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The Asco meteorite (1805): New petrographic description, chemical data, and classification

Jérôme GATTACCECA[1*], Michèle BOUROT-DENISE[2], Franz BRANDSTAETTER[3], Luigi FOLCO[4], and Pierre ROCHETTE[1]

[1]CEREGE (CNRS/Aix-Marseille Université), Aix-en-Provence, France
[2]MNHN, 61 rue Buffon, 75005 Paris, France
[3]Naturhistorisches Museum, Burgring 7, 1010 Vienna, Austria
[4]Museo Nazionale del'Antartide, Via Laterina 8, 53100 Siena, Italy
[*]Corresponding author. E-mail: gattacceca@cerege.fr

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Abstract–We present magnetic measurements, chemical analyses, and petrographic observations of the poorly studied Asco historical meteorite fall (1805). These new data indicate that this meteorite has been previously misclassified as an L6 ordinary chondrite. Asco is reclassified as an H6 ordinary chondrite with shock stage S3. An interesting feature of this meteorite is the presence of chromite-plagioclase assemblages with variable textures.

INTRODUCTION AND HISTORICAL BACKGROUND

The Asco meteorite fell in November 1805 on the island of Corsica (France). Almost nothing is known about the circumstances of the fall. It is the least-studied of a large number of falls that occurred around the beginning of the 19th century in France (Salles 1798; Saint-Ouen-en-Champagne 1799; L'Aigle; Apt 1803, Alais 1806, Charsonville 1810, Chantonnay; and Toulouse 1812, Agen 1814). It is also the only French fall with no sample left in France. The curated mass totals only 41 g. Despite its small mass, the Asco meteorite can be found in no less than 8 different meteorite collections. According to Partsch (1843), the meteorite was originally kept in a church in the village of Asco, and the first identified owner of the meteorite is the Marquis Etienne-Gilbert de Drée (1760–1848). However, Asco is not listed in the catalogs of the mineralogical and meteorite collection of the Marquis published in 1811 and 1814 (Drée 1811, 1814). So, presumably, Asco became part of de Drée's collection after 1814. There is no clue how the meteorite came into his ownership. Around 1826, de Drée's collection was sold to the famous English mineral dealer John Henry Heuland. In 1838, the main mass of the Asco meteorite was sold to the Royal Cabinet of Mineralogy in Vienna. It is noteworthy that during the second half of the nineteenth century, at a time of fierce competition between a handful of private meteorite collectors, samples of such a small meteorite as Asco went through the major private collections around the globe: R. P. Greg's (London, England), F. von Braun's (Vienna, Austria), J. Siemaschko's (Saint Petersburg, Russia), and H. A. Ward's (Rochester, USA). Eventually, as these private collections were being sold, the samples ended up in the major public collections. Today, main samples are curated in the Natural History Museum in Vienna (17.3 g), the Field Museum in Chicago (9.2 g), and the Natural History Museum in Berlin (6 g).

PETROGRAPHY, CHEMICAL ANALYSIS, AND CLASSIFICATION

The Asco meteorite was classified by Mason (1963) as an L6 chondrite with olivine composition Fa_{25} determined by refractive index measurement. However, magnetic susceptibility measurement performed with a Bartington MS2 instrument yielded $\log\chi = 5.33$ (in 10^{-9} m^3kg^{-1}) for an 8.1 g sample from NHM Vienna, and $\log\chi = 5.27$ for a 2.0 g sample from AMNH New York. These values are clearly outside the expected range for L chondrite falls (4.87 ± 0.10 for 142 meteorites [Rochette et al. 2003]). Indeed, this value is in the expected range for H chondrite falls (5.32 ± 0.10 for 144 meteorites [Rochette et al. 2003]). Electronic microprobe analyses (performed with a Cameca SX100 calibrated with natural standards) of a thin section obtained from the main mass in NHM Vienna indicate an olivine composition 19.9 ± 0.4% Fa (19 analyses), and an orthopyroxene composition 17.7 ± 1.3% Fs (17 analyses). These values are in the upper range but compatible with the values observed in

Table 1. Composition (el. wt%) of metal and sulfide in the Asco meteorite. A dash indicates "below detection limit."

	Kamacite	Taenite	Iron sulfide
No. of analyses	22	7	7
Fe	93.1 ± 0.5	54.9 ± 3.8	63.4 ± 0.1
Ni	6.03 ± 0.22	44.6 ± 3.7	–
Co	0.51 ± 0.03	0.10 ± 0.02	–
S	–	–	37.5 ± 0.0
Total	99.6	99.6	100.9

Table 2. Composition (oxides wt%) of silicates and chromite in the Asco meteorite. A dash indicates "below detection limit."

