A SEARCH FOR ACTIVE VOLCANOES AND COMPOSITIONAL VARIATION IN CRUST ON VENUS USING NIGHTSIDE NEAR-INFRARED THERMAL RADIATION.

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Introduction: The thick atmosphere and clouds of Venus restrict methods to observe the surface. However, new spectral windows were discovered at the near-infrared wavelengths, in which thermal radiation emitted from the planetary surface penetrate through the thick Venus atmosphere and clouds [1, 2, 3, 4]. Although, thermal radiation emitted by the venusian surface is disturbed by reflected sunlight on the dayside, it can be observed on the nightside from above the clouds. The calculation of atmospheric radiative transfer model demonstrates that virtually all (>95%) of the radiation observed within the 1.0 μm window is emitted by the surface [3]. This near-infrared window will allow us to measure the venusian surface based on spacecraft observation and ground-based telescopic observation. In this paper, we discuss the feasibility of detecting both active volcanic activity and crustal compositional heterogeneity on Venus using near-infrared observation through this window.

Active Volcanoes: Active lava eruptions can be observed using the 1.0 μm window, since the intensity of thermal emission strongly depends on temperature [5]. A hot surface produced by a lava eruption emits intense radiation compared to the relatively cool surroundings. The excess emission from the hot surface is regarded as evidence of active volcanism.

The detection limit of hot surface is evaluated by the 3-dimensional Monte Carlo simulation [5]. This simulation shows that a typical lava flow (~100 km²) is detectable when the surface temperature is higher than 915 K. Even if crust temperatures were lower than this critical temperature, we have a chance to detect a lava flow. During eruptions, a hot radiative area typically appears on lava flows [6]. Although such areas are only a few percent of the total eruption area in the case of the Kilauea eruption, a large amount of hot thermal radiation is nevertheless emitted and remarkably contributes to observe excess emission [5]. It is also worth to note that their detection limit is rather conservative, since the temperature of the surrounding surface is assumed at 750 K, which is higher than the average surface temperature of 735 K.

A lava lake, which forms in the crater of an active volcano, is also likely to be detected, even though it is a small feature [5]. Surface temperatures of lava lakes are kept relatively high due to the continuous supply of heat from underneath. When the surface temperature is higher than 1200 K, lava lakes as small as 1 km² are detectable [5]. Since the liquidus temperature of basalt is about 1500 K, it seems probable that the surface temperature of lava lake is sufficiently high for detection.

Rapid cooling of exposed lava restricts the detection of lava eruption. According to the results of numerical modeling [7], the time-scale of lava cooling is about 1 Earth day. This indicates that an eruption event becomes undetectable one Earth day after cessation of the eruption. A Venus orbiter stationed six Venus radii from the planet’s center, which
orbits the planet in about 1 Earth day, will
detect most of the eruptions on the nightside.
However, it is difficult to detect short-term
eruptions on the dayside, since the timescale
of lava cooling is much shorter than half a
Venus day.

Compositional Variation in Crust: The
intensity of thermal radiation emitted by the
surface is controlled by not only temperature
but also the surface emissivity. Since emis-
sivity is a function of the mineralogy of the
surface, the measurement at the $1.0\,\mu\text{m}$ win-
dow is useful to estimate the rock types of the
venusian surface. Emissivities at $1.0\,\mu\text{m}$
wavelength is practically determined by the
content of FeO. Since granitic rocks and bas-
saltic rocks are significantly different in the
content of FeO, observation of the $1.0\,\mu\text{m}$
window may be able to distinguish granitic
rocks from basaltic rocks.

Variations in the surface emissivity of the
venusian surface have been searched by some
groups, but they found no signature of large
variations at near-infrared wavelength [2, 3].
To estimate the actual variation in the surface
emissivity, they correct the spatial variations
in the cloud thickness and surface temperature.
However, their analysis neglects the multiple
reflection of thermal radiation between the
atmosphere and the planetary surface. Since
the multiple reflection between the surface and
the atmosphere obscures the variation in the
surface emissivity [8], it is likely that the fail-
ure in detecting the variation in the surface
emissivity is caused by this over simplification
[9]. Re-examinatin of the previous analysis
demonstrates that there may be a large spatial
variation in the surface emissivity as large as
20%, which corresponds to the difference
between granitic rocks and basaltic rocks [9].

The relative uncertainty in the estimation of
the surface emissivity is determined by the
error in the estimation of the surface temepra-
ture [9]. The altimetry map and a near-surface
temperature lapse rate are used to estimate the
surface temperature. Although the error due to
the uncertainty in the altimetry data by Mag-
gellan is significant, the difference in the
emissivities at the $1.0\,\mu\text{m}$ wavelength is large
enough to distinguish granitic rocks from ba-
saltic rocks.

Spatial resolution in the estimation of the
surface emissivity is limited by the intense
scattering by clouds. Numerical calculation
demonstrates that it is of the order of 100 km
[5]. Although it is improbable to detect a small
feature such as the pancake dome, granitic
massifs which are larger than 100 km are de-
tectable [9].

Conclusion: The $1.0\,\mu\text{m}$ window is very
useful to observe the venusian surface. Using
this window, we will be able to detect active
volcanoes and compositional variation in crust
on Venus.

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