Hydrous alteration of lava flows on Mauna Loa (Hawaii) compared to Martian volcanic soils

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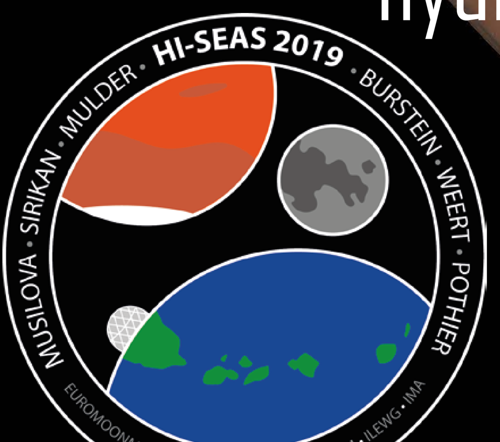
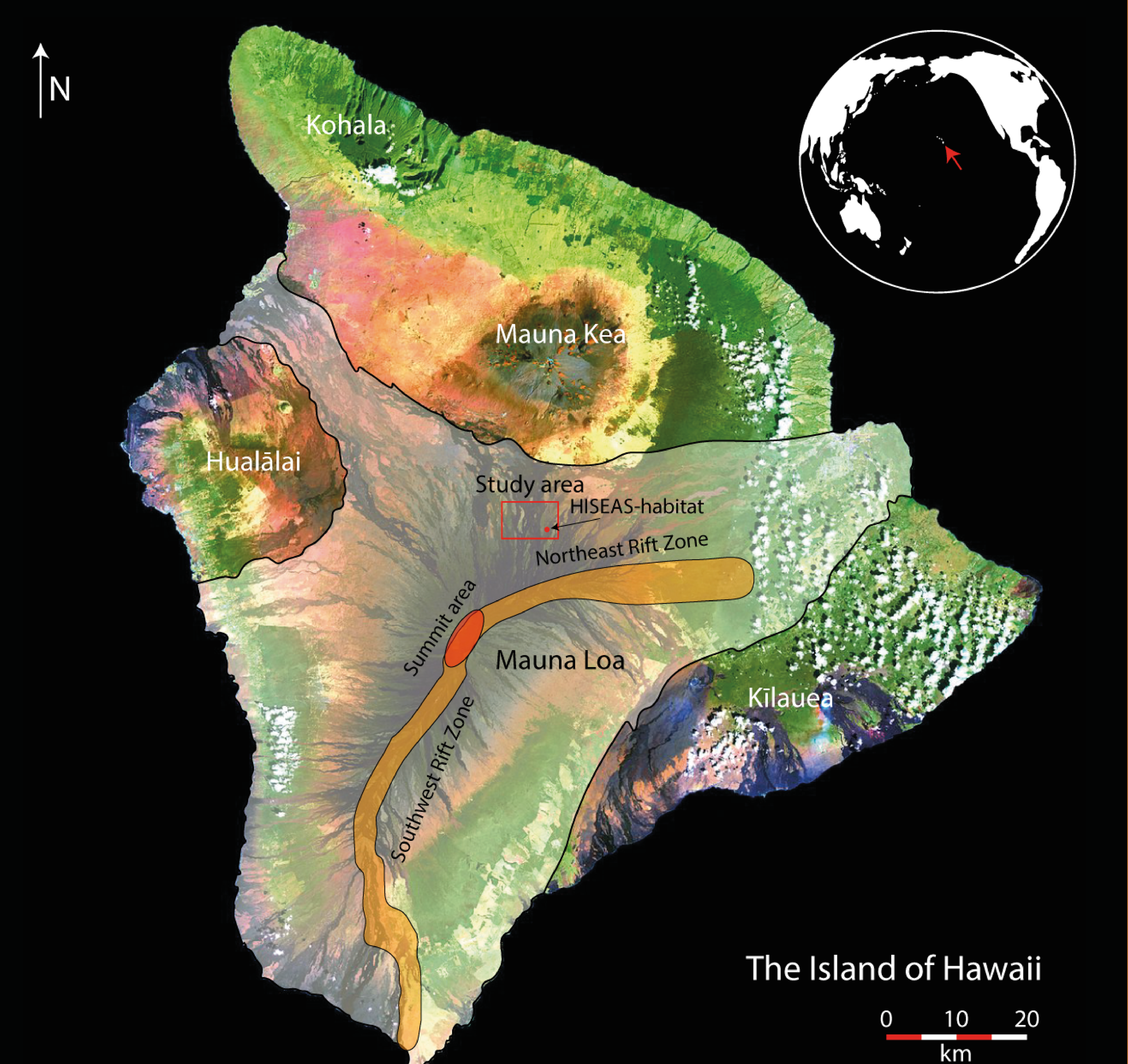
This study is the first to use basaltic rock samples from the shield volcano Mauna Loa (Hawaii) as Martian analogue for a hydrous alteration study. The main purpose of this study is to find analogies between the rock samples from Mauna Loa and Martian datasets in terms of mineralogy and alteration environment. These analogies were found; the study suggests the same type of clay minerals as identified on Mauna Loa have formed in an arid to semi-arid environment at cold to moderate temperatures on an early Mars. These findings add to the assumption that Mars once had an active hydrosphere.



