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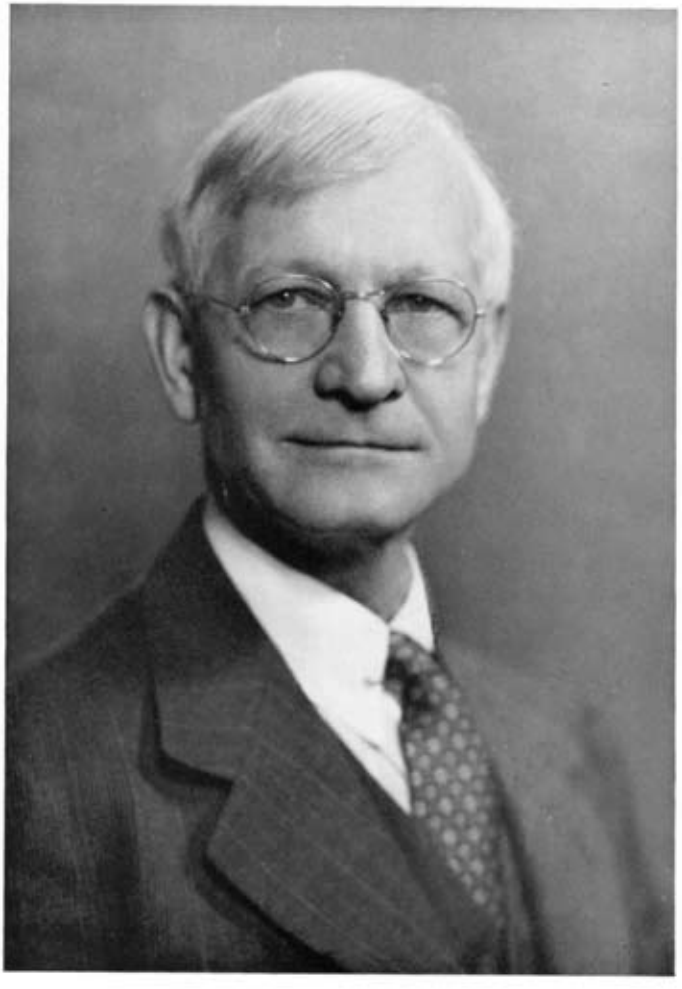
ESPER SIGNIUS LARSEN, JR.

1879—1961

A Biographical Memoir by
A. F. BUDDINGTON

Biographical Memoir



Esper A. Larsen J.

ESPER SIGNIUS LARSEN, JR.

March 14, 1879—March 8, 1961

BY A. F. BUDDINGTON

ESPER SIGNIUS LARSEN, JR., was one of the greatest of field geologists and laboratory petrologists. The volcanics of the San Juan Region of southwestern Colorado, the igneous rocks of the Highwood Mountains of Montana, and the batholithic rocks of southern California were the major objects of his studies. However, not only did he contribute mightily through such regional studies, but the results of two quite different branches of laboratory research by him stand out as classics. He determined the optical properties of over 600 minerals and in 1921 the data were published in a bulletin of the U. S. Geological Survey entitled *The Microscopic Determination of the Nonopaque Minerals*. This, together with the revised edition of 1934 (with Harry Berman), is still the foremost reference work on the subject, found close at hand to the microscope in every petrographic laboratory in the world and a necessity for every student of petrology. A second laboratory contribution was the "Larsen method" for the age determination of rocks, based on the lead-uranium ratio of zircons separated from the rock in question.

Larsen was born March 14, 1879, in Astoria, Oregon. His father came to the United States in 1861 from Bornholm, Denmark, at the age of sixteen with no more than the usual few dollars to his name. His mother was Louisa Pauly, who was born and reared in Akron, Ohio. There were five children besides Esper, Jr.: an older sister and two older brothers and a younger brother and sister. The father ran a grocery store in Astoria, Oregon, at the time of Esper's birth

but the family moved to Portland, Oregon, when he was a very small boy and he grew up and received his schooling there. His father was by then a successful wholesale grocer, who also ran three retail grocery stores and was the first Danish consul in Portland. Esper, Jr., died just six days before his eighty-second birthday. His parents were also long-lived, the father dying at seventy-seven and the mother at eighty-five. A grandson remarks that as a child he remembers his grandfather, Esper Larsen, as a stern man with a strong accent, who kept a barrel of pickled herring in the basement, and his grandmother, whom he last saw in 1931, as a very tiny, sweet, and gentle old lady. The Larsen family was always a close group and any crisis in one part of the family always brought immediate help from the rest.

