Orchid Growing 1. - About Soils and Soil Profiles

by Jim Brydie

When Cynthia and I bought our house block at Hornsby we discovered we knew little about growing plants so we set about to learn and discovered a great pleasure in the garden. Eventually we both completed the Horticulture certificate course at Tafe at Ryde. One subject I was amazed about was the science of what went on in the soil.

So this month, although it may be a little off the main path of orchid culture, I wanted to talk about soil. After all, growing orchids is essentially just a specialist arm of horticulture. I think it is important to understand soil because it is part of the understanding of plants and their needs. To discuss what really is "soil", also explains why growing plants in a garden in soil is very different to growing plants of any kind in pots.

So what is soil? At the most basic level, soil is a complex blend of broken down rock and the organic detritus from plants and animals. And when I say animals in that context I mean in the broadest sense to include mammals, insects, microbes, and even fungi. But soil doesn't just include the detritus of those 'animals', many are still living and breathing and doing their thing in there day by day as you grow plants in it.

The Lemken series on "Skin of the Earth" gives the neat definition : SOIL - ***the product of combining the abiotic soil-forming factors of rock, climate and terrain, and the biotic soil-forming factors of flora, fauna and man.***

All living components of soil life combine to process the discarded organic material from the trees and other leaf growers and to turn that detritus into different organic materials. Other living organisms then process those byproducts and sometimes even eat each other, eventually blending all components together (mineral and organic) into what we call soil.

Soil obviously varies greatly from place to place depending on how and where it was created and is presently functioning. Variables such as : -

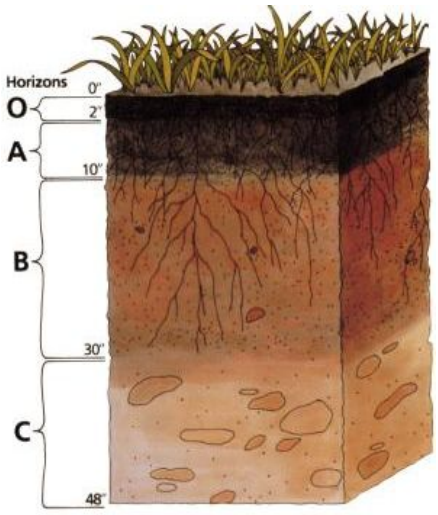
- the type of native rock that made it, and which most likely still underlies it,
- the climate and topography of the area (past and present),
- the trees and other plant life operating in the area and the nature of all the organisms that live in that soil.

Soil Profiles – Given that soils are different in different places, what then is a soil profile?

If you watch a lot of TV cop shows like I do your mind might jump to criminal record descriptions, an example of which might go something like – Caucasian male, 50 years old, dark hair, tattoos, missing tooth, arrested 12 times, multiple convictions, etc.

Well soil profiles aren't quite like that but they are a mechanism for describing a type of soil and what it looks like and how it was formed.

In reality soil is more subtle than just 'all the dirt stuff in the ground'. Soil exists in the ground in layers of variations in its make up. If you cut down into the soil in any given location you will find that these layers within the soil can be fairly clearly defined. Scientists call these layers "Horizons". **example of a basic soil profile (www.nrcs.usda.gov) →**



The cross sectional view of the various layers, running parallel to the surface, is called the Soil Profile.

The scientific designation for the **major** horizons in a soil are the capital letters **O**, **A**, **B**, **C**, and **E.**

Most soils have at least three major horizons -- the surface horizon (**A**), the subsoil (**B**), and the substratum (**C**), but there may be others.

Some soils have an organic horizon (**O**) on the surface, but this horizon can also be buried. The letter **E**, is used for subsurface horizons that have a significant loss of minerals (eluviation). Hard bedrock, which is not soil, uses the letter **R**.

There are other designations, and lower case letters to describe variations with a major horizon, but it serves little purpose at this early stage to make the concept over complex.

