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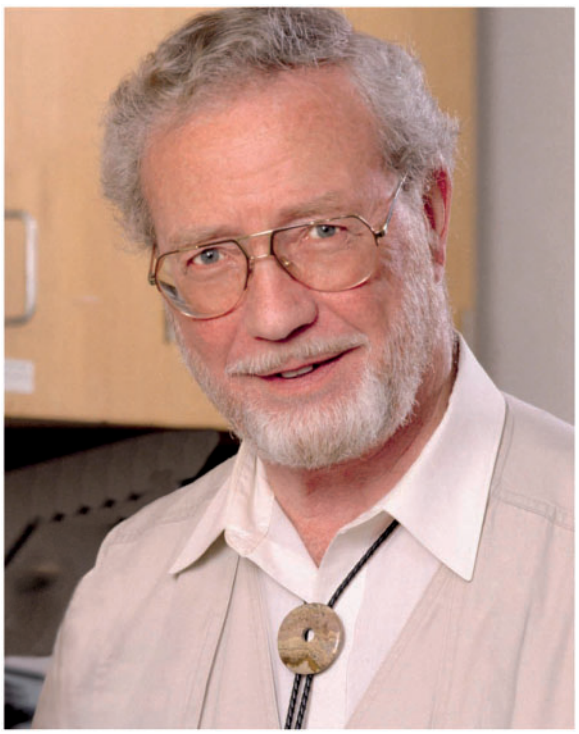
Magma generation and evolution and global tectonics: An issue in honour of Peter J. Wyllie for his life-long contributions by means of experimental petrology to understanding how the Earth works

Foreword



Peter J. Wyllie (Pete) was born in London on 8 February 1930. At the age of 11, he attended Hampton Grammar School, an independent school for boys that has 450 years of history, located in Greater London. In 1949 his love of boxing, first evident at the age of 10, led to him becoming heavyweight champion of RAF Scotland. Otherwise, he was a quiet, warm and happy London boy, a character that has remained in his adult life—warm, kind and generous as both man and scientist. In 1948, Peter sat for the very competitive Gonville & Caius Scholarship Exam at Cambridge University and was awarded an Exhibition worth £40 towards his further education. However, his headmaster suggested that he should try for an Open Scholarship at St. Andrews in Scotland, where he won a Harkness Residential Scholarship worth £100 per year. He first completed his National Service in the Royal Air Force as a Radiotelephony Operator (Aircraftman First Class) (1948–1949) before starting his undergraduate study in Physics and Geology at St. Andrews. In the summer of 1950, towards the end of his first university year, Peter was invited by Harald Drever to join the British West Greenland Expedition (a small university team of only six members, including W. S. Mackenzie) as an assistant glaciologist. After doing glaciology and geology halfway up the west coast of Greenland, Peter became a confirmed geologist, graduating with a BSc in Geology and Physics in 1952. With this experience, he was accepted as Assistant Geologist for the British North Greenland Expedition, a large national team (with 25 members), to explore NE Greenland and its ice sheet from 1952 to 1954. In 1954 he received the Polar Medal from Queen Elizabeth. He obtained his BSc with First Class Honours in Geology in 1955. The 2 years with a husky dog team learning field geology in Greenland from senior geologist J. Douglas Peacock made Peter ready for a life of polar exploration. Indeed, he wished to join the 2 year Commonwealth Trans-Antarctic Expedition, but his Polar mentor Harald Drever advised him first to do research on

Scottish rocks near Skye (PhD completed in 1958), while converting him, with the help of W. S. Mackenzie (by then at the Geophysical Lab in Washington, DC), to another type of geoscientist—an experimental petrologist.

In 1956, 2 weeks after getting married, with his young and beautiful wife Romy he crossed the Atlantic to join Frank Tuttle at the Pennsylvania State University as a Research Assistant. There he was to learn the latest techniques in experimental petrology, and with laboratory experiments he hoped to explore and perhaps explain the origin of those West Greenland olivine-rich lavas to which Drever had introduced him. Peter dearly missed his dog team and ice-carved rocks, but was seduced into the tyranny of the laboratory to begin his most creative, prolific and influential life-long research career in experimental petrology; that is, to use materials in tiny charges and crucibles under high temperatures and pressures to simulate magma generation and evolution in the Earth, initially at crustal pressures but eventually reaching pressures and temperatures corresponding to mantle depths of 150 km. Under Tuttle's influence Peter very early recognized the significance of volatiles in magma genesis in all geological environments.

