Using the Antarctic Rock Record to Better Understand Supercontinent Amalgamation 1.7 Billion Years Ago

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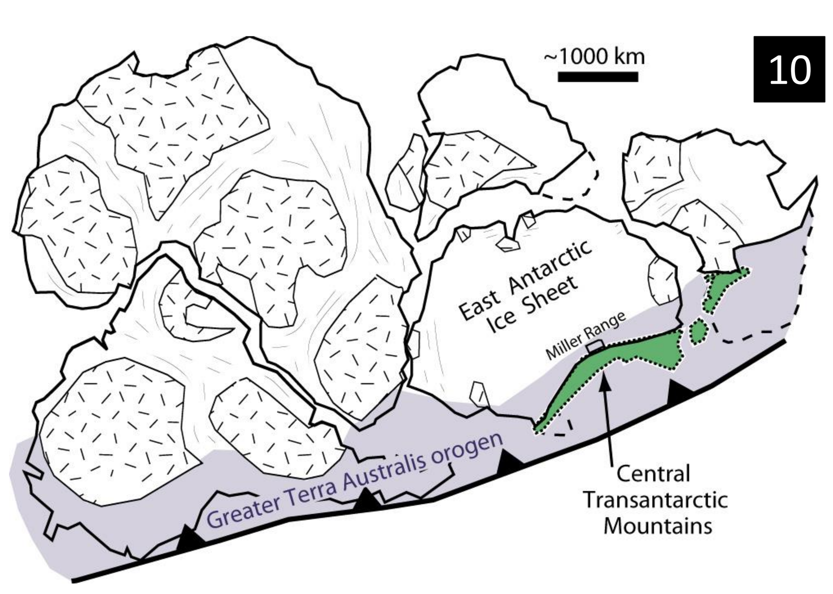
Abstract

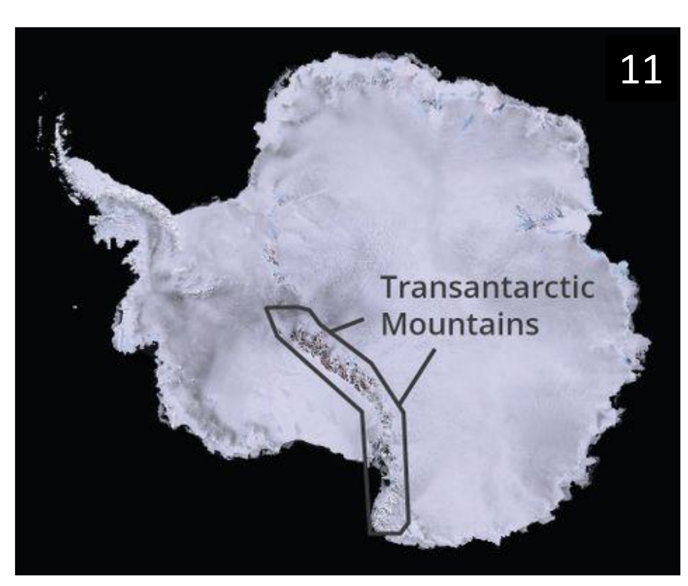
Igneous and metamorphic rocks from the Transantarctic Mountains in Antarctica provide information about crust formation and supercontinent cycles over the past 3.1 billion years (Ga). Igneous rocks record crust formation and possible recycling of older crust. Metamorphic rocks record the tectonic history of the region. Antarctic geology enables analysis of how crust has evolved because it contains a continuous rock record of over 2.5 Ga. There are very few locations that can provide a continuous rock record that spans a large duration of Earth's history. Studying igneous rock ages as well as metamorphic pressure and temperature conditions provides information about the East Antarctic Craton, which is mostly unexposed under the East Antarctic Ice Sheet. These craton rocks may provide insight into previous supercontinent formation of Rodinia, which can better our understanding of how crust formation has changed through time.