HI-SEAS

Sample collection was done during the EuroMoonMars Hawaii Space Exploration Analog and Simulation (HI-SEAS) campaign of February 2019. The HI-SEAS habitat is located on the north-east flank of Mauna Loa, where the geology is Mars-like. The research and technological experiments conducted at HI-SEAS are going to be used to help build a Moonbase in Hawaii, and ultimately to create an actual Moonbase on the Moon.



ALTERATION ON MAUNA LOA

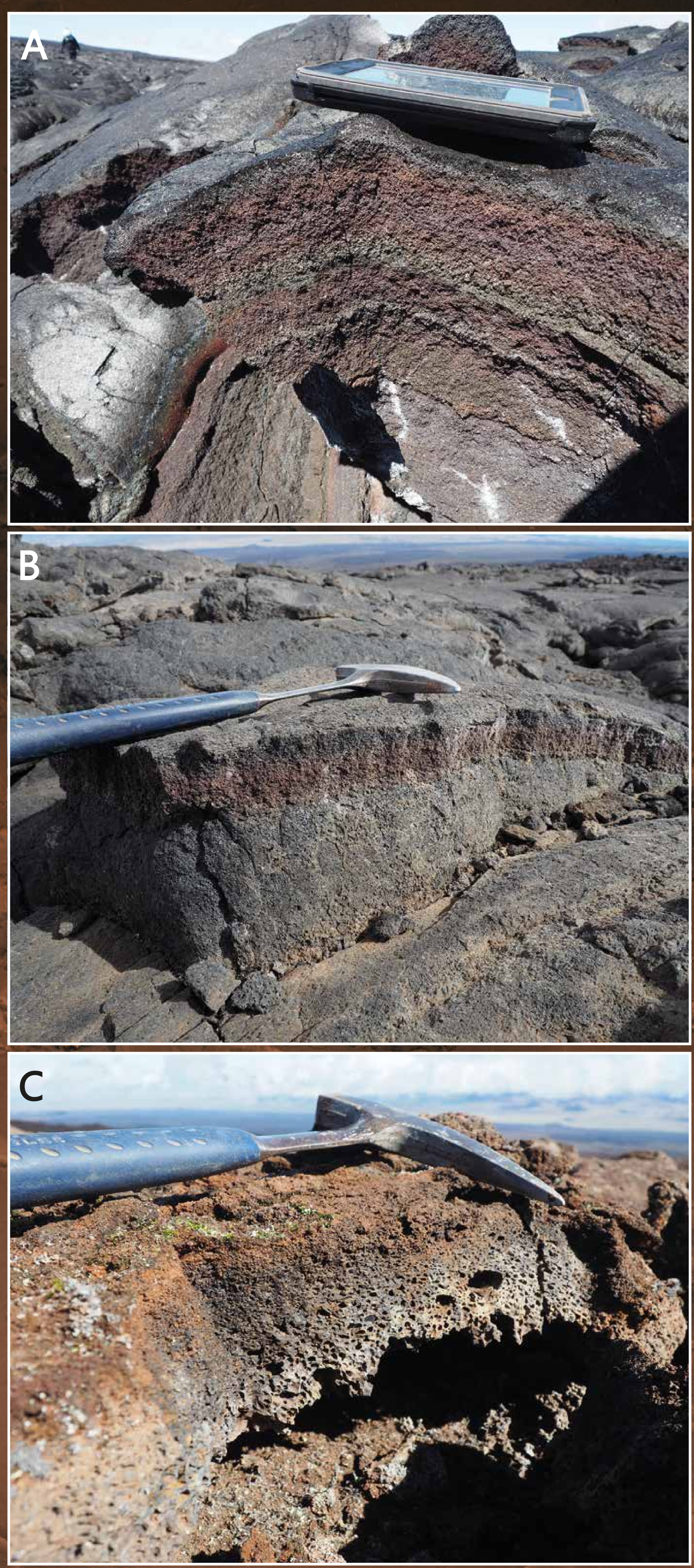


Figure 1: Different stages of hydrous alteration of lava flows as observed in the field; (A): A.D. 1935-1936, (B): 410 ± 60 yr (C): 1838 ± 94 yr [1].

