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"AGeS just got me more excited for the research component of things, because it really opened up . . . this new opportunity to do what is typically a very expensive, kind of inaccessible analysis."

Findings from an Evaluation of the AGeS and AGeS2 Programs

By Amy Myrbo, Ph.D. | July 2024

Background

The National Science Foundation (NSF) funded AGeS1 and AGeS2 programs provided microgrants to geoscience graduate students to work with personnel from, and travel to, laboratories outside their home institutions to analyze geochronologic samples for their graduate research. The program provided awards of about $8500 to students in 2015, 2016, 2017, 2019, 2020, and 2021. The first three years are considered "AGeS1" (25 awards total) and the latter three years are considered "AGeS2" (52 awards total), with the programs supported by two dedicated NSF awards plus supplementary funding for AGeS1. Summative evaluation reports were produced for these projects; the current report takes a retrospective approach by interviewing students who received AGeS awards to understand the longer-term effects of the program on their networks, career pathways, professional growth, and independence, as well as the program's approach of providing awards that are designed to fill a funding gap between the sizes of typical student grants ($1000-scale) and NSF awards ($100,000-scale). This report also briefly examines results presented in the previous evaluation reports for evidence of these impacts.

Methods and Participants

17 past AGeS recipients were interviewed, individually and in small groups: 11 in person at the Geological Society of America (GSA) Connects meeting in October 2022 (prior to which a workshop for AGeS2 recipients was held), and six via Zoom in May 2023. Four total interviewees were AGeS1 recipients, and the balance were AGeS2 recipients. (Attempts were made to arrange interviews with eight additional past recipients, but they were either

unavailable, did not respond, or current contact information could not be located.) These comprise 16% of AGeS1 and 25% of AGeS2 recipients. Data analysis found no new codes after the 13th interview, which agrees with Hennink and Kaiser (2022), who found in a meta-analysis that data saturation is usually reached in nine to 17 interviews or four to eight focus groups. AGeS1 and AGeS2 recipients were interviewed separately because of some differences in their programs: AGeS2 recipients participated in organized activities with their cohorts, and experienced disruptions due to COVID-19 during their programs, while AGeS1 recipients did not. All interviews were recorded, automatically transcribed using Otter.ai, and coded with a thematic analysis approach using Quirkos software and following standard methods (e.g., Kuckartz 2014).

Summative reports from AGeS1 (Eriksson 2016) and AGeS2 (Eriksson 2022), and data on which they were based, were also reviewed, particularly within the context of the findings from the interviews. Demographic data for all AGeS1 and AGeS2 awardees was collated and plotted.

Demographics of AGeS-Grad awardees

Figures 1-5 show selected demographic categories of AGeS1 and AGeS2 Grad awardees, both by year and cumulatively. AGeS1 and 2 supported mainly White students (34), but also at least 13 non-White students. AGeS1 and 2 supported about equal numbers of male- and female-identifying students. Tectonics is the most common area of study for Grad awardees' projects; topics have diversified over time, with more "soft-rock" projects (climate, geomorphology) in Cohorts 2 and 3 of AGeS2. Quaternary methods are most common, but are subequal with low-temperature methods and about 30% more common than strictly high-temperature studies. AGeS has supported about three times as many Ph.D. students as Master's degree students.

Eriksson (2019 and 2020) provides substantial additional context and recommendations around diversity in AGeS, including looking at student retention, comparing the experiences of White male awardees vs. those with minoritized identities, potential obstacles in application submission, the preparation of laboratory personnel for mentoring inexperienced students, and that the program should be sure to provide clarity about the skills that are expected of an awardee (because this clarity may lead to more applicants feeling that they are qualified).

