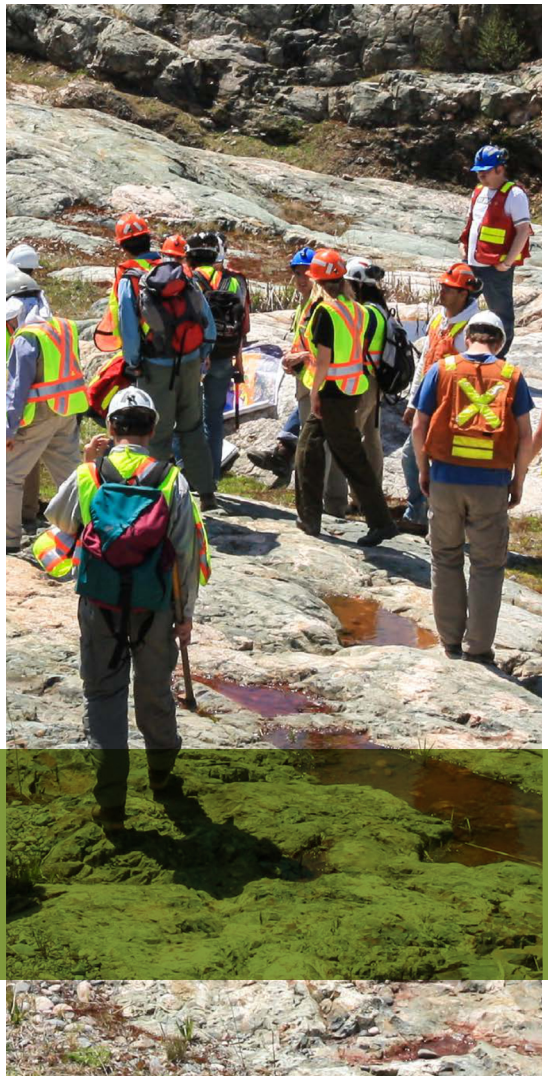
Updated: May 2026

Faculty Ambassador Handbook



FACULTY AMBASSADOR HANDBOOK

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Introduction

Introduction

The Association of State Boards of Geology (ASBOG®) is an organization through which its State Member Boards may act and counsel together to better perform their responsibilities. ASBOG provides a forum to promote, foster, and advance the common interests and purposes of its Member Boards. The supporting membership of ASBOG is its Member Boards. Member Boards are dues-paying State Boards or other legal entities constituted by States, Territories, and the District of Columbia of the United States of America to administer the registration/licensure of geologists.

One of ASBOG's principal duties is to develop standardized written examinations to assess qualifications of applicants who seek licensure as professional geologists. The ASBOG National Geology Examination development and validation procedures are designed to maximize the fairness and quality of the examinations. State Member Boards of registration/licensure are provided with uniform examinations that are valid measures of competency related to the practice of the profession. This process benefits those candidates who are taking the examinations and enhances the protection of the general public.

The National Geology Examinations are administered in the spring and fall of each year. Currently, ASBOG provides its Member Boards with two multiple-choice examinations—the Fundamentals of Geology (FG) and the Practice of Geology (PG). The FG and PG examinations have been developed to assess common knowledge and skills related to the practice of geology throughout the nation. The FG examination emphasizes knowledge and skills that are typically acquired in an academic setting and lead to a baccalaureate degree. The PG examination emphasizes skills and knowledge acquired or expanded in a practice or job setting. Individual Member Boards may require additional testing on local geology, statutes, rules, and regulations that address state-specific issues.

This ASBOG Examinee Candidate Handbook is the official guide to policies and procedures for the ASBOG National Geology Examinations. This guide will provide important information to exam candidates regarding scope; content and development of the licensure exams; a step-by-step guide to register and pay for the computer-based exams and select a testing location; and example practice questions to help prepare for the ASBOG National Geology Examinations.

Please note that ASBOG has not authorized use of its name by any commercial enterprise. ASBOG is not affiliated with, nor does it currently provide information for/to, or endorse, any examination preparation course(s), study guide/manuals/aid (i.e., flash cards), or publication other than its own Official ASBOG Fundamentals of Geology (FG) Prep Course. The ABSOG FG prep course brings together six experienced educators, who are professionally licensed, to review the eight content domains covered on the FG examination. Taking this course does not guarantee that candidates will pass the FG examination. However, upon completion of this course, candidates will be positioned for success, having received a comprehensive foundation from geologists adept in the test methods and subject matter presented in the FG examination, from which additional exam preparation efforts can be focused: https://asbogprep.getlearnworlds.com/

[1] Italicized words here and elsewhere in this document, except for the opening sentence, refer to terms listed in the Glossary (Appendix 1). Some sentences are in italics for emphasis.

Description of Examinations

Description of Examinations

Examination Validity

The FG and PG Examinations are developed following guidelines established in the Standards for Educational and Psychological Testing (1999) published by the American Educational Research Association, the American Psychological Association, and the National Council on Measurement in Education. The procedures are designed to maximize the fairness and quality of the examinations.

Council of Examiners (COE)

A committee of professional geologists serves as Subject Matter Experts (SMEs) on the Council of Examiners (COE). These SMEs represent the profession in terms of geography, ethnicity, gender, age, and area of practice. They supply the expertise that is essential in developing fair and impartial examinations for measuring competency within the profession.

SMEs attend two COE examination development and validation workshops each year. The COE Workshops are held shortly after the examinations have been administered so that the COE can evaluate statistical information and candidates' comments related to the examinations. The process is designed to maximize the fairness and quality of the examinations as measures of competency.

Examination questions are: (1) based on the results of a Task Analysis Survey (TAS), and are, therefore, representative of the important tasks needed for competent practice in the profession; and (2) written and reviewed by the COE. Statistical analyses are also reviewed by the COE so that any substandard items can be eliminated before generating candidates' final scores. The following sections further outline the process used in developing and validating the FG and PG Examinations.

ASBOG Test Blueprints

ASBOG conducts a TAS of the profession approximately every five to eight years to maximize the relevance of the examinations for candidates seeking licensure as professional geologists. The TAS is used to verify those tasks performed by the profession related to public protection. The findings are used to develop test blueprints (test specifications, content outlines) for constructing examinations and writing questions. The test blueprints list the geologic tasks, and the number of questions for each geologic task, to be included in both the FG and PG examinations. The COE reviews examination questions to verify that each question accurately reflects one or more of the tasks listed in the test blueprints.

The FG and PG test blueprints specify the domains/content areas for each examination. The relative importance of different content areas can be determined by reviewing the test blueprints shown in Appendix 2. The construction of the questions differs between the FG and PG examinations. The FG examination emphasizes knowledge and skills that are typically acquired in an academic setting and lead to a baccalaureate degree. The PG examination emphasizes skills and knowledge acquired or expanded in a practice or job setting.

