**Introduction to Clay Minerals**

**Clay minerals** are layer silicates that are formed usually as products of chemical weathering of other silicate minerals at the earth's surface. They are found most often in shales, the most common type of sedimentary rock. In cool, dry, or temperate climates, clay minerals are fairly stable and are an important component of soil. Clay minerals act as "chemical sponges" which hold water and dissolved plant nutrients weathered from other minerals. This results from the presence of unbalanced electrical charges on the surface of clay grains, such that some surfaces are positively charged (and thus attract negatively charged ions), while other surfaces are negatively charged (attract positively charged ions). Clay minerals also have the ability to attract water molecules. Because this attraction is a surface phenomenon, it is called **adsorption** (which is different from *absorption* because the ions and water are not attracted deep inside the clay grains). Clay minerals resemble the micas in chemical composition, except they are very fine grained, usually microscopic. Like the micas, clay minerals are shaped like flakes with irregular edges and one smooth side. There are many types of known clay minerals. Some of the more common types and their economic uses are described here:

**Kaolinite:** This clay mineral is the weathering product of feldspars. It has a white, powdery appearance. Kaolinite is named after a locality in China called Kaolin, which invented porcelain (known as china) using the local clay mineral. The ceramics industry uses it extensively. Because kaolinite is electrically balanced, its ability of adsorb ions is less than that of other clay minerals. Still, kaolinite was used as the main ingredient for the original formulation of the diarrhea remedy, Kaopectate.

**Illite:** Resembles muscovite in mineral composition, only finer-grained. It is the weathering product of feldspars and felsic silicates. It is named after the state of Illinois, and is the dominant clay mineral in midwestern soils.

**Chlorite:** This clay mineral is the weathering product of mafic silicates and is stable in cool, dry, or temperate climates. It occurs along with illite in midwestern soils. It is also found in some metamorphic rocks, such as chlorite schist.

**Vermiculite:** This clay mineral has the ability to adsorb water, but not repeatedly. It is used as a soil additive for retaining moisture in potted plants, and as a protective material for shipping packages.

**Smectite:** This clay mineral is the weathering product of mafic silicates, and is stable in arid, semi-arid, or temperate climates. It was formerly known as *montmorillonite*. Smectite has the ability to adsorb large amounts of water, forming a water-tight barrier. It is used extensively in the oil drilling industry, civil and environmental engineering (where it is known as **bentonite**), and the chemical industry. There are two main varieties of smectite, described in the following:

**Sodium Smectite:** This is the *high-swelling* form of smectite, which can adsorb up to 18 layers of water molecules between layers of clay. Sodium smectite is the preferred clay mineral for drilling muds, for creating a protective clay liner for hazardous waste landfills to guard against future groundwater contamination, and for preventing seepage of groundwater into residential basements. Sodium smectite will retain its water-tight properties so long as the slurry is protected from evaporation of water, which would cause extensive mud cracks. As a *drilling mud*, sodium smectite mixed with water to form a slurry which performs the following functions when drilling an oil or water well: 1) lubricates the drill bit to prevent premature wear, 2) prevents the walls of the drill hole from collapsing inwards, 3) suspends the rock cuttings inside the dense mud so that the mud may pumped out of the drill hole, and 4) when the dense mineral *barite* is added to drilling mud, it prevents *blowouts* caused by internal pressure encountered during deep drilling. Sodium smectite is also used as commercial **clay absorbent** to soak up spills of liquids. High-grade deposits of sodium smectite are found in South Dakota.

**Calcium smectite:** The *low-swelling* form of smectite adsorbs less water than does sodium smectite, and costs less. Calcium smectite is used locally for drilling muds. Much of the domestic supplies of calcium smectite are mined from the state of Georgia.

**Attapulgite:** This mineral actually resembles the amphiboles more than it does clay minerals, but has a special property that smectite lacks - as a drilling fluid, it stable in salt water environments. When drilling for offshore oil, conventional drilling mud falls apart in the presence of salt water. Attapulgite is used as a drilling mud in these instances. Incidentally, attapulgite is the active ingredient in the current formula of Kaopectate.