ORDINARY CHONDRITE MICROMETEORITES FROM THE KORONIS ASTEROIDS. M. J. Genge.

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Introduction: Micrometeorites (MMs) are large (>25 \(\mu\)m) interplanetary dust particles that survive atmospheric entry to be recovered from the Earth’s surface. Amongst those particles that escaped significant heating during atmospheric entry two groups have been identified [1]: (i) fine-grained MMs (fgMMs), which are similar to the fine-grained matrices of hydrated carbonaceous chondrites (CCs), and (ii) coarse-grained MMs (cgMMs), which are dominated by pyroxene, olivine and/or glass and often have igneous textures.

Some cgMMs have selvages of fine-grained matrix and thus indicate that cgMMs and fgMMs may be derived from the same asteroidal parent bodies [2]. These composite particles suggest that the source objects of cgMMs were small mm-sized objects on their parent asteroids and were, therefore, probably chondrules.

The CC-like nature of fgMMs implies that cgMMs likewise sample a CC-like chondrule population. Numerical models of the delivery of asteroidal dust to Earth, however, suggest that a significant fraction is derived from the S-type Koronis Family asteroids that cannot be CC-like materials [3].

In this study the minor element compositions of olivines, pyroxenes and accessory phases from 77 cgMMs are reported in order to identify their parent body associations. The results indicate that ~70% of cgMMs are derived from an ordinary chondrite (OC) chondrule population. Their parent body is, therefore, most likely to be the Koronis Family asteroids.

Results: Seventy seven Antarctic cgMMs, 50-400 \(\mu\)m in size, were examined in this study. The criteria used to determine the extraterrestrial origin of these particles is given in Genge [1]. Radiate pyroxene cgMMs were excluded since their small grain-sizes preclude analysis of the minor element compositions of their phases.

Two chemical groups are recognized amongst the cgMMs: (1) Type I particles, which contain Mg-rich silicates (<Fs0) and <Fs0 and often contain Fe-Ni metal, and (2) Type II particles, which are dominated by Fe-bearing silicates (<Fs10 and <Fs0) and often include FeNi sulphides and Fe-oxides. Olivines and pyroxenes in Type II cgMMs often exhibit normal zoning and these particles occasionally include enstatite (<Fs8) relics. The bimodal distribution of cgMMs is closely similar to that of chondrules. In this study Type II particles comprise ~50% of the particles.

In addition to FeNi metal and sulphide, Cr-bearing spinel and plagioclase feldspar are the most common accessory phases. Chromium spinels have Cr/(Cr+Al) between 0.59 and 1.0. Plagioclase varies from An11 to An80.

The FeO, MgO, MnO, Cr\(_2\)O\(_3\), CaO, TiO\(_2\) and Al\(_2\)O\(_3\) contents of 250 olivines and pyroxenes and glass within the particles were determined by wave dispersive spectroscopy using an electron microprobe. MnO and Cr\(_2\)O\(_3\) contents of olivine are shown in Fig.1. Minor element compositions fall within the range of those of chondrules from meteorites.

Discussion: The abundance of Type II cgMMs of ~50% observed in this study contrasts with the low abundance of Type II chondrules in CCs and yet is similar to that of OCs. In order to determine whether OC-like chondrule materials are present amongst cgMMs the minor element compositions of their consistent olivine and pyroxene were compared with those of the chondrites.

The affinities of the cgMMs were analysed on the basis of their minor element contents of their olivines and pyroxenes into two categories: (1) unambiguous particles that have minor element contents that fall entirely within the range chondrules from only one chondrite group, and (2) ambiguous particles that have compositions consistent with two or more groups. Nearly half of the cgMMs, including the many of Type II particles, have unambiguous affinities to unequilibrated OCs (UOCs). In the majority their high MnO and low Cr\(_2\)O\(_3\) contents of olivine are most diagnostic of an UOC-affinity (Fig.1). Seven Type II cgMMs also have minor element contents that show an unambiguous affinity to the equilibrated ordinary chondrites (EOCs), owing to their restricted minor element ranges and lower CaO and Cr\(_2\)O\(_3\) contents than UOCs.

Amongst ambiguous particles pyroxene-dominated Type I cgMMs that fall entirely within the range of CM2 Type I chondrules are the most abundant. They form a cluster within the CM2 field, which suggests many are derived from CM2-like chondrules. Fifteen particles also have minor elements that fall within the range of UOCs or CV3 chondrites. Although ambiguous, most of these particles are likely to be of UOC origin since no fgMMs with affinities to CV3 matrix have yet been identified.

All seven particles with EOC-like minor element compositions have homogeneous mineral compositions, and lack interstitial glass. Accessory feldspar and chromite compositions within UOC and EOC par-
particles are likewise compatible with those of UOC and EOC meteorites. The two EOC-like particles containing both olivine and pyroxene have compositions that fall in the range of L4-6 chondrites, whilst the six EOC-like cgMMs that contain only olivine or only pyroxene have both H and L chondrite compositions.

Implications: Models of the delivery of asteroidal dust to Earth suggest that the majority of dust particles are derived from the dust bands associated with the Veritas, Themis and Koronis asteroid families [3,4]. Both Veritas and Themis are C-type asteroids and are, therefore, probably the main parent bodies of the CM2-like cgMMs. The Koronis asteroids are S-type asteroids and could be appropriate parent asteroids for OC-like materials if space weathering is responsible for reddening of their spectra. The discovery that 70% of cgMMs are OC-like, representing ~20% of MMs, therefore, confirms both that S-type asteroids consist of OC-like materials and that space weathering occurs on the surfaces of these bodies.

The dust band associated with the Koronis asteroids has been suggested to relate to the recent break-up (5.82 Ma) of the Karin group of the Koronis Family [4]. The OC-like particles observed in this study, therefore, suggest that the 20 km diameter Karin protogenitor was dominated by UOC materials but also included L and H chondrite EOC materials. Furthermore, the occurrence of hydrated matrix on UOC cgMMs suggests the parent body underwent aqueous alteration.

The presence of materials that have experienced such a wide range of alteration on a single 20 km diameter fragment of the original 100 km diameter Koronis protogenitor is contrary to expectation. It seems more likely, therefore, that the Karin group protogenitor was itself a rubble-pile which sampled very different depths within the original Koronis object.

The occurrence of both H and L chondrite materials amongst EOC-like particles is also contrary to the long held view that different OC groups are derived from different parent bodies. The presence of these materials, however, could simply relate to collisional mixing perhaps during the break-up of either the Karin group or the Koronis Family.

Conclusion: Seventy percent of cgMMs are derived from OC-like parent bodies and include equilibrated and aqueously altered materials. Most of the remaining cgMMs are derived from a CM2-like parent asteroid. Models of the delivery of dust to the Earth suggest that the Koronis Family, and more specifically the Karin group, is the parent body of present day OC-dust recovered from the surface of the Earth.