Lamellar Intergrowth of Orthoenstatite and Clinoenstatite [(Mg,Fe)SiO₃] Studied by Lattice Imaging

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Deformation experiments under high static confining pressure and observations on tectonically deformed specimens have shown that orthoenstatite (space group *Pbca*) can be transformed to clinoenstatite ($P2_1/c$) by shear stress (for literature, see Coe, R. S. [*Contr. Mineral. Petrol.* (1970). **26**, 247–264]). The specimen used for the present study was prepared by ion-thinning from an orthoenstatite sample deformed at 800 °C and 5 kb confining pressure at a strain rate of $10^{-4} s^{-1}$. Previous high voltage (650 kV) transmission electron microscopy had revealed submicroscopic lamellae of orthoenstatite (OE) and untwinned clinoenstatite (CE) joined along (100) planes [Coe, R. S. & Müller, W. F. (1973). *Science*, **180**, 64–66]. The transmission electron microscope technique of one-dimensional lattice imaging has been applied now to the same specimen using a JEM 100 B instrument equipped with a side-entry goniometer. Lattice fringes with spacings of 18·2 Å and 9·1 Å corresponding to the (100) planes of OE and CE, respectively, make it possible to distinguish easily the two polymorphs. The lamellae of CE consisted of an even number of lattice units along a^*. This is due to their mode of formation: The shear transformation causes an halving of the (100) spacing of OE, thereby producing twice the number of unit cells of CE [Coe, R. S. (1970); Morimoto, N. & Koto, K. (1969). *Z. Kristallogr.* **129**, 65–83]. The lamellae of OE and CE are sometimes only one and two (100) spacings, respectively, in width.

Theoretical Basis of Diffraction Contrast of Lattice Imperfections in Transmission Electron Microscopy

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The dynamical theory of diffraction, both for X-rays and electrons, was formulated many years ago but for several decades found only limited application in the analysis of diffraction patterns because of the difficulty in obtaining specimens whose defect content was known with sufficient precision. This situation was transformed with the advent of real-space techniques, such as transmission electron microscopy and X-ray topography, which allowed the dynamical theory to be applied to local regions in the vicinity of individual defects instead of to the diffraction pattern coming from the specimen as a whole. As a consequence there has, in the electron case, been an intimate relation between the continuing improvement of the instrumental technology by which these real space images are obtained and the development of the dynamical theory for imperfect crystals which is essential for their interpretation. What may be described as the established theory (see, for example, Hirsch, P. B., Howie, A., Nicholson, R. B., Pashley, D. W. & Whelan, M. J. [*Electron Microscopy of Thin Crystals* (1965). London: Butterworth] was based on a series of approximations suitable for a transmission instrument with a resolution of about 20 Å at an energy of 100 keV operating on ~2000 Å thick films of structures with relatively small unit cells. These approximations, discussed in detail by Howie, A. & Basinski, Z. S. [*Phil. Mag.* (1968). **17**, 1039–1063] include the *deformable-ion approximation* (appropriate for slowly varying strains), the *strong-beam approximation* (appropriate to small unit cells where, with careful choice of orientation, only a very small number of diffracted beams need be considered) and the *column approximation* (appropriate when the lateral spreading of the waves in the crystal is small compared with the resolution achieved). In addition, it is assumed that the small-angle inelastically scattered electrons accepted by the aperture

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