

Chapter 2



EARTH'S DYNAMIC SYSTEMS

Systems

- A “system” defined
 - A group of interdependent materials
 - e.g., a home plumbing system
 - A system has a boundary
 - Matter & energy may interact within the system, and with the surroundings
 - Work may be done by or to the system

Systems

- (1) Dynamic systems - a system in which matter & energy react

(2) Closed systems - a system that only exchanges energy across its boundary



• Open systems - a system that will exchange both matter and energy across its boundary

Most geologic systems are open

Geologic Systems

- Earth is a system
 - Many subsystems
 - Nearly closed
 - Small mass of meteorite and space dust input
 - Solar energy enters the system
 - Produces reactions within the system
 - Causes matter to flow & react



Geologic Systems

- Subsystems
 - A river system
 - Open or closed?
 - Part of the larger hydrologic system
 - Interacts with other subsystems
 - » Groundwater
 - » Oceans
 - » Atmosphere

Change in Geologic Systems

- Flow of energy and matter
 - Changes in one component affect the entire system
 - Flow is predictable
 - Systems move towards equilibrium

Equilibrium in Geologic Systems

- Equilibrium
 - A system at its lowest possible energy level
 - Systems move toward equilibrium
 - Defining the equilibrium state determines the direction of flow

Equilibrium in Geologic Systems

- Potential energy creates the need for flow in a system
 - Gravity
 - Boulders on hillslopes

The Hydrological Cycle is a Subsystem of the Earth System

The complex cycle through which water moves

Global scale

Basic components

Evaporation
Precipitation
Runoff
Infiltration
Evapotranspiration



Wetlands are a component of the hydrologic cycle, and represent an important subsystem.

Hydrologic Subsystems

- Atmosphere – Ocean System
 - Oceans are reservoirs for liquid water
 - Water vapor is transient in the atmosphere
 - Climate system is controlled by ocean-atmosphere interactions
 - Solar heating is driving force behind circulation

Hydrologic Subsystems

- River Systems
 - Surface drainage returns most precipitated water back to the ocean
 - Water flows rapidly through this system
 - Only accounts for ~0.0001% of Earth's water
 - Effective system for transport of weathering products

Hydrologic Subsystems

- Glacial Systems
 - Flow of water in this subsystem is very slow
 - Water can be “trapped” for long periods of time
 - ~10,000 years on average
 - Glaciers contain about 80% of fresh water, but only 2% of Earth's total water

Hydrologic Subsystems

- Groundwater Systems
 - Largest source of fresh liquid water
 - ~20% of all water not in oceans
 - Moves slowly compared to surface water
 - Rock-water interactions are important in this subsystem

Hydrologic Subsystems

- Shoreline Systems
 - Wave action highlights the interface between oceans-large lakes and the land
- Eolian Systems
 - Wind transport in arid regions
 - Wind is a part of the hydrologic system
 - Some water exists in even the most arid climates

Tectonic Systems

- Plate Tectonics
 - A unifying theory that explains the internal dynamics of the Earth
 - Processes that form and deform the Earth's crust
 - Delineation of discrete lithospheric plates
 - Developed in the mid-1960's, but considered much earlier

Tectonic Systems

- Evidence for Plate Tectonics
 - Structure and magnetic properties of the ocean floor
 - Location of earthquakes
 - Heat flow patterns
 - Structure and shape of the continents
 - Distribution of mountain belts, rock types and fossils

Tectonic Systems

- Driving Forces
 - Earth's internal heat source
 - Radioactive decay & residual heat
 - Heat transfer by convection
 - Hot, less dense material rises from the mantle
 - Cool, more dense material descends from the crust

Tectonic Subsystems

- Divergent Plate Boundaries
 - Plates moving apart
 - Hot material rises – abundant volcanic activity
 - New ocean crust is formed
 - Mid-ocean ridge system
 - Continental rift systems



The Red Sea and East African Rift System photographed by the Apollo 17 astronauts (9 December, 1972)

Tectonic Subsystems

- Transform Plate Boundaries
 - Plates move laterally past each other
 - Commonly associated with mid-ocean rift systems
 - Continental zones
 - San Andreas Fault

Tectonic Subsystems

- Convergent Plate Boundaries
 - Plates moving toward one another
 - Compressional forces and deformation of the lithosphere
 - Generation of igneous rocks
 - Volcanic and/or plutonic
 - Continental growth

Tectonic Subsystems

- Oceanic crust at convergent plate boundaries
 - Oceanic crust is more dense than continental crust
 - At convergent margins, oceanic crust will be pushed back into the mantle
 - Subduction
 - Partial melting & formation of volcanic arcs

Tectonic Subsystems

- Continental crust at convergent plate boundaries
 - Continental crust is less dense
 - Cannot be subducted
 - Complex folding and faulting of continental crust
 - Introduction of volcanic and/or plutonic rocks – continent building

Intraplate Tectonics

- Little tectonic activity normally occurs
- Mantle plumes may create hotspots
 - Rising plumes of hot magma from deep within the mantle
 - Isolated volcanoes are formed as magma punctures the crust
 - Island chains form as plates move over mantle plume – Hawaiian Islands

Plate Motion

- Divergent boundaries – mid-ocean ridge system extending through all ocean basins
- North & South American plates moving westward
 - Interacting with the Pacific & other small plates
 - Subduction and transform zones
- Pacific plate moving northwest, forming deep trenches in western Pacific basin

Gravity & Isostasy

- Gravity is a fundamental force of nature
 - A constant force in every system on Earth
 - Causes upward and downward movement in the crust
 - Isostasy
 - Gravitational adjustment of the crust

End of Chapter 2