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INVITED CENTENNIAL ARTICLE

Tweed, twins, and holes

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ABSTRACT

Tweed, twin, and porous microstructures are traditionally studied in mineralogy to understand the thermal history of minerals, and to identify their properties such as chemical transport and elastic behavior. Recently, the same research area has blossomed in material sciences and physics with the aim to design and build devices that are based on the properties of nano-structures. Only the very existence and the properties of tweed, twins, and holes matters in this quest while the crystalline matrix plays only a minor role in the current search for novel device materials. This development has largely bypassed mineralogists while physicists did not profit from the age-long experience of mineralogists in dealing with such materials.

In this Invited Centennial article, I will first discuss some key findings and approaches to foster the transfer of ideas in both directions: mineralogists can potentially inspire material scientists while the physics of the fine structure of twin walls and tweed can help mineralogists understand mineral properties in much more detail than hereto possible. Besides the observation that novel physical properties can spring from microstructures, most recent work also includes the dynamics of microstructures under external stress or electric fields. The dynamics is virtually always non-smooth or "jerky." One of the best studied jerk distribution is that of collapsing porous minerals under stress, where the main focus of research is the identification of precursor effects as warning signs for larger events such as the collapse of mines, boreholes, or even regional earthquakes. The underlying physics is the same as in large earthquakes (which can be modeled but not observed in laboratory experiments). The agreement between laboratory experiments of porous collapse and large-scale earthquakes goes well beyond each quake's statistics and includes waiting-time distributions and the Omori law of after-shocks. The same approach is used to characterize high-tech materials in aircraft industry and functional materials such as used in electronic memory devices, ferroelectric sensors and non-volatile memories and ferromagnets.

Keywords: Ferroelastics, twin structures, tweed structures, porous minerals, martensites, avalanches, jerk dynamics, nano structures, Invited Centennial article