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originally published online August 17, 2016

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Elected FRS 1979

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Michael Lappert was one of the giants of twentieth-century organometallic chemistry. His research, carried out over six decades and leading to about 800 publications, had a profound and influential effect on the field, and his contributions covered almost every block of the Periodic Table. His early reputation was established by his extensive studies in boron chemistry exemplified by the reports of BCl₄⁻, BN cyclobutadiene analogues, triborylamines, BCl₃-catalysed ortho-Claisen rearrangements and evidence for restricted rotation about the B–N bond in aminoboranes. He had a lifelong interest in amides, including those of carbon, and especially electron-rich olefins, which remarkably were the ready source of numerous transition-metal carbene complexes. The last could also be obtained directly from the Vilsmeier reagent. He was the first to show that a carbene complex may act as an initiator of olefin metathesis. Later interests concerned the syntheses of new types of compound from all blocks of the Periodic Table driven by his imaginative use of new types of ligand (either sterically crowded or having no β-hydrogen atoms, often including SiMe₃ or Bu substituents to confer lipophilicity). The use of CHₙSiMe₃⁻ₙ (n = 0, 1 or 2) to stabilize transition-metal alkyl compounds was a major advance, because at the time stable homoleptic (a term he introduced) transition-metal alkyl compounds were unknown. He showed that the –CH(SiMe₃)₂ ligand could stabilize both low-coordinate transition metal and lanthanide compounds. Similarly, carbene analogues of the Main Group 14 elements germanium, tin and lead were obtained. Surprisingly in the solid state, these species were weakly dimerized (for example R₂Sn=SnR₂), and unexpectedly exhibited a pyramidalized geometry at the heavy element. The latter had very significant bonding implications, because it differed fundamentally from the well-known planar structure of the corresponding alkenes. The first persistent or stable paramagnetic heavier Main Group element species MR₂ (M = P or As) and MR₃ (M = Ge or Sn) were also

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obtained while parallel work using –N(SiMe_3)_2 resulted in the corresponding Main Group amido derivatives. Other lipophilic ligands, such as β-diketiminates, were also widely used, as were bulky aryloxo and thiolato ligands, to obtain stable low-coordinate Main Group species. The first examples of d- and f-block species containing bridging alkyl groups were described. Those who worked with him cited his vast knowledge and supportive low-key advisory style, which ensured a contented and productive laboratory atmosphere. In addition to his scientific work, he was deeply interested in opera, literature and the theatre, about which he could talk knowledgeably.

**Early life and education**

Michael Lappert (universally known as ‘Mike’) was born in Brno, in what was then Czechoslovakia, on 31 December 1928, the second son of Julius and Kornelie (‘Nelly’) Lappert (née Beran). Other members of the family lived in Vienna. He and his brother, Martin Josef, enjoyed an extremely happy early life, the family living in a wooden house (now preserved as being of unique architectural interest) in an estate dominated by his maternal grandparents’ large mansion. The Lappert home provided a cultured and musical environment for the children: their mother, a pianist of concert standard, often accompanied their father Julius’s fine baritone singing; both parents were university graduates. The daily routine was extremely full, involving piano and violin lessons, gymnastics, swimming and Hebrew lessons. Czech was spoken, but curiously in later life Mike completely lost his native language. With the Nazis’ assumption of power in Czechoslovakia in 1938, he and his brother were sent by their parents to London on one of the last Kindertransport. Their parents died in Auschwitz, and the brothers never saw them again. The two boys arrived in London at the end of June 1939 and were placed as boarders in Cannock House School, Eltham. Already in England at that time were Dr R. Herrmann (Nelly’s cousin from Brno) and Louise Gross, the daughter of Julius’s cousin, who had both arrived in 1938 but without their spouses. Mike never forgot his debt to Britain for receiving him and was always fiercely and proudly British. Cannock House School was evacuated in 1939 to Sheerness, and the boys were billeted with local families, finding a happy home for about three months. Most school activity consisted of football or cricket in the mornings and lessons in the afternoons. However, this period came to an abrupt end when the town and dockyards experienced the first enemy air-raid of the war and in early 1940 the school hastily returned to Eltham, the brothers remaining as the sole boarders, teaching being carried out by just two masters. Matters came to a head after a visit by a representative of the Czech Refugee Trust Fund, the boys’ guardians. It was concluded that their schooling was inadequate and the boys joined Wilson’s Grammar School near Horsham, later moving to Camberwell, where in 1946 Mike obtained his Higher School Certificate in chemistry, zoology and pure and applied mathematics.

Mike’s aunt Louise Gross (Auntie) had come to Britain via Palestine. Like Mike and Martin she was a refugee who had lost all her belongings to the Nazis. Although she had always directed her own house staff at home, in Britain she lived at first as a servant in the house of a wealthy shipping magnate, because such employment was then often a condition of refugees being granted British residence. She eventually found a flat of her own in north London, and that is where Mike and his brother went to live when they left boarding school. She was an excellent cook and did her utmost to act as a mother to the two.
boys. Mike was extremely lucky in that he was allowed maximum freedom and minimum domestic responsibilities so that he could concentrate on his studies. Later Mike’s home became widely known for the generosity of its hospitality; after Auntie’s death, excellent cooking and great hospitality continued to be a feature of the house that Lorna Lappert (née McKenzie) ran after her marriage to Mike in 1980. Lorna was born in Workington, Cumbria, where she taught after graduating in English at Manchester University in 1961. She later took a post at Marple Hall Grammar School in Cheshire, living in West Didsbury, Manchester, in a house opposite that which Michael and Auntie then occupied. This proximity led to a friendship that culminated in their long and happy marriage, in which they shared a deep interest in travel and culture.

