Marine Glacial formations in the Eastern Ross Sea

Scientific discovery is often serendipitous. In February of 2004 an earth science research expedition was conducted aboard the N.B Palmer in the Ross Sea, Antarctica. The scientists came to the Ross Sea to gather seismic and sonar data in the area to help them to understand marine volcanism and tectonic structures in this region of Antarctica.

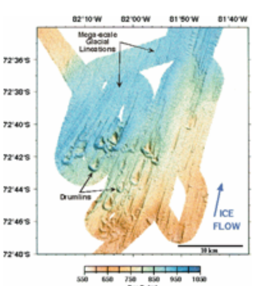
Much of the attention on the cruise was paid to identifying volcanic features like marine seamounts and vents and structural features of tectonic origin like faults. What became clear during the cruise was that the sea floor in this area had been dramatically affected in some of the areas by past glaciers.

Background Information

A primary goal of this activity is to establish a growing, collaborative Polar Learning Community of teachers, students, and researchers. This collaboration has been facilitated through the efforts of researchers at the University of Texas Institute of Geophysics. In 1995, and 2004, Steven Stevenoski, a high school science teacher from Wisconsin had an opportunity participate in a two geophysics research cruises in Antarctica. On both cruises he worked with Dr. Lawrence Lawver, UTIG, conducting marine seismic geophysics surveys. In 2004 Dr. Terry Wilson, Ohio State, collaborated in the research. These scientists made this data available for student investigation following the 2004 cruise. Initial presentations of the data were made at the 2004 AGU Fall Meeting by Lawver, Wilson and Stevenoski and at the 2004 NSTA National Conference by Stevenoski.

This student inquiry has been piloted at two locations. The project has been used at Lincoln High School, Wisconsin Rapids, WI during the 2005 and 2006 school years. During the summer of 2005, Turtle Haste used the data at the John's Hopkins summer program with the Center for Talented Youth at Stanford.

Possible models for the formation of the Pepperoni Features:



SEAMOUNTS: Suggestions that the pepperoni are volcanic features are less likely. Magnetic data from a variety of sources show large magnetic anomalies in this region of the Ross Sea associated with both marine and terrestrial volcanic features. Near to the pepperoni features are sea mounts that have large magnetic and gravitational variation which is expected for these volcanic features. The pepperoni did not show variation in either the magnetic or gravity data indicating that they were not volcanic in origin.

TUYAS: Typical sub glacial volcanic features called tuyas are nearly circular in structure just similar to the pepperoni features are.

DRUMLINS: These features demonstrate the classic drumlin form in terms of their elevation. The slope in the direction of the advancing ice edge is very steep. In those observed the change in elevation is 100 meters over a distance of .2 km. In the opposite direction, a tapered gradual slope is found in classic drumlins and also those observed in the Ross Sea. Those in the Ross Sea had a change of 100 meters in elevation over a distance of 2.0 km. This data is consistent with drumlins observed in terrestrial deposition.

PINGOS: Pingos are typically formed by uplift of large blocks covered by earth which form large mounds as the ice moves upward. These features are not associated with glaciers. Pingos can also be formed as a result ob the uplift of gas hydrates, which are a type of crystalline ice solid in which gas molecules are trapped between the frozen water molecules

OTHER IDEAS: Possible reasons for the circular shape of the pepperoni may be due to marine deposition rather than terrestrial deposition. The Ross Sea formations have been protected from weathering in their marine environment and these formations are associated with ice sheets that are still present. The pepperoni showed little reflectivity in the bathymetric data. Sub glacial formations typically have glassy basalts that would have high reflectivity in the bathymetric data.

ACTIVITY

The data is made available in the form that the scientists would use, topographic maps of the seafloor showing position, distances and elevations. Given this information and additional student research on glaciers and glacial land features these are some sample questions that could be answered.

QUESTIONS:

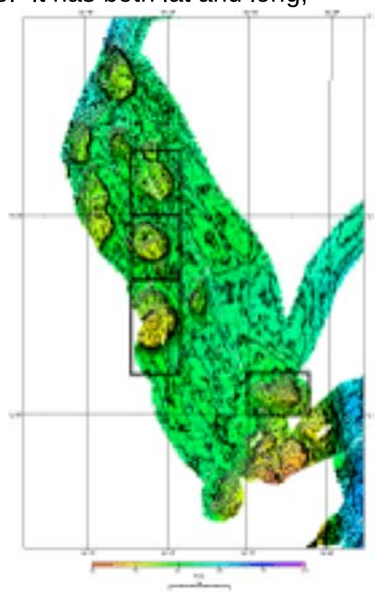
- What evidence is there to suggest that these features are drumlins?
- What evidence is there to suggest that these features are formed by some other method than by glaciers?
- Normal drumlins on land are teardrop shaped, why are these features circular?
- In what direction was the receding glacier moving and where are the remains of that glacier today on Antarctica?

