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Book Review

NEUTRON SCATTERING IN EARTH SCIENCES. Hans-Rudolf Wenk, Editor. (2006) Reviews in Mineralogy and Geochemistry, vol. 63, 471 p. ISBN: 978-0-939950-75-1. $40. http://www.minsocam.org/MSA/RIM/

This volume is a compilation of detailed articles accompanying the presentations made by a range of experts in the field of neutron scattering at the December 2006 Emeryville/Berkeley workshop (sponsored by MSA) hosted by H.-R. Wenk of University of California, Berkeley, who also edited the volume.

The theme was the use of low energy (thermal) neutron scattering and diffraction for the analysis of minerals and rocks, and the goal was to provide a resource that would make the technique and its strengths and versatility more familiar and accessible to Earth sciences new users. This readable volume achieves this goal as a broad and astute presentation of the field and provides a very useful resource for both new and experienced users. With advanced sources like the Spallation Neutron Source (SNS) at Oak Ridge currently commissioning beamlines, it is a good time for the Earth sciences community to take advantage of neutron analysis and increase the user base and representation at these facilities.

Each of the 17 chapters is a very much self-contained article covering background and introductory information, theory, technique, and applications, with an extensive reference list. The authors are instrument scientists, geophysicists, geochemists, mineralogists, and materials scientists who present background and examples of the many different techniques and measurements available at current and anticipated neutron scattering facilities.

The motive to improve familiarity with neutron scattering in Earth sciences has several sources, one being that the exclusively nuclear interactions involved are not as familiar as X-ray or electron scattering, although the principle of wave interference/diffraction is the same. The de Broglie wavelength of a slow (a few km/s) neutron is comparable to that of a several kV X-ray, so the diffraction is similar to X-rays for crystallographic and strain measurements, but the properties of the neutron make it also sensitive to magnetic order, isotopic variations, phonons (the speed is comparable to sound speeds in solids), and more. Perhaps another source is due to the fact that large facilities must be used—there are not yet any thermal neutron sources comparable in size to common lab X-ray systems or electron microscopes. This limit is partially due to the need to shield an energetic source of high luminosity, either a nuclear reactor or a spallation target, and to the space needed to collimate the beams. The volume consequently contains a considerable amount of information on facilities, where they are, what they can do, and how to make contacts and get experiment time.

Comparisons with the capabilities of synchrotron sources appear in several articles, as do discussions of where neutron scattering has difficulty. Samples with large quantities of hydrogen must be treated as inelastic scatterers or have deuterium substitution, samples with small coherent scattering cross-sections may produce no Bragg peaks, and long count times are used since generally fluxes are quite low.

The first two chapters cover more general introductory material, the properties of neutrons and their interactions, the production of neutron beams, and the operation of facilities. Some examples of beamline capabilities at specific facilities are presented. There is a chapter dedicated to the application of Rietveld refinement of Bragg peaks in powder and polycrystal diffraction data, the rest are experiment-based articles on topics such as: single-crystal diffraction, time-dependent measurements and kinetics, texture, non-crystalline materials and pair distribution functions, inelastic scattering, magnetic structures, inhomogeneous samples, and imaging tomography. These chapters are all oriented toward issues in mineralogy and Earth science in general and contain examples of measurements of a wide variety of mineral and rock specimens made under an equally wide variety of environmental conditions—temperature, pressure, uniaxial stress, and magnetic field to name a few.

This volume covers just about every available (and some yet to be) neutron diffraction and imaging measurement of interest to the Earth sciences community, with extensive references and contact information for most of the world's neutron scattering facilities. As always, the value for money on the RiMG series is hard to beat.

T.W. Darling
Physics Department
University of Nevada
Reno, Nevada

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