



AGeS³: Micro-Funding an Inclusive Community Grassroots Effort to Better Understand the Earth System

R.M. Flowers, *Dept of Geological Sciences, University of Colorado Boulder, Boulder, Colorado 80309, USA*; J.R. Arrowsmith, *School of Earth & Space Exploration, Arizona State University, Tempe, Arizona 85287, USA*

MOTIVATION

Geochronology data provide the temporal information required for earth science from the mantle through the critical zone, yet National Academy reports have repeatedly highlighted challenges for geochronology data access, training, and technical innovation. The 2020 National Academies report “A Vision for Earth Sciences, 2020–2030: Earth in Time” recommends that the National Science Foundation’s (NSF) Division of Earth Sciences “should fund a National Consortium for Geochronology.” This recommendation builds on previous National Research Council (NRC) reports that emphasize the importance of geochronology data for addressing first order questions in earth-system science related to climate change, biologic and landscape change, earthquake cyclicality and hazards, and solid Earth evolution.

The Advancing Geochronology Science, Spaces, and Systems (AGeS³ or AGeS-cubed) initiative is an NSF-funded project to increase access to geochronology data and expertise, to support and grow the geochronology community, and to promote inclusive and collaborative science (Fig. 1). Current coordination efforts envision founding the National Geochronology Consortium with an infrastructure trio: Human Infrastructure, Technical Instrument-based Infrastructure, and Cyberinfrastructure (as defined in the 2020 Earth in Time report). AGeS³ is focused on growing the Human Infrastructure pillar in sync with other efforts. To accomplish this, AGeS³ builds on the success and cooperative spirit of the NSF-funded AGeS1 and AGeS2 programs (Fig. 2; Flowers et al., 2019) through the launch of analogous micro-grant opportunities to crowd-source solutions for community-identified geochronology needs.

MICRO-FUNDING

The AGeS³ project will make ~160 strategic micro-awards of US\$8–US\$15k each through a trio of competitive, proposal-driven, peer-reviewed, micro-funding programs (Fig. 1). This initiative will ultimately engage hundreds across the earth sciences in collaborative science, training, review, and governance activities over its five-year duration. It has been suggested that micro-funding (Rappert, 2017) can have a transformative impact on the sciences, as micro-loans have done for the well-being of many populations around the world. The small and flexible AGeS grants can have a cascading effect in the earth sciences, catalyzing cross-disciplinary collaborations, attracting students with diverse cultural and scientific backgrounds, and enabling important scientific advances that may not happen within the bubble of more standard grants.

The three AGeS³ subprograms are:

- The mature **AGeS-Grad (Graduate Student Research) subprogram** (up to

US\$10k awards) will support high-impact collaborative science projects between graduate students, labs, and home institution mentors. These awards provide funds for graduate students to visit geochronology labs for a week or more to acquire data and be mentored by geochronologists on projects of joint interest. AGeS³ anticipates making ~110 Grad awards over five proposal cycles.

- The prototype **AGeS-DiG (Diversity in Geochronology) subprogram** (up to US\$15k awards) will fund pilot initiatives to increase access to geochronology for those underrepresented in the earth sciences. Priority will be given to projects that emphasize authentic research experiences, that mentor multiple students, and that foster a cohort experience for participants. AGeS³ will make ~30 DiG awards over three proposal cycles.

- The new **AGeS-TRaCE (Training and Community Engagement) subprogram** (up to US\$10k awards) will support community-led efforts to address other self-

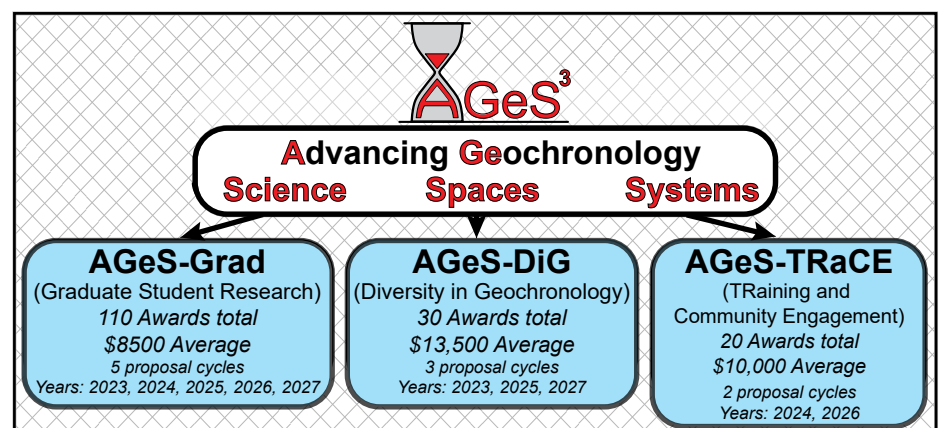


Figure 1. Structure of the AGeS³ initiative that combines the mature AGeS-Grad, the prototype AGeS-DiG, and the new AGeS-TRaCE micro-award programs to advance inclusive science and training in geochronology.

