Structure of mineral/water interfaces in geoscience

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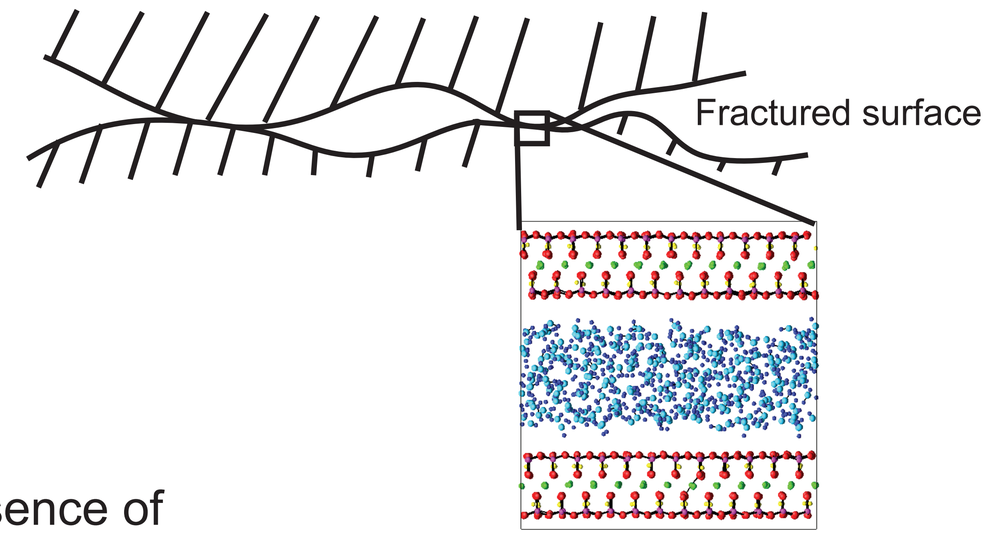
Effect of water on rock friction



Presence of adsorbed water molecules

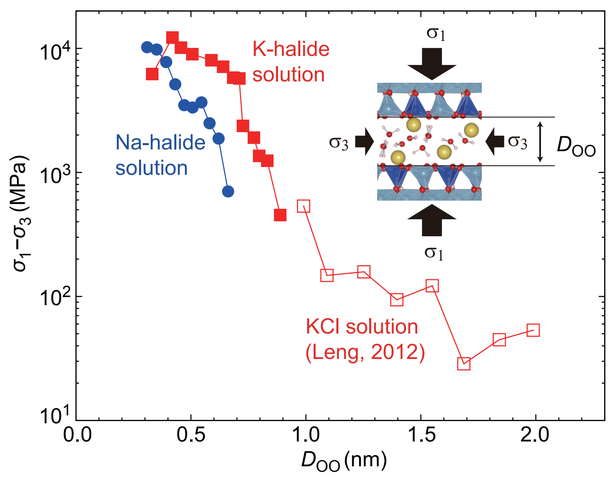
makes frictional strength weak due to

1. Inhibition of direct contact of mineral surfaces
2. Lubrication
3. Chemical weakening

1. Inhibition of direct contact of mineral surfaces

Repulsive hydration force

Strong interaction between adsorbed water and ions on a charged mineral surface



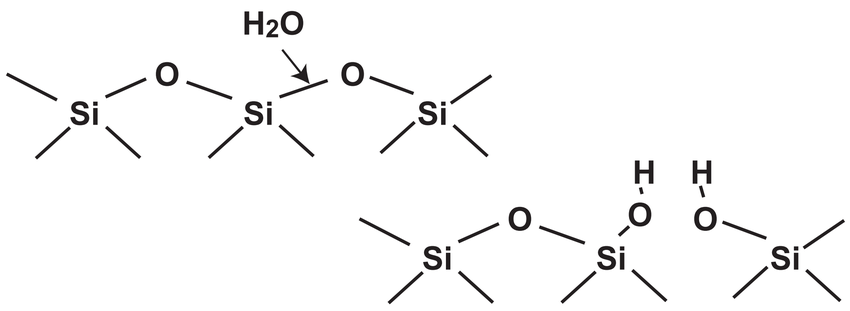
Differential compressive stress to remove adsorbed water between mica surfaces (Sakuma, 2013)

Isodensity profiles of water on a muscovite mica surface (Sakuma et al., 2011)

Interfacial structure is important for estimating the hydration force.

3. Chemical weakening

Adsorbed water may assist chemical reaction at real contact area under applied normal load.



Can we observe the equilibrium structure at real contact area under applied normal load?

