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Study of fracture process and structural properties of kyanite and kaolinite using instrumented indentation.

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Abstract – This work presents a study about fracture process, mechanical and structural properties of kyanite (Al_2SiO_5) and kaolinite ($Al_2Si_2O_5(OH)_4$). In both minerals the hardness and fracture processes are investigated by instrumented indentation. Kyanite and kaolinite presented a hardness of 16 GPa and 0.04 GPa respectively. Structural characterization was studied by Rietveld refinement indicated a triclinic structure for both materials. Fracture processes were studied using nanoindnetation tests and SEM images.The differences in mechanical properties and fracture process were relationed with the strucure theses minerals.

Kyanite and kaolinite are minerals that present several technological applications. Hardness, elastic modulus and toughness are important mechanical properties. Kaolinite (Medellín-Colombia) and kyanite (Minas Gerais-Brazil) mineral samples were analyzed. The characteristics of both minerals are present in Tab. 1. All nanoindentation tests were performed on the cleavage plane being (001) for kaolinite and (100) for kyanite. The mean roughness was 86 nm for kaolinite and 33 nm for kyanite after polishing. Instrumented indentation tests using a Berkovich indenter, using the Oliver and Pharr method [1], showed that the Kyanite present a hardness of 16 GPa (Tab. 1) much higher than kaolinite. After indentation SEM images show fractures induced by the contact in both materials (Fig.1) that are related to fracture of lamellar layers. Rietveld refinement confirmed the triclinic structure theses minerals. The structural simulation in 3D is show in Fig. 2. The very high hardness of kyanite is due to chemical bond of lamellar layers, while for kaolinite there is only Van der Walls forces between the lamellar layers.

Tab. 1 Physical, Nanomechanical and Structural properties

Mineral	Origin	Characteristic	Formule	Symmetry	Cleavage plane	Mohs hardness	Nanohardness GPa
Kaolinite	Medellín Colombia	White	$Al_2Si_2O_5(OH)_4$	Triclinic	(001)	1.5-2	0.04
Kyanite	Minas Gerais Brazil	Blue	Al_2SiO_5	Triclinic	(100)	4.5	16

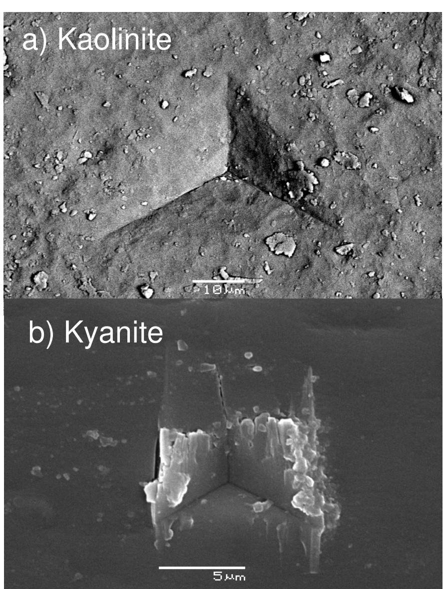

Figure 1: Nanoindentation tests performed in a) kaolinite (load of 100 mN) and b) kyanite (load of 400 mN).

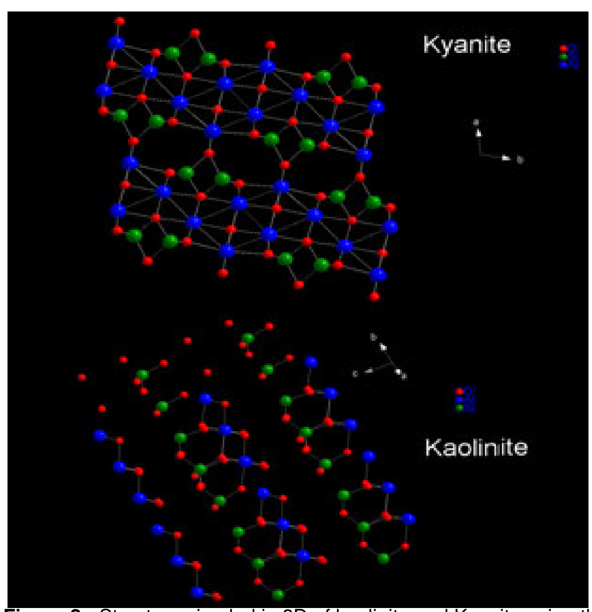

Figure 2: Structure simuled in 3D of kaolinite and Kyanite using the Diamond software. ● O ● Si ● Al

References

[1] W. C. Oliver, G. M. Pharr GM. J. Mater. Res 7 (1992) 1564.