Raman analysis of Basaltic samples from Tenerife Island (Cañadas, Los Azulejos and historical eruptions) with the Exomars RLS Instrument

E. Lalla[1], G. Lopez-Reyes[1], F. Rull[1], J. Medina[1], J.Martinez-Frías[1], A. Sansano[1] and R. Navarro[1]

[1] Unidad Asociada UVA-CSIC
Astrobiology Center - INTA

Introduction

The development of simulation tools and instrument prototypes is necessary in order to test and maximize the future instruments capabilities, specially on the unmaned operation mode on the Exo-mars Mission Rover. The performance of the automatic linear mapping on powdered samples, autofocusing on the surface and auto-adjusting the acquisition parameters at each investigated.

Mineral Species and Phases	Las Cañadas outcrop		Los Azulejos outcrop		Las Arenas outcrop	
	MR	RLS	MR	RLS	MR	RLS
Olivine	X	X			X	X
Forsterite	X	X			X	X
Monticellite		X				X
Amorphous	X	X			X	X
Plagioclase and Feldspar	X	X	X	X	X	X
Orthoclase	X	X	X	X	X	
Microcline				X		
Sanidine		X	X	X		
Anorthoclase	X	X		X	X	X
Albite	X	X	X	X		X
Oligoclase	X	X	X	X		X
Andesine		X		X		X
Labradorite	X	X		X	X	X
Bytownite				X		
Anorthite		X	X		X	
Amorphous	X	X	X	X	X	X
Pyroxene	X	X			X	X
Augite	X	X			X	X
Diopside	X				X	X
Amorphous	X	X			X	X
Fe-Oxides	X	X	X	X	X	X
Hematite	X	X	X	X	X	X
Goethite	X		X			
Magnetite	X	X	X		X	
Amorphous		X		X		X
Ti-Oxides	X	X	X	X		
Rutile	X					
Anatase	X	X	X	X		
Amorphous	X	X	X	X		
FeTi- Spinels	X	X				
Ilmenite	X					
Chromite	X					
Amorphous		X				
Phosphate	X	X			X	X
Apatite	X	X			X	X
Amorphous						X
Amphibole	X	X				
Actinolite	X	X				
Carbonates	X		X	X	X	X
Calcite	X				X	X
Hidrotalcite	X					
Gregoryite			X			
Amorphous				X		
Silicate	X	X	X	X		
Quaztz	X	X	X	X		
Micas and Clays	X		X			
Muscovite	X		X			
Illite	X		X			
Kaolinite	X		X			
Amorphous	X		X			
Sulphates			X	X	X	
Melanterite			X	X		
Gypsum					X	
Zeolite	X		X			X
Analcime	X		X			X
Carbon/Graphite	X	X	X	X		X
Organics	X	X				X
Alterated silicate and without identification	X	X	X	X	X	X

Table 1. Summary of the mineral species detected on the Cañadas outcrop, Azulejos outcrop and Arenas volcano by manned Micro-Raman bulk mode (MR) and Automatic Raman powder mode (RLS). The identification have been done by calculating the peak position, FHWM and relative intensity by gaussian and lorentzian approximation.

[1] Rull, F.; et al, *42nd LPSC*, #2400. [2] Rull, F and Martinez-Frías, J. (2000), *Spect. Europe*, 18, 1. [3] Lopez-Reyes, G. et al. (2012), *GeoRaman Xth*, 151-152. [4] Foucher, F. et al. *Geo-Raman Xth*, 143-144. [5] Lalla, E., et al (2010) *Macla* 13, p. 129-130. [6] Lalla E., et al (2011) *Macla* 15, p. 119-120. [7] Rull F. (2012), *43rd LPSC* #2882.