Together with his colleagues at Penn State (1956–1959, 1961–1965), the University of Leeds (1959–1961), the University of Chicago (1965–1983) and Caltech (1983–present) he determined many phase diagrams, using both natural rocks and synthetic systems. Experiments were conceived and designed with specific geological problems in mind, and the results used to test and constrain hypotheses on the origin of a wide range of magmatic rocks. Most of the results have applications to the origins of granitic rocks, andesites, kimberlites and carbonatites. He often incorporated these applications into broader reviews involving plate tectonics, mantle circulation and other global processes, published in more than 300 scientific journal papers, two textbooks and an edited monograph.

It is fair to say that modern igneous petrology and geochemistry would not be the same without the many original research contributions by Peter Wyllie and his co-authors. In the *Journal of Petrology* alone, he has published 15 papers. In fact, he is the author of the very first paper in the first issue of the first volume of this journal (Wyllie & Tuttle, 1960; see the list below for details of his publications). He also authored the first paper in the second volume (Wyllie, 1961). His first book (1967) was the edited monograph *Ultramafic and Related Rocks*. Remarkably, when plate tectonics theory was still in its infancy, Peter, an experimental petrologist, effectively brought that theory to classrooms through his books *The Dynamic Earth* (1971) and *The Way the Earth Works* (1976), while also lucidly explaining why volcanoes occur where they do. It is also remarkable that, today, essentially all papers invoking the roles of volatiles in magmatism in the crust or under mantle conditions have the imprints of original concepts and ideas worked out experimentally by Wyllie and co-authors. Peter enthusiastically appreciates his good fortune for the contributions of his students, postdocs, and other co-authors, who number about 75. These papers have accumulated more than 9000 citations, giving him an h-index of 54.

Peter's pioneering and original research as a young scientist was recognized by the Mineralogical Society of America with the 1965 MSA Award, and later by the Wollaston Medal of the Geological Society of London (1982), the Werner Medal of the German Mineralogical Society (1987), the Leopold von Buch Medal of the Deutschen Geologischen Gesellschaft (2001), and the Roebling Medal of the Mineralogical Society of America (2001).

His research has also been recognized by his election to the US National Academy of Sciences (1981), Royal Society of London (1984), Russian Academy of Sciences (1988), Indian National Science Academy (1991), National Academy of Sciences, India (1991), Chinese Academy of Sciences (1996) and Academia Europaea (1996), and by Honorary Membership or Fellowship in Mineralogical, Geological or Geophysical Societies in five countries (Scotland, England, Russia, Germany and India). He is also a Fellow of the American Geophysical Union, the Geological Society of America, the Mineralogical Society of America, and the American Academy of Arts and Science. He was honoured by the University of St. Andrews with a Doctor of Science degree (1974), and in 1996 he was appointed Honorary Professor of the China University of Geosciences in Beijing. Furthermore, two minerals, wyllieite and ferrowyllieite, were named after him.

Peter is not only an original researcher, but also a patient and able teacher; many of his former research students and postdoctoral associates are now research leaders in our field today, in many parts of the world. A number of leading scientists in several developing countries (e.g. China and India) have benefited from his teaching, and petrology and geochemistry education in those countries has been greatly enhanced as a result. He is an excellent teacher of undergraduate students as recognized by the Quantrell Award of the University of Chicago in 1979.

Peter's energy and enthusiasm for science are everlasting. He is also a great scientific leader, science advocate and community servant. After a term as department chairman at the University of Chicago, he joined Caltech in 1983 as chairman of the Division of Geological and Planetary Sciences, before returning to teaching and research in 1987, followed by a later term as Division Academic Officer from 1994 until retirement in 1999.

