FACT SHEET
Mineral Composition of SRC

SPANISH RIVER CARBONATITE
"Remineralizing Your Soil"

Minerals verses Elements

The growing awareness of the need to increase the nutritional content of food and enhance soil quality, in both conventional and organic agriculture, describes the need for minerals to achieve sustainable food production. The use of the word "minerals' in this context refers to the chemical elements that are required by living organisms -- commonly referred to as dietary or mineral nutrients. Unfortunately, it is in the same context that soil amendments tend to be evaluated. Described as essential and trace minerals, the quality of rock dust is misleadingly determined by measuring its elemental constituents; misleading, because virtually all Earthly compounds contain all or most of the elements in the periodic table. An office chair is likely to assay like the periodic table and even return good levels of essential macro/micro plant nutrients and trace minerals but, <u>not in a form that would fertilize vegetables!</u> Evaluating the chemistry of rocks alone, therefore, does not indicate the level of their agronomic benefit; an analytic report supplies only the elemental composition not the mineral content, rate of dissolution and such other plant growth promoting properties.

Mineralogy is the study of how chemistry typically organizes into stable inorganic compounds. Minerals are described by their chemical, crystal structure, optical and physical properties. The geological environment in which a mineral was formed plays a significant role in its behavioral characteristics. Ineffectively, agriculture only evaluates the physical properties of mineral inputs by solubility and by fineness. This method is based on the assumption that the smaller the particle-size the larger the surface area, resulting in higher solubility potential. This assumption is correct, but it does not take into consideration the inherent crystal structure that has a major influence on weathering characteristics.

The "Lime Index" is used to determine calcium rock dust effectiveness. This method evaluates the rock's neutralizing capability based on chemistry and fineness characteristics. Under this test, dolomite, a calcium magnesium carbonate, achieves a higher index based on its chemical ability to neutralize soil acidity. Though chemically it may have the potential to achieve a higher neutralizing capacity, increased magnesium content changes the physical behavior of the rock. Dolomite becomes denser and forms a much stronger bond between individual crystals; this substantially reduces its neutralizing capability. Research conducted in the late sixties and seventies on the sorptive capacities of limestone in scrubbers showed that stones with similar chemistries didn't always produce similar results. According to Shaffer from the University of Indiana chemically similar carbonates can differ by more than a thousand percent in the amount of sulfur dioxide they can absorb.

Raw rock phosphate is often singled out because of the mineral apatite's very stable nature and to overcome this stability a higher phosphorous content is desired. Subjected to a fertilizer analysis, these high phosphorous rock dusts normally report 1-3% availability. Beyond chemical and solubility characteristics, apatite mineral behavior changes dramatically due to the geological environment in which the mineral was formed. Changes in chemistry result in changes in crystal lattice structure, size and accessibility to weathering. Francolilte is an apatite mineral where Cl and F have been replaced with CO, resulting in nanocrystalline crystal structure and an effectiveness equivalent to water soluble phosphoric acid fertilizer. This means that a francolite with 5% P_2O_5 will provide more P to the soil system than a fluorapatite with 35% P_2O_5 -- regardless of solubility characteristics.

Plant nutritionists, primarily working with model rhizospheres, have documented the dramatic and astonishingly rapid biomobilization of essential nutrients from phyllosilicates. The transformation of biotite to vermiculite within the soil system is rapid. Experiments conducted by Mortland (1956), Spyridakis et al. (1967) and Weed et al. (1969) documented that biotite functioned as well as soluble sylvite (KCl) as a source of K. Possibly more significant than the bioavailability of potassium, the formation of vermiculite contributes an essential clay mineral to the soil system.

The effectiveness of rock dust products is not entirely due to chemical composition; equally important is the nature of unique physical properties. This results in chemically comparative rock dust products that vary significantly in reactivity, plant and microbial accessibility and soil improvement qualities. Mineral physical properties are regrettably all but ignored in agriculture – except by the proponents of soil remineralization, paramagnetism and biodynamics.

