Figure 2.4  A geologic profile of the Earth's surface. On land the crust is dominated by granitic rocks, largely composed of silicon and aluminum (SIAL). The oceanic crust is dominated by basaltic rocks, with a large proportion of silicon and magnesium (SIMA). Both granite and basalt have a lower density than the upper mantle, which contains ultrabasic rocks with the approximate composition of olivine (FeMgSiO₃). From Howard and Mitchell (1985).
Last few thousand years

Global Soil Regions

Soil Orders
- Alfisols
- Entisols
- Inceptisols
- Spodosols
- Rocky Land
- Andisols
- Gleysols
- Mollisols
- Ultisols
- Shifting Sand
- Aridisols
- Histosols
- Oxisols
- Vertisols
- Ice/Glacier
Tropical, weathered red soil

http://www.soils.umn.edu/academics/classes/soil2125/doc/s4chap2.htm
The central concept of Mollisols is that of soils that have a dark colored surface horizon and are base rich. Nearly all have a mollic epipedon. Many also have an argilllic or natric horizon or a calcic horizon. A few have an albic horizon. Some also have a duripan or a petrocalic horizon.
ULTISOL

The central concept of Ultisols is that of soils that have a horizon that contains an appreciable amount of translocated silicate clay (an argillic or kandic horizon) and few bases (base saturation less than 35 percent). Base saturation in most Ultisols decreases with depth.
Global Biogeochemical Cycle

Oceanic Sedimentation

Vulcanism

Weathering

River runoff

Tectonic subduction

Linkages among Elements

Fig. 6. Steady-state flow net. The circled numbers refer to reactions given in Table IV. Reactions 5 and 6 involve reservoir transfers so that steady-state fluxes are not given. Reservoir areas are proportional to the number of moles contained.
### Total Cycle

**Atmosphere**
- $5.37 \text{ CO}_2$
- $5.37 \text{ O}_2$

**Bio-sphere**
- $27.7 \text{ CO}_2$
- $5.37 \text{ CH}_2\text{O}$

**Ocean**
- $19.6 \text{ CO}_2$
- $5.37 \text{ O}_2$

**Deep Rocks**
- $4.4 \text{ MgCO}_3$
- $4.4 \text{ SiO}_2$
- $0.8 \text{ CaSO}_4$
- $11.0 \text{ CaCO}_3$
- $1.1 \text{ MgSiO}_3$
- $2.5 \text{ CH}_2\text{O}$
- $1.53 \text{ FeSiO}_3$
- $2.7 \text{ NaCl}$
- $0.5 \text{ Na}_2\text{SiO}_3$
- $0.9 \text{ K}_2\text{SiO}_3$
- $0.56 \text{ FeS}_2$

### Phosphorus Cycle

Fig. 15.14 Phosphorous cycle. Whereas the cycles of most non-metals, for example C, O, N, S, involve oxidation-reduction reactions, that of phosphorus operates without them. The main form of phosphorus in the earth is as phosphate ion or its salts, particularly those of calcium. In the biosphere, the phosphate esters, especially the nucleotides, the polyribonucleotides and the phospholipids, are the dominant phosphorus species. Man’s industrial activity is again important in this cycle since phosphate is mined and then added to the soils as fertiliser to promote the development of useful plants, but it may be leached to the rivers and the sea by rain fall and then cause uncontrolled growth of other species that may ultimately endanger animal life, for example of fish, due to the excess consumption of oxygen.
Setting

Climate: cold, no flow for 9 months, avg. temp -9°C, pptn 50 cm (75% in Aug, Sept)
Uniform soils in region derived from volcanoes (248 Ma BP)
Permafrost 200-400-m thick, thaw zone 20-100 cm
Compare rock, soil, suspended and dissolved solids, compute fluxes
Weathering sequence

River sediments → Rocks, pebbles → Fine soil particles → Water samples

Biotic Influence

Fig. 3. Ternary diagram of sommeite compositions. 1 group (solid squares), poe-ehliche silicate (sample 15, 47); II group (solid circles), interstitial smectite (from fraction of soil samples 23, 30, 26, 64, 24a, and RRS 55); Individual symbols used for T, bats (this study); T, L. (reproduced from Tarnap et al., 1992).

Fig. 5. Aluminum-normalized elemental ratios in plant litter, soils and river suspended matter compared to the initial rock (traps). Strong enrichment of plant litter by potassium (factor 8) is out of the scale.
Solid vs. solution phase

Shortcomings

\[ C = k \cdot Q^n \]

\[ F_i = \frac{\overline{C}_i \cdot \overline{Q}}{A} \]

\[ \overline{Q} = \text{average annual flow} \]

\[ \overline{C}_i = \text{conc. at flow } \overline{Q} \]
Calcium Cycle

**Equation:**

\[ \text{Atmos. Dep.} + \text{Weathering} = \text{Outflow} + \Delta \text{Storage} \]

\[ \Delta \text{Storage} = \text{Biol. Uptake} + 2^{\text{nd}} \text{ Mineral formation} + \Delta " \text{Available"} \]

**Figure 30:** Annual calcium budget for an aging forested ecosystem at Hubbard Brook. Standing crop values are in kg/ha and calcium fluxes are in kg/ha-yr. Values in parentheses represent annual accretion rates.
IMPLICATIONS OF SODIUM MASS BALANCE FOR INTERPRETING THE CALCium CYCLE OF A FORESTED ECOSYSTEM

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[Diagram showing calcium balance over time with labels for precipitation, weathering, streamwater, biomass, and depletion.]