The writer is indebted to several of Professor Larsen's students at Harvard, especially C. S. Hurlbut and W. T. Pecora, for the following references to his marriage and home life. Shortly after he joined the U. S. Geological Survey staff in 1909 Larsen met Eva Audrey Smith, daughter of Sylvester Clark Smith, U. S. Representative from Kern County, California, at a dance to which Larsen had been herded by that great chemist, W. F. Hillebrand. The Larsen-Smith wedding in 1910 in Bakersfield was a gala event, and W. C. Mendenhall, later Director of the Survey, served as Larsen's best man. For more than fifty years Mrs. Larsen watched lovingly over her scientist husband, sharing in his successes and bereavements, at times annoyed by his absent-mindedness, but always subordinating her wishes to his. The Larsens opened their home to students on numerous occasions, in one instance allowing a student's sick wife to be nursed back to health over a period of several months. They were truly gracious and charitable. Once, when Larsen was told he should take a vacation from work, he replied, "I have two a year. In the summer I have a vacation from teaching and laboratory and in the winter I have a vacation from field work." In 1948 he attended the International Geological Congress in England. It was the only time he left the North American continent, and this was done under protest and at the insistence of Mrs. Larsen.

The Larsens had two sons, Clark Smith Larsen, who died in 1945 at the age of thirty-three from a heart ailment, and Esper Signius Larsen, III, who died of a coronary failure on October 6, 1961, just a few days short of his forty-ninth birthday. Esper Larsen, III, had followed a career similar to that of his father, receiving the Ph.D. degree in geology at Harvard in 1940. He was a petrographer at the Saranac Laboratory for the study of tuberculosis in 1941–1942 and then joined the U. S. Geological Survey, where he served as a distinguished scientist-administrator. As one of his biographers wrote, "Like his father, he was a humble man, so well-balanced that he never ceased to be amazed that his colleagues came to him for counsel in trust and implicit faith."

After graduation from the Portland public high school, Esper, Jr., because of the temporary financial straits of his family, spent four years working in a wholesale grocery store to accumulate the wherewithal for college expenses. In 1902 he entered the University of California with the intention of studying mining engineering. While at the university he took several advanced courses in mathematics and chemistry along with geology, and under the influence of A. C. Lawson and A. S. Eakle he developed the beginning of his life interest in mineralogy and petrology. He was graduated from California (Berkeley) in 1906 and served the next year there as an instructor in geology and mineralogy. He left the university in 1907, but in 1918 received the Ph.D. degree on submission of a thesis entitled "Areal Geology of the Creede Mining District, Colorado."

After leaving the university he spent two years (1907-1909) as Assistant Petrographer at the Geophysical Laboratory of the Carnegie Institution in Washington. There he worked with F. E. Wright and together they published the classic paper "Quartz as a Geologic Thermometer." Their results suggested a temperature of around 573°C, plus allowance for pressure effects, for the formation of normal granite pegmatite, a figure which still stands. At the Laboratory Larsen was also associated with H. E. Merwin. The principle of determining the index of refraction of a mineral by immersion in a liquid had been demonstrated in the last decade of the nine-

teenth century, but the method for routine exploitation of the principle was developed at the Geophysical Laboratory by F. E. Wright. It consisted simply in having a whole series of liquids available whose predetermined index was known. The method, however, required that the indices of refraction of minerals be known. It was the latter necessity which stimulated Larsen to secure the requisite data and compile his monumental work on the optical determination of the nonopaque minerals, later, while he was a member of the U. S. Geological Survey.

His extensive and intensive review of the optical properties of over 600 minerals for his book on their microscopic determination gave him an unusually fine background for the recognition of new minerals. He was author or coauthor in the description of twenty-four new mineral species.

The study of rocks and minerals based on field work, however, was what really appealed to Larsen, and in 1909 he joined the U. S. Geological Survey, where he remained for fourteen years. From 1918 to 1923 he was in charge of the Petrology section. His field work while with the Survey was concerned largely with a study of the San Juan region of Colorado and New Mexico, one of the world's greatest areas of unmetamorphosed volcanic rocks. In this work he was associated in the early stages with W. H. Emmons in a study of certain mineral deposits and with Whitman Cross in research on the volcanics. Cross had been working on the geology of this area for fifteen years when he was joined by Larsen in 1909. Until 1930, except for three years spent in search for tungsten and molybdenum deposits during the First World War, Larsen returned for at least a part of each summer to his beloved San Juan. Many men had a part in this work. Cross supervised both field and office work until his retirement in 1925. The final preparation of the maps and text of the ultimate professional paper and responsibility for the conclusions were assumed by Larsen, and a considerable part of his time between 1930 and 1949 was devoted to detailed laboratory investigations under the auspices of Harvard University.