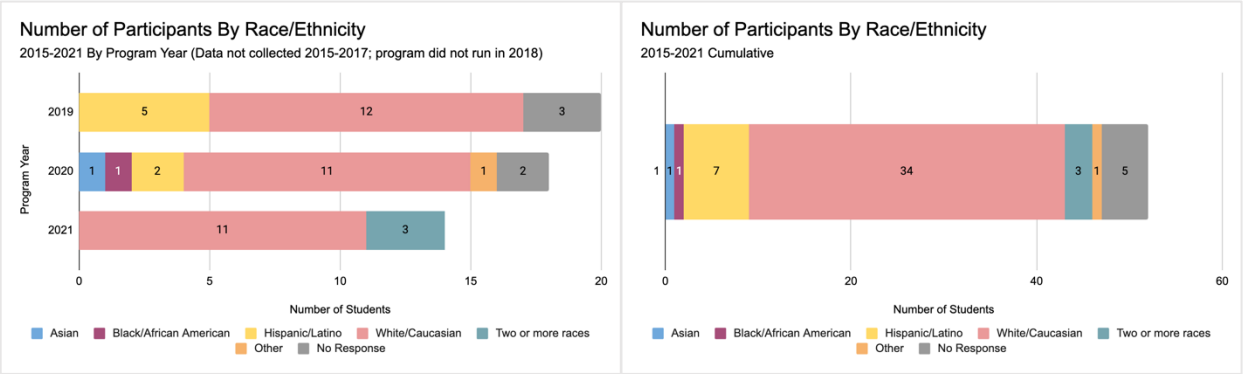

Figure 1. Race and ethnicity of AGeS awardees: by year (left) and cumulative for all award cycles.

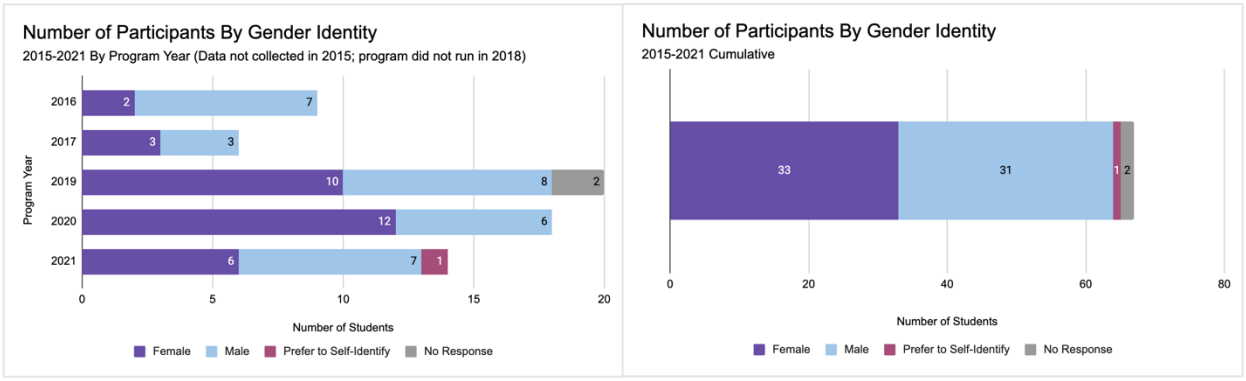

Figure 2. Gender of AGeS awardees: by year (left) and cumulative for all award cycles.

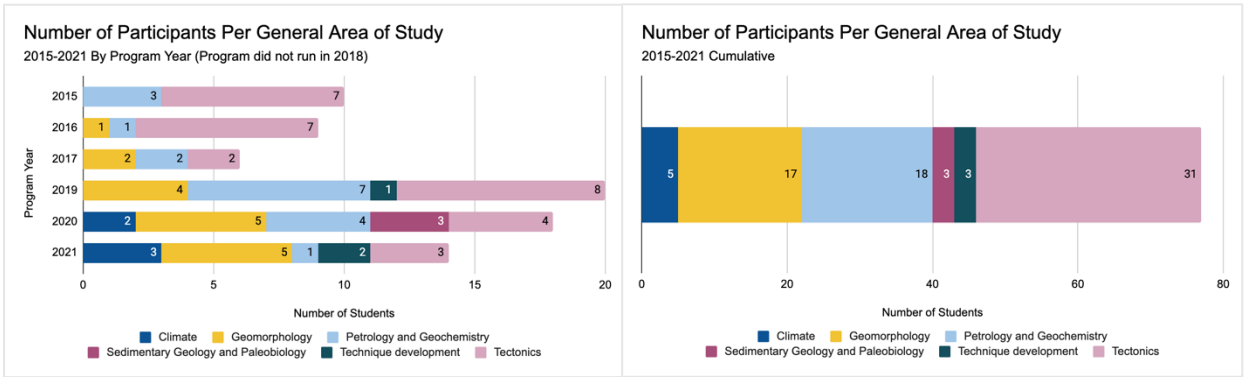

Figure 3. General area of study for projects of AGeS awardees: by year (left) and cumulative for all award cycles.