Examination Development Procedures

Professional geologists (SMEs) have spent a considerable amount of time developing the FG and PG Examinations as fair measures of professional competence. As mentioned, questions on the examinations are reviewed by SMEs during regularly scheduled COE Workshops. These SMEs review statistical results for each item as well as written feedback from candidates who have just taken the examinations. This information is extremely valuable in evaluating the accuracy and fairness of each item in the examinations. Both ASBOG and the individual

Description of Examinations

State Member Boards are continually working to improve the quality of the examinations as fair measures of an individual's competence to practice before the public. The following paragraphs provide more detail regarding the development of the ASBOG National Geology Examinations.

Each FG and PG Examination question written by the SMEs is subjected to a minimum of four peer reviews.

- The first peer review occurs during the development of the question. During an item writing Workshop, each question is written by one or more members of the COE. Each new question is then reviewed independently by three other members of the COE. The purpose of the peer review process is to verify that the keyed answer is the one and only correct answer. This process is also used to make sure that the question is clear and is appropriate for use on the examination.
- All new questions that are accepted are entered into the ASBOG Examination Item Bank and subjected to an additional peer review at a subsequent COE Workshop. This peer review is completed by multiple SMEs at a COE workshop when it is included in the examination, which is reviewed in its entirety before the actual administration.
- Another "external" review occurs after the administration of the examinations. ASBOG encourages candidates to provide comments about specific questions while taking the examinations. Candidate comments become part of the examination review process during the post-examination COE Workshop. The COE reviews all new items and also any items that exhibit unusual statistical properties (i.e., difficult items, items with negative correlations). This review process makes it possible to improve the accuracy of the questions across time.

If the SMEs deem that a particular question has no correct answer (based on candidate comments, statistical information, or an evaluation of the accuracy of the question), then the item is not scored. Candidates will not be given credit for an item which has been deemed to have no correct answer. If the SMEs deem that a particular question has two correct answers (i.e., is a double-keyed question), then candidates who select either answer will be given credit. This process enhances the fairness of the examinations because substandard items (that have no correct answers) are eliminated before calculating candidates' final scores.

Scoring Procedures

Raw scores are calculated by summing the number of correct responses for each candidate. Credit is given for correct responses, while no points are received for incorrect responses. Note that all blank responses (i.e., omitted questions) are scored as incorrect responses. There is no penalty for guessing; therefore, it is to your advantage to answer all questions in the exams.

To ensure national uniformity, ASBOG provides each jurisdiction with a nationally recommended passing score. A scaled score of 70 has been established as a standard of minimum competency and 100 is the highest score possible. Failing scaled scores range from 0 (no correct responses) to 69 (highest failing score). However, the legal authority for making registration/licensure decisions rests solely with the individual jurisdictions and not with ASBOG.

Candidates who fail the examinations receive feedback on their performance levels for the content domains listed in the FG and PG Test Blueprints. A "+" indicates acceptable performance in a particular content domain, whereas a "-" shows substandard performance. The

Description of Examinations

feedback is designed to assist candidates in evaluating their proficiency levels in preparation for subsequent examinations.

Passing Scores

The passing scores on the ASBOG FG and PG Examinations reflect minimum competency and are determined using a criterion-referenced procedure which measures a candidate's performance based on a standard established by the COE. The COE evaluates the difficulty levels of the examination items in relation to minimum competency. Passing scores are adjusted (scaled) based on the difficulty level of each question in the examination so that candidates have the same probability of passing any version of the examinations.

ASBOG does NOT use "fixed-percentage" passing scores such as 70 or 75 percent correct because they fail to consider the difficulty levels of the questions in an examination and their relationship to minimum competency. Similarly, ASBOG avoids "grading on the curve" because registration/licensure is designed to ensure that practitioners possess enough knowledge to perform professional activities in a way that protects the public welfare. The key issue is whether candidates are competent to practice individually and not whether they are competent compared to other candidates.

Statistical Analyses

Statistical analyses are conducted on each form of the FG and PG Examinations. The statistics are valuable in evaluating the performance of the examinations (i.e., estimated reliability, mean, standard error of measurement etc.). The statistical results indicate whether the examinations are reliable and performing well.

The statistical analyses are also useful for isolating items that possess unusual statistical properties (i.e., very difficult, negative correlations). Items that possess negative correlations reveal that candidates with high test scores did poorer on these items compared to candidates with low test scores. Any items that exhibit negative correlations are reviewed during the workshop (by the SMEs) before scores are finalized and distributed to the State Member Board Examination Administrators.

Sample questions for the FG and PG Examinations are presented in Appendix 3 and 4, respectively. The sample questions do not make up complete examinations; however, they do represent the general content areas and formats. They are presented herein as a guide for your preparation for the examinations. The FG and PG Examinations measure some of the same competencies related to the practice of geology, but construction of the questions differs between the two levels. FG questions are designed primarily to recall factual information; the PG questions are focused on candidates' competencies to apply the basic principles of geology, based mainly on work experience.

General Information

General Information

Qualifications

The purpose of registration/licensure is to safeguard life, health and property and to promote the public welfare. Evaluation of the qualifications of candidates who seek registration/licensure provides the first step toward ensuring that this objective is met. While examinations offer one means of measuring the competency levels of candidates, most jurisdictions also screen candidates on the basis of education and experience requirements set forth in State Laws, Rules, and Regulations. The requirements vary across the nation. As the examination shall be administered only to those candidates who have met the statutory and regulatory prerequisites of the State in which they are seeking registration/licensure, it is important that candidates contact the State Member Board office where they are seeking registration/licensure to obtain information with respect to the specific requirements for that State.

Application Procedures / Filing Deadlines

Application forms and instructional information for the examination are available from individual State Member Boards. You should be aware that examination requirements, filing deadlines, and fees vary from State to State. You are responsible for contacting the State Member Board Examination Administrator for this type of information. (Pleasenote that some State Member Boards use a professional testing service in support of processing applications and distributing results.) You are encouraged to allow sufficient time to complete the application process and assemble required data, such as transcripts and letters of recommendation. The State Member Board Examination Administrator will notify you regarding your approval status (i.e., accept/reject).

Examination Schedule

The ASBOG National Geology Examinations are given during the spring and fall of each year. Candidates must contact the geology board for the state in which they wish to seek licensure regarding specific dates for licensure applications and submittal of related required credentials needed for approval to sit for the examination(s). Candidates should understand that each State Member Board has their own cut-off dates for submission of examination requests/approval. Contact information for the different State Member Boards can be found on the ASBOG website through this link:

https://asbog.org/state_boards.html

All ASBOG examinations are be administered by an Examination Administrator contracted to ASBOG using computer-based testing (CBT) facilities. The Examination Administrator contracted by ASBOG for 2023-2025 is
Prometric LLC (Prometric).

