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1928–2007

A Biographical Memoir by

PETER J. WYLLIE

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BY PETER V. WYLLIE

Joseph V. Smith was born on the 30th of July 1928, in Derbyshire, England. He married Brenda Wallis at Crich, Derbyshire, on the 31st of August, 1951, moved to the USA, and their family grew with two daughters, Virginia and Susan. He retired in September 2005 as the Louis Block Professor Emeritus in Geophysical Sciences and the College at the University of Chicago. On Friday the 6th of April, 2007, at age 78, he died of pneumonia at Beth Israel Deaconess Medical Center in Boston. Parkinson's disease had begun to take its cruel toll about five years earlier. He and his wife Brenda moved to Brookline in 2005 to be near their daughter, Virginia, and family, where he suffered a broken hip and several heart attacks before the final event. In the meantime, he continued to write an autobiographical book *Living Safely* which dealt with local and global problems facing our species. As Brenda said: "He was very strong and very stoic. He handled any difficulties in life the way he handled his illness."

In early April, a reporter from the Boston Globe asked me, by phone, for information about Professor Smith. From

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my troubled, garbled conversation the reporter recovered the following quotation: "Joe was one of the great mineralogists of his time, both in an intellectual sense and a practical sense. He did first-rate science that was always at the forefront. And he pursued practical applications in a very powerful way. He was also always looking for the next, best way of studying minerals." His many honors support these statements. These include election as Fellow of the Royal Society of London and member of the US National Academy of Sciences [1986], and award of the Murchison Medal (Geological Society of London), the MSA Award (young scientist award of the Mineralogical Society of America) and the Roebling Medal (the highest research award of the Mineralogical Society of America). He published at least four books and more than 400 scientific papers that spanned several disciplines. There is a mineral, joesmithite, named in his honor by Paul Moore, in 1968 (a plumbous amphibole). Below I have taken the opportunity to offer more comments with outlines of his education, his academic and administrative appointments, his work developing instruments, his books, some of his research programs, and his concerns about stewardship of the Earth and its inhabitants.

Joe Smith was very proud of his first 17 years living on a farm in Derbyshire, England, and always maintained that he was still a farm boy. He attended village schools, and because he was the only candidate for the Cambridge Entrance Examinations, he was excused from all classes so that he could study on his own. He worked through all the Entrance Exams from the previous 30 years and won a scholarship to Gonville and Caius College. His admission to Cambridge University in 1945 would have been considered a triumph for his school. In Joe's own words: "My competitors came from famous public schools such as Eton, Harrow and Winchester and long-established grammar schools. The country mouse was awed but not intimidated.” He earned a B.A. (first class honors) in Natural Sciences in 1948, and advanced to a PhD in crystallography in 1951. He reported “superb teaching” for undergraduates, but found his assigned computations for the structure of calcium carbonate minerals so tedious that he almost quit the academic path. However, he liked the research environment and faculty associates, so he persisted.

William H. Taylor recommended him for a Fellowship at the Geophysical Laboratory of the Carnegie Institution of Washington, and Joe concluded later that this was “perhaps my greatest good fortune.” In fact, his greatest good fortune came first when he “rushed home to get married to Brenda Wallis, a beautiful and intelligent girl from Fritchley, Derbyshire. “We had been at Fritchley elementary school, where she later told me that she had picked me out for a husband at the age of ten!” They married, and sailed to the USA on the *Queen Mary* in 1951.

Joe and Brenda Smith at the 1987 meeting of the International Union of Geodesy and Geophysics in Vancouver, Canada.

For Joe, the Geophysical Laboratory was an intellectual and experimental Mecca. He credited his new colleagues W.S. MacKenzie, O.F. Tuttle, H.S. Yoder and F. Chayes for educating him to some extent in Earth Sciences while still remaining "green as grass. Geology was baffling …" He reported that he found rather primitive facilities for crystallography compared with those at his training grounds in Cambridge University, so he had to build his own X-ray generator from miscellaneous old equipment, chicken wire, and a cocoa tin at a cost of $2. When asked why he had such a fine pair of experimental hands, he would explain that thanks to his upbringing on a farm, he was one of the few crystallographers who could obtain satisfaction from sitting on a stool and milking a cow, the old-fashioned way. He claimed that it was this kind of training that guided him in the construction of his generator that yielded four single-crystal diffraction photos a day.

