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J. FRANK SCHAIRER

1904—1970

A Biographical Memoir by

H.S. YODER, JR.

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J F Schairer

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April 13, 1904–September 26, 1970

BY H. S. YODER, JR.

FEW PEOPLE HAVE GIVEN so generously of their kind help and good cheer to so many as J. Frank Schairer. His multitude of friends reflect on his passing with sadness, yet they cannot help being warmed by the memories of his vigorous and happy life and grateful for his prodigious contributions to experimental mineralogy and petrology. Schairer's researches yielded an immense number of accurate determinations of the melting relations of the common rock-forming minerals at one atmosphere and in vacuo. To many colleagues the greater contribution was his simple and contagious philosophy of life that added zest and joy to all whose lives he touched.

John Frank Schairer was born in Rochester, New York, on April 13, 1904. His father, John George Schairer (1876-1965), was a master lithographer and later a farmer. His mother, Josephine Marie (née Frank) Schairer (1874-1939), taught school for eight years before her marriage in 1903. Frank, the name his parents preferred, was the first born and he was followed by six girls.

EXCEPTIONAL SCHOLASTIC RECORD

When Frank was five years old he entered the kindergarten of Rochester Public School No. 32 with his sister Helen.

They also entered first grade together at Immaculate Conception Parochial School. "He was a bright student, but not bookish," and skipped third grade, according to Helen in 1971. His exceptional scholastic record in grammar school (eight-year program) led to the winning of a Gold Medal. As was the custom in families of modest means, Frank had a magazine route and delivered the *Ladies Home Journal* and the *Saturday Evening Post* in the neighborhood. He fished with his chums in the tributaries of the Genesee River, which flows through Rochester.

In 1917 Frank entered Rochester Cathedral High School (four-year program) where his potential was immediately recognized. Sister Pauline (Smyth) and Father J. E. Grady especially influenced his subsequent development in the field of science. During his first year in high school the family moved from Rochester to a farm near the town of Greece, some 5 miles northwest of Rochester, because of his father's occupational health problem and economic straits resulting from a long strike. The new farm life demanded much of Frank's spare time, yet he maintained honor grades and was a member of the debating team. His mother, always the teacher, imparted her own interest in nature, especially botany, to the family during hikes through the local woods. A small chemistry laboratory was built by Frank in the attic where flares were produced for the neighborhood fireworks display on the Fourth of July. The parental concern and control of the use of the laboratory are well documented by his sisters. There was a great sense of family unity and love, and most of the activities centered on the home. Instillment of good moral values coupled with discipline wisely administered and a sound basic education appeared to be the predominant goals of his parents. All the children were afforded some musical training and Frank learned to play the piano. For those who have heard him sing at church, campfires, or at occasions when the National Anthem was sung, the musical training would seem to have been of no avail.

At the suggestion of his mentors at Rochester Cathedral High School, Frank entered competitive examination for a scholarship at Yale University offered by the alumni association of Rochester. A tie resulted and, after due consideration, the alumni decided to offer both men a scholarship. A loan from an aunt, Miss Mary Schairer, provided some supplementary funds for him to accept the opportunity. Summer employment and waiting tables at Johnson's Eating House provided the remaining money for his support.

HOOKED FOR LIFE

His first interest in mineralogy grew out of a field trip to Old Gillette quarry at Haddam Neck, Connecticut, during a weekend outing spent with a classmate's father, George N. Norton, the local country doctor who had taken geology under James Dwight Dana. Greatly fascinated by the beauty of the well-crystallized minerals in the pegmatite with its highly varied and exotic chemistry, Schairer was hooked on the chemistry of rocks and minerals for life.

At the end of his freshman year in 1922 at the Sheffield Scientific School, Frank won the New York Yale Club prizes in chemistry II and German I. In his sophomore year he won the Samuel Lewis Penfield prize for excellence in mineralogy. At that time the laboratory assistants in the mineralogy course were William W. Rubey (*NAS Biographical Memoirs*, volume 49) and James Gilluly (*NAS Biographical Memoirs*, volume 56), both of whom became prominent members of the U.S. Geological Survey and leaders in the National Academy of Sciences. On the basis of that single course in mineralogy and many field excursions, Schairer helped organize the Yale Mineralogical Society and was elected its first president on October 5, 1923.

With his principal focus on chemistry he found summer employment in the relatively new research laboratories of the Eastman Kodak Company in the synthetic chemicals department under the direction of the highly respected Hans Clarke. Frank's assignment was the synthesis of sodium thioglycolate, a technique that was tricky because of the required purity of chemicals (Shepler, 1971). He was later dismayed to learn that all his efforts were spent merely to produce a chemical for modifying wool fibers and especially for use in the straightening or cold waving of human hair. His sisters recall his returning home at the end of the summer with hands deeply stained chestnut brown!

Schairer's senior year was predominantly devoted to chemistry. He saved his lunch money to buy the three-volume work by H. W. Bakhuis Roozeboom on the principles of heterogeneous phase equilibria to supplement his interests in thermodynamics and phase chemistry. He graduated magna cum laude in the class of 1925 after election to membership in Alpha Chi Sigma (chemistry) and Sigma Xi (scientific research). Time was also found to pursue his interests in organic evolution and advanced petrology. On graduation he had five papers in mineralogy published or in press!