ASBOG Products for Faculty

ASBOG Products for Faculty

Eligibility

Eligibility to sit for the ASBOG National Licensure Examinations varies and is determined by each State Member Board. Candidates seeking licensure in Georgia, Minnesota, and Utah will have an additional step to register for the exams. Candidates from these states must first complete preregistration through the Prometric portal using this link:

https://www.smttest.com/candidatemanagementsystem/cplogin.aspx?cms_cid=590

All other candidates should first contact the geology board for the state in which they wish to seek licensure to start the application process. Contact information for the State Member Boards can be found on the ASBOG website through this link:

https://asbog.org/state_boards.html

How To Register For The Exam

Step 1
Once the State Member Board has approved and pre-registered a candidate to sit for an exam, the candidate will receive an email from registrations@isoqualitytesting.com that will contain instruction for how to register, pay and schedule their exam.

On the following page is an example of the email message that all candidates approved to sit for the exams will receive; this message provides instruction for candidates to follow through with scheduling and payment for the exam(s).

To Be Determined

To Be Determined

What to Bring

All examinee candidates must bring a valid government-issued photo ID with signature in order to be admitted to the examination. Approved forms of ID include:

- Driver's License
- Government Issued ID Card (must have photo and signature)
- Passport
- U.S. Military ID.

No digital IDs or other forms of identification will be accepted. The first and last name on your admission letter must match the name on your photo IDs.

The FG and PG examinations are closed-book examinations. Only the following items are allowed in the testing room:

- The IDs used during the admission process
- Non-QWERTY calculator (without the cover)
- Key to your test center locker
- Eyeglasses (without the case)
- Light sweater or jacket

Items prohibited in the testing room include but are not limited to cell phones, handheld computers/personal digital assistants (PDAs) or other electronic devices, alpha programmable calculators, camera, scanning pens, fitness trackers, pagers, watches, wallets, purses, hats and other head coverings (unless they qualify as religious apparel), bags, coats, books, notes, food, and beverages. Thumbtacks, cardboard, meridian stereographic nets and tracing paper are not necessary and will not be allowed in the testing room. Violation of any of the above-mentioned prohibitions will result in immediate expulsion from the examination site and forfeiture of examination privileges (examination will not be scored) and fees.

What to Expect

Check-In: Candidates are instructed to arrive at least 30 minutes before the scheduled exam. A Prometric representative will confirm that the only items in your possession are ones allowed into the testing area. Candidates will be provided a locker to store all belongings not permitted in the testing room in a designated area outside of the testing room. Candidates must turn off all electronic devices before storing them in the locker.

After candidates complete the check-in process, they will be escorted into the testing area, where a proctor will confirm their identity. After verifying their identity and the exam that will be taken, the proctor will answer any questions you might have and escort you to your workstation and start the exam. During the examination, candidates will be allowed to use the bathroom in the testing facility. The bathrooms will be in the proctored area and candidates will not have access to their locker during a bathroom break.

DAY OF THE EXAM

- [x] Candidate Admission Letter
- [x] Acceptable form of identification
- [x] Approved comfort items

Here is a link to a video that will provide candidates with a detailed overview of what to expect during their upcoming visit to a Prometric test center:

https://www.prometric.com/test-takers/what-expect

Appendix 1: Glossary

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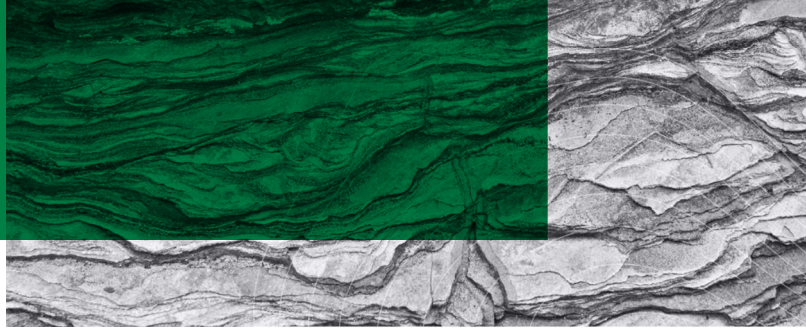


Candidate Comment Forms:
Forms provided to examination candidates as part of the examination process to allow for feedback to ASBOG. The Fundamentals of Geology (FG) forms are yellow and the Practice of Geology (PG) forms are green. Valid, written comments from a candidate who has already taken the Examinations are always welcome and may become a part of the examination review process during the post-examination Council of Examiners (COE) Workshop. Candidate comments are anonymous and used only to improve the quality of the examination items (questions).

COE:
See Council of Examiners.

Council of Examiners (COE):
ASBOG National Examination Committee composed of selected individuals who are Subject Matter Experts (SMEs) in their respective domains and who represent a cross-section of geography, gender, area of practice (specialty), experience, and ethnicity. The COE meets twice yearly as part of the ASBOG COE Workshops, usually about three weeks after the administration of the FG and PG examinations; one of the two Workshops is held in conjunction with the ASBOG Annual Business Meeting each fall.

Criterion-Referenced Approach:
Psychometric procedure used to determine passing scores that reflect a standard of minimum competency.

Domains/Content Areas:
The subject matter within a profession; for example, geophysics, hydrogeology or field methods in the profession of geology.

Examination Administrator:
The State Member Board, or its authorized testing service, actually responsible for administering (proctoring) the examination. Some State boards use their own staff to proctor the examination; some have a State Department of Testing (bureau/agency), and some use a professional testing service. See Proctor.

Examination Item:
Question or problem used in an examination.

Examination Item Bank:
Data base of examination items which are stored on computer after acceptance by the COE.

Fundamentals Of Geology (FG) Examination:
ASBOG National Examination with items related to knowledge and skills acquired in an academic setting that leads to a baccalaureate degree; consists of 140 questions.

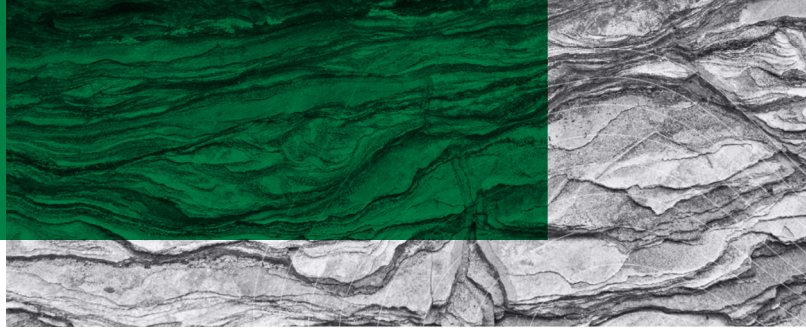
Keyed Answer (KEY):
The one and only correct answer. A new question, developed by one or more of the members of the COE, is independently reviewed/critiqued by three other members (SMEs). The peer review process verifies the keyed answer. The review also focuses on the quality of the item to ensure the question is clear and is appropriate for use on the examination.

Minimum Competency:
The standard used in establishing passing scores on ASBOG Examinations.

Proctor:
Individual(s) administering the examination(s).
See Examination Administrator.

Practice Of Geology (PG) Examination:
ASBOG National Examination with items that assess skills and knowledge acquired or expanded through employment, typically after five years of work experience; consists of 110 questions.

