

08.4-14 MORE ABOUT THE MICROSTRUCTURE OF OPALS. By Jean-Pierre GAUTHIER, Laboratoire de Minéralogie-Cristallographie, 43, Bd du 11 Novembre 1918, 69622 Villeurbanne Cédex, France.

TEM investigations on opals of various kinds and origins have been largely developed in our laboratory (Gauthier, *J. Microsc. Spectrosc. Electron.*, 1985, *10*, 117-128). Thin slices of these materials have been obtained by ion beam milling. Despite eventual difficulties encountered in interpreting images from some sections through the silica ball stackings of gem or potch opals, advantages of the TEM with respect to the SEM technique lie mainly in the following reasons: higher resolution, internal view of silica balls or nodules, visualization of the interstitial materials, possibility of electron diffraction.

Precious opals from numerous deposits (Australia, Brazil, Mexico) exhibit the well-ordered silica ball arrays generating the famous "play of colours". However, they also display all the defects associated with the close-packing lattices: planar defects, single or pair dislocations, interstitials or vacancies, lattice distortion, grains and subgrain boundaries, twinning and microtwinning and perhaps polytypism. The "potch" which consists in a stacking of silica balls having different diameters includes sometimes perfectly ordered regions of identical spheres. The possibility of a two-stage growth mechanism has to be considered. Moreover, some curious microgeodes found in an Andamooka potch lead us toward an eventual many-stage mechanism.

Common opals do not present the silica ball stackings. Depending on their origin, they are amorphous or very poorly crystallized, as shown by TEM and THEED. Examples will be given with Peruvian opal, resinite, white common Hungarian opal, fire opal... A particularly interesting Bresilian matrix opal displayed various aspects of the silica: precious and potch opal, amorphous regions, cryptocrystalline fibers, polycrystalline domains very similar to a siliceous microstructure and monocrystals of  $\alpha$ -quartz.

Investigating synthetic opals, several aspects have been observed in the different species of Gilsonite. Among them, some white or black varieties show a microstructure quite identical to their natural equivalents, so that the transmission electron microscopy do not allow to distinguish them clearly one from the other. Another kind, a porous opal, resembles strongly to the natural cacholong: existence of an interstitial material, sticking effect on the tongue. However, an unusual structure has been found in a third kind of white opal displaying light-green fires (Gauthier, *J. Microsc. Spectrosc. Electron.*, 1986, *11*, 37-52): spherulites of  $ZrO_2$  take place inbetween the silica balls which appear like hot-pressed. Some ideas about the manufacturing Gilson process can be put forward from chemical analyses and E.M. micrographs. Similar observations on some syntheses from outside origins seem indicate that the Gilson know-how has been transmitted to or acquired by the Japanese manufacturers.

08.4-15 DETERMINATION OF THE STRUCTURE OF LENGENBACHITE BY HIGH-RESOLUTION T.E.M. By Williams, T.B., R.I.I.S.O.M., University of Tohoku, Sendai, Japan; Pring, A., The South Australian Museum, Adelaide, Australia; and Hyde, B.G., The Australian National University, Canberra, Australia.

The rare sulphosalt lengenbachite (Solly, R.H., *Mineral Mag.* *14*, 72-82, 1905)  $Pb_{36}As_{24}Ag_{12}Cu_5S_{78}$  (Rösch and Hellner, *Naturwiss.* *46*, p72, 1959) has been examined by HRTEM and electron diffraction in an attempt to elucidate its structure and investigate reports of intense disorder (Makovicky and Leonardson, in Makovicky, E., and Hyde, B.G., *Structure and Bonding* *46* 1981). The morphology of this mineral, found as thin foils or plates frequently curled or twinned, has hindered attempts at X-ray structure determination; although Makovicky and Hyde (Idem.) have suggested a layered structure with two independent sublattices and a large coincidence lattice. Present results confirm these proposals and images from the [001] and [010] zones show a layered structure which is usually very well ordered. Furthermore, the two layers, whose subcells have the axial ratios  $2b(T) = 3b(H)$  and  $13c(T) = 12c(H)$  (T and H refer to the pseudo-tetragonal and pseudo-hexagonal lattices) are seen to be smoothly corrugated in the z direction (see figure). The period of these corrugations, 35 Å, is half the c match of the subcell parameters, and the amplitude is about 1-1.5 Å. In the y direction the layers are completely straight. This structural feature is identical to that observed in cylindrite (Williams, T.B., *Proc. XI Inter. Confer. on Electron Microscopy, Kyoto, 1986*, and Williams, T.B., and Hyde, B.G., in preparation) and franckeite (Idem.), both minerals in the Sn-Pb-Sb-Fe-S system. Work on determination of the layer structures from the TEM data is progressing, by comparison of observed images and computer generated images using the multislice method. Disorder observed has been restricted to some twinning on (100), although (010) electron diffraction patterns show some evidence for (ordered) doubling of the layer-stacking parameter from 18.45 to 36.9 Å.

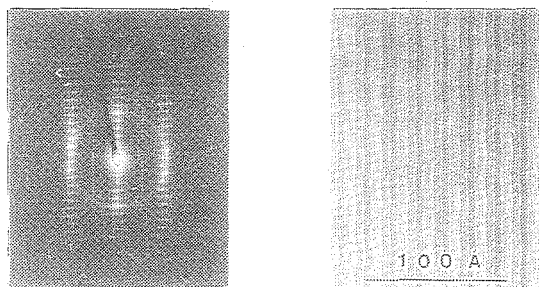


Figure. Electron diffraction pattern and high-resolution TEM image from the [010] zone of lengenbachite.