ANALYSIS OF ALTERED MINERAL PHASES IN YAMATO 593 MARTIAN METEORITE. I. Gyollai[1], A. Kereszturi[1], E. Chatzitheodoridis[2] ([1]HAS RCAES Institute for Astronomy, 1121 Budapest, Konkoly Thege Miklós út 15-17. Hungary, [2]National Technical University of Athens, Greece, e-mail: gyollai.ildiko@csfk.mta.hu)

Introduction: The aim of this work is to identify volatile related formation and alteration of secondary minerals in the poorly analyzed Martian meteorite Yamato 593. Secondary alteration processes related to mineral scale volatile migration could be identified along with the range of probable formation conditions. Secondary alteration products are of high importance in Martian meteorites as they provide insight into the characteristics of wet environments on Mars [1,2]. Integrating these findings into the general knowledge of volatiles on Mars, the possible sources and characteristics of behaviour of volatiles in shallow subsurface igneous environments could be outlined based on knowledge acquired from the nakhlites.

Methods: For textural analysis a polarization microscope NICON Eclipse E600 POL was used. Infrared spectra were collected with a Bruker VERTEX70 FTIR and a HYPERION 2000 microscope with an ATR objective, the measurements were performed for 30 s at 4cm^{-1} resolution. Bruker Optics' Opus 5.5 software was used for the manipulation of the spectra (baseline correction, atmospheric compensation, etc.).The Raman analysis was realized by Renishaw Ramascope RM1000 confocal instrument at the National Technical University of Athens, which has a 632.8 nm He-Ne laser and a Leica DMLM optical microscope attached to it. Spectra were acquired both the previous instrument and an in Via Raman instrument with a 457 nm green laser with spot size smaller than 1.5 μm. The spectra were composed of 5–10 accumulated scans of individual measurements, each acquired for 10 s of integration time.

Results: About 15% of Yamato593 thin section is filled with alteration products both in various veins and also in the groundmass (between larger phenocrysts or megacrysts)—see example spectra in Figure 1, optical images in Figure 2, and BSE images in Figure 3. Siderite and hematite occur between mineral cleavage planes, and in fractures which are mainly filled mainly with secondary siderite and hematite, also around grain boundaries at altered areas of the meteorite. Mn-siderite occurs as a few μm thick veins or as rosette-shaped structures. The co-precipitation of siderite and rhodochrosite is expected to occur from hydrothermal fluids. Sometimes siderite is observed to exist inside the rosetta-structures, which are then rimmed by goethite. Alteration veins in several cases contain antigorite and alunite, as signature of high temperature hydrothermal alteration. Fayalite and diopside are also present together inside the cavities as secondary alteration products, while primary pyroxenes are augite. Feldspar phenocrysts in mesostasis are altered along their fractures and their twin lamellae, where siderite veins (alteration due to Fe-rich fluids), and muscovite are observed as degradation products of feldspar. Chlorite does not seem to be composed of a large OH content, something that is compatible with it high temperature origin. Clay minerals occur in alteration areas together with serpentine. They show sub-micron grain sizes and greenish-grey appearance in transmitted light. The clay minerals occur in alteration cavities (together with siderite), and also in irregular, erosional-exsolution voids in olivines and feldspars.

Weathering products of magmatic minerals: The alteration phases in cavites and in fractures were measured by FTIR-ATR spectroscopy, where montmorillonite, apatite, ferrifayalite, and serpentine were determined (Fig. 1.) The very low intensities of OH bands indicate elevated temperature (for serpentine >300 °C is required). But montmorillonite and hydroxyapathite might be able to keep their OH content, suggesting that they did not experience temperatures above 120–150°C. Especially for the candidate hydroxyapathite the limiting temperature is even lower, at around 50 °C.

