POLAR WEEKEND
ANTARCTIC GAMBURTSEV PROVINCE
(AGAP)

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

TOPIC: Antarctic Gamburtsev Province (AGAP) –
A Mysterious Mountain Range Hidden Beneath the Ice Sheet




PROJECT PERSONNEL: Top to bottom, left to right
Dr. Robin Bell, Geophysicist, Lamont-Doherty Earth Observatory
Dr. Michael Studinger, Geophysicist, Lamont-Doherty Earth Observatory
Nick Frearson, Engineer, Lamont-Doherty Earth Observatory
Adrienne Block, Graduate Student, Lamont-Doherty Earth Observatory

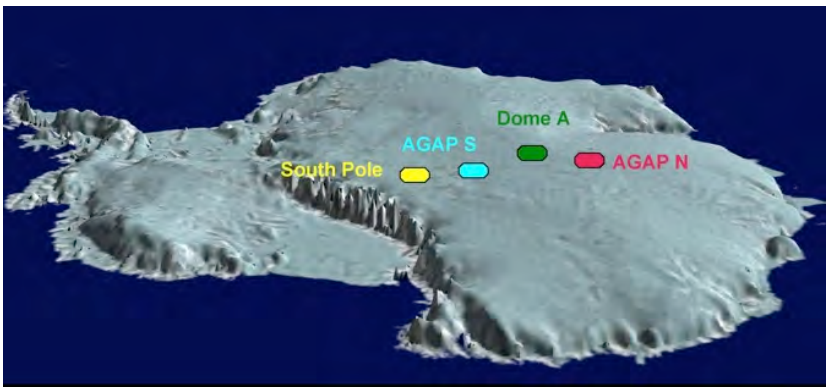
PHOTOS: The field team in East Antarctica (a difficult to access, and high elevation area) during the brief Antarctic summer. Just days either side of the November to January 'weather window' the temperatures drop and the winds increase making field work extremely difficult.

WHERE ON THE MAP ARE WE:

The AGAP project was based in the interior of East Antarctica operating out of two bases on either side of Dome A which were specially constructed for the project. AGAP North was home for the U.K. based British Antarctic Survey (BAS) team, and AGAP South was home to the U.S. based Lamont team. Between these two camps the Gamburtsev Mountains (**red star on the map**) had been detected under 3-4 kms of ice.

GENERAL BACKGROUND INFORMATION ON THE SUBJECT:

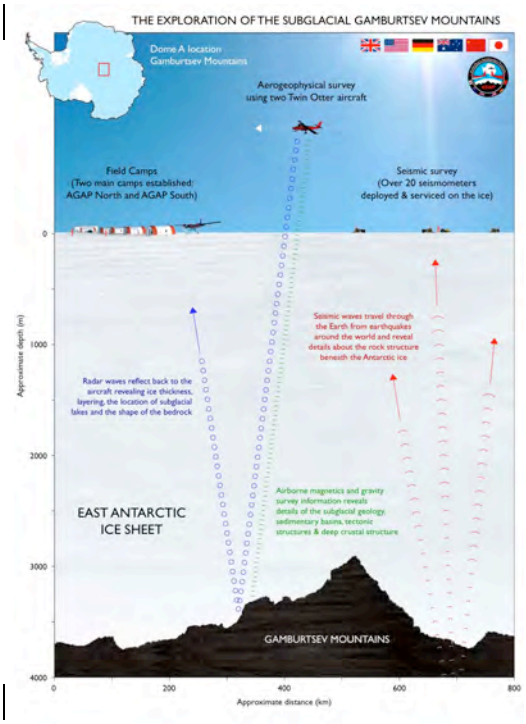
Some problems are too hard to solve alone, and some places are too hard to go to. The Gamburtsev Mountains are deep in Antarctica lying beneath Dome A (the highest and perhaps the coldest place on the East Antarctic Ice Sheet), and just west of the Pole of Inaccessibility. This location is so remote that it is difficult and expensive for any single country to reach and to work from. The International Polar Year **(IPY)** provides opportunities for countries to work together to plan projects and share their resources, and results. This study involved scientists from SEVEN countries: U.S., Great Britain, Germany, Australia, China, Canada, and Japan.



The elevations at each location is:

- South Pole 9,186 ft.
- AGAP N. 9,843 ft.
- AGAP S. 11,482 ft.
- Dome A 13, 000 ft.

