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The contribution of Henry Clifton Sorby (1826–1908) to mineral science and technology

(1 Fig., 1 Photo)

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Vplyv práce H. C. Sorbyho na vývoj geologických, mineralogických a technologických odborov

H. C. Sorby sa narodil 10. V. 1826 v Sheffielde. Pretože bol finančne nezávislý, mohol svoj život zasvätiť vede obdobne ako veľa iných veľkých vedcov — amatérov XIX storočia.

Jeho pravdepodobne najväčší príspevok k rozvoju vedy bolo zavedenie polarizačného mikroskopu na štúdium horninových výbrusov a metalografických nábrusov. V roku 1849 urobil prvý výbrus a v roku 1850 publikoval prvú správu v odbore mikroskopickej petrológie, v ktorej opísal vápnitý pieskovec zo Scarborough (obr. 3).

Sorby zasvätil život všestrannému štúdiu a výskumu a mikroskop bol jeho obľúbeným pomocníkom. Používal ho ako najlepší a najdokonalejší prostriedok na štúdium charakteru hornín, minerálov a kovov. Sorby položil základy mikroskopickej petrografie a metalografie, a tým podstatne ovplyvnil smer vývoja výskumu v mineralogických a geologických vedách.

V článku sa diskutuje aj o jeho príspevku k metodike prípravy výbrusov a nábrusov, mikroskopickej modálnej analýze, metodike určovania indexu lomu, vývoja opakiluminátora, ako aj o jeho zásluhe pri založení sedimentológie a sedimentárnej petrografie.

Práca podáva bohatý materiál o jeho živote, metodike práce, zdrojoch inšpirácie a jeho príspevkoch k rozvoju vedy. Hodnotí sa jeho význam v celoeurópskom meradle, ako aj jeho vzťah k F. Zirkelovi a ďalším význačným vedcom.

Článok doplňajú snímky prvých výbrusov hornín (obr. 1 a 2), prvých opísaných výbrusov (obr. 3) a nábrus tazewellského meteoritu a. i.

Introduction

The Sorby family can be traced back to Robert Sawbrey of Bridgehouses, Sheffield, who died in 1558. By judicious investment of his inheritance Henry Clifton Sorby was able to maintain a house with a laboratory and a workshop and to finance a lifetime of individual scientific investigations on a scale no other person in Sheffield, and few in England could match. Sorby's mother to whom he was devoted, lived with him until her death in 1873 and appears to have been an active assistant in the making of the earliest thin sections of rocks. Sorby was unmarried.

Petrography before Sorby

The study of rocks is as old as geology itself, perhaps older, since, in general, those who studied rocks were mining men, more interested in their economic aspects. Leonardo da Vinci (1452-1519) and other men of the Renaissance recognised that some rocks were once molten. A little later, Agri-

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cola (1494-1558), a recognised mining expert, made observations on crystals. About the middle of the 18th Century, mining provoked the serious classification of rocks in Germany and in 1785 the Academy of Sciences of St. Petersburg offered a prize for the best essay on the classification of rocks (F. Y. Loewinson—Lessing 1954). However, the study of rocks, based only on their chemical composition and their characteristics in the field and in hand specimens, was severely hampered since the mineralogical composition upon which the determination of the genesis of the rock largely depends, was possible only in the very-course grained rocks. The application of the microscope to the problem was doubtless in the minds of many petrologists, although some geologists then

Fig. 1. The first thin section of a rock made for microscopic study dated 1849.
Obr. 1. Prvý výbrus zhotovený k mikroskopickému štúdiu z roku 1849.