STRADDLING THE FENCE

Although registered for a doctorate in chemistry, Schairer made the unusual request to take a master of science degree in mineralogy. The chairman of the Department of Geological Sciences at Yale was then Charles H. Warren, the same man who had earlier, while at the Massachusetts Institute of Technology, launched Norman L. Bowen on a career of experimental petrology involving phase equilibria at the Geophysical Laboratory in Washington, D.C. With the strong support of the faculty of the Department of Geological Sciences, the dean of the graduate school agreed to the request. During the 1925-26 period, Schairer served as laboratory assistant in the Sterling Chemical Laboratory and as president of the Chi chapter of Alpha Chi Sigma. His essay for the M.S. degree was on "The mineralogy and paragenesis of the pegmatite at Collins Hill, Portland, Connecticut." It was given a superior rating and was described as representing "an exceptional amount of original work for an M.S. degree." It is of note that his principal professors included John Johnston, formerly a chemist specializing in high-pressure phenomena in minerals at the Geophysical Laboratory; W. E. Ford, who was revising E. S. Dana's *Textbook of Mineralogy* (fourth edition); H. W. Foote, who made substantial contributions to the chemistry of minerals and was a physical chemist trained by S. L. Penfield; and Adolph Knopf, internationally renown igneous petrologist.

THE ENTHUSIAST

In April 1926 Professor Charles H. Warren wrote to A. L. Day, director of the Geophysical Laboratory in Washington, D.C., recalling that Norman L. Bowen had been a predoctoral fellow there and suggesting a "somewhat similar program" for another graduate student, J. F. Schairer. He is "not only a man of unusual ability, but of really tremendous energy, and his enthusiasm for research work exceeds that of almost anyone I have known for a long time. We have never found it possible here to give him so much work to do that he was not habitually branching off into some piece of research work." The interview that followed shortly was successful, but apparently Warren had difficulty in obtaining the necessary financial support. In the meantime, Schairer worked on the Na_2SO_4-NaCl-NaF-H_2O system under Harry

W. Foote in chemistry. The temperature range was 10-35°C so no special equipment was required. At the end of January 1927 another interview was arranged with Day; Schairer (1964) records his recollections of the discussion:

> At that time Arthur L. Day, director of the Geophysical Laboratory, did not want any young men on fellowships. He said that they were only there for a year, took up time and space, and in one year only found out what they should have done if they only knew how. However, he agreed to see me and talk it over. He found that I had a tremendous interest in phase equilibrium and had been working at Yale on the quaternary system Na_2SO_4-NaF-NaCl-H_2O. He said he wouldn't take me on a fellowship but would give me a job. I was surprised and pointed out that I did not yet have my doctor's degree. He said, "You know that a doctor's degree is merely a certificate that you have had the proper training and I can see that you have had that." So many students fail to recognize this truth and believe that if you have this magic degree you do not have to think or work the rest of your life and that the world owes you a living.

Schairer reported to work on September 1, 1927. His thesis was written at the Geophysical Laboratory and his comprehensive examinations in organic and physical chemistry were mailed to the laboratory and administered by the director. The Ph.D. degree was awarded in June 1928, and the thesis was published in two parts by the American Chemical Society (Foote and Schairer, 1930 a,b). The system investigated was pertinent to the mineral deposits of Searles Lake, California. One of the compounds discovered by Schairer in the synthetic system was $Na_2SO_4 \cdot Na(F,Cl)$. It was later discovered by W. F. Foshag (1931) in the sediments of Searles Lake and named schairerite. The brine that permeates the salt deposit is uniformly 23°C throughout the year, a temperature close to one of Schairer's isotherms. [The ratio of F to Cl in the natural compound has been determined by Brown and Pabst (1971) to be 6:1. Another similar compound with F:Cl equal to 4:1 is known as galeite, and the fluorine endmember, also synthesized by Schairer, has been found in the Kola Peninsula [Kogarko, 1961).]

Because of crowded conditions at the Geophysical Laboratory, Schairer had the good fortune to be assigned a desk in the office of N. L. Bowen, who no doubt had a very sympathetic understanding of Schairer's predoctoral status because of his own similar experience. At that moment Bowen was probably enjoying the most intellectually exciting time of his life. He was preparing his lecture series at Princeton University, given in the spring of 1927, for publication as "The Evolution of the Igneous Rocks," copies of which were not received until December 1928 (Bowen, 1928). Bowen showed Schairer the quenching technique of Shepherd, Rankin, and Wright (1909), now the preferred method for studying silicate phase relations. Together they investigated leucite-diopside, which turned out to be a simple binary system (Bowen and Schairer, 1929). Nevertheless, true to the rule that no system is really simple, they had to devise a method for making compositions on the join in spite of the volatilization of potassium at temperatures ranging from 1200-1740°C, just within the melting point of the pure platinum crucible (1755°C on the Geophysical Laboratory temperature scale).

