VIC METEOR-WRONG: AN UNEXPECTED SULFUR/CARBON ROCKET COMPOSITE FALL.
M. Moreno-Ibáñez[1], J. M. Trigo-Rodríguez[1], M. Martínez-Jiménez[1], J. Alonso-Azcárate[2], M. Amblàs[3] and P. Pujols[3]. [1]Minor Bodies and Planetary Science Group, Institute of Space Sciences (CSIC-IEEC). Campus UAB, Carrer de Can Magrans s/n, 08193 Cerdanyola del Vallés, Barcelona, Spain (trigo@ice.csic.es); [2]Universidad de Castilla-La Mancha (UCLM), Campus Fábrica de Armas, 45071 Toledo, Spain. [3]Agrupació Astronòmica d'Osona (AAO), Carrer Pare Xifré 3, 3er. 1a. 08500 Vic, Barcelona, Spain.

Introduction: Satellite and rocket reentries are often characterized by partially fused rocket components, but rarely other surviving products are described. Lately we have noticed in the framework of the SPMN network studies the use of refractory composite materials that can also survive atmospheric entry [1]. On February 2012 an unusual rocket residue felt in the city of Vic (Catalonia, Spain) as a little stone of 28×23×22 cm^3 shown in Fig. 1. This 13 g specimen was reported falling from the sky by a 10 years old girl called N. Benamar. No other eyewitnesses are known, but her report is consistent with a fall. She noticed it was incandescent, but decided to wait there until collecting the sample. Afterwards, she brought the sample to their relatives, and they decided to show it to the representatives of the Museum Episcopal de Vic who suggested the Associació Astronòmica d'Osona (AAO) to find out more details about its origin. Once arrived to the AAO the sample was finally delivered to the Institute of Space Sciences (IEEC-CSIC). Despite that the non-meteoritic nature was clear due to its low density, the sample was so weird and challenging that we decided to study it carefully. It has been preserved, but it was cut in one corner in order to show the interior and create a couple of thin sections for further study. We conclude that this meteor-wrong is mostly a sulfur-carbon composite containing minor abundances of other elements in its "graphitized" interior. This could represent the first description of such type of residue arrived to Earth's surface. Its description has interest because it could be wrongly interpreted as a meteorite.

Figure 1. The Vic specimen (once cut in the upper corner). It has a bright outer layer that reminds a fusion crust, and its interior exhibits mm-sized bubbles.

Methods: The original specimen was cut to create a couple of thin sections and to obtain material for bulk chemical analysis. These were studied using a Zeiss Scope petrographic microscope. The material is opaque and exhibits a fibrous texture (see Fig. 2). The study of the sections allowed us to establish several regions of interest (ROI).

SEM-EDS techniques. We used a FEI Quanta 650 FEG working in low vacuum BSED mode. The EDS detector used to perform elemental analyses is an Inca 250 SSD XMax20 with Peltier cooling with an active area of 20 mm^2. Some selected areas were explored at different magnification, and SEM elemental mapping together with EDS spectra were obtained.

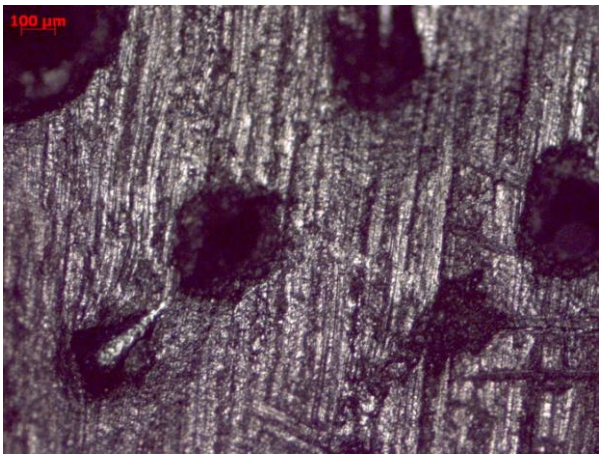

Figure 2. A Vic ROI as seen in RL.

Results: Once the specimen was cut and its interior revealed, it was obvious that the specimen had antropogenic origin because it contained bubbles, and was very different from any known meteorite. Compositionally, a clear confirmation was the clear dominance of C and S and the presence of Si, Mg, Ca, La and V in grains and nodules scattered around the graphitized matrix (see e.g. Fig. 3). EDS provided weight % abundances and a C:S ratio of 10:1 that probably is a reminescense of the original production ratio of the composite [2]. No meteorites are known to be dominated by C and S, because rock forming elements (Si, Mg, O, Ca, etc…) are major components [3-5], and obviously the identified La and V presence identifies Vic specimen as a human product. In any

case, the specimen exhibits a kind of fusion crust probably due to the heating effect during atmospheric deceleration.

Vic bulk composition suggests that the sample is made by a sulfur-carbon composite with minor amounts of other materials probably present in a rocket turbine or in the propellant [2]. Composites have being lately substituting metals and alloys in rockets due to their lower weight and better thermomechanical and isolator properties [1]. The successful application of composite materials for high temperature aerospace applications has resulted in the exploration of cost effective ablative materials that can produce specimens like Vic.