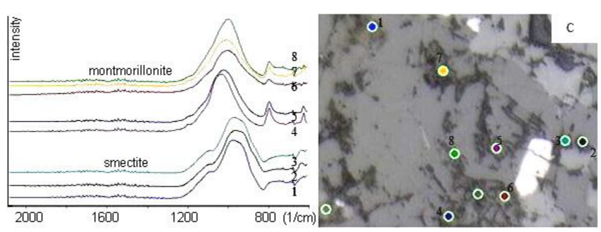

Figure 1. IR spectra of secondary minerals. Kaolinite traces (638, 683 cm^{-1} peaks) appear together with feldspar (955, 1095 cm^{-1}) indicating acidic weathering. The montmorillonite (823, 853, 961, 1000 cm^{-1}) was detected as alteration product of olivine

Acknowledgment: This work was supported by COST TD1308 and COOP-NN-116927 projects.

References: [1] Marion G.M., Catling D.C., Kargel, J.S. (2003) *GCA 67(22)*, 4251–4266. [2]Chatzitheodoridis E., Haigh S., Lyon I. (2014) *Astrobiology 14(8)*, 651–693.

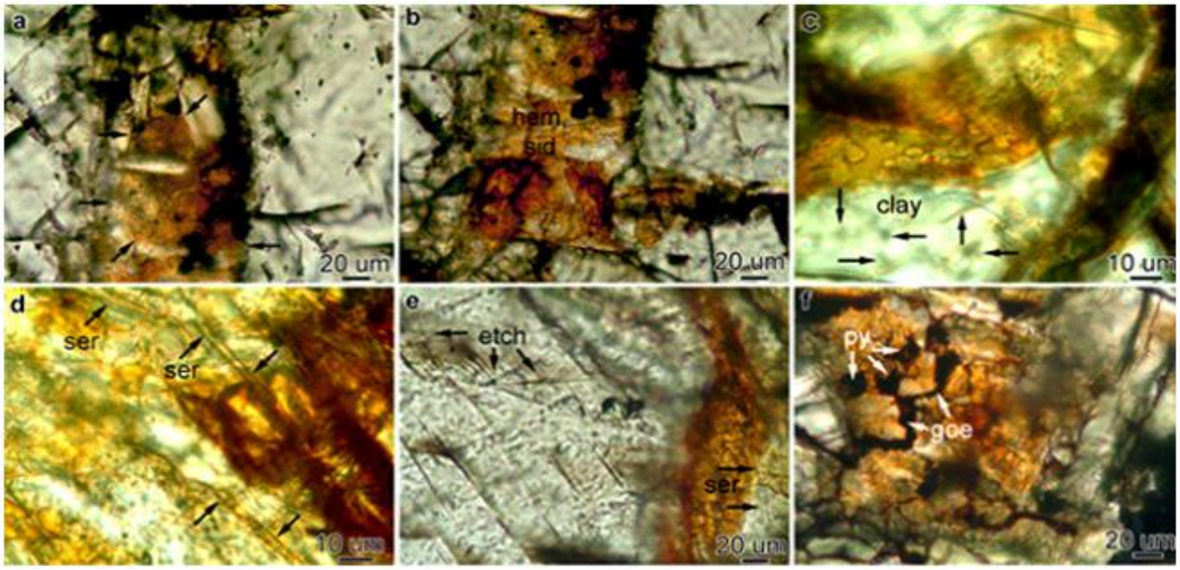

Figure 2. Alteration structures in Yamato 593: a-b): apatite needles are embedded in fine-grained siderite-hematite mixture. c): clay mineralization along the fractures. d): serpentine veins near to goethite "tunnel structure" (right bottom). e): etched erosion near to siderite-hematite filled fracture. f): rosette shaped structure which is filled with hematite-siderite inside and rimmed by pyrite and goethite.