	Olivine	Pyroxene	Merillite	Plagioclase	Chromite
No. of analyses	19	17	5	15	46
SiO_2	39.5 ± 0.4	56.0 ± 0.8	0.08 ± 0.11	63.2 ± 3.1	–
$A_{p2}O_3$	–	0.18 ± 0.02	–	20.8 ± 2.0	6.76 ± 0.19
TiO_2	–	0.20 ± 0.02	–	0.06 ± 0.02	1.96 ± 0.27
FeO	18.5 ± 0.3	11.9 ± 0.9	0.60 ± 0.17	1.51 ± 2.22	28.7 ± 0.4
Cr_2O_3	0.05 ± 0.06	0.19 ± 0.08	0.08 ± 0.06	0.30 ± 0.48	57.8 ± 0.8
MnO	0.46 ± 0.03	0.53 ± 0.02	–	–	0.91 ± 0.06
MgO	41.8 ± 0.5	30.5 ± 0.3	3.55 ± 0.04	1.12 ± 3.32	3.06 ± 0.15
CaO	–	0.66 ± 0.13	46.3 ± 0.4	2.38 ± 0.30	–
Na_2O	–	–	2.64 ± 0.06	8.71 ± 0.92	–
K_2O	–	–	0.05 ± 0.01	1.06 ± 0.65	–
NiO	–	–	–	0.05 ± 0.09	–
V_2O_3	–	–	–	–	0.70 ± 0.04
P_2O_5	–	–	46.3 ± 0.5	–	–
Total	100.3	100.2	99.6	99.2	99.8
Endmembers	$Fa_{19.9}$	$Fs_{17.7}$–$Wo_{1.3}$		$An_{12.3}$–$Or_{6.5}$	$Chro_{80.6}$–$Sp_{14.2}$–$Ulvö_{5.2}$

H chondrites (Brearley and Jones 1998). Chemical analyses of major mineral phases are displayed in Table 1 (metal and sulfides) and Table 2 (silicates and chromite). The composition of kamacite, and more precisely the Co versus Ni content, points to an H chondrite (Brearley and Jones 1998). Sulfides composition yields an atomic Fe/S ratio of 0.97 indicating that troilite is not perfectly stoichiometric, and that a minor amount of pyrrhotite may also be present. Although the co-existence of small (<500 µm) and large (>500 µm) opaques grains would be compatible with a petrographic type 5 (Bourot-Denise et al. 1997), the relatively coarse-grained granoblastic texture, due to recrystallization and nearly complete obliteration of the chondritic structure, indicate a type 6. The plagioclase grains are up to 100 µm in size and their mean size exceeds 50 µm, confirming a type 6 (Van Schmus and Wood 1967).

Chromite in the Asco meteorite displays a number of different textures (Fig. 1). An interesting feature is the presence of chromite-plagioclase assemblages. Such assemblages have been reported in other ordinary chondrites (e.g., Ramdohr 1967; Rubin 2003). Electronic microprobe (EMP) chemical analyses show that the composition of chromite is identical within and outside the chromite-plagioclase assemblages. However, the relative abundance of plagioclase and chromite within the assemblages is very variable. When chromite is not associated with plagioclase, it consists of sub-automorphic crystals 100 µm in size (Fig. 1a), whereas when it is associated with plagioclase it shows a fine-grained polycrystalline structure. The polycrystallinity is more or less pronounced as shown by the evolution visible in Figs. 1b–e. The presence of chromite-plagioclase assemblage has recently been described as a shock indicator indicating a shock level of at least shock stage S3 (Rubin 2003). The Asco meteorite displays other evidence of shock: across the thin section, several veinlets filled with opaque minerals (mostly sulfides) are visible; silicates and chromite are generally strongly fissured; kamacite grains etched with nital (alcohol + 2% HNO_3) show Neumann bands faulted in places (Fig. 2a); troilite is always strongly fissured and display stress twinning that are usually deformed (Fig. 2b); olivine grains display undulatory extinction and lack mosaicism; almost all olivine grains have planar fractures. Based on these shock features, we propose a shock classification S3 (Stöffler et al. 1991; Bennett and McSween 1996).

CONCLUSION

Magnetic measurements performed on the main mass of the Asco meteorite revealed that this meteorite was a misclassified ordinary chondrite. This is confirmed by EMP chemical analyses. The Asco meteorite is reclassified as an H6 chondrite. Shock features point to a