Soil Creation in a bit more detail :

In the very nice series of web articles mentioned earlier – titled "The Skin of the Earth", by Agricultural product company Lemken, they provide well explained information on a series of soil related topics.
Under How is Soil Created they offer :

"Soil is a **complex mixture** of inorganic components (ie rock and its products), dead **organic matter** (humus), **soil-air** and **soil-water** containing dissolved inorganic and organic substances. The in-organic components are mainly silicates. **Clay minerals** are of great importance as a store for plant nutrients.

Dead organic material is converted by soil organisms into **humic substances**, which are then further decomposed. They are the most important natural source of nitrogen fertiliser. They also have many functional groups that can bind cations (positively charged ions).

Humic substances and clay minerals are linked by chemical bonds, to form what is known as the **"clay-humus complex"**, and the humic substances are more effective than the clay minerals in binding nutrients. The most important **plant nutrients** are the cations K+ (Potassium), Ca2+ (Calcium) and Mg2+ (Aluminium), as well as nitrate and phosphate.

In Central Europe, arable soils usually contain 1-2% humic substances, the so-called black earth soils up to 7% and pasture soils up to 10% humus." ----- (and in a later part of the series) : -

"Soils in Central Europe consist of about **50% solid components** and **50% pores**. These are each filled about half with soil-water and half with soil-air. Nutrients and organic substances are dissolved in the soil-water. Among the solid components, 40-47 % are mineral, 3-10 % are organic substances. Peat soils can contain more than 25% organic matter."

Clay and all about it.

As you can see from the Lemken mentions above, a discussion on soil isn't complete unless you also explain CLAY.

When you dig in the garden you may find clay, but what is clay? Apart from it being useful for making pottery and bricks and other things, it is also an important component of the soils themselves.

I didn't want to unnecessarily complicate the discussion on soils so I didn't mention it in the earlier part of the discussion but the stuff does exist and is an integral component in soils and their fertility so it can't be avoided altogether. Which brings us to ask ***what is clay and where does it come from***.

Well clay is a composite material comprised of very fine particles derived from **all of :**

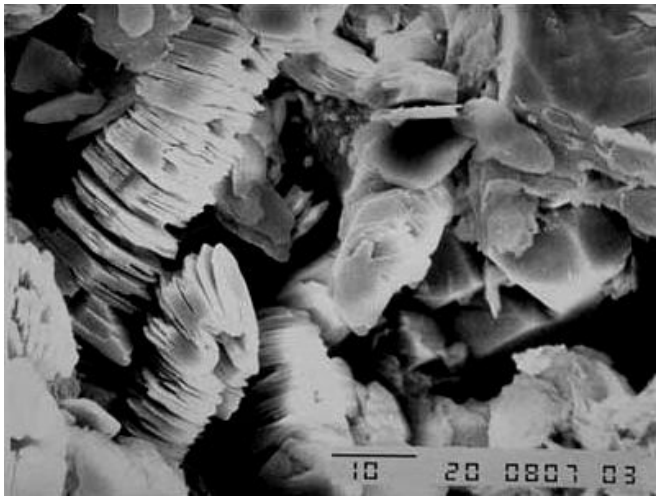
(a) the native mineral rock,
(b) degraded organic material AND
(c) soil chemicals.

One fundamental defining property of clay is its particle size.

You know what a sand grain looks like, well the particles that comprise clay are far smaller. Depending on which science you consult, the defining particle size for clay is quoted as either 1, 2, or 5 microns. (ie 1µ, 2µ, or 5µ). A micron or micrometer is a millionth of a metre, in other words a thousandth of a millimeter which I think you will agree is pretty small. Soil particles just above that size are called silt. So as rock and organic material are worn down and processed and get smaller and smaller, they can, in the right conditions, become clay.

Right conditions? Well clay is more than just a collection of tiny residue particles. To be clay it also must contain ***hydrous aluminium phyllosilicates,*** components that derive from the mineral base. There are a few variations of these minerals that make different clays but they are basically combinations of mostly Aluminium and silicon ions (plus a few other metals) and hydroxoid ions (OH^-). The formula for Kaolinite (one clay type) is given as $Al_2Si_2O_5(OH)_4$

Clay minerals (Kaolinites and others) are crystalline in nature, in a sheet-like structure, and are composed of mainly tetrahedrally arranged silicate and octahedrally arranged aluminate groups. The plate like structure is what makes clay plastic and slippery when wet.



