AN INVESTIGATION OF THE CARBON IN DIFFERENT LITHOLOGIES OF ZAGAMI;
I.P. Wright, C.T. Pillinger, Dept. of Earth Sciences, Open University, Walton Hall, Milton Keynes MK7 6AA, and Monica M. Grady, Dept. of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, U.K.

A consortium has recently been established (1) to study the chemical and mineralogical aspects of the coarse- (0.36 mm) and fine-grained (0.24 mm) lithologies of the Zagami shergottite (2). In light of the information already gained from studying the inventory of carbon in different lithologies of another shergottite, EETA 79001 (3,4), it was considered appropriate to investigate the carbon present in the separate grain size fractions of Zagami. Although the carbon content and isotopic composition of Zagami have been determined previously (5,6) the data were acquired for an unspecified piece of bulk meteorite of unknown lithology. Since Zagami has been subjected to shock pressures of ca. 30 GPa (7), resulting in glassy veins in the fine-grained portion of the meteorite and pockets of shock-melt in both lithologies, it was anticipated that martian atmospheric gases may have become trapped to varying degrees within the two different grain size fractions.

Analyses of an element such as carbon in achondritic meteorites is fraught with difficulty, not least of all since relatively small amounts of terrestrial contamination can effectively obscure any indigenous components. Contamination can take on many forms, although it is most frequently measured by the input of extraneous organic/biogenic materials during handling etc. Compared to other shergottites, Zagami is a fairly recent fall (1962) limiting the time-scale over which organic contamination could have occurred. Furthermore, meteorites collected in recent times have generally been more sympathetically treated. It is already known from the work of Wright et al. (6) that bulk Zagami contains ca. 300 ppm carbon, which represents the lowest carbon content of any non-Antarctic SNC meteorite. While 85%, or more, of this carbon is probably terrestrial organic contamination, Zagami is still one of the most suitable samples available for studying the carbon chemistry of SNC meteorites.

Excess carbon in achondritic meteorites can arise from sources other than organic materials. Indeed, part of the handling protocol used previously in our laboratory (crushing samples in a stainless steel pestle and mortar) is a potential source. The consortium samples received from the University of New Mexico for the current study were cubic pieces, separated from the main mass by sawing, which is useful since the meteorite is not simply fractured along lines of weakness, i.e. prone to the effects of terrestrial contamination and weathering. However, sawing leads to problems for light element analysis, since the implements used to cut the rock invariably contain carbon (e.g. diamond-coated band saw blades, carbon steel etc.). In order to reduce the risk of saw blade contamination, the Zagami samples received from New Mexico were fragmented prior to analysis in an agate pestle and mortar. Individual, mm-sized chunks of material free from cut-faces were then selected for stepped combustion analysis to provide the carbon content and stable isotopic composition of Zagami fine and coarse lithologies shown in the figure.

The coarse-grained sample contains 299.3 ppm carbon, which is comparable with results obtained previously from bulk Zagami (299.7, 324.5 ppm). The fine-grained sample appears to contain more carbon (470.1 ppm). In both the fine- and coarse-grained samples the majority of the carbon combusts below 500°C, implying terrestrial organic contamination. Notwithstanding this contamination, both samples show some evidence for 13C-rich carbonates. The highest δ13C values measured in each experiment occur at 450-500°C (δ13C = -11.0‰, fine; -16.2‰, coarse). Corroboration of the presence of carbonates is usually given by acid-dissolution extractions. Unfortunately, in the case of the Zagami samples, although CO2 was released during acid-dissolution, the isotopic data were compromised due to the presence within the mass spectrometer
of interfering gas species. Considering only the yield data, the fine and coarse samples of Zagami could contain up to 27.0 and 19.2 ppm carbon as carbonate respectively.

By analogy with analyses of other SNC meteorites, the carbon which is released on combustion above 600°C is regarded as indigenous to Zagami. It is presumably mainly magmatic carbon, trapped along grain boundaries and within silicate grains, burning when the minerals are sufficiently plastic to allow exposure of the carbon to oxygen. The release profiles for the two samples are quite similar, if that of the coarse sample is displaced by 100°C to lower temperatures. A shift in release temperature might compensate for the differing grain sizes of the two samples. The isotopic composition ($\delta^{13}$C ca. $-24 \pm 1\%$) is consistent with previous measurements of magmatic carbon in shergottites (6). However, both samples contain surprisingly high amounts of carbon (69.7 ppm (fine) and 83.5 ppm (coarse), compared to 34.7 and 30.5 ppm for previous analyses of bulk Zagami). Indeed, the figure for the coarse fraction is the highest measured of any SNC meteorite. There is little evidence in the whole-rock meteorites analysed for the release of trapped martian atmospheric species at high temperatures from the glass component: although there is an increase in the yield of carbon above 1200°C, there is no concomitant increase in $\delta^{13}$C, implying that if trapped atmospheric species are present, their isotopic signature is obscured by the abundant magmatic carbon. This same effect is observed in EETA 79001 (6), a shergottite in which trapped CO$_2$ is concentrated in a glass fraction, Lithology C. Preparation of glass separates from both coarse and fine fractions of Zagami for isotopic analysis is currently under way.