Appendix 1: Glossary



Raw Score:
Unadjusted score on an examination based on the total number of correct responses. If the COE Subject Matter Experts (SMEs) deem a particular question to have no correct answer (based on candidate comments, statistical information, evaluation of the accuracy of the question, etc.), then that item is not scored (i.e., the FG examination would be graded on the basis of 139 instead of 140 questions. Similarly, the PG examination would be scored on the basis of 109, not 110 questions.) Candidates will not be given credit for an item which has been deemed to have no correct answer. If the SMEs deem that a particular question has two correct answers (i.e., is a double-keyed question), then candidates who select either answer will be given credit. This process enhances the fairness of the examinations because substandard items (that have no correct answers) are eliminated before calculating candidates' final scores.

Scaled Score:
Adjusted score, based on the average difficulty level of each examination (FG and PG). A scaled score of 70 has been established as a standard of minimum competency. On all forms of the ASBOG National Examinations, a scaled score of 70 is the minimum score required to pass and 100 is the highest score possible. Failing scaled scores range between 0 (no correct responses) and 69 (highest failing score).

SME:
See Subject Matter Expert.

Stem:
The introductory portion of an examination item that states a question, states a problem, or presents an incomplete statement.

Subject Matter Expert (SMES):
A geologist who serves on the ASBOG Council of Examiners; SMEs represent the profession in terms of geography, ethnicity, gender, age, and area of practice.

Task Analysis Survey (TAS):
A survey prepared and conducted by the Council of Examiners (COE) to determine the geologic tasks performed by geologists. The survey focuses on tasks that involve protection of the health, safety and welfare of the public. The survey form is mailed to licensed geologists selected at random from the lists of registered/licensed geologists provided to ASBOG by those Member Board States with geologist registration/licensure laws. (Note: The 2015 TAS was distributed in 29 states.) Geologists rate the importance of each task in protecting the health, safety and welfare of the public. Results from the TAS determine the number of questions from each geologic task category to be included in both the FG and PG Examinations.

Test Blueprint:
An outline that lists the domains/content areas (subject matter) and their percentage weights in the FG and PG Examinations.

Appendix 2: FG and PG Test Blueprints

Appendix 2:
FG and PG Test Blueprints

Content Domains	FG %	PG %
A. General and Field Geology	17	17
B. Mineralogy, Petrology, and Geochemistry	12	5
C. Sedimentology, Stratigraphy, and Paleontology	11	5
D. Geomorphology, Surficial Processes,and Quaternary Geology	14	8
E. Structure, Tectonics, and Seismology	12	9
F. Hydrogeology	13	22
G. Engineering Geology	12	18
H. Economic Geology and Energy Resources	9	16
TOTALS	100	100

This ASBOG® Fundamentals of Geology (FG) and Practice of Geology (PG) Examination Knowledge Base consists of eight domains which collectively encompass the scientific and practical knowledge needed to become a licensed professional geologist. The Knowledge Base for Domain A encapsulates the general principles and knowledge of general geology and field methods which provide the foundation for the other seven domains; i.e., the other seven domains implicitly include the Knowledge Base for Domain A. Within each domain, the order in which the items are listed does not reflect their relative importance.

A. GENERAL GEOLOGY AND GEOLOGICAL INVESTIGATIONS

Topics (see Knowledge Base for more details):

Surface and subsurface exploration techniques and interpretations; Geologic and geophysical tools, application, and interpretation; Earth processes; Surface and subsurface mapping and map applications; Geologic section construction; Photogrammetry, terrain measurement, GPS, and GIS; Remote sensing; Image analysis and interpretation; Scale and scale analysis; Measurement theory, accuracy and precision; Geostatistics; Documentation and record keeping; Modeling concepts; Professionalism and ethics; Project planning, management, organization, and economics; QA/QC (FG/PG)

1. Plan and conduct geological investigations considering public health, safety, and welfare, the environment, regulations, and Quality Assurance/Quality Control (QA/QC).
2. Compile and organize available information to plan geological investigations.
3. Collect, describe, and record new geological and geophysical data.
4. Determine positions, scales, distances, and elevations from remote sensing, imagery, surveys, sections, maps, and GIS.
5. Prepare, analyze, and interpret logs, sections, maps, and other graphics derived from field and laboratory investigations.

Appendix 2:
FG and PG Test Blueprints

B. MINERALOGY, PETROLOGY, AND GEOCHEMISTRY

Topics (see Knowledge Base for more details):

Rock and mineral identification; Crystal symmetry, systems, and forms; Igneous rocks and processes; Sedimentary rocks and processes; Metamorphic rocks and processes; Geochemical reactions and diagenesis; QA/QC (FG/PG)

Project planning, management, organization, and economics (PG)

6. Plan and conduct mineralogic, petrologic, and geochemical investigations, including the use of field, laboratory, and analytical techniques.
7. Identify minerals and rocks and their characteristics.
8. Identify and interpret rock and mineral sequences and associations, and their genesis.
9. Evaluate geochemical and isotopic data and construct geochemical models related to rocks and minerals.
10. Determine type, degree, and effects of rock and mineral alteration.

C. SEDIMENTOLOGY, STRATIGRAPHY, AND PALEONTOLOGY

Topics (see Knowledge Base for more details):

Stratigraphic principles; Weathering, erosion, transport, and deposition; Depositional environments; Facies analysis; Basin analysis; Sedimentary structures; Diagenesis; Geologic time; Geochronology; Fossil record and evolution; QA/QC (FG/PG)

Project planning, management, organization, and economics (PG)

11. Plan and conduct sedimentologic, stratigraphic, or paleontologic investigations, including the use of field, laboratory, and analytical techniques.
12. Select and apply appropriate stratigraphic nomenclature and establish correlations.
13. Identify and interpret sedimentary processes and structures, depositional environments, sediment provenance, and geochemical and climatic cycles.
14. Identify and interpret sediment and/or rock sequences, positions, and ages, and interpret sequence stratigraphy.
15. Identify fossils and interpret fossil assemblages for age, paleoenvironmental interpretations, and/or stratigraphic correlations.

D. GEOMORPHOLOGY, SURFICIAL PROCESSES, AND QUATERNARY GEOLOGY

Topics (see Knowledge Base for more details):

Geomorphic processes; Landform analysis techniques; Sea and lake level change; Glaciation; Weathering; Sediment transport; Groundwater and surface water; Low temperature geochemistry; Human-land interaction; Soil development and classification; Remote sensing; GIS; QA/QC (FG/PG)

Project planning, management, organization, and economics (PG)

16. Plan and conduct geomorphic investigations, including the use of field, laboratory, and analytical techniques.
17. Identify, classify, and interpret landforms, surficial materials, and processes.
18. Determine absolute or relative age

relationships of landforms, sediments, and soils.

19. Evaluate geomorphic processes and development of landforms, sediments, and soils, including watershed processes.
20. Apply remote sensing and GIS techniques to interpret geomorphic conditions and processes.

