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A THERMAL HISTORY TALE OF TWO BODIES: WHAT DID THE HED PARENT BODY HAVE THAT THE MOON DIDN'T?

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Impact, brecciation, and regolith working are important processes in the history of small planetary bodies in the solar system. All classes of meteorites contain breccias, particularly the basaltic achondrites, and all returned lunar samples are breccias. We have examined the induced thermoluminescence (TL) properties of lunar and meteoritic samples as a means of comparing the surface properties of the Moon and the HED parent body. Both types of material are basalts originating on airless bodies that have suffered considerable reworking by impact, and our study may provide insights into the differences in impact and related surface processes on large and small bodies.

Hartmetz and Sears have shown that TL peak temperature is a sensitive indicator of the degree of order in the feldspar framework, highly ordered feldspars having TL peak temperatures of ~120°C compared with ~200°C for disordered feldspars [1]. Figure 1 compares TL peak temperatures for basaltic meteorites and lunar samples. In many respects the TL properties of these samples are similar, calcic feldspar being the source of TL in both types of material [2,3]. The major difference is that TL peak temperatures for the meteorites are all ~120°C, and the TL sensitivity of these samples correlates with metamorphic indicators [2]. This is in contrast to the lunar samples, which show a much wider spread in values, as well as having a large population exhibiting peak temperatures in excess of 170°C.

The observed TL peak temperatures and a series of heating experiments on four petrographically diverse eucrites, as well as a lunar highland soil, suggest that the basaltic meteorites have experienced a period of post brecciation metamorphism with temperatures ≤800°C [2]. Assuming this temperature was typical of metamorphic conditions, the thermal model of Miyamoto et al. suggests burial depths of >350 m for the equilibrated eucrites [4]. The high TL peak temperatures of the lunar samples, however, suggests a large population of disordered feldspar and the lack of any appreciable thermal metamorphism.

Since many of the HEDs contain regolith components [e.g., 5], the history of these samples involves both deep burial and regolith processing. In addition, the regolith history must postdate the metamorphism since metamorphism would have destroyed many of the regolith properties. One possibility is that following the metamorphic episode, the HED parent body suffered large, nearly catastrophic impact events that exposed deeply buried material that then experienced a regolith history. Consistent with this, Binzel and Xu have discovered a family of basaltic asteroids that are most likely multikilometer-sized fragments excavated from Vesta through one or more impacts [6].

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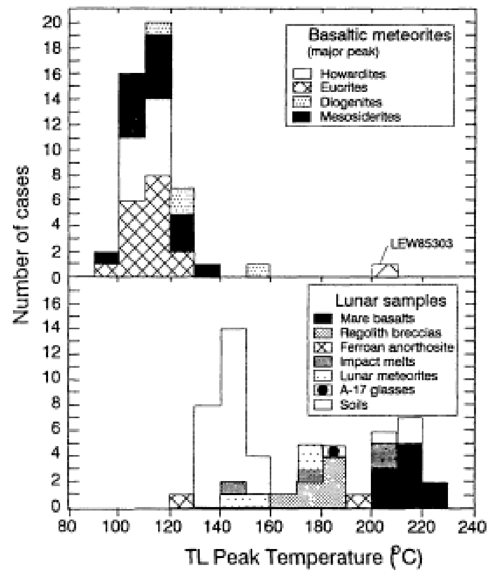

Fig. 1.