

the Society of Economic Geologists, and the Association of Professional Engineers of Ontario.

Dr. Fraser in his lifetime also earned eminent membership in that rare fraternity of hard workers whose imagination and selfless efforts build industries and civilizations.

ACKNOWLEDGEMENTS

We thank all Dr. Fraser's friends, and most of all, C. Byron Fraser, his brother, for their contributions to this memorial.

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In addition to Dr. Fraser's enormous output over the years of speeches, private reports, and memoranda, he published the following scientific papers:

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MEMORIAL OF ARTHUR FRANCIS HALLIMOND

January 17, 1890-September 2, 1968

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Arthur Francis Hallimond was born at Saltburn, N. Yorkshire. He was the son of Henry Tasker Hallimond and Sarah Susannah Cunningham. The families of both his parents belonged in North Yorkshire and the bordering county of Durham. Among their relations were many devout Wesleyans, and one of his father's cousins, John G. Hallimond, who had emigrated to America, was for over 25 years Superintendent of the Bowery Mission in New York.

A. F. Hallimond was at Sir William Turner's School at Coatham, Yorkshire, from 1889 to 1908. He showed quite early an interest in sci-



Arthur Francis Hallimond

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ence and scientific apparatus and he was successful in gaining a Science Scholarship at Pembroke College, Cambridge. There he was fortunate in having as his tutor Arthur Hutchinson, at that time a lecturer in Mineralogy under Professor W. J. Lewis, whom he ultimately succeeded when Lewis died in 1926. Lewis had held the professorship for forty-five years

After reading mathematics in his first year Hallimond proceeded to the Natural Science Tripos taking as his subjects, mineralogy, chemistry, physics and geology. He graduated in 1911 with first class honours.

His first appointment in London was assistant curator of the Museum of Practical Geology under the Geological Survey, then housed in De la Beche's original building of 1851 in Jermyn Street near Piccadilly Circus. Here Hallimond succeeded W. F. P. McLintock who had been appointed to the Geology Department of the Royal Scottish Museum in succession to S. J. Shand. The Curator of the Museum was many years senior to his assistant and Hallimond had every prospect of becoming Curator in due course. However, after the War, in 1920, the Curator was promoted to be Assistant to the Director and McLintock returned from Edinburgh to fill the vacant post. This left Hallimond with no prospect of any other definite appointment under the Survey and resulted in his being assigned, from time to time, to various projects for which his special qualifications made him particularly fitted, and thus his work for the Geological Survey and Museum over the years covered a wide field. He was graded as Senior Geologist in 1922.

Before the War came, in the course of his work on the minerals of the Ludlam Collection in the Museum he had been led to study a fine series of specimens from Cornwall classified as autunite. Using the then available optical and goniometric methods he showed that these specimens included not only autunite proper but also two new minerals. These were named by him bassettite and uranospathite. The papers describing them were communicated to the Mineralogical Society in June, 1915, and consequently they did not attract the attention they would have done in times of peace. However, fifty years later a new uranium mineral was discovered by Dr. Kurt Walenta of Stuttgart and it was named by him, Hallimondite, 'for Dr. Arthur F. Hallimond, London, to whom we owe major contributions to the knowledge of secondary uranium minerals.'

During much of the War Hallimond was away at Stockton, County Durham, applying his mineralogical training to problems of steel manufacture and refractories, working on these and other problems with Dr. J. H. Whiteley. They published papers on the acid hearth, on the metallurgy of carbon steels, and on slags. Later papers on vogtite and monticellite arose out of the same work. Hallimond also was part-author of a

Geological Survey publication on Refractory materials (1918), and he was responsible for the Special Report on the Bedded Iron Ores of England and Wales (1925).

After having published with E. G. Radley a paper on the composition of glauconite in 1922 he was led to a study of the mica group and made laborious recalculations of all the available analyses and published his conclusions between 1925 and 1927. This led to his discussion with A. N. Winchell who, using a selection of the best available analyses, had published a paper which appeared while Hallimond's first paper was in the press. Both authors wrote papers criticizing the other. Winchell proposed formulae for the minerals of the mica group in which the ratio of K_2O to SiO_2 varied from 1:5 to 1:7, while in Hallimond's formulae the ratio was always 1:6. In Winchell's formulae Al_2O_3 could be replaced by $MgO \cdot SiO_2$; Hallimond's assumption was that Al_2O_3 could replace MgO leaving the potash-silica ratio unaffected. Neither author had available the X-ray methods which, a few years later enabled the structural formulae of the micas to be settled and to show that the Al atoms can replace some of the Si in the $(Si, Al)O_4$ tetrahedra as well as replacing some of the Mg in the central brucite-gibbsite layers.

