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FELDSPAR CRISTALLINITY AND POTASSIUM BEHAVIOUR IN SOILS OVERLYING SYENITES: AGROMINERAL APPLICATION

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Introduction

This work is part of a major projet from TERRATIVA MINERAIS S.A., related to agrominerals exploration in Brazil. Since 2011 TERRATIVA MINERAIS screened locations close to agricultural regions with favourable geology & logistics, for syenite rock with up to 14.5% potash content and also high content of other macronutrients. These rocks are uncommon, but TERRATIVA was able to locate them in key areas by using modern geological tools. TERRATIVA is developing five high grade potash mines (with up to 14.5% K_2O) and is planning the installation of four rock powder plants close to important agricultural zones from the Cerrado.

Actually Embrapa is running laboratory and agronomic efficiency tests to certify TERRATIVA rock powder products. Tests will be finished in Q1-2015. A 2 year research program from TERRATIVA with the MIT/USA developed Hydrosyenite, a second generation low cost high efficiency potash fertilizer produced from syenite by hydrotermal process, with controlled accelerated release of potash and also other benefits for agriculture.

The main objective is to present results of the study about weathering profiles overlying syenite rocks in the Triunfo region, Pernambuco state, northeastern Brazil, with special attention for the potassium behaviour from the primary minerals in the bedrock up to the soils. These rocks have been explored by Terrativa company with the main purpose of using them for agromineral applications.

Methods

Several soils profiles overlying syenite rocks were described and sampled in Triunfo region for further chemical and mineralogical analysis. Samples were collected according to horizon profile description.

Mineralogical analysis were carried out by X-Ray Diffraction (XRD) analysis using a Panalytical X'Pert PRO MPD diffractometer with a ceramic X-ray tube (λ CuKα1=1.540598 Å), Kβ Ni filter and a X´celerator Position-Sensitive Detector. Phase identification, cluster analysis and the Rietveld Method for quantitative phase analyses were carried out using the High Score Plus Software, also from Panalytical.

Cristallinity index is a very general term to describe order-disorder in crystal structures, which can be related to microstrain or crystallite size domains (Jenkins & Snider, 1996). In a very simple way, it is related to "peak broadening" in the diffraction pattern, followed by intensities decreasing. For the feldspar cristallinity, peak broadening of the XRD patterns (diffractograms) were analysed using the PROFILE FIT software tool, that calculates the peak profile characteristics by applying a range of adjustable, mathematical profile functions. These functions obtain (more accurate) information on peak characteristics such as position, intensity, and for this work, width and shape, herein described as the Full Width at Half Maximum (FWHM). Profile fitting is most often used to deconvolute severely overlapping peaks into single peaks.

Total chemical analysis were carried out by X-ray Fluorescence (XRF). Available Potassium analysis were carried out at ESALQ University, by extraction from the soil using cation exchange resin and analyzing the filtered extract on an atomic emission spectrometer. The results are reported as mmolc.dm^3.

Geological setting and location

The Icós Norte Project is located in the municipality of Serra Talhada, approximately 415 km west of Recife, the capital of Pernambuco State, Brazil (Silveira Braga *et al.*, 2014). The geology of this region is mainly represented by the Triunfo

batholith, which consist of an assemblage of syenites and mafic rocks (diorite/gabbro) in the form of late plutonic bodies. These rocks exhibit the same mineralogical composition (clinopyroxene, K-feldspar, sphenoid, apatite and magnetite), differing only in relative proportions (Ferreira *et al.*, 1994).

The soil profiles sampled in this work were developed over an alkali-feldspar syenite (AFS), comprising the Icós Norte Target from Terrativa.

Results and discussions

A typical soil profile from the Icós Norte Project is ilustrated in Figure 1, exhibiting the results of K_2O (total), K (Available) and FWHM of the most intense peak from K-feldspar in the XRD pattern.

Soil profiles are not deep in the region, typical from arid to semiarid regions from northeaestern Brazil. Fresh rock outcrops are very common in the landscape overlayed by immature soil profiles mainly comprised by a C horizon (weathered bedrock).

K-feldspar (microcline) is the main mineral in the samples. Main mineralogical observation in the XRD patterns is the kaolinite formation after K-feldspar hydrolisis and increasing in Fe_2O_3 contents to the top of the profiles related to iron oxy-hydroxides formation (Figure 2).

Figure 1 shows the typical K_2O deacreasing to the upper part of the profiles, related to K-feldspar weathering and K release. On the other hand, it very important to notice that available K contents increase to the top. Since no new K-bearing mineral is formed in the soil, K availability is related to K-feldspar structure, that becomes more loose due to upwarding weathering. This can be confirmed by the evaluation of the FWHM values exhibited in Figures 1 and 2. In the lower part of the profile (Sample RO-11), the FWHM value of the main peak of K-felspar is 0.087° 2q. The increasing of this value in the upper samples (0.108, and 0.121 ° 2q for the soil) implies that the peak is broadening and the K-feldspar structure is becoming more weathered and loose, favouring K availability.

Several other profiles were sampled and analysed in the Triunfo region, confirming such mineralogical and chemical behaviour.

