EXPERIMENTAL GROWTH OF FIBERS AND FIBROUS VEINS

by

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Abstract

Experiments on growth of fibers and fibrous veins using analog materials demonstrated that fibers can develop by a distinctive process of growth, called *Taber growth*, which is characterized by accretionary growth of vein-like bodies of fibrous crystals in confined space at the fiber-wall interface, by drawing nutrient from pore solutions in the "wall-rock" on one hand and pushing apart the enclosing walls on the other, through the action of a "force of crystallization". Taber growth differs markedly from the crack-seal model of Ramsay, in that no long-range, wall-parallel cracking is involved, and the growth itself plays an active role in opening a vein. It differs from all models of vein development that involve passive growth of crystals following and keeping pace with externally imposed vein dilation, or involve delivery of solute along a fluid-filled vein crack or fissure, rather than through the wall rocks. Based on extensive experimental observations the detailed characteristics of Taber growth were documented and its essential growth conditions were studied. It was found that the ambient humidity, the pore fluid pressure and the grain or pore size are the principal controlling factors that determine the morphologies of fibers and whether fibrous or non-fibrous blocky crystals grow. Detailed examination of experimental Taber fibers revealed microstructural features that are reminiscent of similar features in natural fibrous veins.

Fibrous veins with various types of fiber curvature patterns were produced under different growth conditions. Examination of the tracking behavior of some typical experimental veins showed that fibers in Taber growth generally track the instantaneous displacement as long as the growth interface remains cohesive and there is no internal deformation within the fiber aggregate. The concept of tracking was criticized and re-evaluated in light of the experimental observations, and a method was developed by which vein displacement histories can be reconstructed using fibers that are known to track the wall-vein displacements.

The displacive characteristic of Taber growth was specially investigated through experiments on growth of fibrous veins under large compressive loading conditions. It was demonstrated that fibrous veins could grow against virtually any pressures or stresses externally imposed on the wall blocks as long as the pressure was not so large as to cause the failure of the blocks and fibers couldn't grow at any other sites against smaller pressures. The crystallization force in Taber growth was analyzed from a point of view of thermodynamics, and it was interpreted as reflecting a *crystallization pressure*, which is defined as the difference between the fluid pressure and the theoretical maximum independent pressure that a crystal can grow against without dissolving under the given supersaturation conditions. Theoretical analysis suggests that the crystallization pressure in Taber growth can attain values of about the same order as geologically realistic values as long as a high supersaturation level can be maintained and growth occurs in confined spaces in a fine porous medium. Further analysis of the surface energy effects on crystallization in a fine-grained medium suggests that the conspicuous displacive crystallization of Taber growth is due to the distinctive process of crystal growth in fine porous media. Solution confined in such a porous medium can become highly supersaturated without much crystallization in the pores, thus producing a large crystallization pressure that is capable of forcing or pushing open a "vein" in the "wallrock" wherever its strength is weakest.

Taber Growth affords significant implications for some natural veins. Fibrous veins formed by Taber growth could be *non-tectonic* as well as synkinematic. Taber growth readily explains why the instantaneous direction of new fiber segments should parallel the instantaneous direction in which older segments of the same fibers are moving away from the vein wall. The possible role of the displacive crystallization of Taber growth in formation of fibrous veins further suggests that some natural fibrous veins may have been forced open by displacive growth.

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