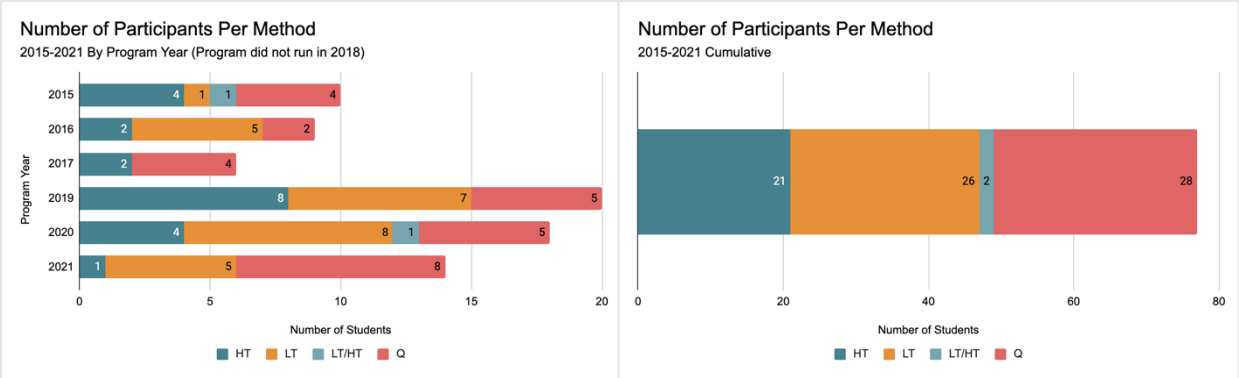

Figure 4. Geochronologic method used in projects of AGeS awardees: by year (left) and cumulative for all award cycles. HT=high temperature; LT=low temperature; LT/HT=a combination of both; Q=Quaternary.

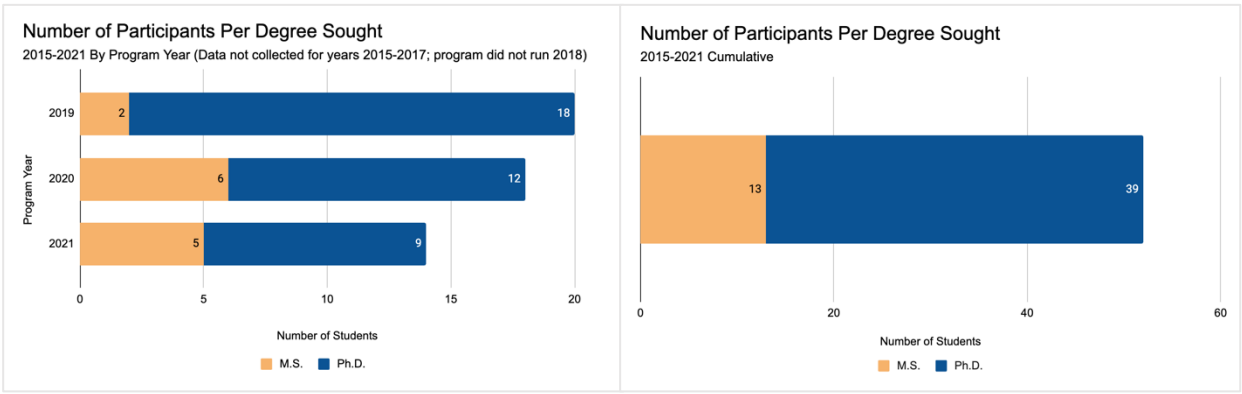

Figure 5. Graduate degree sought by AGeS awardees at the time of their awards: by year (left) and cumulative for all award cycles.

Impact of the AGeS Program

Interviewees shared a number of positive experiences and outcomes from their AGeS awards, particularly citing access to geochronology infrastructure (experts, labs), appreciation of the funding amount, personal and professional growth, development of professional networks, and improved scientific outcomes.

The AGeS1 summative report (Eriksson 2016) noted that

> Major impacts of the AGeS program include success in promoting student scientists and their home advisor to collaborate with geochronologists in interdisciplinary geoscience projects addressing the evolution of the North American continent, the major goal of the EarthScope project. The funds completely funded some projects or parts of larger projects and also have

initiated projects, relationships, and collaborations that have a life span beyond the grant's funding period.

