JAXA Virtual Planet

Instructions for Data Analysis Operations

(English Version)

January 2024

JAXA Virtual Planet
Data Analysis Operations

Revision Record

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Contents

1. Introduction

This document explains analysis operations on JAXA Virtual Planet. Here we will present an example of ratio calculation using KAGUYA MI reflectance maps.

2. Layer Data

2.1. MI Reflectance Map

The MI Reflectance Map is map data that shows the reflectance (=brightness) of the wavelengths below observed by the Multiband Imager (MI) onboard KAGUYA.

Table 1. Center wavelengths and bandwidths of each KAGUYA MI band

Band	Center wavelength [nm]	Bandwidth (half-width) [nm]
Band 1	415.0	20.0
Band 2	750.0	12.0
Band 3	900.0	21.0
Band 4	950.0	30.0
Band 5	1001.0	42.0
Band 6	1000.0	27.0
Band 7	1050.0	28.0
Band 8	1250.0	33.0
Band 9	1550.0	48.0

3. Example of Analysis by Band Rationing

Amounts of substances of the lunar surface can be calculated by rationig of MI bands. Abundance of colored minerals and degree of weathering can also be analyzed. Sections 3.1 and 3.2 show formulas for calculating TiO_2 and FeO volume as examples of calculating amounts of substances of the lunar surface. Sections 3.3 and 3.4 explain analyses of colored minerals and degree of weathering by rationing of MI bands.

3.1. Calculating TiO_2 Abundance

According to Lucey et al. (2000), the formula for the relationship between amount of TiO_2 on the lunar surface (wt%) and reflectance at wavelengths 415 nm and 750 nm is as follows. R415, R750 are the reflectances at 415 nm and 750 nm respectively.

$$\theta\theta_{TTTT} = \arctan\left(\frac{\frac{RR415}{RR750} - 0.42}{RR750 - 0.00}\right)$$

$$TTTTOO_2(wwww\%) = 3.708 \times \theta\theta^{5.979}$$

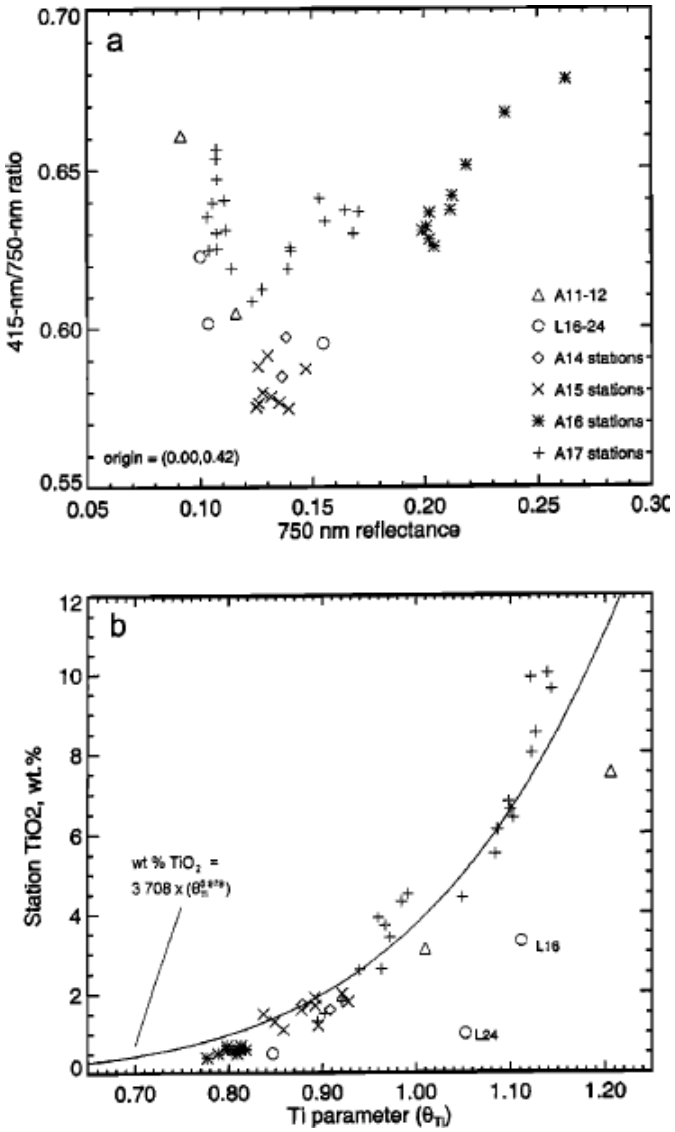


Figure 1. Relationship between $\theta\theta_{TTTT}$ and amount of TiO_2

In the figure above, $\theta\theta_{TTT}$ is the angle of the straight line parallel to the X-axis and the straight line connecting the origin point ($\frac{RR415}{RR750}$= 0.42) with the data points (Lucey et al., 2000)

