American Mineralogist, Volume 93, pages 844–852, 2008

Fracture toughness, hardness, and elastic modulus of kyanite investigated by a depth-sensing indentation technique

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Abstract

Macroscopically bladed kyanite crystals of blue and glassy luster were cleaved along two planes, and the mechanical properties were measured through depth-sensing indentation (DSI). The conventional method to determine fracture toughness (K_{IC}) from indentation is based on radial crack lengths measurements, which is difficult to estimate owing to the ease with which kyanite cleaves. An alternative method is proposed to determine the K_{IC} for the perfect cleavage plane (100) of kyanite based on the estimation of the crack nucleation threshold load from a discontinuity or "pop-in" in the DSI load-unload curve. The toughness value for kyanite in the plane of perfect cleavage (100) determined by the proposed method is K_{IC} =2.1 MPa·m$^{1/2}$. The hardness of 10.7 ± 1.6 GPa for the perfect cleavage plane is lower than the one measured in a plane (010), 18.0 ± 2.9 GPa. The measured elastic modulus for the perfect cleavage plane (100) and for the plane (010) are 297 ± 11 and 405 ± 31 GPa, respectively. These values are in agreement with the published mechanical properties of kyanite, obtained by other techniques. The mechanical behavior is discussed and correlated to fracture patterns during indentation for both crystallographic directions of this mineral.

Keywords: Kyanite, fracture toughness, hardness, elastic modulus, depth-sensing indentation, mechanical properties