Mike’s interest in theatre, film, music and especially opera developed when he moved to London, and he began to keep a detailed written account of all his experiences of culture and science, although not a daily diary. He continued with this for the rest of his life. Wherever he travelled he recorded his experiences, especially of what he saw in a given gallery and of what he heard in specific theatres and concert halls. He noted the principal actors and musicians he heard perform, and what he thought of the productions. He developed an encyclopaedic knowledge of literature and music. When he began to lecture and to attend scientific conferences his accounts broadened. He recorded when and where he spoke, the names of notable people who heard him, the details of place and time of the many conferences all over the world that he attended, and lists of the names of eminent scientists who were also present. This record proved useful for the writing of this account, but it is not obvious why and for whom it was prepared other than for himself. It is unlikely that he intended to publish it.

**Early academic career: Northern Polytechnic, 1953–59**

Mike began to build himself a career for the future. Because university access in the early postwar years was dominated by returning ex-service personnel, Mike (despite feeling that he had performed well during interviews at Imperial College in both 1946 and 1947) was not offered a place and for about a year he joined a small food-analytical enterprise while also attending evening classes at the Regent Street Polytechnic, where he passed the Intermediate Physics examination. Desperate to begin his higher education, he accepted a place at the Northern Polytechnic, now part of the London Metropolitan University, on a two-year BSc course with chemistry as the major and mathematics as the minor component, subsequently fulfilling university requirements by staying for an extra year and graduating in 1949 with first-class honours.

The newly appointed head of chemistry at the Northern Polytechnic was William Gerrard, under whom Mike began his research, completing his PhD thesis entitled ‘Reactions of boron trichloride with alcohols and ethers’ in 1951. Mike worked on organoboron chemistry, which was then a burgeoning area of preparative chemistry. This excited considerable interest among chemists of the time because it was a new and original extension of organic chemistry to one of carbon’s nearest Periodic Table neighbours. Mike quickly exhibited his drive and originality and his research gave him a profound knowledge of reaction mechanisms. When he later changed his area of study to inorganic chemistry, this gave him a unique approach to his subject because other inorganic chemists of the period were generally concerned primarily with structure.
He subsequently accepted the offer of the post of Assistant Lecturer at the Northern Polytechnic, and he enjoyed directing the research of several new entrants while acting as ‘lieutenant’ to Gerrard, who was greatly preoccupied with administrative tasks. In addition to his supervisory duties Mike spent his non-teaching time as an active experimentalist; significant discoveries reported were the first tetrachloro- and tetrabromo-borates (2)*, metaboric esters (5), the interaction of BCl$_3$ with alcohols (7), boron–nitrogen analogues of cyclobutadienes (13), and borazine polymers (8). The first published review (1) on organic compounds of boron proved influential, while another (with Gerrard) (3) covered the reactions of BCl$_3$ with organic compounds. Mike’s co-supervision with Gerrard (3) of 11 doctoral students resulted in 47 papers. Among his co-workers was Edward W. Abel (later Professor of Chemistry at Exeter and President of the Royal Society of Chemistry).

The first detailed infrared spectroscopic characterization of organoboron compounds was reported in collaboration with L. J. Bellamy (4) and L. A. Duncanson (6). A corollary of the infrared studies was the use of trends in the carbonyl stretching frequency $\nu$(C=O) of coordination complexes of ethyl acetate with various Lewis acids, initially BX$_3$ (X = F, Cl or Br) and subsequently several other Main Group element halides, to afford a qualitative measure of their relative Lewis acidity (9).

On becoming a Recognised Teacher of the University of London, Mike’s former role ended and he was able to pursue independent research. In 1953 he was promoted to Lecturer and in 1955 to Senior Lecturer, but despite his success and impressive research productivity he became frustrated with his opportunities for further advancement at the Northern Polytechnic and in 1959 he moved to the chemistry department of the Manchester College of Science and Technology (later the University of Manchester Institute of Science and Technology, UMIST), three graduate students accompanying him to complete their PhD theses.