All clays are good at storing and exchanging ions, and also store a lot of water but there are two types of clays in regard to behaviour with water. Kaolin clays do not swell when they are wet as their plates are bonded more closely together. Smectite clays have spaces between their plates that can take on water. As a body, these swell when wet and shrink when dry which can cause series problems in building areas because the swelling and contraction can affect building foundations above.

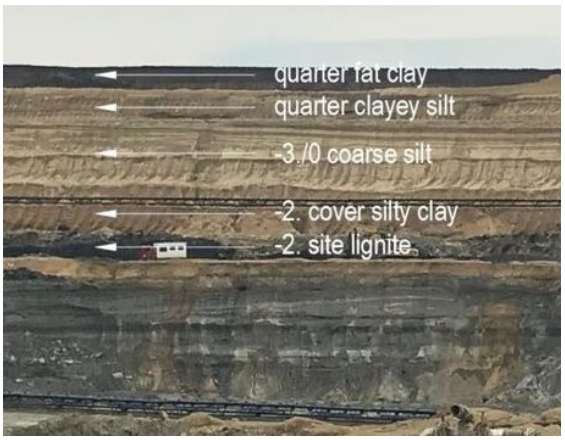
All of which is nothing to do with understanding clays in a horticultural sense but at least it tells you that not all clays are created equal. **(the picture above is from the NZ Science Learning Centre and shows a scanning electron microscope image illustrating the plate like structure of Kaolinite at 1500 times magnification – *Rights: Schlumberger, Houston Texas)***

Clay forms in a variety of ways. It is usually associated with the degradation of Feldspar minerals which are one of the most common native rock minerals on Earth. I assume that is because the Feldspar is where the Aluminium and Magnesium and other formative minerals come from. It also deposits in silt beds like lake bottoms.

The surprising fact about clay and soils is that clay isn't always laid down in strata in the soil as many imagine. The process of wearing down and degrading primary elements is going on continually and there are clay particles scattered through several soil horizons. Soils with less than 40% clay content are called loam. If the 'soil' contains more than 40% clay particles it is regarded as clay so you can see not all clay (as you see it in soil) is purely clay either.

The amount of clay in a topsoil is what makes it sticky and makes a squeezed hand full of moist soil stay together as a ball. Lack of clay content allows the squeezed ball to fall apart (without sticking together), as you might expect of sand.

The picture at the right is a soil profile in a coal mine in Hungary. I include it just to show that the upper horizons contain different proportions of clay.



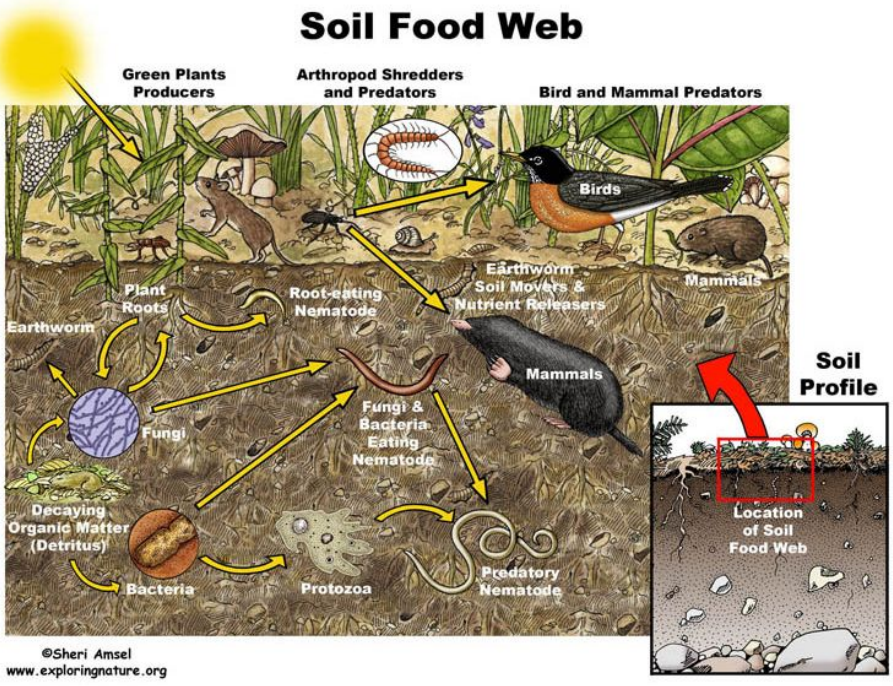
So is clay in your soil a good thig or a bad thing for growing plants? Well like most things in life a reasonable amount is good and too much is bad. Clay content in moderation acts a good retainer for water and ions in the soil. It makes the soil more 'fertile' in that it supports plant growth. Too much, especially if it is the type that swells, is bad because swelling can block the air passages in the soil that the organisms in soil (including plants) need to survive. In extremes, it can become completely waterlogged.

