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Identification of kerogen by SCA device in materials produced by the impact of an extraterrestrial body on Earth

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Abstract

Libyan Desert Glasses (LDGs) are materials formed at high pressures and temperatures by the impact of an extraterrestrial body on Earth 28.5 million years ago. Therefore, the identification of organic matter in them can be an evidence of early life on Earth. In this work, SCA (Structural and chemical analyser) device (SEM-EDS (Scanning Electron Microscopy/Energy Dispersive X-Ray Spectroscopy) plus Raman spectroscopy) was used to search kerogen, which is formed from the maturation of sedimentary reduced organic carbon. In this manner, black shale (kerogen and calcites) was identified in the inner part of the LDGs. This fact could suppose the presence of biological organic material by the time of LDG formation. Moreover, the Raman bands of the black shale spectra were shifted, which could be because of an effect of high pressure and temperature in the formation of the LDGs.

1. Introduction

LDGs are impact glasses formed at high pressures (between 6 and more than 30GPa) and temperatures (between 300 and 1470ºC) after the impact of an extraterrestrial material (meteorite, asteroid or comet) on Earth 28.5 million years ago [1]. Concretely, they have been found in the Western Desert of Egypt (near the Libyan border). They consist of a siliceous matrix with embedded inclusions, which can contain different minerals such as calcite ($CaCO_3$), hematite (Fe_2O_3), quartz (SiO_2), rutile (TiO_2), magnesite ($MgCO_3$), etc. [1]. Apart from inorganic compounds, LDGs could contain organic ones, which could be the key for the search of life in the Solar System. Despite this fact, organic matter in LDGs has been rarely mentioned. The main source of organic matter on Earth is sedimentary reduced organic carbon, which matures to kerogen [2]. Kerogen is the insoluble macromolecular fraction of sedimentary organic matter and is the precursor of oil and gas resources [3]. Therefore, the aim of this work was to identify organic matter in form of kerogen in the LDGs using non-destructive analytical techniques and, thus, to complete and deepen the conditions of formation of the LDGs.

2. Material and methods

2.1 Materials

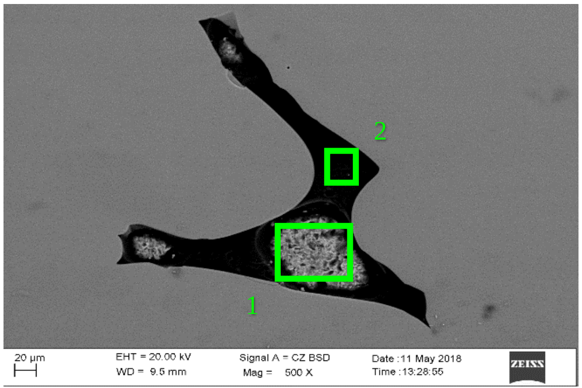
LDGs from the Meteorites Collection of the Basque Country University (UPV/EHU) were studied. Some of the samples were sliced and thin sections were prepared to make the analysis of the inner part of the LDGs easier. This work was focused on the inner side to avoid possible interferences with the atmosphere.

2.2 Methods

SCA, Raman spectroscopy plus SEM-EDS, was employed. SCA allowed us to merge SEM images, EDS analysis and Raman spectroscopy analysis in the same micrometrical point. For that purpose, an EVO 40 Scanning Electron Microscope (Carl Zeiss NTS GmbH, Germany) coupled to an X-Max Energy-Dispersive X-Ray spectroscopy equipment (Oxford Instruments, United Kingdom) and a Renishaw inVia Raman micro spectrometer with a 514 nm argon ion excitation laser (Renishaw, United Kingdom) were used.

3. Results and discussion

Firstly, SEM-EDS analysis was performed in several parts of the LDGs. Thus, C, a possible indicator of presence of organic matter, could be located (see Figure 1). As can be observed in the Figure 1, C together with Ca, S, Si, Mg, Na and O were distinguished in certain cavities of the inner part of the LDGs. It was remarkable the differences of the C percentage in several points. For example, the analysis performed in the point 1 had less C and more elements than in the point 2. Once these results were observed, Raman spectroscopy was used to determine the molecular composition in those points with higher presence of C according to SEM-EDS.



	Atomic%	
	1	2
C	52.42	84.74
O	30.86	15.14
Na	2.72	
Mg	0.79	
Si	11.39	0.12
S	0.05	
Ca	1.77	

Figure 1: SEM image and atomic percentage of the elements found in the selected areas by EDS.

Thus, it was possible to identify kerogen in the point 2 of the Figure 1. However, in order to improve the Raman spectra obtained by SCA, a point-by-point Raman analysis was carried out in the same area. In this way, black shale was detected, not only in that area, but also in different cavities of the sample (see Figure 2). Black shale consists of kerogen trapped in the pores of silicate based on sedimentary rocks and calcites. It is as fossilized organic matter and consists mostly of carbon [4]. Therefore, its identification could reveal the presence of biological organic material by the time of LDG formation. Moreover, it is remarkable that the Raman bands of the black shale were shifted. According to bibliography, high pressures and temperatures can shift their Raman bands [5].

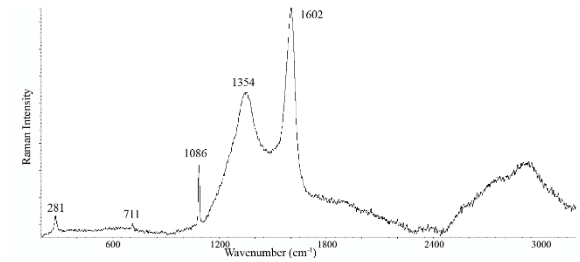


Figure 2: Raman spectrum of black shale (kerogen plus calcite over a silicate matrix).

4. Conclusions

SCA device allowed us to discern areas in the inner part of the LDGs where there was presence of black shale, which could be a signature of previous biological material. Moreover, Raman spectroscopy allowed us to observe that the kerogen could have been subjected to high pressures and temperatures.

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References

[1] Gomez Nubla, L., Aramendia, J., Fdez-Ortiz de Vallejuelo, S., Alonso-Olazabal, A., et al.: Multispectroscopic methodology to study Libyan desert glass and its formation conditions, Analytical and Bioanalytical Chemistry, Vol. 409, pp. 3597-3610, 2017.

[2] Shkolyar, S., Eshelman, E.J., Farmer, J.D., Hamilton, D., Daly, M. G., Youngbull, C.: Detecting Kerogen as a BiosignatureUsing Colocated UV Time-Gated Raman and Fluorescence Spectroscopy, Astrobiology, Vol.18, pp. 431-453, 2018.

[3] Schito, A., Romano, C., Corrado, S., Grigo, D., Poe, B.: Diagenetic thermal evolution of organic matter by Raman spectroscopy, Organic Geochemistry, Vol. 106, pp. 57-67, 2017.

[4] Tuschel, D.: Raman spectroscopy of oil shale, Spesctroscopy, Vol. 28 (3), 2013.

[5] Childress, L.B., Jacobsen, S.D.: High-pressure high-temperature Raman spectroscopy of kerogen: Relevance to subducted organic carbon, American Mineralogist, Vol.102, pp. 391-403, 2017.