GeoEarthScope

Geochronology Working Group Report

September, 2006

GEOEARTHSCOPE
GEOCHRONOLOGY WORKING GROUP

REPORT AND RECOMMENDATIONS
FROM JULY 18 AND 19, 2006 MEETING

8/31/06

Boulder, CO – as viewed from the Marriott! – July 19, 2006

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OVERVIEW

The EarthScope initiative strives to generate an improved understanding of the four dimensional structure and evolution of the North American continent. A multi-disciplinary approach has been launched to achieve these goals with seismology, geodesy, deep drilling across an active segment of the San Andreas fault, and remote sensing being the major tools to look at current lithospheric structure and active deformation. In order to understand longer-term rates of deformation and the evolution of continental structure through time, geochronologic methods coupled with field studies are critical. It is this geochronologic component or “Geoearthscope” that is key to engaging geologists in the EarthScope program. Geologists with an array of interests that span the spectrum from earliest continental genesis (or formation) to modern surface processes will be able to participate in EarthScope through the Geoearthscope , and it will be these scientists who provide the 4^{th} dimension to the North American geoscience picture

Different geochronologic methods target different time scales from tens to billions of years. In order to understand continental evolution that spans 10^9 years it is important that Geoearthscope incorporate a complete array of methodologies. Short term methods such as ^{14}C, cosmogenic isotopes, and luminescence techniques will further serve to tie geologic studies to geodetic results.

Aspects of the EarthScope initiative, such as USArray, are intended to carryon over a ten year period. During such a period, geologic investigations will require millions of dollars to accomplish the collection of field and geochronologic data. As the Geochronology Working Group for GeoEarthScope, our mission was to make a recommendation for the spending of a <$5 million budget that is to be split between LiDar, InSar, and Geochronology activities. For this phase of geochronology data acquisition, we recommend that $2.0-1.5 million be allocated to geochronology laboratories that span an array of methodologies appropriate for time scales from tens of years to several billion years.

MEETING DETAILS

The Geochronology working group met July 18^{th} and 19^{th}, 2006 at the UNAVCO facility in Boulder, Colorado. Group members present included: David Mogk, Anne Blythe, Jim Spotila, David Schwartz, and Mary Hubbard, Chair. Eric Kirby participated by teleconference. Members that were unable to attend include: Ramon Arrowsmith, James Beget, and Tom Rockwell. David Phillips introduced the mission of the working group and Will Prescott introduced the role of UNAVCO. Preliminary results from a national survey on Geochronology Capacity in the United States helped inform discussions about the current state of geochronology in the US and future needs.

The working group focused discussion on the topics:
1) Contribution of geochronology to EarthScope goals
2) Geochronologic methods that best meet goals

3) How to disperse the geochronology budget to labs to create credit for future analyses
4) How to communicate the availability of this credit to investigators in need of age data
5) Recommendations for RFP
6) Proposal review criteria

EARTHSCOPE GOALS AND GEOCHRONOLOGY

Geologic processes that shape our planet include catastrophic events that happen over a period of seconds or minutes, and longer developments that may take tens of millions of years. Rocks that make up our continents include recent volcanic deposits that formed several minutes ago and rocks that formed more than four billion years ago. In aggregate, the North American continent is a product of processes of all time scales and consists of rocks from a broad span of ages. The geology of our continent is what has sustained life on the continent and has contributed to the sustenance of our lifestyle. Rocks break down to form the soil that supports our crops. Flooding rivers have nourished those soils. Geologic hazards force us to think and re-think how and where we live and how we build our structures. Hydrocarbon and mineral resources from the crust have provided us with energy and raw materials. The goal of EarthScope is to integrate data from a variety of geoscience techniques in order to understand the three dimensional structure of North America and how it developed through time. It is this time component that must be accessed through geochronology. Improving our understanding of the geologic history of our continent will allow us and future generations to better manage and utilize geologic resources and live with geologic hazards.

