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| **Concepts, Competencies and Skills Matrix For Curriculum Mapping** |
| Developed from the Geoscience Employers Workshop, Summit on the Future of Undergraduate Geoscience Education and On-Line Surveywith Content Areas from ASBOG Fundamentals of Geology Examination |
| **General Thoughts from the Geoscience Employers Workshop, with Details Added from Summit on the Future of Undergraduate Geoscience Education and On-Line Survey** | I = Introduced, E = Emphasized, FC = Focus of Course |
| Courses |
| Systems Thinking: How systems work and interactEarth as complex, dynamic system with linkages between different systems (lithosphere, atmosphere, biosphere, etc.)/ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|  | • Non linear complex systems• Size of systems – complexity of scale and interactions• Feedback loops, interactions, forcings• Implications and predictions |  |  |  |  |  |  |  |  |  |  |  |  |
| • Energy, mass, fluid transport (movement and flow), residency, and cycles |  |  |  |  |  |  |  |  |  |  |  |  |
| • Work/changes that affect the Earth’s systems• Human drivers and impacts of change, Anthropocene• Environmental transitions• Scales of change• Using the present processes to infer past processes: Advantages/risks |  |  |  |  |  |  |  |  |  |  |  |  |
| • Solar system interaction |  |  |  |  |  |  |  |  |  |  |  |  |
| • Atmosphere – Climate, Weather, Ocean-atmospheric circulation |  |  |  |  |  |  |  |  |  |  |  |  |
| • Hydrosphere – Ocean, Ice, Surface water, Groundwater |  |  |  |  |  |  |  |  |  |  |  |  |
| • Lithosphere – rock cycle, deformation, structure, tectonics |  |  |  |  |  |  |  |  |  |  |  |  |
| • Pedosphere/surface – Geomorphic, Erosion, and Surface Processes, Landscape evolution |  |  |  |  |  |  |  |  |  |  |  |  |
| • Biosphere - Paleontology, Ecosystems |  |  |  |  |  |  |  |  |  |  |  |  |
| • Solar/Earth Interactions – Tidal, Climate; planetary geology |  |  |  |  |  |  |  |  |  |  |  |  |
| • Human/Societal Coupled to Earth – Natural Resources, Energy, Anthropomorphic Climate Change, Natural Hazards• Influence of geology on society• Influences of society on earth processes |  |  |  |  |  |  |  |  |  |  |  |  |
| Processes |  |
|  | • Geochemical Cycles – C, H2O, N, P |  |  |  |  |  |  |  |  |  |  |  |  |
| • Thermodynamics – energy, kinetics, diffusion, heat, mass transfer, fluid flow |  |  |  |  |  |  |  |  |  |  |  |  |
| • Geomechanics/Stress State/Rheology |  |  |  |  |  |  |  |  |  |  |  |  |
| • Geological Time/Earth Evolution |  |  |  |  |  |  |  |  |  |  |  |  |
| • Plate Tectonics/Geodynamics |  |  |  |  |  |  |  |  |  |  |  |  |
| • Tectonic Processes |  |  |  |  |  |  |  |  |  |  |  |  |
| • Depositional Processes |  |  |  |  |  |  |  |  |  |  |  |  |
| • Crystallization Processes |  |  |  |  |  |  |  |  |  |  |  |  |
| Tools |  |
|  | • Statistics/Uncertainty/Probability |  |  |  |  |  |  |  |  |  |  |  |  |
| • Mathematics (differential equations, linear algebra |  |  |  |  |  |  |  |  |  |  |  |  |
| • Field Methods |  |  |  |  |  |  |  |  |  |  |  |  |
| • Geography and spatial thinking |  |  |  |  |  |  |  |  |  |  |  |  |
| • Seismology/Geophysical sensing |  |  |  |  |  |  |  |  |  |  |  |  |
| • Potential Fields |  |  |  |  |  |  |  |  |  |  |  |  |
| • Remote sensing |  |  |  |  |  |  |  |  |  |  |  |  |
| • Analytical/Numerical Modeling |  |  |  |  |  |  |  |  |  |  |  |  |
| • Age Dating |  |  |  |  |  |  |  |  |  |  |  |  |
| • Instrumentation |  |  |  |  |  |  |  |  |  |  |  |  |
| • Cartography |  |  |  |  |  |  |  |  |  |  |  |  |
| Geoscience Concepts: First Summit, Survey and Geoscience Employers Workshop |
| Deep time (including the origin & evolution of life) |  |
|  | • Conventional concepts of geologic time• Paleontology, superposition• Relative vs absolute age• Tools to determine absolute age (radioisotopes, stable isotopes, etc.), precision of data, limitations• Extrapolate from lab to field |  |  |  |  |  |  |  |  |  |  |  |  |
| • Impact on processes• Time scales over which processes are relevant• Specific periods in geologic time that are critical for different processes• Impact of time on “Earth” events (i.e. weathering, geodynamics, resources, etc.) |  |  |  |  |  |  |  |  |  |  |  |  |
| • Events and rates• Duration, frequency, magnitude and residence time• Timing, scale, sequencing and rates of change |  |  |  |  |  |  |  |  |  |  |  |  |
| • Temporal reasoning |  |  |  |  |  |  |  |  |  |  |  |  |
| Climate change |  |
