Infrared spectroscopic observation on Mars: inspection of subsurface permafrost/magma interaction

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It is inevitable to clarify surface composition of planet/satellite with spectroscopic data in order to investigate evolution of the surface structure.

On Mars, many traces of fluvial-like features have been identified by plenty of surface images and have attracted considerable attention so far. Especially, outflow channels clearly have the characteristics unique to surface runoff of huge amount of water. They potentially suggest substantial amount of liquid water would be produced in the shallower part of the martian crust; permafrost layer. As the origin of such liquid water, volcano/ground-ice interaction seems the most probable. The local heating by magmatic intrusion will certainly cause melting of the permafrost. Ogawa et al (2002) numerically simulated the melting process and proposed a plausible (physically-consistent) scenario of producing considerable amount of liquid water to form the observed surface features. Based on this scenario, we here evaluate the possibility of detecting clear evidence of subsurface permafrost/magma interaction.

When hot magma intrudes into the permafrost layer; the ice filled pore space with matrix rock of the crust, it is quite probable that active system of the hydrothermal circulation should appear. The hydrothermal fluid would alter the wall rock around. Some of the altered minerals would migrate to be left on the surface at the time of surface disruption which we assume (see below). So detection of hydrothermal minerals could be direct verification of subsurface permafrost/magma interaction.

According to our scenario, chaotic terrain would correspond to the area where melting of the permafrost should have occurred to result in succeeding release of the water (artesian flow). Chaotic terrain or chasma are seemingly collapsed features, which locate at the initiation points of outflow channels. Our numerical results show that thermal convection in the molten zone works to enhance and focus the melting of the permafrost considerably. Based on the results, our analytical assessment reveals that compaction should have occurred and segregated liquid water would erupt to the ground to form the fluvial features (outflow channels). The event would certainly accompany surface destruction, which we can see as chaotic terrains. So the central area of the chaotic terrain or the flat plateaus around chaos are the likeliest point for sedimentation of the erupted materials at the time of the artesian flow. We need to observe devotedly around these zones to detect hydrothermal minerals

Hydrothermal minerals have typical spectral features in the range of near/middle infrared wavelength. Pyroxene and sulfates, which are likely to be contained in the lava flows, have their absorption bands in the same range. Therefore, we need to map the surface composition with infrared spectrometer. However, up to now, such observation has not been made so much, except for IMS in Phobos-II mission.

In Mars express mission, the loaded spectrometer OMEGA covers the wavelength ranging from visible-near/middle infrared. Therefore, we can map the surface minerals by OMEGA with sufficient resolution to detect traces of the volcano/ice interaction. We should also search for marks of the artesian flow on the surface with images, which could be performed by MIC, loaded on Nozomi. We propose that we should directly observe and confirm the relationship of hydrothermal activity with formation of surface features (outflow channel, chaos, chasma) by OMEGA and MIC.

In presentation, we introduce some images of chaos around Tharsis (the largest volcanic area on Mars) as the candidates for infrared spectroscopic as well as photometric observation. The area is the likeliest point of permafrost/magma interaction.