Introduction to Environmental Geology, 5e

Edward A. Keller

Chapter 1

Philosophy and Fundamental Concepts

Lecture Presentation prepared by X. Mara Chen, Salisbury University

Intro to Geology: summary haiku

Here's geology.
It's the study of the Earth -
complete entity.

Case History: Island of Hispaniola

- Good site for comparative study: Dominican Republic versus Haiti
- Biophysical differences: Rainfall, topography, land use/land cover
- Socioeconomic differences: History, population, economic activities, GDP output
- Reasons for degradation of Haiti's environment and subsequent inability to quickly rebuild after the 2010 large earthquake

TABLE 1.1 Comparison of Haiti and the Dominican Republic on the Island of Hispaniola with Puerto Rico and Cuba

Country	Approximate Area (km²)	Population (millions)	Median Age (years)	Population Growth Rate (percent)	Life Expectancy (years)	Population Density (persons per km²)	Forest Cover (percent)	Gross Domestic Product per Person ($)	Main Environmental Issues (highly generalized)
Haiti	27,800 (about the size of Maryland)	8.1	18	2.26	60	295	3.8	1,600	Extensive deforestation; serious soil erosion; inadequate safe water supply
Dominican Republic	48,700 (about two thirds the size of Vermont)	9.0	24	1.29	72	185	28.4	6,500	Water shortages; eroding soils; coral reef damage; deforestation
Puerto Rico	9,100 (about two times the size of Rhode Island)	3.9	34	0.047	79	437	46.0	18,500	Erosion; occasional drought with water shortages
Cuba	110,900 (about the size of Tennessee)	11.3	35	0.33	77	102	24.7	3,300	Loss of biodiversity; pollution; deforestation

Data from the United Nations and http://rainforestsmorepalau.com

Table 1.1

Earth's Place in Space

- Earth: Geospatially isolated in the universe
- Origin of the universe
- Origin of Earth system: Lithosphere, atmosphere, hydrosphere, and biosphere
- Facing limited resources: Energy, soil, freshwater, forests, ocean fisheries, rangelands
- Global environment: Conflicts and integrated resolutions

Earth History

- **Inception:** 4.6 billion yrs

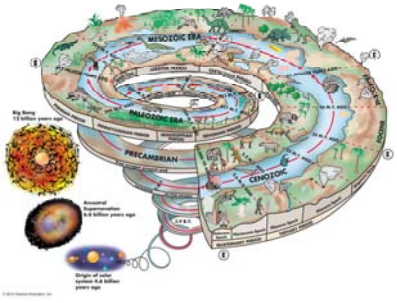


Figure 1.A

Earth Environment (1)

- **James Hutton (1785):** Earth as a superorganism
- **James Lovelock:** Gaia hypothesis
  - Earth is an organism
  - Life significantly affects Earth's environment
  - Life modifies the environment for the betterment of life
  - Life deliberately or consciously controls the global environment
  - Interdisciplinary thinking

Earth Environment (2)

- Earth: Dynamic, alive, and complex
- Everything alive: With a beginning and an end
- Earth environment as a total, as a whole
- Prolong Earth's sustainable healthy life
  - Environment monitoring
  - Environment problems—mapping and analysis
  - Environment problem prevention and protection

Environmental Sciences

- Environment: A complex system with physical, biological, geological, ecological, and geopolitical aspects.
- Requires multidisciplinary research: Environmental geology, environmental chemistry, global climate change, biological diversity and ecosystems, environmental economics, environmental ethics, environmental law, etc.
- Environmental crisis: Population, environmental hazards, resource limitations and contaminations, environment ownership (both in space and over time)

Environmental Geology

- Environmental geology: Applied geology
- Environmental geology knowledge:
  - To better understand environmental problems
  - Geologic knowledge for problem solving
  - Minimize environmental degradation
  - Optimize the use of resources to maximize environmental benefits for the society

Environmental Geology (cont.)

- Earth: Source for habitats and resources, waste disposal, environment and health issues
- Better understand the natural hazards
- Land and water resources: Use, planning, and management
- Geologic aspect in every environmental condition

Fundamental Concepts

- Five fundamental concepts
  - Population growth
  - Sustainability
  - System and change
  - Hazardous Earth processes
  - Scientific knowledge and values
- Other important concepts in environmental geology
  - Finite resources, obligation to future

Human Population Growth (1)

- Number one environmental problem: Nearly 7 billion by the year 2010
- "Population bomb?" Exponential growth
- Exponential growth
  - Growth rate (G): Measured as a percentage
  - Doubling time (D): D = 70/G
- Above Earth's comfortable carrying capacity: Use more resources, need more land space, generate more waste
- Earth as the only suitable habitat in the foreseeable future

Human Population Growth (2)

- Population Bomb: About to Explode?