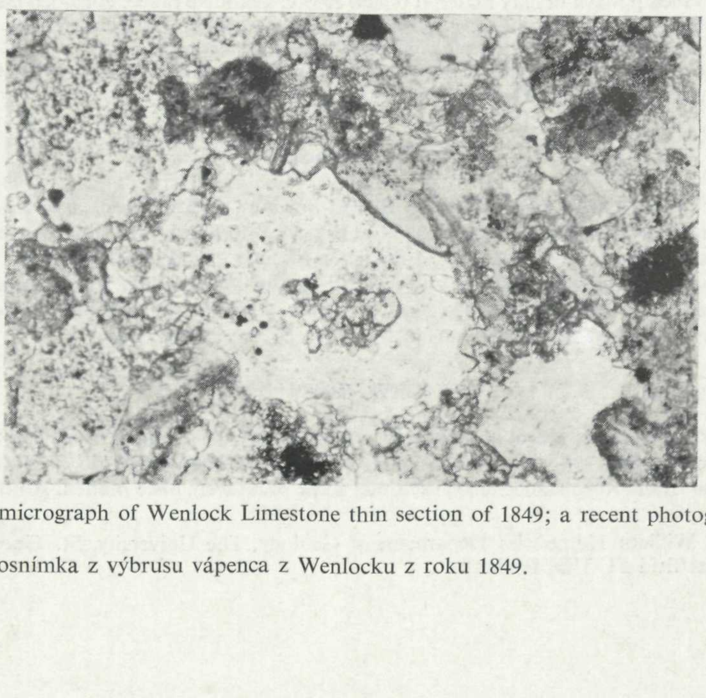

Fig. 2. Photomicrograph of Wenlock Limestone thin section of 1849; a recent photograph by the writer.
Obr. 2. Mikrosnímka z výbrusu vápenca z Wenlocku z roku 1849.

(and indeed even much later in the 19th Century) held strongly to the view of de Saussure that „one must not look at mountains through microscopes")[1]

Although lapidaries, especially in Edinburgh, were grinding and politishing thin slabs of coloured agates and the preparation of thin sections of fossil wood and similar objects was well known to many naturalists in the early part of the 19th Century, their methods had not been applied to the study of rocks, although thin sections of minerals had been made for David Brewster before 1816.

The credit for this crucial step must go to Sorby who made the first thin section of a rock for microscopical study in 1849 (Figures 1,2) although no account of this rock were published at that time

The Preparation of Thin Sections of Rocks

H. C. Sorby (1889) has left an account of how he came to prepare "what is probably the first transparent section of a rock". It appears that during a railway journey he fell into conversation with Willian Crawford Williamson whose maternal gradfather and uncle were skilled lapidaries. From them he had learnt the use of diamond and emery wheels and became skilled in the preparation of hard substances (bones and teeth) for microscopical study. Williamson told him of his methods of making thin sections and later gave Sorby instruction in the art at his home in Mancester. By 1849 Sorby had realised the potential of the technique and had applied it to the study of rocks.

F. Y. Loewinson—lessing (1954) states that A. Oschatz was making thin sections in Germany in 1852, probably without any knowledge of Sorby's work. It may well be that others were developing imilar techniques at about the same time, but nothing is known of them.

In 1868, Sorby wrote a short article for the 4th edition of Dr. Lionel S. Beale's book "How to work with the Microscope" in which he gave a short account of his method of making thin sections of rocks. A more detailed account of the technique was given by David Forbes (1869) who had, almost certainly, learnt it from Sorby. A full description of his methods was not given by Sorby until 1882, although there is no evidence that he ever attenpted to keep them secret. Essentially, his methods were those of the modern slide maker. He seems to have preferred specimens flaked off with a hammer, rather than cut with an iron disc. These flakes were smoothed with coarse and then fine emery on zinc plates and polished on a variety of sandstone or marble slabs. He was careful not to use polishing powders, since if it were to work into any cracks or cavities, it would be far more objectionable than any slight want of polish. The prepared piece of rock was then attached to a glass plate with Canada Balsam and the other side ground down and polished. Sorby also devised a method of impregnating friable rocks with balsam before grinding and also a method of transferring finished sections. For some materials, Sorby used fine emery paper held on a glass plate and in this way prepared sections of salts soluble in water. He also suggested etching thick rock slices with diluted acid where calcium carbonate was present, in order to reveal more clearly the structure of the insoluble portion.

Sorby made a his sections on pieces of glass 16/10 inches square, rather than on the 3 inch by 1 inch slide then used by naturalists and used universally in Britain at the present time. He prefered the square glass because he believed he had greater control over the section during grinding and arrived at the particular size by the chance that it was the size of glass that fitted a polariscope which he had made. Similar techniques were used for making plished specimens of metals and described in Beale's book.

