Pairing Unbound: Fragmentation of Antarctic Meteorites. P.H. Benoit and D.W.G. Sears. Cosmochemistry Group, Dept. Chemistry and Biochemistry, University of Arkansas, Fayetteville, AR 72701 USA. E-mail: COSMO@uafsysb.uark.edu

Antarctic meteorites are found as accumulations on icefields, and many of these samples are fragments of individual meteorites, or "pairs". We have used natural and induced TL data to search for potential pairings among 882 Antarctic samples, using literature noble gas concentrations and radionuclide activities as additional criteria when possible. We did not impose geographic proximity criteria, instead using it as an independent test of proposed pairings. We identify 78 new potential pairing groups, in addition to 136 groups previously identified. Some pairings cross icefield boundaries and are probably "false positives". About 80% of the possible pairings joined meteorites found in close proximity. The proposed pairing groups often have distributions on the ice similar to modern fall strewn fields and the size-frequency distributions of Antarctic pairing groups are similar to those of modern falls, suggesting that most fragmentation occurs during atmospheric passage rather than in the ice.

About 50% of modern falls apparently did not fragment during atmospheric passage (Fig. 1), and the remainder typically break into two or three pieces. However a small proportion of meteorites break into dozens or even hundreds of pieces. Meteorite finds also occur as multiple fragments. In the case of hot and cold desert meteorite concentrations [1.2] it is often not apparent which fragments are "paired". Petrographic examination of thin-sections is a useful technique for pairing [3], but is difficult to apply to hundreds of samples from the large accumulations. Analytical data, such as cosmogenic noble gas abundance and cosmogenic radionuclide activity, can also be applied [4]. Mössbauer spectroscopy provides a measure of weathering, which can be used for pairing studies [5]. These techniques have limitations, notably the limitation that all these properties are not unique within meteorite classes and petrologic types. Ideally, combinations of petrographic and quantitative data are successful but in practice the data are too sparse. As a result, pairing efforts have tended to be technique specific and usually confined to specific geographic locations.

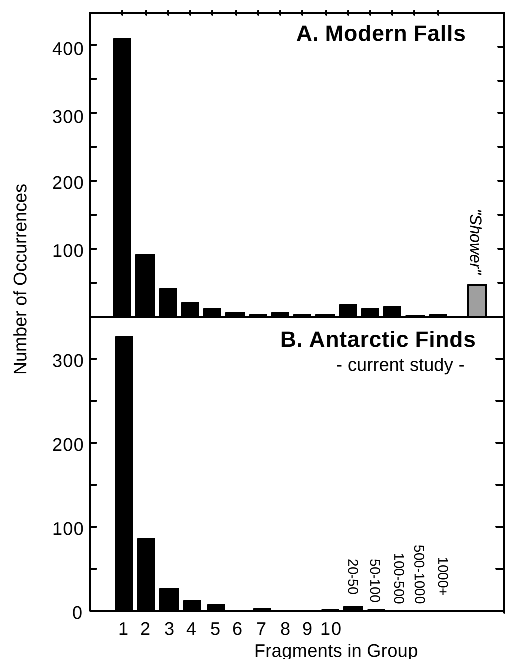

Fig. 1. Frequency of pairing group sizes, modern falls and Antarctic meteorites .

We have applied natural and induced thermoluminescence (TL) data to pairing within the Antarctic collection [6]. Natural TL levels reflect thermal history in space and terrestrial history, notably surface exposure in the case of Antarctic meteorites [7]. Within meteorite classes, induced TL intensity (TL sensitivity) reflects metamorphic history and weathering and induced TL peak temperature reflects metamorphic peak temperature and cooling rate [8]. TL pairings are not necessarily unique, and might just identify similar space and terrestrial weathering histories, rather than fragmentation of a single meteorite.

