Clay Minerals

1.1 Origin of Clay Minerals

"The contact of rocks and water produces clays, either at or near the surface of the earth" (from Velde, 1995).

Rock +Water → Clay

For example,

The CO_2 gas can dissolve in water and form carbonic acid, which will become hydrogen ions H^+ and bicarbonate ions, and make water slightly acidic.

$$CO_2+H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$$

The acidic water will react with the rock surfaces and tend to dissolve the K ion and silica from the feldspar. Finally, the feldspar is transformed into kaolinite.

Feldspar + hydrogen ions+water → clay (kaolinite) + cations, dissolved silica

$$2KAlSi_3O_8+2H^+ +H_2O \rightarrow Al_2Si_2O_5(OH)_4 + 2K^+ +4SiO_2$$

•Note that the hydrogen ion displaces the cations.

1.1 Origin of Clay Minerals (Cont.)

- The alternation of feldspar into kaolinite is very common in the decomposed granite.

- The clay minerals are common in the filling materials of joints and faults (fault gouge, seam) in the rock mass.

  Weak plane!

1.2 Swelling Potential

Practically speaking, the three ingredients generally necessary for potentially damaging swelling to occur are (1) presence of montmorillonite in the soil, (2) the natural water content must be around the PL, and (3) there must be a source of water for the potentially swelling clay (Gromko, 1974, from Holtz and Kovacs, 1981)

TABLE 6-2 Probable Expansion as Estimated from Classification Test Data*

Degree of Expansion	Probable Expansion as a % of the Total Volume Change (Dry to Saturated Condition)†	Colloidal Content (% −1 μm)	Plasticity Index, PI	Shrinkage Limit, SL
Very high	> 30	> 28	> 35	< 11
High	20–30	20–31	25–41	7–12
Medium	10–20	13–23	15–28	10–16
Low	< 10	< 15	< 18	> 15

*After Holtz (1959) and U.S.B.R. (1974).
†Under a surcharge of 6.9 kPa (1 psi).

U.S. Bureau of Reclamation

Holtz and Kovacs, 1981

1.3 Cation Exchange Capacity (cec)

- The quantity of exchangeable cations is termed the cation exchangeable capacity (cec) and is usually expressed as milliequivalents (meq) per 100 gram of dry clay (from Mitchell, 1993).

- One equivalent = 6.02×10^{23} electron charges or 96500 Coulombs, which is 1 Faraday.