More than a thousnd of Sorby's slides and other microscopical objects are preserved in the Department of Geology, University of Sheffield and are still in their original condition.

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1) This remark of de Saussure is frequently quoted and taken literally. I suspect that this is a misresentation of his intention. To de Saussure goes the credit for being the first geologist to climb and explore mountains and to learn their structure by first hand acquaintance. It is possible tha he intended his remark to be a scathing criticism of those „natural philosophers" who hypothesized on the origin of mountains without ever leaving their armchairs. (D. W. H.)

The Rise of Microscopical Pertography

The first paper ever to describe the microscopical structure of rocks was read by Sorby at a meeting of the Geological Society of London on November 6th, 1850 and was published in the Quarterly Journal in 1851 (H. C. SORBY 1851). The paper shows that Sorby was fully conversant with the use of polarised light, both parallel and convergent in microscopy and that he was able to distinguish between agate (chalcedony), quartz and calcareous spar (calcite) (Figs. 3,4). He also observed the variation of orientation of calcite crystals in small reniform bodies. The paper is also noteworthy for the quantitative data on the mechanical composition of the rocks, measuring particles down to 1/20,000 of an inch (about 1 μm).

This new method of examining rocks was received unsympathetically, although this did nothing to diminish Sorby's enthusiasm. Over the next thirty years he published numerous papers in which the microscope played a central role culminating into two Presidential addresses to the Geological Society of London in 1879 and 1880, on the nature and origin of sedimentary rocks. Earlier, in 1877, his Presidential Address to the Royal Microscopical Society drew a comparison between the chatacteristcs of minerals derived from the decomposition and breakup of granites and the same minerals derived from schists. From his studies of the shapes of the grains he believed that it would be possible ro deduce the nature of the parent rock from which a sand had been derived. This paper, was in fact, the first major essay on sedimentary petrology ever published.

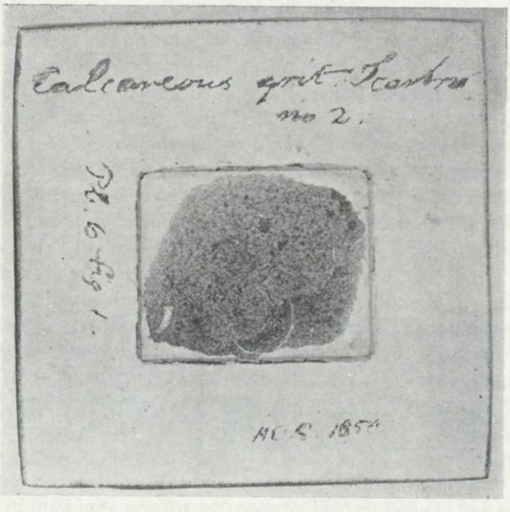

Fig. 3. The first thin section of a rock to be described in print. This section of the Calcerous Grit of Scarbro (Scarbrough), England was made in 1850 and described by Sorby in 1851. The caption on the slide „Pl 6. fig. 1.“ refers to a privately printed Appendix to Sorby's Presidential Adress to the Geological Society of London in 1879. The Society declined to publish these illustrations and very few copies of the Appendix are still in existence.
Obr. 3. Prvý výbrus, ktorého popis bol publikovaný (vápnitý pieskovec zo Scarbro (Scar brough)); vyhotovený v r. 1850, popísaný v r. 1851.

It has another important characteristic in that it illustrates Sorby's interest in "petrology" rather than in "petrography". Perhaps he was running too fast for his contemporaries and it was not until the 1870's that they began to catch up with him. For as Loewinsson-Lessing has said, the post--microscopic era began in 1870 when Zirkel published his work on basalts and not in 1851 when Sorby first described a calcareous sandstone.