By combining these rock records, we can reveal how the original crust formed and how continental crust forms supercontinents. The mineral zircon is highly resistant to alteration such as metamorphism, and records when igneous rocks form before any deformation. When preexisting rocks undergo metamorphism, the pressure and temperature conditions can be recorded in minerals that are not resistant to deformation such as monazite. Both zircon and monazite can be analyzed and dated using a mass spectrometer. This information can help us understand the metamorphic and igneous history of the past supercontinents. Results will determine when and where plate tectonics occurred at the Antarctic continent, possibly revealing how early plate tectonics initiated.

Location

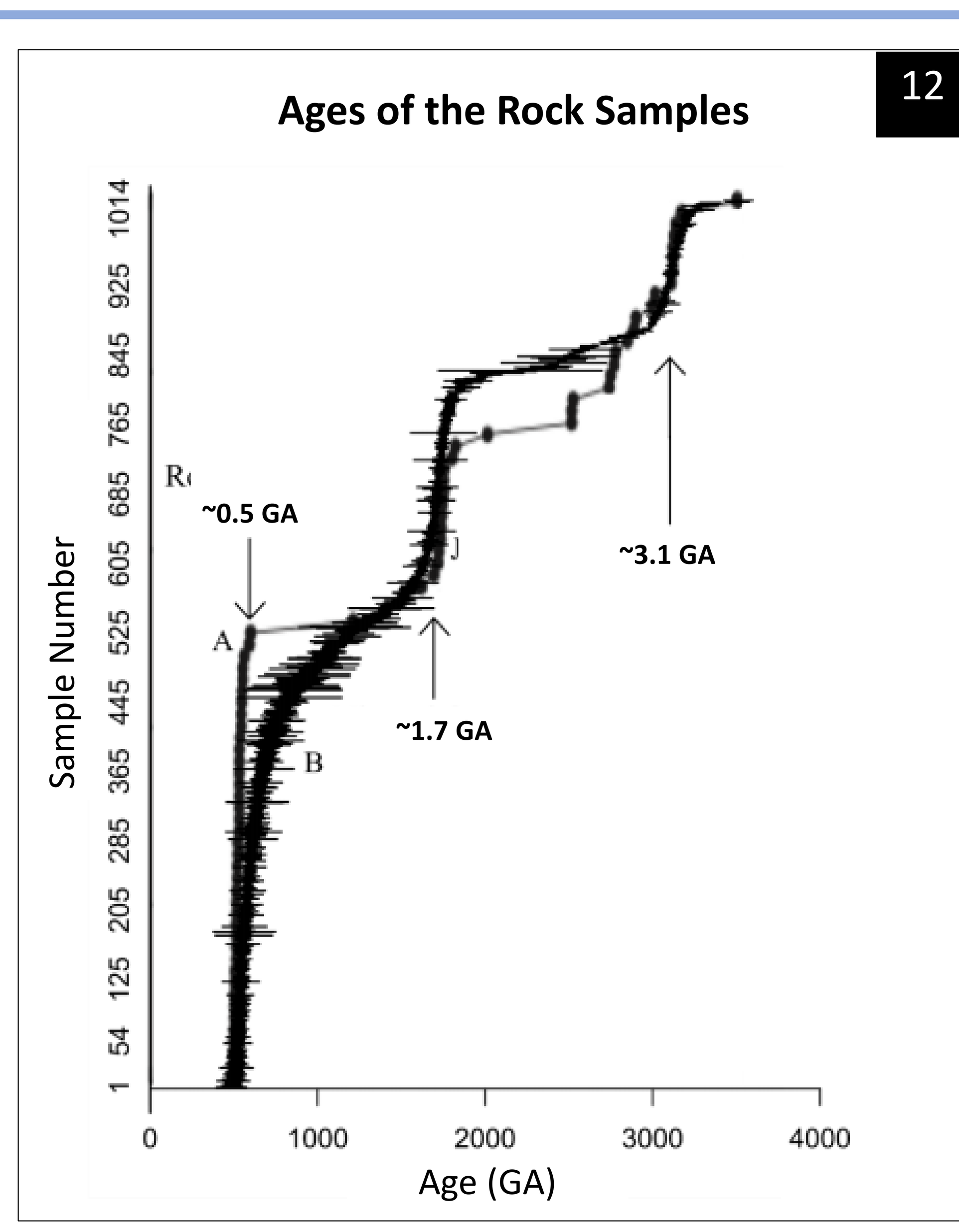
The sample set of rocks we are studying come from Miller Range, Antarctica in the Central Transantarctic Mountains (cTAM), in Antarctica. This location is special because of its continuous rock record. It covers over 2.5 billion years and several supercontinents in the Earth's history.





