The Geoscience Workforce
Today and Future Trajectories

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Thank you to our sponsors

- American Association of Petroleum Geologists
- AAPG Foundation
Where are we now?
Who are the working geoscientists?

US Geoscience Employment by Highest Degree Level, 2017

- MS (Geo degree), 146,300
- BS (Geo degree), 115,500
- PHD (Geo degree), 39,800
- PHD (non Geo degree), 30,800
- BS (non Geo degree), 38,500
- MS nonGeo, 15,400
• 88% of geoscience employers received government assistance

• Effective geoscience unemployment rate was 4%.
Geoscience Student Enrollment 1956-2021
United States Colleges and Universities

- Undergraduate
- Graduate
Geoscience Theses, Dissertations, and Faculty Publications Available in GeoRef

Source: AGI GeoRef

ashed earth, science, and people
Employment Sectors of Bachelor's Graduates, 2020-21

- **Prof Services (16%)**
  - Waste Mgmt (6%)
  - Federal (16%)
  - State (6%)

- **Oil & Gas (6%)**
  - Finance (3%)

- **Mining (6%)**
  - Construction (9%)
  - Research Institute (3%)

- **Utilities (3%)**
  - Food Service (3%)
  - Mgmt (3%)

4YC (12%)
Employment Sectors of Master's Graduates, 2020-21

- Mining (18%)
- Oil & Gas (6%)
- Prof Services (6%)
- Waste Mgmt (6%)
- Local Gov (6%)
- Federal (12%)
- State (24%)
- Health Care (6%)
- 4YC (6%)
- Research Institute (6%)
Employment Sectors of Doctoral Graduates, 2020-21

- Federal (16%)
- Prof Services (16%)
- Research Institute (13%)
- 4YC (45%)
- State (6%)
- Non-Profit (3%)
Changes in occupational status, Feb 2020 - Mar 2022
Recent geoscience graduates, Classes of 2014-2021

Diagram showing transitions between statuses:
- Student
- Post-doc
- Academic faculty
- Non-academic professional
- K-12 faculty
- Unemployed
- Retired

Legend:
- Initial population
- Most recent population
- Transitions between statuses
Salaries Remain Competitive
Projected Geoscience Workforce Changes by Industry 2018-2028

Source: AGI Geoscience Workforce Program; Data derived from the U.S. BLS Employment Projections
Employers continue to primarily hire at the Bachelor’s and Master’s degree level.

During Summer 2021, just over half of employers reported hiring at the doctorate level, with this percentage declining in Fall 2021 and rebounding after.
Diversity
Progress, Setbacks, and New Strategies
In 1972, underrepresented populations was 2% of the geoscience workforce.

1972-2016, really was negligible progress.
Workforce Participation by Occupation
Hispanic and Latino

Credit: AGI, data derived from the U.S. Census Bureau and U.S. Bureau of Labor Statistics
Workforce Participation by Occupation
Black and African-American

Credit: AGI, data derived from the U.S. Census Bureau and U.S. Bureau of Labor Statistics
Diversity, We can’t “Don’t Look Up”

Racial Demographic Trends in College Enrollment

- White
- Black
- Hispanic
- Asian/Pacific Islander
- American Indian/Alaska Native
- Two or More Races*

Education Data Initiative source: National Center for Education Data Statistics

* A multiracial category did not appear until 2010.
The Mid-21\textsuperscript{st} Century Workforce?

The current major will be an experienced practicing professional into the 2060’s

Consider the likely evolution by then….
Back at the 2007 AGU….

Noted that the labor gap would emerge, but that the group that puts forward profound innovation will win….

… and the statisticians won.
Rise of Machine Learning in Geoscience

\[ D = \text{Total Labor Demand (FTE)} \]
\[ X = \text{Economic Activity Per Person} \]
\[ n = \text{Total Workers} \]
\[ X' = \text{New Economic Activity Per Person} \]

If \( X' = 5X \), then \( n \) drops substantially, while \( D \) remains the same.
Mining Industry and Machine Learning

- Mining companies determined 80-82% of their geoscientists time was in searching, cleaning, and prepping data
- Energy Companies reported 79% in data effort
- GoldCorp collaborated with IBM to develop Watson for Natural Resources
Is Machine Learning Effective in Geoscience?

- Contrived problems had a 35x decrease in solution time using Watson than a senior geoscientist team.
- First real-world problem:
  - Senior geoscientist team: 1080 person-hours to solve the problem
    - Nearly all of the time was in data management and processing.
  - Watson for Natural Resources: 14 minutes
Is Machine Learning a Threat?

