KSAR GHILANE 002 (KG 002) - A NEW SHERGOTTITE: DISCOVERY, MINERALOGY, CHEMISTRY AND OXYGEN ISOTOPES. J. Roszjar[1], A. Bischoff[1], J. Llorca[2], and A. Pack[3], [1]Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany, j_rosz01@uni-muenster.de, [2]Institut de Tècniques Energètiques, Universitat Politècnica de Catalunya, Diagonal 647, ed. ETSEIB, 08028 Barcelona, Spain, [3]Geowissenschaftliches Zentrum, Universität Göttingen, Goldschmidtstrasse 1, 37077 Göttingen, Germany.

Introduction: Ksar Ghilane (KG) 002 is the 100st known Martian meteorite and the first discovered in the Ksar Ghilane recovery area, Tunisia (January, 2010; Fig. 1a). Here we report on the mineralogy, bulk chemistry and oxygen isotope characteristics of this basaltic rock, which is in many respects strikingly similar to the highly evolved Martian meteorites Los Angeles and Northwest Africa (NWA) 2800.

Methods: Detailed petrologic and chemical investigations of KG 002 were carried out by optical and electron microscopy on four different thin sections using a JEOL 6610-LV SEM equipped with energy dispersive spectrometers (EDS), a JEOL JXA 8900 Superprobe EPMA at WWU Münster, Germany, and a Zeiss Neon 40 field emission SEM equipped with EDS at Universitat Politècnica de Catalunya, Spain. The modal mineral abundance (Table 1) of KG 002 was obtained by quantitative EPMA grid analysis. A 2.065 g fragment from the interior of the meteorite was finely ground using an agate mortar and pestle and four aliquots of 79.94, 77.79, 61.94 and 58.01 mg were finally used for bulk chemical analyses. An acid digestion treatment in a sealed Teflon reactor and an alkaline fusion in a zirconium crucible were used. Bulk rock analyses were performed by means of inductively coupled plasma-mass spectrometry (ICP-MS) using a Perkin Elmer Elan 6000 instrument and inductively coupled plasma-optical emission spectroscopy (ICP-OES) performed on a Perkin Elmer Optima 3200 RL instrument (Barcelona). The oxygen isotope composition was analyzed by means of laser fluorination in combination with gas chromatography continuous flow isotope ratio monitoring mass spectrometry (GC-CF-irmMS) at the University of Göttingen. Approximately 1 mg of bulk powder was loaded, along with terrestrial MORB glass ($\delta^{18}O$ = +5.6 ‰) and NBS-28 quartz ($\delta^{18}O$ = +9.6 ‰) standards.

Results and Discussion: Ksar Ghilane 002 is a single stone, weighing 538 g (Fig.1b). The surface of the meteorite has been subjected to weathering, resulting in the removal of the majority of the fusion crust. It is a coarse-grained basaltic shergottite (Fig. 1c,d), mainly composed of maskelynitized plagioclase (~52 vol%) and pyroxene (~37 vol%). It also contains Fe-rich olivine (~4.5 vol%), large Ca-phosphates, including merrillites and Cl-apatites (~3.4 vol%), minor amounts of silica or SiO_2-normative K-rich glass, pyrrhotite, Ti-magnetite, ilmenite, and accessory baddeleyite.

Table 1. Modal abundance of major phases (vol%).

	KG 002	Los Angeles			NWA 2800
		[1]	[1]	[2]	[3]
Plagioclase (maskelynite)	51.7	43.6	44.8	45.0	47
Pyroxene	36.7	37.7	43.7	41.6	39
Silica (or SiO_2-normative, often K-rich areas)	2.6	4.9	2.4	2.7	2
Fa-rich olivine	4.5	4.2	1.9	1.9	
K-feldspar (or glass)	-	2.4	1.6	3.7	
Ca-phosphates	3.4	2.7	2.4	2.3	
Pyrrhotite	0.3	0.7	0.6	-	
Oxides	0.8	3.7	2.4	1.7	2

The largest crystals of pyroxene and plagioclase in KG 002 reach sizes of ~4 mm and ~5 mm (Fig. 1d), exceeding those of most other basaltic shergottites including Los Angeles, e.g. [4], except for NWA 2800 [5]. Pyroxene compositions in KG 002 are $Fs_{26-95}En_{3-50}Wo_{2-41}$. They typically range from cores of about $Fs_{29}En_{41}Wo_{30}$ to rims of about $Fs_{68}En_{14}Wo_{17}$. Most plagioclases (maskelynite) are $Ab_{41-49}An_{39-58}Or_{1-7}$ in composition, but some can be as anorthitic as An_{93}. Olivine mainly occurs within symplectitic intergrowths, in paragenesis with ilmenite, or at neighbouring areas of symplectites. These minerals are Fa_{90-95} in composition. Ksar Ghilane 002 is heavily shocked (S5) as indicated by mosaic extinction of pyroxenes, maskelynitized plagioclase, the occurrence of localized shock melt glass pockets and low He concentration [6]. Two analyses of oxygen isotopes confirm that this rock is a normal member of the shergottite-, nakhlite-, and chassignite- (SNC) suite of meteorites. Mean values of the two analyses are: $\delta^{18}O$ = +5.15 ‰, $\delta^{17}O$ = +3.03 ‰, and $\Delta^{17}O$ = +0.33 ‰. Bulk chemical data also indicate that KG 002 belongs to the main group of basaltic shergottites. Major element contents of KG 002 fall within the range of basaltic shergottites, in accordance with the petrography and mineral chemistry.