New scientific and personal relationships have been formed among scientists and laboratories that will potentially lead to a more detailed understanding of processes addressing the EarthScope goal. A new group of scientists are more aware of the EarthScope goals, and perhaps more importantly, will continue interdisciplinary work involving geochronologists and new users of this type of data. There is widespread support among these participants of continuing this program for initiating these relationships and for the cost-effective use of NSF funds.

The AGeS2 summative report (Eriksson, 2022) noted similar themes, with students benefiting in the areas of new collaborations; professional opportunities, providing content for their CVs, access to a large network of scientists, visibility such as invited talks, helpful mentors, and job and postdoc offers.

Access to Infrastructure

"I think [AGeS] has a really important role, especially for grad students. Because finding money is hard. Getting NSF grants is hard, and AGeS is kind of like these GSA research grants, it's a small pool for someone to potentially be able to actually finish their degree. And without it, I think a lot of people can't."

Microgrants are the central feature of the AGeS program and during AGeS1 and AGeS2 made it possible for 77 graduate students to access geochronology for their thesis or dissertation research. The structure of AGeS is designed to not only pay for analyses, however, but also to support the student's learning from and collaboration with experts at geochronology labs. In both previous surveys (reported in the 2016 and 2022 summative evaluation reports) and recent interviews, awardees described how they were able to gain training and knowledge by working with personnel from the labs they visited, before, during, and after their visits, as well as obtain analyses they would not have been able to afford without AGeS funding. Outcomes of this access, including additional methods-based thesis chapters, multiple publications, long-term collaborations, and affective changes like improved self-confidence and independence, are described in sections below.

Microgrant Strategy

"I don't know of any other research grants for students that actually give that amount of money. I think most of them, it's a couple of thousands, maybe 2000. So that was even one of the reasons why I went with AGeS was that the amount

was more than you get as a student usually. It's not like a faculty kind of grant but it's – it makes you feel like a PI. It's, it's like you, you're in charge of your own destiny, when you get the money and say, I'm in charge of this research, it makes you feel more like a scientist."

Several participants commented that the dollar amount of AGeS microgrants "fills a perfect niche" in funding available to graduate students. Most favorably compared it to the GSA Grad Student Research Grants, which in 2022 provided an average of $2301 per student (GSA, n.d.). With smaller awards such as those from GSA, as one student noted, "you can get, like, geochem done, you can do some other types of analyses, but geochron never costs $2K." Since graduate students usually cannot or do not apply directly to NSF for analytical costs (the NSF Graduate Research Fellowship Program, GRFP, only includes funding for salary and tuition), AGeS funding is at the higher end of dollar amounts of awards they can receive themselves. The positive feedback to their own or their advisors' additional funding was also mentioned by two interviewees, both of whom described how they used the pilot data to build a strong case in NSF proposals, in one case for a successful GRFP. Eriksson (2016) noted that "several of the [AGeS1] students leveraged this grant to obtain funds from other sources including their own university and organizations such as the Geological Society of America."

The dollar amounts of the microgrants were largely held to be "generous" and sufficient for both travel and analytical costs, though some awardees had access to other complementary funding sources through their advisors or departments, some had to economize on their travel, and some received free analyses from the laboratories they worked with, either because of the labs' errors or because of the enthusiasm of the lab leadership for the student's project. The additional travel funding provided to students who attended the pre-GSA AGeS2 workshop was also appreciated, and allowed some students to attend the GSA Connects meeting when they otherwise might not have.

In a survey administered in early 2022, home institution advisors also described the benefits of the AGeS microgrant strategy to their own careers as faculty:

"Without AGeS funding we would have been unable to do this project, and the AGeS grant allowed me to fund raise for logistical aspects of the project that were otherwise challenging to fund."

"This program was hugely beneficial for my two PhD students and for my research program (I am pre-tenure). For one of the projects, the results will be used to motivate a full proposal to the NSF EAR SGP program. Some of the results from the other project were incorporated into a submitted NSF CAREER proposal. For both projects, the support from AGeS helped provide support to get the projects off the ground."