During his intensive training period at the Geophysical Laboratory, he managed to write his thesis and complete a major work on "The Minerals of Connecticut." He had collected the data while he was at Yale by hiking to the various mineral localities, occasionally using a streetcar or train to reach the more distant parts. His *Bulletin of the Connecticut Geology and Natural History Survey* records many reports of the first discovery of the rarer minerals and corrects several misidentifications. In Schairer's view some of the quarries were a "mineralogist's paradise."

According to Schairer (1964) the only directive he ever received from the director of the Geophysical Laboratory was that he could do anything he "chose to do but he hoped it would have something to do with iron oxides." With this slight nudge Bowen and Schairer investigated the iron-oxide systems with great vigor. From the incongruent fusion relations of acmite ($NaFe^{3+}Si_2O_6$) on the $Na_2O \cdot 4SiO_2$-Fe_2O_3 join (Bowen and Schairer, 1929) they investigated the ternary Na_2SiO_3-Fe_2O_3-SiO_2 (Bowen, Schairer, and Willems, 1930). They clearly stated that the system was not really ternary because small amounts of iron were in the ferrous state. Obviously, the next system to do was FeO-SiO_2, but the charges oxidized in air and attacked the platinum crucible and all ceramic containers. Bowen and Schairer solved this problem by using pure iron crucibles in an inert (oxygen-free nitrogen) atmosphere. In this way the Fe_2O_3 content of the liquid was controlled reproducibly in the presence of native iron and subsequently determined by chemical analysis. Development of this important buffering technique, now used for other metal-oxide systems, led to the successful investigation, with various colleagues, of the following systems relevant to rocks and rock-forming minerals.

Ca_2SiO_4-Fe_2SiO_4	1933
CaO-FeO-SiO_2	1933
MgO-FeO-SiO_2	1935
Albite-Fayalite	1936
Nepheline-Fayalite-SiO_2	1938
CaO-FeO-Al_2O_3-SiO_2	1942
CaO-MgO-FeO-SiO_2	1950
FeO-Al_2O_3-SiO_2	1952

These systems contain practically all the important end members and many of the simple solid solutions of the rock-forming minerals: olivines, pyroxenes, pyroxenoids, melilites, feldspars, feldspathoids, cordierite, iron oxides (e.g., wüstite, magnetite, and hematite), and the SiO_2 minerals.

The complexity of the two quaternary systems led Schairer to express the major courses of fractionation of liquids as a flow sheet. The boundary curves within the tetrahedral models could thereby be laid out in two dimensions and the relationship of the various invariant points exhibited with clarity. The flow sheet concept has since been applied to the even more complex relationships of natural rocks that tend to concentrate at or near invariant points in multicomponent space.

The applications of these systems to the steel and ceramic industries were greatly appreciated, but Schairer was true to his major goals in spite of the accolades from those industries (Schairer, 1942):

> As you probably know, my major interest has always been the application of physical chemistry to geological problems, particularly the problem of the origin of igneous rocks and their minerals. My attitude has always been that my major studies should be on rock-forming minerals and that I should confine my attention to systems of direct or very close interest in solving mineralogical or geological problems. If these studies had ceramic, metallurgical, or other scientific interest it was all to the good, but I have never instituted any research project because it was of special interest to ceramics or metallurgy. Thus, I do not wish to pose as a bona fide ceramist, although I have always had a kindly and sympathetic interest in problems in the general chemistry of ceramics.

He was not a bona fide metallurgist either, but it did not prevent him from making a major contribution in that field during World War II as described below.

The motivation for investigating the iron-bearing systems was primarily the pursuit of knowledge, but another driving force was probably the escalating argument between colleagues N. L. Bowen and C. N. Fenner regarding the concentration of FeO and SiO_2 in the residual liquids undergoing crystallization differentiation. Bowen argued that fractional crystallization leads to the enrichment of residual liquids in iron relative to magnesium, but is overshadowed more commonly by an overwhelming increase in the alkali and silica content. Fenner, on the other hand, advocated the more rarely observed trend of absolute enrichment of residual liquids in iron. Fortunately the argument was resolved later when due regard was given the state of iron oxidation (Osborn, 1959), and both the Bowen trend and the Fenner trend could be demonstrated in the laboratory.

FELDSPARS AND FELDSPATHOIDS

The first system to be investigated at the Geophysical Laboratory was the plagioclase solid solution series (Day, Allen, and Iddings, 1905). The high viscosity of the feldspar melts was the chief difficulty; albite glass also resisted crystallization even in subsequent experiments by Bowen (1913). Seeding was of no avail. For this reason, Bowen and Schairer (1936, 1938) tried to use fayalite as a flux in promoting the crystallization of albite, and some success was achieved. Even in preliminary studies (Schairer and Bowen, 1947) on the more general systems Na_2O-Al_2O_3-SiO_2 (Schairer and Bowen, 1956) and K_2O-Al_2O_3-SiO_2 (Schairer and Bowen, 1955), containing albite and sanidine respectively, considerable difficulty was found in growing the feldspar crystals. Schairer (1951) finally arrived at a solution to the kinetics problem. By a process of acclimation involving successively lower treatment temperatures of the liquid with intermediate crushings of the glass, he was able to produce the appropriate structure in the liquid so that crystallization took place promptly below the true melting point. From then on it was possible to study the alkali feldspar join (Schairer, 1950) and the ternary feldspars (Franco and Schairer, 1951).