E. STRUCTURE, TECTONICS, AND SEISMOLOGY

Topics (see Knowledge Base for more details):

Fractures, faults, and folds; Rock fabric; Rock mechanics; Structural analysis; Plate tectonics; Tectonic regimes; Volcanism; Structural and seismic history; Paleoseismology; Earthquake processes; QA/QC (FG/PG)

Project planning, management, organization, and economics (PG)

21. Plan and conduct structural, tectonic, or seismic investigations, including the use of field, laboratory, and analytical techniques.
22. Identify and define structural features and relationships to construct and interpret cross sections and structural projections, and perform statistical analyses.
23. Interpret deformational history through structural and tectonic analyses.
24. Develop and apply tectonic models to identify geologic processes and history.
25. Evaluate earthquake mechanisms and paleoseismic history.

F. HYDROGEOLOGY

Topics (see Knowledge Base for more details):

Groundwater and surface water systems and processes; Aquifer characterization; Hydrogeologic modeling; Low temperature aqueous geochemistry; Contaminant transport and geochemistry; Isotopic and tracer studies; Hydraulic properties of fluids and earth materials; Site investigation methods, tools, and applications; Geophysical techniques; Landform analysis; Weathering; QA/QC (FG/PG)

Well drilling; Well design and construction; Soil and water remediation techniques; Water resources management and protection; Project planning, management, organization, and economics (PG)

26. Plan and conduct hydrogeological, geochemical, and contaminant investigations, including the use of field, laboratory, and analytical techniques.
27. Define and characterize hydraulic properties of vadose and saturated zones.
28. Design groundwater monitoring, observation, extraction, production, or injection wells.
29. Evaluate water resources, assess aquifer yield, and determine sustainability.
30. Characterize soil and water quality, and assess chemical fate and transport.
31. Manage, develop, protect, or remediate surface water or groundwater resources.

Appendix 2:
FG and PG Test Blueprints

G. ENGINEERING GEOLOGY

Topics (see Knowledge Base for more details):

Landform analysis techniques; Soil and rock weathering; Groundwater and surface water systems and processes; Low temperature geochemistry; Human-land interaction; Soil and rock mechanics; Soil and rock classification and engineering properties; Geologic hazards; Hazard and risk analyses; Cost/benefit analyses; Site investigation methods, tools, and applications; Geophysical techniques; QA/QC (FG/PG)

Land restoration and hazard mitigation; Mine closure; Image analysis and interpretation; Remote sensing; GIS; Earth and rock construction methods; In-situ and laboratory testing; Project planning, management, organization, and economics (PG)

32. Plan and conduct engineering geological investigations, including the use of field and laboratory methods.
33. Identify and characterize physical and index properties of earth materials.
34. Provide recommendations for engineering design, land use decisions, environmental restoration, and watershed management.
35. Identify, map, and evaluate geologic hazards and processes.
36. Interpret land use, landforms, and geological site characteristics using remote sensing data, maps, records, and GIS.
37. Develop plans, interpretations, and recommendations for ground behavior during infrastructure development or hazard mitigation.

H. ECONOMIC GEOLOGY AND ENERGY RESOURCES

Topics (see Knowledge Base for more details):

Exploration and development techniques; Geophysical techniques; Petrophysical techniques; Geochemical analysis; Geostatistical analysis; Mineralization processes; Characteristics of mineral deposits; Energy resource systems; Characteristics of hydrocarbon traps; Industrial minerals, coal, and earth materials; Exploration risk and economics; Resource/reserve assessment; Safety hazards and risk analysis; Professionalism and ethics; QA/QC (FG/PG)

Exploration drilling techniques; Drill program design and management; Assaying; Land restoration and hazard mitigation; Mine and well decommissioning; Project planning, management, organization, and economics (PG)

38. Plan and conduct resource exploration, evaluation, and reclamation programs, including the use of conceptual models, and field, laboratory, and analytical techniques.
39. Collect and interpret data necessary to locate mineral or energy resources.
40. Determine the presence and distribution of resources based on surface and subsurface data.
41. Perform economic evaluation and reserve assessment.
42. Calculate quantity and quality of resources.
43. Conduct geological studies for design, abandonment, closure, waste management, and reclamation and restoration of energy development or mineral extraction operations.

Appendix 3: Knowledge Base

Association of State Boards of Geology

General Geology and Geological Investigations (Domain A)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

A-1. Earth systems and processes
- A-1.1 Earth history
- A-1.2 Earth systems (e.g., geosphere, hydrosphere, atmosphere, biosphere)
- A-1.3 Geological cycle and processes (e.g., rock types, plate tectonics)
- A-1.4 Hydrologic cycle and processes (e.g., evaporation, precipitation, ocean currents)
- A-1.6 Energy sources and cycles (e.g., solar vs. geothermal, global energy balance)
- A-1.7 Carbon cycle

A-2. Sources of geological information
- A-2.1 Government agencies (e.g., USGS, USDA, NRCS, state geological surveys)
- A-2.2 Scientific literature (e.g., peer-reviewed publications, geological field trip publications, graduate theses)

A-3. Geological and geophysical tools, techniques, and interpretation
- A-3.1 Subsurface investigation (e.g., drilling, rock coring, soil sampling)
- A-3.2 Rock and soil logging and description
- A-3.3 Surface and borehole geophysics (e.g., seismic refraction/reflection, resistivity, GPR, televiewer)

A-4. Field notes, documentation, and record-keeping

A-5. Global positioning, coordinate systems, and datums
- A-5.1 Coordinate systems and datums (e.g., types and applications)
- A-5.2 Global Positioning Systems (GPS)
- A-5.3 Measurement accuracy and precision

A-6. Scale and scale analysis
- A-6.1 Scale types, applications, and analysis
- A-6.2 Horizontal and vertical scales and relationships (e.g., vertical exaggeration)

A-7. Surface and subsurface mapping and map applications
- A-7.1 Topographic maps, slopes, and profiles
- A-7.2 Geologic maps, symbols, and applications
- A-7.3 Strike and dip, apparent dip, thickness and depth
- A-7.4 Isopach and isoconcentration maps

A-8. Remote sensing, image analysis, and Geographic Information Systems
- A-8.1 Aerial imagery and photogrammetry
- A-8.2 Remote sensing (e.g., infrared, radar imagery, satellite imagery, and Light Detection and Ranging (LiDAR))

A-8.3 Geographic Information Systems (GIS) and applications

A-9. Analysis and interpretation of geological sections and sequences
A-9.1 Geologic cross sections, boring logs, and geologic maps
A-9.2 Sequence of geological events (e.g., relative geologic time)

A-10. Project planning and development (***PG Only***):
D-10.1 Work scoping and cost estimating
D-10.2 Literature and regulatory review
D-10.3 Site-specific data, maps, and health & safety plans
D-10.4 Hazard identification and analysis

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Mineralogy, Petrology, Geochemistry (Domain B)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