Results

The rocks we dated are mostly 0.5, 1.7, 3.1 billion years old (Ga). This data supports the theory that old continental crust is reworked into new crust because most of the rocks in this area seem to be created at a few points in time. Looking at the ages of the samples, it seems like the crust in the area was not being continuously created from new mantle material. Instead new rock was created mainly at 0.5, 1.7, and 3.1 Ga ago.



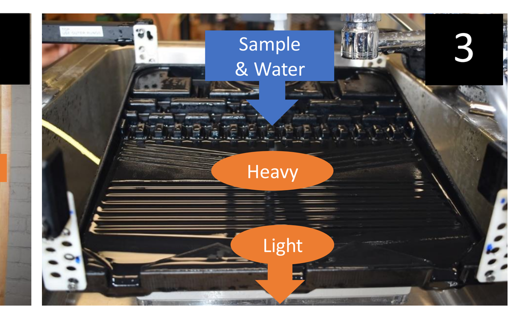
Acknowledgements

Eureka Program
CSEP and CNSI
Elizabeth Erickson
John Cottle
Nicole Aikin
Alex Johnson
UCSB Earth Science Department

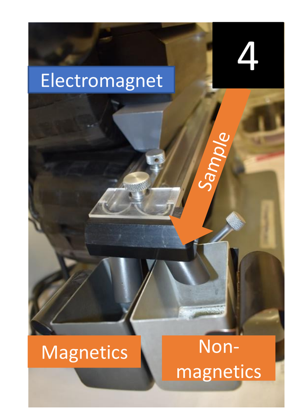
Methods

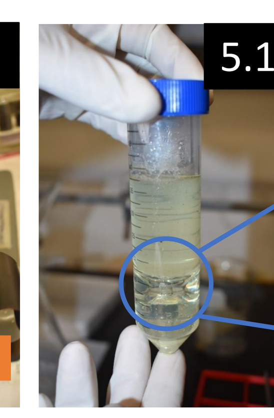
Mineral Separation:

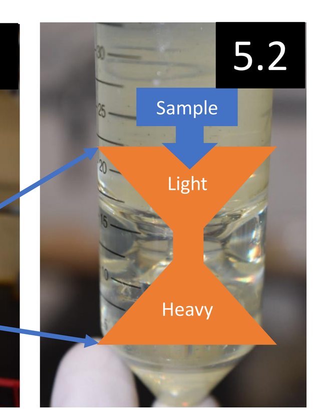
1. First the rock samples are crushed using a sledgehammer and then the Rock Crusher.
2. Then the crushed rock samples are sieved to using a 355 µm sieve. For the next steps we use material smaller than 355 µm.

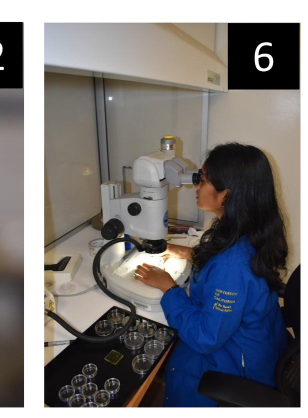


3. Next, we water table the sample. We are using a prototype water table which has grooves and hangs at a slope. We run a mixture of sample and water over the higher side so when the table shakes, light material rises up and the water washes it over the table. We use the material left in the first or first two grooves next for the next steps because they have the densest material left in them.
4. After the sample from the water table has dried, we run it through the Frantz. It uses an electromagnet to separate magnetic and non-magnetic minerals.

