



**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

Applied geoscience for our
changing Earth



Mike Edmunds: Fifty Years of Water, Rock and Interaction

**George Darling
British Geological Survey
Wallingford, UK**

A career in numbers

Over his career, Wyndham Michael ('Mike') Edmunds achieved:

- **>100** refereed journal papers, and currently has an h-index of **36**
- **>30** books/chapters as author and editor
- directed **220** MSc students
- supervised **16** PhD students (and examined many more)
- presented at **5** scientific society/university distinguished lecture series
- received **3** scientific awards
- attended all **14** WRI symposia up to 2013 (only person to do so)

But how did it all start?



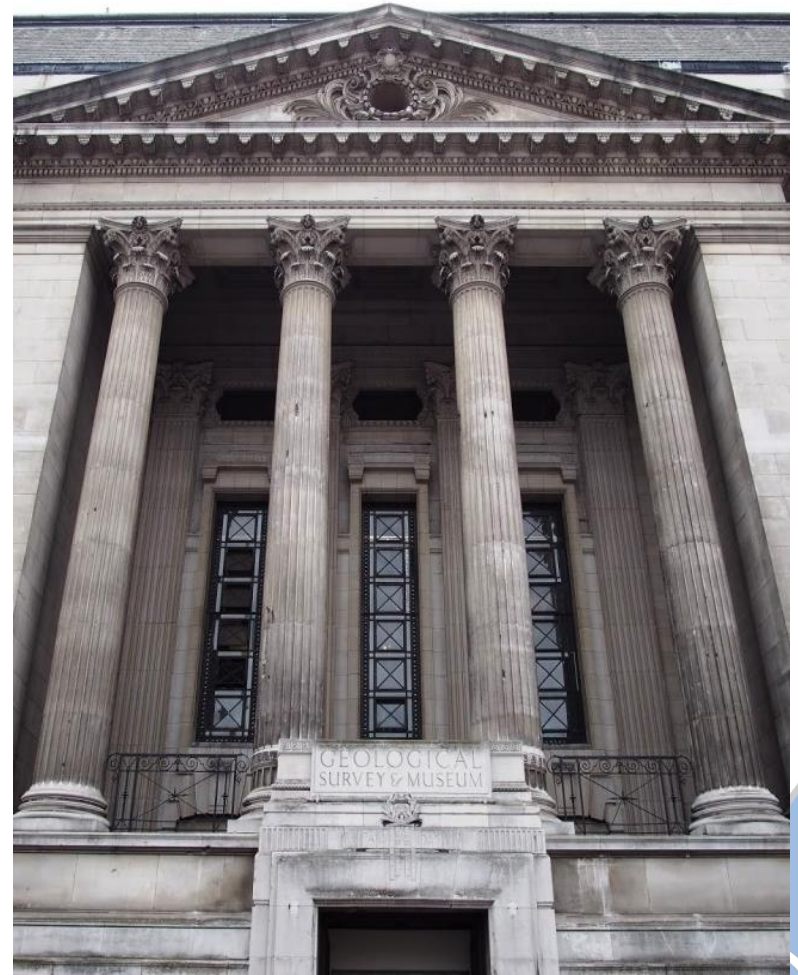
Early days: education and research

- Mike studies French, German and Geography for his A-levels (exams based on Yr 12–13)
- Decides he wants to study Geology at Liverpool U so undertakes a 1-yr conversion course
- Arrives at Liverpool in 1958
- Achieves BSc (hons) in 1962
- Undertakes PhD in poly-metamorphic rocks in NW Ireland specialising in garnets
- Finishes at Liverpool in 1966 (PhD eventually awarded 1968)