**Manchester College of Science and Technology, 1959–64**

Mike’s initial appointment was to a lectureship in inorganic chemistry but he was quickly promoted to Senior Lecturer. The colloid scientist B. A. Pethica, the organic mechanistic expert G. Baddeley and the teacher and author R. B. Heslop were influential colleagues. The Chemistry Department at UMIST was experiencing a transformation under its new head of department, Professor Robert Haszeldine (FRS 1968). Before his arrival it had been a department teaching mainly applied and part-time classes in the Faculty of Technology of the University of Manchester, but Haszeldine was determined to raise it at least to parity with the more highly recognized department in the Faculty of Science in that part of the University of Manchester often referred to as ‘Owens’. To this end he modernized the Chemistry Department so that up-to-date spectroscopic facilities were available, even including one of the few commercial nuclear magnetic resonance (NMR) spectrometers manufactured by AEI in Manchester. The drawback was that Haszeldine did not delegate authority and in the early 1960s he was formally the research director of about 100 graduate students via several lieutenants, all being authorities in their own right. Mike was not inclined to take part in such an arrangement and formed his own research group, obtaining independent funding from various sources, while taking advantage of the facilities that the department had to offer. He shared a large laboratory in which

* Numbers in this form refer to the bibliography at the end of the text.
his students worked with other researchers, not his students, who later made their own careers in chemistry; these included A. P. Lever, J. A. Connor and G. J. Leigh. Mike’s work began to expand and blossom in an atmosphere that certainly encouraged him to do so, but he also took advantage of life in Manchester, cultivating his lifelong interests in music, the theatre and active sport including skiing, and in walking, often in the nearby Peak District. One consequence of his exploring the Lake District was his later purchase of the cottage at Eaglesfield (near Cockermouth in Cumbria), in which John Dalton, the proponent of the atomic theory, had been born (see below). However, still frustrated by the lack of opportunities for further promotion at UMIST, he moved to the new University of Sussex in 1964.

RESEARCH ACHIEVEMENTS AT UMIST

Mike’s research at UMIST was carried out by a total of 12 postgraduates, among whom were Harry Cragg (later to occupy a senior role at the University of Kent and sometime Lord Mayor of Canterbury), T. A. George (later Professor at the University of Nebraska), K. Jones (later Reader at UMIST) and B. Prokai (later vice-president of American Cyanamid). Three postdoctoral researchers included P. N. K. Riley (later of John Dalton College), J. C. Kotz (later co-author with K. F. Purcell of a very influential inorganic chemistry textbook) and K. Brockelhurst (later Professor of Biochemistry at Queen Mary College). The first monograph on inorganic polymers (11) and in which Mike wrote one chapter (10), which appeared in 1962, was co-edited with G. Jeffery (Jeff) Leigh (later OBE, Deputy Head of the AFRC Unit of Nitrogen Fixation and Professor of Environmental Science at Sussex University), who became a lifelong friend.

The idea of π-bonding in boron compounds was explored by both proton NMR studies on the hindered rotation about the B–N bond in BCl(NMe2)Ph (24) and measurement of ionization potentials in the series BClₙ(NMe₂)₃₋ₙ (with J. B. Pedley—the first of several joint projects) (20). A continuing theme involved the addition of BX(L)(L′) moieties across the multiple bond of an organic compound, for example in the chloroboration of alkynes to afford alkenylboranes (14). Other notable achievements during this period were the isolation of the first triborylamine (15), tri(primary-amino)boranes (12), the amino- and alkoxy-boration of isocyanates and isothiocyanates (16) and syntheses of a series of boron–sulfur compounds (21). Mike’s initial departure from boron chemistry, exemplified by the discovery of a series of organotin amides and their use as reagents (17, 18), represented a major development in his work.

UNIVERSITY OF SUSSEX, 1964–2014

In early 1964 Mike accepted an invitation from Professor Colin Eaborn (FRS 1970), the first Dean of the School of Molecular Sciences at the recently founded (1961) University of Sussex, to join as Reader in Inorganic Chemistry, and in October that year he began to teach the final undergraduate year of the first chemistry intake. The new environment proved to be much more conducive to his research, which flourished enormously. He was promoted to full Professor in 1969 (Research Professor 1997; Emeritus Professor 2011) and showed, with other Sussex colleagues, that a chemistry department in a new university could nevertheless attain international stature as a centre of excellence.
Among Mike’s fellow inorganic chemistry specialists on his arrival at Sussex were the lecturers Alan Pidcock, Michael Ford-Smith and David Smith, who had been appointed at the inception of the university, and were soon augmented in 1966 by the appointment of John Nixon (FRS 1994), also as a lecturer, who moved from his post at St Andrews University. Senior organic and physical/theoretical chemistry colleagues included A. I. Scott (FRS 1978), J. N. Murrell (FRS 1991), A. D. Jenkins and E. A. R. Peeling (who had played a major role in designing the chemistry laboratories in collaboration with the architect Sir Basil Spence). Harry Kroto (FRS 1990) (later Sir Harry, President of the Royal Society of Chemistry and Nobel laureate) had also recently joined Sussex as a Tutorial Fellow in Physical Chemistry.

The multidisciplinary Agricultural and Food Research Council (AFRC) Unit of Nitrogen Fixation led by Professor Joseph Chatt FRS had also recently moved from Queen Mary College to occupy an adjacent custom-built building on the Sussex campus. Its Deputy Director with responsibility for its biological group was John Postgate (FRS 1977). Among the AFRC personnel who actively contributed over the years both to the weekly inorganic chemistry seminar programme and to undergraduate and post-graduate teaching were Jeff Leigh, Ray Richards, Jon Dilworth, Chris Pickett and Richard Henderson. Seminars, sponsored independently by both AFRC unit and university members, were attended by both groups, and regular visits by international visitors were commonplace. It was akin to having two inorganic chemistry departments on the same campus!