EARLY AND LATE CRYSTALLIZING MINERALS

In 1935 Schairer and Bowen produced a preliminary phase diagram for $NaAlSiO_4$-$KAlSiO_4$-SiO_2, which Bowen (1937) later described as "petrogeny's residua system." The system is of great petrologic interest because it contains compositions like those of the final liquids yielded at the end stages of the fractionation of rock magmas. The diagram was revised in 1950 by Schairer (1957), but proof of the concept came after an incredibly large number of detailed experiments, mainly by Schairer and his colleagues.

Forsterite-Nepheline-Silica	Schairer and Yoder (1961)
Fayalite-Nepheline-Silica	Bowen and Schairer (1938)
Diopside-Nepheline-Silica	Schairer and Yoder (1960)
Anorthite-Nepheline-Silica	Schairer (1954)
Spinel-Nepheline-Silica	Schairer and Yoder (1958)
Forsterite-Leucite-Silica	Schairer (1954)
Fayalite-Leucite-Silica	Roedder (1951)
Diopside-Leucite-Silica	Schairer and Bowen (1938)
Anorthite-Leucite-Silica	Schairer and Bowen (1947)
Spinel-Leucite-Silica	Schairer (1954)

The removal of the early-formed crystals, in each case the first phase named in the left-hand column above, did indeed result in the fractionation of liquids toward the residua system. The deductions from field evidence overwhelmingly support this concept documented quantitatively in the laboratory principally by Schairer.

Progress on the grand plan to verify the concept that the residual liquids generated by the fractionation of basic magmas were enriched in alkali-aluminosilicates was slowed by Bowen's move to the University of Chicago in the fall of 1937, and brought to an abrupt halt by the onset of World

War II. No one since has had the courage, time, or support to undertake the quaternary systems involving both the potassium- and sodium-bearing phases.

THE EXPEDITER

The trustees of the Carnegie Institution of Washington and its president, Vannevar Bush, then director of the Office of Scientific Research and Development, made the Geophysical Laboratory staff available to the government without charge to aid in solving defense problems. It was recognized early in 1941 that the solution to the hypervelocity (>3,500 feet per second) gun problem depended on an understanding of the fundamental causes of gun erosion. The investigation of gun erosion was undertaken by the Geophysical Laboratory because of its special capabilities with the techniques of high-temperature and high-pressure research. Techniques developed for the study of minerals and rocks under conditions believed to exist deep in the earth proved to be directly applicable to the study of reactions between powder gases and gun barrel metals. The Geophysical Laboratory devoted full time to the problem and specific tasks were assigned to the staff. Schairer was a consultant to Division 1 from November 1941 to December 1942 and July 1943 to September 1944; and a special assistant from October 1944 to June 1946.

The successful development of the stellite-lined machine gun barrel was expedited through the close cooperation of fifteen of the division's contractors. Schairer's role is described by Burchard (1948):

> The "spark plug" who fired the enthusiasm of these contractors—even when their efforts seemed to be of no avail in making refractory metals behave—was J. F. Schairer. Through his tireless efforts, which involved spending half his time traveling from one laboratory to another, each one of this group of contractors was kept fully informed of the progress being made by

> the others. Through his grasp of the ramifications of this exceedingly complex metallurgical program, he was able to pick up information at one laboratory and relay it to another one which could use it.

The new caliber 0.50 machine gun barrel could withstand the firing of "thirty times as many rounds as would ruin ordinary steel barrels fired on the same schedule . . ." By the beginning of 1944 the modified barrels were adapted as standard by the War Department and used in the Pacific campaigns. The same alloy was greatly instrumental in expanding the practical experimental range of pressure vessels used in hydrothermal research at the Geophysical Laboratory after the war.

For his exceptional services Schairer received in 1948 the President's Certificate of Merit and His Majesty's Medal for Service in the Cause of Freedom (Great Britain).

BACK TO FUNDAMENTAL SCIENCE

The Geophysical Laboratory was able to conclude most of its war work by June 1946, and the objectives of future research were focussed and defined (Adams, 1946). Of the five major fields of interest outlined, the first identified was the study of fusion relations of minerals and of related equilibria. An essential part of the laboratory's proposed program was, therefore, to expand the past studies on the anhydrous combinations of the principal rock-forming oxides to complete the existing information on the compositions and mutual stability relations of the rock-forming minerals. With this mandate Schairer renewed his research with characteristic vigor and the help of an array of staff members, fellows and visiting investigators:

Na_2O-MgO-SiO_2	Schairer, Yoder, and Keene (unpub.)
Na_2O-FeO-SiO_2	

MgO-Al_2O_3-SiO_2	Keith and Schairer (1952)
K_2O-MgO-Al_2O_3-SiO_2	Schreyer and Schairer (1961)
K_2O-MgO-Al_2O_3-SiO_2	Schairer (1954)
Na_2O-MgO-Al_2O_3-SiO_2	Schairer and Yoder (unpub.)
CaO-MgO-Al_2O_3-SiO_2	Chinner and Schairer (1962)
Na_2O-Al_2O_3-Fe_2O_3-SiO_2	Bailey and Schairer (1966)
CaO-MgO-Fe_2O_3-SiO_2	Huckenholz, Schairer, and Yoder (1968)

(Brief accounts and the preliminary phase diagrams for those systems not described in detail will be found in the *Annual Reports of the Director of the Geophysical Laboratory.*) In addition, work on the ferrous iron systems continued and some of the investigations incomplete at the beginning of the war were prepared for publication.

