BIOGRAPHICAL MEMOIRS

Sir George Malcolm Brown. 5 October 1925–27 March 1997

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Biogr. Mems Fell. R. Soc. 1998 **44**, 65-76, published 1 November 1998

SIR GEORGE MALCOLM BROWN

5 October 1925–27 March 1997

Elected F.R.S. 1975

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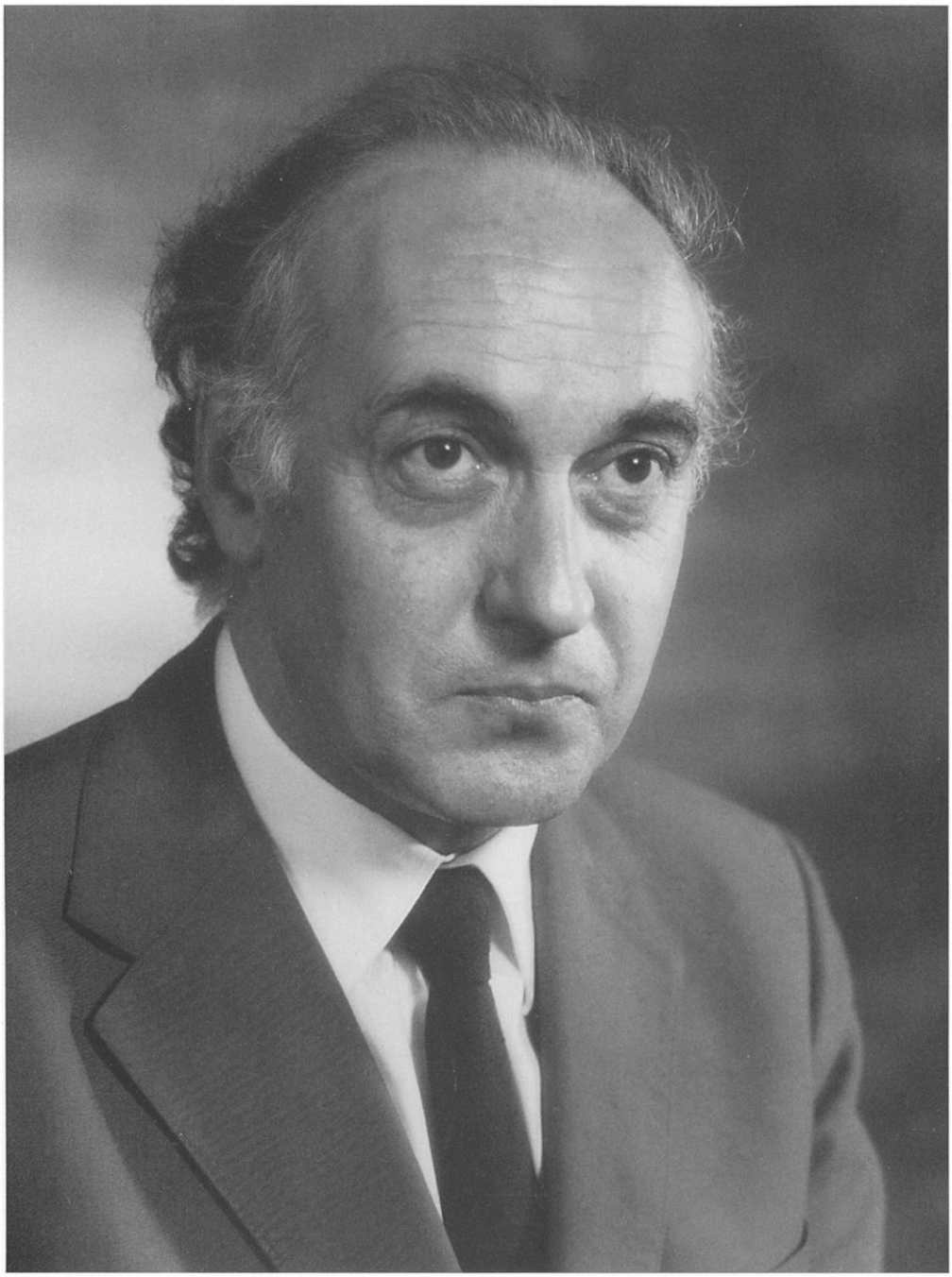
With the death of Sir Malcolm Brown, successively University Lecturer in Petrology at Oxford, Professor of Geology at Durham, and Director of the British Geological Survey, British science lost one of the most distinguished representatives of the immediate post-war generation and the international geological community lost one of its best-loved and respected members. He died at Oxford, of pancreatic cancer, on 27 March 1997 at the age of 71.