• Only if we do not evolve!

• Traditional occupations are disappearing (loggers, interpreters, etc)

• Move towards the “augmented geoscientist” – who focuses on domain problem solving with robust tools at their disposal.
Integration Evolution
The Emerging Goal:
Broad Competency with a Spike

- Engineering
- Rock Mechanics
- Geology
- Geophysics
- Business
Traditional View of Labor Classes
A New “Labor Pyramid” for Geo

**Geologic Cognitive:**
Fully utilize their geoscience problem solving to tackle the hard problems

**Makers/Sensors:**
The multiskilled geoscientist who knows the geoscience and can apply a spectrum of science and engineering to develop new data feeds
Geoscience Goes “Gig-lite?”

Upstream (Oil, Gas, Minerals, Water)

Downstream

Major Companies

Geo Jobs Growth

Smaller Firms

Geo Jobs Growth
Other Apparent Factors

- AI/ML greatly reducing middle-skill geo jobs
  - Seismic/Strat Interpreters
  - Loggers
- Spread of fixed-price contracts
  - Shifting risk to smaller firms
  - Demanding higher skills/agility for increasing margin
- Increase in the singleton geoscientist
- Geosciences need to become solution providers
  - Skillfulness and innovative thinking are winning traits
What skills?

- Core geologic understandings
- Core scientific understandings in physics, chemistry, biology
- Ability to work quantitatively
- Licensure keeps ALL doors open
- Think of co-curricular skills or requirements:
  - HAZWOPER certification
  - FAA Drone Pilots License
  - Python/R programming
  - GIS/visualization
COVID-Era Graduates Skills Reflection
Skills Wished had Gained

- Proficiency with virtual platforms
- Machine learning, AI, data science
- Data visualization and mapping software
- Lab skills
- Field skills
- Database management
- Programming skills
- Project management
- No
“With every retirement we destroy a geoscience job. With every new hire we are creating a geoscience job we can’t even begin to describe. The new hires will define these jobs of the future.”

- Daniel Malchuk, BHP at PDAC 2018
Headwinds

A robust future workforce faces systemic challenges
How do we go from 18% to 2% in 1 year?

Pandemic had an outsized impact, but we failed to support our in-progress undergraduates.
DEI needs to be sequenced I-E-D

- We need an inherently and obviously inclusive environment and community
- We build the tools and processes to ensure equity for individuals to thrive in the geosciences
- With a welcoming community and tools to help everyone join the geosciences, then we can actually realize a diverse geoscience community
The New Generation of Action

*Changing the Geosciences for the Better*

- GeoASCEND
  - Cultural Change
- On to the Future
  - Professional onboarding and engagement of students
- Bridge Program
  - Fostering graduate education
- LANDInG
  - Leadership development
- NAS Science Workforce for NASA SMD
  - Change science operations
The Enrollment Cliff

External and Internal Factors

• Demographics of College-Age Students
  • Each generation requires a new higher ed business model
  • Its hard to cut back….

• Complications from the Pandemic
• Obvious Pathways to Employment
• The Loan Forgiveness Marketing Debacle

There will be winners and losers
The Curse of Demographics
Be Afraid, Very Afraid

US Population Change from 2010-2019 by Age
Hundreds of thousands of people

Millennials

Gen X
Demographics Drive University Business Models

- Gen X remembers the mass budget cuts and losses in education
- The Millennial years fueled a binge
  - Debt loading
  - Focus on “experience” and broadening of education’s role
  - Big budgets, big overhead, and…. It was a different time
- More than 25 years ahead of at best no-growth
Change Amplifier

- Push into work/life balance needs
- Generational transition through deaths and retirements
- Acceleration of automation
- Utility of data communications
- Disruption of consumption economy
- Shift in energy portfolio
- Shift in nature of employment
An Unforced Fumble in Valuing College
Bad Marketing with Loan Forgiveness

- Loan forgiveness signals higher education is not worthwhile – requiring a federal bailout to “customers”
  - Terrible way to attract first-gen students
- Did nothing to address the cost of attending college
- Coupled with high inflation and interest rates
  - Less cash for tuition
  - Potentially more difficult loan terms in the future
  - Easy loans fueled higher ed inflation
A New Future for Geoscience

- The work of geoscience will be different
- Who does the work will be different – if there are enough people
- The occupations and applications will be different

- How do we today support the development of a robust future?