MINERALOGICAL MAGAZINE

VOLUME 51 NUMBER 357 MARCH 1987

Electron Microscopy in Mineralogy and Petrology

THE Hallimond Lecture for 1986 was given by Professor J. Zussman, on the topic 'Minerals and the Electron Microscope'. A complementary meeting on 'Electron Microscopy in Mineralogy and Petrology', was convened by Dr P. E. Champness and was held on 23–24 April 1986 in the Department of Physics, University of Manchester. The aim of the meeting was to review recent techniques and applications of transmission and scanning electron microscopy. Over half the papers were 40 minute invited contributions which were intended, in part, to be tutorial in nature. Most of the papers that were presented are either published here in full or as abstracts.*

In the first review paper *Jefferson* discussed the use of high-resolution electron microscopy for the determination of defect structures and completely new phases. He showed that images cannot necessarily be interpreted as projections of the electron density of the sample. Careful attention must be paid to instrumental and specimen-dependent factors that may affect the image. Ideally experimental images should be compared with computer-simulated images of the proposed structure, though this may be rather expensive in computer time! *Christy's* paper illustrated the use of HREM to unravel the structural complexities of sapphirine. In particular he showed that $\frac{1}{2}[001]$ (010) faults are common and give rise to triclinic twins, monoclinic lamellae and more complex periodic structures.

In the second invited paper *Lloyd* concentrated largely on orientation contrast and electron tunnelling in the scanning electron microscope. Both techniques are relatively new and obviously have the potential to provide crystallographic information from geological material that cannot be obtained in other ways. *Middleton* described the role that analytical SEM plays in archaeology. His examples included the characterisation of geological raw materials, the elucidation of the processes used to transform these materials into useful objects and the characterisation of changes which archaeological objects may undergo during burial or storage.

Returning to techniques in the TEM, *Champness* described how convergent-beam electron diffraction (CBED) can be used to determine the point group and space group of crystalline materials as small as 20 nm in diameter. She also showed that polytypes or polysomes may be distinguished from CBED patterns taken perpendicular to the layer stacking. The first day ended with the Hallimond Lecture in which *Zussman* drew on his experience over some 30 years with transmission electron microscopy of serpentines and amphiboles.

The second day began with a review by *Lorimer* of microanalysis in the TEM. He described how quantitative chemical analyses may be obtained from areas less than 20 nm in diameter. The identity of particles considerably smaller than this may also be found by a simple, graphical technique.

The rest of the morning was devoted to papers in which analytical electron microscopy (AEM) played an essential role. *Curtis* reviewed recent work by his group on diagenetic clay minerals. They have found that authigenic clay minerals have compositions that conform closely to ideal phyllosilicate structures and conclude that AEM is the only analytical method that can routinely avoid contamination by other phases. *Worden's* study of the breakdown of phengite and chlorite during pyrometamorphism showed that, although the reactions had not gone to completion, there had been significant chemical interaction between the phyllosilicates and the surrounding rock. In particular SiO_2, Na_2O and K_2O had diffused into the pseudomorphs. AEM was used by *Mulvaney* to identify the phases present in iron ore sinters and by *Dickinson* to investigate the microstructural reasons for colour variation in sphalerites. In the last paper of the morning *Barber* reviewed the two-phase microstructures and associated

* For abstracts of several papers not offered for publication see Mineralogical Society Bulletin No. 69.

Mineralogical Magazine, March 1987, Vol. 51, pp. 1–2

defects in carbonates with the dolomite and calcite structures. The second phase consists of thin coherent ribbons or, less commonly, a modulated structure.

In the first of two papers on the use of electron microscopy to study deformation structures, *Knipe* reviewed the microstructures that are developed in fault zones under a range of environmental conditions. In the second paper *Maddock* employed high-voltage TEM and back-scattered SEM to examine the microstructures and to determine the deformation mechanisms in an experimentally deformed sandstone and a quartz–kaolinite gouge. *Brown* described the interaction between exsolution lamellae and later mechanical albite twins in a peristerite. On entering the twinned region the lamellae were found to become thin, en-echelon discs.

In an application of TEM to soil science *Jones* measured the thickness of ferrihydrite coatings that built-up on kaolinite particles under different concentrations of ferrihydrite and different pHs. Returning to applications of TEM to mineralogical reactions, *Brearley* examined the fine-grained breakdown products of a biotite that had undergone pyrometamorphism. Unlike Worden, he found no evidence of reaction with surrounding phases. By comparison of the microstructure with those produced experimentally, he was able to estimate that the rock had been at peak temperature for less than 48 hours.

To round off the proceedings *Putnis* emphasised that sample characterisation by TEM is essential to any study of properties that are dependent on structural state. Techniques that have recently been combined with TEM are calorimetry, solid-state ^{29}Si NMR and measurement of magnetic properties.

P. E. CHAMPNESS