Mike’s research activity during his initial years at Sussex still mainly concerned boron chemistry, with little indication of the enormous range of topics that he would subsequently explore. He attracted graduate students and postdoctoral workers from all over the world, and during his career he published some 800 scientific papers, covering many different areas of the Periodic Table, a productivity that few other researchers have matched. Indeed, it was rumoured among generations of students that his ambition was to publish papers on every element in the Periodic Table, an aspiration that he came very close to fulfilling! Over his career he supervised 116 doctoral and 8 MSc students and worked with 101 postdoctoral fellows and 16 sabbatical visitors. His friendliness and helpfulness were widely appreciated and he extended personal hospitality to all his students and many visitors. His generosity was widely known and legendary.

Professor Philip Power (FRS 2005), a former student and subsequently a major international inorganic chemistry figure in his own right, has given a first-hand account of the modus operandi of the Lappert research team (see Power 2015), pointing out that ‘virtually all the synthetic work involving air and moisture-sensitive compounds was carried out using Schlenk techniques and the group did not have a dry box, a fact which renders the synthetic accomplishments all the more impressive.’ The research unit was described by Power as an informal but well-knit team, short on ceremony and long on esprit, imagination and practical skills. Laboratory hours were flexible and Mike’s direction was low-key, combining his nice sense of humour with a mastery of understatement in offering suggestions. The team was highly industrious, with no sense of pressure, since Mike strongly believed that his students should be self-motivating and persistence would eventually yield results. Group meetings stressed the importance of keeping accurate records and awareness of developments in the literature. There were frequent group discussions of important new papers, during which students quickly became aware of the huge breadth of Mike’s research interests. He was perceived as an essentially private person, the group being largely unaware of other personal aspects of his life such as his fluency in German and the tragic nature of his early life. Their overall impression of him was one of warmth.

On the social side the twice-yearly receptions at his home were eagerly anticipated, hosted in the early days by his ‘Auntie’ Louise Gross, and later by his wife Lorna.
Although Mike’s contributions to chemistry at Sussex University were inevitably dominated by his research activity, he was also active on the teaching and social fronts, participating enthusiastically in initiatives such as the organometallic crash course, the chemistry-by-thesis BSc degree, and career weekends at the University White House in the Ashdown Forest. The organometallic crash course involved teaching the subject intensively over a short period of one week rather than the conventional method of spreading the material over a term or semester. Three inorganic faculty members were involved, each offering a different topic but interacting as a trio at daily problem-solving and quiz sessions. The course, which ran for several years, proved popular with faculty and students alike.

Mike also regularly participated in year-round lunchtime games of tennis on the nearby university hard courts (other participants included Sir John ‘Kappa’ Cornforth FRS, John Murrell, John Nixon, Tony McCaffery, Ray Richards, Malcolm Topping, Gerry Lawless and Hazel Cox), Mike being the acknowledged master of the high defensive lob! This activity certainly contributed to the excellent collegiate atmosphere and strong community spirit that prevailed at Sussex during this period. Other important features were the weekly inorganic discussion group meetings and the annual Isle of Thorns career weekends for final-year undergraduates, where the atmosphere was deliberately informal: students stayed overnight and on the Saturday evening faculty offered light-hearted ‘entertainment’. The multifaceted lifestyle of chemistry faculty at Sussex during this period has been particularly well documented in MOLSBOOK (see Murrell 2009), with a front cover designed by Sir Harry Kroto.

In 1993, in the introduction to a special issue of Journal of Organometallic Chemistry dedicated to Mike, his former student, Professor David Cardin of Reading University, wrote (see Cardin 1993):

To those of us who are fortunate enough to know Michael Lappert personally, either as students, collaborators in joint projects, or colleagues (enjoying from time to time his famous hospitality!), it seems incredible that this issue is to celebrate his 65th birthday. It seems even more incredible in view of his continuing visits around the world, frequently coupled (as at home) with visits to concerts, operas and art galleries to think of him retiring. In this connection it might be worth reflecting that Giuseppe Verdi, a composer over whose works he has been known to enthuse, did what is generally considered his best work in his eighties.

The following year a symposium and dinner was held at Sussex University in Mike’s honour entitled ‘40 years of research’. Many of his former students attended, and the invited speakers, spanning the four decades, were his long-standing friend Professor Heinz Nöth from Munich, Professor Edward Abel, Professor Colin Raston, Professor Phil Power FRS, Professor Dave Cardin and Dr Gerry Lawless. At Mike’s specific request the word ‘retirement’ was not mentioned during the meeting and he went on to publish a further 250 papers over the next 20 years!

The celebration in 2005 of 40 years of successful publication by the Royal Society of Chemistry journal Chemical Communications provided a clear indication of the continuing influence of Lappert’s research work. The editors of the journal drew attention to the top 40 most-cited authors and congratulated Mike on coming top of the list with no fewer than 5913 citations (about 800 more than his nearest challenger). Another Sussex colleague, also high in the publication list, was Peter Hitchcock, who carried out most of the hundreds of X-ray crystal structure determinations on the Lappert group compounds during his Sussex period.