In the field, hydrous alteration can be recognized by the removal of metallic surface layers (Fig. 1A), horizons enriched in ferric iron (Fig. 1B) and the presence of brown horizontal surface layers (Fig. 1C). The upper 10 cm of 8 differently aged horizontally emplaced pahoehoe lava flows (90 to >10.000 years old) were sampled.

Combination of petrographic microscopy, SEM-EDS and SWIR hyperspectral imagery made it possible to estimate the chemical compostion of the present hydrated minerals. Additionally, XRF was used to study the elemental changes along the depth profiles through the samples. The main detected alteration products include Fe,Mg-smectites, hydrated silica, Al-silicates, Al-hydroxide and palagonite. These products formed due to the interaction between meteoric water and basaltic rocks (Fig. 2).

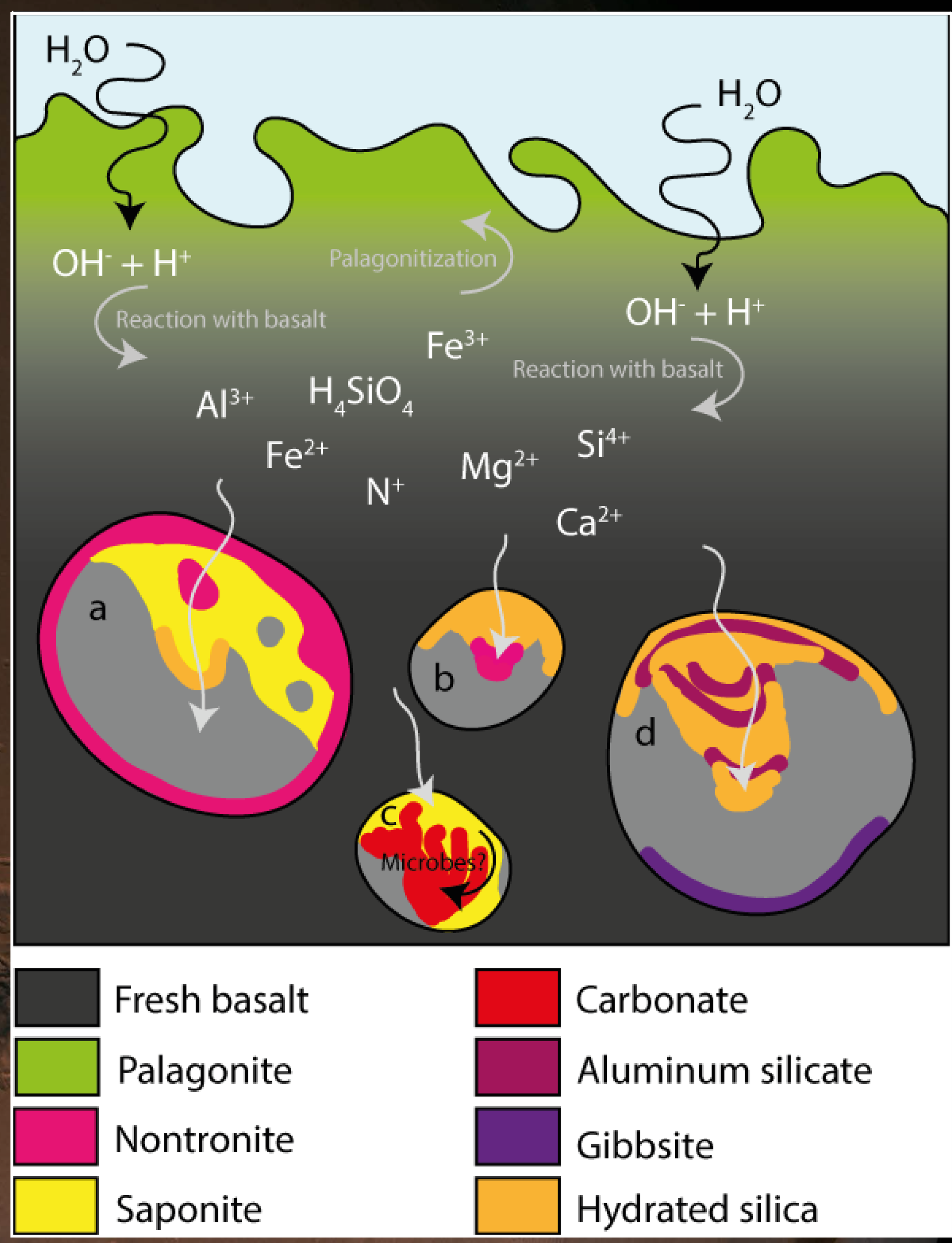


Figure 2: This figure shows the observed secondary products. The alteration products mainly appear within pores present in the basaltic rocks. Void a shows the evolution of a nontronite coating. Voids b and d show the developments of a hydrated silica coating and void c the evolution of a saponite coating overprinted by carbonate.