|  | • What is climate change? Geologic scale vs. present change• Significant climate change in geologic past• Relevant space and time scales• Continental vs local scale change• Proxy records• Rate of climate change; rapid change |  |  |  |  |  |  |  |  |  |  |  |  |
| • Driving forces and causal mechanisms• External forcing vs. internal forcing• Dependence upon spatial and temporal scale and feedbacks• Impact of plate tectonics, atmosphere-earth interactions, etc.• Human-induced climate change |  |  |  |  |  |  |  |  |  |  |  |  |
| • Carbon cycle |  |  |  |  |  |  |  |  |  |  |  |  |
| • Difference between weather and climate |  |  |  |  |  |  |  |  |  |  |  |  |
| • Impacts of climate change• Water resources, hydrologic cycle, other climate change effects• Biosphere implications, ocean acidification, sea level rise• Implications on soil, agriculture• Economics and social aspects of climate change• Climate element to environmental consulting and hydrogeology as well as petroleum exploration |  |  |  |  |  |  |  |  |  |  |  |  |
| Natural resources (including energy) |  |
|  | • Understanding of what is included in “natural resources”• Economic geology (commodities and finite resources)• Energy, water, minerals, geologic materials |  |  |  |  |  |  |  |  |  |  |  |  |
| • Solid vs. liquid resources, geographic distribution, uses |  |  |  |  |  |  |  |  |  |  |  |  |
| • Ecosystem services, analysis of renewable and nonrenewable (finite) resources |  |  |  |  |  |  |  |  |  |  |  |  |
| • Resource dependency and limits• Finite resource or commodity• Understanding your environment (where do our materials, energy, and medicines come from)• Ore and fossil fuel supply and demand and getting it to market• Time and space scale of formation and depletion, sustainability• Economics and viability of resources• How things are made• Process from ore to refined product• Process from fossil fuel to energy or material objects |  |  |  |  |  |  |  |  |  |  |  |  |
| Surface processes (including relationship between landscape and process) |  |
|  | • Sediment deposition & erosion • Stream/River flow, morphology, deposition, erosion, effect of floods• Transport relationships (all surface processes)• Magnitude and frequency relationships of surficial deposits• Subsurface analogs |  |  |  |  |  |  |  |  |  |  |  |  |
| • Terrestrial and marine surface interactions• Biological, chemical, and physical interactions• Rates of chemical and physical changes |  |  |  |  |  |  |  |  |  |  |  |  |
| • Landscape alteration (geomorphology)• Surface mechanical and chemical processes• Karst formation• Glacial till and overburden thickness |  |  |  |  |  |  |  |  |  |  |  |  |
| • Habitability, sustaining life• Ties to natural hazards |  |  |  |  |  |  |  |  |  |  |  |  |
| Earth materials |  |
|  | • What is a rock, mineral? Rock cycle |  |  |  |  |  |  |  |  |  |  |  |  |
| • Rocks: physical and chemical properties• How measure, scale of measurement• Mechanical characteristics• Scales of heterogeneity• How change over time |  |  |  |  |  |  |  |  |  |  |  |  |
| • Processes that form rocks and minerals• Processes and conditions of formation• Localizing mechanisms for deposits• Fluid dynamics, flow and fluid chemistry• Role of microbiology and organisms |  |  |  |  |  |  |  |  |  |  |  |  |
| • Resource applications, organic-inorganic materials |  |  |  |  |  |  |  |  |  |  |  |  |
| Earth structure |  |
|  | • Structure of Earth |  |  |  |  |  |  |  |  |  |  |  |  |
| • Mechanical and compositional layers |  |  |  |  |  |  |  |  |  |  |  |  |
| • Tools for defining earth structure (seismic waves, analysis of earthquakes, etc.) |  |  |  |  |  |  |  |  |  |  |  |  |
| • Deformation• Stress and strain• Rock mechanics & deformation processes• Fractures, faults, folds, other structural features, etc. |  |  |  |  |  |  |  |  |  |  |  |  |
| • Plate Tectonics, including• Basin formation• Episodic nature, planning perspectives, uncertainty |  |  |  |  |  |  |  |  |  |  |  |  |
| • Structural controls on resource accumulations |  |  |  |  |  |  |  |  |  |  |  |  |
| Natural hazards (Addressed under other areas) |  |
| Hydrogeology (including water, rock, microbe interactions) |  |
|  | • Water cycle |  |  |  |  |  |  |  |  |  |  |  |  |
| • Groundwater/aquifers, confined vs unconfined aquifers• Phase behaviors • Saturated vs unsaturated conditions• Scales of heterogeneity in space and time• Contaminant transfer |  |  |  |  |  |  |  |  |  |  |  |  |
| • Biogeochemistry and aqueous geochemistry• Microbe interactions• Nutrient cycling |  |  |  |  |  |  |  |  |  |  |  |  |