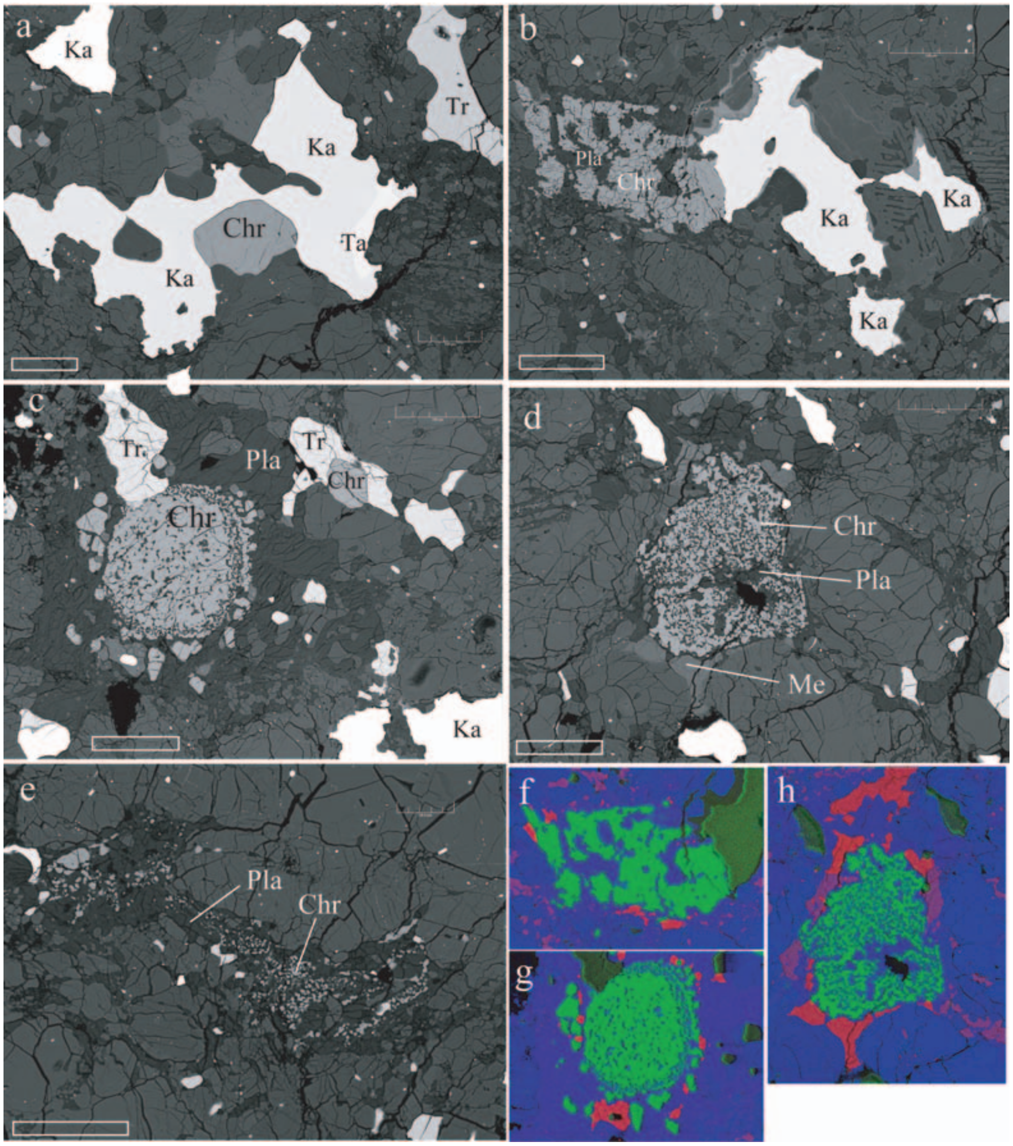

Fig. 1. a–e) Backscattered electron images of chromite-plagioclase assemblages in Asco. Scale bar is 100 µm. Chr = chromite, Pla = plagioclase, Ka = kamacite, Ta = taenite, Tr = troilite, Me = merillite. f–h) Elemental composition map of the chromite-plagioclase asemblages visible in pictures (b), (c), and (d), respectively. Green = Cr (chromite), red = Ca (merillite), blue = Si (silicates), purple = calcic pyroxene.

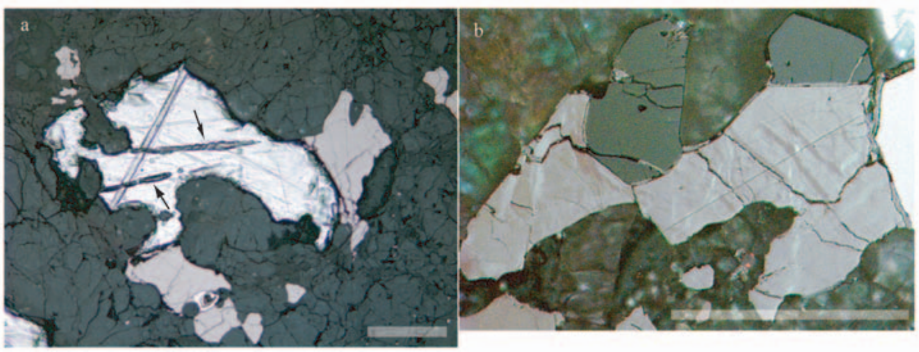

Fig. 2. a) Reflected light optical microscope image of a kamacite grain (etched with nital) exhibiting deformed Neumann bands (arrowed). b) Transmitted and reflected light optical microscope image (crossed nicols) showing troilite grains with shock-induced twinnings. Scale bar is 100 µm in both images.

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