He was born at Redcar, north-east Yorkshire, on 5 October 1925, the second son of George Arthur Brown, a legal clerk, and Anne Brown, (née Fellows). Malcolm's early boyhood was spent at Wensley in the Yorkshire dales where, from 1930 until 1937, he attended the village school and developed an early interest in the local rocks and other aspects of natural history. Returning with his family to Redcar, Brown entered Sir William Turner's (Coatham) School. At this juncture his father died, leaving the family in conditions of some poverty. His years at Coatham were not particularly distinguished, giving little indication of the academic brilliance Brown was to display from his undergraduate days onwards. Although the general quality of teaching at the school may not have been outstanding, Brown acknowledged the lasting influence of one of his teachers, R.J.C. Williams, who stressed scientific method and principles and the ethics of learning, and further strengthened the boy's interest in, and aptitude for, science and natural history. At school, also, he developed the deep love of poetry which was to last all his life.

On leaving school in 1944, Brown joined the Royal Air Force and spent six months as a cadet on a 'short course' at the Durham Colleges. His main subjects were physics and mathematics, but he also attended some classes given by L.R. Wager, who had recently been appointed to the Chair of Geology in succession to Arthur Holmes, and who was later to exert a deep and lasting influence on Brown's life and career. He continued his aircrew training in Canada, but hostilities ceased before Brown saw operational service and after demobilization he returned to Durham in October 1947 as an undergraduate, with the original intention of



reading chemistry. In his first year he also took courses in zoology and renewed his acquaintance with geology, and he soon decided to concentrate on geology rather than on chemistry.

At Durham, Brown was a member of that immediate post-war generation of ex-service students whose maturity and sense of purpose will never be forgotten by those of us who taught them. Even among that group, Brown's dedication to his subject was remarkable, as was his persistence in seeking from his teachers a satisfactory, in-depth explanation of a point perhaps too glibly glossed over in lecture. The Durham Geology Department in his day boasted an academic staff of but four: L.R. Wager, W. Hopkins, F.H. Stewart and E.A. Vincent. Of these, three had major interests in petrology and mineralogy and it was for these subjects that Brown, too, showed his early predilection. He fell particularly under the spell of Wager, whose enthusiasm, authority and instruction, especially in the field, exemplified the very spirit of scientific enquiry, igniting a flame in Brown that would burn undimmed for the rest of his life. Brown's three years as an undergraduate at Durham saw a truly exceptional rate of intellectual and personal development as, in addition to his academic work, he found time to row, play rugby and to become deeply involved in the affairs of the newly founded Natural History Society.

Malcolm Brown took first class honours in geology in 1950. Wager was about to move from Durham to take up the Chair of Geology at Oxford and arranged to take Brown (whom he always regarded as by far the best pupil he had ever taught) with him as a research student. Not only in the latter capacity was Malcolm Brown a considerable asset to Wager; in the frigid and often unhelpful atmosphere of Oxford in the early 1950s, there grew up a mutual regard and trust which quickly led to a close and lifelong friendship, deeply valued by both men.

Oxford, 1950–67

Ultrabasic rocks of Rum

For his first research problem, Wager set Brown to work on the spectacularly stratified ultrabasic rocks of the Hebridean island of Rum. These had been little investigated since Alfred Harker's work for the Geological Survey, published in 1908, when the complex had been interpreted in terms of successive sill-like injections of ultrabasic magma of peridotitic and allivalitic composition. Wager's own magnum opus, carried out in collaboration with W.A. Deer and published in 1939, had been his detailed and penetrating work on the layered basic Skaergaard intrusion in eastern Greenland. He was beginning a programme of reinvestigation of one or two of the British Tertiary igneous centres, applying some of the knowledge and experience gained in the course of his Greenland work. Sir Edward Bailey, along with J.E. Richey, had paid a brief visit to the island of Rum some ten years or so before Brown started work there, and had published his opinion that Wager and Deer's ideas on the origin of igneous layering would be inapplicable in the case of Rum. However, an early joint paper by Wager and Brown disagreed, and they put forward their own preliminary views on rhythmic layering in the Rum rocks. Brown's brilliant DPhil thesis, the substance of which was published in *Philosophical Transactions of the Royal Society* in 1956 (1)* further broke new ground in demonstrating fundamental differences between the Rum and Skaergaard

*Numbers in this form refer to the bibliography at the end of the text.