Conclusion

Soil profiles in Icós Norte area are immature and K_2O contents typicaly decrease progressively toward the top of the profile. K_2O contents are relatively high in top soils (~ 5%) compared to humid/tropical regions (<0.01%). The main reason is related to arid to semi-arid climate where physical weathering domains over chemical weathering. The mineralogy of the soils is dominated by K-feldspar, whose crystallinity decreases to the top of the profiles, increasing K release/availability.

Clay minerals contents in the soils are very low, mainly related to kaolinite derived from K-feldspar hydrolisis (no K adsorption/retention).

Keywords: K-feldspar, soil profile, X-ray Diffraction, Agrominerals

References

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Silveira Braga, F.C; Leite, A.A. da S.; Oliveira, M. A. de; Martins, E. de S.; Gabos, M. B.; Angélica, R. S. 2014. K-Alternative Fertilizer Project: Biotite-bearing ultrapotassic deposit in Bahia state. In: 16th WORLD FERTILIZER CONGRESS OF CIEC, 2014, Rio de Janeiro, Brazil.

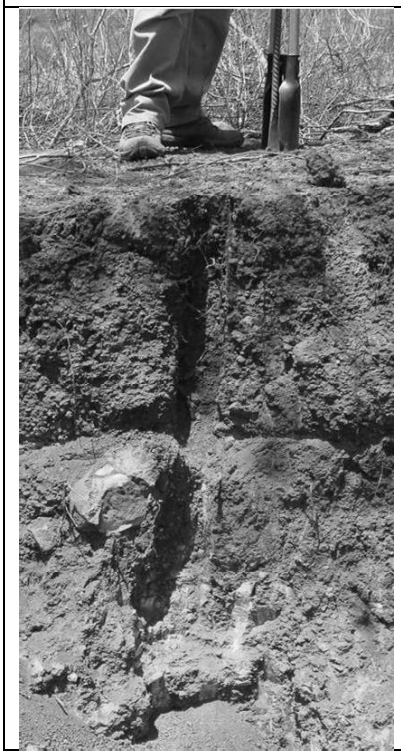
Soil Profile	Horizon Description	K_2O(%)	K_{avail}	FWHM
	SO-03 – Transported soil , with pisolites.	5.62	2.1	0.121
	RO-10 – Pisolitic and concretionary horizon: mm to cm sub-rounded fragments of weathered rock, indicating sub-aerial exposure and reworking.	10.1	1.4	0.108
	RO-11 – C Horizon: Saprolite with centimetric fragments of fresh and weathered syenite.	13.0	1.1	0.087

Figure 1. Typical soil profile from the Icós Norte Project, exhibiting the results of K_2O (total), K (Available, in mmolc.dm^3) and FWHM (in °2q) of the most intense peak from K-feldspar.

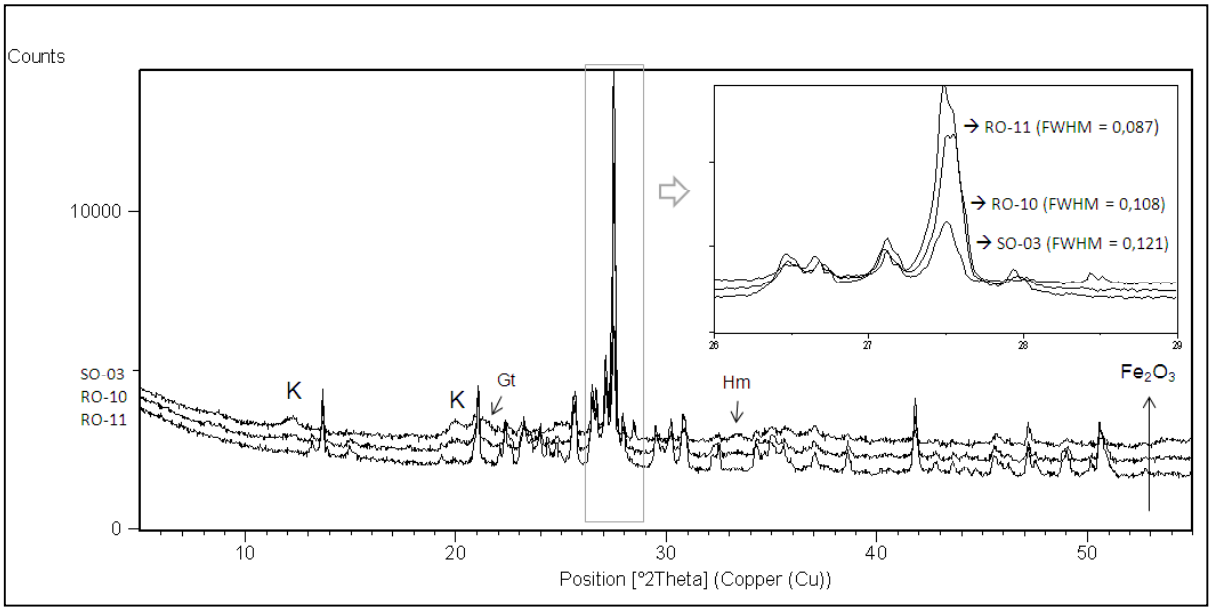


Figure 2. XRD patterns of the soil profile (three samples) from Figure 1, mainly composed by K-feldspar. In detail, one observes the K-feldspar most intense peak used for the FWHM measure and crystallinity evaluation. K: kaolinite; Gt: goethite, Hm: hematite.