A significant innovation, established around that period by Mike and Heinz Nöth, was the series of Anglo-German Inorganic Chemistry Meetings (AGICHEM), inaugurated in 1991 as...
a joint venture of the Gesellschaft Deutscher Chemiker and the Royal Society of Chemistry. The first meeting, held at Brighton and chaired by Mike and Heinz, was so successful that subsequent biannual conferences were held at Stuttgart (1993), Brighton (1995) and Marburg (1997) before the UK venue for the meeting became more diversified; the most recent meeting was held in Edinburgh in 2014.

A further career milestone was Mike’s period as President of the Dalton Division of the Royal Society of Chemistry from 1989 to 1991. An interesting feature of his role in this office was, as previously mentioned, that he also owned the cottage at Eaglesfield in the Lake District in which John Dalton was born, which he and his wife Lorna visited on many occasions (see figure 1). Furthermore in 2003, to mark the bicentenary of Dalton’s famous paper setting out his ‘Table of the relative weights of the ultimate particles of gaseous and other bodies’, Mike, together with his Sussex colleague John Murrell, published an article entitled ‘John Dalton, the man and his legacy: the bicentenary of his Atomic Theory’ (101).

Remarkably, over the 20-year period following his formal retirement in 1994, Mike continued to write, publish and review huge numbers of research papers and he regularly attended weekly chemistry seminar programmes until he had a fall while playing tennis on the Sussex university campus courts at lunchtime on 28 March 2014, sustaining injuries from which he died. A celebration of his life was held at the Meeting House on the Sussex University campus on 2 July 2014; and roughly a year after his death, former colleagues and students from all over the world packed a Royal Society of Chemistry Dalton Division one-day meeting in his honour held on 1 April 2015 in Burlington House, London. In what was widely regarded as a meeting of exceptionally high quality, lectures were delivered by distinguished speakers from the UK, the USA, Australia, New Zealand and Germany, including a contribution from Nobel laureate Professor Richard Schrock FRS. Repeated references were made to Mike’s many seminal ideas in a wide variety of fields. Sussex colleagues David Smith and John Nixon described his early life and reminisced about his Sussex career. His extraordinary generosity
and kindness shown to students and colleagues alike was also acknowledged. At the end of the meeting, Mike’s widow, Lorna, was presented with a bound volume of his 30 most influential papers entitled ‘The influence of Michael Lappert on the chemistry landscape’ (see Arnold et al. 2014). Further tributes included a special issue of Organometallics 34, 2035–2706 (2015), the front cover of which is reproduced in figure 2.

Friends and colleagues at Sussex University decided that a fitting tribute to Mike would be the placing of wooden bench at the tennis court side at Sussex University, just a short distance from his office. It has the following citation:

IN MEMORY OF MICHAEL LAPPERT, FRS, MUCH-LOVED COLLEAGUE, INSPIRATIONAL SCIENTIST AND INDOMITABLE TENNIS PLAYER.

50 PRODUCTIVE YEARS AT SUSSEX

RESEARCH ACHIEVEMENTS AT SUSSEX UNIVERSITY

Period 1964–74

Boron halides were used to synthesize divalent platinum halogeno-complexes (22), and the structure of the transient BF₂Cl was established by microwave spectroscopy, in collaboration with H. W. Kroto (40). Calorimetric studies were introduced in 1965 on complexes of ethyl acetate with Group 13 halides (19) and iridium(I) complexes obtained by dehydrochlorination of iridium(III) hydrochlorides (30). Organometallic diazoalkanes (23) afforded heterocycles via addition to 1,2-dipoles (26); a Sussex collaboration with Professor A. D. Jenkins (27), involved kinetic studies on titanium amides as initiators for acrylonitrile polymerization.

A very important development during this period was the introduction of ligands containing –CHₙ(SiMe₃)₃₋ₙ groups, which subsequently became very widely used by others (25, 31).
Notable syntheses based on this paradigm included \([\text{Cu}\{\text{CH}_2(\text{SiMe}_3)_4\}]\) (32), \([\text{Y}(\text{CH}_2(\text{SiMe}_3)_3)\text{(thf)}_2]\) (33), where thf represents tetrahydrofuran, and \([\text{Cr}\{\text{CH}(\text{SiMe}_3)_2\}_3]\) (38).

Furthermore, the concept that kinetic rather than thermodynamic effects were crucial for the stabilization of metal or metalloid Main Group element compounds under ambient conditions led to the isolation of the first two-coordinate tin and lead alkyls, \([\text{M}\{\text{CH}(\text{SiMe}_3)_2\}_2\] (M = Sn or Pb) (34), which are analogous to carbenes. It was subsequently shown that although these species afford weak dimers analogous to the alkenes in the solid state, unlike their carbon counterparts they did not have planar structures but instead exhibited pyramidalization at the heteroatom. This differing behaviour of the heavier Main Group p-block elements opened up a series of major developments in this area. Electron spin resonance studies in solution revealed the existence of the persistent stannyl radical \([\text{Sn}\{\text{CH}(\text{SiMe}_3)_2\}_3]\) (35). The work, involving sabbatical visitor Professor Harold Goldwhite, stimulated studies on phosphorus and arsenic compounds and also afforded similar stable radicals (44).