Student Growth

> *"[AGeS] really did set me up with the, I think, kind of sitting down and figuring out what's something worthwhile to spend my time on, how to structure a proposal, how to hustle to get money to do the things that I want to do. And, you know, that's kind of what I've been doing since then."*

Awardees described numerous different types of personal and professional growth associated with their experiences in the AGeS program. In several cases AGeS supported research directions or projects that students had conceived of themselves (i.e., not their advisors' projects), which helped them feel more confident, motivated, and independent. All four AGeS1 interviewees characterized their AGeS-funded research as their own, usually the first project they had designed, and one said that in interviews for faculty positions when asked how much of the research was their own idea versus their advisor's, they were able to say, "It was just me. And that felt nice. That's a lot of confidence for early group people, at least for me, like, I needed that. I realized that it helps to have that boost. You know, I've done this before. I can do this. I can do a whole thing, start to finish, find money for it, convince people it's worthwhile." Recipients also described how, by learning one geochronologic technique, they felt much more capable of learning and applying other systems, and in two cases how the skillsets and experience helped them to obtain jobs. The value of having an AGeS award on one's CV was also noted, both because it is considered prestigious, and because it is a proposal that the student wrote themselves.

An AGeS2 recipient described how AGeS "allowed me to have more freedom in what I do, because then I don't have to go to my advisor and be like, 'money, please.'" Independence was also noted in the context of the trust a lab placed in the student by letting them run instrumentation themselves. Students also described how managing their project showed them the importance of deliberate communication between members of a research team, and how they have used those skills in working with mentees and new collaborators.

Some students, however, reported either that they wished that they had had more independence (in one case where COVID led to the lab doing all the work for the student), or that they had had more support. The latter was described in several cases where the lab that the student had worked with to develop the proposal was for some reason unable to conduct the analyses, because an instrument was down, key personnel moved institutions, or other reasons. These students described frustration with the lack of engagement of the new lab advisor and/or personnel, being put off for a year and a half (one to three months at a time) due to instrument issues, and feeling isolated at the lab they visited because the faculty, lab personnel, and students interacted with them only minimally. Some expressed the wish that AGeS leadership had been able to intervene or talk to the lab advisor on their behalf, due to the students' own inexperience and the power differential. In one case a student described the lab "accusing" them of mixing up their samples when the results did not conform to expectations (the student demonstrated that the previous geological interpretation had been

incorrect instead), and another described that the lab was "not very helpful" after it sent the results because the "bad" data generated "made their lab look bad" (the student acknowledged that this was their own "projection").

Network Development

> *"I think that for me, it was the people that I met, and then continue to run into at meetings and other events, and we talk and collaborate and learn from each other. Even if they were years older than me, I'd still – still today, I'll send them an email and say, 'Hey, what do you think about these samples' or whatever, which is invaluable."*

> *"My network amongst the actual dating community has grown immensely – like the actual PI's that run these labs – because I met not just [faculty], but several other people who do that kind of work and have reached out and collaborated with people, both internationally and domestically in that, but then since then, to like other types of dating techniques. I'll reach out to someone and be like, 'Hey, do you know someone who does this,' they'll point you to someone and then go, 'Hey, I'm an AGeS person.' And they go, 'Oh, we're in the program too.' And so they're really generally more willing to work because AGeS has now developed its own brand."*

The value of AGeS for students to build their networks was one of the strongest themes in the interviews, especially among AGeS1 recipients, who may have more perspective in how these connections have grown and affected them over time. They described how their lab visits, projects, and presentations exposed them to new people, who in turn exposed them to additional groups of people. One said that "I feel like from the work I did, through AGeS, I now know a lot of people in my discipline," and others mentioned having current projects (publications, NSF awards) with people they had met during their lab visits, including other visitors to the lab at the time they were there.

AGeS2 recipients particularly described the benefits of having met others in the 2019-2021 cohorts at the pre-GSA workshop, and both the future benefits of having potential collaborators and the already-realized benefits of being part of a community. One put it this way: "And I kind of got home and I had this realization, I was like, 'Oh, my God, for the first time in my life, I can say I have colleagues.'" Another described the "camaraderie" and welcome ability to both compare notes about graduate school experiences and share photos of their cats. Some also took advantage of the new connections to explore possible Ph.D. and postdoc advisors based on the advice of their peers. Seeing others from the workshop at the GSA Connects meeting was also valuable: "I've been like waving going all around the conference, which is so funny, because like, I hardly know them. But that's really cool."

