Senior Thesis

Age and Provenance of a Granitic Clast from Reckling Moraine on the East Antarctic Ice Sheet

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Introduction

The Reckling Moraine is located about ten miles northwest of Reckling Peak in the Transantarctic Mountains (T.A.M.) of southern Victoria Land. It consists of sediment and boulders that are accumulating on the East Antarctic ice sheet in an area about thirty miles north of the Allan Hills, shown in Figure 1. The boulders in the Reckling Moraine were presumably derived from bedrock under the ice and therefore provide an opportunity to study the geology of the western flank of the T.A. M. that is now covered by ice.

A granitic clast, found by Dr. Lou Rancitelli of the Battelle Memorial Institute at the Reckling Moraine, was dated in this study by the Rb-Sr method in order to use the date to determine the provenance of this type of clast.

Geology of Southern Victoria Land

According to McKelvey and Webb (1961) the rocks of southern Victoria Land consist of a basement complex composed of igneous and metamorphic rocks overlain by sedimentary rocks of Paleozoic to early Mesozoic age. These rocks were divided into formations listed in Table 1.

The Ferrar Dolerite of Jurassic age occurs mainly
Figure 1. Map of Antarctica (Based on McMurdo Sound Area, Antarctica Map published by Molenaar Maps)
Table 1. Stratigraphy of Southern Victoria Land, East Antarctic Ice Sheet (McKelvey and Webb, 1961).

<table>
<thead>
<tr>
<th>Age</th>
<th>Formations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td>McMurdo Volcanics</td>
</tr>
<tr>
<td>Upper Tertiary</td>
<td>Ferrar Dolerites</td>
</tr>
<tr>
<td>Jurassic</td>
<td>Beacon Supergroup</td>
</tr>
<tr>
<td>Devonian</td>
<td>Kukri Peneplain</td>
</tr>
<tr>
<td>Ordovician</td>
<td>Granite Harbour Intrusives</td>
</tr>
<tr>
<td>Cambrian</td>
<td>Older Granite-Gneiss</td>
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</tbody>
</table>
as sills intruded into the Beacon Sandstone. The initial 
$^{87}\text{Sr}/^{86}\text{Sr}$ ratios of these basalt flows are anomalously
high ($^{87}\text{Sr}/^{86}\text{Sr} = 0.710-0.712$) compared to basalts else-
where ($^{87}\text{Sr}/^{86}\text{Sr} = 0.703-0.705$) (Faure et al., 1974).

The Beacon Supergroup consists of sandstones
interbedded in some locations with shale and coal. Quartz
arenite, interbedded graded siltstone and orthoquartzite
facies are also found in this formation of Devonian to
Triassic age. This rock group may show graded bedding,
cross lamination, cross bedding and ripple marks.

The basement rocks in this area are cut by the
Kukyri Peneplain and were formed during the Ross Orogeny
approximately 500 ± 20 m. a. (Faure and Jones, 1974).
The Granite Harbour Intrusives consist of igneous rocks
containing a variety of rock types including boulder-sized
pegmatites and fine-grained plutonic rocks. These
intrusives cut Precambrian granitic gneisses.

Methods

The granitic clast was crushed and sieved to -60
mesh +120 mesh. The non-magnetic fraction was removed
on a Frantz isodynamic magnetic separator and a 3 gram
fraction was ground to -200 and compressed into a
pellet for x-ray fluorescence. The remaining portion
was further separated using a solution of bromoform and acetone. The potassium feldspar collected at the top while the plagioclase and quartz sank to the bottom. These two samples were also crushed to -200 and made into pellets.

Concentrations of rubidium and strontium were determined by x-ray fluorescence. Each sample was run three times to reduce error. The rubidium and strontium concentrations in parts per million (ppm) and the subsequent Rb/Sr ratios were calculated using standard methods in use in the Laboratory for Isotope Geology and Geochemistry.