A significant achievement was the direct synthesis from the electron-rich olefin \((\text{CH}_2\text{PhN})_2\text{C}=\text{C}(\text{NPhCH}_2)_2\) of a platinum(II) complex of the carbene \(:\text{C}(\text{NPhCH}_2)_2\) (28). A structurally similar NHC carbene, first reported by Arduengo and co-workers (see Arduengo et al. 1991) and now extremely well known, has found wide synthetic and catalytic applications. The Lappert group subsequently exploited a variety of electron-rich olefins as precursors for a wide range of carbone–transition-metal complexes (48), which featured in a comprehensive review (36) also including the extensive work of the group of E. O. Fischer in Munich. Dismutation of electron-rich olefins having different substituents at the nitrogen atoms was shown to be catalysed by rhodium(I) complexes (29). A further method of generating a carbone–transition-metal complex involved a three-fragment oxidative addition reaction (39). Similarly, oxidative addition of an alkyl halide to zerovalent platinum was shown to proceed by a radical process (37). Collaboration with Professor A. W. Johnson FRS, who had recently moved to Sussex from Nottingham, on vitamin B12 chemistry as a model to the above carbone–metal chemistry led, inter alia, to a kinetic and mechanistic study of the coenzyme B12-dependent enzyme ethanolamine ammonia-lyase (41).

**Period 1975–86**

The remarkable versatility of the Lappert research group is exemplified by the following selections from his published work during this period. A major review with P. Lednor of free radicals in organometallic chemistry (45) was very influential, as was the report of the synthesis of stable P(II) and As(II) alkyls and amides (46) and a method for generating either \([\text{M}(\eta^5-\text{C}_5\text{H}_4\text{R}^1)_2\text{R}^2]^–\) (M = Ti, Zr or Hf; R1 = H or SiMe3, R2 = X(SiMe3)) from the M(IV) precursor and sodium naphthalide (52).

Collaboration with Sussex colleague J. B. Pedley in the calorimetric determination of the heats of alcoholysis of Ti, Zr and Hf chlorides, alkyls, amides and alkoxides led to the observation that the M–X bond energy terms (X = C, N or O) decreased in the order Hf > Zr > Ti and to the important conclusion that bond strengths decrease with atomic number in a Main Group element but the reverse is the case in the transition metals (42). A joint venture with the Haaland–Fjelderg electron diffraction team (59) led inter alia to the determination of the gas-phase structure of the lithium amide \([\text{Li}\{\text{N(SiMe}_3)_2\}_2]\).

Dark blue \([\text{Th}(\eta^5-\text{C}_5\text{H}_5(\text{SiMe}_3)_2)_2]\), the first crystalline thorium(III) compound, was obtained by Na/K reduction of \([\text{Th}(\eta^5-(\text{C}_5\text{H}_5)\text{(SiMe}_3)_2\text{Cl}_2]\), metallic thorium being the co-product. Collaboration with Edelstein’s group (using the SiMe2Bu3 analogue), involving
variable-temperature electron paramagnetic resonance, magnetic measurements and optical spectra, established that the green reduction product had a 6d\(^1\) rather than a 5f\(^1\) electronic ground state (66, 84). The very widely used bis-trimethylsilylcyclopentadienyl ligand, \(\eta^5\)-C\(_5\)H\(_5\)(SiMe\(_3\))\(_2\) (abbreviated to Cp") was introduced in 1981 in the context of early (f\(^0\)–f\(^3\)) lanthanocene and related Sc and Y chlorides, including the synthesis and X-ray structural characterization of \([\text{Pr}()]\eta^5\)-[C\(_5\)H\(_5\)(SiMe\(_3\))\(_2\)]\(_2\)(μ-Cl)\(_2\) (55). This led to a detailed survey of such data for the complete 4f-metal series and of hetero-bimetallic analogues such as \([\text{Ln}()\eta^2\)-μ-Cl]\(_2\)(ML\(_2\)) (M = Li or Na, L = a neutral donor) or \([\text{AsPh}_4]\)]\(\text{NdCp}^\prime\prime\)) (57).

The first examples of bridging (μ-Me)\(_2\)-4f-metal species \([{\text{MCp}_2()}\mu\text{-Me}])\(_2\) and \([{\text{MCp}_2()}\mu\text{-Me}])\(_2\)AlMe\(_2\)] (where Cp represents cyclopentadienyl, C\(_5\)H\(_5\)) were prepared (43) and early transition metal meso-metallacycles \([\text{M}()\text{CH(SiMe}_3\text{C}_6\text{H}_4\text{CHSiMe}_3\text{-o})\text{Cp}_2\)] (M = Ti, Zr, Hf or Nb) displayed reversible one-electron reduction (60). Among extensive contributions to carbene-metal chemistry was the synthesis and structures of cis- and trans-[Mo(CO)\(_4\)](A)\(_2\]) (A = carbene), complexes and a kinetic study of their interconversion (56). Surprisingly, treatment of \([\text{Nb}(\eta^5\text{-C}_5\text{H}_4\text{Me})\text{CH}_2\text{SiMe}_3\text{Cl}]\) with Na/Hg in thf under an atmosphere of CO\(_2\) yielded the crystalline Nb\(^{III}\)?η\(^2\)?CO\(_2\) complex, the carbon dioxide having unexpectedly displaced the chloride ion (54).