In describing the complex quaternary systems to audiences unfamiliar with phase equilibria, Schairer would use his "magic cheese knife" with which he would cut the tetrahedral model in various directions. Each cut would display the results of a join representing real or assumed end members that he had investigated. His clarity of presentation, punctuated with humor and wit, brought an understanding nonspecialists rarely achieved. In his humility he usually failed to inform the listener of the years of effort, multitude of time-consuming experiments, and the great care taken to achieve accuracy that had been required for each of the works described graphically as "cuts." He was indeed a perfectionist who remained productive through great efficiency and industry.

THE BASALT SYSTEMS

With the formulation in the fall of 1958 of the simplified basalt tetrahedron by Yoder and Tilley (1962), based on the principal normative components of basalts, Schairer laid aside the oxide-system approach to the investigation of the major rock-forming minerals. The tetrahedral model of basalts, the most abundant rock type in the earth's crust, was later expanded by Schairer and Yoder (1964) to include the melilites. It was possible thereby to represent a wide variety of both alkaline and tholeiitic basalts and determine their melting behavior and interrelationships.

He now tackled the basalt system with incredible vigor, coming to work early and leaving late. The halls of the laboratory still ring with Schairer's evening departure as he loudly announced that he was "saturated with all solid phases." The critical planes investigated included:

Forsterite-Nepheline-Silica	Schairer and Yoder (1961)
Forsterite-Diopside-Silica	Schairer and Yoder (1962) Kushiro and Schairer (1963)
Forsterite-Diopside-Albite	Schairer and Morimoto (1958)
Diopside-Enstatite-Albite	Schairer and Morimoto (1959)
Diopside-Nepheline-Silica	Schairer and Yoder (1960)
Forsterite-Diopside-Nepheline	Schairer and Yoder (1960)
Nepheline-Diopside-Akermanite	Schairer and Yoder (1964)
Nepheline-Akermanite-Wollastonite	
Akermanite-Wollastonite-Albite	
Akermanite-Diopside-Albite	
Akermanite-Nepheline-Albite	
Nepheline-Diopside-Wollastonite	

The major conclusion from this vast amount of data was that major igneous rock types clustered on or near critical univariant curves and the principal invariant points of the natural multicomponent system.

The basalt tetrahedron consists of five oxide components (SiO_2,Al_2O_3,CaO,MgO,Na_2O), yet after public presentation someone in the audience would invariably ask about the effects of Fe, Ti, Mn, or some other element. About 99 percent of most rocks can be represented by ten elements, but it was clear that the systematic investigation of the ten-component system was some years ahead. A short cut was initiated by Yoder and Tilley (1962) in which the melting relations of natural basalts themselves were investigated with the same care and precision as the pure synthetic systems. By means of a sequence of studies on a wide variety of natural basalts (Tilley, Yoder, and Schairer, 1963, 1964, 1965, 1967, 1968), it was demonstrated that the simple, pure systems appropriately displayed the melting behavior of complex natural rocks. It was evident that a full understanding of the behavior of most igneous and metamorphic rocks would be achieved by the systematic study of the simple systems, including the various volatile constituents, rather than the haphazard study of selected rock varieties. The advantages of the simple systems approach include control of the entire range of compositional variables, the effects of a single variable can be evaluated, and principles can be demonstrated unambiguously. On the other hand, there are several disadvantages with the use of natural rocks as starting materials. The results apply only to a single bulk composition and are not applicable to related rock types. The rock may have endured other processes subsequent to consolidation; the rock was not necessarily all liquid in the early stages of formation; the rocks do not necessarily represent equilibrium assemblages; and the large number of degrees of freedom result in multiple interpretations that do not lead to establishing fundamental principles.

ENDMEMBER MINERAL SYSTEMS

Concurrent with the above-described petrological programs Schairer had a continuing interest in the detailed study of the major mineral groups. The phase relations of the olivines and the ternary feldspars have already been mentioned. Other groups include the pyroxenes, melilites, and the garnets. In almost every group his studies were the pioneering efforts to elucidate the melting behavior and limits of solid solution between endmembers.

Building on the work of Allen et al. (1909), Bowen (1914), and Atlas (1952), Boyd and Schairer (1964) outlined the solvus on the join diopside-enstatite. Bowen, Schairer and Posnjak (1933) displayed the complexity of ferrosilite-hedenbergite. The join enstatite-ferrosilite was investigated in great detail by Bowen and Schairer in 1935. The feature of major petrologic interest was the nature of the orthopyroxene-clinopyroxene inversion, a potential geothermometer. Even though the results have been reinterpreted and reinvestigated many times since, the inversion characteristics of those pyroxenes continue to hold the attention of petrologists. Because of the difficulty of preparing iron-rich compositions exactly on the plane, it was evident that the investigation of the pyroxene quadrilateral, diopside-hedenbergite-enstatite-ferrosilite, was to be an enormous undertaking. To get a preliminary view of that system, natural analyzed pyroxenes were used (Yoder, Tilley, and Schairer, 1963). The general relations have been verified by others by considering compositions off the plane of the pyroxene quadrilateral; however, the melting relations for the pure system have not yet been determined. Pyroxene solid solutions that included components rich in Al, Fe^{3+}, Cr, and Na were also investigated, usually with Fellows, who could maintain the fast pace kept by Schairer.

