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Stephen R. Meyers
University of Wisconsin-Madison

Bradley S. Singer
University of Wisconsin-Madison

Mark D. Schmitz
Boise State University

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IsoAstro Geochronology Workshop: The Integration and Intercalibration of Radioisotopic and Astrochronologic Time Scales; Madison, Wisconsin, 18–23 August 2014

By Stephen R. Meyers, Bradley S. Singer, and Mark D. Schmitz 2 January 2015

Numerical dating of the geologic record provides an essential framework for interpreting the rich history of our planet. Common applications include the determination of dates for extinction events and climate reorganizations, the assessment of rates of paleoenvironmental and paleobiologic change, and the correlation of rocks across vast expanses. Such investigations have yielded crucial insight into the mechanisms that shape Earth's surface environments over geologic time. But as geoscientists increasingly pursue high (spatial) resolution stratigraphic analyses in "deep time," the short temporal scales (<100,000 years) of the processes investigated push the limits of high-precision geochronology.

Concerted efforts over the past decade have yielded transformative advances in the accuracy and precision of U-Pb and $^{40}Ar/^{39}Ar$ radioisotope geochronology, which provide the backbone of the latest Phanerozoic time scale. Major achievements have included, among others, the reduction of interlaboratory bias with new U-Pb tracer solutions, the development of chemical abrasion methods to address the problem of lead-loss (U-Pb), improvements in the calibration of $^{40}Ar/^{39}Ar$ monitor minerals, and instrumental advances that greatly reduce analytical uncertainties.

In tandem, astrochronology has emerged as an important tool for enhancing the accuracy and precision of high-resolution time scales, especially through ash-poor intervals that cannot be directly dated with radioisotopic methods. Astrochronology uses the geologic record of climate oscillations—those ascribed to periodic changes in the Earth's orbit and rotation—to measure the passage of time from rhythmic layers in strata.

Major advancements in astrochronology derive from improvement of the theoretical astronomical models, the acquisition of high-quality paleoclimate records and their integration with bio-chemo-magneto-litho-stratigraphy and radioisotopic data, and the development of statistical methodologies to assemble and evaluate cyclostratigraphic records. Astrochronology is now even used to calibrate and evaluate radioisotopic geochronology.

While these three techniques are broadly employed, there exist many conceptual barriers between the historically disparate fields. To address this issue, the National Science Foundation sponsored a summer workshop and short course in August focusing on the integration and intercalibration of radioisotopic and astrochronologic time scales. The workshop was held at the University of Wisconsin-Madison, and in attendance were undergraduate and graduate students, postdocs, and faculty from 28 institutions located in eight countries.

The workshop reviewed the basic theory underlying each geochronologic method (U-Pb, $^{40}Ar/^{39}Ar$, and astrochronology), with an emphasis on understanding the challenges inherent in the interpretation of radioisotopic and astrochronologic data, the sources of uncertainty in developing high-precision time scales, and the power of combining multiple chronometers. Investigation of each technique was aided by interactive lab practicals to provide hands-on experience with data analysis. This included astrochronology tutorials with the software Astrochron: An R Package for Astrochronology, a new Web-based interactive U-Pb practical, and analysis of $^{40}Ar/^{39}Ar$ data with the software Isoplot.

Participants also delivered 22 research talks that explored a wide range of questions for which an understanding of geologic time is essential and toured geochemistry labs used for geochronologic research. The IsoAstro workshop content illustrates how the development of state-of-the-art "high-resolution" time scales is a truly interdisciplinary pursuit, and research in this field provides tremendous new opportunities for integration across disciplines.

—Stephen R. Meyers, Department of Geoscience, Univ. of Wisconsin-Madison, Wisc.; email: smeyers@geology.wisc.edu (mailto:smeyers@geology.wisc.edu); Bradley S. Singer, Department of Geoscience, Univ. of Wisconsin-Madison, Wisc.; Mark D. Schmitz, Department of Geosciences, Boise State University, Boise, Idaho

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