FACT SHEET

Primary Clay Minerals
Biotite (Potassium Mica)

SPANISH RIVER CARBONATITE
"Remineralizing Your Soil"

Soil is described as the outer thin layer of loose material, which supports life on earth. It is the interaction between the earth's atmosphere, hydrosphere, (water), lithosphere (rocks) and biosphere, (all living things), that produces soil. This complex interaction results in the formation of a group of secondary minerals of fundamental importance to life known as clay. It is a clay's permanent structure, colloidal size, large surface area and unique physical properties that play a major role in the biochemical cycling of plant nutrients and soil formation.

Clay has numerous definitions; agronomists use the term to describe particle –size in the mechanical analysis of soil. This has resulted in grouping all clay minerals together into one constant progression where there is no discernable difference from one clay mineral species to the next. Geologists on the other hand, classify clays into two main groups:

1. **Low-activity clays** – these clays are characteristic of silica and alkali, (base element), depleted environments, (i.e. acid soils). The clays usually founds in such environments are kaolinite and aluminum, iron and manganese oxides. Low activity clays have low cation exchange capacities (CEC) and small surface areas. Soils predominated by these clays are referred to as old. These soils are highly oxidized, generally infertile and usually have symptoms of metal toxicity. Soils predominated by these clay mineral types are well drained soils, where total hydrolysis results in a complete loss of silica and cations.

2. **High-activity clays** - these clays are charged and have more hydrated clay layers. High activity clays have large surface areas and corresponding high CEC, containing an abundance of Ca^{++}, Mg^{++} and Fe^{++} ions. Soils predominated by these clays are referred to as early mature to mature, (young soils have not formed clay minerals and are almost entirely comprised of primary minerals). These soils generally are very fertile. Examples of clays minerals belonging to this group are vermiculite, illite and montmorillonite. Soils predominated by these clay mineral types occur where hydrolysis is less pervasive resulting in only partial losses of silica and alkalies.

The intensity of clay weathering and soil aging is a function of climate, soil parent material and human influences, Soils impacted by acid rain, chemical fertilizers and tillage has resulted in clay destruction and accelerated soil aging. This results in loss of silica, alkali elements, exchange capacity, soil surface area, soil aggregation, plant nutrient uptake and increases soil compaction and metal toxicities.

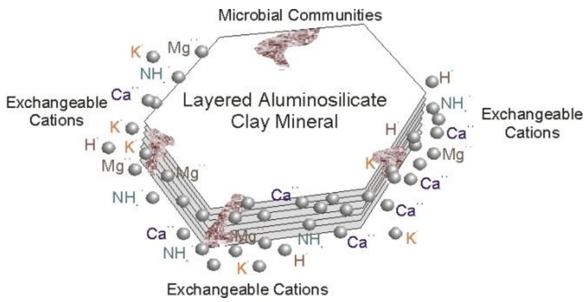
The division of clays into high and low energy aids the geologist in determining the type of clays, soil genesis and the age of soils. For the agronomist and environmentalist this information is critical in determining the impact of human activity on soil health and determining the best coarse of action in restoring soil vitality.

<u>The Properties of Clay</u>

"*Any clay, even a monomineral clay is a population of different particles. Each particle is itself a population of micro-domains. When the environment changes, each micro-domain and each particle starts changing. Each of them shift towards a new thermodynamic equilibrium according to its own speed: population dynamics are going on. Population dynamics apply to clay mineralogy today*" (Millot, 1989).

Clays are tiny nanocrystalline particles and are essential components of the earth's surface. They are layer-type aluminosilicates, referred to as phyllosilicates. They arrange themselves into a structure of platelets similar to a deck of playing cards referred to as a colloid. This results in these compact nanocrystalline structures having very large surface areas. Illites have a specific surface area of 97.0 m^2/gram and kaolinite 16.0 m^2/gram. The best way to describe this incredible phenomenon is to tear the pages out of a book and place the torn pages side by side. The rather small book would cover a very large area and the number of pages would determine how large the area would ultimately be.

Clay minerals have the property of sorbing certain anions and cations and retaining them in an exchangeable state, (Grim, 1968). Agronomists have focused on the cation exchange properties but very little work has been done on clay weathering resulting in negative reactions such as aluminum toxicity but also in very positive attributes such as nitrogen fixation and anion exchange. In general the most common exchange cations and in the sequence of relative attractive forces are: Al^{3+}, Ca^{2+}, Mg^{2+}, $NH_4^+ \sim K^+ > Na^+$, (Juma 2002). Common anions in clay materials are: SO_4^-, Cl^{2-}, PO_4^{3-}, NO_3^-.



The importance of ion exchange and the exchange reaction are of fundamental importance in soils. Plant growth and soil structure are dependant on this process. Drever (1994) and Shwortzman (1993) suggested the most critical factor affecting microbial enhancement of soil mineral weathering and, in turn nutrient uptake by plants, is soil stabilization. While soil aggregation decreased physical weathering rates the increased soil surface area and water retention significantly enhanced chemical weathering.

<u>Clay Weathering – Biotite to Vermiculite</u>

"*The transformation of biotite to vermiculite with the release of the interlayer K is perhaps the most important biologically mediated geochemical reactions occurring in the rhizosphere*" (Banfield, *Proc. Natl. Acad. Sci. USA 96,* (*1999)*.

All clays are classified as secondary or sedimentary in origin. There is only one group of primary rock forming minerals that are classified as clay; they are the micas. The most important agromineral mica is biotite. Biotite is a charged potassium, (~ 12% K_2O), phyllosilicate that carries its unique structure through various transformations to become the most reactive clay colloid in our soils, (~ CEC 180 meq/100g). As the potassium is released, the exchange capacity is increased and is characteristic of the clay mineral illite. With complete removal of K interlayer planes vermiculite and montmorillonite clay minerals are produced, (Hinsinger, P., Elsass, F. Jaillard, B. & Robert, M. (1993) *J. Soil Sci.* 44, 525). Vermiculites are classified as high activity clays. This means that this group of clays has a wide range of mineralogy resulting in a wide range of compositions where the interlayer spaces are charged and hydrated to various extents resulting in a wide diversity in behavior, (Pedro 1997).

"Plant nutritionists, primarily working with model rhizospheres, have documented the dramatic and astonishingly rapid biomobilization of essential nutrients from phyllosilicates (Hinsinger et al. 1992, Leyval and Berthelin 1991)." Barker, Welch, Banfield (2000).

The transformation of biotite to vermiculite within the soil system is rapid. Experiments conducted by Mortland (1956), Spyridakis et al. (1667) and Weed et al. (1969) documented that <u>biotite functioned as well as soluble sylvite (KCl) as a source of K</u>. Possibly more significant then the bioavailability of potassium the formation of vermiculite contributes an essential clay mineral to the soil system.

<u>Spanish River Carbonatite™</u>

The Spanish River Carbonatite is an exceptional source of both biotite and vermiculite (10% combined). Though not widely recognized in agriculture today, ongoing research will demonstrate that biotite is a far more effective potassium source then soluble potassium fertilizer. As well as an excellent source of potassium, biotite contributes to the development of high-activity clays within the soil.

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