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K-ALTERNATIVE FERTILIZER PROJECT: ULTRAPOTASSIC SYENITE DEPOSIT IN PERNAMBUCO STATE

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Introduction

Brazilian Cerrado soil is poor in macro and micronutrients. Despite Brazil being one of the top countries in agribusiness, Brazil has only one producing potash mine so that more than 90% has to be imported. This very uncomfortable dependence also has a significant impact on the country's trade balance. Due to actual low potash market prices, it is unlikely that any significant new production capacity will be developed in Brazil from the local potash salt deposits.

Embrapa is the leading Brazilian research institute for agriculture and to change the Brazilian dependence on imported potash, strongly supported the amendment 12,890 (2013) to the Brazilian Fertilizer Law 6,894 (1980), thus defining officially rock powder with proven agronomic efficiency as soil remineralizer and alternative potash fertilizer.

Since 2011 TERRATIVA MINERAIS screened locations close to agricultural regions from the Cerrado and 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.

In this scenario, TERRATIVA has several ultrapotassic igneous rocks projects in different regions of Brazil. In addition, the company is looking at areas with potential for soil conditioners such as the Icós Norte Project.

Location and geological setting

The Icós Norte Project is located in the municipality of Serra Talhada, approximately 415 kilometres west of Recife, the capital of Pernambuco State, Brazil (Fig. 1).

The Icós Norte Project is geologically located in the domain of the Triunfo batholith, which consist of an assemblage of syenites and mafic rocks (diorite/gabbro), such as co-magmatic inclusions and 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 geological map of the Icós Norte Target performed by Terrativa is illustrates at Fig. 2. The unit called as AFS is comprised by alkali-feldspar syenite. The SDG unit includes rocks resulting from mechanical blend of mafic and felsic magmas (magma mingling). The GRN unit includes granites, granodiorites and quartz-syenite.

Mineralogy and chemistry

The alkali feldspar syenite (AFS unit – Fig. 3) is predominantly composed by alkali feldspar (75 to 85%) and clinopyroxene (aegirine-augite serie – 25 to 15%). Amphibole, biotite, titanite, opaque minerals, plagioclase, zircon and apatite occur as accessory minerals (<1% each one). The rock has phaneritic texture, equigranular to inequigranular, holocrystalline, leucocratic to hololeucocratic (Fig. 3). Alkali-feldspar crystals are predominantly microcline, subhedral to anhedral, with films and diffuse

pertites types. Fine intergranular albite crystals are common.

The syenite has very high K_2O content (predominantly greater than 12%) and high ratio K_2O/Na_2O (greater than 6), allowing classifies it as ultrapotassic, as defined by Foley *et al.* (1987). Based on surface and borelos chemical data, the three units mapped have the following K_2O and SiO_2 content: AFS (Alkali Feldspar Syenite): $K_2O \geq 9\%$; SDG (Mingling = syenite + diorite/gabbro): $5\% \leq K_2O < 9\%$ and $SiO_2 < 63\%$; GRN (Granite): $K_2O < 9\%$ and $SiO_2 \geq 63\%$.

Mineral potential estimates

The mineral potential estimates was based on the data of 20 core boreholes (2,961 metres) executed by TERRATIVA in Icós Norte target. Based on the compilation from surface and borehole data was generated the geological model present in Fig. 2. The Dip (Z direction) was considered as the direction with more data correlation. Inverse Distance to the 2rd power (IQD) interpolation was used for the grade estimation. The model was blocked to a regular 50 m x 50 m x 10 m block model to account for dilution prior to pit optimization. The pit shell limits (Fig. 3) are restricted to areas with higher grades (Area A B). The Mineral Potential Statement for the Icós Norte deposit is tabulated in Table 1 using a cut-off grade of 12.50% of K_2O

Preliminary agronomic tests

Agronomic tests with the K silicate agromineral (100% < 0.15 mm) for corn crop has been done by Embrapa. In a pot experiment was applied the recommended dose to corn crop based in total K rock content (100 mg of K per kg of soil, equivalent to 240 t ha^{-1} of K_2O). The plant dry mass in the treatment with the K silicate agromineral from the Icós Norte Project were not different from the control treatment. The plants development were similar the treatment with the same dose of a known biotite schist. Those results are supported by the laboratory experiment. Extractants representing the soluble fraction were used and showed relative low extraction of K (0.3 g kg^{-1} for citric acid and 0.4 g kg^{-1} for Mehlich-1).

A hydrothermal process has been developed by MIT to form a second-generation of K-releasing powder, called hydrosyenite (Gadois *et al.*, 2014). The hydrosyenite produced with samples from Icós Norte Project showed very high extration of K (14.5 g kg^{-1} for citric acid).

Conclusions

Icós Norte Potash Project mineral potential is amenable to open pit mining of a ultrapotassic syenite using a cut-off of 12.50% of K_2O. Agronomic data indicate that processed sample (hydrosienite) shows very high extration of K.