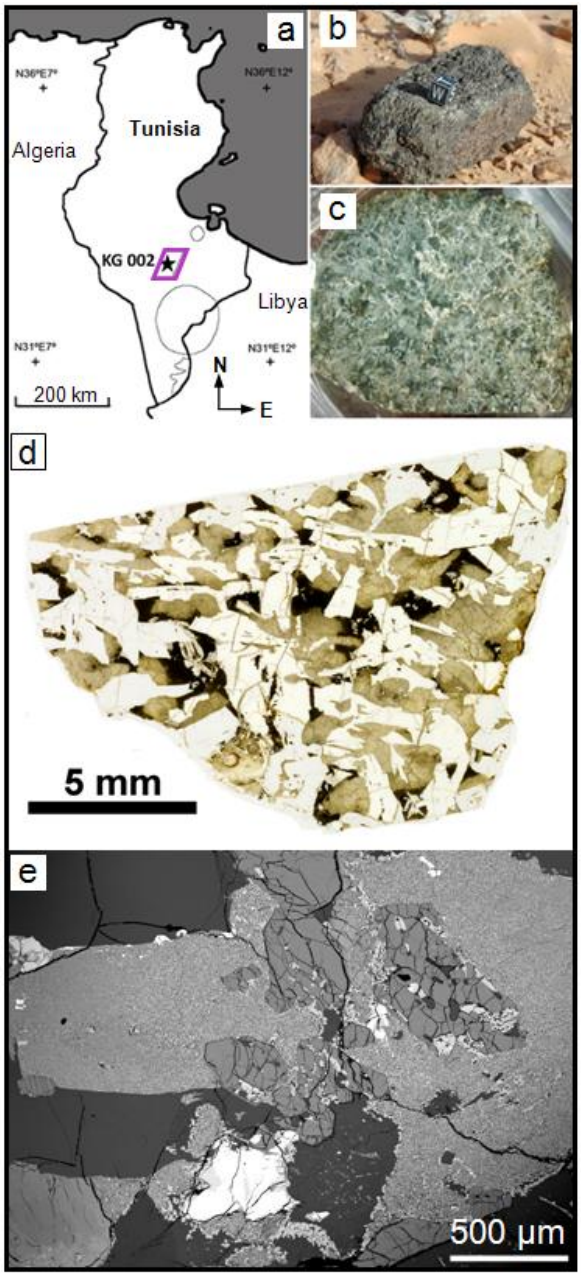

Fig.1 (a) Discovery location of KG 002 in the Ksar Ghilane collection area, Tunisia; **(b)** the KG 002 single stone, 10 × 4.5 × 3.5 cm; weathering effects are seen by removal of the majority of fusion crust; **(c)** sawn surface showing light green pyroxene crystals and abundant maskelynite (clear), view width: ~3 cm; **(d)** photomicrograph of a KG 002 thin section illustrating the coarse-grained basaltic texture, clear = maskelynite, tan = pyroxene, black = symplectite patches and opaques; **(e)** enlarged BSE image of large merrillite grains (medium grey), located in a fine-grained symplectite area surrounded by maskelynite (dark gray) and sulfide (white).

According to the moderate abundances of K (1873 ppm), U (0.16 ppm), Ba (112 ppm), and Sr (109 ppm) and the fresh appearance of sulfides, KG 002 is not significantly weathered, although a positive Ce anomaly is recognized in the rare earth element (REE) pattern. Ksar Ghilane 002 exhibits a REE pattern similar to Los Angeles and other shergottites, slightly depleted in LREE, including the less evolved Zagami and Shergotty meteorites (Fig.2). The occurrence of a pronounced positive Eu anomaly (Eu/Eu*~1.4), similar to the basaltic shergottite Dhofar 378, but in contrast to the highly-evolved Los Angeles shergottite, provides evidence for complex magma genesis and mantle processes on Mars. The compatible trace element abundances (such as Ni, Co, Cr, and Cu) of KG 002 are strikingly similar to those reported for Los Angeles, which in turn are distinct from other basaltic shergottites, thus providing additional evidence for their strong affinity. The positive Ce anomaly (Ce/Ce*~1.2), also seen in the REE pattern of the strongly weathered Dhofar 019 shergottite [7,8], is likely related to terrestrial weathering [9], in accordance with the moderate U, Ba, and Sr enrichments.

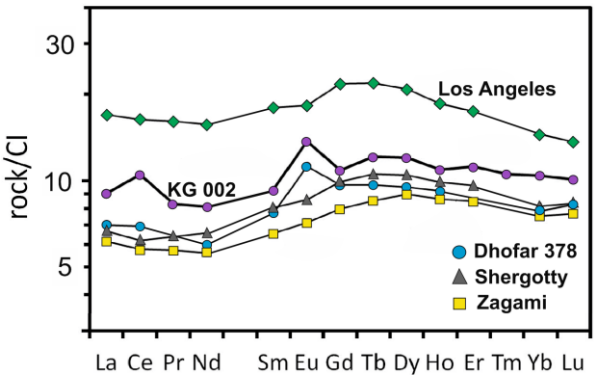

Fig.2 REE pattern of KG 002, relative to other basaltic shergottites. Data sources are [10-12].

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