Hidden Mountains: The AGAP project focused on an airborne geophysical exploration of the interior section of the East Antarctic ice sheet. 50 years ago, a Russian overland crossing (traverse) found evidence of a mountain range hidden 3 km below the ice. They located the peaks by setting off seismic explosions, which sent sound waves down into the Earth. From the wave returns, they learned that the surface of the Earth was much closer to them than they had expected. They had found a hidden mountain range! They named the range Gamburtsev after one of their great geophysicists.



Airborne Geophysics: An overland traverse and seismic explorations are very useful for collecting science information, but to survey a large area, airborne geophysics collected by flying track lines in an established grid allows you to cover a much larger area. Think of the grid lines like mowing the lawn! A pattern of lines are set out in an area and planes fly back and forth collecting data just like passing a mower over the lawn. Unlike the blades on a lawnmower, the tools this project will use are radar to image through the ice sheet, magnetics to look at the composition of the underlying bedrock, and gravity to determine size and density of the underlying structure. Together they will peel back the roughly 4 km-deep layer of ancient glacial ice, to expose the mountains and lakes hidden below to develop a better understanding of their origin and how they interact and influence the overlying ice sheet.

TERMS YOU SHOULD KNOW (VOCABULARY):

Precambriam – old geologic time ~500 mya

Craton – old piece of continent – a stable part of continental crust

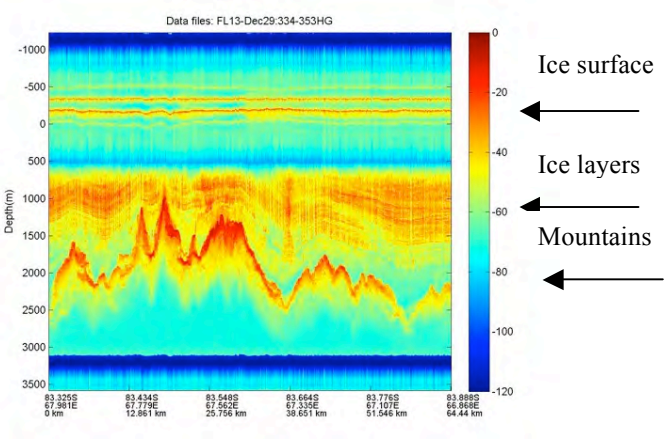
Ice core – sample of an ice sheet collected by drilling a hole through the ice; serves as a proxy to inform us about climate in the past.

IPY – International Polar Year (IPY) is a 125 year old concept when scientists around the globe work together to solve scientific questions and problems in the polar regions

Dome A – Highest point on the East Antarctic Ice Sheet

Pole of Inaccessibility – way in the interior of the Antarctic continent, the point furthest away from any point on the coast. **Fun Fact:** There was a statue of Vladimir Lenin (former Soviet leader) left here in 1958 by the Russians! He is still there facing his homeland of Russia!

WHY ARE WE STUDYING THIS IN THE POLAR REGIONS?

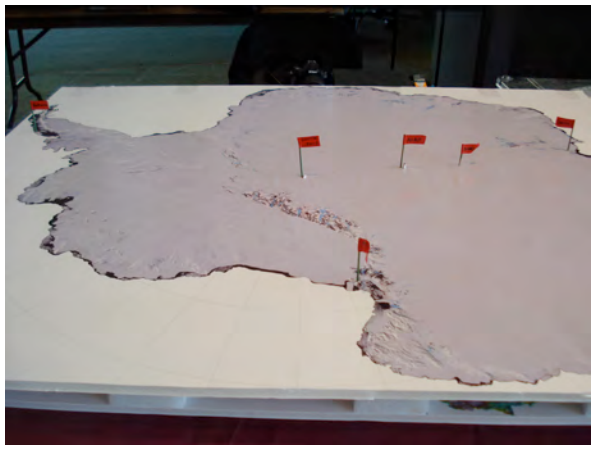


These are Mysterious Mountain Ranges – Mountains are normally formed by either (1) continents colliding into one another; OR (2) hot spots creating volcanoes as they push up OR (3) continents tearing apart. None of these have happened recently in East Antarctic. There is no good reason for a mountain range to be there. Geologists have classified this area of Antarctica as part of a Precambrian craton (a 500 million year old piece of continental crust). This is a big mountain range, about the size of the European Alps!! SO how did it end up in the middle of this old stable continent? The image shown here is straight from the field! This is what the scientists were seeing on their screens. The red reflection is the top of the underlying mountain range.