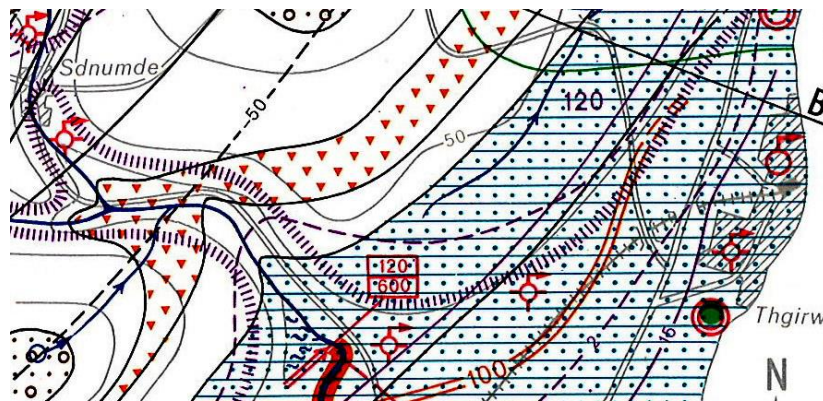
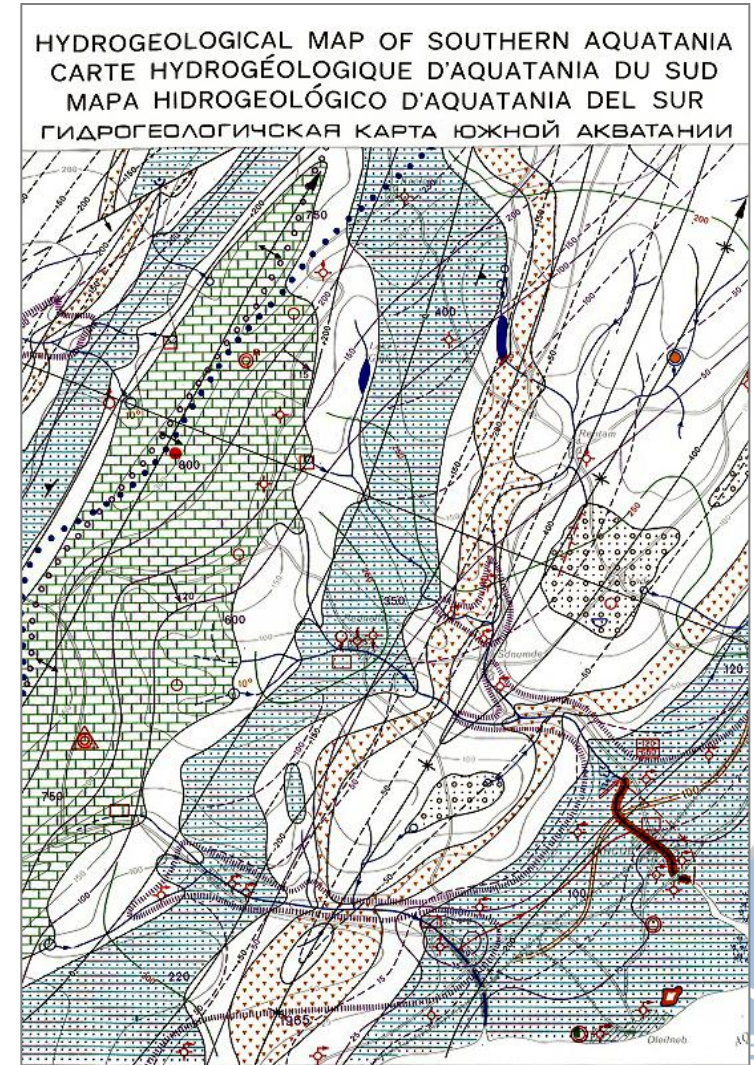
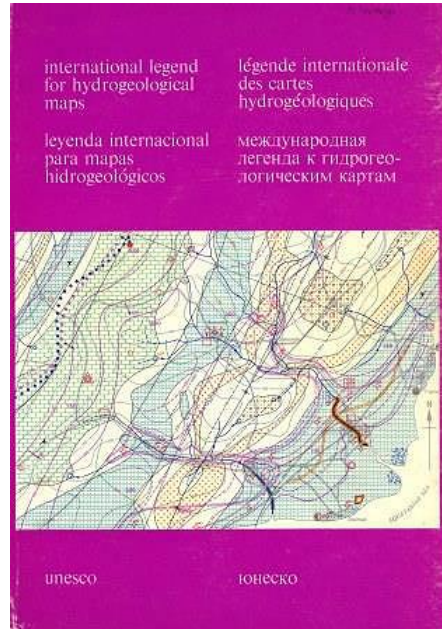
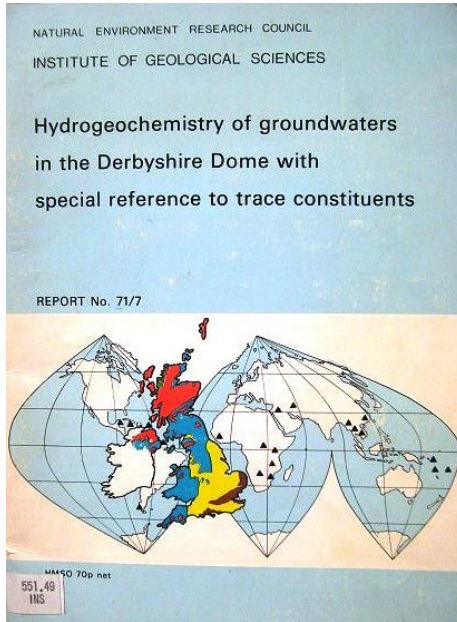


Early days: first job

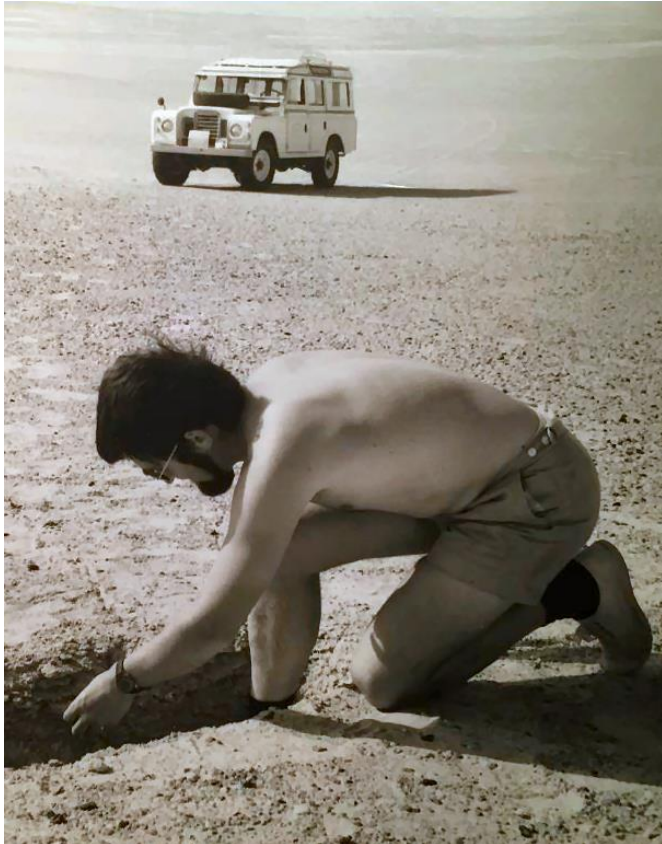
- Mike was interviewed mid-1966 for employment at the NERC's Institute of Geological Sciences (IGS)
- He was offered a job in the Hydrogeological Department and started in autumn 1966
- Mike was initially put to work on the hydrochemistry of the UK's natural groundwaters
- A early interest was aroused in the UK's spa waters including the thermal waters of Bath and Buxton
- However within a couple of years he found himself working overseas