RLS Simulator at Unidad Asociada Uva-CSIC

Figure 1. The ExoMars RLS Simulator automatic mode acquired a total of 30 spectra per sample, with automatically calculated integration time and number of accumulations at each point. Laser wavelength: 532 nm. Spot size: 50 microns

Minerals detected by XRD and Quantification by RIR (Reference Intense Ratio)

Some sample have been analyzed by XRD and quantified by RIR using the X-Powder program:

Mineral Species (Azulejos)	Sample 1	Sample 2	Sample 3
K-Feldspar	59,2	46,2	*****
Silicate	0,9	10,4	20,2
Zeolite	0,9	9,8	*****
Micas and Clays	31,7	25,7	21,6
Plagioclase	*****	2,8	36,9
Pyroxene	*****	*****	5,8
Sulfate	*****	*****	8
Fe-Oxides	*****	*****	3,5
Amorphous Stuff	7,3	5,1	4,0

Table 2. XRD identification and Semi-quantification by RIR of the Azulejos outcrop

Mineral Species (Las Arenas)	Sample 1	Sample 2	Sample 3
Plagioclase	24,3	72,9	39,1
Pyroxene	46,4	10,7	43,1
Olivine	16	12,9	14,4
Fe-Oxides	5,3	0,5	0,0
Amorphous Stuff	7,7	3	3,4

Table 3. XRD identification and Semi-quantification by RIR of the Las Arenas Volcano

Mineral Species (Cañadas)	Sample 1	Sample 2	Sample 3
Plagioclase	44,2	12,3	*****
K-Feldspar	19,3	29,5	53,4
Pyroxene	27,9	22,4	10,2
Silicate	*****	30,2	11,4
Olivine	*****		1,7
Mica and Clays	*****		16,4
Amorphous stuff	8,6	5,6	6,9

Table 4. XRD identification and Semi-quantification by RIR of the Cañadas Caldera

Selected sample from Tenerife Island (Las cañadas, Los Azulejos and historical eruptions)

Las cañadas Caldera: shows 20 million years of volcanic formation with erosive processes, hydrothermal activity, sub-aerial processes and diffusive emission processes caused by the volcanic activities.

Los Azulejos: This outcrop shows variety of alterational processes where be seen analcime, clay minerals and illite group minerals. Also the rock/fluid interaction shows mushrooms textures and fluid circulation processes corresponding to sulfate, manganese and iron oxides .

Las Arenas Volcano: The magma erupted by the volcano icorresponds to basaltic lava and the zones reflect the processes related to the primary volcanic paragenesis as well as the metheoritic alteration processes

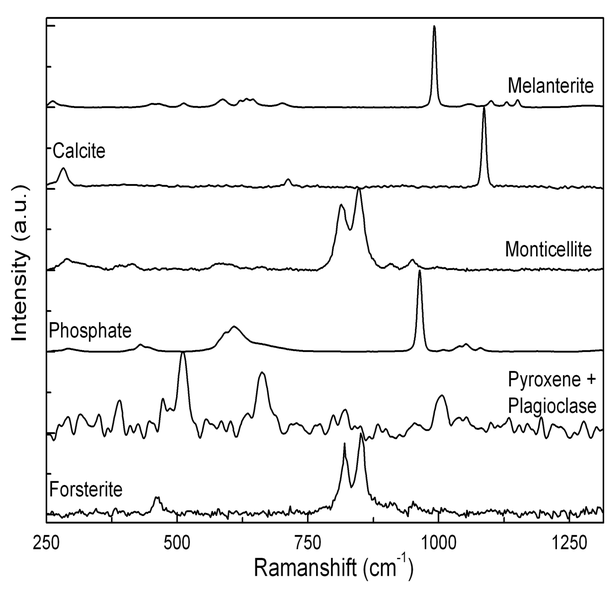

Figure 2. Raman Spectra of some Mineral species detected on the different samples by the RLS ExoMars Simulator in automatic mode

Conclusion:

- **The RLS Exomars Simulator results endeavour the automatic analysis of powdered samples, which allows us to detect minor phases with respect to the bulk in some cases. However in others some mineral species might be lost it can be lost.**
- **The laser power has to be chosen carefully due to some minerals species are thermolabile and can be damaged (See Table 1), a more detailed study of laser power/thermolabile minerals is necesary**
- **Tenerife basaltic material shows to be an excelent material for carrying this kind of experiment, where it can be found primary basaltic species and secondary mineral species.**
- **Raman identification and XRD quantification is an excellent combination for a correct identification of the alterational process. (1) Los azulejos has suffered a diffuse volcanic emission, subsurface hydrothermal alteration and weathering process. (2) The Cañadas outcrop has suffered subsurface hydrothermal alteration, submarine alteration and weathering processes. (3) The arenas negras volcano has suffered only weathering processes.**