I was introduced to J.V. Smith in a series of papers on feldspars by MacKenzie and Smith that were required reading during my honors year and as a graduate student. William Scott MacKenzie had been the Teaching Assistant during my undergraduate years at the University of St. Andrews, Scotland, and he had made his way to the Geophysical Laboratory in 1952, via Cambridge. He introduced Joe to the feldspars, and the combination of Joe's knowledge of solid-state chemistry and physics with Mac's knowledge of minerals and rocks generated a remarkable series of papers, and a life-long friendship. That was when Joe realized that he must learn petrology and geology.

Before examining his developments with instruments and broader Earth and Planetary Sciences, let us preview his successive travels and appointments. After Washington, the Smiths returned to Cambridge where Joe was a Demonstrator between 1954 and 1956. Then, Frank Tuttle invited

Joe to join him as Assistant Professor in the Division of Earth Sciences at Pennsylvania State University, which had become home for several former Geophysical Laboratory scientists. Joe did not want to leave England, but in his own words "on checking around, no suitable tenured position was available. Oxford paid strictly by age, and my advanced experience did not count; Bristol decided that I would be better off at Penn State; and Cambridge stated that no tenured positions would-be available for some years." English newspapers at that time were full of stories about the 'brain-drain', and the Smiths joined the movement in November 1956. That was when I first met the Smiths in person, because Harald Drever (St. Andrews) and MacKenzie had arranged for me to join Frank Tuttle as research assistant in 1956, while I completed my St. Andrews PhD. I returned to Leeds University in 1959, and the Smiths moved on to the University of Chicago in 1960; Joe was full professor at the age of 32. I returned to Penn State in 1961, and was in turn enticed to the University of Chicago by Joe Smith and Julian Goldsmith in 1965. We shared 18 years together in the intimate community of Hyde Park, with growing families and scientific goals. After my family moved to the California Institute of Technology in 1983, I watched Joe's expanding horizons with awe. When he retired in 2005, at age 77, he had been a Chicago professor for 45 years.

Joe Smith's Chicago colleague Robert Clayton described him as "an entrepreneur in the development of instruments." When Joe arrived in 1960, he devoted about four years, as a pioneer, to the building of an electron microprobe for the Department of Geophysical Sciences, and in developing the techniques that made the machine work successfully. In the early 1960s there were many analysts who said that the electron probe would never yield quality results because there were just too many problems. The task was rather like making science fiction become fact. The Chicago department was one of the first to have a successful instrument, an instrument that is now ubiquitous in geology departments. Twenty years later, he devoted similar efforts to the ion microprobe. For establishment of the difficult analytical procedures he gave much credit to Ian Steele, Ian Hutcheon and Ron Draus.

From the mid-1980s, Joe became intensely involved with a second-generation of synchrotrons that were built to optimize X-ray and infrared beams. In addition to participating in national planning for these advanced radiation sources, he was Principal Investigator for a program at Brookhaven National Laboratory to set up a national facility for X-ray fluorescence analysis. When a high-energy source was assigned to Argonne National Laboratory, managed by the University of Chicago, he was asked (as the local expert) to build the facility at the Advanced Photon Source. In 1988, at 60 years of age, Joe somewhat reluctantly accepted this administrative load. He reported that this set him on a 12-16 hour day through the next five years before turning over the facility to Keith Moffat, Mark Rivers, Steve Sutton, James Viccaro and Joy Talsma. But he did not neglect research. In 1989 he organized a multi-institutional, multidisciplinary group of scientists to use the Advanced Photon Source. CARS, the Consortium for Advanced Radiation Sources, developed into a productive activity spanning three sectors for the application of X-rays to: structural biology; chemistry and material sciences; and geo-soil-environmental sciences. CARS raised millions of dollars through 15 years. Joe was director until 1993. He noted that although this turned him effectively into a full-time businessman as he hunted for money, it also required that he read widely. He became increasingly concerned about the use of the world's limited resources for war rather than for humanity, and he became interested in the toxic elements that affect the health of so many people around the world. This influenced his research and writing from the 1990s. So, let us return to some aspects of his research development.