Early days: first appearances in print



Working in Libya: intro to the arid zone



- From 1967-74 he was a member of a team working in Libya on the aquifers intended to supply the Great Man-Made River
- This project started Mike's life-long interest in arid zone recharge estimation, and how hydrogeology links with palaeoclimate

GROUNDWATER RECHARGE AND PALAEOCLIMATE IN THE SIRTE AND KUFRA BASINS, LIBYA

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Institute of Geological Sciences, Wallingford OX10 8BB (Great Britain)

(Received May 11, 1978; revised and accepted July 14, 1978)

Journal of Hydrology 40, 215–241 (1979)



Libya: the 1979 paper

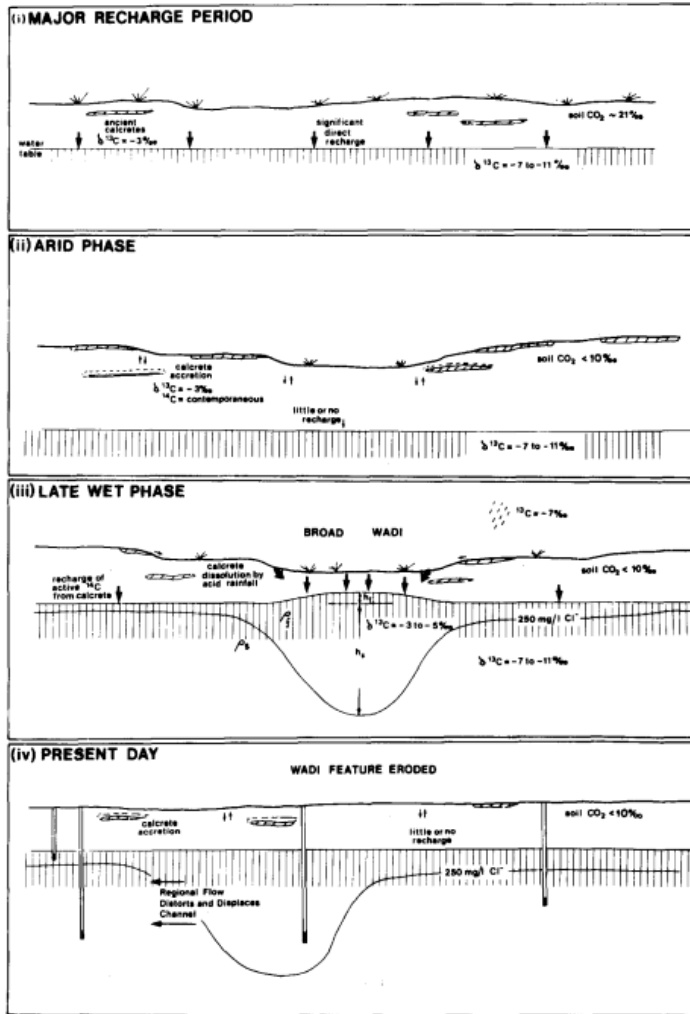


Fig. 4. Hydrological model illustrating the development of the freshwater channel; the probable stable C-isotope compositions of reactive aqueous and solid phases at each stage are indicated. For further explanation see text.