B-1. Mineralogy
- B-1.1 Mineral groups (e.g., silicates, oxides, carbonates, sulfides)
- B-1.2 Mineral chemical and physical properties (e.g., composition, density, hardness, magnetism, luminescence, anisotropy related to crystal structure)
- B-1.3 Hazardous minerals and processes (e.g., asbestiform minerals, Pb-bearing minerals, silicosis)
- B-1.4 Material characterization methods (e.g., X-Ray Diffraction, X-Ray Fluorescence, ICP-MS, Scanning Electron Microscope)

B-2. Igneous petrology
- B-2.1 Igneous rock classification (e.g., intrusive and extrusive, mineral- and chemistry-based classification schemes)
- B-2.2 Magma evolution and phase diagrams (e.g., fractionation, nucleation, exsolution)
- B-2.3 Igneous petrogenesis and tectonic settings (e.g, mid-ocean ridge spreading centers, subduction zone volcanism, hotspots)
- B-2.4 Volcano types, eruption styles and volcanic deposits (e.g., stratovolcanoes, fire fountains, volcanic explosivity index)

B-3. Sedimentary petrology
- B-3.1 Sedimentary rock classification (e.g., siliciclastic, carbonates, evaporites, biochemical)
- B-3.2 Mineralogy of sediment & sedimentary rocks (e.g., common mineral occurrences in different environmental settings)
- B-3.3 Diagenesis (e.g., common clay minerals, oxides and oxyhydroxides, alteration of silicate minerals, redoximorphic features)

B-4. Metamorphic petrology
- B-4.1 Metamorphic rock classification (e.g., foliated and non-foliated)
- B-4.2 Metamorphic facies and tectonic regimes (e.g., greenschist, blueschist, granulite)
- B-4.3 Mineral/metamorphic rock associations (e.g., index minerals and associations)

B-5. Geochemistry
- B-5.1 Chemical composition of the Earth's layers (e.g., most common elements in Earth's crust, mantle, and core)
- B-5.2 Element classification and associations (e.g., halides, transition elements, noble elements)
- B-5.3 Chemical weathering (e.g., Reduction-Oxidation reactions, dissolution and reprecipitation reactions, hydrothermal alteration)
- B-5.4 Stability diagrams (e.g., pH/Eh diagrams, P-T diagrams, T-X_i-diagrams)

B-5.5 Isotope geochemistry and geochronological techniques (e.g., U-Pb, K-Ar, Rb-Sr, ^{14}C methods, and optically stimulated luminescence)

B-6. Project planning and development (***PG Only***):
- B-6.1 Scope of work and cost estimate
- B-6.2 Literature and regulatory review
- B-6.3 Site-specific maps (GIS) and health & safety
- B-6.4 Site-specific data

Sedimentology, Stratigraphy, and Paleontology (Domain C)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

C-1. Stratigraphic principles
- C-1.1 Naming conventions (e.g., bed, units, members, formations, contacts)
- C-1.2 Rules (e.g., superposition, original horizontality, cross-cutting relationships)
- C-1.3 Unconformities (e.g., non-conformities, disconformities, paraconformities, angular unconformities)
- C-1.4 Using and interpreting stratigraphic columns, cross sections, fence diagrams
- C-1.5 Geochronology (e.g., geologic timescale, geochronologic methods)
- C-1.6 Correlation (e.g., geomagnetic polarity reversals, rock types, index fossils)

C-2. Sedimentary structures
- C-2.1 Primary (e.g., cross-bedding, ripples, flute and tool marks)
- C-2.2 Secondary (e.g., concretions, stylolites, Liesegang banding)
- C-2.2 Biogenic (e.g., burrows, trails, stromatolites)

C-3. Diagenesis
- C-3.1 Post depositional changes (e.g., compaction, recrystallization, dissolution, replacement, cementation, lithification, reduction-oxidation reactions)

C-4. Facies analysis
- C-4.1 Fabric (e.g., porosity, permeability, packing, isotropic vs. anisotropic)
- C-4.2 Facies changes (e.g., movements of shorelines, shallowing or deepening upwards successions)
- C-4.3 Facies-depositional environment relationships
- C-4.4 Relative sea level change (e.g., transgression, regression)

C-5. Depositional environments
- C-5.1 Clastic environments
  - C-5.1.1 Textural indicators (e.g., grain size, shape, angularity)
  - C-5.1.2 Non-Marine (e.g., glacial, eolian, alluvial, fluvial, lacustrine)
  - C-5.1.3 Transitional (e.g., deltaic, tidal, beach, lagoon, barrier island)
  - C-5.1.4 Marine (e.g., shelf, slope, rise, abyssal plain)
- C-5.2 Carbonate environments
  - C-5.2.1 Platform and bank
  - C-5.2.2 Ramp
  - C-5.2.3 Pelagic
- C-5.3 Evaporite environments

C-6. Fossil record and evolution
- C-6.1 Connections to structure of geologic time scale

C-6.2 Index fossils
C-6.3 Biostratigraphy

C-7. Basin analysis
C-7.1 Sequence stratigraphy
C-7.2 Seismic stratigraphy
C-7.3 Depositional systems
C-7.4 Global cycles (e.g., Milankovitch cycles of eccentricity, obliquity, precession)
C-7.5 Facies architecture
C-7.6 Provenance

C-8. Project planning and development (***PG Only***):
E-8.1 Scope of work and cost estimate
E-8.2 Literature and regulatory review
E-8.3 Site-specific maps (GIS) and health & safety plan
E-8.4 Site-specific data

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Geomorphology and Surficial Processes (Domain D)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

D-1. Basic processes
- D-1.1 Driving forces (e.g., climate, gravity, tectonics)
- D-1.2 Resisting forces (e.g., lithology, structure, friction)

D-2. Weathering and soil development
- D-2.1 Chemical weathering processes (e.g., oxidation, dissolution, hydrolysis) and products (e.g., clay minerals, laterite)
- D-2.2 Physical weathering processes (e.g., frost wedging, sheeting) and products (e.g., talus, grus)
- D-2.3 Soil development (e.g., profile/horizon development, residual [in-situ] vs transported)

D-3. Analysis of surficial materials
- D-3.1 Grain size analysis (e.g., sieve, hydrometer)
- D-3.2 Soil classification systems (e.g. USDA, USCS)
- D-3.3 Age dating techniques (e.g., relative vs. absolute; optical stimulated luminescence [OSL], radiocarbon)

D-4. Fluvial processes and landforms
- D-4.1 Erosional processes and landforms (e.g., cut bank, point bar)
- D-4.2 Depositional processes and landforms (e.g., delta, alluvial fan)
- D-4.3 Hydraulic gradient and equilibrium
- D-4.4 Channel morphology, patterns, and profiles (e.g., meandering, braided, dendritic, trellis)
- D-4.5 Sediment grain size and distribution
- D-4.6 Effects of external influences (e.g., climate, urbanization, changes in base level)

