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Discovery of Meteorites on a Blue-Ice Field near the Frontier Mountains, North Victoria Land, Antarctica

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Members of the West German GANOVEX IV expedition 1984/85 (German Antarctic North Victoria Land Expedition) discovered a high concentration of meteorites on a blue-ice field northeast of the Frontier Mountains. As a result of a systematic search, a total of 42 meteorites were discovered.

The Frontier Mountains pierce the polar ice sheet over a length of approximately 8 km with a NW-SE trend. Glacial flow from the polar regions approaches from WSW, flowing around the mountain range at both ends (Figure 1). Due to the barrier function of the range, the ice surface to the southwest is higher than in the northeast by an estimated 200 m. Large areas of crevasses caused by the stepwise descent of the ice sheet occur at both ends of the Frontier Mountains. A blue-ice field has formed on the lee side of the range, characterized by high rates of sublimation and abrasion due to frequent strong catabatic and foehn winds, as well as compressive ice flow, as evident from the occurrence of numerous dust bands.

The crevasse pattern outside the valley is obviously controlled by the flow pattern of the ice masses around the Frontier Mts. Meter-wide crevasses run parallel to the trend of the Frontier Mts. in zones in which the elevation rapidly decreases. Past the range to the E, the crevasse orientation swings gradually from NW-SE to SW-NE, while crevasse widths decrease to a few cm. Noteworthy are the surprisingly deep depressions in the blue ice, reflecting changes in elevation by more than 100 m (estimated).

The current glacial situation has evolved through various stages. By the orientation of grooves and striae on bedrock at various levels of elevation, at least three different stages of glaciation characterized by different ice-flow directions can be distinguished:

- Grooves only at the highest points of the range were formed by an SSE-NNW trending ice-flow (long arrows in Fig. 1). In analogy to glaciological observations in the Dry Valleys, we assume an Upper Miocene age for this episode.

- A lowering of the ice surface of the polar ice sheet (Pliocene?) resulted in a change of the flow direction toward SW-NE (medium size arrows in Fig. 1).
- A further reduction of surface elevation of the polar ice sheet exposed the Frontier Mountains to a large extent. Now, glacial flow controlled by topography prevails (short arrows in Fig. 1).

Today, the following situation has evolved:

The greatest depression in the blue-ice field to the E of the range occurs in a valley an the southeastern end of the Frontier Mountains. The valley serves as a preferred channel for catabatic and foehn winds that are the cause of the locally high degree of sublimation and abrasion. The mass losses are counteracted by blue-ice moving into the valley from the east (nearly opposite of the regional flow direction).

The thickness of the blue ice was measured with a radio echo sounding instrument (RES) along the profile A-B (see Fig. 1) parallel to the long axis of the valley. From the 0 to 300 m mark, a complicated reflection pattern was observed for depths of more than 150 m indicative of an irregular subsurface pattern at the interface ice-bedrock. Reflections from this interface are indicated in Figure 2a as bars. Dots represent reflections from a non-horizontal surface.

The interpretation of the available RES-data is depicted in Figure 2b. A local glacier entering the western end of the valley apparently sustains at its bottom a ground moraine judging from the extensive reflection pattern for depths below the first major reflection. The side reflections (dots in Fig 2a) are apparently caused by a buried lateral moraine at the glacier front. No evidence, however, is seen at the ice surface. The pressure on the lateral moraine is balanced by the inflowing blue-ice from the E. RES-measurements on the blue-ice in general yield a less complicated reflection pattern past the first major reflection indicative of a smoother ice-bedrock interface.

An obvious connection of the reflectors with steeply dipping dust bands, trending almost perpendicularly to the long axis of the valley, was not detected. The lateral separation of these dust bands, slightly parabolic, ranged from a few dm to about 30 m.

The highest concentration of meteorites were found within an area of 300 m by 1 500 m within the valley. With reference to profile A-B, most meteorites were found between the 600 m to 900 m marks (see Fig. 2).

The largest meteorite, about 14 cm long, was discovered about 3 km ESE of the entrance to the valley. The blue ice there is very sparcely covered by wind-blown rock fragments of local origin.

The main discovery site, is covered by an almost unbroken veneer of rock fragments. Trending from W to E, the size of the rock fragments increases steadily from pebble size to boulders with diameters in excess of 3 m. The latter are on top of an ice ridge at the E-entrance to the valley (identical with point B of Fig. 2), surrounded by a rock veneer several cm thick.

The total weight of the recovered meteorites is 1.2 kg, however, only 7 specimens have masses larger than 10 g. The specimens from the main discovery site are moderately weathered; cuts through the specimens show brown limonitic staining throughout, but most of the metal has been preserved. Preliminary mineralogical investigations of the larger specimens show that these meteorites belong to different petrological and chemical types of H- and L-group chondrites. Noble gas and ^{10}Be analyses of 7 meteorites yield different records of irridation which exclude pairing of these investigated samples. Two H-group chondrites - FRO 8405 (H3) and FRO 8409 (H4) - contain large amounts of solar trapped gases (^{4}He: 1.8×10^{-3}ccSTP/g). A brecciation, however, is not visible in hand specimens because the brown staining obscures any primary structure.

^{26}Al has been measured in 4 of these meteorites. FRO 8403, an H6 chondrite with a ^{21}Ne-exposure age of about 5 million years, has a ^{26}Al-activity of 29.2 dpm/kg. This number corresponds to a terrestrial age of about 6.6×10^{5} years and is one of the longest terrestrial ages for Antarctic meteorites observed so far.

Figure 1: Ice flow-directions around Frontier Mountains. The orientation of grooves and striae on bedrock, caused by three differnt stages of glaciation, are shown:

long arrows: Upper Miocene glaciation
medium size arrows: Pliocene (?) glaciation
short arrows: third recognized stage of glaciation

The meteorite field is shown as hatched area. Most meteorites were found along the eastern margin of the field. RES-measurements were carried out along line A - B.

Figure 2a: Results of RES-measurements along A-B. Bars mark first major reflections indicative of the ice-bedrock interface. Dots mark reflections from inclined surfaces.

Figure 2b: Interpretation: The ice masses on the left end of the profile are part of a local glacier approaching from the west. At its base we suspect a ground moraine of unknown thickness. The glacier is apparently bounded at its front by an ice-buried lateral moraine. From the east, blue-ice enters the valley. The internal structure of the blue-ice, as shown, is inferred from the occurrence of dust bands at the blue-ice surface.