

Lattice Structure in Precious Opal

by

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Research by Sir C. V. Raman into the cause of the color in precious opal¹ has been made available recently by the publication of photomicrographs of the structure which produces the colors, together with details of more advanced X-ray investigation and spectrographic work. The latter demonstrates very clearly the monochromatic nature of the light emitted; the X-ray work establishes the presence of cristobalite and suggests the presence of tridymite, while the photos show the film-pack structure demonstrated by the present writer.²

The remarkable point is that an apparent paradox is established: the presence of regular crystal structure in a substance which has heretofore been widely known as a typically amorphous mineral. This is a complete contradiction of terms. Common opal may be completely amorphous; precious opal is not. Rather, precious opal consists of an amorphous matrix of hyalite which contains

random blocs of crystal lattices formed of parallel laminae, presumably with the structure of cristobalite.

Previously, little attention had been paid to the idea of regular structures in colloid gels, and the subject is perhaps new to many gemologists. But it now appears that, given suitable conditions, other colloids, such as agar, gelatin, and soap, may develop incipient crystallization and that each may have its particular habitual form, as crystalline minerals have.

Gemologists can expect to hear more of colloids, and it may therefore be helpful to explain just what they are. Originally, they were described as substances which, on drying out from a solution (or sol), gave not a crystalline residue but an irregular mass or jelly (gel). This, however, is not all satisfactory. Many substances will produce crystals under some conditions but amorphous deposits under others; e.g., sugar, calcium carbonate, malachite. Indeed, most

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crystalline salts may be produced in a colloid form (sodium chloride, iron carbonate, and pitchblende, for example). Currently, colloids are defined by particle size. Solutions which contain relatively large separate groups, or aggregates, of molecules cannot crystallize, so they form irregular gels. Solutions containing individual molecules offer an opportunity to these to build up into regular crystal forms; therefore, on evaporation, they can and do develop crystals.

In the case of most opal (a colloid form of silica) the molecules, when first produced by chemical reaction, consist of tetrahedra of silicon tetra-oxide (SiO_4). These polymerize very rapidly (i.e., the single molecules join up by sharing oxygen atoms) and form chains (Si_2O_6), several parallel chains forming rods. These can build up further but frequently fail to do so; rather they dry out as an amorphous gel of small, irregularly interwoven threads a condition which has been well described as "brush-heap structure." This forms common opal.

In the case of precious opal, the silica chains, threads, or rods have oriented themselves into lattices, films, or sheets. This is only possible under critically ideal conditions, but specimens may be obtained which show clearly the various stages in the development. These range from the finest, thinnest films, hanging like a tinted drape in the transparent hyalite, to thick sheets of parallel fibers reflecting strong spectrum

colors; and finally to packs of films, reminiscent of a deck of cards, which are equal, parallel, and regularly spaced. The effect of this film-pack structure is to produce very intense colored reflections and to regulate the wavelength of the light so that only a narrow band is visible in the spectroscope, as distinct from the broad bands of pleochroic light resulting from thin plates, as in cracks (iris quartz), or oil on water.

Dr. Raman's X-ray investigations support previous workers in America² and Australia³, who have found that cristobalite normally occurs in precious opal; but he goes further and demonstrates the presence of tridymite, which had not been previously established. Here again his photos are very convincing and show a great step forward.

The illustrations he offers, showing the film-pack structure, are most impressive. The writer has seen similar formations under the microscope but photographs were not possible, and it makes me very happy to see my arguments so well supported. In over two thousand specimens gathered during eighteen months in the field, two or three have shown the film-packs so well developed as to be plainly visible to the unaided eye—parallel edges of the laminae serrated on the fractured surface where the break has gone through the block which clearly prove the existence of the structure postulated. Now we have photo-micrographs as well.

References

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