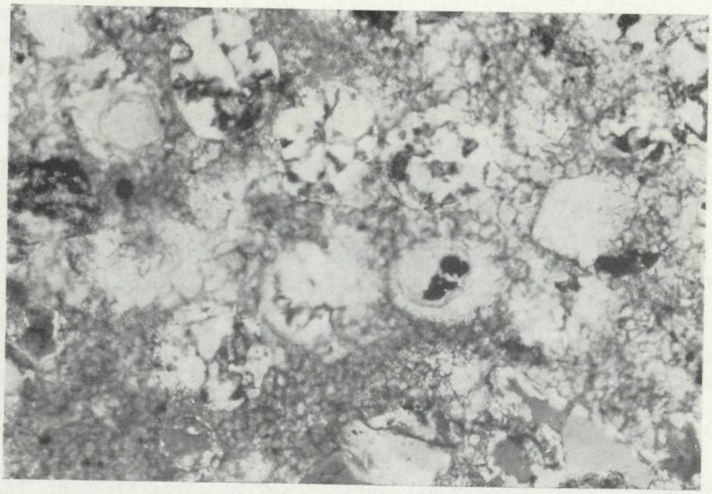

Fig. 4. Calcareous Grit, Scarbro (Scarborough), England; a recent photomicrograph of the thin section of Figure 3.
Obr. 4. Mikrosnímka z vápnitého pieskovca zo Scarborough (porovnaj s obr. 3).

Sorby and Zirkel

In 1861 Sorby and his mother visited Germany where, in Bonn, he met Ferdinand Zirkel, who was to become his greatest disciple and can be said to have founded the great German school of petrography. They became lifelong friends and in almost every letter to Sorby, Zirkel expresses his indebtedness to "the master" for introducing him to microscopical petrography. It is perhaps of interest that Zirkel made no reference to the work of Oschatz in any of his letters to Sorby. Had he not, by a fortunate concidence, met Sorby, the history of petrography might have taken a different course.

Meteorites and Metals

To many and especially to the geologist, Sorby is best known for his application of the microscope to the study of rocks. Important as this was, it was by no means his only conttribution to science. Of equal importance was the application of the microscope to the study of metals. In 1855, Sorby was sent a box of specimens which included a few fragments of completely fused slate. Three years later, he received further fragments of fused rocks from W. Hawkens in Birmingham and from George Richardson in Leeds, who was acting on the order of J. G. Mitchell. The last named had 23 cwts (approximately 1200 kg) of Mount Sorrel syenite fused in a reverberatory furnace. The melt was allowed to cool slowly, and although there was considerable variation in texture of the solidified rock, most of it remained glassy.

Sorby published a brief account of this work in 1863 and showed that the dissimilarity between the original rock and the artificial product could be explained in terms of the cooling history and the environment of the melt (H. C. Sorby 1863) This observation is probably one of the earlier contributions to the crystallisation of magmas.

In the same year as the publication of this important paper, that is, in 1863, there appears in Sorby's diary on 27th April the words, "Read about meteorites" and on 28th July, the now famous entry "discover the Widmannstättischm fig. in L iron". These lines mark the very day on which modern metallography was born.

There can be little doubt that Sorby was led from the study of the fused products of igneous rocks to the consideration of fused materials from outside the earth, that is meteorites, and fused materials of much less chemical complexity, that is, metals, almost simultaneously despite his later claim (H. C. SORBY 1898) that they were successive steps. Sorby's publications on meteorites (Fig. 5) were few in number, although he was able to show that there are certain features of physical structure which connect meteorites wich igneous rocks.