Attention to Main Group element chemistry was not neglected, and a series of crystalline, monomeric, thermochromic (yellow-to-red), divalent Ge, Sn or Pb amides, M(NR\(_1\)R\(_2\))\(_2\) (R\(_1\) = SiMe\(_3\), R\(_2\) = SiMe\(_3\) or Bu; M = Ge, Sn or Pb; or R\(_1\) = R\(_2\) = GeMe\(_3\), SiEt\(_3\) or GePh\(_3\), was prepared from the appropriate lithium amide and metal(II) chloride (49). Bulky silylmethyl and related trialkyls of Group 13 metals included the X-ray-authenticated InR\(_3\) (53). Similarly, reaction of ECl\(_3\) (E = P or As) with 3LiNHAR (E = P or As; Ar = C\(_6\)H\(_2\)Bu\(_3\)-2,4,6) gave the novel, crystalline, orange (P) or red (As), two-coordinate imides E(=NAR)(NHAR) (61).

Gas chromatographic studies of homogeneous catalytic reactions included hydrosilylation (via co-condensation of metal atoms at −196 °C), of isoprene with triethoxysilane below 0 °C, affording quantitative and regio- and stereo-selective yields of (Z)-1-triethoxysilyl-2-methyl-2-butene (50). This period ended with two major reviews. The first, ‘Metal σ-hydrocarbys, MR\(_n\): stoichiometry, structures, stabilities, and thermal decomposition pathways’, introduced the terms ‘homoleptic and heteroleptic’ into coordination and organometallic chemistry (47). The second, entitled ‘Bridged hydrocarbonyl or hydrocarbon binuclear transition-metal complexes: classification, structures, and chemistry’, afforded a comprehensive survey of a topic that came into prominence after 1970 (58).

### Period 1987–96

The role of heavier Group 14 element carbene analogues, MX\(_2\) (M = Ge, Sn or Pb; X = CHR\(_2\), NR\(_2\), OAr or SAR; R = SiMe\(_3\), Ar = C\(_6\)H\(_2\)Bu\(_3\)-2,4,6), in transition-metal chemistry was comprehensively reviewed (70). Following Denk and West's discovery of the first room-temperature-stable gaseous silylene, and its structure determination by electron diffraction, the Lappert group prepared the crystalline silylene, Si\{N(CH\(_2\)Bu')\}\(_2\)C\(_6\)H\(_4\)-1,2, and showed that it underwent oxidative-addition reactions (78).

Other important milestones in widely differing areas of chemistry included:

(i) identification of the chelating ligand \([\eta^2\text{-C}_2\text{=CHSi(Me)}_3\text{]}\text{O}\) as a key component of the industrially important Speiers hydrosilylation catalyst (63, 73);

(ii) a low-temperature single-crystal X-ray and neutron diffraction study of Me\(_2\)Mg, which revealed the first example of an intermolecular weak (agostic) γ-methyl-metal interaction (71);
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(iii) lipophilic calcium and strontium alkyls, amides and phenoxides obtained directly from the corresponding metal, in collaboration with Sussex colleague Geoff Cloke (FRS 2007) (74);
(iv) establishment of the linear structure of MnR₂ in the gas phase (67);
(v) first examples of neutral homoleptic 4f-metal(III) alkyls, [LnR₃] (Ln = La or Sm); the former being pyramidal with unusually short La···HCH₂ contacts (68);
(vi) metal-vapour syntheses affording bis-(η-1,3,5-tri-t-butylbenzene) sandwich complexes of zerovalent titanium, zirconium and hafnium (65); and
(vii) metal complexes containing the novel benzene 1,4-dianion (79).

Studies, in collaboration with the groups of R. A. Andersen, J. C. Green and A. Haaland, on 3d⁶, 3d⁷ and 3d⁸-metal amides M(NR₂)₂, which are monomeric in the gas phase, were shown by electron diffraction to have an N–M–N core and by photoelectron spectroscopy and molecular orbital calculations to have ⁶A₁, ⁴B₁ and ⁴A₂ ground states, respectively (69). Novel two-coordinate germanium arylamides and related crystalline tin(II) amide [Sn{N(H)Ar}₂] compounds were also described (72).

Particularly exciting achievements were long-sought-after examples of transition-metal complexes containing a metal–phosphorus double bond, [MCp₂(=PAr)] (M = Mo or W; Ar = C₆H₅Bu₃-2,4,6), which were obtained in crystalline form, the structure of the Mo compound revealing a short Mo–P distance and a Mo–P–C angle of about 116°, consistent with the existence of a stereochemically active lone pair at phosphorus (64).

Interestingly, the first examples of neutral mononuclear 4f-metal thiolates, for example [Sm(SAr)₃] and [Yb(SAr)₂(dme)], could be obtained directly from the corresponding metal-alkyl precursors (75), and a further important observation was the transformation of the ubiquitous –CH(SiMe₃)₂ ligand into the corresponding β-diketiminate -N(SiMe₃)C(Ph)C(H)C(Ph)N(SiMe₃)⁻, on treatment with PhCN (76). Such β-diketiminate ligand systems were subsequently developed extensively by the Lappert group.