3.2. Calculating FeO Abundance

According to Lucey et al. (2000), the formula for the relationship between amount of FeO on the lunar surface (wt%) and reflectance at wavelengths 750 nm and 950 nm is as follows. (R750 and R950 are reflectances at 750 nm and 950 nm respectively.)

$$\theta\theta_{FFFF} = -\arctan\left(\frac{\frac{RR950}{RR750} - 1.19}{RR750 - 0.08}\right)$$

$$FFFFOO(wwww\%) = 17.427\theta\theta_{FFFF} - 7.565$$

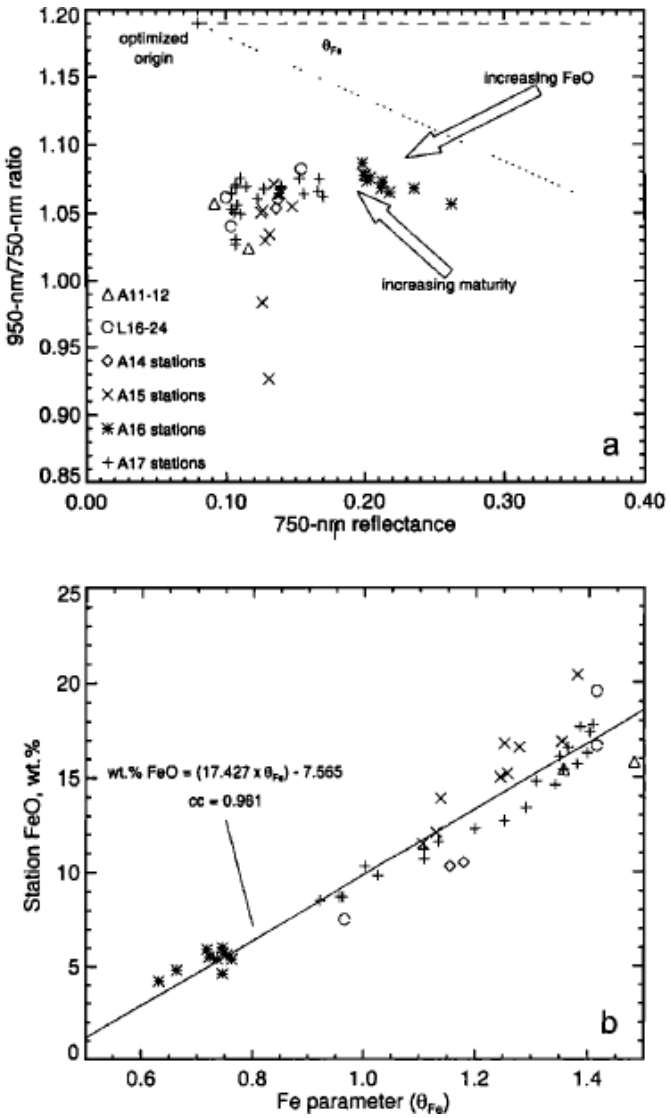


Figure 2. Relationship between $\theta\theta_{FFFF}$ and amount of FeO (Lucey et al., 2000)

3.3. Abundance of Colored Minerals

On the MI reflectance map, there is absorption of colored minerals (basic minerals such as pyroxene) at the 950 nm band. On the other hand, they are not susceptible to absorption at the 750 nm band.

Therefore, we can analyze the abundance of colored minerals by comparing 950 nm (Band 4) with 750 nm (Band 2). The larger the value of 750 nm / 950 nm, the more colored minerals there are.

