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Chirfa meteorite: the largest specimen from Mars

The Martian meteorites (MMs) are peculiar igneous rocks distinguished from other achondrite meteorites based on their different petrography, mineralogy, mineral-chemistry, major and trace elements, and isotopic compositions. To date, MMs are classified into three main groups: Shergottites (basalts), Nakhlites (clinopyroxenites), and Chassignite (dunite). In addition, two unique types of meteorites have been found: ALH84001 (orthopyroxenite) and NWA 7034 (and the related pairs) regolith breccias. The basaltic shergottites, the most abundant MMs (about 90% of the total MMs), can be further subdivided into the following subgroups: basaltic (45%), olivine-phyric (30%), poikilitic (18%), gabbroic (5.5%), augite-rich (0.9%) and pigeonite-rich NWA 10414 (0.5%) [1].

In this work, we present the preliminary petrographic results of a new MM found on 18th November 2023 in the Sahara Desert near Chirfa, Niger (coordinate: 21o05'12.72"N, 11o26'07.76''E). It represents the largest individual Martian sample hitherto described in the Meteorite Bulletin database – total weight ⊠ 24.6 Kg.

A centimeter-size fragment has been embedded and polished for petrographic investigations. Backscattered images were acquired by scanning electron microscopy (SEM) at the Centro di Servizi di Microscopia Elettronica e Microanalisi (MEMA) of the Università degli Studi di Firenze, Italy. Quantitative analyses were obtained by electron microprobe (EMPA-WDS) at the same center.

Backscattered images show a coarse-grained texture, with crystals ranging from tens to hundreds of microns, dominated by pyroxene, plagioclase (possibly maskelinite), and olivine. Large elongated prismatic pyroxene (up to 2.1 mm) and olivine (up to 2.5 mm) crystals may also occur. Oxides, phosphates, and sulfides are present as accessory phases. Pyroxenes are subhedral to euhedral (also occurring with a lath-like appearance within plagioclase) and, generally, show low-Ca cores (average En68Fs27Wo5) surrounded by Ca-rich rims (average En49Fe38Wo13), although complex zoning patterns are commonly observed. However, a poikilitic texture containing olivine chadacrysts (⊠100μm) enclosed by pyroxene oikocrysts (mm-size) is also present. Olivine grains are both subhedral and euhedral and generally show normal zoning from the Fo65 core to the Fo34 rim. The Fe/Mn ratio ranges from 50.4 to 55.5 and from 27.8 to 36.3 for olivine and pyroxene grains, respectively. Maskelinite mainly occurs in both lath-like and interstitial textures (⊠15 vol%). The size ranges from ⊠100μm up to 1mm, and the average composition is about An50Ab48Or2. Tiny veins (⊠50 μm in thickness) mainly composed of granular calcite are present.

Olivine gabbroic shergottite are coarse-grained igneous rock predominantly composed of pyroxene, olivine and makelinite. Likewise, the poikilitic shergottites contain poikilitic olivine set in a groundmass of smaller olivine, pyroxene, and maskelinite. Moreover, the olivine gabbroic shergottite, a relatively new shergottite subgroup, has been proposed as link between gabbroic and poikilitic shergottites. The coarse grained and poikilitic texture, and the abundance of maskelinite (>10 vol%) found in the Chirfa meteorite, suggest more affinities to olivine gabbroic shergottite rather than poikilitic, or other shergottite subgroup. In conclusion, we propose that Chirfa meteorite, the larger specimen from Mars, is an olivine gabbroic shergottite. Remain ambiguous the attribution of the grain size affinity – gabbroic or micro gabbroic – in which their use appears ubiquity in the literature data. However, further studies to shed light on the detail attribution are currently in progress.

We believe the argument worthy, and further petrographic, petrologic, and geochemical investigations could improve our understanding of the Martian geological processes.

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