The agrogeological potential of the Stjernøy apatite-biotite-carbonatite (Finnmark, NO) as slow-release rock fertilizer – possibilities and challenges

Heim, M.[1], Bleken, M.A.[1], Gjengedal, E.L.[1], Hillersøy, M.H.[1] & Gautneb, H.[2]

[1] Dept. of Plant and Environmental Sciences, Norwegian University of Life Sciences, Box 5003, NO-1432 Ås

[2] Geological Survey of Norway, NO-7491 Trondheim

The apatite-biotite carbonatite on Stjernøy (Finnmark) is part of the neck-like, late-stage (ca 530 Ma) Stjernøy alkaline intrusive complex in the Seiland Igneous Province (SIP), which is dominated by 570-560 Ma mafic magmatic rocks. The SIP is situated in the Caledonian Kalak Nappe Complex, deformed under amphibolites-facies metamorphic grade and thrust at ca 420 Ma (Roberts et al., 2006). Nepheline syenite of the Stjernøy alkaline intrusive complex has been mined for glass and ceramic purposes for almost 50 years (North Cape Minerals). The calcite carbonatites and associated fenitized rocks, situated N of the syenite, are being prospected for phosphate and U/Th -minerals, grades of apatite locally reaching >10 %, radiogenic elements however being almost absent. Inspired by an intense natural vegetation and earlier plant experiments, showing the promising K-effect of the biotite carbonatite (Bakken et al., 1997, 2000), we here present the potential of crushed whole rock or mineral concentrates as agricultural input, a rock fertilizer with slow release of essential plant nutrients like K, P, Ca, Mg, Zn etc. Rock fertilizers have several environmental advantages compared to soluble, industrial fertilizers (Heim & Bleken, this volume).

Selected parts of the apatite-biotite carbonatite can be classified as agricultural lime (c. 50 % calcite) with a P (2)-K(3)-Mg(3) fertilizing effect (numbers = % wt of element). Magnetic mineral separation can give a biotite concentrate, a K(7)-Mg(6) fertilizer, and a remaining apatite lime with P(3). P from magmatic apatite has low availability to plants at the high pH found in a lime-rich environment, so removal of most calcite will be necessary (potential use as agricultural lime). The resulting apatite concentrate, together with biotite, gives the possibility to produce various P-K-Mg fertilizer blends (e.g. 4-5-4), rock fertilizers that ecologically (and economically?) are superior to industrial fertilizers. All rocks being multi-element materials, actual rock fertilizers have to be certified for amount and speciation of elements which are detrimental to soil and plants (heavy metals, radiogenics, etc). Biotite-rich carbonatites from Stjernøy have locally up to 1 % Ba and 0.75 % Sr (c. 50 x normal values). Especially Ba is known to have an ecotoxic potential when bio-available. Since Ba substitutes for K in biotite and Sr for Ca in calcite, and both minerals are easily weathering, Ba and Sr should (theoretically) be bio-available e.g. in the plant's rhizosphere. Preliminary results of a comparative field study on sub-soil, soil and plants on Ba- and Sr-rich and -poor bedrock on Stjernøy are presented. The results of this study, supplied with plant (pot) experiments, will be critical for whether the Stjernøy carbonatite can be applied as rock fertilizer. With future high P- and K-fertilizer prices the actual rocks will, sooner or later, find application as plant fertilizer, either as source for industrial phosphate, or, hopefully, as rock fertilizer, giving a maximum use of the mineral resource in accordance with sustainability requirements of e.g. the EU.

References:

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'Rocks for crops' – the potential for agricultural use of mineral and rock fines (rock powder) in the Northern Countries.

Heim, M.* & Bleken, M.A.

Department of plant and environmental sciences, Norwegian University of Life Sciences, Box 5003, N-1432 Ås, Norway. *michael.heim@umb.no

Weathering of rocks is the main source of plant nutrients (20 elements) in natural ecosystems. In industrialized agricultural systems nutrients removed by crops are replenished by high-cost and high-energy produced soluble NPK-fertilizers (processed P- and K-mineral resources), resulting in environmental problems like eutrophication, greenhouse gas emission, poor soil structure etc. In addition industrial fertilizers usually contain only some of the "macro" nutrients needed by plants in large quantities, and do not sustain the soil reservoirs of "micro" nutrients that, in small quantities, are essential for plant growth, a praxis which can result in lowered soil fertility.

Crushed rocks and minerals (rock powder) are able to supply soil and plants with all nutrients, except N. The release is mainly dependant on mineral chemistry, grain size, climate and soil biology, and is slow compared to industrial fertilizers. This gives rock powders a potential as multi-nutrient inputs with long time supply to soils, preferentially applied in combination with other fertilizers. Their production (crushing, evt. dry mineral separation) is energy efficient and the application methods are well established (e.g. agricultural lime). Because of low nutrient contents, usually large quantities should be applied, and in this respect production from local rock sources is advantageous. High energy and NPK-fertilizer prices make rock powders, where available, a not only ecologically but also economically interesting supplement to conventional agricultural inputs.

In the Nordic Countries, mainly FIN, SWE and NO, mineral industry produces large quantities of, in part, finely crushed mineral and rock waste materials. As by-products, stored in land deposits, mineral fines in many cases have a potential for agricultural application, depending on chemistry (e.g. content of heavy metals) and location compared to users. On the other hand, there are rocks with exceptional plant nutrient characteristics (e.g. apatite-biotite-carbonatite) that could be mined for rock powder purposes alone. Examples from Norway are used to illustrate the rock powder concept: possibilities, challenges, limiting factors and needs for further research.

Peter van Straaten, founder and leader of the international 'Rocks for crops'-partnership initiative states "Soils, the foundation for survival and food security, are increasingly over-exploited in some parts of the world .... soils are degraded, eroded and successively 'mined' of their nutrients, in sub-Saharan Africa 22 kg N, 2.5 kg P and 15 kg K per ha and year" (van Straaten, 2006). Especially in poor countries in the tropics and sub-tropics, where naturally depleted soils are common, the input of rock powder can sustain/reestablish soil fertility. In the Nordic Countries the use of rock powder might result in reduced application of soluble fertilizers and lowered negative environmental impact of agriculture.

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van Straaten, P. 2006. Farming with rocks and minerals: challenges and opportunities. An Acad Bras Cienc 78, 731-747.