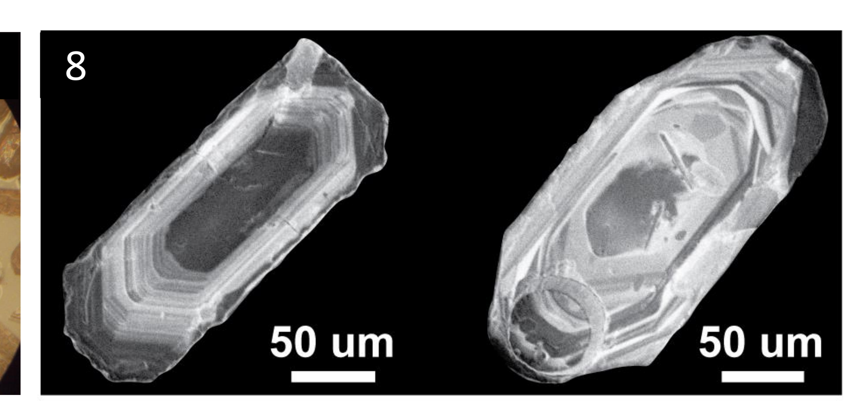








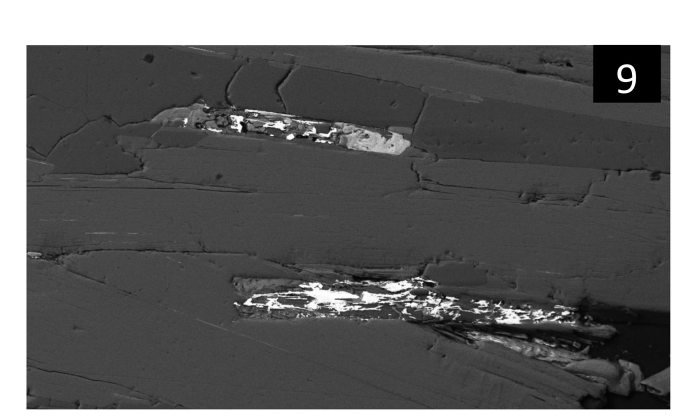
5. Then we further separate the non-magnetic minerals using heavy liquid separation. We use MEI, a dense liquid with a density lower than zircon and higher than other minerals in the sample such as apatite. Zircon will sink and other material will float.
6. After that, we pick zircon. We put the sample into a petri dish use a microscope to see the grains up close. We use tweezers to create a pile of zircon in the petri dish and a pipette to move the zircon grains to another dish.



7. Next, we create a mount with the zircon stuck to one surface. We polish the mount until we get to the core of most of the zircon grains.
8. After the mineral separation process is done we use cathodoluminesce light to image the internal structure of the zircon and understand its growth pattern, core, and more.
9. We also use Laser-Ablation Split-Stream (LASS) and Inductively-Coupled-Plasma Mass-Spectrometry (ICP-MS) to date and study the chemistry of the zircon.

Analyzing Thin Sections

1. First, we use the Scanning Electron Microscope (SEM) to identify monazite, the mineral we want to study.
2. Then, we use a microprobe to map the chemistry of the mineral.
3. Lastly, we use mass spectrometry to date the mineral and understand its chemistry in order to learn about the pressure-temperature when it underwent metamorphism.



An image of Monazite (the bright white material) taken on the SEM

References

Figures 1-7.2: Elizabeth Erickson. **Figure 8:** Modified from Annen, Blundy, and Sparks (2006) Journal of Petrology, 47(3), 505-539. **Figure 9:** Alex Johnson. **Figure 10:** Modified from Paulsen et al., 2016, Geology. **Figure 11:** http://tamcamp-pgc.dev.umn.edu/sites/tamcamp.pgc.umn.edu/ files/antarctica-tam.jpg. **Figure 12:** Adapted from Goodge and Fanning, 2016, Precambrian Research. **13.** Goodge and Fanning (1999) Geology, 27(11), 1007-1010. **14.** Goodge and Fanning (2016) Precambrian Research, 285, 242–271 **15.** J.W. Goodge et al. / Precambrian Research 112 (2001) 261–288