SHOCK AND ANNEALING IN EL CHONDrites.

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Shock has affected the structure, texture and mineralogy of EL chondrites of all petrologic types. **EL3**: Shock stages range from S2-S5; many samples are foliated. Impact deformation caused foliations in OC [1]; it is likely that EL3 foliations also formed by impact. Extensive shock melting is precluded by the presence of excess $^{53}$Cr in EL3 sphalerite [2]. **EL4**: The three rocks I studied are impact-melt breccias (IMBs) of shock-stage S2. QUE 94368 contains euhedral enstatite grains protruding into kamacite and euhedral graphite laths surrounded by metal and silicate; these features are characteristic of enstatite-chondrite IMBs (e.g., EH Abee [3]). QUE94368 contains euhedral grains of sinoite (Si$_2$N$_2$O) that probably crystallized from the melt [4]. Grein 002, which was partly impact melted, contains euhedral grains of enstatite, graphite and sinoite [5]. MAC02747 contains euhedral grains of enstatite and graphite. **EL5-EL6**: Nearly all of these rocks are S2, but many EL6 chondrites have features suggesting much higher shock levels at an earlier period. Blithfield is a chondrule-free IMB with large sulfide-rich, kamacite-poor clasts, a metal-rich matrix, and cm-size metal veins. Hvittis is a fragmental breccia with impact-melt-rock clasts. Atlanta contains a sulfide-rich, kamacite-poor clast and cm-long metal veins. NWA 2213 has euhedral grains of enstatite and graphite, kamacite grains with small troilite blebs, and troilite grains with small kamacite blebs. Forrest 033, GRO95626 and QUE97462 contain euhedral grains of enstatite and graphite. Other EL6 chondrites also contain euhedral enstatite grains. Euhedral grains of sinoite occur in Forrest 033, Hvittis, Jajh de Kt Lalu, Pillister, Ufana, Yilmia, ALHA81021, LEW88714, EET90102 and Neuschwanstein. Diopside is present in EL3 MAC88136 [6], EL4 Grein 002 [5], EL6 EET90102 [7] and EL6 NWA 2213. Diopside is probably a primary phase in EL3 chondrites. In EL4-6 chondrites, diopside may have formed by reaction of oldhamite and enstatite at high temperatures followed by quenching [7]. The brecciated and melted textures of some EL6 chondrites and textural and mineralogical similarities to the impact-melted portions of EL4 chondrites (including the presence of sinoite, diopside, euhedral enstatite and euhedral graphite) suggest that at least some EL6 chondrites are annealed IMBs. The EL4-6 chondrites may have formed from EL3 chondrites by variable degrees of impact heating, burial beneath insulating regolith material, and annealing. Annealing in the EL4-6 chondrites erased shock effects in pyroxene, producing grains with sharp optical extinction. Subsequent impacts caused undulose extinction to develop in pyroxene, changing the rocks’ shock-classifications to stage S2. It is unclear to what extent the decay of short-lived radionuclides contributed to EL-chondrite metamorphism. About 60% of EL6 chondrites have similar $^{21}$Ne CRE ages (27±6 Ma) [8,9] suggesting that these rocks were in the same location on their parent asteroid and likely experienced similar shock and thermal histories.