cases. The rocks in both intrusions were interpreted in terms of processes of sedimentation as crystals of the constituent mineral phases separated from the magma under the influence of gravity and convective circulation, though the influence of the latter in the Rum case was less obvious. Brown's meticulously detailed work on the individual mineral phases and the rhythmic layering displayed by the Rum rocks, varying in scale from that contained within the area of a single microscope slide to units hundreds of feet in thickness, led him to the conclusion that, whereas the Skaergaard intrusion represented the extreme fractional crystallization *in situ* of a single mass of basaltic magma some 300 cubic kilometres in volume, the Rum intrusion had involved crystallization within a much smaller volume, of successive batches of essentially similar parent magma. The Skaergaard intrusion thus represented an essentially 'closed' magmatic system as far as the major components were concerned. Rum, by contrast, represented an 'open' system in which the crystallization products of small batches of similar magma, periodically replenishing a much smaller chamber, showed very little compositional range: highly calcic plagioclase, forsteritic olivine and Ca-rich clinopyroxene.

If the compositional variation of the main mineral phases of the Rum ultrabasic complex—the 'cryptic variation' in Wager's term—was, in contrast to the Skaergaard, almost non-existent, the separation of those phases into rhythmically arranged layered units was just as spectacular and in some instances more so. The efficacy of a simple gravitational model involving the sinking of dense phases, such as olivine, pyroxene and Fe–Cr–Ti oxides, through the magma, in attempting to explain nearly monomineralic layers has been hotly debated, as has the concomitant role of intermittent convection currents within the magma chamber. Brown, in his life-long involvement with layered intrusions, followed Wager in assessing most of the available evidence to favour the gravitational model as providing the predominant mechanism in the formation of these igneous masses. In the case of Rum, subsequent research has modified some of Brown's conclusions in detail, but his fundamental ideas remain valid.

If, as suggested by Wager and Brown, the crystallization of very many—if not all—basic plutonic complexes encompasses some degree of physical sorting of the constituent crystals, then the role of the still-liquid magma surrounding the precipitated phases will be important in the processes leading to the final consolidation of the rocks as the temperature falls. In some rocks the preserved textures, as seen in thin section under the microscope, will give clear indications as to the nature and role of this interprecipitate liquid; in others, the situation is much less apparent. Brown's work on Rum was followed soon after by a study by W.J. Wadsworth of the south-western extension of Brown's area. Their work and Wager's continuing study of the Skaergaard rocks led the three to define jointly in a seminal paper (3) the criteria for the textural recognition of various types of igneous 'cumulates'. They erected a genetically based nomenclature, which has found wide acceptance. While gravitational settling and convective circulation remain dominant processes, Brown has stressed in particular the importance of the sequence of nucleation of the various mineral phases, and of 'adcumulus' growth dominated by ionic diffusion, in the formation of uniform monomineralic layers such as the Rum anorthosites.

Expedition to Greenland, 1953

Two factors slightly delayed the submission of Malcolm Brown's DPhil thesis: his appointment as a departmental demonstrator in mineralogy in 1952, and his participation in the East Greenland Geological Expedition, led by Wager and Deer, in the summer of 1953. As

well as the opportunity to see the Skaergaard intrusion at first hand in the field, and to draw comparisons and contrasts with Rum, Brown was able also to visit the alkaline Kangerdlugssuaq intrusion with Wager, the expedition adding much to Brown's geological experience. He proved himself an ideal expedition member: when a colleague, D.S. Weedon, had the misfortune to dislocate a finger, it was Malcolm Brown, with no specific medical knowledge, who found the courage to manipulate and realign it.

Pyroxene minerals

On the completion of his DPhil degree in 1954, Brown was elected to a Commonwealth Fund (Harkness) Fellowship, which he used to visit Princeton to work with Professor Harry H. Hess. He also took the opportunity to travel widely in the United States, visiting many classic geological and mining localities and acquiring a wide range of new geological friends and acquaintances. At the Institute for Advanced Studies at Princeton, Malcolm Brown made the acquaintance of Albert Einstein; one of Brown's treasured possessions was a photograph of the two of them together.

In the laboratory at Princeton, Brown undertook a fresh examination of the pyroxene minerals from the Skaergaard intrusion, using new material made available by the previous year's expedition. Hess had recently published the first detailed, modern researches into the pyroxene group and Brown was able to make use of the unrivalled facilities of Hess's laboratory. He set out first to define the complete course of pyroxene crystallization—both Ca-rich and coexisting Ca-poor varieties—through the whole differentiated layered series of the intrusion, from Mg-rich to Fe-rich members. Although Deer had separated and analysed a few representative samples for the 1939 memoir, and I.D. Muir and P.E. Brown had subsequently supplemented these, Malcolm Brown was the first to tackle the whole genetic series. In the early 1950s, there were no electron probe microanalysers and the problem had to be tackled by laboriously separating pure samples of the pyroxenes from their parent rocks for analysis by classical 'wet chemical' methods. Hess possessed one of the first Frantz isodynamic (magnetic) mineral separators, and Brown infinite patience. Week by week, little sample tubes containing anything from 50 mg to a gram or two of pure pyroxene concentrate would arrive by registered air mail at the present writer's laboratory for analysis, and gradually the now classic complete Skaergaard pyroxene compositional sequence emerged (2, 5).

