別紙様式８

研 究 主 論 文 抄 録

論文題目　Comprehensive Analyses and Applications of Synthetic Aperture Radar (SAR)Data to Active Volcanoes for Characterizing Surface Geology, Geomorphology,and Crustal Deformation
(活火山における表層地質，地形，地殻変動の特徴抽出のための合成開口レーダ (SAR) データの総合的な解析と応用)

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主論文要旨
《本文》

The application of the microwave remote sensing for active volcanoes was demonstrated in this study. In term of remote sensing for active volcanoes, each sensor with their frequency used has advantageous and disadvantageous. The advantageous of the optical sensor is effective to detect detail rock type because it can detect rock forming minerals based on their albedo detected by the sensor. This sensor also can discriminate clearly the vegetation area. However, this sensor could not detect the area under canopy vegetation. Moreover, this sensor is also affected by atmospheric condition. Therefore, detecting surface geology is effective only in a good atmospheric condition without vegetation covered study area. On the contrary, the SAR data produced by microwave sensor could detect surface material at day or night and regardless atmospheric condition. However, this sensor has high geometric distortion due to off-nadir looking mode. Removing geometric distortion from SAR images is a complicated work because it needs a transformation from slant range to ground range using local incidence angle and assisted by accurate digital elevation data. However, this study demonstrated a technique to minimize the geometric distortion in the SAR data. A simple technique is a ratio operation for two SAR data with the same path, row, and looking angle. After ratio take into account, the distortion pixel value in the SAR image will be located around one because the sensor works with the same properties for the two data (Chapter 2).

Some application also used a combination with optical sensor data to detect rock condition more detail such as detecting alteration zone. Chapter 3 discussed comprehensive combination of SAR intensity data and optical sensor data to detect the alteration zone. The heat from a geothermal system changed the rock formation physically and chemically. The physical change of the rock is decomposition from solid rock to fragile rock and soil. Since the SAR data is effective to distinguish the rough and smooth surface, the decomposed-rock can be detected. On the other hand, the heat from a geothermal system also changed the rock formation chemically. The rock forming mineral commonly change to soil minerals such as kaolin, montmorillonite, halloysite, and mordenite. The optical sensor is effective to detect the rock type based on their mineral properties. Therefore, combination of the both sensor is effective for mapping the alteration zone in an active volcano. The SAR data is composed by a complex data. Therefore, the intensity and phase data can be extracted from it. The usability of C- and L-band frequencies, single- and full-polarimetric data type, intensity and phase data for characterizing volcanic surface geology is summarized as follows.

The usability of C- and L-band frequency of SAR data is discussed in Chapter 4. The slant range resolution of C-band is higher than L-band frequency. Therefore, the C-band frequency could discriminate the volcanic product more detail because it used wavelength about 5.6 cm than the L-band frequency, which has wavelength about 23.6 cm. The different roughness of pyroclastic flow deposits could be classified well. However the C-band is still affected by vegetation, therefore mapping under canopy vegetation is difficult. On the contrary, the L-band frequency can penetrate the canopy vegetation. However, this frequency could not discriminate material size lower than 23.6 cm. Therefore, combination of C- and L-band is effective to estimate the surface geology under thick vegetation as discussed in Chapter 4.

Another SAR data type is a full-polarimetric data. This data provided a fully polarization type: HH, HV, VH, and VV. HH is a receiver antenna recorded horizontal signal from horizontal transmission signal and HV is a receiver antenna recorded horizontal signal from vertical transmission signal. Using four combination polarizations improved the capability the SAR data for characterizing volcanic surface condition. The application of SAR full-polarimetric data for detecting geomorphologic units is demonstrated in Chapter 5. Detecting geomorphologic units is more complicated than detecting rock type or vegetation because each geomorphologic unit contained not only rock type but also process occurred in the past. The process could be erosion, denudation, and geological structure such as faulting. Chapter 5 gave a comprehensive alternative solution to detect geomorphology based on surface roughness information.

The SAR intensity data consist of magnitude of the material at surface. High intensity value will occur when the much backscatter signal is recorded by receiver. On the contrary, when less backscatter signal is recorded by receiver, the intensity value will be low. Thus, the variation of the SAR intensity value depends on roughness, slope, and dielectric constant of material. Therefore, this data can be used for mapping the change of volcanic product laterally. In the case of detecting the change of volcanic product vertically or deformation, the SAR phase data could be used to estimate the uplifting or subsidence area as demonstrated in Chapter 6. The method used to estimate deformation is a multiplication of two SAR phases data termed as Interferometric SAR (InSAR) analysis. Further application of InSAR is to correlate between surface deformations with subsurface pressure. Using Mogi's source model the simple correlation between deformations at surface with pressure from magma reservoir could be performed.

The application of SAR data for natural disaster from volcanic eruption is discussed in Chapter 7. The estimation of dome eruption at the summit was discussed in view point of primary hazard assessment. For the secondary natural disaster from lahars, a combination data with ASTER images is used. Detecting dome eruption soon after eruption and lahars in the rainy season was included the estimation of their flows.