The investigations in the San Juan region resulted in a series of papers culminating in 1956 in a joint publication with Whitman Cross of the Professional Paper of the U. S. Geological Survey entitled *The Geology and Petrology of the San Juan Region of Southwestern Colorado.*

The work in the San Juan country required the geologist to be a "mountain man," for the topography is rugged and the altitudes in many places over 12,000 feet. Larsen has described the method of work as follows:

> We camped in the mountains in places convenient to our work. Beautiful campsites were common, excellent water was abundant in nearly all parts, and wood could be found nearly everywhere below timberline. Feed for stock was excellent in most parts of the mountains and most of the time our stock kept in fine condition with no feed other than the grass they could find near camp. We moved camp by a pack train of mules. So far as possible we worked from horseback and it is remarkable how large a part of these rugged mountains can be traversed without trail by a good horse that is trained in mountain work. Of course, much work had to be done on foot, as the local relief is commonly several thousand feet.

This was the kind of life that demanded much but yielded the keenest of satisfaction to one who, like Larsen, was keyed to it. The San Juan report dealt not only with petrology but with all aspects of the geology of the region.

To the writer of this memoir the most outstanding results of interest to petrologists as a whole deriving from the San Juan studies were the papers entitled "Petrologic Results of a Study of the Minerals from the Tertiary Volcanic Rocks of the San Juan Region, Colorado," published in 1936, 1937, and 1938, written in coauthorship with several associates, one of whom was Larsen's son. Here, for the first time in the history of petrology, was presented a superb unified systematic study of the phase petrology of a wide variety of volcanic rocks of a single region, correlated with their bulk composition and interpreted by one thoroughly familiar with the geologic relationships and history as revealed by personal field studies. The

data, including twenty-three chemical analyses of rock-making minerals, are a permanent contribution to the literature.

The interpretations of the chemical relationships of the volcanic rocks were based on over a hundred chemical analyses. As a result of his studies Larsen found that in the lavas of the San Juan Mountains there are probably more tridymite and more cristobalite than quartz. The tridymite was especially prevalent in the groundmass of rhyolitic volcanics. His studies of the phenocrysts in relation to the composition of the groundmass in which they occurred led him to conclude that most of the plagioclase phenocrysts did *not* crystallize from a magma of the composition of the lavas in which they were found. Similarly, many of the other kinds of phenocrysts were also of foreign origin. He concluded that, whereas some phenocrysts might be due to sinking or floating, most are the result of thorough mixing of two partly crystallized magmas or by reaction on solidified rock. The papers also contain curves showing the relative volumes of residual liquids and their composition where maximum fractional crystallization of plagioclases of different compositions occur—data fundamental to discussions of magmatic differentiation by crystal fractionation.

The summer of 1906, following his graduation from the University of California, was spent by Larsen as an assistant to Dr. W. C. Mendenhall in geologic mapping in the Corona quadrangle of southern California. On essential completion of work in the San Juan region in 1930 Larsen returned to the region of his first field work, the Corona quadrangle of southern California and the adjacent Elsinore and San Luis Rey quadrangles. His prime interest here was a study of a part of the southern California batholith. Several of his Harvard students assisted him in this work, which required in all about twenty-two months (1930–1932, 1936, 1938) in the field. He was able to demonstrate that in the area studied the batholith was complex and emplaced by over twenty separate injections, largely by stoping. From a study of the San Juan lavas Larsen had concluded that they were largely the product of fractional crystallization of

basaltic magma. Similarly, he concluded that the different rocks of the batholith—the gabbros, tonalites, granodiorites, and a little granite—were formed from an intermediate gabbro magma by crystal differentiation modified by assimilation in depth.

In 1923 Larsen became Professor of Petrography at Harvard University, where he remained until his retirement in 1949. There is unanimity amongst his students that Professor Larsen was not a good lecturer, yet at the same time that he was one of the most inspiring and one of Harvard's great teachers. One of his students wrote, "His mind usually raced far ahead of his tongue and he frequently corrected himself after the students had laboriously written in their notebooks what he had first told them." Another writes, "He rambled all over the place in his lecturing, speaking in such a simple and self-effacing way that a stranger never would take him for an outstanding scientist," and again, "His saying one word when he meant the opposite was exasperating for students who did not know already what he really intended to say." But his obviously superior scholarship, his stimulating informal discussions, and his patience and interest in his students far outweighed all else.