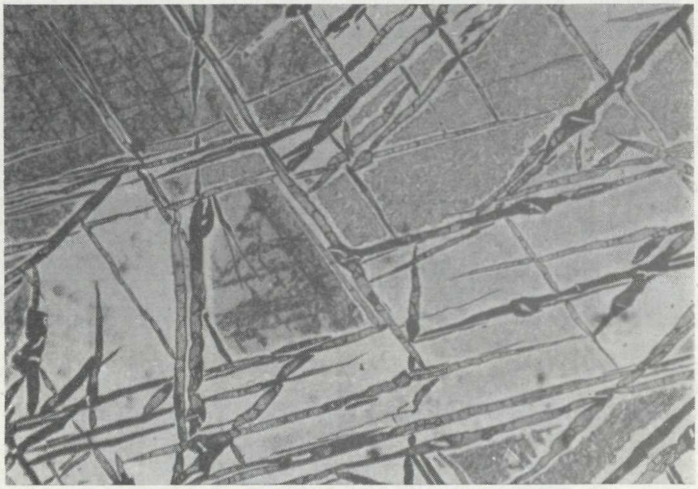

Fig. 5. The Tazewell mateorite, an iron meteorite from Claiborne County, Tennessee, U. S. A. wich fell in 1853; polished surface covered by glass slip cemented with Canada balsam, made in 1863. The specimen is still in perfect condition; a recent photograph.

Obr. 5. Tazewellský meteorit: železný metrorit z Claiborne, Tennessee, USA, ktorý padol r. 1853. Naleštená plocha je aj teraz, vo výbornom stave

Sorby's early metallurgical work in the years of 1863—8 attracted little attention either from his fellow scientists or from those who might have benefitted greatly from it, the producers of iron and steel. In 1884, Sorby returned to his studies of iron and steel and at last was able to illustrate his papers with photomicrographs. Not only did he identify seven microscopically distinct constituens whose names have since become commonplace (ferrite, pearlite, cementite, hardenite or martensite, graphite, sorbite and slag) but he used the structures observed to deduce directly the sequence of events that had given rise to the structures.

Sorby showed that, "except in a few very special cases, iron and steel are not analogous to simple minerals, but to complex rocks. Such being the case, the microscopical examination of properly prepared sections throws much light on the causes of their varying properties". (H. C. SORBY 1885).

Although relatively little interest had been shown in Sorby's earlier work on metals, his contributins in the 1880's stimulated an extremely rapid accumulation of knowledge and by 1900 the situation was probably little different from what it would have been had there been a continuous, but of necessity slower, growth following his first annoucements (C. S. SMITH 1960) Once again, Sorby is seen to have been far in advance of his contemporaries.

Other Contributions to Science

Sorby's active scientific career spanned sixty-two years and in this time he published over 15 papers (D. W. HUMPHRIES 1965a, based on T. SHEPPARD 1906). There were also published some sixty accounts of lectures he gave to the Sheffield Literatury and Philisophical Society. His studies covered the fields of geology, metallography, chemistry, microscopy, archaeology, spectroscopy, marine biology, meteorology and history. To date, no complete account of his scientific contributions has been written, although Higham (1963) has given a valuable synopsis of his life and background, while C. S. SMITH (1960) and D. W. HUMPHRIES (1965b, 1967) have described some of his contributions to petrography, microscopy and metallography.

It is customary to attribute the birth of what is now called 'modal analysis' to A. DELESSE (1848) alghough he only measured those constituents of polished slabs which were visible to the unaided eye. Sorby in 1853 almost certainly aware of Delesse's work, made probably the first determination of the proportion of components seen in thin section using the microscope. Sorby drew his slides with a camera lucida on to sheets of strong, even paper, cut this up into pieces each of which represented an individual grain. The grains were sorted and the surface area for each component determined by the ingenious method of weighing the pieces and comparing the total weight with the weight of a piece of the same paper of known area.

The quartz wedge is a familiar accessory to the polarising microscope. It was first suggested by Biot, but its use seems to have been restricted to the study of polarised light itself. Sorby, in 1877, briefly noted the application of the quartz wedge in mineralogy and referred to it again in 1879, but these are his only references to what is now regarded as an essential tool in petrography. A technique which he thought to be of far greater importance was the determination of the refractive index of minerals, on which he wrote many papers. In 1877, Sorby had published a table of refractive indices of some 80 minerals, for he realised the value of the refractive index in determinative studies. Arising out of this work was the observation that the crosshairs of the microscope eyepiece served the important purpose of keeping the focal length of the eye fixed while making the measurement.

Working with metals and meteorites, Sorby quickly found that the existing methods for reflected light illumination were inadequate. He therefore devised two new illuminators, one of which employed a parabolic mirror which reflected light from a source at the side of he microscope down onto the specimen, while the other used a tiny plane mirror in a similar manner but gave very nearly true vertical illumination.