Soil Organisms

Early in the article I mentioned soil organisms but you might be surprised at the scope of what that encompasses. Wikipedia tells us : "Soil life, soil biota, soil fauna, or edaphon are a set of collective terms that encompasses all organisms that spend a significant portion of their life cycle within a soil profile, or at the soil-litter interface. These organisms include earthworms, nematodes, protozoa, fungi, bacteria, different arthropods, as well as some reptiles such as snakes, and species of burrowing mammals like gophers, moles and prairie dogs. Soil biology plays a vital role in determining many soil characteristics. The decomposition of organic matter by soil organisms has an immense influence on soil fertility, plant growth, soil structure, and carbon storage."

For most humans, we know there are worms and bugs and fungi in the soil but we never really think about what they are doing and how important it is. We can't directly influence what is going on down there so who cares? But we really should at least know that there is a vital and active process of interaction going on down there.

It is a bit like what's going on inside our bodies. We eat food that gets processed by body chemicals and bacteria and we get sustenance from the process. We don't have to know exactly how it works but we should know that it does.



In relation to soil, it is a very complex set of interrelationships.

The TV streaming channel "Curiosity", has been recently streaming a fascinating show on the life of the inter-relationships between the various soil fauna from the microscopic level to earthworms. The show is called "Secret Life Underground – The Skin of the Earth". Curiosity is available on Fetch but you may also be able to find it on the internet or via other streaming services.

I am not really qualified to try to explain how it all works but to roughly summarise, it seems most plant leaves contain too many tannins to be immediately palatable to micro fauna so the first stage of decay is usually fungal attack on the surface layer of dead plant material. Once the fungus has converted the tannins, all sorts of other little bugs like springtails, mites, millipedes, sow bugs and others eat the leaf material left behind by the fungi and then various others eat the exudates of the first level eaters. ***(picture above comes from https://www.exploringnature.org/db/view/Soil-Food-Web)***

Worms are the biggest of this level of food processors. There are essentially 3 kinds of earthworms - first the surface

only dwellers, then those that live only underground, and finally those that continually burrow vertically up and down through the soil, collecting leaf debris from the surface and dragging it below to digest. These vertical burrowers are vital for aerating the soil with their tunnels as well as their role in transporting plant organics throughout, and especially to lower levels in the soil.

So, Getting back to the practical point of all This – Pots vs Garden?

The soil in backyards or in the wild is virtually a living organism. It contains minerals and also organic chemicals derived from the processes of reprocessing the dead plant and animal material on its surface. It has structure only because it is a living combination. It is fertile because of the life it contains. If you put garden soil in a pot, isolated from the garden, it soon ceases to be alive and fertile. It doesn't work, it will de-aerate and eventually compact. It will lose structure.

When we grow orchids or other plants in pots, we use (or should use) artificial soil substitutes. These substitutes aren't naturally fertile and must have artificial fertilisers added to sustain the plants we grow in them. They have structure when we apply them only because we choose (or engineer) the structure we want by the components we choose and how we apply them. All plants including orchids need a medium enabling a mix of air, water, and solids, and a medium that has some ability to store and release the cations (positively charged ions) of our fertilisers.

That fundamental difference is what I raised at the start. And while it has taken me an inordinate amount of paper and words to get there, I hope you have at least enjoyed the process of reaching the explanation.