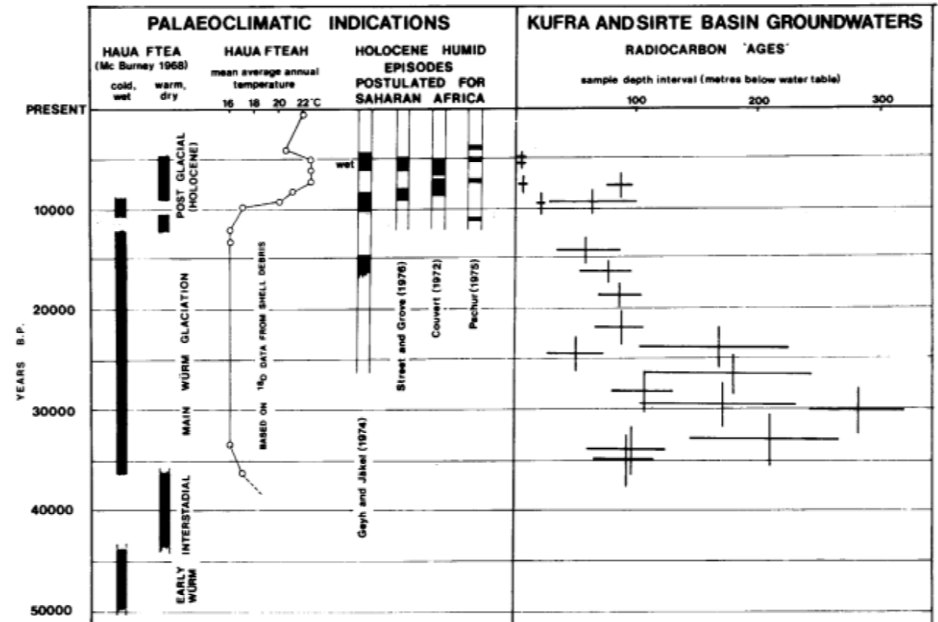


Fig. 6. Ages of groundwater in the Kufra and Sirte basin compared against indirect palaeoclimatic evidence for the Sahara region for the Late Pleistocene and Holocene.

Start of WRI and Mike's involvement

- In the late 1960s Mike researched into down-dip chemical changes in an important UK aquifer, the Lincolnshire ('Lincs') Limestone of eastern England
- He presented his findings at the *Symposium on Hydrogeochemistry and Biogeochemistry* held in Tokyo in September 1970
- At this meeting the setting up of various IAGC interest groups was proposed by the late Prof M G Valyashko, including WRI to '*study water–rock interaction under various temperature and pressure conditions, compile key programs, develop methods, and determine transportation forms of components*'.
- Having taken this suggestion on board, Brian Hitchon and Don White convened an informal meeting of WRI ('WRI-0') at the 24th IGC in 1972
- A total of 16 interested parties attended, including Mike
- It was agreed that WRI-1 would be held in Prague in 1974, in the capable hands of Tomas Pačes



Mike's first influential paper

- The Proceedings from the 1970 Tokyo symposium were eventually published in 1973
- Included was Mike's Lincolnshire Limestone paper *Trace element variations across an oxidation-reduction barrier in a limestone aquifer*
- Although not a refereed paper as such, this is widely recognised as one of the first studies of down-dip hydrochemical changes
- It was not simply an academic exercise, but discussed aquifer development, fate of pollutants and well corrosion

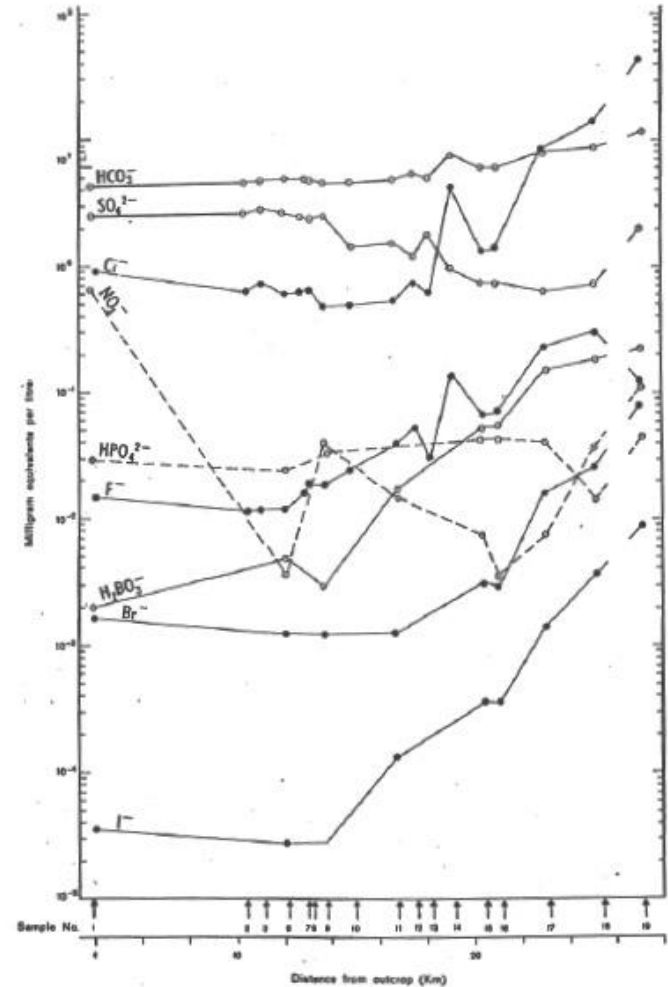
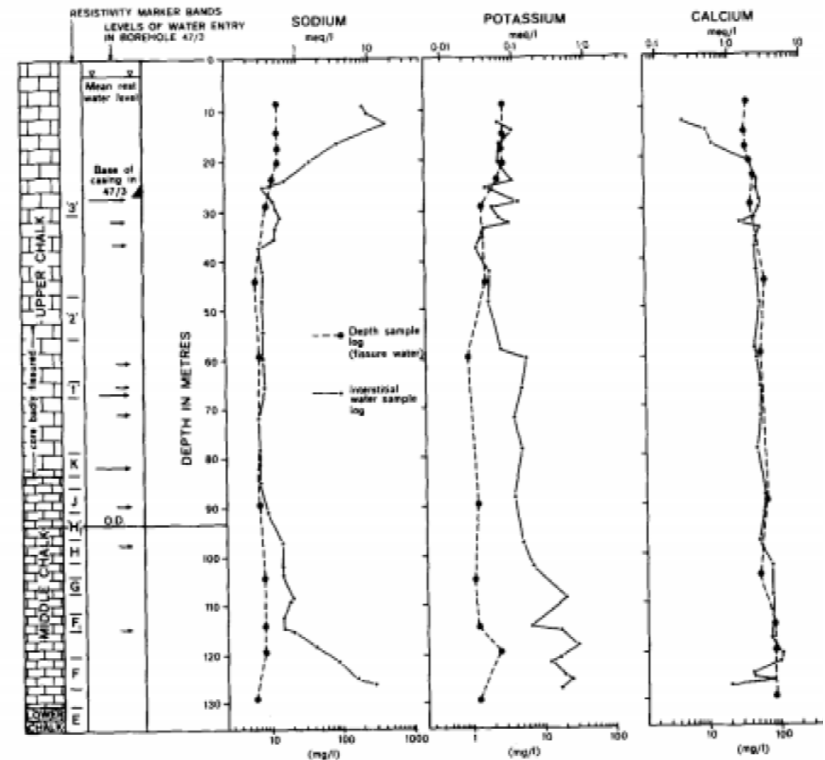