ALTERATION ON MARS

The Hawaiian mineral spectra were compared with remote sensing data from Mars orbital spacecrafts. Comparison shows that the alteration products on Mars are similar to the hydrous alteration products found on Mauna Loa (Fig. 3).

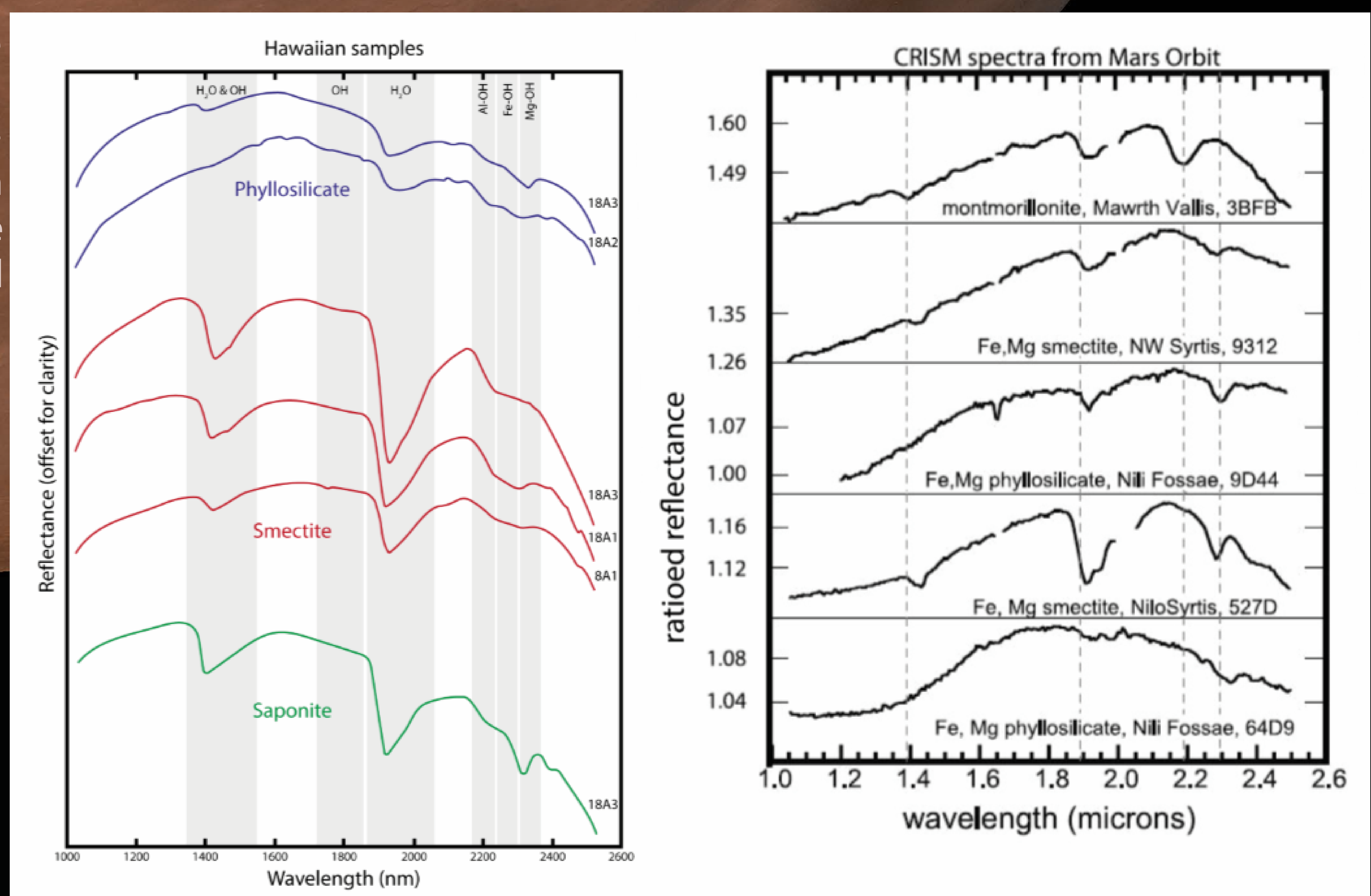
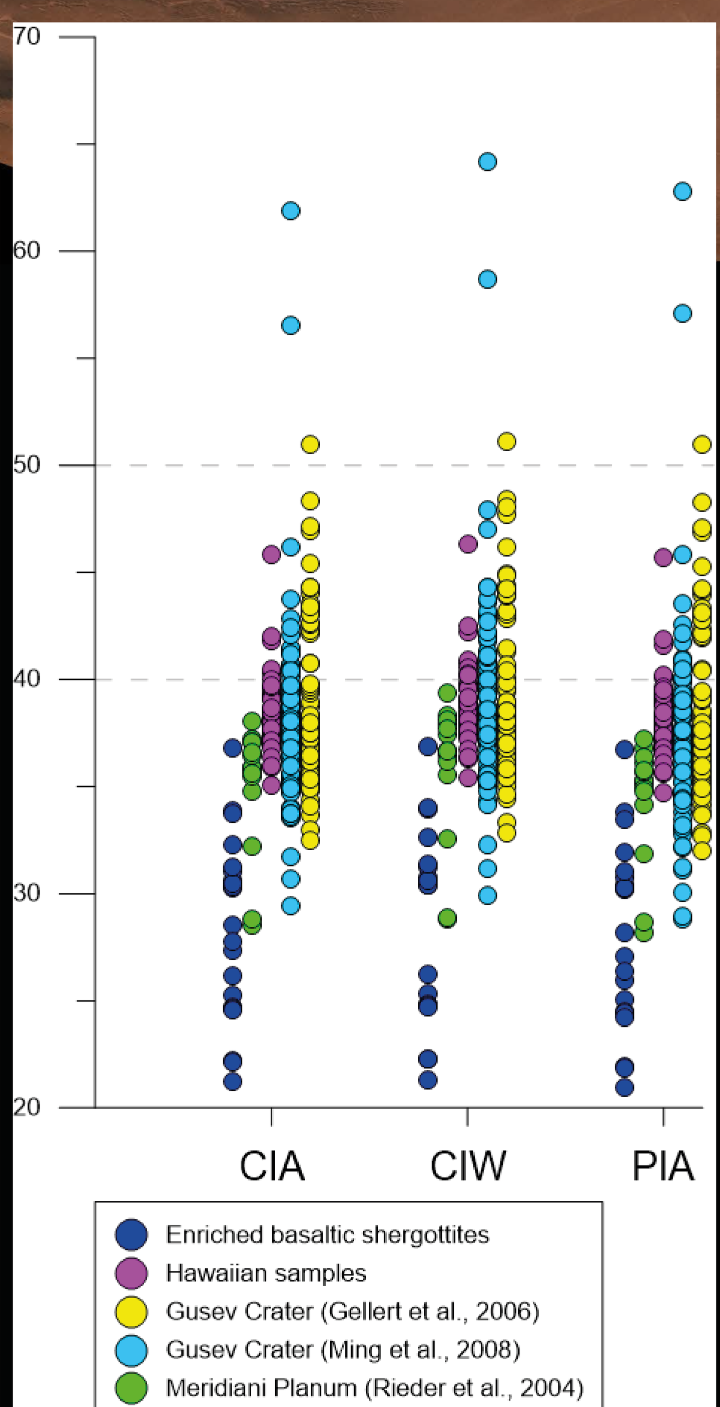


Figure 3: Smoothed SWIR spectra of the Hawaiian samples on the left and CRISM spectra with the same wavelengths from Mars Orbit on the right [2].



The Hawaiian XRF data was compared with APXS data from MERs Spirit and Opportunity and Martian enriched basaltic shergottites [3-6]. Geochemical weathering indices [7-9] were calculated for both datasets (Fig. 4). Obtained values for the Hawaiian rocks indicate alteration and weathering processes acting on the top 2-3 cm of the rock samples with ages >400 years. This happened in an arid to semi-arid environment at cold to moderate temperatures [10]. The Martian datasets plot along the Hawaiian dataset, suggesting similar conditions for alteration. These observations are consistent with the assumption of a present active hydrosphere on an Early Mars [11].

Figure 4: CIA = Chemical Index of Alteration [7], CIW = Chemical Index of Weathering [8] and PIA = Plagiclase Index of Alteration [9]. Values <40 indicate no weathering or alteration; 40-50 indicate minor weathering and alteration under cold to arid circumstances; >50 increasing amount of weathering and alteration under warmer and wetter conditions [10].

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