| • Subsurface-surface water interactions |  |  |  |  |  |  |  |  |  |  |  |  |
| • Economics and public policy• Groundwater quality• Regulatory standards |  |  |  |  |  |  |  |  |  |  |  |  |
| Technical and Non-Technical Skills from Geoscience Employers Workshop |
| Geoscience Thinking |  |
|  | • Earth Science Habits of Mind/Geoscientific Thinking• Temporal and spatial thinking• Systems thinking• Geologic Reasoning and synthesis |  |  |  |  |  |  |  |  |  |  |  |  |
| • Problem solving in the context of an open and dynamic system• Understanding context of the problem• Asking appropriate questions |  |  |  |  |  |  |  |  |  |  |  |  |
| • Problem solving in 3- and 4-D• Ability to work on problems with no clear answers• Managing uncertainty in problem solving• Have a passion for solving problems |  |  |  |  |  |  |  |  |  |  |  |  |
| • Working by analogy, inference and the limits of certainty |  |  |  |  |  |  |  |  |  |  |  |  |
| • Intellectual flexibility – applying skills in new scenarios |  |  |  |  |  |  |  |  |  |  |  |  |
| Technical Skills |  |
|  | • Problem Solving with data• Data collection and interpretation, use and application of data• Begin with understanding of how data will answer question, purpose of collecting data• Evaluation of data, data quality• Understanding data and uncertainties• Make predictions with limited data• Use of appropriate methods, reading & interpreting graphs |  |  |  |  |  |  |  |  |  |  |  |  |
| • Quantitative/Math Skills – integrate into geo courses throughout• Differential equations/linear algebra• Probability and statistics (to understand risk)• Understanding of scale• Critically evaluate literature, encourage critical thinking |  |  |  |  |  |  |  |  |  |  |  |  |
| Field and Technology Skills |  |
|  | • Field Camp and Field Experiences• Improves spatial cognition, creative problem solving, teamwork, geoscience synthesis• Data supports field skills are unique and essential, difficulty to replicate or substitute |  |  |  |  |  |  |  |  |  |  |  |  |
| • GIS – Most essential for building large data sets |  |  |  |  |  |  |  |  |  |  |  |  |
| • Data Analysis Skills• Ability to handle and analyze Big Data• Use of visual models, modeling tools (Stella, Modflow, Matlab, etc.)• Integration of technical and quantitative skills, programming, application development |  |  |  |  |  |  |  |  |  |  |  |  |
| • Technological diversity (need skills and training beyond point and click, and type) – i.e., not just black box |  |  |  |  |  |  |  |  |  |  |  |  |
| • Preparation for life-long learning• How to learn and use new technology and software |  |  |  |  |  |  |  |  |  |  |  |  |
| Non-Technical Skills |  |
|  | • Oral and written communication competency• Science writing and verbal communication, knowing your audience• Public speaking• Listening skills |  |  |  |  |  |  |  |  |  |  |  |  |
| • Project management• Ability to work in teams• Be a leader and a follower• Don’t divide work, iterative process between students with different backgrounds/disciplines• Goal Setting• Solution-oriented approaches• Conflict resolution (open-minded – answer may lie in the conflict space• Managing problems on the front end• Time Management |  |  |  |  |  |  |  |  |  |  |  |  |
| • Professionalism, interpersonal skills• Ethics, ethical awareness, codes of conduct, awareness of implicit biases• Business acumen and risk management• Cultural interactions, cultural literacy, emotional literacy, learning styles• Leadership• Career awareness/resume/interview preparation |  |  |  |  |  |  |  |  |  |  |  |  |
| • Global perspective |  |  |  |  |  |  |  |  |  |  |  |  |
| • Understand societal relevance |  |  |  |  |  |  |  |  |  |  |  |  |
| Content Areas from ASBOG Fundamentals of Geology Examination |
| No.  | Task Statements | FG Test Blueprint (TAS 2015) |  |
| A. General and Field Geology - 21% |  |
| 1 | Plan and conduct geological investigations considering human health, safety, and welfare, the environment, regulations, professionalism and ethics, and Quality Assurance/Quality Control (QA/QC).  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | Compile and organize available information to plan geological investigations.  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | Collect, describe, and record new geological and geophysical data.  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| 4 | Determine positions, scales, distances, and elevations from remote sensing, imagery, surveys, sections, maps, and GIS.  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 | Prepare, analyze, and interpret logs, sections, maps, and other graphics derived from field and laboratory investigations.  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| B. Mineralogy, Petrology, and Geochemistry - 11% |  |