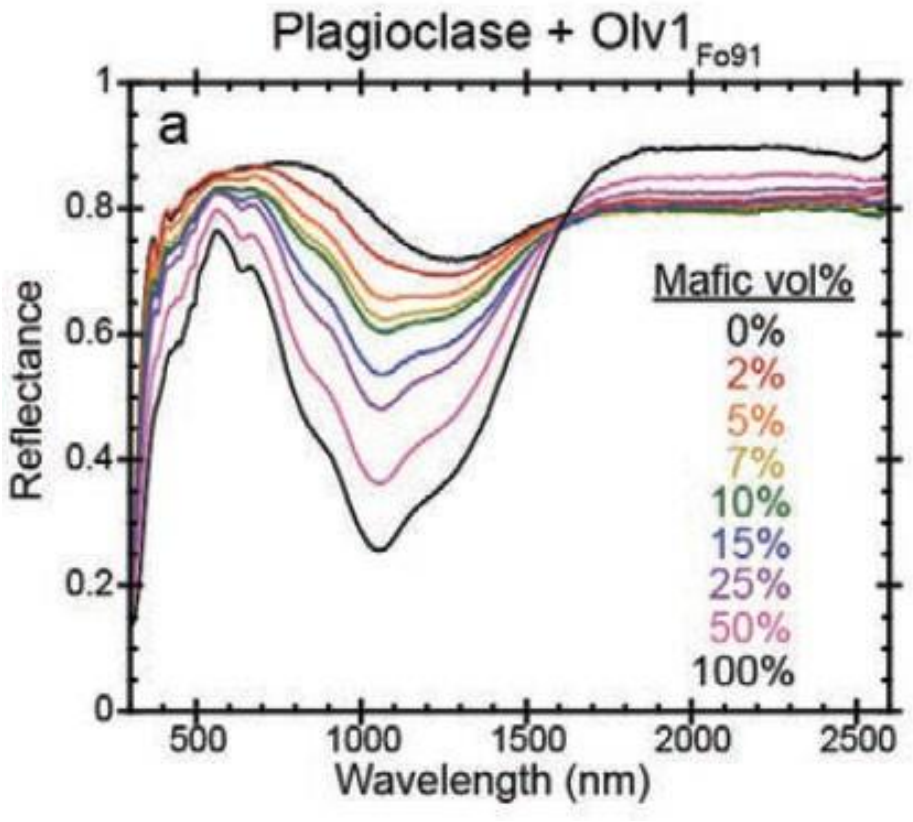


Figure 3. Reflectance spectra of the mixture of colorless minerals (plagioclase) and colored minerals (olivine (0000001_{FFFF91}))
(Cheek and Pieters, 2014)

3.4. Degree of Space Weathering

Since the lunar surface has no atmosphere, it is constantly bombarded by micrometeorites and cosmic radiation. The resulting effects cause the reflectance spectra to change over time (weathering) as follows (in the figure below).

- Depth of absorption decreases.
- Slope (rising line) increases overall.
- Reflectance declines overall.

Therefore, we can analyze the degree of weathering (old vs. new) by comparing 750 nm (Band 2) with 415 nm (Band 1). The larger the value of 750 nm / 415 nm, the more weathering has occurred - in other words, the older it is.

