Rapid Atmospheric CO_2 drawdown into Basaltic Andisols of Mt. Etna

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Due to its C-sequestration potential and limited content of environmentally harmful metals, weathering of basalt is increasingly discussed as one pathway towards negative C-emissions. Application of crushed basalt as a soil amendment could accelerate atmospheric CO_2-drawdown, help restore soil fertility and stabilise soil pH. A frequently voiced concern of this approach is the long time required in field trials to determine realistic CO_2-consumption rates, the fate of soil organic carbon (SOC) and toxic metal mobility.

Here we report on a geochemical study of andisols formed on the volcaniclastic Chiancone Formation (CF), deposited 5 Ka ago during the partial collapse of the eastern flank of Mt. Etna. Notably, soils on the CF receive frequent addition of naturally fine-grained ash and lapilli, causing up-ward growth of the weathered residue – the hallmark feature of andisols. The extremely fertile CF soils on the foothill of Etna have been cultivated since ancient times and local groundwater dissolved inorganic C ($\delta^{13}C$= -16‰) is dominated by oxidised SOC and not volcanic CO_2 ($\delta^{13}C$= -1‰).

Low elevation soils are very fine-grained, composed of X-ray amorphous clays and Fe-Al-humus complexes and devoid of pedogenic carbonates. Pyroxenes are the only detectable residues of the ash deposited by documented recent Strombolian events, glass having weathered to nano-clays. Soils over the CF have accumulated to 2-4 m thickness. SOC is largely of C3 plant origin with $\delta^{13}C$ of -24‰. Two minimum atmospheric CO_2 sequestration rates were calculated independently: i) 3.4×10^6 mol/km^2/yr from the accumulation of weathered ash to form andisol since CF deposition (with major and trace elements and SOC ^{14}C); and ii) 2.1×10^6mol/km^2/yr from export of atmospheric C dissolved in groundwater of the aquifer contained in the flank collapse structure (with water budget and multi-tracers).

We argue that these geochemically-derived natural long-term CO_2-consumption rates are relevant to agricultural soil amendment with vesicular basaltic scoria. If applied to global arable land, weathering of basaltic scoria amendment holds significant prospect for atmospheric CO_2 reduction on the order of 10-20 ppm per decade.