The Origin of Carbonatites

Carbonatites belong to the family of igneous rocks referred to as ultramafic, a very unique group of "high reactivity", mineralogically complex rock occurrences. No other igneous rocks[1] have provoked such fascination. Ultramafic rocks, also described as alkalic rocks, have been the subject of intense geological investigation over the past 50 years. These alkalic rocks are characterized by rarity, high concentrations of volatiles (CO2, H2O, etc.), incompatible elements, lithophile elements, (those with a strong affinity for oxygen and having a greater free energy of oxidation) and a wide spectrum of rock and mineral types. Alkalic rock formations show a strong correlation with major continental fractures, which penetrate to the mantle (Sage, 1983). Ultramafic trends in North America are associated along the Pacific Rim of Fire and ancient tectonic boundaries. The overriding characteristic of alkalic rock formations is the incredible variations they exhibit in mineralogy, texture and grain size. The very best rock dust amendments produced in North America are often influenced or contained within these trends. Although akalic rocks comprise less than 1% of all igneous rocks, one third of all rock names are designated alkaline, totaling more than 250; truly a testament to their mineral diversity.

There is only one known active carbonatite volcano in the world, Ol Doinyo Lengai, located within the African Rift Valley. The semi-nomadic Maasai people of Tanzania gave the mountain its name, the English translation being "Mountain of God". The Serengeti, located in northern Tanzania, is host to the largest land animal migration on earth. The thick layers of ash ejected from Ol Doinyo Lengai form calcareous hardpans from which the rich nutrient soils of the plain are formed.

Recent interest in these unique geological occurrences is the result of a greater understanding of the biologicallly induced mechanisms that shape our planet. The rock cycle is indispensable to the proliferation of life, the cycling of life essential chemistry such as carbon, nitrogen and silica, and lastly, the regulation and cycling of the Earth's air and water. Ultramafic rocks play an indispensable role in these processes; in fact geologists are convinced that ultramafic rocks could play a pivotal role in accelerating atmospheric CO_2 sequestration. The mineral characteristics that promote this phenomenon, when incorporated into functioning soils, result in enhanced soil aggregation and microbial habitat and, in consequence, greatly

[1] The word igneous is derived from the Latin word meaning fire. Igneous rocks are formed through the cooling of magma -- either below the surface of the Earth, as an intrusive rock, or on the surface, as extrusive lava.

improved carbon and nitrogen soil content along with a significant increase in plant available essential chemistry.

The group of rocks called Carbonatites represents approximately 30% of ultramafic rocks. This equates to a global area of exposed carbonatites in the order of 200 square miles. Carbonatite complexes can vary between being very simple to being the most complex mineralogy types of igneous rocks. Consisting almost entirely of calcite and dolomite, carbonatites may be a variety of carbonates accompanied by silicates, phosphates, sulfates, iron oxides, RE carbonates, sulfides, fluorides and niobium oxide minerals. In excess of 50 minerals have been found in carbonatites, (Pecora, 1956).

The Origin of the Spanish River Carbonatite

The birth of Spanish River Carbonatite is unique amongst unique carbonatites. A rock, 10 kilometres (6 miles) in diameter and travelling at approximately143,000 kilometres per hour, (89,000 mph), impacted the Earth. The resulting catastrophic shock wave resulted in a plume of super-heated rock, from the deepest part of the crust, catapulting into the Earth's early atmosphere; only to return under the pull of gravity in a great splat; extensively turning the crust inside out. After the dust had settled, a hole that was originally 250 kilometres (155 miles in diameter) was created, in addition to a molten rock lake that was three times the size of the current super volcano Yellowstone caldera. Yet, out of this Hades, scientists theorize that, similar to what occurred in Yellowstone, the vast network of hydrothermal vents and complexity of mineral constituents created the very conditions necessary for life.

This catastrophe, referred to as the Sudbury Event, is the leading hypothesis for the genesis of the Sudbury nickel basin and fortuitously, the Spanish River Carbonatite Complex. The modern surface of the deposit consists of the very roots of the original outflow of igneous material. These remnants of the impact site are known as the Sudbury Basin, and this deep magma resulted in the deposition of one of the richest nickel deposits in the world. Near the outer perimeter of the Sudbury Basin is a volcanic pipe representing the lower depths of an ancient volcano, which we refer to as the Spanish River Carbonatite Complex. The pipe linked the mouth of the volcano, on the surface, to the liquid magma far below, and it is now filled with solidified granitic material. The granite is comprised of calcium, magnesium, silica, phosphorous, potassium minerals, rich in life essential chemistry and primary minerals; precursors to life-essential secondary clays.