To determine strontium isotope ratios, the samples were prepared to be analyzed on the mass spectrometer. Enough of the powdered samples, previously ground to pass through the -200 mesh, was used to yield 50 micrograms of Sr and was dissolved in "B" acid. This mixture is composed of hydrofluoric acid, nitric acid and sulfuric acid. The strontium was separated by cation exchange and organic contaminants were oxidized with perchloric acid. The strontium was then loaded on the filament of the mass spectrometer and the mass spectrum of each sample was scanned an average of 120 times.
Rb-Sr Date of the Granite Clast

The $^{87}\text{Rb}/^{86}\text{Sr}$ ratio was calculated from the Rb/Sr concentration using appropriate factors for different $^{87}\text{Sr}/^{86}\text{Sr}$ values. The results of these analyses are summarized in Table 2. In Figure 2 a graph of $^{87}\text{Sr}/^{86}\text{Sr}$ versus $^{87}\text{Rb}/^{86}\text{Sr}$ was plotted. Using the slope of the line drawn through three points, the date of the granitic clast was calculated to be $475.9 \times 10^6$ years. From this date it was concluded that this granitic clast is part of the Granite Harbour Intrusive Formation, which therefore must be present under the ice.

Dolerite Samples

Two dolerite clasts were also collected from the Elephant Moraine located 50 miles northwest of the Allan Hills (Figure 1). These rocks had striations on one surface suggesting movement of ice over them. Weathering rings, approximately one inch thick, were apparent on a fresh cut through the center. In thin section, these rocks were medium to fine grained, crystalline, and composed mainly of plagioclase and pyroxenes. These samples were analyzed for rubidium and strontium concentrations and $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. The $^{87}\text{Rb}/^{86}\text{Sr}$ ratio was calculated from the Rb/Sr ratios and then the initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios were calculated assuming an age of $170 \times 10^6$ years. These initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios
<table>
<thead>
<tr>
<th>Sample</th>
<th>Sr (ppm)</th>
<th>Rb (ppm)</th>
<th>Rb/Sr</th>
<th>87Sr/86Sr</th>
<th>87Rb/86Sr</th>
<th>87Sr/86Sr</th>
</tr>
</thead>
<tbody>
<tr>
<td>K-feldspar</td>
<td>139.5</td>
<td>406.4</td>
<td>2.912</td>
<td>0.76593</td>
<td>0.00031</td>
<td>8.4734</td>
</tr>
<tr>
<td>Plagioclase and Quartz</td>
<td>96.56</td>
<td>67.29</td>
<td>0.6967</td>
<td>0.7220</td>
<td>0.00025</td>
<td>2.0195</td>
</tr>
<tr>
<td>Unseparated Non-magnetic Fraction</td>
<td>111.5</td>
<td>181.6</td>
<td>1.628</td>
<td>0.74201</td>
<td>0.00042</td>
<td>4.7262</td>
</tr>
</tbody>
</table>
Figure 2. Rb-Sr Isochron for the Granitic Clast, Reckling Moraine
are 0.7080 and 0.7110 and are reported in Table 3. These ratios can be seen in Figure 3 on the graph of $^{87}\text{Sr}/^{86}\text{Sr}$ versus time.

The initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios are anomalously high when compared to other basaltic rocks. These above-normal values lead to the conclusion that the two dolerite samples were derived from the Ferrar Dolerite Formation under the ice.

**Conclusion**

The date calculated from the granitic clast shows that this rock must be from the Granite Harbour Intrusives. The high initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of the dolerites make evident that this rock is part of the Ferrar Dolerites. These rocks were transported at the base of the East Antarctic ice sheet as indicated by the surface striations and then were brought to the surface by the movement of the ice. The rocks could not have come from the nearby Allan Hills due to the northerly direction of the ice movement at this locality. Furthermore, these rocks could not be from an area south of Reckling Moraine on the East Antarctic ice sheet because there are no outcrops of any kind in that area. Therefore, rocks in the Reckling Moraine are derived from under the ice and belong to the formations of the Granite Harbour Intrusives and the Ferrar Dolerites.
Table 3. Analytic Data for Dolerites, Reckling Moraine

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sr</th>
<th>Rb</th>
<th>Rb/Sr</th>
<th>(\frac{^{87}Sr}{^{86}Sr})_{m}</th>
<th>(^{87}Rb/^{86}Sr)</th>
<th>(\frac{^{87}Sr}{^{86}Sr})_{initial}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dolerite with striations</td>
<td>118.6</td>
<td>30.86</td>
<td>0.2593</td>
<td>0.70978 ± 0.0004</td>
<td>0.7098</td>
<td>0.7080</td>
</tr>
<tr>
<td>Dolerite</td>
<td>120.5</td>
<td>31.10</td>
<td>0.2580</td>
<td>0.71279 ± 0.0006</td>
<td>0.7128</td>
<td>0.7110</td>
</tr>
</tbody>
</table>
Figure 3. Strontium Evolution Diagram
References