This is Changing Ice - Ice sheets are continually changing and subglacial lakes and underlying water seems to be an important part of this movement. Water moves under the ice sheet through a complex system of under-ice rivers, streams, lakes and even swamps. Scientists believe water under the ice sheet lubricates the underside of the ice making the ice sheet slide faster – like greasing the underneath. The moving water seems to have a direct link to ice sheet stability.

HOW DOES THIS AFFECT US HERE IN THE UNITED STATES?

We can study ice sheet formation and stability by looking at the Gamburtsev Mountains in East Antarctica since ice sheet modelers feel that the mountains are a key starting point for the ice sheet. Ice sheet formation and stability is key to understanding future impacts of ice sheet change and global sea level rise. The East Antarctic ice sheet is the largest in the world and slow to change, but it holds enough water to contribute ~ 230 feet to Sea Level Rise. When we say slow to change, keep in mind that scientists estimate that the Antarctic ice sheet took ~800 thousand years to grow to its current size.



THE INTERACTIVE MAP OF ANTARCTICA

ACTIVITY YOU CAN TRY:

Make your own Antarctica: Attached are 3 maps for this project. Start by printing the two full sheet attached maps from LIMA (Landsat Image Mosaic of Antarctica) for the overlying ice sheet and Bedmap (Bed topography of Antarctica) for the underlying bedrock on $8^{1/2}$ X 11 paper. Back them with tagboard or poster board (*Alternative*: *cardboard*). Then use small pieces of Styrofoam placed around the edges to keep the ice sheet map elevated from the bedmap. You now have an ice sheet over the continent of Antarctica.

Next, we will mark the camps and bases using toothpicks with red flags made of colored tape, or paper. Use the maps below and the above write up to locate the South Pole, McMurdo station, Palmer station and the AGAP camps. Now create some of the features under the ice sheet – you can use clay, construction paper or you can just draw on the map with colored markers. Use the maps and information provided in the various images in this packet to locate and create small versions of some of the features under the icesheet such as: Lake Vostok, The Transantarctic Mountains, Mt. Sidley the highest Antarctic volcano 4,285m (14,058 ft), Vinson Massif 4,897m (16050 ft) and the Gamburtsev Mountains.

