MEMORIAL OF CLARENCE NORMAN FENNER

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Clarence Norman Fenner was born on July 19, 1870, on a farm near Paterson, New Jersey. His father, William Griff Fenner, born in 1834 in Chili near Rochester, New York, was the son of a clergyman who, after graduation from Oxford University, migrated with his wife from England to New York state. The son at fifteen years of age left home to make his way in New York City. He was successful and in time became a member of the mercantile firm of Field, Chapman, and Fenner. He bought a farm near Paterson and in 1865 married Miss Elmina Jane Carpenter of North Greece near Rochester, New York. Miss Carpenter was the daughter of Dr. Carpenter, a country physician of English descent. Mr. Fenner commuted each week day between his home and the city. It was in this house that Clarence was born and in which he died on December 24, 1949, 79 years later. In the early part of this century the town of Clifton was extended to include this area which is two miles from Paterson.

Clarence Fenner was educated in private schools in Paterson, namely, that of Miss Riggs, of Mr. Waters, and of Dr. McChesney. In 1888 he spent the summer in Europe in company with Dr. McChesney. On his return home he entered the School of Mines of Columbia University and in 1892 graduated with the degree of Engineer of Mines. He became a mining geologist and saw service in this country, in Canada, in Mexico, and in South America. In 1907, after fifteen years' experience in the field, he returned to Columbia University to earn his Master's degree in 1909 and the Ph.D. in 1910.

Thereupon he joined the staff of the Geophysical Laboratory of the Carnegie Institution of Washington as Petrologist. He remained with the Laboratory until 1938 when he retired, because of age, after 28 years of research work chiefly on petrological and mineralogical problems. He returned to the old home in Clifton to live with his brother Herbert and to continue his researches on petrological problems in his own field; this included a trip to South America to revisit some of the petrologically interesting localities. While in Arequipa, Peru, he prepared a long paper on the geology of the Arequipa area; this paper was published in Spanish by the University of Arequipa after translation by Professor Carlos Nicholson of the University. This article was illustrated by 25 plates.

Dr. Fenner's first independent research problem in the laboratory was the elucidation of the stability relations of the silica minerals. In this field he showed remarkable aptitude and skill in manipulation of laboratory apparatus and for obtaining significant data of observation. He tested

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and retested his conclusions with the result that his data on the silica minerals have stood the test of time and are now accepted. He studied the stability ranges of quartz, including its reversible inversion at about 575° C to the high temperature form which is stable to 870° ± 10° C. The stable form from this temperature to 1470° ± 10° C is β_2-tridymite. Above this temperature β-cristobalite is stable to its melting temperature at 1713° ± 5°, according to later determinations by J. W. Greig. Fenner found for the two low temperature forms of tridymite: α-tridymite stable below 117° and β_1-tridymite stable between 117° and 163° C; both inversions are rapid and reversible. The high temperature form, β_2-tridymite persists between 163° and 1470° ± 10° at which temperature it inverts very sluggishly but reversibly to β-cristobalite. This mineral in turn also has a low temperature form, α-cristobalite; the inversion temperature ranges between 220° and 275° depending on the previous heat treatment of the sample; the inversion is rapid and reversible. No satisfactory explanation has yet been found for the observed changes in the inversion temperature.

Fenner's thesis for the Ph.D. degree was on the Watchung basalt and the paragenesis of its zeolites and other secondary minerals. In this thorough study he became intensely interested in the replacement of minerals by others as the result of changes in environment and was able to use this knowledge to advantage later in investigations on replacement minerals produced by pneumatolytic and hydrothermal processes. In his extensive field studies of ore deposits in mines he had been impressed by the magmatic transfer of ore-producing elements either in the gaseous state as pneumatolitic emanations or as hydrothermal solutions. His later studies at Katmai, Alaska, at Yellowstone Park, Wyoming, and elsewhere in North and South America convinced him of the soundness of this hypothesis and led him to reject the hypothesis that fractional crystallization is the principal, if not the sole, factor leading to differentiation in magmas.