In 1929 various geophysical methods of geological surveying were being tested by the Survey in England and Hallimond was put in charge of preliminary magnetic surveys. His results were published in the Summaries of Progress for 1929, 1930, and 1931. He returned to this kind of work briefly in the Second World War. The earlier geophysical trials were discontinued in 1931.

In the course of some decorative work on the roof of the old Museum building, it was discovered that some of the cast-iron beams supporting the roof were fractured, probably as a result of a nearby bomb explosion during the 1914-18 War. The building was pronounced unsafe for visits by the public. It was partially closed and the need for any improvements in or additions to the existing exhibits ceased. Plans were set on foot for a new building to house the Survey offices and laboratories and the Museum, which resulted in the present fine building at South Kensington familiar to many geologists as the reception centre for the International Geological Congress in 1948. As soon as the move was decided upon plans were drawn up for the utilization of exhibition space. Exhibits were planned in detail and specimens to be used in the exhibits were selected and packed; labels were drafted and printed in readiness for the move. In this work Hallimond was responsible for all the exhibits of metallic and nonmetallic minerals of economic importance. All was in readiness for 1933 but the move was not made until 1935, as the building was first used for the International Monetary Conference. Four years

later all the new exhibits were being dismantled partly for safe storage but mainly to make way for the wartime London Regional Control headquarters. The Survey retained the use of the laboratories and some of its laboratories and workrooms; work went on with increased activity in many fields. Hallimond carried out some magnetic surveys in collaboration with A. J. Butler and V. A. Eyles, and did some work on the magnetization of rocks with E. F. Herroun. He also did some work on air flotation methods for mineral separation and on minerals in aluminous cements.

By the end of the War Hallimond was becoming interested in the optics of polarizing microscopes, and in 1944 he wrote a note on the use of polaroid as a replacement for Iceland spar. He had a flair for instrument design as well as a thoroughly sound knowledge of optics, and this made him a very useful member of the committee set up in England in 1944 to investigate the manufacture of polarizing microscopes.

Late in 1945 he visited Germany as leader of a party sent out to study the manufacture of petrological microscopes in that country, and an official report was issued in 1946. One outcome of all this work was a series of papers with E. W. Taylor on an improved polarizing microscope (1946-48) discussing phase-contrast and its uses, and on the Universal Stage. Next he prepared a *Manual of the Polarizing Microscope* published by Cooke, Troughton and Simms in 1948 to accompany their new range of petrological microscopes. Hallimond wrote a new edition of this work in 1953, and a revised edition was completed shortly before his death.

The study of opaque minerals and methods of polishing specimens for examination in reflected polarized light claimed his attention in 1949: he devised an apparatus for polishing specimens, a vertical illuminator, and photometer for use with polarizing microscopes (1950-54). Descriptions of this apparatus and of the methods to be used were embodied in the 1953 edition of his 'Manual.' Much of this work was done after his retirement in 1950 in a laboratory he fitted up in his own home. He was a consultant for Cooke's (later Vickers) and he also did some important work for a firm of glass makers, particularly on opaque inclusions in glass.

Hallimond was a bachelor. He lived, during the later part of his life, in his own house in Golders Green, a pleasant suburb in north-west London. He had many hobbies and interests apart from his work. One of the earliest of these was 'wireless' in the days of crystal sets and cat's whiskers. He used a motorcycle for getting about the country and visiting geological sections, sometimes with a student passenger on the pillion. Between the Wars he was Scoutmaster of a troop of Boy Scouts

at Hornsey in north London and he organized many camps for the troop on the Continent. He was sufficiently fluent in French and German not only to organize such camps but to make and maintain to the end contacts with many foreign mineralogists and other scientists.

In addition to being a Fellow of the Mineralogical Society of America (1944), he was a Fellow of the Geological Society of London, and a member of the Institution of Mining and Metallurgy, the Geologists Association, and the Royal Microscopical Society.

He had joined the Mineralogical Society of Great Britain in 1912 and he had served on the Council for many years and he was runner-up for the Presidency in 1964. He was a founder member of the Committee on Ore Mineralogy of the Society and he was Chairman of the Clay Minerals Group from 1957 to 1959

His work with Dr. Whiteley on steel manufacture and slags was recognized by the award of Carnegie Scholarships in 1919 and 1923, and of the Lyell Award of the Geological Society of London in 1926.

He died in London on September 2, 1968. In his will he left a sum of money to the Mineralogical Society of Great Britain and this is to be used to endow an annual Lecture to be called the Hallimond Lecture.

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