Network development is emphasized throughout the previous evaluation reports as a major outcome of the AGeS program. Eriksson (2016) noted

> Unanimously, Students, Home Advisors (HA), and Laboratory representatives (LR) said that the collaborations are new. The student's noted research collaborations between themselves and their home advisory with the analytical laboratory. HA noted that although some of them had known people in the labs or had planned to work together sometime in the future, the AGeS program was a precipitating factor in providing new scientific collaborations. Interestingly, both students and LR appreciate personal as well as scientific relationships that extended their scientific network that included students, post-docs, and other scientists in the lab's institution. All respondent types repeatedly noted that collaborations would continue in the future with other students and with other scientific projects.

Responses of AGeS2 awardees to a survey in 2022 (Eriksson 2022) describe a variety of new scientific collaborations, including with lab directors, researchers, postdocs, and graduate students at other institutions (including personal relationships as well as professional ones), and foreign researchers visiting the labs at the same time. They also describe collaborations resulting in new research abstracts and manuscripts, co-authorship on papers, and research expansion into new subfields.

Improved Science

> *"But we had one paper on one of the provinces come out in* GRL *[*Geophysical Research Letters*] in 2021. And another one in* Geology *last year, and then trying to get the rest of the data out into a paper hopefully, sometime before this year is over, but I'm pretty busy. Doing my best. But, you know, three papers ultimately came out of it."*

Many interviewees noted the scientific benefits of their participation in AGeS, from the number of publications supported (several recipients said they had or will have two to three papers out of the award), to past and ongoing NSF awards, to an entire thesis chapter on the nascent method utilized in their AGeS project, to the point made earlier about AGeS enabling students to pursue their own research ideas.

The list of presentations and publications that have come out of AGeS awards is a strong quantitative measure of the scientific merit of the program - though a lagging one, given that papers are published some years after the date of the award. As pointed out by Eriksson (2022), "[t]he publication list documents [the] academic success of the students as researchers. (MUST be updated as this is a major outcome.)" One recommendation of the current report will be that keeping up with cataloging and disseminating the publications stemming from

AGeS projects should be a priority, and that proactive steps might be taken to supplement self-reporting by awardees.

The structure of AGeS, wherein the student, home advisor, and lab personnel share responsibility for the success of the project appears to strongly support student learning and feelings of competence that extend beyond the specific geochronologic system used. As one recipient described their lab experience, "I felt like I thought I understood the [instrument] and just like the [geochronologic system] before, but then I got to sit and talk with [faculty/lab director] a bunch, I got to sit and talk with [postdoc1] a bunch and [their] other postdoc, [postdoc 2] and, and some of [their] undergrads or other grad students and I, I just gained a deeper understanding that I didn't even realize I needed. Classic, you know. You can always learn more." One student characterized AGeS funding as "absolutely critical" to completion of their thesis work, and others echoed this sentiment. Earlier surveys of both AGeS1 and AGeS2 confirm the breadth and depth of methodologies and scientific content that the students learned through their projects: for instance, Eriksson (2016) provides quotes about the innovative and interdisciplinary nature of the science supported by AGeS.

Stress and Mental Health

> *"I feel like . . . I didn't do enough, and I didn't learn as much as I wanted to or as much as other people would have."*

Several students described sources of stress and poor mental health during the program, including anxiety in advance of their lab visits, the lack of lab advisor engagement in some cases (noted earlier), and in one case feeling that they had to put up a false front of competence and professionalism to the lab personnel, when they wished they felt comfortable asking questions. The most common concern was that they were not competitive with the rest of the AGeS recipients, especially with respect to meeting others (in particular those from elite research institutions) at the pre-GSA workshop. One described this feeling as "crippling imposter syndrome," and another as thinking, "Wow, I like, feel like I'm not at this level." Many students compared themselves to others and their projects to others' projects, some favorably ("It looked like my project was not any, like, far above or below any of the other ones necessarily") and some not ("I don't know – it just seems like I did really basic stuff. I just got [data], and everyone had these really complex issues"). Still, some of those same students, and others, noted that it was a comfort to hear that other students had also had difficulties, or were overwhelmed by graduate school or confused by interpreting their data.

Workshop

> *"I literally told everyone like, it was the best short course I've ever attended . . . it was so inspiring, not only meeting the cohort of AGeS awardees, and you*

know, like building that those connections and that, you know, that like kind of bond, you have been AGeS awardees, but it was also so inspiring, seeing, you know, like the mentors of the AGeS program."