TO LEARN MORE ABOUT THIS TOPIC: http://www.ldeo.columbia.edu/agap

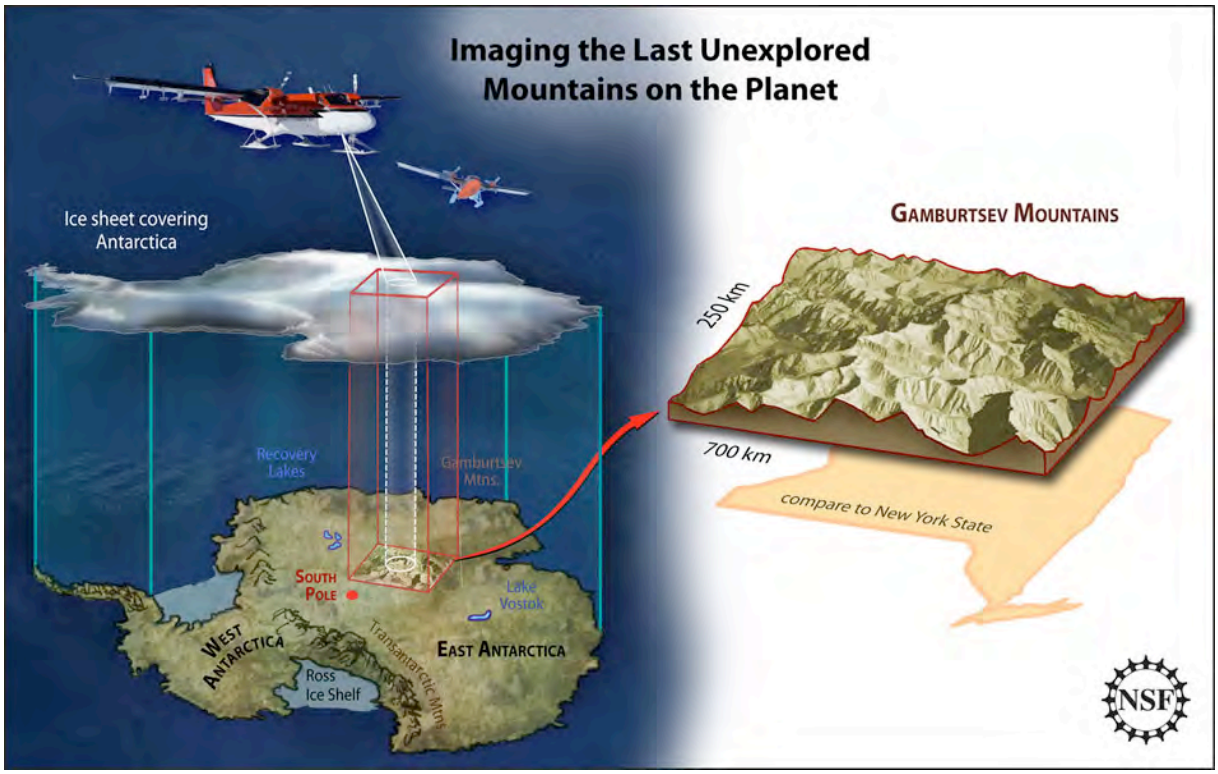