Mineral Content of Spanish River Carbonatite

The Spanish River Carbonatite (SRC) is comprised of four major rock units defined by mineral composition. These divisions are sovite, silicocarbonatite, pyroxenite and syenite. All major rock units are quarried together to produce current SRC product.

Ongoing research is in response to current SRC users that desire individual mineral constituents in order to address specific fertility concerns. These minerals include respectively: magnesium, phosphate, potassium and silica mineral constituents.

Spanish River Carbonatite

Average Mineral Composition

Mineral	Emperical Formula	Approx. %	Comments
			Sulfide Minerals
Sphalerite	(Zn,Fe)S	trace	Source of zinc, sulfur, iron
Chalcopyrite	CuFeS2	trace	source of copper, sulfur, iron
Pyrrhotite	Fe(1-x)S (x=0-0.17)	trace	Source of sulfur, iron
Pyrite	FeS2	trace	Source of sulfur, iron
			Carbonates
Calcite		40	
Siderite	Fe2+(CO3)	trace	source of iron
Magnesite	Mg(CO3)	minor	reactive source of magnesium
Bastnasite	La(CO3)F	trace	source of REE's (lanthanum)
			Oxide Minerals
Magnetite	Fe3+2Fe2+O4	minor	Magnetite is a very important biogenically produced mineral from a wide variety of organisms. Source of iron.
Hematite	Fe3+2O3	minor	Source of iron
Rutile	TiO2	trace	
			Phosphates
Apatite Group	Ca5(PO4)3(OH)0.33F0.33Cl0.3	8.94	Commonly referred to as hard rock phosphate
			Sulphates
Barite	Ba(SO4)	trace	
			Silicates
Olivine - Forsterite	Mg2SIO4	trace	
Pyroxene Series - Aegirin	NaFe3(Si2O6)	minor	The pyroxenite series totals approximately 10% of SRC,
- Acmite		trace	it is a highly reactive magnesium silicate when incorporated into the soil converts to high activity clays
- Ferrosilite	Fe2+MgSi2O6	minor	
- Enstatite	Mg2Si2O6	minor	
Forsterite	Mg2(SiO4)	4.14	Magnesium silicate used in lasers, refactory materials and gems
Amphibole - Arfvedsonite	Na3Fe24Fe3(S8O22)(OH)2	minor	
Biotite Series	KMg2.5,Fe20.5(AlSi3O10(OH)	5	Exceptional source of potassium upon releasing K into soil converts to high activity clay vermiculite
Vermiculite	Mg1.8Fe2+0.9Al4.3SiO10(OH)	5	Exceptional high activity clay
Serpentine		trace	
Sphene - Keilhauite	Ca0.95REE0.05Ti0.75Al0.2Fe3	minor	Rare earth bearing mineral species
Qaurtz	(SiO2)	trace	
Corundum	(Al2O3)	trace	Corundum is a gem with color variations resulting rubys, and sapphires.
Alkali Feldspars - Orthoclase	KAlSi3O8	4.09	Slow release potassium silcate
- Microcline	KAlSi3O8	minor	
Plagioclase Feldspars - Albit	Na0.95Ca0.05Al1.05Si2.95O8	6.49	Slow release sodium, calcium silicate
Arfvedsonite	Na3Fe2+4Fe3+(Si8O22)(OH)2	minor	
Chlorite	(Mg,Fe++)5Al(Si3Al)O10(OH)	trace	
Leucite	KAl(Si2O6)	trace	Slow release potassium silicate
Kalsilite	KAlSiO4	trace	Slow release potassium silicate
Nepheline	Na0.75K0.25Al(SiO4)	minor	Slow release sodium, potassium silicate
Carnegieite	NaAlSiO4	trace	Rare form of nepheline
Thernardite	Na2(SO4)	minor	Very reactive source of sodium and sulfur
Gehlinite	Ca2Al2SiO7	minor	Calcium silicate
Wollastonite	CaSiO3	5.19	Regarded as a bioactive calcium silicate in the regeneration of bones.
Fayalite	Fe2+2(SiO4)	4	Iron Silicate
Riebeckite	Na2Fe2+3Fe3+2(Si8O22)(OH)	trace	Sodium, iron silicate

Note: Trace equals less then 1%; minor equals less then 4%

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