Larsen's absent-mindedness became legendary. It was as much a part of his character as his gentleness, thoughtfulness, and kindness. He always conducted his graduate courses at his home in Belmont and, as one of his students writes,

> Here, in addition to dispensing wisdom and refreshments, he made a valiant but generally unsuccessful effort to learn the students' names. This trivial obstacle was something he never successfully mastered and the students, forewarned by their predecessors, amiably responded to names of those long since departed from the Harvard scene.

One story has it that, when writing on the blackboard in an informal seminar at his home, he was apt to put the piece of chalk in his mouth and try to write on the blackboard with his cigarette. According to another, after his retirement to Washington a colleague was in the habit of picking him up at a certain corner and giving him a ride to the office. One morning the host was a bit early and

he noticed Larsen about two blocks from the usual corner, pulled up alongside him, and called to him to get in. Larsen politely refused, saying he would get a ride a couple of blocks down. The driver stopped at the next corner, waited for him, and then, addressing him as Professor Larsen, asked him to get in and received the same polite refusal. But when the driver waited for him at the usual corner, Larsen stepped in, wholly unaware of what had gone before. Larsen himself recognized his failing, for in a review of a book in 1935 he wrote, "Too much elaboration in nomenclature may retard progress. I speak with feeling as I have a poor memory for such things."

In 1933 Larsen chose Central Montana in general and the Highwood Mountain area of Montana in particular as a suitable training ground for his graduate students in studies on the geology of the igneous rocks. Several men participated in this work, which resulted in a series of papers and a summing up incorporated with his own observations in a publication entitled *Petrographic Province of Central Montana.* This paper was primarily concerned with defining the "petrographic provinces" of the region which, he declared, must be defined both in terms of place *and* of time. The provinces were discriminated primarily on the basis of the systematic variation in chemical composition for associated *series* of rocks. He developed a system of his own for plotting the constituents and drawing variation diagrams. B. F. Buie, C. H. Burgess, David Griggs, and C. S. Hurlbut participated in these studies, and W. T. Pecora in those in the Bearpaw Mountains.

The last three decades of Larsen's active research were a period of intense discussion and controversy among petrologists concerning the origin of granite. To what extent were the great bodies of granitic rock emplaced as magma, to what extent were they the product of granitization of solid rock or the result of metamorphic recrystallization of suitable sedimentary or volcanic rocks? N. L. Bowen, one for the world's leading exponents of the magmatic origin for granitic rocks, in a volume dedicated to Larsen on his retirement from Harvard, contributed an article entitled "The Mak-

ing of a Magmatist," in which he set forth the background which doubtless had led Larsen to his emphasis on magma as the major origin for batholithic granite masses. Bowen wrote of him:

> He probably scorns a label, preferring to be regarded as one who keeps an open mind as indeed he is, but it is no great distortion of the truth to say that Professor Larsen is a magmatist. He would not, at least, regard this designation as a term of contempt, nor should he, for he acquired magmatist views as a result of long years of arduous field studies in difficult but rewarding terranes and of equally arduous investigations of materials and collation of facts gleaned in the field.

The tremendous volume of lavas and volcanics studied by Larsen in the San Juan region was unequivocally of magmatic origin. Associated with them were bodies of rock showing the same range of chemical composition as the effusive lavas but with such size and structural relations to the surrounding rocks that they were called dikes, sheets, sills, laccoliths, and stocks. Yet similar textures could be found in their chill facies, and these masses too were reasonably called of magmatic origin. With such a background it was only a further step, long as it might be, to interpret the great southern California and later the Idaho batholith as composite bodies built up by successive magmatic intrusions. This problem continues to be one of active debate.

Larsen also systematically interpreted the diversity of the igneous rocks of all three regions in which he worked—the San Juan, southern California, and Central Montana—as the product of a slow differentiation at depth by fractional crystallization of a *basaltic* magma, with some further differentiation through crystal fractionation after eruption toward the surface, and modified by assimilation and locally by mixing of different magmas.

