A STRANGER IN THE MIDST: SEARCHING FOR RELICT GRAINS FROM RARE METEORITE TYPES IN MID-ORDOVICIAN LIMESTONE STRATA.

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Introduction: In the Middle Ordovician period the flux of cosmic material to Earth was dramatically increased, following the breakup of the L-chondrite parent body in the Main Asteroid Belt [1-4]. Globally, abundant meteorites and micrometeorites settled in the sediments on the sea floor. The Komstad Limestone Formation in Killeröd, Scania, contains an interval exceptionally rich in L-chondritic chromite grains indicating a very high degree of condensation [1,2]. The interval also has very low amounts of terrestrial chrome spinels. This facilitates the search for chromite from other, more rare types of meteorites, including, for example, lunar meteorites potentially ejected by impacts of L-chondritic asteroids on the Moon. Particularly interesting is also to look for grains similar to those from the recently discovered fossil meteorite Österplana 065 (Öst 065) at Kinnekulle [5,6]. This meteorite, also referred to as the mysterious object, belongs to a previously unknown group of meteorites that has not been recorded among the meteorite finds on Earth today. Based on a cosmic-ray exposure age for Öst 065 similar to coexisting abundant fossil L chondrites, Öst 065 may be a fragment of the body that hit and disrupted the L-chondrite parent body.

Materials and methods: One hundred kilograms of the thin interval (9.71-9.84 m in [2]) of the Komstad Limestone from the Killeröd quarry were dissolved in HCl and HF acids. The residue was sieved and chromite grains were picked from the size-fraction 63-355 µm. The grains were embedded in epoxy, polished with 1 µm diamond paste and analyzed with SEM-EDS for chemical composition. Based on their chemistry the grains were divided into extraterrestrial (equilibrated ordinary chondritic) chromite (EC) grains and other chrome-spinel (OC) grains [1]. Molar ratios, mainly Cr/(Cr+Al) and $Fe^{2+}/(Mg+Fe^{2+})$, were calculated for all grains to further distinguish between terrestrial and extraterrestrial spinels [7].

Results and discussion: In the 100 kg of rock 507 EC grains (4.95 grains/kg) and 17 OC grains (0.17 grains/kg) were found. Based on the chemical affinity of the grains they were further divided into subcategories. The average chemical composition of the EC grains plot within the range of L chondrites. This is consistent with the results of Heck et al. [8] who based on oxygen three-isotopic analyses of 120 mid-Ordovician, post-breakup EC grains found that >99% of the grains are L-chondritic. Six of the grains in the present study contain nickel, which is interpreted to represent chromite that resided in the fusion crust of micrometeorites. Three of the nickel-bearing grains are classified as OC but are most likely partially melted EC grains. No typical lunar chrome spinel grains were discovered. Twelve of the OC grains are terrestrial, and have similar composition to chrome spinel from igneous ultramafic and mafic rocks from subduction regimes [7]. One OC grain, however, deviates in its composition from both terrestrial and chondritic chromite, but has an elemental composition similar to that of chrome spinel grains from Öst 065. This single OC grain falls within the ranges of Öst 065 grains in all oxides except for a smaller amount of FeO. The Cr/(Cr+Al) and $Fe^{2+}/(Mg+Fe^{2+})$ ratios are also similar to that of Öst 065. A second OC grain has similar ratios, but deviates in more than one oxide. The Öst 065 meteorite represents one of ca. 100 fossil meteorites found at Kinnekulle, with all the others being L-chondrites [6]. Finding one or two grains similar in composition to the chrome spinel grains of the Öst 065 type among 507 EC grains supports the notion that meteorites of this type represented on the order of one percent of the meteorite flux to Earth in the mid-Ordovician. We stress, however, that oxygen three-isotopic analyses of the two grains are required in order to ascertain their affinity to the Öst 065 type of extraterrestrial material.

Conclusion: The present study in combination with the oxygen isotopic results for 120 EC grains of Heck et al. [8] show that 99% or more of the micrometeorites that fell on the sea floor within one million years after the L-chondrite breakup were L chondrites.

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