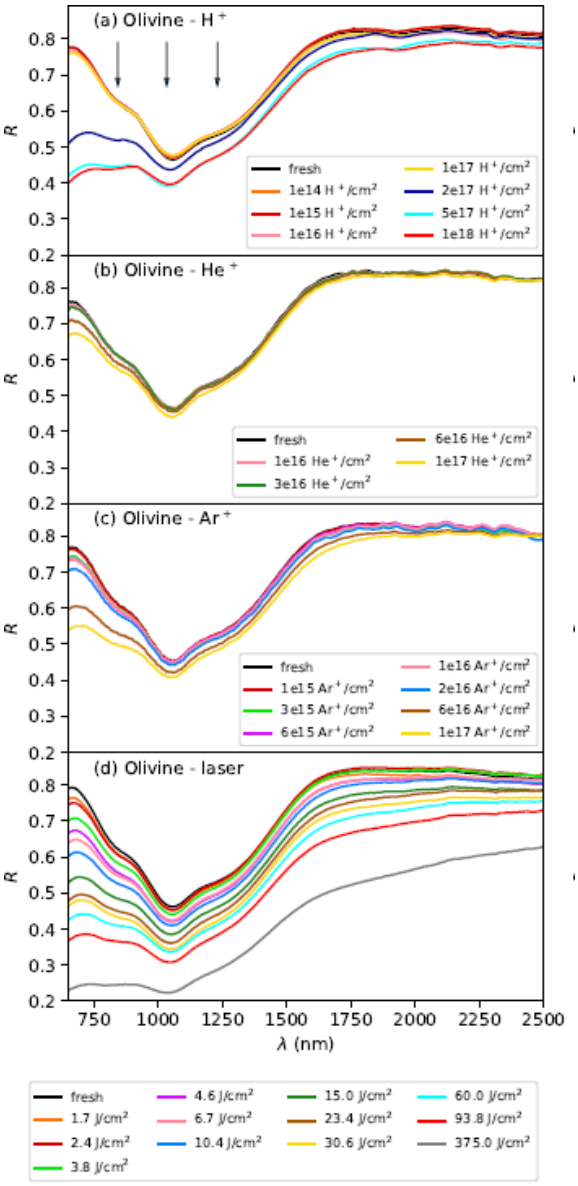


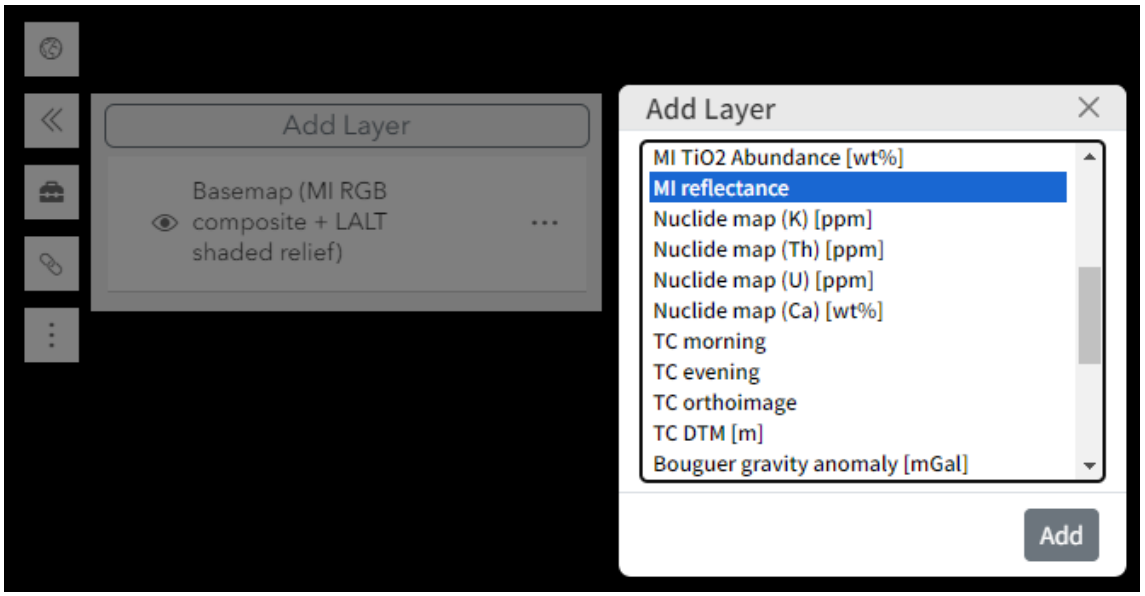
Figure 4. Reflectance spectra of Olivine during ion and laser irradiation (Chrbolková et al., 2021)

4. Procedures for Arithmetic Operations on JAXA Virtual Planet

4.1. Band Rationing

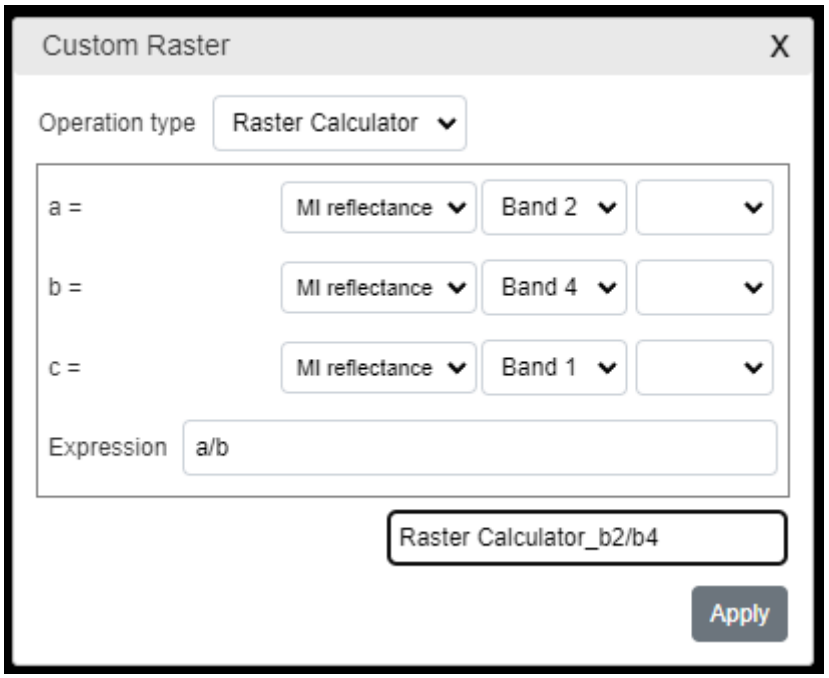
In this section, we present an example of the procedure of operations when analyzing abundance of colored minerals by band rationing of MI reflectance on JAXA Virtual Planet.