The study of the melilites began with akermanite-gehlenite-pseudowollastonite by Osborn and Schairer (1941), now a classic both in the theory of fractionation involving solid solution and in experimental methodology. They also prepared a preliminary diagram for akermanite-iron-akermanite. The ternary melilites, akermanite-gehlenite-sodium melilite, posed problems of a different order. The sodium melilite endmember was stable only at high pressures, but the limits of solid solution determined by Schairer, Yoder, and Tilley (1965) at 1 atmosphere were close to those found in melilite-bearing igneous rocks. That work involved the investigation of the melilite joins in gehlenite-nepheline-wollastonite and akermanite-nepheline-wollastonite; the ternary liquidus; four isothermal sections in the crystal + liquid regions of the ternary; and some portions below the ternary solidus where kinetic problems were evident. The results from the pure system were tested with analyzed natural melilites.

The *Annual Reports of the Director of the Geophysical Laboratory* record many other results on important mineral systems that, unfortunately, were never described in detail. Each investigation opened the door to a new array of problems, and for Schairer there was a compulsion to get on with the exciting chase. His meticulous notes on each experiment, calibration, and material preparation contain a wealth of information on the behavior of silicates. It is difficult to imagine that the determination of any silicate phase diagram in the future will be investigated with the same care and accuracy that were the hallmark of Schairer's work. New analytical tools (e.g., electron microprobe and scanning electron microscope) will indeed reduce the work, but it will still take another person who, in Schairer's words, has "learned to think like a silicate."

In recognition of his precise phase equilibria determinations and contributions to experimental mineralogy and petrology, Schairer received the Hildebrand Award of the Washington Chemical Society in 1942, the Arthur L. Day Medal of the Geological Society of America in 1953, and the Roebling Medal of the Mineralogical Society of America in 1963. He was elected to the National Academy of Sciences in 1953.

THE STORY TELLER

To keep abreast of the key problems of interest to geologists, Schairer traveled extensively in the United States and in Europe and Japan, particularly to visit field parties. For more than twenty summers he organized month-long excursions to key outcrops mainly in the western states usually with several of the young Fellows from the Laboratory. The excursions were run with great efficiency and always in good humor, with Schairer managing the cooking. He only balked at cooking a steak well done. The fellows not only learned considerable geology but also the names, both common and botanical, of the wild flowers, which he could identify by the hundreds. The pH ranges of tolerance of the plants and shrubs were often clues to the underlying rock types. Living in the rough and spending long, difficult days hiking have always been part of a geologist's life, but few have enjoyed the discussions around the campfire at night with so many talented investigators.

Schairer was a masterful story teller and each excursion—sometimes referred to as his endowed vacation—generated humorous events that he would turn into a captivating yarn. A favorite was the technique of cracking an egg that had been transported on a pack mule in the desert for weeks.

How to eat cod fish cheeks that were "too good for city folks" or the preparation of smoked eels, steamed clams, and slumgullion, and why the Pope never tasted turtle soup were part of the menu. Other stories included the burning of the underwear ceremony, how to ride a rented horse, and endless bear and skunk encounters. He was an expert on varieties of beer, but some doubted his qualifications when he announced that, "There is no such thing as bad beer." In his stories he usually bore the brunt of the joke. His acumen for storytelling developed early in his life and was aided and abetted by his sisters in spontaneous fun sessions. He never talked about other people; his rule was, "If you can't say something nice, keep your mouth shut." The story he particularly liked to tell arose from his encounters with the mountain people during the blazing of the Appalachian Trail. One short version goes like this.

> We started up the hollow and passed the time with everybody. Everybody was friendly but distant. After all, we were foreigners—anybody who lives more than 2 miles away was a foreigner. Then we started out on an old road. It got narrower and more and more gullied. Finally it was just a mountain trail.
>
> All of a sudden around a sharp bend in the trail came two mountaineers. One was an older man with a white beard, and the other was a younger man carrying a gunnysack in which it was obvious there were four two-quart jars of corn liquor.
>
> So we just sat there. And there was an awkward pause. And then the conversation got going as they do in the great circle of the mountains—it was a hell of a fine day, or damned if it wasn't. You start with the weather and you end with the weather.
>
> And the next thing you talk about is the crops, which are important to the mountain people, for if the crops are bad they might starve.
>
> And then the talk was about illness, the miseries, as they called it. And about that time everybody was sick, with inadequate food and inadequate housing, and so forth.
>
> And then another adequate topic of conversation was this proposed Shenandoah National Park, was that all nonsense or was it going through.

And we said, Yes, they are going through, and they might make their plans accordingly.

