MALOTAS: A NEW VIEW OF AN OLD FALL FROM ARGENTINA

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Introduction: In the morning of June 22nd, 1931, a meteorite fall was reported in the province of Santiago del Estero, Argentina. MALOTAS is the official name given to the type H5 ordinary chondrite as the registered fall 1931, which we have re-investigated with surprising results.

Historical aspects: In 1931 collected rock samples of this recent meteorite fall were given to Professor Juan A. Olsacher from Córdoba University who decided to inspect the fall locality and collect some further pieces. His report [1] indicates that the fall covered an area of 5 x 2.5 km with the main axis having a NE to SE direction in the vicinity of the Dulce River. Therefore many of the individual pieces were likely lost. As the area was covered by a dense forest he was able to collect three pieces only. His studies showed that "*the meteorite is made up of fragments that correspond to two different types based on their composition and structure: one is chondritic, composed by olivine and pyroxene with abundant metallic minerals; the second one is feldspar-rich with scarce presence of the previous components and with an ophitic texture" [1]*. During a visit of the small meteorite collection of the Museo de Mineralogía y Geología Dr. Alfred Stelzner in 2015, one of us (MEV) found that two different stones (a chondrite and an achondrite) were exhibited in the showcase, labeled as "*Malotas, 1931*". After further investigation of the achondritic fragment, the meteorite turned out to be a basaltic eucrite. Below is a description of both rocks.

The eucrite: is an individual, fully encrusted piece weighing 62.4 g. The interior is very fresh covered by a very shiny black fusion crust. Optical and electron microscopic investigations reveal that the sample is a basaltic monomict breccia, mainly consisting of coarse- and fine–grained silicate domains. There are few shock features record by crystals with only some faint undulatory extinction and one melt vein cross-cutting the sample. Microprobe examination of two polished sections reveal very similar silicate compositions for the coarse- and fine-grained lithologies: Low-Ca pyroxene $Fs_{62.5\pm0.8}Wo_{2.23\pm0.9}$, Ca-rich pyroxene $Fs_{26.9\pm0.9}Wo_{43.9\pm1}$, and plagioclase $An_{82.1\pm3.4}$, with minor, secondary anorthitic plagioclase with $An_{95.71\pm2.7}$. Spinel composition is $Chr_{0.74}$-$Her_{0.18}$. Since the Ti contents of spinels in basaltic eucrites seems to be diagnostic of its thermal metamorphic grade [2], variations in the Cr, Al and Ti contents allow a classification as to metamorphic type 4. Trace element compositions of the coarse- and fined-grained lithologies are similar, with REE (~20 × CI), characterized by a flat pattern with a negative Eu anomaly (~15 × CI). This characteristic together with the bulk rock FeO/MgO ratio and La and Sc concentrations, indicate that this meteorite belongs to the group of Stannern-trend eucrites. Replicate analyses of stable oxygen isotopes (in ‰), obtained by laser fluorination revealed values of: $\delta^{17}O$ of 1.785 and 1.775; $\delta^{18}O$ of 3.779 and 3.787; $\Delta^{17}O$ of -0.208 and -0.222. MALOTAS (b) is the official name given to this basaltic eucrite (approved: 4 July, 2018), because this meteorite might be connected to the 1931 fall event according to [1]. However, as there are still some doubts on the pairing of the individual rock fragments, it was approved as a 'find, doubtful fall".

The chondrite: exhibited in the showcase of the museum as Malotas 1931, is an ordinary chondrite with a total mass of 79.4 g. A petrographic study of two thin sections revealed the occurrence of relict fragments and chondrules. Among the latter, barred olivine, radiating pyroxene and porphyritic olivine pyroxene chondrules are the most abundant. The rock has minimal shock features, e.g., faint undulatory extinction and absence of planar fractures. Major element analysis of the main mineral phases are: olivine ($Fa_{24.56}$) and pyroxene ($Fs_{21.17}$; $Wo_{1.47}$), consistent with an L-type classification. This is in conflict with the officially accepted classification of MALOTAS with a chemical composition of olivine Fa_{19}, [3], Co concentration of 1100 µg/g [4], and a magnetic susceptibility of 5.40, consistent with an H-type. Since the main mass of MALOTAS (4712 g) is in the E. Jawerbaum private collection (Buenos Aires), further studies are on the way to compare fragments of MALOTAS to those of the chondrite in the Museo de Mineralogía y Geología of Cordoba. The discovery of these new fragments, provides the opportunity to (re)evaluate the 1931 fall under a different view: Was it a polymict fall?.

Refernces: [1] Olsacher (1931) Imprenta de la Universidad, Cordoba, 1-18; [2] Yamaguchi (2000) *Meteoritics and Planetary Science*, **35**, Suppl. A174; [3] Mason (1963) *Geochimica et Cosmochimica Acta*, **27**, 1011-1023; [4] Ligner et al., (1987) *Geochimica et Cosmochimica Acta*, **51**, 727-739.