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BOOK REVIEWS

Rock deformation and failure transitions

Duba, A. G., Durham, W. B., Handin, J. W and Wang, H. F. (editors) 1990. *The Brittle–Ductile Transition in Rocks (The Heard Volume)*. American Geophysical Union Geophysical Monograph 56. Price $42 ($29.50 AGU Member price).

This volume is one of the latest in the excellent series of collections of papers on particular research themes in pure geophysics, the AGU Geophysical Monographs. It is dedicated to the memory of Hugh Heard, following his untimely death in 1987 from cancer. Hugh made seminal contributions over a period of 35 years to geologically-oriented rock mechanics. His published papers generally included exceptionally detailed descriptions of the design of experimental apparatus and procedures. He was a remarkable innovator in the field of experimental techniques. I myself was privileged to learn from him during his sabbatical visit to Imperial College whilst I was a final year graduate student. However, Hugh was no dry experimentalist, but was equally interested in addressing the problems of the extrapolation of experimental data to the conditions of natural rock deformation.

The present volume reflects the range of Hugh's own interests and contributions, insofar as it is organized into two major sections. The first, comprising 13 papers, deals with scientific topics more-or-less related to the titular theme of the volume. The second section, comprising 10 papers, is devoted to a range of experimental techniques in rock mechanics.

The 'brittle–ductile' transition is a 'buzzword' of present times, with many geologists and geophysicists regarding it as being characterized by a particular depth in the Earth's crust. Many readers may therefore be astonished to find that in a book of this title the simple concept of a 'brittle–ductile' interface is not mentioned, neither in the initial keynote review of brittle–ductile transitional phenomena by Evans, Fredrich and Wong, nor anywhere else in the book. The popular view of brittle–ductile transitional phenomena, taken from a lithospheric-scale viewpoint, looking inwards, represents a gross oversimplification. All the authors in this volume examine modes of rock failure from a rock mechanics perspective, looking outwards. From this point of view brittle–ductile transitional phenomena are complicated. Whilst rules-of-thumb, useful for some purposes, can be derived, they must be regarded with great caution.

The remaining scientific papers deal with specific topics, although many of them are only peripherally connected with failure mode *transitions*. Kronenburg *et al.* describe the localization of a plastic shear zone in granitic rocks, in which high shear strains apparently correlate with high intragranular water content of quartz. Carlson *et al.* present a numerical simulation of thermal cracking in granite, and Tullis *et al.* describe experiments in which plastic flow localization becomes concentrated along cataclastic fault 'precursors' in feldspathic rocks.

Chester and Logan demonstrate further developments in studies at the Texas A & M Laboratory of the frictional behaviour of halite in simulated fault zones. From the same laboratory two further halite studies are included. Horseman and Handin describe the development of a high precision apparatus for triaxial studies on rock salt (this paper might have alternatively been included in the techniques section). Russell *et al.* describe stages in the development of a state-variable description of the flow of halite. This is an approach to the description of the constitutive behaviour of rocks which does not presume steady-state flow, and hence is of more general applicability than the familar power-law creep description. However, it requires a more comprehensive range of testing techniques and the acquisition of higher quality mechanical data than has been usual in the past.

As if to emphasize the fact that not all of Hugh Heard's contributions to materials science were on rocks, one paper on the mechanical properties of a metal alloy is included. In this, Chockshi and Mukherjee describe the use of moderate hydrostatic pressures to suppress cavity formation in and to enhance the ductibility of a superplastic Al–Li alloy.

Bernabe and Brace describe experimental data encompassing the cataclastic faulting to flow transition for Berea sandstone. This study involves the measurement of volume strains concurrently with deformation. Although such techniques have sporadically been applied for almost 30 years it is clear that an adequate description of the mechanical properties of brittle rocks cannot be obtained without attention to volume strains.

Kirby *et al.* describe aspects of anomalous brittleness in the deformation of hydrous minerals at high pressure, and relate it to anomalies in their thermal behaviour. Hacker and Christie describe experiments on both natural amphibolites and finer-grained samples synthesized by hot pressing. They found brittle behaviour over a wide range of conditions, except that plastic flow developed from precursory brittle faulting (cf. Tullis *et al.* earlier). The final two papers in this section deal, respectively, with shock loading of sandstone (Brown *et al.*) and microstructures and preferred crystallographic orientations of plagioclase in naturally deformed basic rocks (Ague et al.).

The techniques section of the volume is largely a review of a wide range of experimental methods, some traditional and some more exotic. Paterson reviews the geological philosophy behind the design of triaxial test equipment and describes in some detail the features of his latest gas-medium deformation machine. Green and Borch describe their new developments of the solid-medium technique, in which they trap a volume of molten salt around the test specimen capsule, in order to allow more precise measurements of differential stress at confining pressures up to 3 GPa. Sotin and Poirier describe a sapphire anvil cell which can be used for ultrahigh creep tests at low temperatures.

Cooper *et al.* demonstrate the use of a four-point bending sample configuration, which admits controlled variation of mean stress across a sample. They use this at high temperature to study effects arising from partial melt migration along the mean stress gradient. In a related paper, Kohlstedt describes the use of high resolution analytical TEM to deduced the distribution of partial melt in a peridotite.

One of the last topics worked on by Hugh Heard was the flow of ice over a wide homologous temperature range: Heard *et al.* describe the apparatus used to deform ices between 77 and 273 K. Amongst the unusual sample geometries which can be used to examine the effects of stress-state variations within a single test, Meike and Heard describe the truncated cone test. Mackwell *et al.* describe a high-resolution uniaxial creep apparatus, designed for single crystal work at high temperatures. Duba *et al.* describe equipment for the measurement of the electrical conductivity of silicates at high temperatures and controlled oxygen fugacity and, finally, Getting *et al.* describe the measurement of seismic attenuation at very low (natural) amplitudes.

In conclusion, this volume will serve as an indispensable reference work for researchers in the field of rock mechanics and related areas. It is also especially useful as a collection of descriptions of a wide range of experimental techniques, and is a fitting testament to the memory of Hugh Heard.

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A manual for teaching structural geology

Hatcher, R. D. and Hooper, R. J. 1990. *Laboratory Manual for Structural Geology*. Macmillan Publishing Co., New York, U.S.A. 217 pp. Price $25 approx. (softback).

This book aims to provide the core material for the laboratory-based component of a one-semester course in elementary structural geology. One of its strongest attributes is that it contains a wealth of properly structured examples which work, providing ample material for anyone