MINERALOGY OF ARTIFICIALLY HEATED CARBONACEOUS CHONDRITES

M.E. Zolensky[1], M.E. Lipschutz[2] and T. Hiroi[1]; [1]NASA Johnson Space Center, Houston, TX 77058; [2]Dept. Chemistry, Purdue University, West Lafayette, IN 47907.

Abstract: We have examined suites of heated Murchison (CM2) and Allende (CV3) samples heated in the range 400-1200°C, in a H_2 atmosphere with a pressure of 10^{-5} bar for periods of 1 to 4 weeks. We used a combination of X-ray diffraction, electron microprobe and TEM analyses to determine the mineralogy of these samples.

Introduction: Several carbonaceous (C) chondrites have been discovered which exhibit evidence of having undergone aqueous alteration followed by a parent body heating event, possibly related to the former process [1]. Our understanding of these heating events is limited by a paucity of information concerning the compositional and mineralogical effects of C-chondrite heating under different environmental conditions. Thus, we have been characterizing suites of C chondrites subjected to laboratory heating under plausible parent body conditions. To date we have examined Murchison (CM2) and Allende (CV3), which together represent the most abundant types of C chondrites. Both suites have been heated in the range 400-1200°C, in a H_2 atmosphere with a pressure of 10^{-5} bar for periods of 1 to 4 weeks. We used a combination of X-ray diffraction, electron microprobe and TEM analyses to determine the mineralogy of these samples. This abstract complements another in this volume which describes the mineralogy of the Murchison samples as determined by Mössbauer spectroscopy [2], and earlier work on their reflectance spectroscopy [3]. Akai has been performing complementary heating experiments on samples maintained in a vacuum [4].

Murchison The CM2 chondrites experienced extensive aqueous alteration, and they typically consist predominantly of phyllosilicates (serpentines ± chlorite), tochilinite, olivine, glass, pyrrhotite and minor pyroxene and Fe-Ni metal. Olivine and orthopyroxene compositions huddle around Fo_{99} and En_{99} (see Fig. 1). We observed the following mineralogical changes in heated Murchison samples (although we examined samples at 100°C steps, only the most interesting changes are noted here).

400°C: Well-crystalline serpentine is now a minor phase; some has been replaced by a poorly crystalline, so-called "intermediate phase" [4]. Tochilinite has been destroyed, some pyrrhotite has been replaced by Fe-sulfate. Olivine is still a minor component of matrix.

500°C: Serpentines are entirely replaced by the intermediate phase.

600°C: Recrystallization (and coarsening) of matrix and chondrule rims is evident.

700°C: The abundance of Fe-Ni metal in the matrix has substantially increased.

800°C: The intermediate phase has now been replaced entirely by olivine. Olivine, now the most abundant mineral (including matrix), has a heterogeneous composition, with a greatly reduced population peak at Fo_{99}; likewise orthopyroxene.

1000°C: Olivine compositions are evenly distributed between Fo_{99}-Fo_{50}; likewise for orthopyroxene. Chondrules are beginning to recrystallize. Matrix olivines and Fe-Ni metal grains continue to coarsen.

Allende The CV3 chondrites experienced minimal aqueous alteration (compared to the CMs), and they typically consist predominantly of olivine, with minor pyrrhotite and/or troilite, pyroxene, Fe-Ni metal, saponite, glass and refractory phases in CAIs. Olivine and orthopyroxene compositions bunch around Fo_{55} and En_{55} (see Fig. 1). The mineralogical changes in heated Allende samples were not as dramatic as those observed in Murchison, until 1200°C. The major observed mineralogical effect (until 1200°C) was a progressive increase in the amount of Fe in olivine, beginning at grain rims and spreading core-ward with increasing temperature, which suggests that the Fe was acquired from matrix phases.

800°C: All olivines have Fe-rich rims; no olivines are observed to be more Mg-rich than Fo_{92}.

1000°C: Fe-Ni metal grains are very abundant in matrix. Chondrules are beginning to recrystallize.

1200°C: The meteorite has completely recrystallized to coarse-grained olivine (Fo_{64-67}), with interstitial augite, chromite, Fe-Ni metal and rare FeS. Large vesicles are evident, presumably from the volatilization of S.

These mineralogical data are being compared to those for naturally heated C chondrites. We are also examining the mineralogy of the Allende samples by Mössbauer spectroscopy, and collecting their optical reflectance spectra. These latter results will then be compared to optical reflectance data of asteroids, in an effort to better understand their evolution.

