with isolated chloroplasts, but do not explain many other data presented at this meeting and elsewhere. The ideas of Warburg vary considerably from those of most other workers in photosynthesis, and no reconciliation between them appears possible at the present time.

A great many of the papers attempted to present a brief review and overall perspective of the work from each particular laboratory over the past 2 or 3 years. In view of this, and the rather extensive coverage of active laboratories at the meeting, the volume to be published by the National Academy of Sciences–National Research Council in the near future should be a valuable record of the state of photosynthetic research in the early 1960's.

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Silica

Various aspects of present and future research on silica were discussed at the annual symposium of the American Ceramic Society (New England Section) at Massachusetts Institute of Technology, 29 October.

C. Frondel (Harvard), in his introductory remarks, considered areas where research is still needed for the understanding of the various polymorphs of silica. He revealed that quartz as an entity has been well known for over 2000 years and reviewed the three periods in which the investigation of silica polymorphs has been especially intense. Currently the details of the crystal structure and chemical composition of the silica polymorphs and silica glass are under intense study. Water in silica minerals may occur as tetrahedral OH groups. He noted also that the silicon-oxygen bond lengths vary considerably both in silica and silicates and that symmetrical SiO_4 tetrahedra are only approximations of the true structure. Recent investigations have settled affirmatively the controversies regarding the existence of tridymite in the pure state;

however, it is still a matter of conjecture why cristobalite shows such little variation in crystal structure while tridymite is known to be quite variable.

While Frondel had suggested that only 11 polymorphs of silica exist and thought it unlikely that many new ones will be discovered, Sosman (Rutgers) remarked that in his opinion there are 22 or more polymorphs of silica. Sosman considers that there are nine varieties of tridymite, six of which are varieties of tridymite S, as described by investigators at Pennsylvania State University, and three are varieties of Pennsylvania State's tridymite M. Frondel's classification adheres to Fenner's long-standing recognition of only three tridymites. In addition, Sosman lists five amorphous phases, including what he calls "silica M," produced by neutron bombardment, "supra-piezo-vitreous silica," and "compacted silica."

William Campbell (Lexington Laboratories), who suggested the theme of the meeting, spoke briefly on the microsolid solutions in quartz. He noted variations in physical properties such as density, unit cell dimensions, absorption spectra, indices of refraction, and radiation darkening in relation to specimen composition. The principal experimental difficulty is obtaining the degree of precision necessary to observe the small variations in composition.

The hydrothermal crystal growth of quartz was discussed primarily from a kinetic point of view by R. Laudise (Bell Telephone Laboratories). He showed that the principal reaction for silica dissolution in pure water was:

$$SiO_2 + nH_2O \rightarrow SiO_2 \cdot nH_2O$$

with $n = 2$. To increase the solubility of silica in water, it is necessary to add some mineralizer, typically sodium hydroxide. Laudise proposed a consecutive reaction scheme consisting of the following steps: dissolution, transport by thermal convection, diffusion in the solvent phase, chemisorption, surface diffusion on the growing crystal, and attachment at kink in crystal. The latter three can be grouped as the phase boundary step and indications are that in a typical condition of hydrothermal growth, the phase boundary reaction is slowest and therefore dominates the process. A number of other crystals, including garnets, have been grown by this technique.

Discussing the optical spectra of rare earths in fused silica, W. Nelson (Owens-Illinois Glass Company) concentrated on the effects that are obtained by introducing two rare earth ions into fused silica. In general the amounts of doping were less than 200 parts per million on an atomic basis. He speculated about the mechanisms of energy transfer between the rare earth ions.

For example, in the case of terbium-europium, the terbium fluorescence in the absence of europium is similar to the fluorescence of crystalline anhydrous terbium chloride. However, when small quantities of europium are added, the fluorescence becomes similar to that of crystalline terbium nitrate. Both the absorption behavior for the exciting radiation and the emmission behavior are drastically changed. The europium-terbium pair was described as behaving in a "catalytic" way, that is, the presence of europium causes the fluorescence of terbium when excited with ultraviolet. This reaction is not coincident with a terbium absorption because the europium itself does not fluoresce. The case of cerium-terbium is termed "parasitic" by Nelson because, after additions of terbium, the ions act as if they were "sapping" energy from the excited states of the cerium ions. For the combinations of lutecium-europium and of praseodymium-gadolinium the interactions are more complex and difficult to explain even conceptually.

Prior to the work of S. Weissmann (Rutgers), some investigators believed that quartz and fused silica heavily damaged by radiation approached a common state. This was based on the similarity of the density and diffuse x-ray diffraction patterns in these two cases. By use of a variety of techniques, such as electron transmission microscopy, electron diffraction, x-ray back reflection, divergent beam technique, and small angle scattering, Weissmann was able to prove the existence of micro crystals of quartz in radiation-damaged fused silica. In the case of radiation-damaged quartz he proposes a model based on the presence of clusters of silicon in the remnants of the screw channels of quartz structure. The data he amassed by these techniques proved consistent with this model and permitted calculation of the density changes from radiation that agreed with measurements.

Elias Snitzer (American Optical Company; inventor of the glass laser) discussed glass lasers and glass structure. In his early remarks Snitzer explained the principles of optical lasers, pointed out the fundamental advantage of a four-level system, such as the neodymium glass laser, and compared it with the three-level system, such as the ruby laser. His major point was that in the former case it is necessary only to have a small fraction of the ions in an excited state, while in the 3-level system at least half the ions must be in the excited state. Snitzer's research with neodymium glass lasers has led him to postulate that the neodymium site in silicate glass is typically a slightly distorted icosohedron. This argument is favored because the interstice in an icosohedron formed with oxygen ions is very nearly the appropriate size for a neodymium ion. In addition, icosohedra are formed from triangular sides, and triangles of oxygen are available from sides of the silica tetrehedra that are the primary structural unit of silicate glass. Icosohedral symmetry is not found in simple crystalline materials because of the inability of icosohedra to fill space. However, in the case of glass or liquids this limitation is overcome by the amorphous structure of the material adjacent to icosohedra. Furthermore, the postulated diagram for the energy level of neodymium in silicate glasses shows splitting of the ground state into two states, similar to that obtained with icosohedral symmetry. Other possible structural arrangements would require a different degree of ground state splitting. Snitzer has been able to use the principle of icosohedral coordination of the neodymium ion as a guide in the development of optimum glass compositions as hosts for the neodymium ion.

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Forthcoming Events

February

2–5. American Inst. of **Chemical Engineers**, annual, Boston, Mass. (J. Henry, AICE, 345 E. 47 St., New York, N.Y.)

2–7. Institute of **Electrical and Electronics Engineers**, winter meeting, New York, N.Y. (A. P. Fughill, Detroit Edison Co., 2000 Second Ave., Detroit, Mich. 48226)

2–8. **Teratology**, workshop, Commission on Drug Safety, Gainesville, Fla. (D. C. Trexler, Commission on Drug Safety, 221 N. LaSalle St., Chicago, Ill. 60601)

2–11. Scientific-Technical **Documenta-**