In 1979, Sorby purchased the yach "Glimpse" and so opened another chapter in the extraordinary story of research and innovation (Fig. 6).

At sea and in the estuaries of southern England he turned again to the study of sediment movemen and laid the foundation of yet another 'modern' discipline — sedimentology. His interests extended

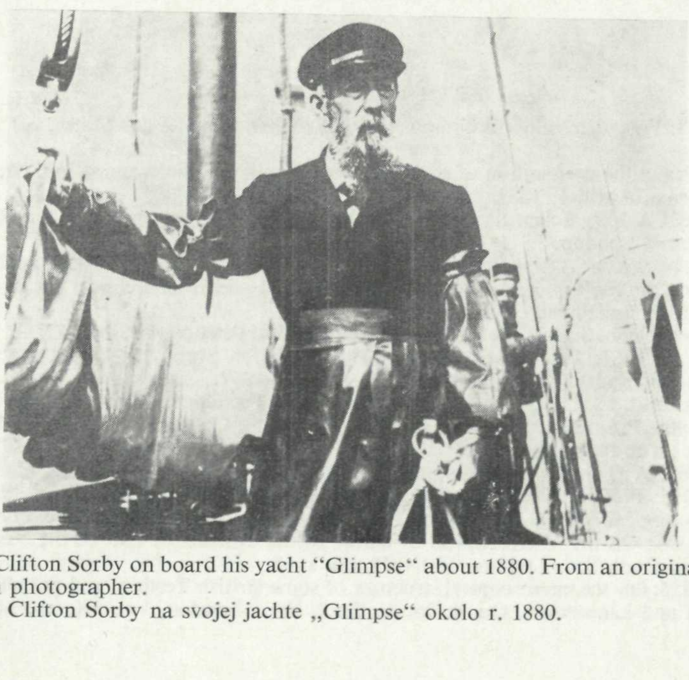

Fig. 6. Henry Clifton Sorby on board his yacht "Glimpse" about 1880. From an original photograph by an uknown photographer.
Obr. 6. Henry Clifton Sorby na svojej jachte „Glimpse" okolo r. 1880.

to marine biology and his technical ingenuity led to the development of methods of preserving marine organisms which have not been successfully repeated, although Sorby's specimens still exists as proof of their existence. He devised methods of differential staining which have become commonplace in the biological laboratory. At the age of 80 years he broke his leg and was confined to bed. Despite this he continued his work and completed the great papər on sediments which was published in 1908, just after his death, by the Geological Society of London.

Conclusion

In this brief account of some of Sorby's acheivements, much has been neglected. Nothing has been said of the great controversy concerning the origins of slaty cleavage in rocks, or of Sorby's work on fluid cavities in crystals and their evidence of the environment of the formation of the igneous rocks. Nor yet again has anything been said of his ventures into spectroscopy. In characteristic fashion he devised a spectroscope for attachement to the microscope and examined the absorption spectrum of many substances, including minerals and the colouring matter of plants and animals.

Towards the end of his life, Sorby became intensely interested in education and the possibility of a University being created in his home town. He lived to see this founded in 1905, but was never involved in teaching. The present Chair of Geology carries his name as does a Fellowship which he endowed. Sorby was President of several learned Societies and ultimately his work was rewarded by the Royal Society which awarded him its highest honour, a Gold Medal. He received other medals and awards, but this gave him the greatest pleasure.

Sorby did much more than apply the microscope to the study of rocks. He observed, he measured he applied immense power of reasoning and in his own words: "In the discovery of the new he was kept away from the old, and he supposed that it would go on like that to the end of the chapter Perhaps after all itt was better to invent new things than to work up the old."

Perhaps we should be content that Sorby kept on inventing new things and gave us both tools and ideas still fundamental to the present day study of Mineral Science and Technology. Whatever development the future may bring, we owe much to the genius of Henry Clifton Sorby: "Sheffield's Prince of Scientists" (Sheffield Daily Telegraph, March 10th, 1908).

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