Joe started off as a crystallographer, and followed his structural interests into mineralogy. The early series of feldspar papers by Smith and MacKenzie guided Joe deeper into the details of this most important rock-forming mineral of the Earth's crust. He described Tom Barth as a genial host at the 1963 NATO Institute on Feldspars at Oslo, and blamed him for the inspiration to begin writing a treatise on feldspars. The task was facilitated in 1965 by preparation of a course on feldspars during a term visiting at the California Institute of Technology. I saw Joe at work on this treatise. He was a literature soak. He went on most Saturday mornings to the library armed with index cards and pen, and returned with a stack of notes. I had the impression that he checked every worth-while journal, gathering information on feldspars (and anything else that caught his fancy). He also copied and collected abstracts. Furthermore, he seemed to remember nearly everything that he collected on those cards. His encyclopedic knowledge and critical insight were well represented 10 years later when his treatise on *Feldspar Minerals* appeared in two volumes (Smith, 1974). One reviewer wrote that libraries should purchase two copies, because the first set would soon be worn out. A third volume was published in 1988 (Smith and Brown, 1988). These books identified Joe Smith as the world's feldspar authority.

Joe's textbook on *Geometrical and Structural Crystallography* (Smith, 1982) followed the monumental feldspar monographs. The contents are very different from the crystallography that I enjoyed as an undergraduate and I cannot write about them with insight. The book cover comments: "...unique approach begins on a simple level with symmetry, packing and topology as a framework for subsequent study of crystal structure.

Complicated mathematics and theorems are avoided in the early chapters. Point group symmetry and equivalent positions are developed early in the text, so that the shapes of crystals are explained on the basis of atom construction." There are more than 200 illustrations, and graded exercises divided into three levels planned to encourage the development of thinking in three dimensions. Joe's office and laboratory were full of three-dimensional models of crystal structures of real minerals and designer zeolites.

During the feldspar-production years, Joe began to work on the structures of zeolites as a consultant to the Linde Division of Union Carbide Corporation at Tonawanda, NY. He started consulting originally in 1956 to pay family fares for visits to England, and he fell into one of the great success stories of industrial chemistry. Zeolite molecular sieves have revolutionized catalysis, and this led him into quite a different world. Donald Breck and Edith Flanagan of Union Carbide guided Joe, and he described them as brilliant chemists ready to preserve the scientific integrity of his research. I understand that Joe designed possible zeolite structures and compositions, and they synthesized the minerals. Joe's role was to answer basic questions concerning how many zeolite frameworks were possible; how were structural frameworks of the existing zeolites assembled from sub-units, and could the pieces be assembled in other ways; was there a limit to the size of windows for the molecular sieves; how many atoms could be expected to go into the zeolite frameworks; where did the exchangeable cations reside in the crystal structures; ands on. This basic crystallographic research had huge societal impact. One synthetic zeolite became a commercial success as a component of washing powder that replaced the phosphorus compounds that promoted noxious algal blooms in rivers and lakes. Other zeolites replaced the old amorphous catalysts and tripled the yield of gasoline from oil. The world of molecular sieves is one in which major oil companies sue each other over patents on the use of zeolites as catalysts for cracking petroleum. Joe Smith was called on as an expert witness in at least one of those suits. For their meticulous research on synthetic zeolites, Joe has expressed debts to his academic colleagues Gerry Gibbs, Joe Pluth and Michael Bennett.