Final period, 1997–2014

Mike Lappert reached the normal age of retirement of 65 years at the end of 1993, but he was granted an employment extension until 1997 to allow him to continue to supervise postgraduate research students until 2003 and to be part of the Chemistry Departmental Research submission to the University Grants Committee. Thereafter he continued as a Research Professor with postdoctoral workers until his death. From 1997 until his death he supervised 7 postgraduates and 25 postdoctoral scientists. The work during this time continued along the lines of the earlier periods described above. He continued to explore the chemistry of bulky ligands that could stabilize otherwise unusual metal complex stereochemistries and oxidation states, and expanded the chemistry of less-common metals, especially rare earths, and of low oxidation states of these and many other elements.

His work, even in single publications, often involved a wide range of topics, so that summarizing his research under specific headings is quite challenging. The references quoted should generally be regarded as typical of the subject discussed rather than a comprehensive record. Two closely related earlier communications published in 1994 (76, 77) attracted 114 citations each, showing their scientific significance. Each describes the straightforward preparation of two highly lipophilic monoanionic ligands, azaallyl and β-diketaminato, and the introduction of these ligands into early transition and Main Group metal chemistry. He was one of the first to realize that the β-diketaminato (or NacNac) ligands that he employed
were suitable for supporting a wide range of coordination chemistry, providing the advantage of steric protection of a metal centre, and similar to the widely used acetylacetonate ligand. Diketiminates are formally condensation products of a ketone and an amine, and variation of the two starting materials gives rise to a wide variety of similar but different materials with a range of reaction and steric properties. Such β-diketiminate ligands became particularly popular ancillary groups in various fields of organometallic and coordination chemistry, with significant contributions using the Lappert bis(trimethylsilyl) substituted β-diketiminate. Mike himself continued to be active in this area and, along with Bourget-Merle and Severn (99), published a definitive review on the subject of NacNac ligands. These were designed to support low-oxidation-state lanthanum compounds but Mike continued to exploit their use in a wide range of transition-metal coordination compounds, in both spectator and non-spectator roles (73, 95, 100, 102, 105, 108, 112, 115, 118, 120, 125).

As mentioned earlier, an abiding interest of Mike’s was the chemistry of carbenes and of analogous metal(II) derivatives from Periodic Group 14, and the olefins from which they may be derived. He published a review of his work in this area in 2005 (109). Reactions between the heavier members of this Group were investigated (80–82, 85, 86, 91, 96, 107, 110, 116) and Mike also collaborated with other independent researchers whose specialities included various spectroscopic techniques and thermochemistry, the information from which would complement that obtained from his own specific researches (83, 87, 97, 103, 111).

Of special importance are the reactions of the various divalent heavier Group 14 element carbone-analogues with carbonyl groups (80) and their ready insertion into metal–nitrogen bonds (81) and specific P–P bonds of organophosphorus cage compounds (116). Particularly interesting was the report (in collaboration with the groups of Cowley, Rankin and Power) of the spontaneous generation of stable pnictinyl radicals from ‘Jack-in-the-box’ dipnictines and a detailed examination of solid-state and gas-phase structures and a theoretical investigation of the origins of steric stabilization (97).

A range of sterically crowded Lappert-type ligands was used to investigate new chemistry of a wide range of metallic elements, many of which, such as the rare-earth derivatives, have become readily available only relatively recently. In addition to the examples cited above, especially noteworthy is a report of complexes of aluminium(I) (88). Later publications describe the use of the NacNac ligand with magnesium (92), cobalt, iron and zirconium (118, 104), thallium (93), a considerable number of different lanthanides (89, 106, 119, 123, 126), alkali metals (94), titanium, zirconium and iron (113), tin (114), zinc (117, 127), a wide range of further transition elements (90, 121) and even some non-metal clusters (124). Remarkably, even with this enormous output, Lappert also published a review (98) and contributed to several books (51, 62, 122).

Awards and Honours

Mike Lappert was the recipient of the first Royal Society of Chemistry Medal for Main Group chemistry (1970). He was also an Organometallics Medallist (1978) and a Tilden (1972), Nyholm (1994) and Sir Edward Frankland (1998) Lecturer. He received the F. S. Kipping Award for Silicon Chemistry from the American Chemical Society in 1976 and the Alfred Stock Memorial Prize in 2008. This latter is the premier award of the Gesellschaft Deutscher Chemiker for inorganic chemistry, which is presented every two years and only rarely to a non-German scientist. Probably because of his family history, of all the honours
he received during his career he was proudest of this. Since 1950 the only other UK recipient was Professor H. J. Emeléus FRS. Mike was elected a Fellow of the Royal Society in 1979 and was President of the Dalton Division of the Royal Society of Chemistry from 1989 to 1991. He was a Science and Engineering Research Council Senior Fellow (1980–85) and held honorary doctorates of the Universities of Munich (1989) and Murcia (2013). From 2000 he was an Honorary Professor of Shanxi University in China. He lectured worldwide during his academic career and also held positions as Visiting Professor at the Universities of Alabama, Alberta, Auckland, British Columbia, Chinese University of Hong Kong (where he was Royal Society Tang Professor), University of California at Davis, Rennes, Waterloo, Western Australia and Wisconsin (where he was the first McElwain Awardee for Inorganic Chemistry).

**CAREER SUMMARY**


**ACKNOWLEDGEMENT**

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