In connection with the secondary minerals occurring in the Watchung basalt Fenner solved two problems, namely: (*a*) the early appearance of albite crystals in the cavities of the basalt; and (*b*) the former presence of babingtonite crystals which were subsequently removed by solution with only their casts remaining. Fenner discovered in 1914 in the Francisco quarry at Great Notch a small number of babingtonite crystals which had escaped solution and which exhibited the optical and crystallographical properties characteristic of babingtonite. As a rule its crystals occur enveloped in decomposition products; but they were observed so often in cavities that little doubt exists that they are portions of the original crystals. They are found associated with crystals of anhydrite.

The quartz pseudomorphs after babingtonite show sharp prismatic angles which agree fairly well with those of babingtonite. Fenner's recognition of the casts as those of original babingtonite crystals was accepted by mineralogists and thus cleared a mystery that had long puzzled them.

During World War I the Geophysical Laboratory was assigned to aid in the production of optical glass. In December 1917 Dr. Fenner, after some months at the Bausch and Lomb plant in Rochester, was placed in charge of the optical glass plant of the Spencer Lens Company at Hamburg, New York. He succeeded in producing excellent optical glass from the start; he placed the plant on a production basis and extended its capacity many fold. By so doing he contributed his share to the success of his country in winning the war.

In 1919 he was a member of the National Geographic Society's expedition to Mt. Katmai, Alaska; in 1923 he was the leader of the Geophysical Laboratory's expedition to the Katmai region. Between 1928 and 1934 he conducted geological investigations in Yellowstone National Park and became still more interested in magmatic and volcanic processes. At the same time he devoted much energy in developing methods for study of the uranium and thorium minerals and in devising chemical methods for their separation and analysis. These were important factors in studies bearing on the age of the earth and its determination by various methods.

Dr. Fenner's main interest was not in mineralogy nor in chemistry, though he made many excellent analyses of rocks and was well trained in physical chemistry; his interest was chiefly in petrology and in ore deposits, in their development and mutual relationships and in the chemical and mineralogical changes which accompany shifts in environment. His contributions to volcanology, based on extended field studies in the Katmai region, in Yellowstone Park and other areas, followed by painstaking laboratory investigations of the collected field specimens are recognized as fundamental to the development of the science of volcanology. In the Katmai region he proved that the highly siliceous rhyolite magma on rising from the depths encountered near the surface beds of overlying andesite. Materials from the andesite were engulfed and incorporated into the rhyolite, thus forming masses whose composition was intermediate between that of the rhyolite and of the andesite. He proved that this absorption and partial digestion of the andesite by the rhyolite took place near the surface and not at depths; that the sources of energy both for the assimilation and for the violent explosions themselves were the escaping magmatic volatiles whose exothermic chemical reactions produced the necessary heat. He showed that the intermittency in violent volcanic explosions is due to the time required for the exothermic reactions in the escaping gases to develop. He proved by chemical analyses that in the series of intermediate rocks the variation in the amount of each chemical oxide was linear. This proof by Fenner of the importance of the transfer of material in the gaseous state and of the surficial character of some of the most appalling volcanic outbursts has revived interest in the general subject of pneumatolytic and hydrothermal processes, and called attention to their importance in the crystallization and differentiation of igneous rocks.

Personally Dr. Fenner was quiet and unassuming, thoroughly reliable in every way and ever conscious of our restricted knowledge. In his approach to problems he was strictly scientific and was loath to draw a conclusion before probing its validity from all directions. He was a member of many scientific and honorary societies in this country and abroad.

It was a real pleasure for us of the Laboratory to know him well and to discuss problems with him. His mind was of the rare type, keenly analytical but tolerant and conscious of how little we know of what is to be known. Ever a gentleman and with ability to think and to express himself clearly, he was not dogmatic nor sarcastic even under trying conditions. We knew that in his passing we had lost a good friend and petrology had lost one of its best observers and expounders.

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