EFFECTS OF ARTIFICIAL SHOCK ON ARGON RETENTION IN AN ORDINARY CHONDRITE.
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Experiments were conducted to examine the effects of various levels of artificial shock on the distribution and retention of radiogenic argon in the Leedey L-6 chondrite. Many naturally shocked materials have suffered Ar loss and redistribution which, it has been generally assumed, was due to post-shock thermal heating rather than shock itself. Artificial shock experiments can minimize post-shock heating and examine the effects of shock alone. However, two previous experiments on the effects of artificial shock on Ar redistribution in geological materials (1,2) demonstrated that atmospheric Ar absorbed on the samples can be strongly implanted and can mask radiogenic Ar. Neither of these experiments demonstrated any obvious redistribution of radiogenic Ar or K for shock pressures up to 2.7 GPa.

The Leedey chondrite was selected because it was sufficiently coherent that many thin sample disks (7mm dia. and 0.6mm thick) could be cored from it. Individual disks were loaded into the target wells of custom-machined, stainless steel sample holders in a dry nitrogen atmosphere. Each entire target assembly was placed in a vacuum chamber and repeatedly flushed with CO/CO2, then evacuated to a pressure of $10^{-6}$ torr in the inner target chamber and $10^{-2}$ torr in the outer impact chamber. A cylindrical plastic slug with a metal flyer plate in front is launched in a 20mm gun barrel and impacts the sample holder to create a shock wave. Pressures generated in the target are deduced from the measured impact velocity and from previously determined Hugoniot equations of the state (e.g., see 3). Pressure accuracy is ± 5%; peak pressure duration is < 1μsec.

Sample disks were shocked to four pressures: 29, 41, 45, and 69 GPa (1 GPa = 10 Kbar). About 45mg of material from each shock level and an unshocked sample were irradiated with fast neutrons; the remainder was used for petrographic study. The isotopic composition of the argon released upon stepwise heating of each irradiated sample was measured in a mass spectrometer. These analyses showed that essentially no atmospheric argon was implanted during artificial shock. In spite of previous evidence that Leedey had not suffered Ar loss, the Ar-39/Ar-40 data for unshocked Leedey indicates some loss of low-temperature Ar-40.

Petrographic examination of unshocked Leedey suggests an earlier shock-heating event, which presumably was the cause of the observed Ar-40 loss. Much of the feldspar appears to have been converted to maskelynite; however, other component minerals, especially olivines, are relatively unfractured and unstrained. Petrographic examination of artificially shocked Leedey shows pronounced mechanical alterations due to laboratory shock, but surprisingly little phase transitions, i.e., melting. The pyroxenes and olivines of the 29 and 45 GPa samples were thoroughly fractured and comminuted into extreme mosaic-type structures. The more strongly shocked samples show isotropic, irregular patches of finely crushed material which has been injected into neighboring cracks and even shows some flow features. Additional maskelynite formation and melting of grain margins occurred in some samples. The sample shocked to 69 GPa shows less macroscopic mechanical disaggregation than the 45 GPa sample, which is consistent with experiments of (4).
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The four shocked Leedey samples show only small losses of radiogenic Ar relative to the unshocked Leedey. The averaged Ar-39/Ar-40 ages for the unshocked and 29, 41, 45, and 69 GPa shock levels are 3.95, 3.98, 3.53, 3.33 and 3.65 Gy, respectively. The intermediate average age for the 69 GPa sample is consistent with our observation that this sample experienced intermediate levels of disaggregation, and suggests that artificial shock pressures higher than 70 GPa under these experimental conditions would not cause greater Ar-40 loss. Logs of Ar-40 from those phases which degas at lower temperatures (up to 700°C) is more pronounced and shows a stronger correlation with shock intensity. For example, the apparent Ar-39/Ar-40 ages at 0.05 fractional release of Ar-39 for the unshocked 29, 41, 45, and 69 GPa samples are 3.8, 3.4, 2.7, 2.2, and 1.9 Gy, respectively. These trends indicate that small amounts of Ar-40 (up to 16%) have been lost from feldspar-related minerals in proportion to increasing artificial shock pressures. Evidence also exists in the Ar-39/Ar-40 release curves that some Ar-40 has been redistributed among phases by the artificial shock. There is no evidence in the K/Ca ratios of any redistribution of K, however. Argon is also more easily degassed from shocked samples, presumably as a result of the observed decrease in mean grain size. The temperatures by which 50 percent and 90 percent of the Ar-39 has been degassed average ~100°C and ~150°C lower, respectively, for the shocked samples compared to the unshocked samples.

These Leedey data suggest that strong shock alone will not cause appreciable degassing of argon from material with low porosity. Although artificial shock produced obvious effects of appreciable localized heating in Leedey, the small volume of shocked material would produce very short characteristic cooling times (e.g., seconds to minutes). Such short cooling times would not permit significant Ar diffusion loss. The use of thermal models to explain Ar loss in naturally shocked materials therefore appears justified. Shock theory predicts that artificial shock on silicates with much higher porosity than the Leedey disks used should produce much more sample heating and melting. An experiment to measure Ar loss in artificially shocked, crushed Leedey is under way.

REFERENCES:


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