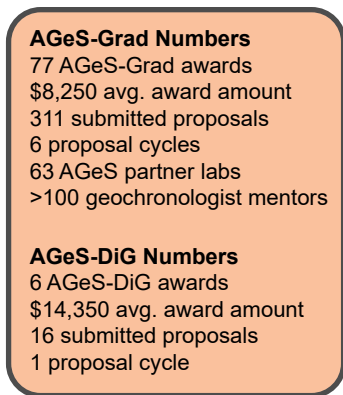


Figure 2. Project numbers associated with the AGeS1 and AGeS2 programs. The AGeS-DiG program was first piloted in 2022.

identified geochronology needs. Examples of AGeS-TRaCE projects include, but are not limited to, accessible webinars, tutorials, and workshops on best practices, lab procedures, instrument design, statistics and uncertainties, or data interpretation; focused meetings to discuss interlaboratory calibration, spikes, new and emerging chronometers, data management systems, or modeling tool development; and other community needs. AGeS³ plans to fund ~20 TRaCE projects over two proposal cycles.

A common element of the three activities is making small investments that cumulatively advance the field. The well-established AGeS-Grad program will promote interdisciplinary science between graduate students and geochronology labs. The prototype AGeS-DiG and new AGeS-TRaCE programs will serve as innovation incubators, addressing challenges in diversity, inclusion, disciplinary expertise, and technique development by enabling the grassroots ideas of community members to be piloted and grown.

BUILDING ON THE SPIRIT OF AGES1 AND AGES2

AGeS³ expands and adapts the successful model used by the AGeS (Awards for Geochronology Student) research program

(Flowers et al., 2019). The AGeS program was created as a collaborative strategy to address needs articulated in the 2012 NRC report “New Research Opportunities in the Earth Sciences” (NRC, 2012) to expand access to geochronology data and training. AGeS has accomplished this through a competitive graduate student micro-support program supported by two NSF awards (AGeS1 and AGeS2). Each year this funding opportunity has provided a concrete deadline to motivate new connections between geochronology data users and experts to discuss and tune ideas for cross-disciplinary research. Through this process, hundreds have been involved in AGeS proposals (Fig. 2). AGeS1 and AGeS2 count 87 abstracts; 30 peer-review articles published, in review, or in substantial preparation; and many other presentations and products. The AGeS program has also developed a loose consortium of 63 U.S. partner labs and >100 affiliated geochronologists, consisting mostly of individual-investigator based facilities that contain the majority of the geochronology technical infrastructure distributed across the U.S. The list of partner labs on the AGeS website continues to offer a key informational resource to connect geochronology data consumers and producers. For each lab, information about instrumentation, training, sample preparation, analysis, analytical rates, and contact personnel is provided. The successful trajectory of this micro-award program will continue in AGeS³ through the AGeS-Grad activity.

A COLLABORATIVE GEOSCIENCE MODEL

AGeS³ is designed around a collaborative geoscience model that harnesses expertise and creativity across the earth sciences to address challenges in geochronology. Assessment and evaluation will provide formative feedback to shape the initiative over its arc. Belonging, accessibility, justice, equity, diversity, and inclusivity (BAJEDI) will be integrated throughout all activities. In particular, AGeS-DiG provides the opportunity to evaluate, test, and learn new

approaches to BAJEDI, which can be assimilated into other community efforts. Still broader engagement and integration will be sought through annual, virtual, fully open AGeS community meetings, and an AGeS³ website that will host project summaries and other tangible products. AGeS³ adopts a formalized governance model that includes steering and review committees with rotating members who will balance experience with new engagement. Evaluation of the structure, administration, and governance of AGeS³ can contribute to the development of a potentially transferable or generalizable model of community-led initiatives.

For more information about AGeS³, go to www.agesgeochronology.org.

ACKNOWLEDGMENTS

We are grateful to all of the AGeS review panels for their substantial time and energy invested in the proposal evaluation process. AGeS³ is supported by NSF Frontier Research in Earth Science awards EAR-2218547, -2218544, -2218504 to R.M. Flowers, J.R. Arrowsmith, V. McConnell, and L. Arthurs. AGeS2 was supported by NSF EAR-1759200, -1759353, -1759201 awards to R.M. Flowers, J.R. Arrowsmith, and V. McConnell. AGeS1 was supported by awards EAR-1358514, -1358554, -1358401, -1358443 to R.M. Flowers, J.R. Arrowsmith, T. Rittenour, B. Schoene, and J.R. Metcalf.

REFERENCES CITED

- Flowers, R., Arrowsmith, J.R., McConnell, V., Metcalf, J., Rittenour, T., and Schoene, B., 2019, The AGeS2 (Awards for Geochronology Student research 2) Program: Supporting Community Geochronology Needs and Interdisciplinary Science: *GSA Today*, v. 29, no. 3, <https://doi.org/10.1130/GSATG392GW.1>.
- National Academies of Sciences, Engineering, and Medicine, 2020, *A Vision for NSF Earth Sciences 2020–2030: Earth in Time*: Washington, D.C., The National Academies Press, <https://doi.org/10.17226/25761>.
- NRC, 2012, *New research opportunities in the earth sciences (NROES)*: Washington, D.C., The National Academies Press, 117 p.
- Rappert, B., 2017, *Fostering data openness by enabling science: A proposal for micro-funding*: *Data Science Journal*, v. 16, <https://doi.org/10.5334/dsj-2017-044>.

MANUSCRIPT RECEIVED 5 SEPT. 2022

MANUSCRIPT ACCEPTED 11 SEPT. 2022