Figure 5. Variation in concentration of major and trace anions with distance from the outcrop.

Mike's first WRI paper

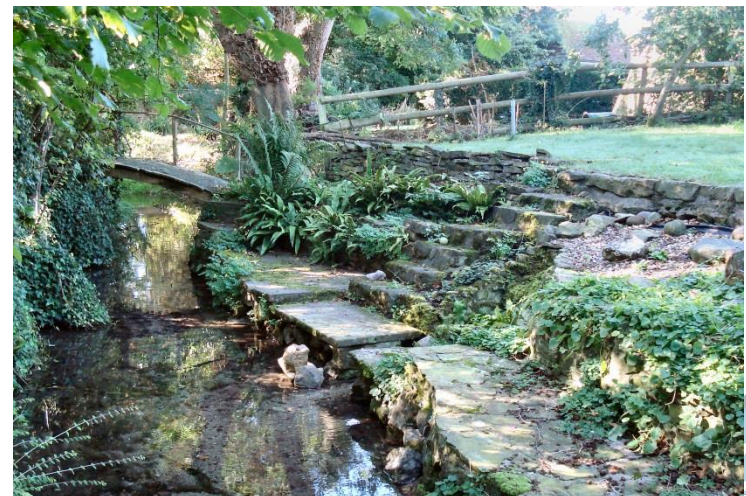
- At WRI-1 in Prague, Mike presented a paper on *Chemical variation of pore waters from the Cretaceous chalk of England*
- This was a follow-on to his first co-authored paper: Edmunds W M, Lovelock P E R and Gray D A (1973) Interstitial water chemistry and aquifer properties in the Chalk of Berkshire, England. *J Hydrol* 19, 21–31
- This discussed the results from a cored B/H in the Chalk west of London, and showed that the pore waters were as much as 10 times more mineralised than the water moving through the fractures
- The paper also demonstrated a link between physical and chemical properties in the aquifer



- He went on to repeat this with further, deeper BHs, most notably at Trunch (470 m deep)

1977: Relocation to Wallingford

- In the mid-1970s, the IGS decided to relocate out of London to save on office rentals
- The Hydrogeological Dept. was relocated to NERC's Wallingford campus, already home to its Institute of Hydrology
- The relatively primitive analytical facilities at the London office could now be replaced with state-of-the-art equipment
- The move took place in 1977, enabling Mike to find his dream home, complete with chalk stream in the back garden



'State of the art' in 1979

IGS REQUEST TO PURCHASE (Items exceeding £100)

Goods will be required to be consigned to:
 HYDROGEOLOGICAL UNIT
 INSTITUTE OF GEOLOGICAL SCIENCES
 CROWMARSH GIFFORD
 WALLINGFORD
 OXON OX10 8BB

PLEASE TENDER ON:
 Minimum No. of Tenders
 0 - £ 999 : 3
 £ 999 - £ 9 999 : 4
 £10 000 - £99 999 : 5

All Single Tenders must have a statement in support attached.

SPECIAL CONDITIONS

Item No.	Particulars Specification or Drawing No.	Articles (BLOCK LETTERS)	Quantity
1		Complete Quantovac 390000 Inductively Coupled Plasma installation	1
2		Voltage Regulator	1
3		Recommended spares and operational supplies	1

Estimated gross cost: £79,725
 Subtotal: 314.0
 VAT: HY

Inspection to be to the satisfaction of:
 Mr D. L. Miles

Repayment project:
 Signed: _____ Date: _____
 Approved: _____ Date: _____

Dr. Sabine

The attached paper by Dr. Edmunds and general correspondence relates to the Plasma Emission system for Hydrogeology.

As you know, I recognise that acquisition of such a multi-element facility is essential for the hydrogeochemists if they are to maintain the scientific standing which they have achieved in the last few years, irrespective of its application to the DOE Contract. Accordingly, I ask that high priority should be given to allocation of funds at an early date.

D.A. Gray
 D.A. Gray
 19th February, 1979

c.c. Mr. Day
 Dr. Edmunds ✓

Enc.