Again following earlier work by Hess and Poldervaart, and building on it, Brown commenced detailed optical and X-ray diffraction studies of the exsolution and inversion textures displayed by the minerals. He examined particularly the inversion of monoclinic pigeonites to orthopyroxenes, with the concomitant exsolution of Ca-rich phases, and the often puzzling textures and interrelationships of the extreme Fe-rich members of the clinopyroxene series, for which the Skaergaard rocks provided unique material. The results of this work are admirably summarized by Brown himself in Wager and Brown's *Layered igneous rocks* (13, pp. 38–48) and in his well-illustrated article in *Encyclopaedia Britannica* (14).

Malcolm Brown maintained a lifelong interest in the pyroxene group of minerals, on which he became probably the world's leading authority. After reliable electron microprobe analysers became available, he returned to the complexities of exsolution textures and their interpretation, particularly in collaboration with F.R. Boyd at the Geophysical Laboratory in Washington, and later studied pyroxenes in the lunar basalts.

While working with Hess at Princeton, Brown also made good use of Hess's excellent facilities for X-ray diffraction work to study in some detail the effects of ionic substitution on

the unit cell dimensions of the chemically analysed Skaergaard pyroxenes, and provided a useful diagram relating Ca:Mg:Fe ratios to the monoclinic cell dimensions b and $a \sin \beta$ (4).

Origin of the Skye granites

On his return from Princeton in 1955 Brown was appointed to a newly established university lecturership in petrology at Oxford and continued his close collaboration with L.R. Wager in various areas of research. Back at Durham, in 1945, Wager, in collaboration with F.H. Stewart, had begun a reinvestigation of the Tertiary central intrusive complexes of the island of Skye, and this work was continuing at Oxford. While Malcolm Brown was carrying out his own work in Rum, other research students (including J.M. Carr, D.S. Weedon and P. Zinoviev) were taking a fresh look at the basic and ultrabasic mass of the Cuillin Hills. Wager meanwhile, together with F.H. Stewart at Durham and other research students, including J.D. Bell and R.N. Thompson, was working on the contrasting granitic complexes and hybrid rocks of the Red Hills.

Having completed and published his work on Rum and rounded off the work on the Skaergaard pyroxenes, Malcolm Brown began to take an active interest in some of the problems posed by Skye. Important among these was to explain the close spatial and temporal association of the gabbroic Cuillin mass and the granitic Red Hills. At this time, the famous 'granite controversy' was raging and the field relationships strongly suggested an intrusive magmatic origin for the Skye granites, rather than a more gentle *in situ* metasomatism of the country rocks, as would be advocated by Arthur Holmes and Doris Reynolds, among others. The relative abundance of granitic material, however, militated strongly against an exclusive origin by the classical concept of crystallization-differentiation of a parental basic magma, such as that represented by the Cuillin gabbros and the extensive basalt lava fields of northern Skye. Petrological and chemical studies led Brown to postulate, with considerable confidence, an origin by the partial melting of pre-Cambrian (Lewisian) basement rocks, the heat source having been provided by a deep-seated mass of basic magma, the presence of which had recently been suggested by geophysical (gravity) survey.

The partial melting idea as such was not entirely new, but recent work by G.P Black and by P.J. Wyllie had suggested that the depth and temperatures at which such crustal anatexis took place would critically determine the composition of the melt product. Encouraged particularly by Wyllie, Malcolm Brown accordingly took himself off to Leeds University, where facilities were available, and carried out reconnaissance melting experiments on chemically analysed granites from Skye and Rum at 1000 kg/cm^2 water vapour pressure. By analogy with experimental results in the system orthoclase–albite–silica–water made at the Geophysical Laboratory by Tuttle and Bowen, Brown was able to demonstrate convincingly that partial melting of the local basement Lewisian rocks at a depth of 3–4 km could yield the Red Hills' granitic magmas. Further experiments with samples of an analysed Torridonian arkose (overlying the Lewisian basement in the region) confirmed melting of the Torridonian at higher crustal level as the probable origin of the localized, compositionally distinct tridymite-bearing granophyre of Coire Uaigneich.