And we got back to the weather, if it was a good day it was a good day for a drink, or if it was a bad day, we need a drink.

And the fellow says, "Do you fellows ever drink?"

And I said, "I don't mind if I do."

And he brought out a two-quart fruit jar.

Charlie is a nice guy, but he doesn't drink. It was the most embarrassing thing in the world. I rushed up to Charlie and grabbed the two-quart fruit jar. I nearly knocked him down. I swung the fruit jar up, took a good swig, and swung it down again, and I said, "Charlie doesn't drink, but I drink for him." And I took another good swig.

So they thought it was so cute I got Charlie's drink.

And there was an awkward pause. And it suddenly dawned on me that I had a drink in my pack. We never drank on the trail, because climbing mountains and drinking liquor didn't go too well together, but Sunday night when we got in Mrs. Meig's before dinner a right good snort was always appreciated.

And so we weren't carrying a two-quart fruit jar, but I had a pint thermos bottle filled with liquor in my pack. And I said, "Won't you have a drink of my liquor?" And I went over to get it out of my pack.

The mountaineers can't figure what anybody would put in those packs.

So I pulled out my raincoat and my flashlight and what was left of a sandwich, and the liquor wasn't there, it was in the side pocket. So I pulled out everything trying to find it. And finally I pulled out this pint thermos bottle and handed it to the fellow.

And he took a drink and he looked very startled. He took another little drink, and he handed it back. I put it back in the pack and tied up the pack and we set down and there was an awkward pause.

Then the old fellow says, "I can tell you where you-all got that liquor." And I said, "You can?" And he said, "Yes, that is Hazel Hollow liquor."

And Hazel Hollow was about 30 or 40 miles to the north.

And I said, "Yes?"

And he said, "I can tell you who made that liquor."

And I said, "Can you?"

And he said, "That is Jack Dodson's liquor. And I can tell you when you got that liquor."

"How can you tell me that? When I got it, it was in a two-quart jar."

> But he was right all the time. And he looks at me and said, "You must be Mr. Frank."
>
> Schairer was too much for them; they all called me Mr. Frank.
>
> Here I give a guy a drink of liquor, and he tells me my name. And I said, "Would you mind telling me how you do it?"
>
> He said, "Each hollow has its own formula. There is only one make of liquor in Hazel Hollow, and this is Jack's. And Jack has only made three batches this year. The first batch he was terribly thirsty, so he let the batch burn. It couldn't have been that, because it was burned. And having burned the first batch he was terribly cautious, and the second batch was perfect."
>
> That was the batch I had. In fact, it was so good that word got around and it only lasted three days. So he knew within three days of when I bought it.
>
> It couldn't have been that third batch, because he had stored the third batch.
>
> The first batch was burned, the second was that good batch, and it only lasted three days and I had it.
>
> "And Jack never sells any of his liquor to anybody outside the mountains but this fellow Frank, and so you must be Mr. Frank."

Here was a down-to-earth man who was at home with sincere and simple people. The so-called trappings of success—fancy car, big house, and designer clothes—were not of interest to him. He had a disdain for politicians and lawyers, but in spite of this fact his son was successful in both fields. Some colleagues wondered how he managed to be elected to such high offices in the professional societies. In one case he was not even present at the meeting at which he was nominated! His answer was that he just tried to be honest and straightforward in his dealings with others.

He was a deeply religious man who usually said his nightly prayers together with his wife Ruth. Although he was devoted to the Catholic faith and received communion with great humility, he was not impressed with (nor did he participate in) its more elaborate ceremonies. Even while working in the field, however, he rarely missed Sunday Mass, rising early to avoid delaying the others and returning in time to cook breakfast. The Bible he carried was in French. One of his favorite stories included a description of his confession with the Bishop of Quimper. The hour-long discussion in the confessional about the best fishing spots in France was totally misinterpreted by the other parishioners waiting in line.

THE ORGANIZER

Shortly after arriving in Washington, Schairer joined the Wild Flower Society, but discovered they were a "bunch of piddling old ladies" who "took an hour to walk a mile." On November 22, 1927, he joined with friends holding similar views and formed the Potomac Appalachian Trail Club. He served first as treasurer and then as supervisor of trails. They started blazing trail near Harper's Ferry, West Virginia, and worked south through Virginia. Under Schairer's supervision the club constructed and blazed about 260 miles of the Appalachian Trail from 1928 to 1932. Their work contributed to the formation of the Shenandoah National Park that had been authorized in 1926 and was established on December 26, 1935. From his contacts with the mountaineers Schairer learned to square dance. With his usual enthusiasm he became a charter member of the Allemande Lefters, a square dance group in Palisades, Maryland. As the group matured it was occasionally referred to as the Allemande Leftovers.