Mike could be very persuasive: £79,725 was a lot of money in 1979



Consolidation at Wallingford

During the period 1977–79 the hydrogeochemistry labs were commissioned, including AA spectrophotometers from the London lab, one of the early ICP-OES instruments, a very early ICP-MS instrument, and a stable isotope mass spectrometer



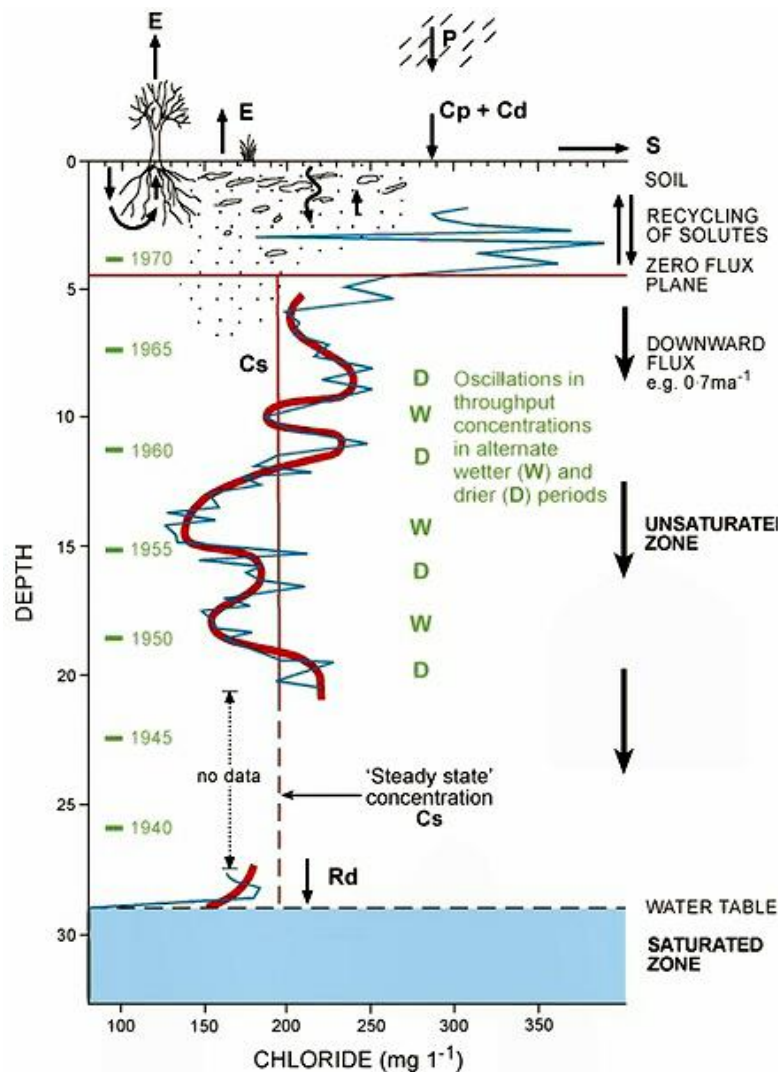
The 1980s

- With the laboratories set up and a team behind him, Mike was able to to work on a wide range of projects including:
- Acid rain – a problem due to the amount of SO₂ being produced by power plants etc
- Arid zone recharge
- Trace element characterisation of UK groundwaters
- Palaeo-groundwaters
- The geothermal potential of deep sedimentary basins and HHP granites
- Founder AE of Applied Geochemistry, and organising WRI-6



The arid zone continued: 1

- After his experiences in Libya, Mike wanted to follow his own research agenda
- He found an ideal semi-arid site in SE Cyprus where the UK still has an air base
- There he could concentrate on applying the chloride mass balance (CMB) method of recharge estimation
- And then he persuaded the Royal Air Force to fly sand samples back to the UK...



The arid zone continued: 2

- Mike further developed the CMB method in Senegal with the aid of the University of Dakar
- He collected cored profiles in areas with different amounts of rainfall
- He was able to use the RAF again to transport his sand samples back to UK



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Journal of Hydrology 156 (1994) 47–59

Journal
of
Hydrology

[3]

Estimating the spatial variability of groundwater recharge in the Sahel using chloride