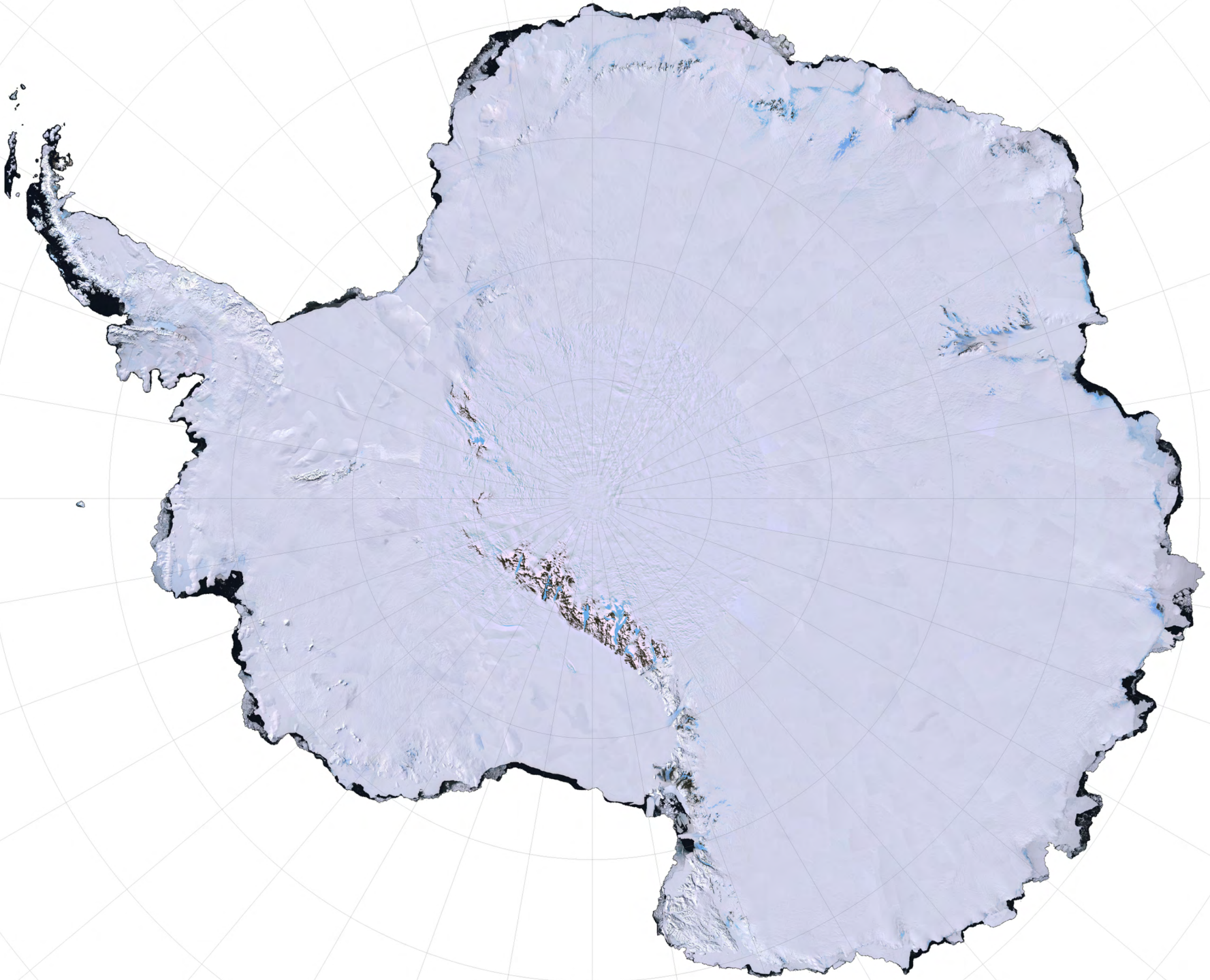
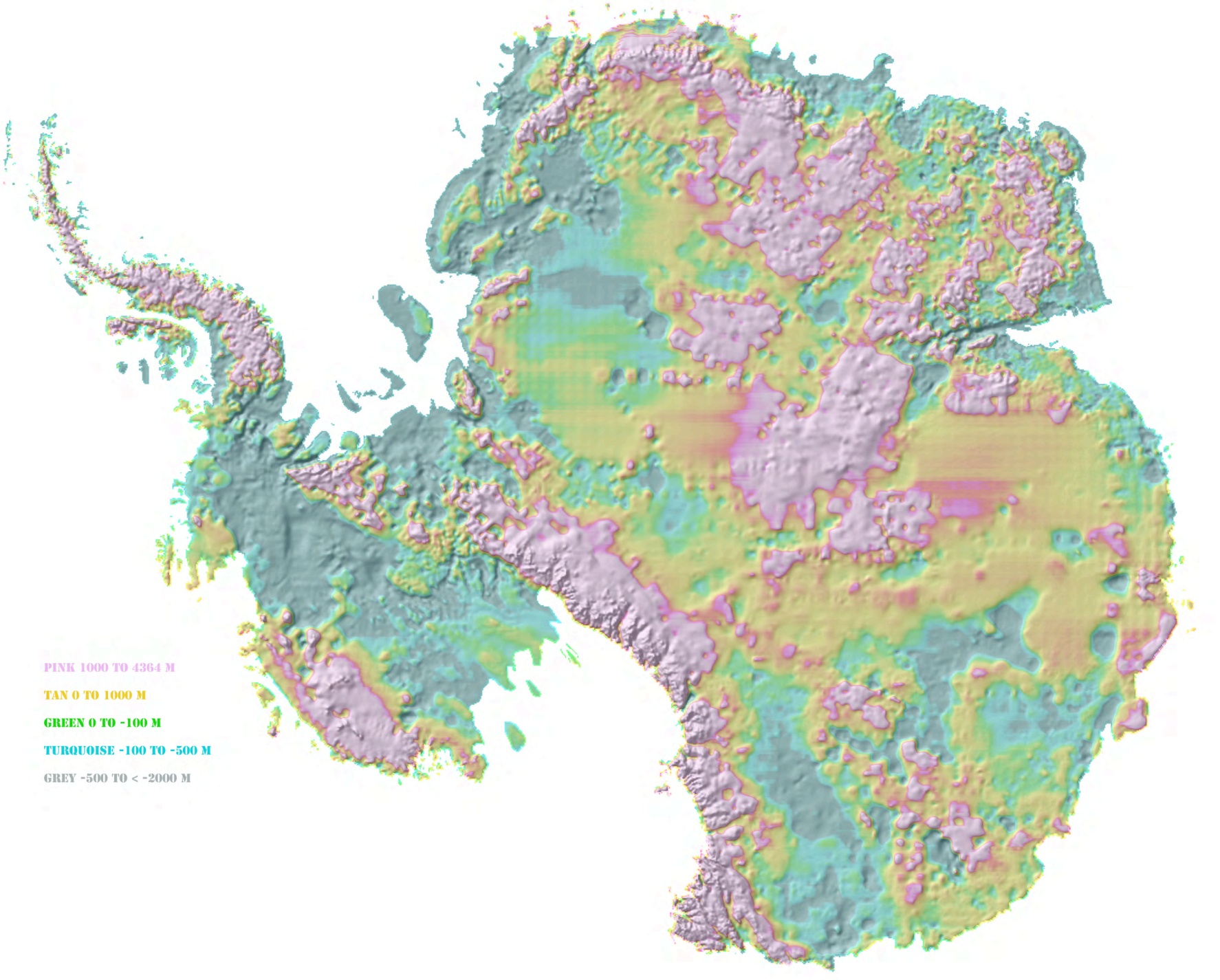