D-5. Mass movements and slopes
- D-5.1 Factors initiating movement (e.g., angle of repose, role of water)
- D-5.2 Classification of movement type (e.g., slump, slide, earthflow, debris flows, lahars)

D-6. Aeolian processes and landforms
- D-6.1 Erosional processes (e.g., deflation) and landforms (e.g., blowouts, desert pavement)
- D-6.2 Depositional processes and deposits (e.g., loess, dunes)

D-7. Glacial processes and landforms
- D-7.1 Formation, movement, and mass balance

D-7.2 Erosional processes (e.g., plucking, abrasion) and landforms (e.g., arete, cirque, horn)
D-7.3 Depositional processes and landforms/deposits (e.g., lateral moraines, kettles, till)
D-7.4 Sediment grain size and distribution
D-7.5 Isostatic effects
D-7.6 Effects of changing variables (e.g., climate, ice temperature, albedo)

D-8. Karst processes and landforms
D-8.1 Erosional processes and landforms (e.g., sinkhole, sinking stream, cave)
D-8.2 Hydrology and drainage
D-8.3 Cave development

D-9. Coastal processes and landforms
D-9.1 Erosional processes and landforms (e.g. wave-cut platforms)
D-9.2 Depositional processes and landforms (e.g. spits, barrier islands, tombolo)
D-9.3 Waves, tides, and currents
D-9.4 Drivers and effects of sea level change (relative and absolute, past and future)
D-9.5 Beaches and shorelines

D-10. Volcanic processes and landforms
D-10.1 General features (e.g. vent, crater, caldera)
D-10.2 Intrusive (e.g., dike, sill, batholith) and extrusive landforms (e.g. cinder, composite, shield)
D-10.2 Types of volcanic eruptions (e.g. plinian, strombolian) and associated deposits

D-11. Project planning and hazard analysis (***PG Only***):
D-11.1 Work scoping and cost estimating
D-11.2 Literature and regulatory review
D-11.3 Site-specific data, maps, and health & safety plans
D-11.4 Hazard identification and analysis

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Structure, Tectonics, Seismology (Domain E)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

E-1. Structural interpretation
- E-1.1 Three-point problems and structure contours
- E-1.2 Predicting depth and thickness of strata/faults
- E-1.3 Outcrop patterns and structural rule of "Vs"
- E-1.4 Interpretation of geologic maps and cross-sections

E-2. Deformation styles
- E-2.1 Brittle deformation (e.g., faults, fractures, joints)
- E-2.2 Ductile deformation (e.g., folds)

E-3. Structural fabrics
- E-3.1 Fabric development (e.g., linear, planar, shear)
- E-3.2 Fabric analysis (e.g., stereonet, rose diagram)

E-4. Classifications
- E-4.1 Fault classification (e.g., dip-slip, strike-slip, oblique-slip)
- E-4.2 Fold classification (e.g., anticline, syncline, monocline)

E-5. Mechanical properties of rock
- E-5.1 Stress, strain and strain rate
- E-5.2 Mohr circle (e.g., determination of shear strength, friction angle, cohesion)
- E-5.3 Conditions of brittle, brittle-ductile, and ductile deformation

E-6. Seismic/paleoseismic history
- E-6.1 Exploration methods
- E-6.2 Age determination
  - E-6.2.1 Absolute age determination (e.g., OSL, ^{14}C)
  - E-6.2.2 Relative age determination (e.g., cross cutting relations)

E-7. Plate tectonics/tectonic regimes/earthquake processes
- E-7.1 General characteristics of earth layers (e.g., density, seismic velocity)
- E-7.2 Earthquakes at plate boundaries (e.g., depth and magnitude)
- E-7.3 Tectonics and volcanic activity

E-8. Project planning and development (***PG Only***):
- E-8.1 Scope of work and cost estimate
- E-8.2 Literature and regulatory review
- E-8.3 Site-specific maps (GIS) and health & safety plan
- E-8.4 Site-specific data

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Hydrogeology (Domain F)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

F-1. Hydrologic cycle and hydrostratigraphy
- F-1.1 The hydrologic cycle
- F-1.2 Aquifers, aquitards, and hydrostratigraphy
- F-1.3 Saturated and unsaturated systems (e.g., vadose zone, water table, and phreatic zone)
- F-1.4 Watershed mass balance and processes (e.g., evaporation, transpiration, precipitation, infiltration, sublimation, and recharge)
- F-1.5 Stream discharge and hydrographs
- F-1.6 Groundwater/surface water interaction (e.g., streams, lakes, springs, and wetlands)
- F-1.7 Water resources management and protection (PG)

F-2. Hydrogeologic properties and principles
- F-2.1 Hydraulic head and hydraulic gradient
- F-2.2 Hydraulic parameters (e.g., porosity, hydraulic conductivity, permeability, and transmissivity)
- F-2.3 Groundwater flow concepts (e.g., Darcy's Law, specific discharge, and average linear velocity equation)
- F-2.4 Groundwater storage (e.g., specific yield, specific retention, storativity, and specific storage)

F-3. Groundwater flow systems
- F-3.1 Groundwater flow systems and flow nets
- F-3.2 Groundwater flow models
- F-3.3 Zones of Influence and well interference
- F-3.4 Karst and fractured rock flow systems

F-4. Hydrogeologic methods of investigation
- F-4.1 Types of wells, well drilling methods, and construction (PG)
- F-4.2 Laboratory hydraulic tests (e.g., permeameter tests)
- F-4.3 Single-well tests (e.g., slug tests and specific capacity tests)
- F-4.4 Multiple-well tests (e.g., confined, leaky, unconfined, time-drawdown, and distance-drawdown pumping and recovery tests)
- F-4.5 Pumping test boundary conditions
- F-4.6 Investigating the unsaturated zone (e.g., tensiometers, lysimeters, gypsum blocks, and time domain reflectometry)
- F-4.7 Hydrogeophysical methods (e.g., borehole geophysics, surface resistivity, seismic, and ground penetrating radar)

F-5. Aqueous geochemistry and contaminant hydrogeology
- F-5.1 Groundwater geochemical parameters

F-5.2 Groundwater contaminants
F-5.3 Contaminant fate and transport (e.g., advection, sorption, dispersion, diffusion, degradation) and breakthrough curves
F-5.4 Groundwater remediation (PG)
F-5.5 Isotopic and tracer studies

F-6. Project planning and development (PG only)
F-6.1 Scope of work and cost estimation
F-6.2 Literature and regulatory review
F-6.3 Site-specific maps and health and safety plans

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Engineering Geology (Domain G)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

G-1. Geologic properties, soil origins (in-situ and transported), and groundwater

G-2. Soil mechanics
- G-2.1 Soil properties: physical and index (e.g., grain size, soil gradation, density/unit weight, water content, void ratio, porosity, cohesive, non-cohesive)
- G-2.2 Soil classification (e.g., sieve analysis, specific gravity, Atterberg limits)
- G-2.3 Classification systems (e.g., USCS, AASHTO)
- G-2.4 Compaction and consolidation
- G-2.5 Shear strength (e.g., cohesive v. non-cohesive soils)
- G-2.6 Stability of soil slopes