Another organization he helped form, in March 1947, was the National Capital Orchid Society. He served as its president for two terms, in 1949 and again in 1963. For twenty years he was editor of its bulletin. In 1957 Schairer was president of the Eastern Orchid Congress. With untiring energy Schairer kept alive the sparkle, fun, and fascination of growing orchids. He was an inspiration to many growers because he was able to maintain over seventy-five varieties in a windowsill environment that was the envy of many commercial growers. As he would say in his many lectures to clubs and societies, "You've got to think like an orchid." He had very simple ways of tailoring the humidity, sun, and temperature to the needs of each variety on his sun porch. His successes influenced many commercial growers who, with elaborate greenhouses, expanded the number of varieties for public sale. It was his custom to give the back part of his best plants to club members with the recommendation that they follow suit. Except for the bridal bouquet for his daughter Jeanne, the spectacular blossoms were plucked only to enhance the health of the plant. In addition to his interest in orchids he led an annual tour in May to see the trilliums in bloom on Skyline Drive in the Shenandoah National Park.

Schairer would organize a fishing trip when there was a lull in his many activities. He learned the hard way that the opening of the fishing season was not a national holiday. The only reprimand in the files of Dr. Day, director of the Geophysical Laboratory, was a letter to Schairer in regard to unauthorized absences for long fishing weekends. It seemed thoroughly incongruous that such a highly energized person would stand for hours in cold water patiently waiting for a fish to bite. It took considerable persuasion during geological field trips to prevent him from dropping his line in every tempting stream.

During his professional career Schairer served as president of the Mineralogical Society of America (1943); president of the Geochemical Society (1967); president of the Volcanology, Geochemistry and Petrology Section of the American Geophysical Union (1956-59); vice-president of the Geological Society of America (1944); and vice-president of the International Association of Volcanology. In addition, he was elected to the Petrologist's Club on December 20, 1927, and served as its secretary-treasurer (the presiding officer) for five years.

THE FAMILY TIES

The Schairers were a close and loving family. Frank's frequent trips home during college and after his move to Washington continued until the death of his mother on November 13, 1939. He married Ruth Naylor, who shared his fondness for the outdoors, on July 20, 1940. Frank had followed his own advice to the young Fellows: Take your bride-to-be on the trail. After rain, cold, blisters and hunger, you—or she—can make sure that love is not blind. They honeymooned on Upper Kintla Lake in the remote northern section of Glacier National Park, Montana.

Twins John (Jack) Everett and Jeanne Evelyn, born on February 17, 1943, were a constant joy for all the family. Frank's father made long visits to Washington and took great pride in wheeling the twins down the avenue.

His six sisters are Helen and Marion Schairer of Rochester, New York; Mrs. Emily Callahan of Bridgeport, New York; Rosemary Schairer and Mrs. Virginia Meagher of Anchorage, Alaska; and Margaret Turner of Victor, New York. Jack Schairer now resides in Madison, Wisconsin, and Mrs. Jeanne Rzeszut lives in Anchorage, Alaska. Mrs. Ruth Schairer continues to enjoy their retirement home in Chevy Chase, Maryland.

REST AT LAST

Mandatory retirement occurred on June 30, 1969, but as Schairer put it, "They retired me one day and rehired me the next day." His part-time employment, with supplemental remuneration, did not diminish his full-time contribution. At a banquet in his honor on April 21, 1969, over 100 friends saw a pictorial review of his life. He was presented with "The Schairer Volume," a special volume of the *American Journal of Science* (vol. 267A), consisting of twenty-eight papers on new phase equilibria studies by his colleagues, former fellows, and a few other experimentalists. Hardcover copies of the volume were bound in blue and gold, the Yale University colors.

The end of this happy and productive life came on September 26, 1970, when Schairer died suddenly while splashing about in the waters of the Chesapeake Bay near the summer home of his brother-in-law at Point-no-Point, Maryland. All his furnaces were loaded with runs, a manuscript on a quaternary system was in preparation on his desk, and Fellows were awaiting his help on their projects.

A large number of his friends came personally to pay tribute to the man for his integrity, extensive knowledge, contagious enthusiasm, and for the great pleasure he gave to all. Most fittingly, his casket was covered with orchids, *Cattleya chevy chase.* After services at the Shrine of the Most Blessed Sacrament at Chevy Chase Circle he was laid to rest in section 17, lot 4, in Washington's Rock Creek Cemetery.

Twenty-five years have slipped by since Schairer's death; yet the personal memories are still vivid and the Schairer stories are frequently recalled by the Geophysical Laboratory staff. Schairer's phase diagrams remain the firm foundation on which igneous rocks are discussed today.

IT IS A PLEASURE to acknowledge the kindness of Frank's six sisters in preparing their recollections in 1971 of his early days at home and school. Professor Brian J. Skinner arranged to have copies of files sent from the undergraduate school, graduate school, and alumni office of Yale University. James H. Shipler provided confirmation of Schairer's employment at the Eastman Kodak Company and some background on his synthesis of organic chemicals. Free access to the files of the Geophysical Laboratory was made available through

the courtesy of its director, Charles T. Prewitt. The officers of the various societies with which Schairer was associated are thanked for providing confirmation of his election, offices, and awards. The manuscript was reviewed at various stages by Gordon Davis, F. R. Boyd, F. Chayes, B. Mysen, D. K. Bailey, M. L. Keith, S. A. Morse, and E. F. Osborn. The special help of Mrs. Ruth Schairer in providing the more personal details of their family life is greatly appreciated. No one would agree more than Frank on how an understanding and loving wife can provide the necessary environment for a happy and successful life.

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