Conclusions: The fall of Vic specimen in 2012 is to our knowledge the first of this class. It opens the possibility of collecting new materials as by-product of the development of new materials in the context of space exploration. This meteor-wrong is mostly formed by a sulfur-carbon composite containing minor abundances of Si, Mg, Ca, O, La and V in grains and nodules trapped in a "graphitized" matrix. Its fall demonstrates that these materials are also falling from near-Earth space, and adopting curious shapes that could be confused as meteorites for non-initiated people.

Acknowledgements: Finantial support from the Spanish Ministry (project AYA2011-26522). We also thank the family of N. Benamar for sharing the specimen for scientific study. SEM-EDS studies were made at the CIN2 (ICN-CSIC) Electron Microscopy Division.

References: [1] Sanoj, P. and Kandasubramanian B. (2014) Journal of Composites, Art.ID. 825607; [2] Wen Z. et al. (2014) *Int. J. Electrochem. Sci.*, 9, 1. [3] Anders E. and Grevesse N. (1989) *GCA*, 53, 197. [4] Lodders K. et al. (2009) Landolt-Börnstein - Group VI Astronomy and Astrophysics Numerical Data and Functional Relationships in Science and Technology Volume. Springer-Verlag, Berlin, 42 p. [5] Brearley A. and Jones R.H. (1998) In Planetary Mate-rials, ed. Papike J.J., Washington, D.C.: Min. Soc. of America, 1-398.

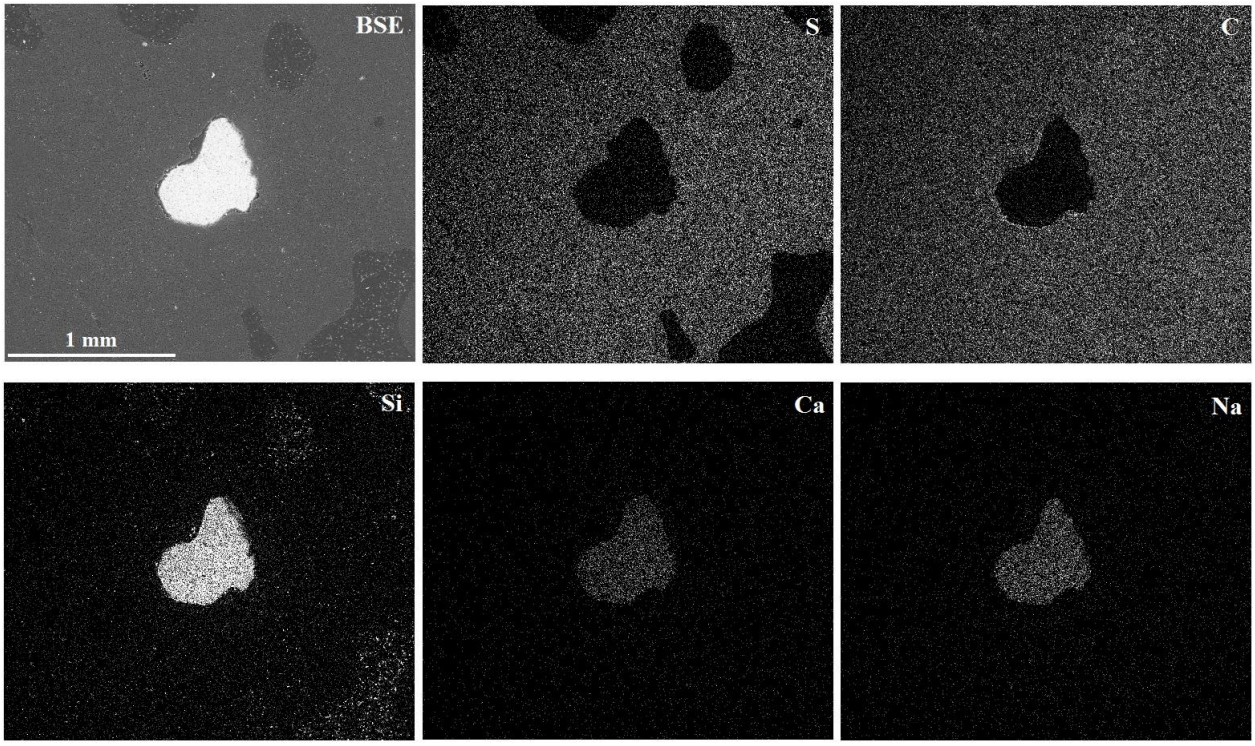

Figure 3. EDS elemental mapping of Vic specimen showing a mm-sized nodule embedded in the sulfur-carbon composite. In the nodule a minor content of Mg, O, and Al was also noticed. In the backscatter electron (BSE) and S images several *dark* bubbles on top and in the lower right corner are noticeable.