National Aeronautics and Space Administration

RADAR REFLECTIVITY EXPERIMENT

Measurements for volcano and earthquake monitoring

Garrett J. Benjamin
California State University Fresno
Science Teacher and Researcher (STAR) Program
Dr. Friedemann T. Freund
Principal Investigator at the SETI Institute
Senior Scientist at the NASA Ames Research Center

Abstract

This experiment is a further continuation of the research done by Dr. Friedemann Freund, Dr. Robert Dahlgren, and Colin Williams in 2009. This experiment showed a ~5% increase in radar reflectivity on the cold surface of a rock when a sub-volume of the rock heated. Before large earthquakes and volcanic eruptions the earth sends out signals. Increased stress and temperature activates electronic charge carriers within the Earths crust.

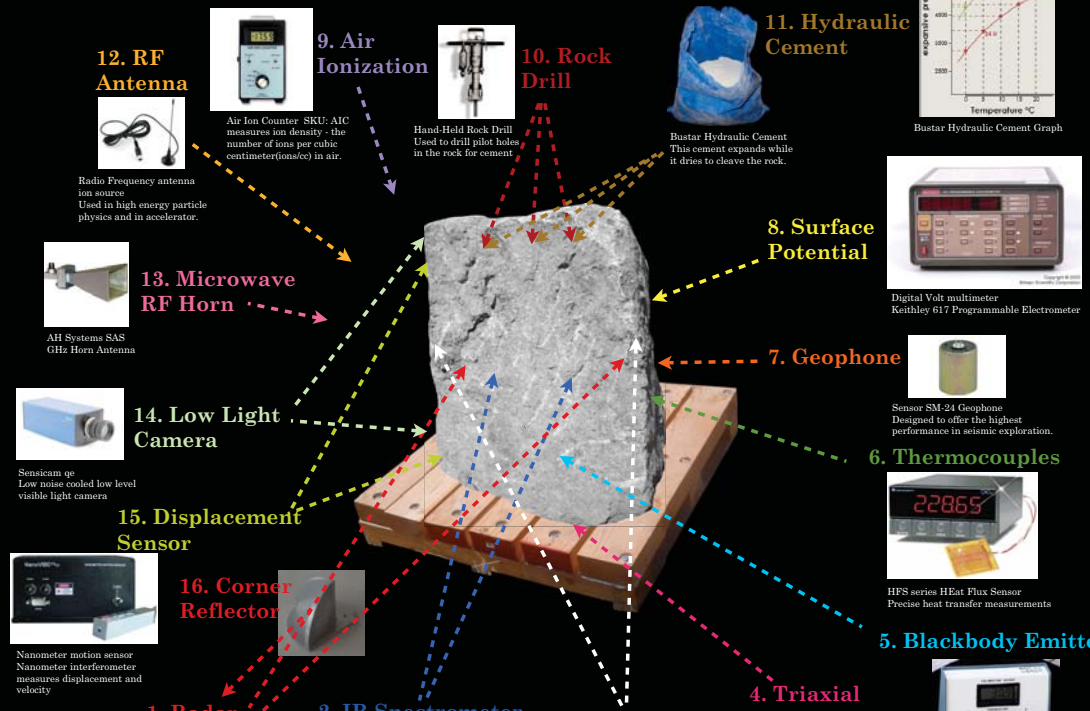
This experiment involves stressing large granite boulders with hydraulic cement inserted into the rock. Many tools will be used in monitoring the rock. Each one of these monitoring devices will observe changes as a function of time during build-up of stress prior to rock fracture.

Introduction & Theory

Before earthquakes and volcanic activity occur increasing stress and rising temperatures activate mobile electronic charge carriers in rocks deep in the Earth's crust. These charge carriers are known as positive holes and are remarkable in their ability to diffuse out of rocks. When the positive holes arrive at the Earth's surface they lead to a range of processes that can be detected remotely by satellite assets.

We plan to conduct lab experiments measuring the effects on 2-4 ton rocks. Using hydraulic cement inserted into the rocks over time will generate large amounts of pressure to cleave the rock. During this build up of pressure many analytical tools will be used.

Equipment & Methodology



12. RF Antenna

Radio Frequency antenna
ion source
Used in high energy particle physics and in accelerator.

9. Air Ionization

Air Ion Counter SKU: AIC
measures ion density - the number of ions per cubic centimeter(ions/cc) in air.

10. Rock Drill

Hand-Held Rock Drill
Used to drill pilot holes in the rock for cement

11. Hydraulic Cement

Bustar Hydraulic Cement
This cement expands while it dries to cleave the rock.

Bustar Hydraulic Cement Graph

13. Microwave RF Horn

AH Systems SAS
GHz Horn Antenna

8. Surface Potential

Digital Volt multimeter
Keithley 617 Programmable Electrometer

14. Low Light Camera

Sensicam qe
Low noise cooled low level visible light camera

7. Geophone

Sensor SM-24 Geophone
Designed to offer the highest performance in seismic exploration.

6. Thermocouples

HFS series HEat Flux Sensor
Precise heat transfer measurements

15. Displacement Sensor

Nanometer motion sensor
Nanometer interferometer measures displacement and velocity

16. Corner Reflector

5. Blackbody Emitter

Blackbody Calibration source
PYRETHRUM CS
Used in calibration of the ground penetrating radar.

1. Radar

Ground-penetrating Radar
PulseEKKO 1000
Radar pulses to image the subsurface of rocks

2. IR Spectrometer

Infrared Spectrometer Vertex 70 Bruker
Measures the infrared region of the electromagnetic spectrum

3. IR Camera

Infrared camera Cyclops TI 814
Thermal imaging camera
Forms images using infrared radiation

4. Triaxial magnetometer

Inductive Magnetometers
Zonge Instruments
Measures the strength and direction of the magnetic field

Left to right - 3 rocks prepped for experiment and 2.2 ton rock and Garrett prior to transport

Results & Conclusion

Currently, there are no results to report. The experimental set up and guidelines are still being worked out with NASA officials and the Safety committees at NASA Ames Research Center. We however predict that our results will show similarities to the 2009 pilot study. This pilot study using 1.2 GHz radar showed a ~5% increase in radar reflectivity off a smooth gabbro surface. The reason for this is believed to because of the large numbers of positive holes arrive at the surface. A ~5% change in the radar reflectivity could easily be observed in synthetic aperture radar (SAR) images. Such changes could indicate a run up of stress leading to fault line failure.

Future Work

The long-term goal is to determine whether changes in radar reflectivity presage earthquakes or volcanic activity. Based on preliminary findings radar reflectivity holds promise to be an indicator for pre-earthquake and volcanic activity. This concept will lay the foundation for further work to apply this concept to satellite missions with radar capabilities. Our project has the potential of revolutionizing NASA's Natural Disasters Plan and this country's approach to national and global challenges posed by earthquakes and volcanoes.

Acknowledgements

SETI Institute, NASA Ames, STAR Program, National Science Foundation California State University Fresno, Edna DeVore, Pamela Harman, Bob Dahlgren, Tom Bleier, Matthew Stemm, Gary Cyr, John Keller, Bryan Rebar, and Colin Williams.

Plastic Pallets used for a platform in the experiment

www.nasa.gov

Thursday, July 22, 2010