Sandi
DOE plans on using this dating technique in addition to other dating techniques in fluid inclusion study. Pls. pass a copy on to Bret and Phil.
Thanks,
Chad
7/21

SEMINAR ON

"APATITE (U-Th)/He CHRONOMETRY: A NEW TECHNIQUE FOR DATING THE COOLING OF ROCKS THROUGH VERY LOW TEMPERATURES"

by

Prof. Ken Farley
Division of Geological and Planetary Science
California Institute of Technology

at

2:30 PM, Wednesday, July 14

in

Keystone Room
WRD National Training Center
Bldg. 53
Denver Federal Center

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My research centers around noble gas geochemistry and its applications to a range of Earth Science problems. Below I describe my laboratory facilities and several of the projects we are currently pursuing.

Caltech Noble Gas Lab

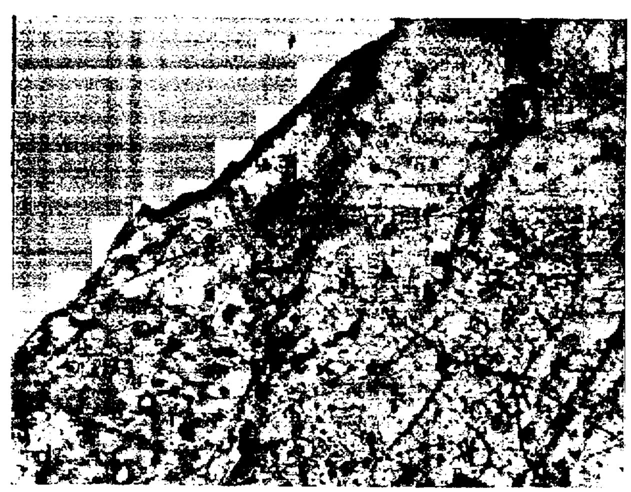
My laboratory consists of a MAP 215-50 noble gas mass spectrometer and associated vacuum systems for the analysis of the abundance and isotopic composition of helium, neon, argon, krypton, and xenon. A second system, based on a BALZERS Quadstar quadrupole mass spectrometer, is used for high precision noble gas abundance determinations using isotope dilution. Both instruments are fully automated for high sample throughput and improved reproducibility. We can extract noble gases from a variety of geological materials including water and gas samples, for example as collected from volcanic hotsprings. We can also release noble gases from rocks, minerals and sediments using vacuum crushing, conventional vacuum fusion, and heating with a Q-switched Nd-YAG laser. After extraction the noble gases are purified of contaminants such as CO_2 and N_2 using SAES getters, and adsorbed on a variable temperature (8 - 450 kelvin) cryogenic cold trap built by Janis Research. The individual noble gases are then thermally desorbed and analyzed with the mass spectrometers. The laboratory automation system is run by custom software created with Labview.

Current Research Activities

Isotope Geochemistry of Ocean Islands

Lavas erupted at ocean island volcanos (such as Robinson Crusoe island[5], left) have diverse chemical and isotopic compositions which constrain the evolution of the Earth's interior and atmosphere, the return of material to the Earth's interior at subduction zones, and the process of formation of volcanic rocks. I am particularly interested in the isotopes of helium, which show that the Earth's interior has experienced variable degrees of outgassing to form the atmosphere. We have recently investigated the He isotopic composition of lavas from Papua New Guinea[24], the North American Basin and Range Province, Kauai (Hawaii), and American[2] and Western Samoa[14].

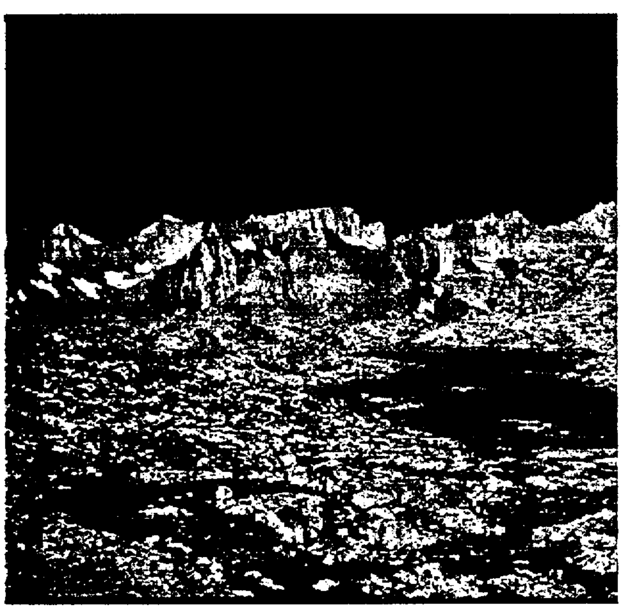
The heavier noble gases (neon, argon, krypton, xenon) also have an interesting story to tell about planetary evolution[29]. Unlike helium, which is not retained by the Earth's gravitational field, these gases have accumulated in the atmosphere from volcanic emissions throughout the history of the Earth. By comparing the composition of the atmosphere with the Earth's interior it is possible to constrain when and how the atmosphere formed. The key to this field is