Brown's paper (6) describing this work represents one of his most significant contributions to petrology and, though based on observations, experiments and arguments relating to rocks from Skye and Rum, has wide implications for the origin of granitic rocks throughout the British Tertiary igneous province and indeed further afield. While later workers have expanded and refined Brown's original concepts, given strong support by more recent geochemical and isotopic studies, his original ideas have stood the test of time.

Layered igneous rocks

In the late 1950s, L.R. Wager conceived the idea of writing a book which would bring together the results of studies of layered igneous complexes from all over the world. The work would embody the fundamental ideas and principles which he and Brown, in particular, had established over the years, and it was natural that he should invite Malcolm Brown to come in as joint author. As well as the Skaergaard intrusion and various Hebridean complexes, Wager and his students had been involved in the study of complexes in other parts of the world, notably in south-western Greenland. In addition, an extensive international literature had built up since the publication of the original Skaergaard memoir in 1939. Neither Wager nor Brown, however, had seen at first hand the world's largest and most impressive layered complex, the Bushveld of South Africa, and accordingly, in preparation for work on the book, they paid a visit of several weeks in the summer of 1958.

The now classic work *Layered igneous rocks* (13) was long in gestation, and the process was not always easy. The book enshrines a vast amount of petrological, mineralogical and geochemical detail brought together in a single, easily accessible source. Brown's part in it was a major one. Wager had written the sections dealing with the Skaergaard intrusion and with the broad principles of layered intrusions in general; Brown had the chief responsibility for the remainder, a responsibility which increased upon Wager's untimely death in November 1965. It was then left to Brown to add the finishing touches to the work and to see it through the press. Finally published in 1968, it remains to this day an authoritative work in its field. To celebrate the 25th anniversary of its publication, Malcolm Brown was guest of honour at an international conference on layered igneous rocks, held at Johannesburg in 1993. The resulting symposium volume—appropriately edited by a former pupil of Brown's, R.G. Cawthorn, and to which Brown contributed a thoughtful Foreword (16)—records a further 25 years' research on various layered intrusions and resulting changes in interpretative emphasis.

Mention might also be made here of Malcolm Brown's deep involvement with the prestigious *Journal of Petrology*, founded in 1960, of which he was the first, and very effective, Managing Editor, guiding the journal's fortunes in exemplary fashion for seven years. He also served a number of other journals in an editorial or advisory capacity.

Visit to the Geophysical Laboratory

Having deposited the manuscript of *Layered igneous rocks* with the publisher, Malcolm Brown was able to accept a long-standing invitation to visit the Geophysical Laboratory at Washington as a Carnegie Senior Fellow. Already known personally and by scientific reputation to the Director and senior staff, Brown had hoped some years earlier to take up a fellowship there and to participate in the experimental work in petrology and mineralogy for which the laboratory is internationally renowned. Indeed, in 1962 he had declined the tentative offer of a permanent post on its staff, feeling that his commitment to the work he was doing with Wager and his loyalty to the latter and to the Oxford department precluded his acceptance.

Brown's tenure of the fellowship in 1966–67 was scientifically very profitable and his colleagues at the Laboratory were deeply impressed by his efficiency and amazing productivity in research, finding him a personally delightful visitor who fitted perfectly into their team. He returned, with F.R. Boyd and D.H. Lindsley, to the problems of phase relations, inversion and exsolution in the pyroxenes (7–9). With A.J. Naldrett he studied the reaction of pyrrhotite with orthopyroxene solid solutions (10); with J.F. Schairer and H.S. Yoder he

studied the melting relations of calc-alkaline rocks from the West Indies and the Solomon Islands (11); and with J.F. Schairer and C.E. Tilley (of Cambridge), the nepheline–diopside–anorthite system and its bearing on the genesis of the alkaline igneous rocks (12).

DURHAM, 1967–79

Returning from Washington in September 1967, Malcolm Brown prepared to leave Oxford, after a stay of some 17 years, to take up the Chair of Geology at his old university, Durham, which had fallen vacant by Professor Kingsley Dunham's appointment as Director of the Geological Survey of Great Britain. The Durham Department of Geological Sciences, founded in 1924, had had as its successive Professors of Geology three of the most distinguished geologists of their day: Arthur Holmes, Lawrence Wager and Kingsley Dunham, and Malcolm Brown was admirably to continue the tradition.