G-3. Rock mechanics
- G-3.1 Classification and index properties (e.g., rock type, weathering, deformation)
- G-3.2 Rock mass classifications (e.g., rock fabric orientation, joint spacing, joint/planar surface features, joint filling materials, rock quality designation [RQD])
- G-3.3 Rock strength failure criteria (e.g., uniaxial compressive strength, shear strength of discontinuities, tensile strength, Hoek-Brown geological strength index, Mohr-Coulomb)
- G-3.4 Failure modes (e.g., wedge, topple, planar)
- G-3.5 Planes of weakness and testing planes (e.g., friction angle, cohesion of failure planes, water content of fractures)
- G-3.6 Deformability of rock (e.g., direct shear test, ripability)
- G-3.7 Kinematic analysis (e.g., stereonets)

G-4. Geologic hazards
- G-4.1 Hazard and risk analysis (e.g., floods, landslides, earthquakes, subsidence, erosion)

G-5. Engineering geology methods of investigation
- G-5.1 Well drilling methods (e.g., direct push technologies, sonic, hollow stem, rotary)
- G-5.2 Geophysical methods (e.g., borehole geophysics, seismic refraction, surface resistivity, ground penetrating radar)
- G-5.3 Image analysis and interpretation

G-6. In-situ and laboratory testing
- G-6.1 In-situ testing (e.g., standard penetration testing, cone penetration testing, infiltration, slug/pumping test)
- G-6.2 Laboratory testing (e.g., triaxial, uniaxial, point load, drained, undrained)

G-7 Project planning and development (*PG only*)

G-7.1 Scope of work and cost estimation
G-7.2 Literature and regulatory review
G-7.3 Site-specific maps and health and safety plans

Mineral and Energy Resources (Domain H)

[Note: Examples given below are descriptive only and are not all-inclusive lists of items]

H-1. Ore/mineral systems and principles
- H-1.1 Ore minerals and their economic use(s)
- H-1.2 Mineral system/ore formation processes
  - H-1.2.1 Magmatic (e.g., disseminated deposits, vein/lode deposits, sulfide deposits, pegmatites, kimberlites, carbonatites)
  - H-1.2.2 Hydrothermal deposits (e.g., porphyry, volcanogenic massive sulfide, epigenic, geothermal brines)
  - H-1.2.3 Sedimentary ore deposits (e.g., placer, banded iron formations [BIF], evaporites, laterites, phosphorites)
  - H-1.2.4 Metamorphic deposits (e.g., skarn)
  - H-1.2.5 Meteoric/Groundwater (e.g., U-V roll front deposits)

H-2. Geologic energy resources
- H-2.1 Coal deposits
- H-2.2 Oil and natural gas reservoirs
  - H-2.2.1 Traditional systems
  - H-2.2.2 Unconventional systems
- H-2.3 Geothermal energy
- H-2.4 Nuclear energy (e.g., uranium mineral systems)

H-3. Prospecting/exploration techniques
- H-3.1 Geophysical (e.g., resistivity, gravity, seismic refraction/reflection, magnetic susceptibility, aeromagnetic surveys)
- H-3.2 Geochemical (e.g., soil, rock, groundwater/surface water sampling)
- H-3.3 Drilling techniques (e.g., air/mud rotary, reverse circulation, diamond core)
- H-3.4 Remote sensing and GIS (e.g., geologic maps, aerial imagery/photography, lidar, hyperspectral/multispectral imaging)
- H-3.5 Petrophysical (e.g., bulk, grain, texture)
- H-3.6 Analytical methods (e.g., fire assay, atomic absorption spectroscopy, inductively coupled plasma, x-ray fluorescence, microprobe)
- H-3.7 Geostatistical analysis approaches – spatial modeling (PG)

H-4. Development techniques
- H-4.1 Resource and reserve assessments
- H-4.2 Quality and quantity evaluation
- H-4.3 Economic evaluation (e.g., cutoff grade)
- H-4.4. Mining methods
  - H-4.4.1 Surface methods
  - H-4.4.2 Underground methods

H-5. Environmental, health, safety, and security
- H-5.1 Geological aspects that affect human health and environment
- H-5.2 Extraction techniques
- H-5.3 Waste management

H-6. Reclamation and restoration

H-7. Project planning (***PG Only***):
- E-7.1 Scope of work and cost estimate
- E-7.2 Literature and regulatory review
- E-7.3 Site-specific maps and health & safety plan
- E-7.4 Site-specific data

To Be Determined

To Be Determined

1.
You have received a map from a client. You determine a 150-foot property line measures 3 inches on the map. You need a final scale at 1 inch = 20 feet (1:240). What percentage of enlargement or reduction is needed?

A. 250% enlargement
B. 250% reduction
C. 500% enlargement
D. 500% reduction

2.
A remote sensing procedure that would be best suited for detecting temperature variations in buried karst terrain is:

A. side looking airborne radar
B. near-infrared photography
C. false color infrared imagery
D. long-wave infrared scanning imagery

3.
The following measured section was made in a semiarid region where Tertiary volcanism has been extensive. The section is described from top (Unit 4) to bottom (Unit 1). What can be concluded about the origin of the soil horizon (Unit 4)?

Unit 4: 1 ft. Soil, red-brown, sandy, abundant quartz grains and red microcline, some quartz silt and montmorillonite (smectite).
Unit 3: 20 ft. Basalt, upper 2 ft weathered irregular and altering to clay with abundant vertical fissures filled with clay and residual soil. Rock is easily broken with a hammer, but becomes hard below 2 ft. About 3 ft below top and extending downward for 5 ft is a zone containing vesicles which at top are oriented nearly horizontal but at the base are essentially vertical. A representative sample taken from the unit indicates the following: Texture: aphanitic to porphyritic, uniform throughout. Mineralogy: 20% labradorite, lath-like crystals about 2 mm long; 10% hornblende, thin crystals about 3 mm long; 70% matrix, finely crystalline, not glassy.
Unit 2: 5 ft. Clay, silty, red, swells noticeably when wet, grades downward into rubble composed of fragments of weathered, dark gray granite.
Unit 1: 15 ft. Rock, dark gray, generally aphanitic texture, with very finely crystalline ground mass containing few crystals identified as microcline, biotite, and albite.

The soil horizon (Unit 4), was derived from weathering:

A. of Unit 3, in a humid climate
B. of Unit 3, in a semiarid climate
C. and transported from another source
D. of another basalt flow

4.
A small oil field is located on the crest of a large anticline. A regional reverse fault is mapped along the flank of the anticline. At shallow depths in five out of the twenty wells, faults intersected by the bore holes caused 100 to 200 feet of missing section. A reasonable interpretation of the structure is:

A. normal faulting in a tensional setting
B. reverse faulting in a compressional setting
C. compressional faulting and folding followed by shallow normal faulting
D. compressional faulting and folding followed by shallow reverse faulting