UV-VIS REFLECTANCE SPECTROSCOPY OF THE KG 002 SHERGOTTITE. J. Llorca, Institute of Energy Technologies and Center for Research in Nanoengineering, Technical University of Catalonia, Diagonal 647, 08028 Barcelona, Spain. E-mail: jordi.llorca@upc.edu.

Introduction: Mars exploration may benefit from reflectance spectral measurements of small areas of the surfaces of Martian rocks on Mars Exploration Rovers. To that end, reflectance spectral measurements of our Martian meteorite collections –hands-on samples of Mars– are required to better constrain spectral features vs. mineralogical data relationships. Here, the UV-visible spectra recorded over several areas of the KG 002 shergottite are reported, which may be useful for both in-situ characterization of Martian rocks by a rover as well as non-destructive laboratory characterization of Martian meteorites. KG 002 is a coarse-grained basaltic shergottite similar to Los Angeles and NWA 2800 and it is the feldspar (maskelynite)-richest rock among the Martian meteorites.

KG 002: Ksar Ghilane 002 (KG 002, 538 g) was recovered in January 2010 in Tunisia [1]. Besides the major phases maskelynite and pyroxene, the rock also contains Fe-rich olivine, Ca-phosphates (merrillite and Cl-apatite), silica (and/or SiO_2-normative K-rich glass), amorphous K-feldspar, pyrrhotite, Ti-magnetite, ilmenite, and baddeleyite as minor or accessory mineral constituents [2]. A typical feature of KG 002 is the high abundance of symplectitic areas composed of fine-grained intergrowths of fayalite, Ca-pyroxene, and a silica phase, which may have formed by the breakdown of pyroxferroite at low pressure during slow cooling. It should be noted that the symplectites in KG 002 (up to 2 mm in apparent size) are larger than in other Martian meteorites indicating that the pyroxferroite crystals had to be very large prior to their breakdown [3]. As observed for most of the shergottites, all plagioclase in KG 002 has been transformed to maskelynite by shock indicating a shock stage of S5. The shock event producing this conversion is probably also responsible for the formation of impact melt patches of variable chemical compositions and He-loss in the bulk rock [2].

Major element concentrations clearly indicate the basaltic composition of the rock. Ksar Ghilane 002 has CaO- and Al_2O_3-concentrations higher than that of other shergottites, consistent with the highest modal feldspar abundance among these rocks [2]. Considering the REEs, KG 002 has a similar pattern as Los Angeles showing a slight relative depletion of the light REE, however the concentrations are about a factor of two lower than those in Los Angeles. There is a small positive Eu-anomaly of KG 002, which may indicate a complex magma genesis and might be explained by abundant plagioclase accumulation.

The noble gas data suggest that gases with a composition inferred to be typical for the Martian interior (possibly mantle) dominate the inventory of trapped noble gases [4]. In addition, there may be some influence from elementally fractionated atmosphere. Although KG 002 does not represent a mantle rock, the source region of the magma (carrying the noble gas isotope signature) might thus be within the mantle. The apparent crystallization ages are within the previously reported range for shergottites (~100-600 Ma), and may result from resetting events. In terms of a comparison with Los Angeles, whilst differences in gas concentrations and isotopic ratios have been observed, the similar apparent crystallization age/resetting event and strong resemblance in CRE ages may provide evidence for a launch-pairing, which may have happened ~3.0 Ma ago [2].

The magnetic phase composition (and magnetic behavior) and Mössbauer spectroscopy of KG 002, Los Angeles and NWA 2800 is nearly identical and at odds to the other basaltic shergottites, thus providing further evidence that KG 002, LA 001/002 and NWA 2800 can be seen as launch paired (clons) [5].

UV-vis: The spectral data was collected with a Shimadzu UV3600 spectrometer equipped with an integrating sphere at the Center for Research in Nanoengineering of the Technical University of Catalonia–BarcelonaTECH. For calibration of the detector a standard baseline was created using $BaSO_4$ as substrate, which provided a 100% reflectance signal better than 1σ along the spectral range analyzed.

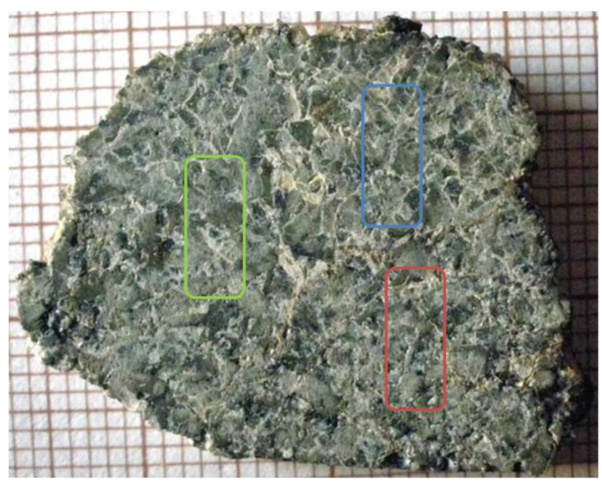

Figure 1. Slice of the KG 002 shergottite used for the spectral measurements (the squares measure 1 mm^2).