References: [1] Ikeda (1992) *NIPR Symp. 5*, 49; [2] Morris et al. (1994) *LPSCXXV*, this volume; [3] Hiroi et al. (1993) *Science 261*, 1016; Akai (1992) *NIPR Symp. 5*, 120.

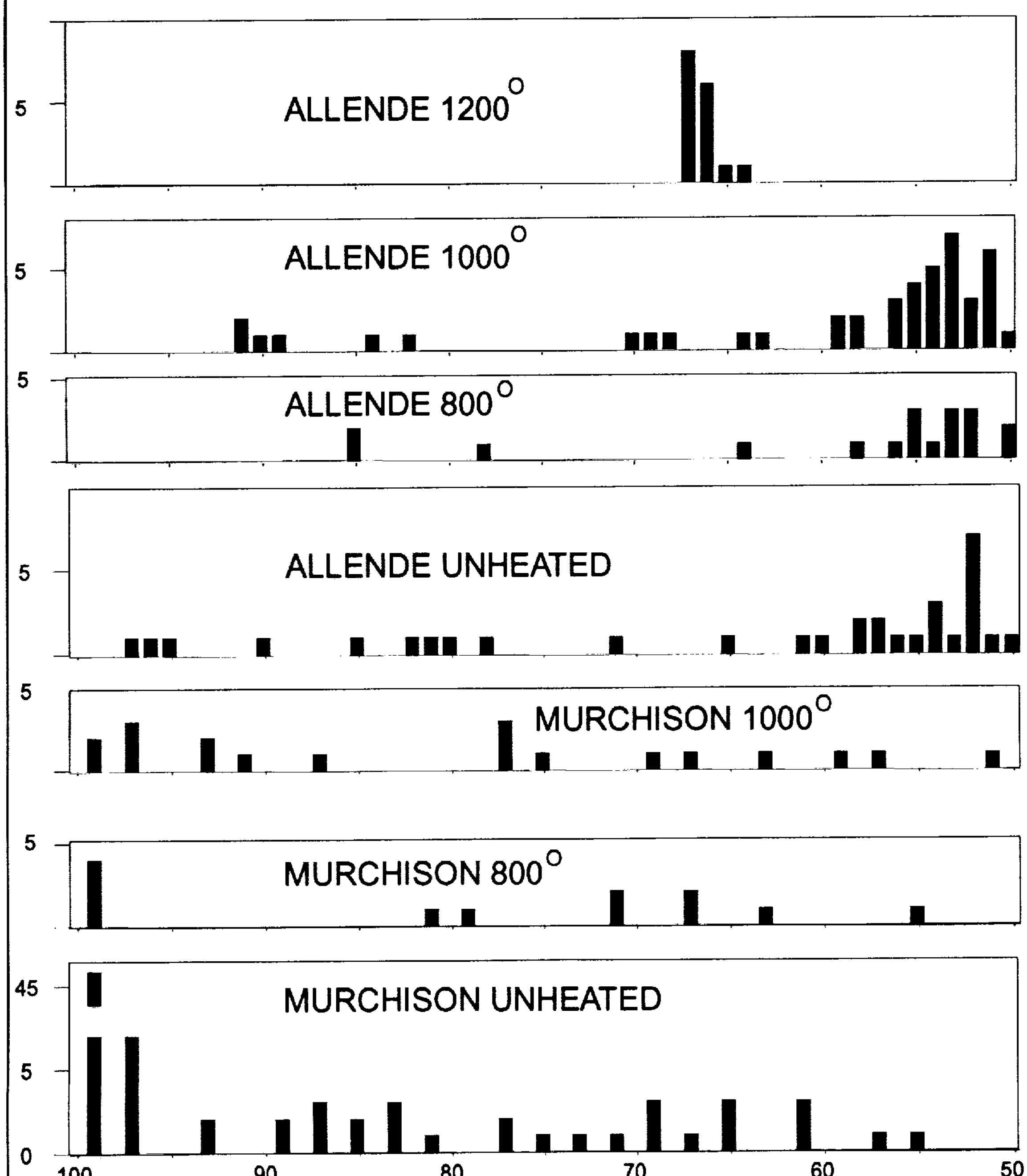

Figure 1. Olivine analyses from unheated and heated samples of Murchison and Allende. Note the height of the Fo_{99} peak for unheated Murchison, which is shown here in a greatly abbreviated fashion.