"I think it has made my conference more enjoyable because I keep on seeing like, friendly faces."

As noted in several places in this report, the pre-GSA workshop was seen as having great value to the participants, both in terms of learning and community building. The positive response may in part have been due to these students' experience with the previous 2.5 years of COVID and the limitations on in-person activities during that time, but responses suggest that it was a valuable experience beyond that. Participants highly valued the discussions in breakout groups, though some felt that they had little to contribute to discussions about human infrastructure and other topics, because of their lack of experience, and took these as more of opportunities to listen and learn. Participants recommended that this meeting occur as part of AGeS3 if possible. One student, however, said that they somehow didn't hear about it until it was occurring.

AGeS3 PIs report that there are "remote workshops scheduled for AGeS3, not in-person workshops. But we're being proactive via the network committee in arranging informal in-person meet-ups among the cohorts at meetings. (e.g., Cordilleran GSA)."

Promoting AGeS to Others

"You should keep it going forever. Yeah. It's an awesome opportunity. I can't speak enough about it. Yeah, I bring it up all the time, during like, when I'm talking to undergrads, okay. 'If you ever have an idea that like requires you to do geochronologic work outside your institution? Like, here's a link to this website that you know, this program, that's really great.'"

Several students described how they frequently recommend that other students they meet apply for AGeS awards. One said that they had "told like three people today [during GSA] to apply to AGeS." An AGeS1 recipient was glad to hear of continued funding for the program because they had been hesitant to recommend it, not knowing whether the awards were still being offered. Another described helping a mentee with their application. Similar enthusiasm of AGeS participants (including home institution advisors, labs, and reviewers as well as students) is described in both previous evaluation reports (Eriksson 2016, 2022).

Conclusion and Recommendations

AGeS is clearly a resounding success, based on these interviews and previous survey data summarized in evaluation reports. The program is constantly improving based on feedback from students, advisors, geochronology laboratories, student proposal reviewers, and evaluators, and is expanding into new areas beyond the graduate student focus. Recommendations based on this report are:

1. Implement the recommendation of the pre-GSA workshop participants to make willing previous AGeS awardees' contact information available to prospective applicants. Talking with AGeS recipients during proposal preparation could increase comfort levels, improve proposals, and decrease novelty space (e.g., Orion and Hofstein 1994) for prospective applicants. This effect could act similarly for new recipients to talk with past recipients, as well as their current cohort members, during their projects.

2. Conduct a longitudinal survey of past AGeS recipients, especially from AGeS1. These students provided valuable and interesting perspectives in interviews. AGeS1 and AGeS2 recipients' responses could continue to be treated separately, given their differences in experience (cohorts, COVID), but the more significant differences noted between the two groups in this small study were their career stages (two of four interviewed were tenure-track faculty, and two were postdocs applying for faculty positions). *Note: as of July 2024, this recommendation is being implemented, with a longitudinal survey in development.*

3. The list of publications stemming from AGeS projects is the strongest academic indicator of the success of AGeS. Keeping up with cataloging the publications is likely a challenge, but should also continue to be a priority. (The list may be up to date, but the evaluator could not locate it in a brief search of the AGeS3 Google Drive folder and AGeS website.) Dissemination of that list, e.g., through the AGeS website and in reports to NSF, is a way to show the strong impact of AGeS funding and infrastructure on new science.[1]

4. The set of surveys administered in December 2021 and January 2022 may represent the lowest-hanging fruit for further analysis. These files represent a nice snapshot of all three cohorts of AGeS2-Grad awardees and their progress on their projects, from near the end of the AGeS2 award. The advisor and lab feedback is highly supportive, and includes positive impacts on at least one early-career faculty member's tenure package;

[1] If not already being used, there may be ways to partially automate collection of new publication information to supplement self-reporting of publications by past AGeS awardees. This might involve automated searches with manual review, collection of participants' unique researcher IDs (ORCIDs) in the longitudinal survey and periodic review of ORCID records, or other approaches.

outcomes of AGeS' support for a student who is a member of a minoritized group to be mentored by a faculty member who is also a member of a minoritized group; and several references to presentations, publications, or grant proposals resulting from students' AGeS projects. Reviewer feedback is similarly positive, with some constructive feedback for improvement.

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