The period of Larsen's professional activity was also one in which the Carnegie Geophysical Laboratory of Washington pioneered systematic *quantitative* experimental physico-chemical studies of constituents pertinent to the problems of the diversity of igneous rocks and made outstanding contributions to their understanding. Larsen

had himself spent two years in research at the laboratory and was therefore favorably inclined toward use of the experimental data. However, as a result of his extensive and intensive observational studies in field and laboratory of the natural rocks, he had come to have an inherent recognition of both the principles and the complexities of their relationships. As a result he felt that the available principles and data based on experiment were not yet adequate to warrant acceptance as controls having first priority where inductions from the rocks seemed to indicate contrary interpretations. The present writer is in complete sympathy. A book by N. L. Bowen, *The Evolution of the Igneous Rocks,* is a classic presentation of the application of experimental physico-chemical data to the problems of igneous rocks. Larsen wrote in a review: "Since progress is much delayed by overconfidence in our knowledge, the reader is warned that Bowen's great reputation, his vigorous presentation, and the positiveness of geophysical arguments may mislead one into concluding that the whole matter is unquestionably settled."

One procedure for determining the age of rocks has come to be known as the "Larsen method." Hurlbut has outlined the historical development of the idea. He writes:

> The last decade before his retirement from Harvard, Larsen became interested in the measurement of geologic time, and over a third of his publications from then on dealt with this problem. Although he had long been interested in the subject, his active participation began while determining the rare elements in the rocks of the southern California batholith in which he found that the radioactivity was concentrated in the zircon and a few other rarer accessory minerals. Would it be possible, he questioned, to separate the zircon, determine its radioactivity by the measurement of alpha emanations and its content of radiogenic lead by spectroscopic means? If this could be done and a lead-uranium ratio obtained, the age of the rock could be determined. Aided by a generous grant from the Geological Society of America and after ten years of careful, painstaking and often frustrating work on the part of Larsen and several assistants, this supposition was confirmed. The *Larsen method* is today one of the standard procedures of age determination.

Professor Larsen retired from Harvard in 1949 and returned to

Washington, D. C., where he became a consultant to the Geochemistry and Petrology Branch of the U. S. Geological Survey. There he remained active until 1958, when poor health forced his complete retirement. During this active period his main researches were centered on studies on the lead-alpha age method, the distribution of uranium in the rocks of the San Juan region, and the Mesozoic batholiths in the western United States. In this work he was associated with younger colleagues, several of whom were his former students. The last publication carrying his name as coauthor appeared in the year of his death.

Professor Larsen was a member of the National Academy of Sciences (elected 1944), the American Academy of Arts and Sciences, the American Institute of Mining, Metallurgical and Petroleum Engineers, the Geological Society of America, the Mineralogical Society of America (a charter Fellow, and President in 1928), Society of Economic Geologists, Mineralogical Society of Great Britain, and the Geological Society of London. He received the highest award of the American Mineralogical Society, the Roebling medal, and of the Geological Society of America, the Penrose medal. In 1950 a volume entitled "Studies in Petrology and Mineralogy" and published in the *American Mineralogist* was dedicated to him. Over half the papers it contained were written by his former students, and he derived great personal satisfaction from this *Festschrift.*

This biography has been based substantially upon a memorandum supplied by Esper Larsen, III, before his death and upon biographical memorials prepared by W. T. Pecora for the Geological Society of America and by C. S. Hurlbut, Jr., for the *American Mineralogist.* The writer is also indebted to former students of Professor Larsen at Harvard, C. H. Burgess, J. K. Gustafson, John B. Lyons, and Arthur Montgomery, for their personal recollections.

Larsen was author or coauthor of 130 published papers. He will be remembered by all his associates as a man of keen balanced judgment in scientific matters, an always active contributor to science, and a warm personality who never spoke disparagingly of anyone.

KEY TO ABBREVIATIONS

Am. J. Sci. = American Journal of Science
Am. Mineral. = The American Mineralogist
Bull. Geol. Soc. Am. = Bulletin of the Geological Society of America
Calif. Div. Mines Bull. = California Division of Mines Bulletin
Econ. Geol. = Economic Geology
Geol. Soc. Am. Mem. = Geological Society of America, Memoir
J. Geol. = Journal of Geology
J. Wash. Acad. Sci. = Journal of the Washington Academy of Sciences
Proc. Geol. Soc. Am. = Proceedings of the Geological Society of America
Trans. Am. Geophys. Union = Transactions of the American Geophysical Union
U. S. Geol. Survey Bull. = United States Geological Survey, Bulletin
U. S. Geol. Survey Prof. Paper = United States Geological Survey, Professional Paper
Z. Krist. = Zeitschrift für Kristallographie

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