Polishing Rock Salt

At the 1885 meeting of the American Association for the Advancement of Science in Ann Arbor, Michigan, Samuel Pierpont Langley (1834–1906)—the astronomer at the Allegheny Observatory in Pittsburgh, pioneer of flight, and soon-to-be second secretary of the Smithsonian Institution—presented a paper entitled "Some Hitherto Unmeasured Wavelengths." Langley's astronomical research in Pittsburgh was largely confined to studies of the sun, because the ever-present smoke from the city's industrial mills blocked the view of more distant stars on most nights. His efforts to measure how much solar radiation was absorbed by the Earth's atmosphere led him into spectroscopic investigations of sunlight. In his paper, he described the resolution of the Fraunhofer lines—dark lines caused by absorption of radiation by cooler elements in the sun's outer atmosphere—in the infrared region of the spectrum with previously unhoped-for precision. Indeed, he was able to see the nickel absorption line located between the two sodium lines of the spectrum for the first time. This tremendous advance in the field of infrared spectroscopy was made possible, he said, through the use of rock salt prisms made by the Pittsburgh optician John A. Brashear (1840–1920).

The Irish scientist John Tyndall (1820–1893) had earlier established that rock salt (NaCl) would be a valuable material in the investigation of the infrared portion of the spectrum because of its transparency at those wavelengths. But by the 1880s, no one had devised a method of polishing rock salt to optical quality. The softness of rock salt and the tendency of its surface to dissolve in absorbed moisture made the task difficult. Indeed, many scientists said that rock salt could never be polished well enough to resolve Fraunhofer lines.

Not easily discouraged, Langley turned to the best opticians of his day to solve the problem. He gave a French optician named Hoffman the first chance, but Hoffman's prisms were able only to resolve the major Fraunhofer lines at best. In a paper entitled "A Practical Method of Producing Accurate Rock Salt Surfaces for Optical Purposes," presented right after Langley's paper at the Ann Arbor meeting, Brashear attributed the low quality of Hoffman's prisms to the process of rubbing the rock salt crystal on a broadcloth surface to polish it; this led to rounding of the corners of the crystal, causing "overcorrection."

"This is fatal to good results in any optical surface," Brashear noted.

Langley next approached George Clark of Alvan Clark & Sons, a noted telescope lens maker in Cambridgeport, Massachusetts. Clark succeeded in producing one excellent rock salt prism for Langley but declined to supply more. Clark later told Brashear that he had had to wipe the finished rock salt surface on his palm or arm to remove excess moisture, but more often than not, this ruined the planarity of the polished surface.

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At this point, Langley turned to Brashear, a self-taught Pittsburgh optician whose interest in the stars had taken him out of the steel mills and into prominence as a craftsman of lenses and mirrors for telescopes. The two had worked closely together on many projects before, so it is surprising that Brashear was not approached earlier.

Brashear labored for five weeks without success. Then, as he described in his autobiography A *Man Who Loved the Stars*, he had a breakthrough: "I had been working all of one day and had given it up for a time, tired and weary. I wakened early the next morning, and an idea came to my mind as to how to master the problem. I could scarcely wait until after breakfast to try the method. It was eminently successful…" (p. 81).

Brashear described the successful technique to his Ann Arbor audience. In grinding and polishing glass blanks for mirrors, it was common to use a circular bed made of pitch upon which various grades of abrasive would be applied. In this case, Brashear prepared a planar pitch surface with an area approximately three times the surface of the prism he was trying to manufacture. He then applied a fine rouge polishing powder and water to the pitch bed, and began to rub the rock salt on the polishing surface, using long strokes across the diameter of the circular mat. He noted that "motion *must be constant*, for a moment's rest is fatal to good results, for the reason that the surface is quickly eaten away, and irregularly so, owing to the holes that are in the pitch bed." Even the most carefully prepared pitch surface had small holes in it, but Brashear's method eliminated this as a problem.

The key technique—the one that had popped into Brashear's mind upon awakening that fateful day described in his autobiography—came next. After a few minutes of polishing, the moisture began to evaporate rapidly. "A careful watch must be kept upon the pitch bed," Brashear told his audience, "and as the last vestige of moisture disappears the prism is to be slipped off the polisher in a perfectly horizontal direction, and if the work has been well done, a clean, bright and *dry* surface is the result." By waiting for all the moisture to disappear while the prism was still on the polisher, Brashear eliminated the drying step—such as Clark's wiping the polished prism on his palm—that frequently ruined the surface. Removing the prism from the polisher horizontally eliminated any possible distortion that might be caused by adhesive forces if lifted vertically.

Using this technique, Brashear succeeded in making excellent rock salt prisms in about 10 minutes. Furthermore, the technique was not difficult, so it could be "easily carried out by any physicist who desires to work with rock salt surfaces."

Immediately following his presentation, Brashear was nominated and elected as a fellow in three sections of the American Association for the Advancement of Science, a tribute to this significant contribution to spectroscopy, and a fine honor for a man with very little formal education. He was named acting director of the Allegheny Observatory from 1898–1900. His reputation as a preeminent maker of telescope objectives and other scientific instruments eventually gained him worldwide recognition.

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FOR FURTHER READING: John A. Brashear, "A Practical Method of Producing Accurate Rock Salt Surfaces for Optical Purposes," *Proceedings of the American Association for the Advancement of Science* **34** (1885) p. 76; John A. Brashear, *A Man Who Loved the Stars: The Autobiography of John A. Brashear* (University of Pittsburgh Press, 1988); and Foil A. Miller, "Historical Note on the Origins of Several Useful Infrared Techniques," *Applied Spectroscopy* **46** (7) (1992) p. 1095.

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