Forward modeling of microboudinaged columnar grains: simplified microboudin palaeo-piezometer

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Proportion of microboudinaged columnar grains embedded within metamorphic rocks is the key gauge to evaluate the differential stress during plastic deformation. We present the forward modeling for microboudinaged grains, and propose the simplified microboudin palaeo-piezometer.

The modeling consists of the weakest-link theory and shear-lag model. The weakest-link theory for the fracturing of fibre minerals are derived the probability density function of fracture strength as a function of aspect ratio and strength (Masuda et al., 1989). We obtain the fracture strength of each columnar grain from generating sample numbers at random from above probability density function by the inverse transform method. Shear-lag model (Zhao and Ji 1997) is the stress-transfer model for stress distribution along a fibre connecting the far-field differential stress with the tensile stress. If the tensile stress is higher than the fracture strength on a certain grain, we regard this grain becoming the microboudinaged grain. We also assume that the distribution of fracturing points in each grains conform to the Beta distribution. We collected the shape data of the columnar grains from tourmaline grains embedded with in the metachert from East Pilbara Terrane. We measured the width, length, and fracturing point of the microboudinaged grains of 1432 tourmaline grains with their long axes ±15° to the mean orientation. Base on the tourmaline grain shape data, we calculate the variation of the proportion of microboudinage grains with respect to the far-field differential stress from 0 to 20 MPa.

Our calculation shows that the increasing of proportion of the microboudinaged grains coincides with the increasing of the far-field differential stress. At 20 MPa, 70% of grains were microboudinaged. The proportion of microboudinaged grains with respect to aspect ratio, which is fundamental data in the microboudin stress analysis, shows significantly similar distribution pattern in natural microboudinaged tourmaline grains. Thus, our modeling surely reproduced the microboudinage of columnar mineral grains. We focus the results on the proportion of the microboudinaged grains with respect to far-field differential stress, and construct the simplified microboudin palaeo-piezometer to estimate the far-field differential stress from the proportion of the microboudinaged grains. We demonstrate the stress analysis to tourmaline grains embedded within metachert using the simplified microboudin palaeo-piezometer, and compare with usual microboudin palaeo-piezometer.

References

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