Currently the EarthScope data collection is focused along the Pacific/North American plate boundary. Methodology in progress includes: seismology, GPS, strain measurements, and drilling of the San Andreas fault. Upcoming methods will include LiDAR and InSAR. Generally these methods address the current deformation of the crust through the location of faults and the tracking of strain over a several year period. Seismology can provide insight regarding deeper structure of the crust, but the not the timing of structural development. In order to extend our knowledge of crustal evolution back in time we need geochronologic data regarding the age of rocks, the cooling history of regions, the surface residence time of rocks, etc. This data can be coupled with other geologic, geophysical, and geochemical data to complete our understanding of processes responsible for building our continent including the formation of resources, and the development of hazardous settings. In short, "No dates, no rates."

GEOCHRONOLOGIC METHODOLOGY

We recognize that there is an array of geochronologic methods that have different applications to geoscience studies. Geochronology is not a one-size-fits-all proposition; each method has its own requirements in terms of sample selection, sample preparation, analytical methods, data reduction, and interpretation of results. Some techniques (e.g. ^{14}C) readily yield single ages without a need for unusual intervention on the part of the analyst, whereas, other techniques (e.g. long-lived radioisotopes) require careful characterization of samples (e.g. CL and BSE imagery, Xray elemental maps of zircons and monazites) and application of more than one isotopic system (e.g. U-Pb, Lu-Hf, Nd-Sm). Even the choice of instrumentation (e.g. TIMS v. LA-ICPMS) will yield significantly different results with respect to precision and accuracy. The best approach to obtaining geochronologic data must be determined judiciously by collaboration between geologists and geochronologists to obtain meaningful results that will answer the key scientific questions; i.e. the right tool for the right job.

For purposes of discussion we categorized methods in three groups: short term, mid-term, and long-term. Short term methods date rock age, rock exposure, or cooling through a closure temperature on the timescale of zero to several hundred thousand years. There are many techniques in this category including ^{14}C, cosmogenic isotopes (Be, Al, He, Cl), luminescence (optical or thermal), tephrochronology, dendrochronology, obsidian hydration, lichenometry, amino acid racemization, and U-series isotopes. Paleontology and paleomagnetics can also provide age data in the short timescale. Applications of short term methods are particularly useful for neotectonic studies, sedimentation rates, and erosion rates. We anticipate that the cost for a short-term geochronology study of 6-10 ages would cost about $10,000.

Mid-term methods provide age data on a timescale of 100 thousand to 10 million years. Common methods in this category include U-Th/He, fission track, and $^{40}Ar/^{39}Ar$. Generally these methods are dating the time since the rock material cooled through a closure temperature. Different minerals and different applications of the technique focus on different closure temperatures with a range from ~75°C to ~500°C. Applications of mid-term techniques include uplift, sedimentation, and volcanology studies. Cost per analysis would be about $700-850 with a cost per study around $10,000-$20,000.

Long-term methods are applied when anticipated ages are greater than 10 million years. All of these methods utilize radiogenic isotopes including U-Pb, Pb-Pb, Lu-Hf, U-Th, Rb-Sr, Nd-Sm, Re-Os, and Ar-Ar. Analyses are made with mass spectrometers of various types with the exception of electron microprobe chemical analysis (EMPA) of monazite. These methods are typically applied to metamorphic age studies, crust and mantle age determination, as well as the determination of magmatic ages, detrital ages, and cooling ages. Per sample cost is on the order of $3000 with a cost per study of about $20,000.

DISPERSAL OF MONEY TO ANALYTICAL LABS AND USE BY PI'S

As discussed, we propose that UNAVCO issue an RFP to operators of geochronology laboratories to apply for credit toward analyses at their lab that can be used by PI's who are funded on EarthScope science projects. These funded projects can include those funded by any NSF program as long as the project encompasses EarthScope goals. Proposals from lab operators would be submitted prior to knowledge of which PI's will receive funding therefore lab operators will base their proposals on the types of geochronologic analyses they can provide, relevance to EarthScope goals, and their past track record of constructive working relationships with other researchers. Lab operators should detail the cost per analysis and should build into that cost the cost of sample preparation, analysis, interpretation and any institutional overhead costs. Ideally lab operators will develop a working relationship with the PI, however, in some cases the method may lend itself to simply a pay-per-age arrangement. The PI would not actually spend money from a grant, but rather the PI would indicate in their proposal that they are requesting to spend lab credits at one of the funded laboratories. This request should be confirmed with a letter of collaboration from the director of the funded laboratory.