Peter has been President of the following organizations: the Mineralogical Society of America (1977–1978;

Vice President 1976–1977; Past President 1978–1979), the International Mineralogical Association (1986–1990; Vice President 1978–1986; Past President 1990–1994), and the International Union of Geodesy and Geophysics (1995–1999; Vice President 1991–1995; Past President 1999–2003). He has served as editor, member of editorial boards, and Chair and member of many more national and international societies and committees.

In honour of Peter Wyllie for his life-long contributions to understanding how the Earth works and in celebration of the 50th Anniversary of *Journal of Petrology*, for which he was Managing Editor (1965–1967), a special symposium on magma generation and evolution and global tectonics was held during the 2009 Annual Goldschmidt Conference in Davos, Switzerland (21–26 June 2009). The symposium was unprecedented in its size, having two full days of oral presentations and one full day of posters, with a total of 90 contributions. This *Journal of Petrology* issue represents a collection of papers resulting from this symposium, and is dedicated to Peter Wyllie by his friends, colleagues, former students and those whose careers have benefited from his inspiration and encouragement.

SELECTED PUBLICATIONS OF PETER J. WYLLIE

A detailed scientometric study of the publications by Wyllie and his co-authors and their impact has been provided by Sangam *et al.* [Sangam, S. L., Kiran Savanur, Manjunath, M. & Vasudevan, R. (2006). Scientometric portrait of Prof. Peter John Wyllie. *Scientometrics* **66**(1), 43–53]. That study compiled 337 papers by Wyllie and his co-authors. Below is a representative selection of 50 publications, resonating with the Golden Jubilee of the *Journal of Petrology*.

Yaoling Niu, Durham University, UK

Marjorie Wilson, The University of Leeds, UK

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Wyllie, P. J. (1957). A geological reconnaissance through South Germania Land, Northeast Greenland. *Meddelelser om Grønland* **157**, 1–66.

Wyllie, P. J. & Tuttle, O. F. (1959). Effect of carbon dioxide on the melting of granite and feldspars. *American Journal of Science* **257**, 648–655.

Wyllie, P. J. & Tuttle, O. F. (1960). The system $CaO–CO_2–H_2O$ and the origin of carbonatites. *Journal of Petrology* **1**, 1–46.

Wyllie, P. J. & Tuttle, O. F. (1960). Experimental investigation of silicate systems containing two volatile components, Part 1. Geometrical considerations. *American Journal of Science* **258**, 498–517.

Wyllie, P. J. (1961). Fusion of Torridonian sandstone by a picrite sill in Soay (Hebrides). *Journal of Petrology* **2**, 1–37.

Wyllie, P. J. & Tuttle, O. F. (1961). Experimental investigation of silicate systems containing two volatile components, Part II. The effects of NH3 and HF, in addition to H_2O, on the melting temperatures of albite and granite. *American Journal of Science* **259**, 128–143.

Koster van Groos, A. F. & Wyllie, P. J. (1963). Experimental data bearing on the role of liquid immiscibility in the genesis of carbonatites. *Nature* **199**, 801–802.

Wyllie, P. J. & Tuttle, O. F. (1964). Experimental investigation of silicate systems containing two volatile components. Part III. The effects of SO_3, P_2O_5, HCl, and Li_2O, in addition to H_2O, on the melting temperatures of albite and granite. *American Journal of Science* **262**, 930–939.

Wyllie, P. J. (1965). Melting relationships in the system $CaO–MgO–CO_2–H_2O$ with petrological applications. *Journal of Petrology* **6**, 101–123.

Boettcher, A. L. & Wyllie, P. J. (1968). Melting of granite with excess water to 30 kilobars pressure. *Journal of Geology* **76**, 235–244.

Lambert, I. B. & Wyllie, P. J. (1968). Stability of hornblende and a model for the low velocity zone. *Nature* **219**, 1240–1241.

Boettcher, A. L. & Wyllie, P. J. (1969). The system $CaO–SiO_2–CO_2–H_2O$: III. A second critical end-point on the melting curve at 32·5 kbars and 515°C. *Geochimica et Cosmochimica Acta* **33**, 611–632.

Watkinson, D. H. & Wyllie, P. J. (1969). Phase equilibrium studies bearing on the limestone-assimilation hypothesis. *Geological Society of America Bulletin* **80**, 1565–1576.