high precision, low-blank analyses, and this is the driving force behind the laser extraction system in my laboratory. We have measured the Ne-Ar-Xe composition of CO_2-dominated fluid inclusions in some extraordinary xenoliths (pieces of the mantle entrained in lavas) from Samoa[3] (photomicrograph at right).

In a collaborative project with Ed Stolper and post-doc John Eiler here at Caltech and John Valley at the University of Wisconsin we have been extracting oxygen from ocean island olivines. The isotopic composition of oxygen in olivines records interaction of mantle magmas with shallow crustal material, and also provides unique confirmation of "crustal recycling"- the processing of subducted crust into the mantle and back into magmas which are erupted at ocean islands. We have worked on lavas from Pitcairn Island[16], Hawaii[20], and a variety of other localities[21].

Cooling Histories from Helium Thermochronometry



In the last few years we have developed a new technique for establishing very low temperature cooling histories of rock masses. Thermal histories are important for example for studying tectonic histories, especially mountain range exhumation, and for resource exploration (e.g., hydrocarbon maturation). The technique is based on the radioactive decay of uranium and thorium to ^4He in the mineral apatite. At elevated temperatures characteristic of the crust at a depth of a few km, helium diffuses from apatite as rapidly as it is supplied by radioactive decay. As rocks cool, the rate of helium diffusion drops exponentially; above about 80°C, we have found that helium is almost instantly lost, but is quantitatively retained by 40°C[19]. By measuring He, U and Th concentrations in apatite crystals we can calculate how long it has been since the crystal cooled through the critical interval 40-85°. We have undertaken theoretical[30, 18] and laboratory studies of the relevant phenomena, and have applied the technique to the San Jacinto[23] and San Bernardino Mountains[28] near Palm Springs, CA. Along with Brian Wernicke and Martha House, we have investigated helium ages of the Sierra Nevada[26, 33] (left, at the Kern-Kaweah Divide) as part of a major program for understanding this range.

Cosmic Dust in Seafloor Sediments

Geochemical investigations using the element Iridium have demonstrated that the major species extinction horizon that marks the end of the Cretaceous Era (65 million years ago) was caused by the catastrophic impact of a large extraterrestrial object with the Earth. This event demonstrates that the Earth's biological and climatic systems are very sensitive to the accretion of material from space. While Iridium provides a tool for recognizing large, episodic impact events, it is not very sensitive to the large and temporally continuous accretion of cosmic dust (photomicrograph, left, showing 10 micron grain) submillimeter grains which rain down at a rate of about 40 million kg per year.

I have recently worked to determine the accretion rate of cosmic dust back through time, by analyzing the rare isotope ^3He in deep sea sediments. This isotope is extremely abundant in extraterrestrial matter, and in most seafloor sediments more than 95% of the ^3He derives from cosmic dust. My results reveal striking variations in the cosmic dust accretion rate with time, which, intriguingly, are temporally correlated with both large impact events[15] and global glacial cycles[17]. I am presently working to understand whether these correlations indicate causality, or are simply coincidental. Confirmation of a causal relationship would provide critical insights to the behavior and sensitivity of the Earth system to extraterrestrial events. My most recent work seems to suggest the occurrence of a comet shower - a period of strongly enhanced cometary activity, possibly caused by gravitational perturbations associated with passage of a star close to our solar system - at 36 million years ago[34].

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Current Teaching

1. Ge-101 Introduction to Geology and Geochemistry
2. Ge-149 Marine Geochemistry
3. Ge-236 Noble Gas Geochemistry

Publications

Last Updataed January 1998

Want a reprint or preprint? Contact me: **farley@gps.caltech.edu**

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