Methods. Induced and natural TL data were reported in [6], and we also use data reported in several issues of the *Antarctic Meteorite Newsletter*. Candidates for pairing must be of the same petrologic class and type, have natural TL levels within 10% and TL sensitivities within 15%, and have similar induced TL peak temperatures [8]. We attempt to confirm potential pairings with cosmogenic noble gas abundance and radionuclide activities, although such data are very sparse. Our TL database consists of 882 equilibrated ordinary chondrites, mainly from the Allan Hills (170), Elephant Moraine (200), Lewis Cliff (212), and Queen Alexandra Range (160).

Results. We delineate 78 potential pairing groups, in addition to the 136 groups previously found. Thirty-three of the new groups involve meteorites from the same icefield, the remaining 45 groups involving meteorites from geographically separated fields. Only 3 groups encompassed three or more fields.

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Using only the pairing groups involving samples from the same field, the frequency of pairing groups tends to decrease with their size (Fig. 1b). The frequency distribution is similar to that of the modern falls (Fig. 1a), although larger pairing groups (those containing 20+ members) are underrepresented in the Antarctic collection.

Discussion. Strewn-fields can cover tens to a few hundred kilometers [9], and ice flow over tens to hundreds of thousands of years could lead to sample separation and dispersal to widely separate ice fields. However, most of the interfield pairings incorporate only members, and often involving fields very widely separated, suggesting that most or perhaps all these pairings are "false positives". We assume that such "false positives" would be randomly spread across the entire collection, while true interfield pairings would be restricted to fields in close proximity, or sharing a common ice current. However, this is not the case and intrafield pairings are much more common than expected from the number of samples, despite the removal of geographic proximity from our pairing criteria. This suggests to us that many intrafield pairings are authentic, and there is no significant interfield pairing.

Antarctic pairing groups identified mainly by TL methods tend to form concentrated, often elongated fields on the ice. Pairing group distributions were previously shown for Allan Hills and Lewis Cliff [6] and a map for pairing groups from Pecora Escarpment is shown in Fig. 2. Pecora Escarpment pairing groups tend to occur as linear arrays up to 10 km long (the PCA 91027 and 91028 groups) or as very concentrated groupings, with no more than 1 km between samples (the PCA 91012 and 91009 groups). Cases involving more dispersed pairing (>10 km between samples), such as those noted at Elephant Moraine, tend to involve small samples (<30 g) and probably reflect the effects of aeolian transport [6].

The size-frequency distribution of Antarctic pairing groups is similar to that of modern falls (Fig. 1). This may suggest that terrestrial weathering and erosion have minimal effect on the fragmentation of Antarctic meteorites. The apparent lack of large pairing groups in the Antarctic collection probably reflects the sampling limitations for TL, the smallest meteorites (<20 g) not being analyzed.

Conclusions. Applying TL data, in conjunction with other petrographic or analytical data when available, we find that pairing is about as prevalent in the Antarctic collection as it is among the modern falls, and thus that about 50% of Antarctic samples are members of pairing groups. Although we did not use geographic proximity as a pairing criteria, we find that pairing groups tend to be limited to single fields. Furthermore, the separation of samples on fields tends to be only a few kilometers, and thus comparable to strewn fields among modern falls.

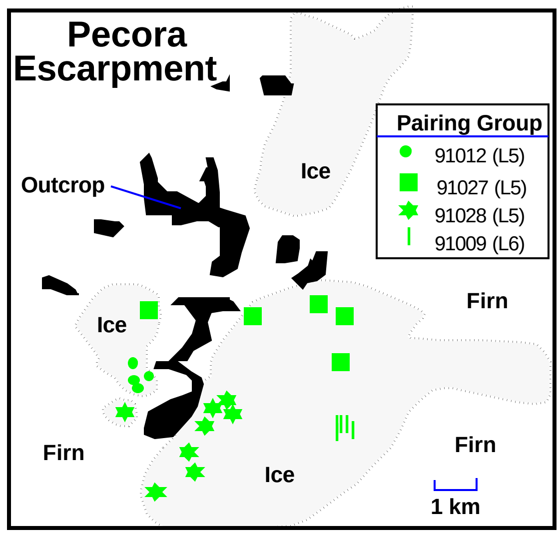

Fig. 2. Location of paired samples at Pecora Escarpment, Antarctica .

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