the terrestrial water cycle also became clear during the Cassini/Huygens mission. Titan lacks a global ocean, but the atmosphere contains a huge amount of condensable methane corresponding to a liquid layer of 5 m depth. Titan's methane hydrological cycle is much more affected by chemistry than the terrestrial counterpart. Atmospheric methane has a net source (surface) and a net sink (photochemistry) on geologically short timescales. Models suggest that rainfall is only possible because nitrogen and ethane can be dissolved in liquid methane, suppressing the freezing point and slowing evaporation. Availability of ethane at cloud-forming altitudes relies on the ethane production by photochemistry. This paper gives a survey of Titan's hydrological cycle, elucidating the role of chemistry and apparent analogies and differences to the terrestrial hydrological cycle.

References

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Geochemical dynamics in an active margin of East Asia: Implications from the temporal and spatial geochemical evolution of magmatism in northern Kyushu, SW Japan

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The margin of East Asia has been a locus for various tectonic events, having been affected by many arc-trench systems and back-arc basins. The upper mantle is expected to be complicated in physico-chemistry, reflecting the active tectonic environment. In order to decode the evolution of the upper mantle, clarification of the temporal and spatial geochemical variations in volcanic products is essential. Here, attention will be paid to Neogene non-subduction-related mafic volcanism in northern Kyushu, southwest Japan, ranging in age from ca 10 Ma to 0.5 Ma. The volcanism broadly has shifted eastward by ~150 km over time, and both alkali and sub-alkali lavas occur together. Their geochemical variations cannot be explained only by shallow processes such as fractional crystallization and crustal assimilation, and might reflect geochemical evolution of the upper mantle. Based on major and trace element abundances, the northern Kyushu volcanic rocks can be divided into three series: alkali basalt, sub-alkali basaltic rocks, and High Mg andesite (HMA). The alkali basalts in northern Kyushu have trace element distribution patterns similar to oceanic island basalts (OIB), suggesting asthenospheric sources within the convecting upper mantle. The sub-alkali basaltic rocks and HMA in northern Kyushu have incompatible element ratios that differ from OIB. Their compositions range from OIB-like patterns moderately depleted in HFS elements to strongly depleted patterns. These geochemical variations are best interpreted as an indication of interaction of asthenospheric-derived alkali basaltic magma with two chemically distinct lithospheric mantle sources: one is characteristically more depleted in Sr-Nd-Hf isotopic compositions and the other is isotopically enriched in these isotopic compositions. The relative contributions of these lithospheric mantle sources have changed over time and space. Contributions to the western region change from enriched to depleted character, whereas in the east, it has related its enriched character. This suggests that involvement of these lithospheric mantles in the genesis of sub-alkali basaltic rocks and HMA may be related to Tertiary lithospheric thinning caused by asthenospheric upwelling. Furthermore, isotopic compositions of alkali basalt derived from the asthenosphere change systematically over time and space, possibly associated with the opening of the Sea of Japan and rifting of the northern part of the Okinawa Trough.