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"Virtual Mineral Separation" of Pyroxene from Plagioclase for Cosmogenic ^{3}He Exposure Dating

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In this project, we present a "Virtual mineral separation" approach to cosmogenic noble gas analysis that could greatly improve the cost and efficiency of measuring the cosmogenic nuclide ^{3}He in pyroxene for exposure dating.

Cosmogenic nuclide exposure dating uses the accumulation of cosmogenic nuclides to determine the exposure history of mineral matter. These cosmogenic nuclides are rare isotopes produced by cosmic-ray interactions with matter near the Earth's surface. In Antarctica, cosmogenic nuclides are commonly used to date geologic events and quantify geomorphic processes such as glacial and ice sheet retreat, glacial deposits, and moraine formation; all of which expose fresh clast and rocks at the surface. The Ferrar Dolerite predominantly consists of calcic plagioclase and several pyroxenes and is one of the dominant lithologies of clast exposed at the surface of many surficial deposits throughout the Transantarctic Mountains in Antarctica. Therefore, cosmogenic nuclide measurements such as ^{3}He on the Ferrar Dolerite pyroxene are important for dating glacial events and understanding the rates of erosion and landscape disturbances throughout ice-free areas of Antarctica.

Currently, the procedure for measuring ^{3}He in pyroxene involves two steps; separating and purifying the pyroxene, followed by heating the pyroxene under vacuum and analyzing the released ^{3}He using a noble gas mass spectrometer. While the latter procedure is rapid, efficient, and automated, the first step is time-consuming (weeks to months), labor-intensive, and requires the use of hazardous chemicals. Here we exploit the use of thermally activated diffusion of ^{3}He in minerals present in the Ferrar Dolerite. Preliminary results of step-heating diffusion experiments on both single and bulk grains of pyroxene and plagioclase show these minerals to have different activation energies and diffusion kinetics at temperatures below ~300°C. This makes it possible to heat a whole-rock sample of the Ferrar Dolerite (consisting of plagioclase and pyroxene) at a low temperature to degas ^{3}He released from plagioclase with negligible loss from pyroxene, followed by heating at a higher temperature to degas the remaining ^{3}He from pyroxene; ultimately resulting in separate measurements of ^{3}He inventory in both minerals without physically separating the minerals.