Having already, from a diffident beginning, proved himself at Oxford an accomplished lecturer and an inspiring tutor, his lecture courses at Durham—particularly the critical and exacting courses for first-year students—quickly became legendary for the breadth and balance of their material and for the lucidity of their delivery. Brown found no difficulty in making converts to his subject and several of his ablest students stayed on to carry out postgraduate research under his supervision.

Brown also exhibited a considerable flair for organization and administration, and indeed an unusual liking for these tasks, doubtless closely linked to his deep concern for the welfare of others. His colleagues on the teaching and technical staffs, as well as his undergraduate and graduate students, not only respected his ability but found him a deeply likeable, sincere and inspiring leader, with the essential attribute of a sense of humour. Not unnaturally, Malcolm Brown was soon sought after to undertake wide-ranging duties and responsibilities in the university at large, serving, among much else, as Dean of the Faculty of Science and Pro-Vice-Chancellor. To the end of his life, Malcolm Brown retained the deepest sense of loyalty and commitment to his alma mater; he was proud to become the first President (1983–88) of the Durham University Research Foundation and Society of Research Fellows.

Lesser Antilles

In 1960, Wager and Brown had initiated a new research programme on the volcanoes of the West Indies. A succession of jointly supervised research students worked on various of the 15 islands of the 700-km long arc of the Lesser Antilles, including P.E. Baker on St Kitt's, J.F. Lewis on St Vincent and J.F. Tomblin on St Lucia. On his move to Durham, Brown continued this programme, supervising the work of H. Sigurdsson, R.J. Arculus and K. Wills, and publishing important papers dealing more broadly with the structure and evolution of the whole island arc and the chemical development of its magmas and rocks. He received much help from his colleague, Grenville Holland, in producing large numbers of X-ray fluorescence spectrometric analyses.

Lunar petrology and evolution

Malcolm Brown's most noteworthy achievements in research during his time at Durham stem from his involvement, from 1968 onwards, in the study of the lunar surface samples returned in the NASA Apollo programme, having been chosen as one of the small handful of British Principal Investigators.

The time of the acquisition of the first samples of lunar rock and regolith fortunately coincided with a series of great steps forward in the field of analytical geochemistry. The electron probe microanalyser, first developed a few years earlier, had by then become a reliable analytical tool. X-ray fluorescence spectrometry, similarly, had reached a state of refinement when, apart from its inability to differentiate between the oxidation states of iron, it had virtually replaced classical 'wet chemical' analysis of rocks and minerals. Both techniques had the great advantage, in the context of rare and precious lunar samples, of being non-destructive. Parallel developments in mass-spectrometry, and the recognition of the patterns of isotopic fractionation in several key elements, led not only to the unequivocal age determination of the lunar samples but added vital parameters in the consideration of lunar petrogenetic processes.

The Apollo research programme involved a great number of scientists, predominantly American, in a wide range of specialist disciplines. Malcolm Brown, leading his small Durham team (C.H. Emeleus, J.G. Holland, A. Peckett and R. Phillips) was himself no narrow specialist, but a widely experienced field and laboratory petrologist. He was better qualified than most to see the problems posed by the lunar rocks in broadest context and thus to direct the work of his more specialized colleagues towards the goal of understanding the natural processes which had shaped the structure and composition of the moon throughout its history. Dr C.H. Emeleus recalls:

> It was an inspiration to work with Malcolm on this, even if it made one deeply unpopular at home! The lunar samples arrived in Durham towards the end of October 1969, and kept coming as the thin sections circulated amongst labs. I think we had two days (Christmas Day and Boxing Day) completely off the work between their arrival and Malcolm's and my departure for the NASA conference in January 1970, and that on top of our normal, fairly heavy teaching loads. Roy, Grenville and I produced the data, Malcolm interpreted them, made suggestions for things we might follow up (that evening!), integrated our results with what he was finding from the petrography, and wrote the papers. By comparison with some of the US labs, our team was small and we did not produce their vast quantities of data. However, ours were used to maximum effect—I well remember Malcolm's elegant use of our thin lines of pyroxene determinations, and thinking what he could have made out of the swarms of data points presented by one lab with very little attempt at explanation of their significance.

In all, the Durham group published some 30 papers on lunar petrology and mineralogy, many providing fine examples of their leader's knowledge and imaginative use of all the data at his disposal, even at the earliest stages of the overall Apollo programme.

