therefore any petrographic method applied to them must depend largely, if not entirely, upon refractive indices. Such methods[66] do not differentiate between quartz and other minerals of the same or similar refractive index, such as the feldspars, mica, talc, and some other minerals frequently found associated with quartz. They are intended to be rough estimates only, and give a maximum value rather than a true quartz value. However, in many situations a knowledge of the composition of the minerals from which the dust was generated can be used advantageously and can give the maximum estimate the status of a true value by ruling out any interfering minerals in the same refractive index range that are known not to be present.

By X-ray Diffraction. Where all of the dust particles are less than 5 μ in diameter, the only successful means so far devised of determining the crystalline free silica content is by means of x-ray diffraction. When x-rays strike an object some of the rays are diffracted. If the x-rays are monochromatic and a beam of parallel rays is directed at a finely powdered pure material, this diffraction assumes a characteristic and reproducible pattern that can be registered as lines on a photographic film (Figure 11). The rays that pass directly through the powdered substance provide a reference mark. This same material, whether in its pure state or mixed with other matter, will reproduce the same pattern even though many other lines may be produced by other constituents in the mixture. The pattern then serves as a reliable identification, which is thought to depend upon crystalline structure.[67] The density of the lines in the diffraction pattern of any substance

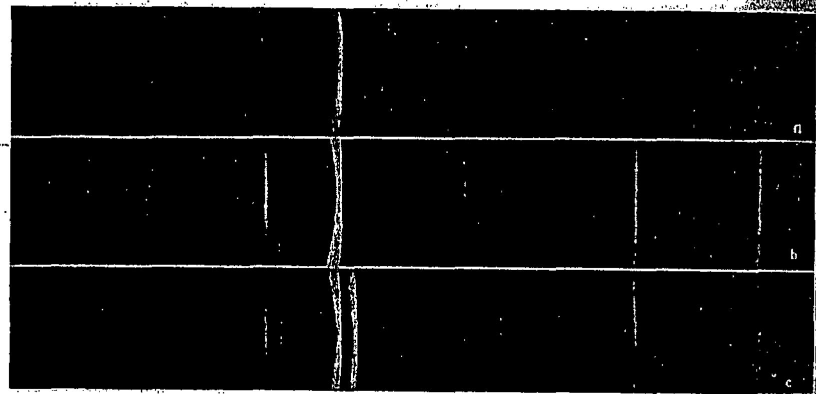

Figure 11. X-ray diffraction patterns of (*a*) quartz in dolomite, (*b*) pure quartz and (*c*) quartz in albite. (Courtesy H. H. Schrenk, U. S. Bureau of Mines.)

[66] H. L. Ross and F. W. Sehl, *Ind. Eng. Chem., Anal. Ed.*, **7**, 30 (1935). W. D. Foster and H. H. Schrenk, *U. S. Bur. Mines Rept. Invest.* No. **3368**, 1938.

[67] J. D. Hanolvalt, H. W. Rinn and L. K. Freval, *Ind. Eng. Chem., Anal. Ed.*, **10**, 457 (1938).

depends upon the amount of that substance in the sample. Quartz has four lines that are sufficiently intense for quantitative measurement. By the use of an internal standard[68] and a microphotometer for measuring the relative density of the lines of the unknown and those of the internal standard, quantitative measurements of satisfactory accuracy may be obtained.[69] For good results, samples for analysis must be ground to 200 mesh or smaller, and after the internal standard has been added the sample must be further ground and mixed. A special type of stainless steel ball mill, using methanol as a dispersing agent, has been used for this purpose, being operated 24 hours.

A recent development has been the advantageous use of Geiger counter spectrometers for determining the densities of the lines in the diffraction pattern, with better resolution in some instances of partial overlapping of lines, and, in some cases, obviating the need for an internal standard.

BACTERIA AND OTHER MICROORGANISMS

The sampling and evaluation of microorganisms in the atmosphere have received much attention in recent years, but the procedures are still in an experimental stage. There are several collection methods that employ the principle of impingement, such as the air centrifuge,[70] the funnel device,[71] the slit impinger,[72] Shaw's prescription bottle sampler,[73] the sieve device,[74] and the exposed agar plate or petri dish method. Simple Folin scrubbers,[75] beaded scrubbers,[76] and atomizer scrubbers[77] have also been used, and they give much higher results than methods that collect the microorganisms on a solid surface. The size of the organisms and their tendency to form clusters or clumps have an important bearing on the relative collection efficiency of a method. With the scrubbing devices any clumps or clusters are broken up, whereas they may register as one colony by impingement. Discussions of these devices including a comparison of their performances have been published.[78]

The sampling media[79] have a still greater influence upon results, not only as

J. W. Ballard, H. I. Oshry and H. H. Schrenk, *U. S. Bur. Mines Rept. Invest.* No. **3520**, 1940.

J. W. Ballard and H. H. Schrenk, *U. S. Bur. Mines Rept. Invest.* No. **3888**, 1946.

W. F. Wells, *Am. J. Pub. Health*, **23**, 58 (1933).

A. Hollaender and J. M. DallaValle, *U. S. Pub. Health Repts.*, **54**, 574 (1939).

R. B. Bourdillon, O. M. Lidwell, and J. C. Thomas, *J. Hyg.*, **41**, 197 (1941).

R. Schneiter, A. Hollaender, B. Caminita, R. W. Kolb, H. F. Fraser, H. du Buy, P. A. Neal and H. B. Rosenblum, *Am. J. Hyg.*, **40**, 136 (1944).

H. G. du Buy and L. R. Crisp, *U. S. Pub. Health Repts.*, **59**, 829 (1944).

L. F. Rettger, *J. Med. Research*, **22**, 461 (1910).

S. M. Wheeler, G. E. Foley, and T. D. Jones, *Science*, **94**, 445 (1941).

L. S. Moulton, T. T. Puck, and H. M. Lemon, *Science*, **97**, 51 (1943).

H. G. du Buy, A. Hollaender, and M. D. Lackey, *U. S. Pub. Health Repts.*, Supplement No. 184 (1945). M. Frobisher, Jr., *The Fundamentals of Bacteriology*. 4th ed., Saunders, Philadelphia, 1949.

R. Schneiter, J. E. Dunn, and B. H. Caminita, *U. S. Pub. Health Repts.*, **60**, 789 (1945).