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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 Survey  with 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 interact  Earth 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>) | | | | | | | |