Oil recovery

Maximum rate of oil recovery is 30%

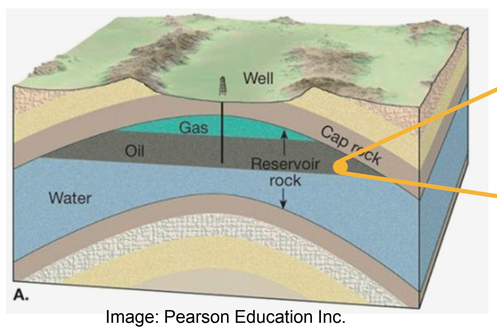
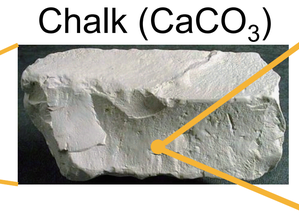
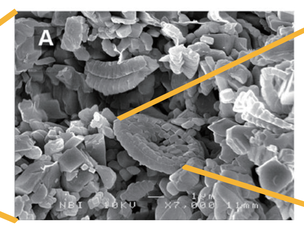
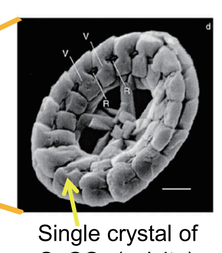


Image: Pearson Education Inc.

Chalk ($CaCO_3$)





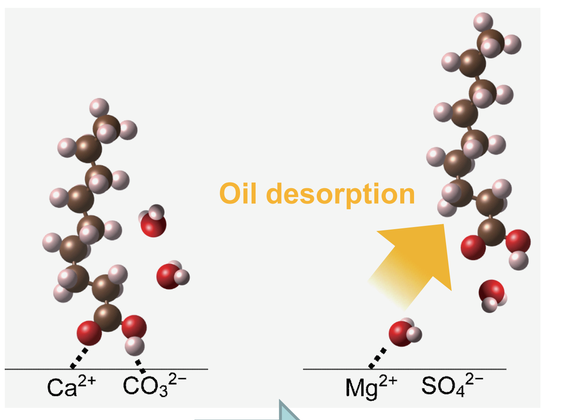


Single crystal of $CaCO_3$ (calcite)

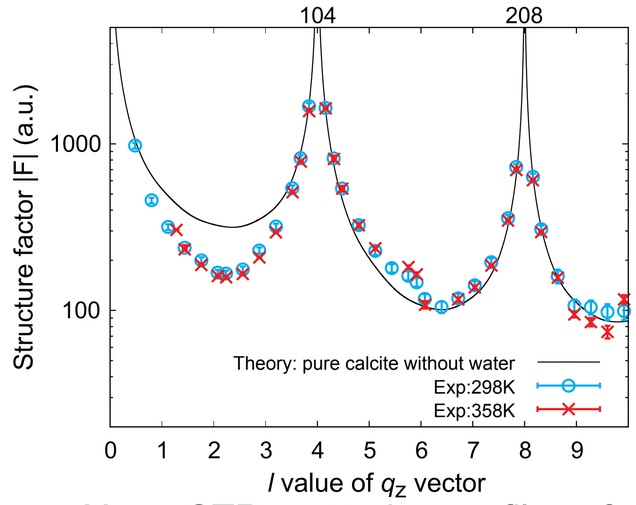
Young *et al.*, 1999, *J. Struct. Biology*

Wettability alteration of mineral surfaces

Structure of mienral surface is important !