While feldspars and zeolites were still perking away, the Apollo Program to land men on the moon and to return rock samples was steaming to a boil, and Joe couldn't resist the excitement. He became a principal investigator and extended his research to the origin of lunar rocks, which completed his transition from crystallographer through mineralogist to petrologist. Apollo 11 in July 1969 returned the first lunar rock samples to Earth. The results were presented in March 1970 at the first Lunar and Planetary Science Conference. Joe reported the first new mineral on the Moon, *pyroxferroite*, and presented a model for a hot Moon which contradicted the dominant, standard model that the Moon had remained cold during its formation. The hot Moon of Joe Smith and his Chicago team (of about nine colleagues) were given a somewhat frigid reception. Joe presented a model relating the mineralogy and petrology of the rocks to the differentiation of a very large body of magma, with feldspars rising to form the light-colored highlands. He credited John Wood for a related interpretation of floating feldspars. Joe maintained that the Moon's surface must have been extensively melted in a series of catastrophic meteorite impacts. At a press conference afterwards, Harold Urey, the eminent former Chicago faculty member, stated that he couldn't imagine how someone from his Alma Mater dared to propose such a ridiculous scheme. The moon had accreted as a cold body, and the presence of lavas demonstrated only that some local events had temporarily caused minor heating. A decade later, magma oceans on both moon and Earth appeared to be accepted even by those who wrote in 1971: "this is not possible" and "entirely lacking in supporting evidence" and "encounters a fatal difficulty." What Joe did, in fact, was to look at the evidence, reach a conclusion, and state it, despite the fact that it ran counter to 1970 rules. A farm boy ploughs his own furrow. His co-authors were convinced. The lunar work expanded Joe's horizons to the origin of planets.

His research, his intensive extended reading, and his deliberations were well represented by his Hallimond Lecture for the Centenary of the Mineralogical Society of Great Britain, published as: *Mineralogy of the Planets: a Voyage in Space and Time* (Smith, 1979). This began and ended with verses from Milton's *Paradise Lost.* He was saddened by developments in the Space Program after Apollo, writing in his acceptance of the Roebling Medal (Smith, 1983): On this happy occasion, "I will not pursue the present state of the space program which is increasingly bedeviled by the evil consequences of political and nationalistic rivalries."

The Apollo Program established a surplus of excellent analytical facilities for a small number of returned samples, and Joe joined other investigators in seeking ways to put the facilities to continued good use. Barry Dawson reminded me that I had put Joe in touch with him because he had a superb collection of rare African rocks. Joe visited Barry in St. Andrews in August 1971, returning with selected samples. Barry visited Chicago in April 1972, and returned for later visits that led to an incredibly productive series of joint papers dealing with analyses and interpretations of mantle nodules and other African beauties. Barry Dawson was one of the organizers of the First International Kimberlite Conference of 1973, when De Beers opened up several kimberlite mines for detailed, guided tours. Smith and Dawson presented three papers on intricate mineralogy. Joe was one of the many participants who had their eyes opened in the darkness of deep mines to the complexities of kimberlite magmas. Excellent fieldtrips were organized, and I recall fragments of stimulating stories of Joe riding (or failing to ride?) a donkey (or was it a mule?) on the mountains of Lesotho. Joe thus graduated as a field geologist.

At that time, it was widely held that diamonds had precipitated from kimberlite magma; they were phenocrysts rather than xenocrysts. Diamonds had been found in a few eclogites derived from the mantle (some said 'crust'), and Vladimir Sobolev in 1969 had described a xenolith of pyrope-bearing serpentine containing diamond. Dawson and Smith were the first to identify diamond in a xenolith of garnet lherzolite, a rock that was recognized as a common upper-mantle rock. This was potentially an abundant source of rare xenocrystic diamond. It was probably this discovery that led to the general acceptance of the idea that most diamonds were just getting a ride on the kimberlite magma train as it shot through the crust.

Joe's lunar research had attracted him to the role of asteroid impacts in the origin of the moon, and their ancient and potential effects on Earth. This topic became lively with the general acceptance in 1980 that events caused by the asteroid impact at Chicxulub were responsible for the dinosaurs' extinction. Then came the concept of the 'nuclear winter' that might follow a major nuclear exchange capable of killing up to 1 billion people in the first few days. Joe was strongly affected by these discussions, and became increasingly concerned about the state of the world and the dismal prospects for its future. During the 1980s he began to write, and make conference presentations, about natural hazards such as earthquakes, volcanoes and threats presented by Earth-colliding asteroids and comets. In 1983, he was asked by the American Geophysical Union to organize a session at the December meeting in San Francisco on 'The Geophysical Consequences of Nuclear Explosions'. As he read the preliminary reports, Joe found that he was becoming obsessed by mental images of burning cities and broken bodies. Then he was invited to present a paper on natural hazards at the 'Fourth International Seminar on Nuclear War' in the hilltop town of Erice in Sicily. This 1984 conference included representatives of the nuclear powers giving papers on military and diplomatic planning. Joe reported that the participants were psychologically incompatible.