W.M. Edmunds^{*a}, C.B. Gaye^b

^aBritish Geological Survey, Crowmarsh Gifford, Wallingford, OX10 8BB, UK

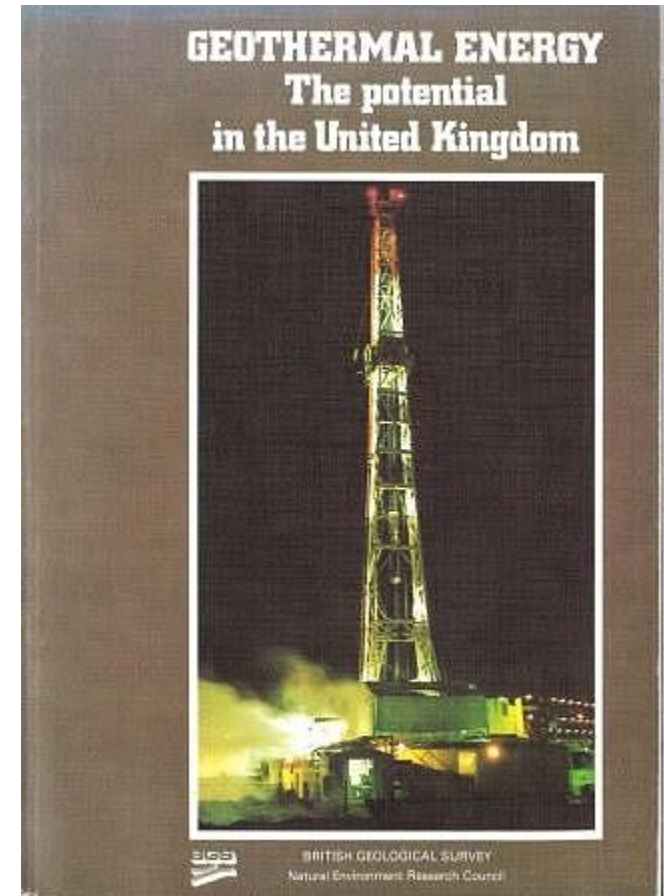
^bDépartement de Géologie, Faculté des Sciences et Techniques, Université Cheikh Anta Diop, Dakar, Sénégal

(Received 16 April 1993; revision accepted 3 November 1993)

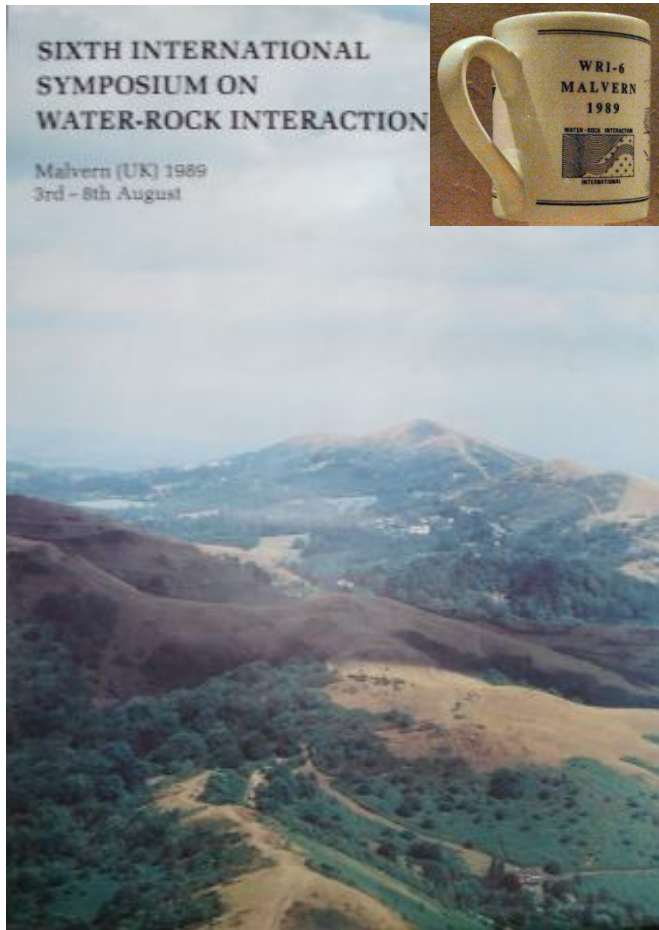


Geothermal resources of the UK

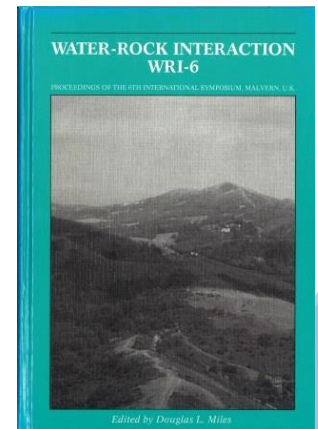
- Samples from deep (1–2 km) sedimentary basin brines were obtained from specially-drilled and hydrocarbon exploration BHs
- A picture of geochemical conditions in the deep subsurface was compiled
- Overlapping with this project was a study on Hot Dry Rock (HDR, now EGS) systems on an HHP (high radioelement) granite in Cornwall



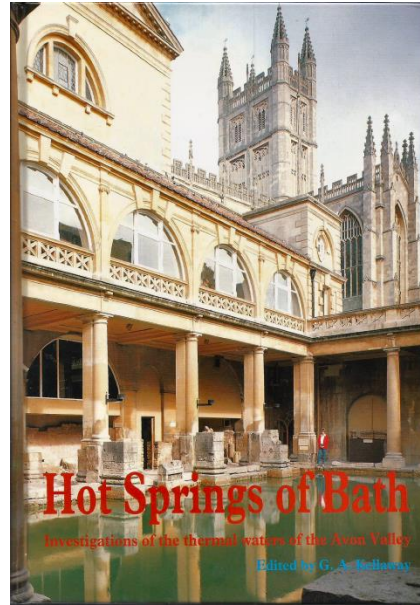
August 1989: WRI-6 in the UK



- Mike's turn to be Secretary-General of a WRI symposium
- Held in the spa town of Malvern, instead of Bath as originally planned
- 350 participants (+ excellent weather!)
- Successful post-symposium field trip to Cornwall