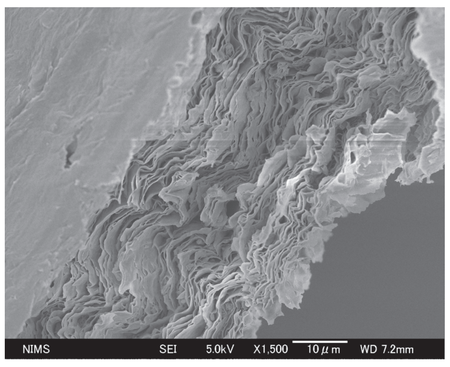


Ion substitution (**ion switch**) induces the desorption of oil molecules



X-ray CTR scattering profiles of calcite/salt water interface

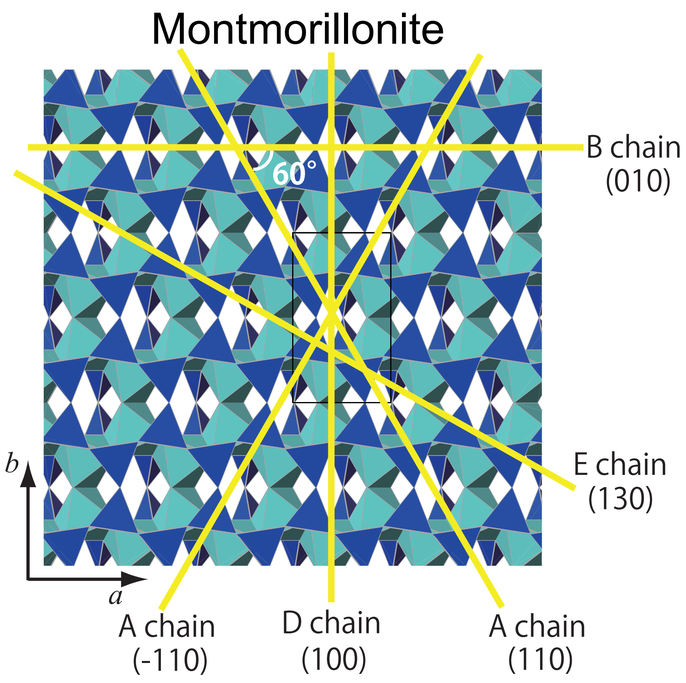
Structure of clay minerals



Edges of clay minerals:
Extremely reactive in aqueous solution

Ion adsorption on edge sites:
Important to use clay minerals as a buffer to retard the radionuclide diffusion from radioactive waste repositories to the outside.

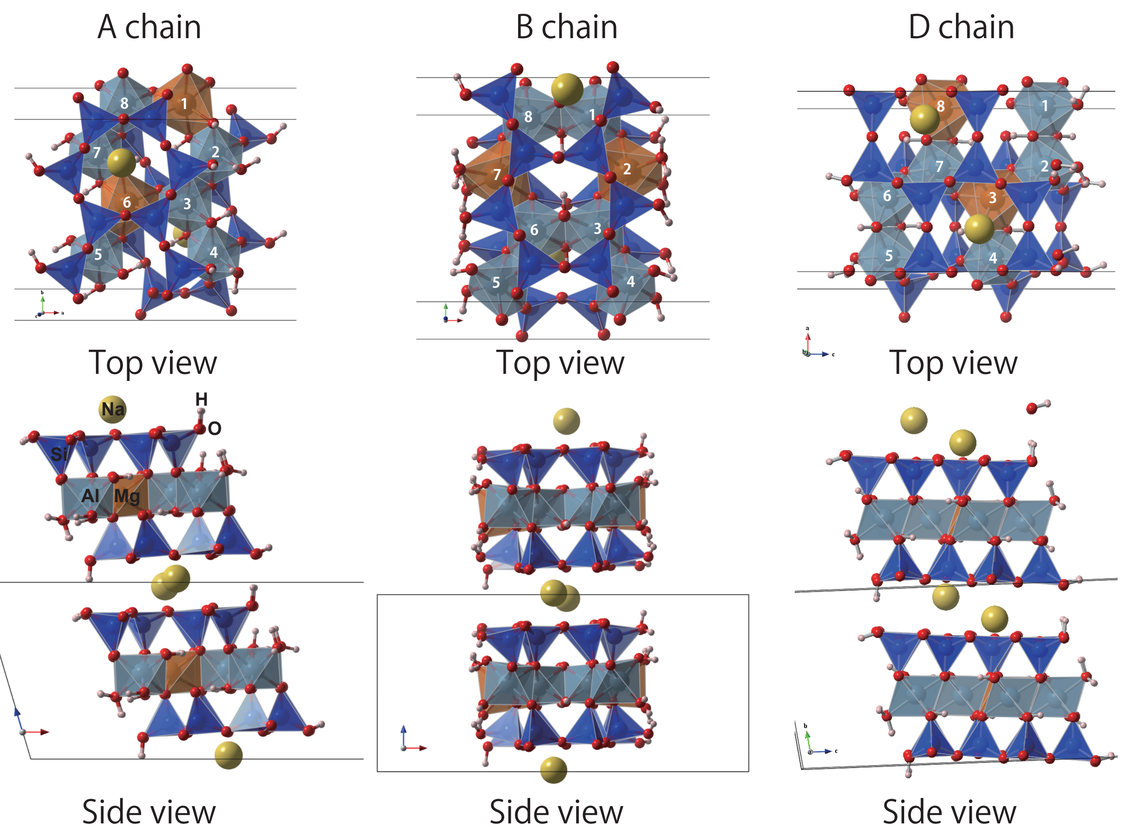
What is a plausible edge plane?



Criteria: White and Zelazny, 1988

1. Stable crystal faces are parallel to one or more continuous chains of strong bonds.
A, B chains
(White and Zelazny, 1988)
D chain (Churakov, 2006)

2. The smallest unit should consist of one octahedron and one tetrahedral sheet.



Characterization of edge structures of clay minerals is crucial for developing new functional materials!