In 1983, he wrote in the final paragraph from his acceptance of the Roebling Medal of the Mineralogical Society of America (Smith, 1983): "Let me finish with a hope for the future. Currently the forces of love and friendship seem to be weakening in the world in the face of scientifically-based technology misdirected by fear, hatred and greed. There is no simple choice for an individual scientist, and the easy out is to get on with research and hope for the best. I trust that this society and other ones will make a special effort to develop programs that will increase international cooperation in as many ways as possible. Just consider how research and teaching in mineralogy and other sciences could be improved around the world with just one percent of the money spent on war machines. This is a small goal which is not immediately relevant to the pressing problems of neutron bombs and cruise missiles. But in the long term, international ties between scientists can help to establish that we all belong to one human race, and must learn to live in peace on this planet." This concern for the future intensified through his years with synchrotron-based research.

In 1993, when Joe relinquished the directorship of CARS, he was relieved to return from administration to a professorial life of research and teaching. His science reflected his concerns about the future of the human race. In 1998 he organized a National Academy of Sciences Colloquium on 'Geology, Mineralogy, and Human Welfare'. His opening paper included reviews of emerging chemical microscopes that use neutrons, synchrotron X-rays, and electrons. These were revolutionizing the study of mineral surfaces, fluids and microbes and had many applications to agriculture and soils, trace elements and food quality, the hazards of toxic elements and asbestos, and the formation of ore deposits. Other contributions dealt with topics such as the consequence that as human society expands its dominion over Earth, using natural geological resources, it is increasingly threatened by the destructive power of volcanic eruptions, earthquakes, landslides, floods and storms. The natural geological processes become hazards.

Similar concerns were manifest in his teaching. The University of Chicago College required a 3-term sequence of science courses, general education for non-science students. This was known in the 1970s as 'Rocks and Stars'. In the late 1990s, Joe took on the third term and organized a course entitled 'Geology and Human Welfare'. This was designed to convey the links between Earth science and the human condition. Topics included industrial technology and Earth resources, volcanoes and earthquakes and their impacts, floods and landslides, atmospheric physics and chemistry, military affairs and geology, and ecology and ethics. The geology of the Chicago region included field trips. He felt fulfilled through the three years that he taught this course to intelligent students. Some of the themes covered in the National Academy Colloquium and in the teaching course were developed in a long review paper (Smith, 2000).

Starting in 1998, Joe published several papers on biochemical evolution, beginning with his old friends the feldspars and zeolites (Smith, 1998). His course 'Geology and Human

Welfare' led him to ponder the reasons for human evolution in East Africa, which he discussed with Barry Dawson, his collaborative African expert (now at the University of Edinburgh). During four years of discussions, Barry came up with a correlation between fossil remains and the unusual carbonatite volcanism in the Rift Valley, which could produce soils high in nutrients such as phosphorus. Joe related this to the importance of biological nutrients in a favorable environment for good health. They speculated whether volcanic trace elements might have been a propelling influence on hominid evolution by effecting gene mutation. Their joint manuscript has not been published, but Joe has a paper: *Geochemical Influences on Life's Origins and Evolution* (Smith, 2005). He noted that after the first living cells were generated by geochemistry on internal mineral surfaces, about 4 billion years ago, life evolved with utilization of energy from the sun and incorporation of selected elements. Then he drew on emerging evidence from metabolism, gene regulation and medicine and its possible relationship to geochemistry and an evolving large-brained primate population that happened to be in a good place during the right volcanic interlude.

After retirement Joe Smith was trying to complete his multi-dimensional, autobiographical book (Smith, 2007). Two quotations from that text provide his message to all of us: "Even in 2006, most people are quite unaware of the ecological effects of their actions and the critical need for sustainability. Training in geology, astronomy and ecology, and thinking about the future should be a key feature of school, college and university curricula." "Let us leave a better world for our own grandchildren and every grandchild around the World."

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