Keywords: Alternative K-fertilizer, Ultrapotassic syenite, Soil Conditioner

References

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Table 1. Mineral Potential Statment*, Icós Norte Potash Project, Pernambuco State, Brazil

	Tonnage T X 1000	K_2O (%)	SiO_2 (%)	Al_2O_3 (%)	Fe_2O_3 (%)	CaO (%)	MgO (%)	TiO_2 (%)	P_2O_5 (%)	Na_2O (%)	MnO (%)	BaO (%)	LOI (%)
Area A	3,259	12.63	62.06	15.75	3.33	2.2	0.85	0.31	0.16	1.54	0.06	0.61	0.29
Area B	25,664	12.82	61.52	15.97	3.37	2.34	0.89	0.36	0.19	1.38	0.07	0.68	0.4
Total	28,924	12.80	61.58	15.94	3.37	2.33	0.88	0.35	0.18	1.4	0.07	0.67	0.39

The mineral potential is reported within a conceptual pit shell at a cut-off grade of 12.50 % of K_2O for AFS Domain, with density value of 2.53g/cm^3. Optimization parameters include a selling price of US$89.73 per tonne of concentrate, a process recovery of 100 percent and overall pit slopes of 55 degrees.

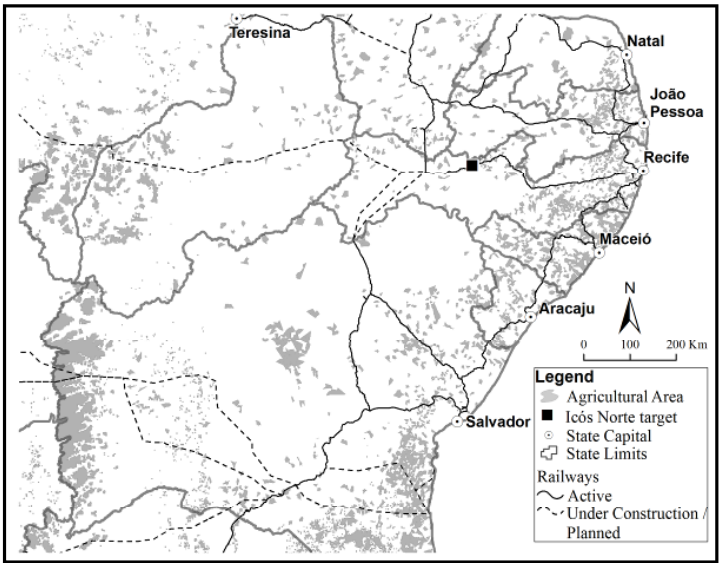

Figure 1. Location of Icós Norte syenite target.

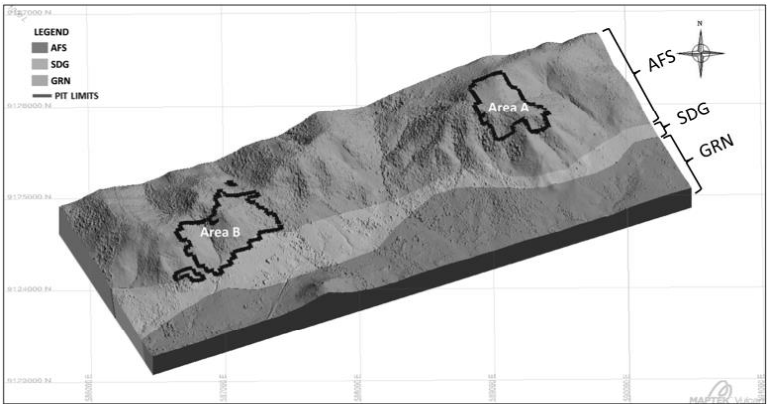

Figure 2. Overview of the 3D geological model with the location of the pit shell limits.

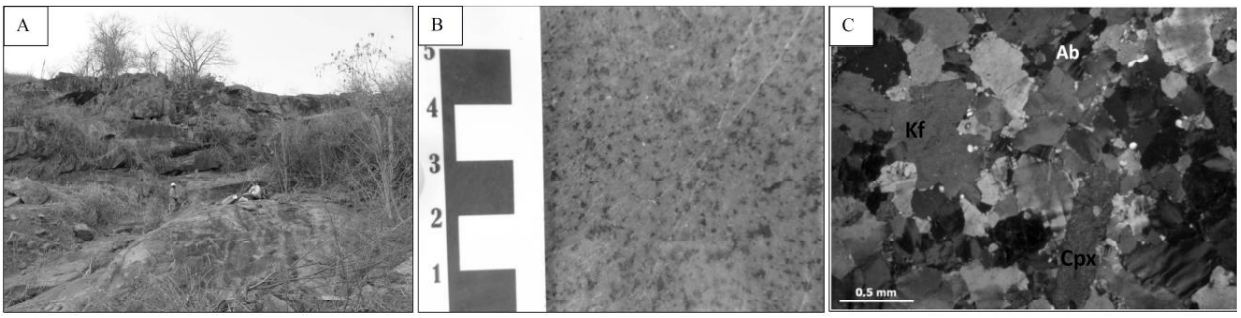

Figure 3. Pictures of the alkali-feldspar syenite from Icós Norte Project. (A) Outcrop, (B) Detail in a sample, (C) Photomicrography (X nicols) showing the texture of the rock (Abbreviations: Kf – alkali-feldspar, Cpx – clinopyronexe, Ab – Albite).