While Malcolm Brown was involved in much mineralogical work—including the identification of two new minerals in the ZrO_2–TiO_2–FeO series and unknown terrestrially—it is in his interpretative petrology that his major contribution to lunar science lies. During a discussion at the Apollo 11 Conference at Houston early in 1970, drawing on his experience of layered igneous intrusions, he made the controversial suggestion that the crystallization history of the moon might be regarded in many ways as a gigantic version of something like the Skaergaard. This notion clearly required that at an early stage in its history the moon must have been very largely in a molten state, a concept that many of the geophysicists found difficult to accept. But people came to realize that the chemical evidence for such a model was strong and Brown's original concept, further developed later by Taylor and Jakes, and by Brown himself (e.g. 15), is now widely accepted.

In the years during and after the Apollo programme, general scientific and public interest

in the moon ran high (a tiny sample of lunar soil put on public display at Durham attracted long queues) and Malcolm Brown was widely sought after as a lecturer and a speaker at scientific meetings, where the style and lucidity of his beautifully illustrated communications were greatly admired. Brown's contributions to lunar research, taken along with his previous record, were recognized by his election to the Royal Society in 1975.

British Geological Survey, 1979–85

Malcolm Brown's career took a new turn when he left academic life in 1979, on his appointment to the directorship of the Institute of Geological Sciences (IGS), a post traditionally regarded as the most important in British geology. The Institute had been formed by the amalgamation of the former Geological Survey of Great Britain and the Directorate of Overseas (formerly Colonial) Geological Surveys, and had expanded greatly in staff and resources under the directorship of Kingsley Dunham between 1967 and 1976. Since 1971, however, the application of Lord Rothschild's 'customer–contractor' principle had placed the Institute in a steadily tightening financial straitjacket; by 1979, some 80% of its income was provided by payment for work commissioned by various government departments. In addition, the Institute was by then a unit of the Natural Environment Research Council (NERC), a body prone to involve itself in detail in the Institute's affairs, in stark contrast to the relatively relaxed attitude of its predecessor, the old Department of Scientific and Industrial Research.

Brown faced difficult challenges on his appointment. As an active research scientist he was anxious to nurture the Institute's role in fundamental research, of necessity becoming diminished because of the overriding preoccupation with commissioned research, often of a more routine nature, and which largely precluded the Institute's formulation of its own programmes. And shortly he would face very large reductions even in the income from commissioned research as the new Thatcher government of 1979 began its policy of drastic cuts in public expenditure, especially in education and science, and the commissioning departments in their turn had to make economies.

Additionally, the Institute was due to move away from London into new quarters at Keyworth, near Nottingham, a prospect that led to dissatisfaction on the part of some staff and a consequent lowering of morale. By his own personal efforts and example the new Director did much to calm feelings and the move to Keyworth, enthusiastically supported and organized by Malcolm Brown, has in the event proved an outstanding success. Sadly, however, the Institute lost the fine Geological Museum in South Kensington.

Appointed from outside the organization and new to Civil Service ways, Brown found the viscous resistance to change inherent in a venerable and conservative institution irksome. It was with the younger, scientifically active members of his staff with whom he established the closest rapport and in whose work and career prospects he took a first-hand interest. It is reported that manuscripts submitted by the staff for the Director's formal approval before publication would come back not simply endorsed with the word 'Approved', but covered with comments and suggestions in Malcolm's spidery handwriting and accompanied by an invitation to come and chat about the work. When drastic staff cuts became necessary in the 1980s, Brown was able to arrange matters so that the services of a high proportion of the promising younger scientists could be retained, so as to ensure the future health of the organization.

In the organization of the Institute's work, Brown sought to break down the conventional borders between the various departments and disciplines represented within the IGS and to set up interdisciplinary teams of scientists to interact with one another in the solution of a specific problem. Projects carried out in North Wales and in the Lake District provide examples. Brown achieved a major success in securing nearly £1 million from NERC to fund this innovative approach. He also did much to encourage increased collaboration between university and IGS scientists (as the recent publication of geological maps and memoirs for Snowdonia, Shetland, Rum and the adjacent 'Small Isles' testifies). These links with the universities were the more significant since financial stringency had forced drastic curtailments in the Institute's own field programmes.

Although his first two or three years with the IGS were difficult and not entirely happy, Brown achieved much, despite being hampered by ill health, culminating in major heart surgery. He had the relocation to Keyworth well under way and had seen a considerable revival in the research spirit of the organization. He had successfully piloted the IGS through the Butler enquiry into its function and very existence, and in 1985 wrote the organization's first formal terms of reference and the first stragetic plan establishing the framework for the whole future activity of the Survey. In common with his immediate predecessors, Malcolm Brown's relationships with NERC were less than easy, despite the high regard he had attained as a member of that Council from 1972 to 1975, and perhaps largely to be attributed to the inappropriate placing of the IGS within NERC in the first place.