1. Select “MI reflectance” from “Add Layer” on the (Layer List) at the top-left of the screen, and click “Add.”



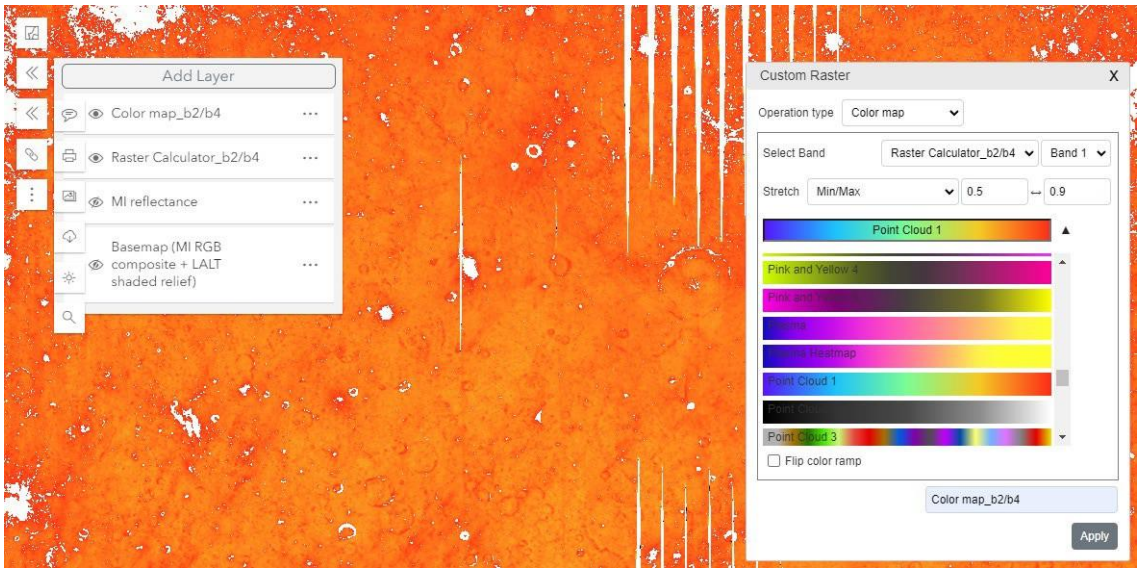
2. Click (Custom Raster) in (Toolbox) to bring up the detailed settings screen for custom raster.

3. Select “Raster Calculator” as the operation type, and select the bands for the applicable calculation. If you want to apply
exponent or logarithm calculations and pass them on to the calculation formula, select functions from the lists to the right of the band names.
3.3 When performing an analysis of colored minerals according to section 3.3, set a and b to Band 2 and Band 4.



4. Specify the calculation formula in “Expression.”
   When performing an analysis of colored minerals according to section3.3, it will be performed at Bands 2 and 4, so specify these as a/b.
5. Select any name of your choosing for “Output Layer name” and click the “Apply” button.
6. The calculation results will be added to the layer, and will be displayed on the map.

7. Bring up the detailed settings screen for custom raster again. Set operation type to “Color map” and enter your ratio calculation results from 6 for Select Band, enter the minimum and maximum values for Stretch, then choose a type of color map and click “Apply.” Your calculation results will then be displayed with a color map and color range for easy viewing.


Add Layer
Color map_b2/b4
Raster Calculator_b2/b4
MI reflectance
Basemap (MI RGB composite + LALT shaded relief)
Custom Raster
X
Operation type
Color map
Select Band
Raster Calculator_b2/b4
Band 1
Stretch
Min/Max
0.5
0.9
Point Cloud 1
Pink and Yellow 4
Point Cloud 3
Flip color ramp
Color map_b2/b4
Apply