| 7 | Identify minerals and rocks and their characteristics.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 8 | Identify and interpret rock and mineral sequences and associations, and their genesis.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 9 | Evaluate geochemical and isotopic data and construct geochemical models related to rocks and minerals.  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |
| 10 | Determine type, degree, and effects of rock and mineral alteration.  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |
| C. Sedimentology, Stratigraphy, and Paleontology - 12% |  |
| 12 | Select and apply appropriate stratigraphic nomenclature and establish correlations.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 13 | Identify and interpret sedimentary processes and structures, depositional environments, and sediment provenance.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 14 | Identify and interpret sediment and/or rock sequences, positions, and ages.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 15 | Identify fossils and interpret fossil assemblages for age, paleoenvironmental interpretations, and/or stratigraphic correlations.  | 3 |  |  |  |  |  |  |  |  |  |  |  |  |
| D. Geomorphology, Surficial Processes, and Quaternary Geology - 13% |  |
| 17 | Identify, classify, and interpret landforms, surficial materials, and processes.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 18 | Determine absolute or relative age relationships of landforms, sediments, and soils.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 19 | Evaluate geomorphic processes and development of landforms, sediments, and soils, including watershed functions.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 20 | Apply remote sensing and GIS techniques to interpret geomorphic conditions and processes.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| E. Structure, Tectonics, and Siesmology - 11% |  |
| 22 | Identify and define structural features and relations, including constructing and interpreting structural projections and statistical analyses.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 23 | Interpret deformational history through structural and tectonic analyses. | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 24 | Develop and apply tectonic models to identify geologic processes and history. | 3 |  |  |  |  |  |  |  |  |  |  |  |  |
| 25 | Evaluate earthquake mechanisms and paleoseismic history.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| F. Hydrogeology - 12% |  |
| 27 | Define and characterize hydraulic properties of saturated and vadose zones.  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| 29 | Evaluate water resources, assess aquifer yield, and determine sustainability.  | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| 30 | Characterize water quality and assess chemical fate and transport. | 6 |  |  |  |  |  |  |  |  |  |  |  |  |
| G. Engineering Geology - 11% |  |
| 33 | Identify and evaluate engineering and physical properties of earth materials.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 35 | Identify, map, and evaluate geologic, geomorphic, and seismic hazards.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 36 | Interpret land use, landforms, and geological site characteristics using imagery, maps, records, and GIS.  | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| H. Economic and Resources Geology - 9% |  |
| 39 | Compile and interpret the data necessary to explore for mineral and energy resources.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 40 | Estimate the distribution of resources based on surface and subsurface data.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 42 | Determine quantity and quality of resources.  | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| Total Number of Items  | 140 |  |
| Notes:1) Actual course numbers (e.g., GEO 101) should be substituted for columns 1-12.2) Cells may be color-coded after assignment of I, E, FC for easier identification of gaps. | Matrix compiled by J. Ebert, SUNY Oneonta. Modeled after matrix of D. Mogk, Montana State University (See <http://serc.carleton.edu/NAGTWorkshops/departments/degree_programs/matrix.html>) |