Malcolm Brown's retirement in 1985 at the statutory age of 60 coincided with the sesquicentenary of the foundation of the Geological Survey under Sir Henry de la Beche, and in presiding over the celebrations at Keyworth, he could view his own contribution with some satisfaction. One of his later achievements must not be overlooked: a widely welcomed change of title from IGS to 'British Geological Survey' (BGS). Brown felt very strongly about the essentially field-based nature of many of the Institute's main responsibilities, and felt that the title should once again incorporate the time-honoured concept of a 'survey'.

He received a knighthood in the Queen's Birthday Honours of 1985 and it was a source of personal satisfaction to Brown to receive the informal intimation that he was being honoured as much, or more, for his scientific work as for his directorship of the Survey.

In the ten years of his retirement, Malcolm Brown continued an active and varied professional life, as a consultant geologist and as a member of various national and international bodies. His close contacts with American scientists, visiting professorships at Berkeley, Oslo, Brasilia and Berne, and the wide international relationships of the BGS, particularly with the Commonwealth countries, had given Malcolm Brown unusual opportunities to make good use of his retirement. Space precludes a detailed listing, but among much else, he undertook under the aegis of the United Nations an assignment to make recommendations to the Government of India for increasing the efficiency of the Geological Survey of India, with its staff of 17500. He acted as Chairman of the Board of the International Geological Correlation Programme; was President of Section C (Geology) of the British Association for the Advancement of Science in 1988; and served on the Council and various committees of the Royal Society. Outside his scientific work in retirement, Brown took up the study of the classical guitar, and devoted a day each week to voluntary work at a local cottage hospital.

Malcolm Brown was awarded the Wollaston Fund (1963) and the Murchison Medal (1981) by the Geological Society of London. As well as his Durham DSc, he was awarded honorary

degrees of DSc by the University of Leicester (1985) and by the Open University (1990). He was elected to Fellowship in the Royal Society of Edinburgh in 1966. At Oxford, he was a Foundation Fellow of St Cross College (1965).

Brown was an ambitious man, but never aggressively so; self-confident, yet extremely modest, indeed diffident. He always assessed accurately his own potential to do a particular job or to pursue a particular policy, and would then get on with it quietly and without fuss. He soon grew to be respected for his sincerity, his clarity of vision and his tenacity in seeing a task through to the end. He thoroughly enjoyed applying to organizational and administrative work the same kind of rigorous, logical approach that he brought to his science, but always tempered with humanity and understanding.

By many, Malcolm Brown will be remembered as a man with two distinct facets to his personality: the intensely serious and the completely relaxed. To his work he would apply the most intense concentration until he felt it was time to stop. Then the man who loved company and conversation would appear, always companionable and fun to be with. His interests ranged widely—literature, poetry, science, politics—and he was always well informed and firm in his opinions. He had a well-developed, often iconoclastic, sense of humour and a quick wit. He was fond of parties and informal gatherings of all kinds and acquired something of a reputation for 'letting his hair down'. Parties at his home in Durham, after the summer examinations, became legendary. He had a taste, especially in his younger days, for dashing sports cars, not always of the highest mechanical reliability.

Brown's zest for life was not always apparent on first acquaintance. While he could appear rather self-contained, he was in fact the warmest and most open-hearted of men, with whom friendships, though selective, were for life and deeply cherished. Integrity and constancy were two of his most notable attributes. And the humour was never far below the surface.

Malcolm Brown was married twice, first to Valerie Gale in 1963 (marriage dissolved 1977) and second, in 1985, to Sally Marston, whom he met at the British Geological Survey. His second marriage was an exceptionally happy one, and by it he acquired two step-daughters to whom he became deeply devoted; he had no children of his own.

Acknowledgements

Malcolm Brown's brother, Mr Douglas A. Brown, and Lady (Sally) Brown have very kindly provided details of his family life and early years. I wish also to express my particular gratitude to Dr C.H. Emeleus, of Durham University, and to Dr S.R. Taylor, of the Australian National University for their help, particularly with regard to the lunar programme. Dr H.S. Yoder, of the Geophysical Laboratory, Carnegie Institution of Washington, has provided warm reminiscences of Malcolm Brown's visits there. Dr J.D. Bell, Dr K.G. Cox, F.R.S. and Professor S. Moorbath, F.R.S. have kindly read the text in draft and made helpful comments. A bibliography prepared by Dr S.J. Prince of the British Geological Survey, of which he kindly provided a copy, has been helpful in compiling that appended to this Memoir.

The frontispiece photograph, taken in 1975, was given to the Royal Society by the Godfrey Argent Studio and is reproduced with their kind permission.

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