Image of Ganburtsev Mountains under the ice sheet by Zina Zeretsky

Map from LIMA, http://lima.usgs.gov/

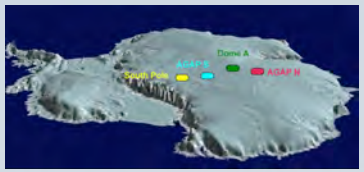



PINK 1000 TO 4364 M
TAN 0 TO 1000 M
GREEN 0 TO -100 M
TURQUOISE -100 TO -500 M
GREY -500 TO < -2000 M

The Heart of Antarctica: Scientists Uncover the Earth's Last Hidden Mountain Range

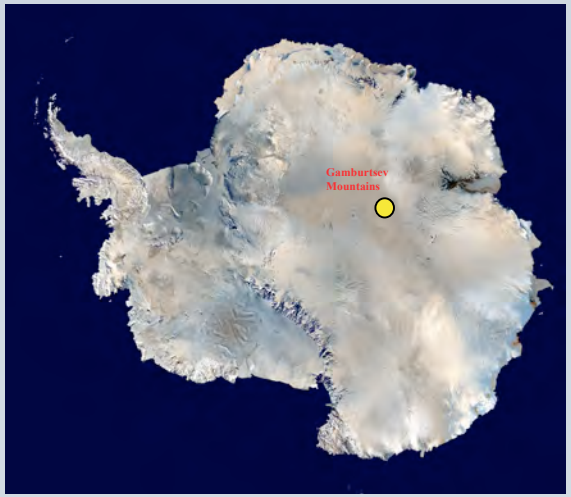
WORK IN ANTARCTICA

Operating from two newly constructed base camps with 3000 pounds of cargo, science teams mounted a 10 week expedition during the austral summer while temperatures hovered at -30 degrees F. Three aircraft and ground crews gathered information. Using radar, magnetics, lasar and gravity equipment, scientists imaged from the surface of the ice sheet all the way down to the bedrock at its base. Seismometers installed in the ice listen for earthquakes. When combined the data will provide an image from the top of the ice to hundreds of miles below the ice surface.



THE SCIENCE PROCESS

Using small twin otter aircraft to carry the equipment, and often flying 20 hours a day, researchers collected data over 74,500 miles. Imaging the 400 mile long Gamburtsev Mountain range meant collecting data over an area the size of New York State.



The AGAP project focused on an invisible world in one of the most remote areas on Earth, East Antarctica. Organized as part of a large international effort through the fourth International Polar Year, the project peeled away the roughly 2 mile deep layer of million year old glacial ice, to expose the mountains and lakes hidden below. Working from two camps, AGAP-S and AGAP-N, the scientists and technical crew embarked on one of the major scientific expeditions of our century.

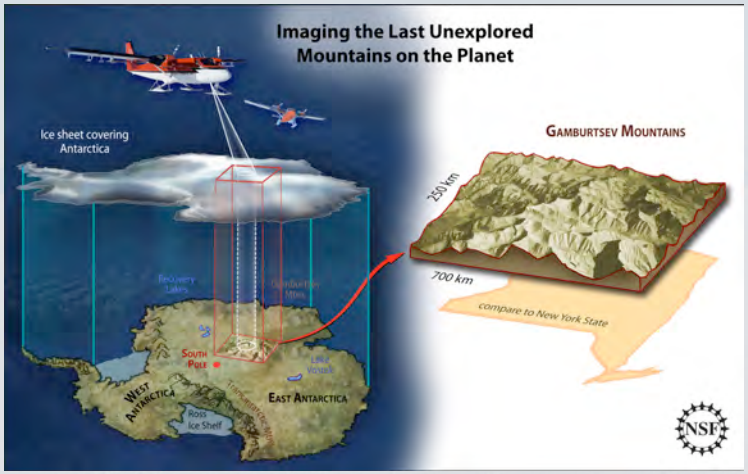
WHAT DO WE SEEK TO LEARN?

There are many important science questions that the research teams hope to answer with the data collected…Perhaps the most important is how these mountains MAY be linked to ice sheet formation and global changes in climate. The East Antarctic Ice Sheet formed 35 million years ago when the climate suddenly cooled. Were these hidden mountains the birth place for the existing East Antarctic Ice Sheet, the largest remaining ice sheet in the world…fully seven times larger than any other?

Understanding how the climate system relates to the ice sheet and the land forms that lie below is key to predicting how the ice sheets will respond to climate change and influence sea-level rise.

SEEING THROUGH THE ICE

Below is a graphic created from the collected data sets. This example shows the survey area bedrock topography (the ground surface) overlain by ice surface elevation. From images like this we can begin to actually see 'through the ice' and understand the land formations that lie below, and how they might interact with the ice sheet.

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Lamont Team Heading up the Project

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For more information, please visit:

http://www.ldeo.columbia.edu/agap