Proposals from the lab operators will be reviewed by the Geochronology Working Group and recommendations for funding will be made to UNAVCO. Ideally there will be a balance between short-term, mid-term, and long-term methodologies, however, a surplus of highly exceptional proposals from one category, coupled with an under-representation from another category could tip the balance such that the best proposals are funded even if there are a greater number from a particular category of analyses.

Once funding decisions are made it will be critical that UNAVCO communicate to NSF which laboratories have received funding and how many “age credits” were funded at that lab. UNAVCO will then have to work with NSF to ensure that proposals are funded to use those credits, and to monitor how many credits are available at each NSF funding cycle [This includes an up to date tally of both funds expended for ages and funds encumbered]. Labs and PI’s will have the responsibility to submit a quarterly report to UNAVCO to provide and update on the spending of credits. Credits allocated and credits spent will be posted on a website so that researchers are aware of where credits are still available to be incorporated into future proposals.

Once laboratories have received funding for age credits, and PI’s have received approval from NSF to use those credits, there will be an obligation on the part of the PI to make the resultant ages and interpretations available to the public as part of the data product once the PI’s have had a reasonable (we suggest 2 years) time to publish the data. Generally this data product will include the sample location, description of the geologic setting, raw data, processed data, and an interpretation. There will be an effort to integrate this data product with the currently-being-developed digital database Earthchem.

RFP RECOMMENDATIONS

The working group suggests that 10-15 awards to geochronology labs should be made for amounts of $15,000-$250,000. These awards would be expected to be spent during a five year period. Lab operators would be expected to render services on a best efforts basis to PI’s who are funded by NSF to conduct EarthScope research. GeoEarthScope is aware that not all geochronologic analyses yield interpretable age data.

- UNAVCO should draft an RFP that requires lab operators to detail the following:
- Proposed geochronologic method

- Laboratory instrumentation
- Laboratory standards used
- Laboratory procedure (operating voltage, counting time, etc. – similar to manuscript text)
- Analytic uncertainties
- Turn-around time
- Work /Business plan for mode of operation with PI's
- Terms for which lab is available (w/ sample prep or w/o sample prep, PI involved in analytical work or not, collaborative or non-collaborative relationship with PI)
- Long term plan for laboratory and institutional support (technicians etc.)
- Expected product
- Budget—(This can be in the form: X number of analyses done for $YYY, within 3-5 years).
- Budget explanation Labs should demonstrate how the cost/unit was determined; e.g. based on previous years' work so much was required for sample prep, some other amount for instrument time, additional time for data representation and interpretation, some amount of time for lab administrative costs, communications with collaborators, etc.

A timetable for the RFP, project selection, and distribution of funding is proposed as follows:

Fall 06	RFP generated and distributed by UNAVCO
JAN 07	Proposals due –UNAVCO copies and distributes to committee
FEB 07	committee meets for selection
APRIL 07	funds distributed to laboratories
JULY 07	NSF accepts EarthScope science proposals
NOV 07	Successful PI's receive notification from NSF

CRITERIA FOR SELECTION

The working group will review all laboratory proposals that are submitted and will meet to discuss and select proposals to be selected. An effort will be made to balance the selected proposals between the various timescale categories, however, only meritorious proposals will be selected even at the expense of a balance of methodologies. Selection criteria will be based on clear presentation of the requested items in the RFP and a proven laboratory or lab operator track record. The committee will also evaluate the viability of the budget. There is no intention to go strictly with the low-bidder.