Figure 1.4

Human Population Growth (3)

- Compares four countries

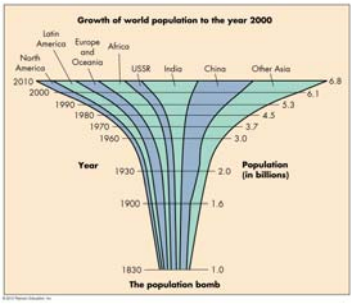
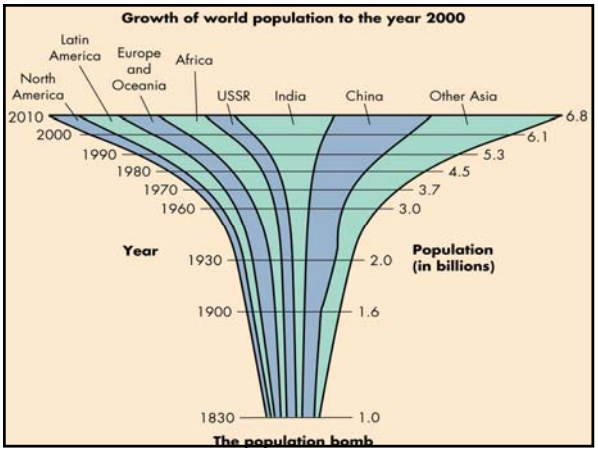


Figure 1.5a



Human Population Growth (4)

Uneven growing pace and distribution

- By 2050, 3 billions more people
- Almost all of the growth in developing countries
- No easy answer to the population problems
- Education is paramount, especially woman's education. As people become more educated, the population growth rate tends to decrease
- Good news: The rate of population growth is decreasing

Sustainability (1)

Sustainability: The environmental objective

- An evolving concept
- Expectation and reality
- Criteria variations in space and over time
- Is a long-term concept and has long-term implications
- Requiring careful resources allocation, large-scale development of new technology for resource use, recycling, and waste disposal

Sustainability (2)

Measuring sustainability

- Use and consumption of non-renewable resources
- Natural replenishment and renewable rates
- Global consumption versus replenishment of resources
- Development and improvement of human environment versus viable environment
- Not lead to environmental crisis

Sustainability: The Death of Aral Sea (3)

- Once a prosperous vacation spot in 1960
- Water diversion for agriculture
- Dying sea surrounded by salt flats
- Largely irreversible

Figure 1.B

Earth's Systems and Changes (1)

- System conditions: Open versus closed systems
- System input-output analysis
- System changes: Types of changes, rates of changes, scales of changes, etc.
- Rates of change: Average residence time
  - T = S/F

    (T: residence time, S: total size of stock, F: average rate of transfer)

Earth's Systems and Changes (2)

- Earth: A dynamic system
- Four interconnected subsystems: Lithosphere, atmosphere, hydrosphere, and biosphere
- Four subsystems are interconnected and interdependent
- Present human activity key to understanding the future

Predicting Future Changes

- Uniformitarianism
  - The present is the key to the past
  - The present is the key to the future
  - Changes of frequency and magnitude: Geological processes and human activities
- Environmental unity: Chain of actions and reactions
- Earth system
  - Gaia hypothesis: Earth is a living organism
  - Complex and interrelated subsystems
  - Global perspective on environment

Hazardous Earth Processes

Hazardous Earth processes and risk statistics for the past two decades

- Annual loss of life: About 150,000
- Financial loss: > $20 billion
- Millions of life loss during the past 20 years, particularly catastrophic from a major natural disaster in a developing country (2003 Iran quake, ~30,000 people, 2004 Asia tsunamis, ~300,000)
- More property damage occurs in a more developed country

Scientific Knowledge and Values (2)

- 3-D environmental problems
- Changes of environment in the 4-D (time)
  - Expansiveness of geologic time
  - Broad spectrum of geologic processes
  - Great variations in rates of geologic processes
- Scientific methods for complex environmental problems

Science and Solution

- Science: Accumulated knowledge
- Knowledge: Basis for decision making
- Scientific methods: Formulate possible solutions to environmental problems
- Scientific design: Structure more suitable for certain environmental settings
- Scientific info: Public awareness and environmental regulations

Scientific Knowledge and Values (1)

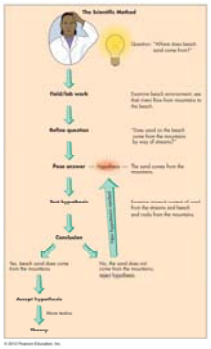
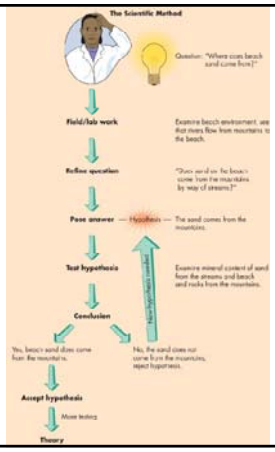


Figure 1.14



Closer Look: Knowledge, Imagination, and Critical Thinking

- Knowledge: What is known
- Imagination: No limits, leading to out-of-the-box thinking of the unknown
- Scientific investigation: Needs critical thinking
- Critical thinking: Significance, logic flow, relevance, breadth and depth, clarity, fair test

Geological Time Dimension

- The important variable that distinguishes geology from other sciences
- Varied rate of geological processes: mm/yr to km/s
- Humans are a super agent of change
  - Holocene epoch
  - Industrialization and global environmental changes
- Culture and environmental awareness: Land ethic

Solving Environmental Problems

- Difficult processes
- Environmental problems tend to be complex
- Rapid changes, slow recognition, slower actions
- Some changes are of irreversible nature
- Environmental policy links to environmental economics in infancy

Precautionary Principle

- Scientific certainty not required to take a precautionary approach
- Scientific proof not possible in dealing with many environmental problems
- Maybe difficult to apply
- Lead to a proactive approach with an emphasis on environmental unity

Applied and Critical Thinking Topics

- Do you think the Earth is a living organism? Why or why not?
- Why are people in Haiti so vulnerable to major natural hazards?
- Why did you take this environmental geology course?
- Would an exponential negative growth of human population be a solution to many environmental problems?
- Are there any conflicts between global environmental unity principle and regional economic development?