Wyllie, P. J. & Boettcher, A. L. (1969). Liquidus phase relationships in the system $CaO–CO_2–H_2O$ to 40 kilobars pressure with petrological applications. *American Journal of Science* **267A**, 489–508.

Lambert, I. B. & Wyllie, P. J. (1970). Low-velocity zone of the Earth's mantle; incipient melting caused by water. *Science* **169**, 764–766.

Robertson, J. K. & Wyllie, P. J. (1971). Rock–water systems, with special reference to the water-deficient region. *American Journal of Science* **271**, 252–277.

Wyllie, P. J. (1971). The role of water in magma generation and initiation of diapiric uprise in the mantle. *Journal of Geophysical Research* **76**, 1328–1338.

Lambert, I. B. & Wyllie, P. J. (1972). Melting of gabbro (quartz eclogite) with excess water to 35 kilobars, with geological applications. *Journal of Geology* **80**, 693–708.

Huang, W. L. & Wyllie, P. J. (1973). Muscovite dehydration and melting in deep crust and subducted oceanic sediments. *Earth and Planetary Science Letters* **18**, 133–136.

Wyllie, P. J. (1974). Limestone assimilation. In: Sørensen, H. (ed.) *Alkaline Rocks*. New York: John Wiley, pp. 459–474.

Irving, A. J. & Wyllie, P. J. (1975). Subsolidus and melting relationships for calcite, magnesite, and the join $CaCO_3$–$MgCO_3$ to 36 kilobars. *Geochimica et Cosmochimica Acta* **39**, 35–53.

Maaløe, S. & Wyllie, P. J. (1975). Water content of a granite magma deduced from the sequence of crystallization determined experimentally with water-undersaturated conditions. *Contributions to Mineralogy and Petrology* **52**, 175–191.

Stern, C. R., Huang, W. L. & Wyllie, P. J. (1975). Basalt–andesite–rhyolite–H_2O: crystallization intervals with excess H_2O and H_2O-undersaturated liquidus surfaces to 35 kilobars with implications for magma genesis. *Earth and Planetary Science Letters* **28**, 189–196.

Wyllie, P. J. & Huang, W. L. (1975). Influence of mantle CO_2 in the generation of carbonatites and kimberlites. *Nature* **257**, 297–299.

Wyllie, P. J. & Huang, W. L. (1976). Carbonation and melting reactions in the system CaO–$MgOSiO_2$–CO_2 at mantle pressures with geophysical and petrological applications. *Contributions to Mineralogy and Petrology* **54**, 79–107.

Wyllie, P. J. (1977). Crustal anatexis: an experimental review. *Tectonophysics* **13**, 41–71.

Wyllie, P. J. (1977). Peridotite–CO_2–H_2O, and carbonatitic liquids in the upper asthenosphere. *Nature* **266**, 45–47.

Wyllie, P. J. (1977). Effects of H_2O and CO_2 on magma generation in the crust and mantle. *Journal of the Geological Society, London* **134**, 215–234.

Wyllie, P. J. (1978). Mantle fluid compositions buffered in peridotite–CO_2–H_2O by carbonates, amphibole, and phlogopite. *Journal of Geology* **86**, 687–713.

Wyllie, P. J. (1979). Magmas and volatile components. *American Mineralogist* **64**, 469–500.

Wyllie, P. J. (1980). The origin of kimberlites. *Journal of Geophysical Research* **85**, 6902–6910.

Sekine, T. & Wyllie, P. J. (1982). The system granite–peridotite–H_2O at 30 kbar, with applications to hybridization in subduction zone magmatism. *Contributions to Mineralogy and Petrology* **81**, 190–202.

Wyllie, P. J. (1982). Subduction products according to experimental prediction. *Geological Society of America Bulletin* **93**, 468–476.

Wyllie, P. J. & Sekine, T. (1982). The formation of mantle phlogopite in subduction zone hybridization. *Contributions to Mineralogy and Petrology* **79**, 375–380.