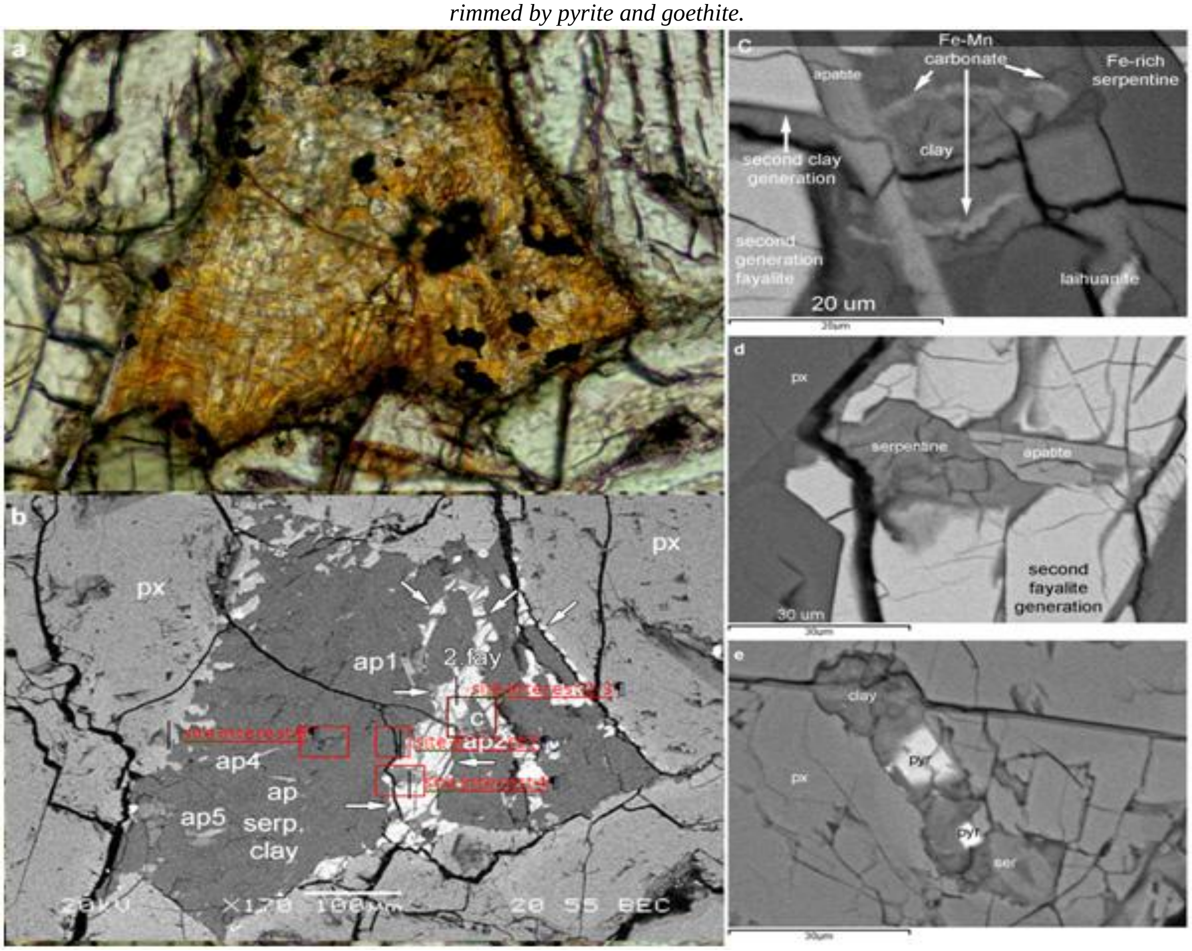

Figure 3. BSE mapping of Yamato 593, area 3, which was formed by the almost complete erosion of olivine by intense alkaline weathering. This area is composed of remnants of olivine, which were transformed to ferrifayalite and are crossed by serpentine veins. The cavities of secondary fayalite grainsare filled with serpentine, apatite (d), and clay with Mn-siderite (c). The altered cavities contain pyroxene, clay, pyrite, serpentine (e).