EXPOSURE HISTORY AND FISSION TRACK AGES OF APOLLO 15 GREEN GLASS SPHERULES

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A combined study of microcraters observed with a scanning electron microscope (SEM), and of etched tracks observed with SEM and optical microscopy revealed that a batch of Apollo 15 green glass spherules shows evidence of rather low exposures to both micrometeorites and heavy cosmic ray particles.

In scanning ~ 50% of the surfaces of 24 spherules, only 2 high velocity impact craters were observed, although one spherule showed a high density of shallow pits.

No spherules show track density gradients, which would have indicated irradiation on the top ~ 100 μm of regolith. Natural track densities are in the region of ~ 8×10^5 to 2×10^7 tracks/cm^2. Crystals from the same soil sample show track densities higher by an order of magnitude than these values.

Accelerated Fe ions at normal incidence to the surface of polished spherules are found to produce etchable tracks at residual ranges of ~ 70 μm (cf. an etchable range of ~ 20 μm for Fe in pyroxene crystals). The lower natural track densities in the glass, thus most probably reflect thermal annealing of cosmic ray tracks, glasses being less retentive of tracks than crystals at any given temperature.

Diameter distributions of tracks in these glasses show a prominent peak at ~ 2 μm which is attributed to fission tracks. Uranium contents and fission track ages of some spherules will be reported at the meeting. Reactor irradiation of these glasses with thermal neutrons has been carried out.

CONDENSATION OF RARE EARTHS

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There has been considerable speculation about the origin of fine-grained inclusions from Allende since the discovery that they contain highly fractionated REE patterns. Based on the REE pattern of a single inclusion, Boynton (1) proposed that the more refractory heavy REE condensed in solid solution in perovskite and were removed from the gas prior to condensation of the fine-grained inclusions. REE activity coefficients in perovskite varying by a factor of 50 from Nd to Lu were needed to fit the observed pattern. Using the best available thermodynamic data and the condensation curve for perovskite, we have attempted to model all published REE patterns for fine-grained inclusions. Thermodynamic data can be selected from within their error bounds such that abundances of all REE except Tm and Yb relative to that of La can be matched by incomplete condensation of gas left after ideal solution in, and removal with, perovskite. Once a selection is made to fit one inclusion, however, REE patterns of other inclusions cannot be fit, even with variation of the temperatures of peroskite removal and residual gas condensation. Although deviations of observed REE patterns from those calculated in the ideal solution model can be made to shrink through invocation of activity coefficients, the functional relationship between these and ionic radius must be made to differ greatly in order to fit different inclusions at the same temperature, clearly an unacceptable solution. These models require unreasonably large deviations from ideality for the temperatures under consideration (>1600°K). Also, for some inclusions, the activity coefficients from Nd to Lu are required to vary by a factor of ~200. Such variations are extremely unlikely for elements of such similar ionic radii, particularly since series of REE compounds, like $NdAlO_3$ to $LuAlO_3$, are known to be isostructural with and to have simialr unit cell volumes to perovskite. The addition of a component with a flat REE pattern to the composition produced by the ideal solution model can explain all features of REE patterns in fine-grained inclusions except that the predicted enrichment of Tm relative to other heavy REE and depletion of Yb relative to light REE are not large enough. In view of the many adjustable parameters in models such as these and the persistent uncertainty about the origin of these inclusions, attempts to derive fundamental thermodynamic quantities such as activity coefficients from them are baseless.

(1) Boynton, W. V. (1975), *Geochimica Cosmochimica Acta* **39**, 569

TERRESTRIAL IMPACT STRUCTURES: THE CANADIAN CONTRIBUTION

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The twenty-three meteorite impact structures recognized in Canada provide excellent examples of practically all degrees of shock metamorphism, and variations in crater morphology and preservation. The structures range from simple bowl-shaped craters, 2 to 4 km across, through complex central uplift craters, to multi-ringed structures up to 100 km in diameter. With the exception of one crater excavated in a sedimentary sequence, the target rocks are largely crystalline. Canadian impact structures range in age from 1840 m.y. to < 5 m.y. and their degree of preservation is generally a function of age and size. However, some relatively old small structures have been exceptionally well preserved as a consequence of post-impact sedimentary cratonic cover. All aspects of diagnostic low to moderate pressure shock effects occur, including shatter cones, microscopic planar deformation