ANALYSIS

Students and scientists will both have the opportunity to analyze these data to understand these features. This is a unique opportunity for students to take the lead in interpreting the origin of these previously unseen marine formations. The goal of this investigation is to use the data from an inquiry based focus for students to develop their own hypotheses for the origin of these unique formations. Students and teachers will be encouraged to share their conclusions with one another and with the scientists through an online community established at The University of Texas Institute for Geophysics at Austin. This is intended to be a long-term project with additional marine polar data sets added for student analysis in the future.

MATERIALS

The original contour map of the Ross Sea floor is provided for the students. It has both lat and long, scale and contour intervals given. The "pepperoni" features are identified in boxes labeled a, b, and c. A fourth box, labeled, d is an example of a seamount.



Each of the four boxes has been enlarged so that the contours can be more easily identified.

PROCESS

Divide the students into groups of 4, each given a different feature to work with. (This can also be done as an individual project as well.)

Have the students create longitudinal graphs through the feature so that they can get a perspective of shape of the feature if they were standing and looking at it from the side. They should work together so that the scales of the graphs are the same for the four features. Once the graphs are completed they should create a list of similarities and differences.

Students should be given the option of creating scale 3D models of their features. This will help them visualize the feature and help them to make comparisons between typical glacial and geological features found on land.

Students then should begin by answering the questions given above. The teacher or the group may come up with other questions as well.

The group should come up with a consensus of what they think they thing these features are. The final report may be in the form of a scientific journal article, poster, presentation, or other determined by the teacher.

EVALUATION

CATEGORY	4	3	2	1
Participation	Used time well in lab and focused attention on the experiment.	Used time pretty well. Stayed focused on the experiment most of the time.	Did the lab but did not appear very interested. Focus was lost on several occasions.	Participation was minimal OR student was hostile about participating.
Data	Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in written form, but no graphs or tables are presented.	Data are not shown OR are inaccurate.
Analysis	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends or predictions are made based on the data.	The relationship between the variables is not discussed.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.
Components of the report	All required elements are present and additional elements that add to the report (e.g., thoughtful comments, graphics) have been added.	All required elements are present.	One required element is missing, but additional elements that add to the report (e.g., thoughtful comments, graphics) have been added.	Several required elements are missing.

RESOURCES

Pepperoni and Gas Hydrates links:

http://gsc.nrcan.gc.ca/beaufort/pingos_e.php

http://arctic.fws.gov/permcycl.htm
http://www.mbari.org/news/news_releases/2003/paull_pingos.html
http://www.mbari.org/news/news_releases/2007/paull-plfs.html
http://www.eurekalert.org/pub_releases/2007-02/mbar-mbt020607.php
http://energybulletin.net/26624.html
http://energybulletin.net/news.php?cat=8

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- Observations of the grounding-line area at a floating glacier terminus, R.D. Powell, M. Dawber, J.N. McInnes, Department of Geology, Northern Illinois University, A.R. Pyne, Antarctic research Centre, Victoria University of Wellington, Wellington, NZ, Annals of Glaciology 22 1996,
- Subglacial and Submarine Volcanism in Iceland, S.P. Jakobson, Icelandic Institute of Natural History, Mars Polar Science 2000
- Constraints on the Former Antarctic Ice Sheet from Sea-Level Observations and Geodyunamic Modelling, D. Zwart, K. Lambeck, M. Bird, J. Stone, The Antarctic Region: Geological Evolution and Processes 1997, p 821-828
- Aeromagnetic Evidence for a Volcanic Caldera(?) Complex Beneath the Divide of the West Antarctic Ice Sheet, J.C. Behrendt, C.A. Finn, D. Blankenship, R.E. Bell, Geophysics Research Letters, v25, no. 23, Dec 1, p.4385-4388, (1998),.

STANDARDS

National Science Standards - http://www.nap.edu/readingroom/books/nses/
Texas Science Standards - http://www.tea.state.tx.us/rules/tac/chapter112/index.html
Science Benchmarks - http://www.project2061.org/publications/bsl/online/bolintro.htm
Science for All Americans - http://www.project2061.org/publications/sfaa/online/sfaatoc.htm
Online searchable index of the Science Benchmarks
http://www.sciencenetlinks.com/benchmark_index.htm
GAS website provides links to all state standards - http://www.geosociety.org/educate/standards.htm