Soil—genesis?
a soil redox poem*

Barret Wessel, Doctoral Student
University of Maryland, USA

Once there was a rocky planet, covered in basalt and granite,
Recently accreted from chondritic and achondritic spoil,
Acting on this newborn surface, forces of constant disturbance,
Began their action weathering, weathering the rock to soil.
Yet the planet was not ready, ready to form any soil;
Regolith, and nothing more.

Then life arose, a newborn change, filling its oceanic range,
Powered by redox chemistry through ceaseless chemical reactions.
Finding electron acceptors, free high delta-G acceptors,
And electron donors, donors to complement half-reactions,
Life was good at finding new ways, ways of energy extraction.
Lithotrophs, and little more.

Wächtershäuser's big idea, that the oldest fossil stria,
Was left by microbes of the iron-sulfur hydrothermal roil,
Indicates organic matter, made from carbon in this splatter,
Carbon oxides, oxidizing agents in the almost-boil,
Paired with sulfide-sulfur, reducing agent; still no soil.
Sediment, and nothing more.

Though the details are lost to time, lost to eons of changing clime,
We know two point five billion years ago photosynthesis evolved.
Organic matter filled the seas, and chemotrophs it did appease,
O_2 reduced by oxidizing metal atoms once dissolved.
When the system saturated, it showed a problem left unsolved.
Anaerobes, and little more.

The oxygen catastrophe, destroyed most life most callously,
Forcing evolution of enzymes to deal with this new toxin.
Thus arose microbes aerobic, no longer oxygen phobic.
As an electron acceptor, O_2 has assumed its station,
Metabolism driven by the delta-G of respiration.
Soil genesis, in sight.

With light and oxygen at hand, organisms spread to the land,
Photosynthesis driving organic matter accumulation.
Finally the land had soil, plants evolved, died, became oil.

In the places with poor drainage, more water than that of hydration,
Once the oxygen is gone, Eh drops, denitrification.
Wetland soils, soon to be.

As nitrate becomes ammonia, you might smell a new aroma,
Though at pH 7 manganese gains electrons after nitrate
Eh still falls, as does pe, the same phenomena you see,
Already blackish brown is gone, then iron two too will migrate,
This all requires SOM, perhaps some is carbohydrate.
Carbon, here gives electrons.

Now the soil has gley color, and we can reduce another,
Though water table fluctuation may cause mottles to appear,
Sulfate next, reduced to sulfide, reduced to hydrogen sulfide,
Except around aerenchyma, plant roots where metals may adhere,
All of these redoximorphic features and hydrophytes make clear,
Wetland soils, here we have.

Carbon next reduced by carbon, methanogenesis a bargain
For those microbes who have nothing left but CO_2 and SOM.
Then in very rare conditions, protons take electron addition,
Becoming H_2 gas and leaving, perhaps from some bucolic fen.
And where we are on this spectrum, we can tell with platinum
Measure voltage, solve log K.

And thus concludes this epic tale, I hope it hasn't seemed too stale.
But what, you ask, would happen if the soil should drain out?
Why, the process then reverses, O_2 the soil intersperses
Metal ions are oxidized and coat particles all about,
Should this go on for long enough, one day non-hydrophytes may sprout.
Soil, dynamic, alive.

*Chemical formulas and acronyms should be read as written; ex. O_2 reads "oh two", not oxygen. Written for Dr. Bruce James' course in soil chemistry.