

## Minerals, Meteorites, and Metallography

On May 6, 1885, Henry Clifton Sorby gave an invited lecture before the Iron and Steel Institute in London about the metallographic studies of ferrous metals he had completed 20 years earlier. Though he presented no new results, the speech electrified the assembled metallurgists. As Sorby's biographer Norman Higham wrote in *A Very Scientific Gentleman*, this meeting led to "the modern development of metallography, a development of such outstanding importance that its neglect by metallurgists from 1864 to 1885 can only be wondered at."

Sorby was born May 10, 1826 in Sheffield, England. In grammar school, he won an arithmetic contest whose prize was a book entitled *Readings in Science*, which consequently determined his career path. Though he would not join his father's successful cutlery business, income from it would provide him with four years of private tutoring in science and mathematics. Eventually, it would finance his lifelong ventures as an independent amateur scientist, and allow him to take up or abandon scientific topics as he pleased.

In the early 1800s, geology was a hot topic. It had only recently begun to be approached systematically instead of speculatively. Debates raged about how rocks were formed. Sorby noted from his readings on the subject that the analytical techniques being applied to rocks could not possibly answer this question. At the time, scientists were grinding rocks into powder and dissolving them in acid to determine their chemical composition, but these techniques revealed nothing about their mineral structure and how they were formed.

Around this time, others were examining thin slices of fossilized wood, as well as teeth and bones, under a microscope. Soon Sorby was applying the technique to rocks. He would take a thin chip of rock and polish it on one side before gluing it to a glass slide. Then he would grind and polish the opposite face of the sample until it was as thin as 1/1000th of an inch. Viewing samples under a microscope using transmitted light, he could resolve particles measuring 1/2000th of an inch in diameter. Furthermore, he used polarized light to identify calcite, quartz, and chalcedony in some samples. Despite this modest success, attempts

were made to discourage him from such investigations. Most notable was the admonition of geologist Daniel Sharpe, who was trying to discover why slate cleaved into planes, that "One must not look at mountains through a microscope." Sorby silenced Sharpe in 1851 when his observations of slate led to a definitive explanation for its planar cleavage.

His foray into metallurgy came through his correspondence with R.P. Greg, who had published an atlas of meteorites in 1861. Soon, he was examining meteorites under his microscope. Because their high iron content prohibited the transmission of light, he had to examine his samples using reflected light.

"It was a natural thing that I should be led from the study of the microscopic structure of rocks to that of meteorites," Sorby wrote later, "and in order to explain the structure of meteoric iron I commenced the study of artificial irons." He obtained samples of various irons and steels from W.P. Beale of Rotherham, who had carefully prepared the samples so that, as he wrote to Sorby, "there can be no doubt that whatever difference we find in their structure is due to the mechanical process."

Sorby cut very thin slices of the meteorites and metals—which was not necessary when using reflected light—and then polished and etched them with dilute nitric acid to reveal their structure. Initially, he sketched what he saw in the microscope or even made prints of the surfaces of etched metals by pressing them onto paper. In August of 1864 he teamed up with commercial photographer Charles Hoole to experiment with making photomicrographs, and about a week later they were successful. The method is not known, although the noted metallurgist and historian Cyril S. Smith speculates in his book *A History of Metallography* that Sorby might have used an oxyhydrogen light and wet collodion photographic plates.

The next month he presented these first photomicrographs to the British Association for the Advancement of Science at Bath, revealing different structures including a pure iron phase, a mixture of iron and carbon, and graphite and slag phases. He was also able to relate the structures to the mechanical processes that caused

them. Although he received favorable reviews from a few colleagues, he promptly dropped his studies of metals to pursue the more fashionable science of spectroscopy. No one was inspired enough to take up where Sorby left off, and metallography essentially languished for 20 years.

Finally, in 1885, John Percy, President of the Iron and Steel Institute, who had attended Sorby's presentation in 1864 and was aware of new work on microstructure by Adolph Martens, persuaded him to dust off his old results and present them again. The timing was right, and his work was now recognized as a great advance in metallurgy. Other scientists took up the work in earnest. Sorby returned briefly to metallography, using the higher magnification powers of the newer, improved microscopes to determine the structure of pearlite in steel—layers of relatively pure iron and an iron-carbon phase only 1/60,000th of an inch apart. Smith credits him with identifying for the first time "seven microscopically distinct constituents whose names have since become commonplace," and also using these structures "to deduce directly the sequence of physical events that had given rise to the structures."

Sorby's paper summarizing his results was published in 1887 in the *Journal of the Iron and Steel Institute*, after which he abandoned the field again. By this time he was president of Firth College, later the University of Sheffield. He was also active in both the Royal Society and the Geological Society, and in 1876 founded the Mineralogical Society, serving as its first president. He had received many awards during his career, including election as a Fellow of the Royal Society in 1857 followed by a Royal Medal in 1874, and an honorary doctoral degree from the University of Cambridge in 1879. Sorby died in March of 1908.

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FOR FURTHER READING: Norman Higham, *A Very Scientific Gentleman: The Major Achievements of Henry Clifton Sorby* (Pergamon Press Ltd, London, 1963); Cyril S. Smith, *A History of Metallography* (The University of Chicago Press, Chicago, 1960); and Sir Archibald Geikie, *The Founders of Geology*, 2nd. Ed. (Macmillan, London, 1905).

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