Figure 1 shows the slice of KG 002 used for the measurements. Three areas were selected (slot of ~1×0.6 cm^2). Their corresponding UV-visible spectra are shown in Figure 2.

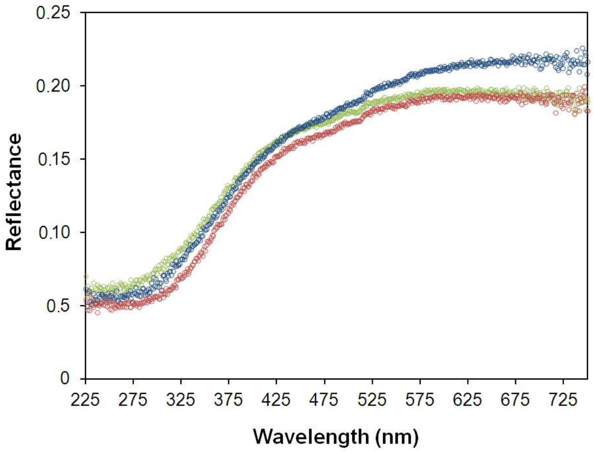

Figure 2. Spectra of KG 002 recorded over the three areas shown in Fig. 1 (the color of each spectrum corresponds to that of the area shown in Fig. 1.

The spectra are quite similar and are characterized by having two major reflectance bands centered at about 430 and 650 nm. These spectral features correspond well to that of pyroxene. There is no additional reflectance bands at about 400 and 550 nm, which might indicate the presence of olivine. This is in accordance to the modal abundance of major phases calculated from EPMA analyses of KG 002 (vol %): 51.7% maskelynite, 2.6% silica, 36.7% pyroxene, 4.5% Fa-rich olivine, 3.4% Ca-phosphates, 0.3% pyrrhotite, and 0.8% oxides [2]. Therefore, the main signatures in the UV-vis spectrum of KG 002 correspond well to the abundant pyroxene phase, whereas the small amount of olivine in the meteorite cannot be detected.

The pyroxenes in KG 002 are strongly zoned and typically crossed by numerous cracks (Figure 3). Their compositions range from $Fs_{26-96}En_{3-50}Wo_{2-41}$, with Mg-rich cores of about $Fs_{29}En_{41}Wo_{30}$ to Fe-rich rims of about $Fs_{68}En_{14}Wo_{18}$ [2]. However, the spectral analysis cannot resolve compositions and modal abundances of different types of pyroxenes and the presence of a significant amount of maskelynite. For that reason, spectral measurements in the near to mid-IR are in progress, which are more sensitive to the composition of mafic minerals.

Concerning the differences among the three reflectance spectra recorded over different parts of the KG 002 shergottite, they likely reflect different mineral modal distributions of the selected slots. In addition to maskelynite and pyroxene crystals, approximately 10-15 vol% of the KG 002 shergottite consists of 50 µm to 2 mm wide symplectite patches of a fine-grained vermicular to microgranulitic intergrowth of fayalite, Ca-pyroxene, and silica in ~2:2:1 proportion [2]. They could be responsible for the differences observed in the high wavelength (525-750 nm) part of the spectra (Figure 2).

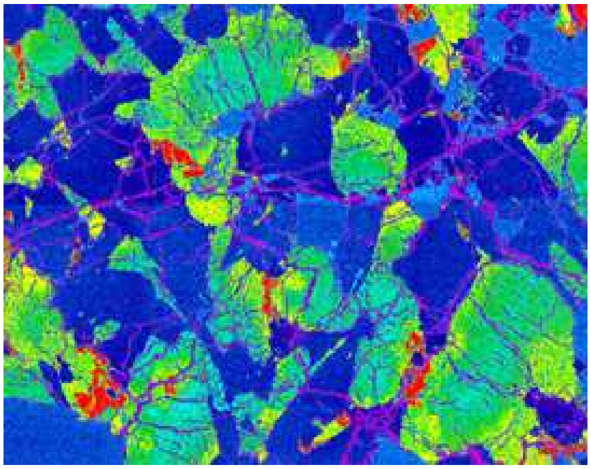

Figure 3. SEM composite image of KG 002. Dark blue corresponds to maskelynite, yellow to Fe-rich pyroxene and green to Mg-rich pyroxenes.

References: [1] Llorca J. et al. (2013) *LPS XLIV*, Abstract #1404. [2] Llorca J. et al. (2013) *Meteoritics & Planet. Sci., 48*, 493-513. [3] Roszjar J. et al. (2012) *LPS XLIII*, Abstract #1780. [4] Cartwright J. A. et al. (2012) *LPS XLIII*, Abstract #1213. [5] Hoffman V. H. et al. (2012) *75th Met. Soc. Conf.*, Abstract #5107.