Wyllie, P. J., Huang, W.-L., Otto, J. & Byrnes, A. P. (1983). Carbonation of peridotites and decarbonation of siliceous dolomites represented in the system CaO–MgO–SiO_2–CO_2 to 30 kbar. *Tectonophysics* **100**, 359–388.

Wyllie, P. J. (1984). Constraints imposed by experimental petrology on possible and impossible magma sources and products. *Philosophical Transactions of the Royal Society of London, Series A* **310**, 439–456.

Wyllie, P. J. (1988). Solidus curves, mantle plumes, and magma generation beneath Hawaii. *Journal of Geophysical Research* **93**, 4171–4181.

Wyllie, P. J. (1988). Magma genesis, plate tectonics, and chemical differentiation of the Earth. *Reviews of Geophysics* **26**, 370–404.

Wyllie, P. J., Sekine, T., Johnston, A. D., Carroll, M. R. & Rutter, M. J. (1989). Interactions among magmas, vapors and rocks in subduction zones: experimental studies from slab to mantle to crust. *European Journal of Mineralogy* **1**, 165–179.

Wyllie, P. J., Baker, M. B. & White, B. S. (1990). Experimental boundaries for the origin and evolution of carbonatites. *Lithos* **26**, 3–19.

Wolf, M. B. & Wyllie, P. J. (1991). Dehydration-melting of solid amphibolite at 10 kbar: textural development, liquid interconnectivity and applications to the segregation of magmas. *Mineralogy and Petrology* **44**, 151–179.

van der Laan, S. R. & Wyllie, P. J. (1993). Experimental interaction of granitic and basaltic magma and implications for mafic enclaves. *Journal of Petrology* **34**, 491–517.

Nichols, G. T., Wyllie, P. J. & Stern, C. R. (1994). Subduction zone melting of pelagic sediments constrained by melting experiments. *Nature* **371**, 785–788.

Wolf, M. B. & Wyllie, P. J. (1994). Dehydration-melting of amphibolite at 10 kbar: effects of temperature and time. *Contributions to Mineralogy and Petrology* **115**, 369–383.

Wyllie, P. J., Wolf, M. B. & van der Laan, S. R. (1997). Conditions for formation of tonalites and trondhjemites: magmatic sources and products. In: de Wit, M. J. & Ashwal, L. D (eds) *Tectonic Evolution of Greenstone Belts*. Oxford: Oxford University Press, pp. 256–266.

Lee, W. J. & Wyllie, P. J. (1998). Petrogenesis of carbonatite magmas from mantle to crust, constrained by the system CaO–$(MgO + FeO^*)$–$(Na_2O + K_2O)$–$(SiO_2 + Al_2O_3 + TiO_2)$–$CO_2$. *Journal of Petrology* **39**, 495–517.

Wyllie, P. J. & Lee, W. J. (1998). Model system controls on conditions for formation of magnesiocarbonatite and calciocarbonatite magmas from the mantle. *Journal of Petrology* **39**, 1885–1893.

Lee, W. J., Huang, W. L. & Wyllie, P. J. (2000). Melts in the mantle modeled in the system CaO–MgO–SiO_2–CO_2 at 2·7 GPa. *Contributions to Mineralogy and Petrology* **138**, 199–213.

Lee, W. J. & Wyllie, P. J. (2000). The system CaO–MgO–SiO_2–CO_2 at 1 GPa, metasomatic wehrlites, and primary carbonatite magmas. *Contributions to Mineralogy and Petrology* **138**, 214–228.

Wyllie, P. J. & Ryabchikov, I. D. (2000). Volatile components, magmas, and critical fluids in upwelling mantle. *Journal of Petrology* **41**, 1195–1206.

BOOKS

Wyllie, P. J. (ed.) (1967). *Ultramafic and Related Rocks*. New York: John Wiley, 464 p.

Wyllie, P. J. (1971). *The Dynamic Earth: A Textbook in Geosciences*. New York: John Wiley, 416 p.

Wyllie, P. J. (1976). *The Way the Earth Works: An Introduction to the New Global Geology and Its Revolutionary Development*. New York: John Wiley, 296 p.

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CONTENTS

[*S*] Contains supplementary data available at *Journal of Petrology* online.