Thermal waters of Bath Spa



- Mike had a long-term interest in the thermal waters of the Bath-Bristol basin, driven by collaboration with John Andrews of Bath University
- He contributed to several chapters of the Bath book of 1991
- One of his last first-author publications was on the age and origin of the water (*Appl. Geochem.*, 2014)



The 1990s

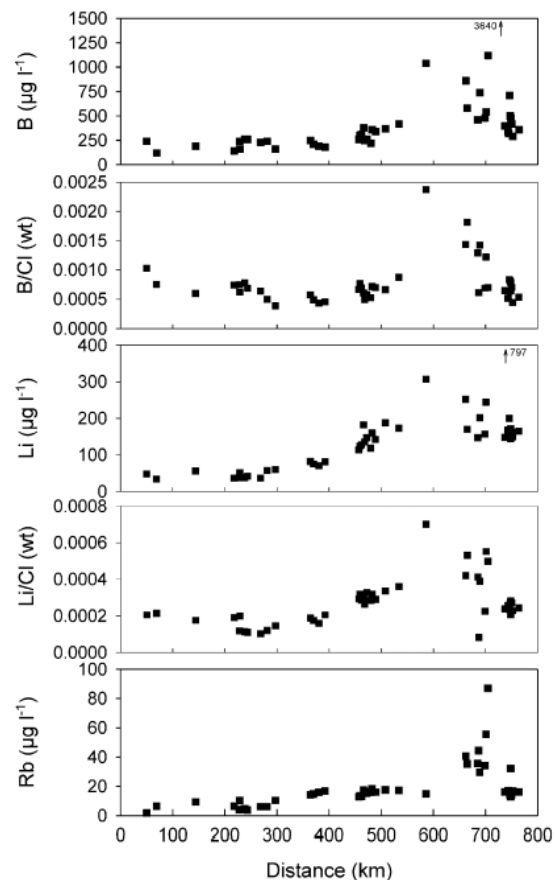
- The 1990s saw upgrading of lab instrumentation and acquisition of new staff; Mike also now occupied a 'special merit' position allowing him to do more of what he wanted, principally:
 - Arid zone (continued)
 - Baseline-UK
 - Gold
 - Far east of Russia (Oleg Chudaev to elaborate...)
 - Palaeaux EU collaboration
 - Geochemistry and health
 - Sahel groundwater
 - Chair of the WRI Working Group



The arid zone continued: 3

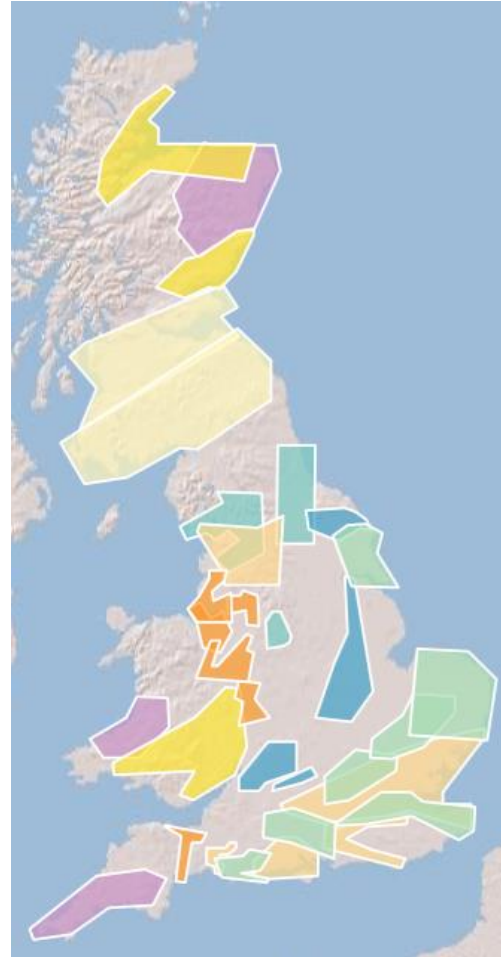


As well as moving the CMB work to Tunisia, Mike developed his interest in flow-line evolution with the aid of Algerian and Tunisian colleagues. The result was a paper looking at a 750 km hydrogeochemical cross-section of the CI aquifer, a major groundwater resource in NW Africa.



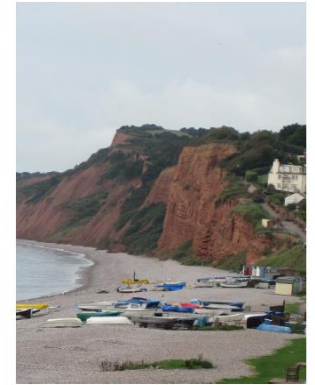
Baseline-UK

- Baseline was a long-term project essentially to characterise the water quality and trace element contents of British aquifers
- The project was co-funded by the Environment Agency in England and Wales, with Scotland eventually following via co-funding from the Scottish EPA
- The project began in the late 1990s and ran until 2015, producing 30 reports for England & Wales, and five for Scotland



Baseline groundwater chemistry:
the Sherwood Sandstone of
Devon and Somerset

Groundwater Programme
Open Report OR/11/060



Baseline Scotland: groundwater
chemistry of the Carboniferous
sedimentary aquifers of the
Midland Valley

Groundwater Programme
Open Report OR/11/021



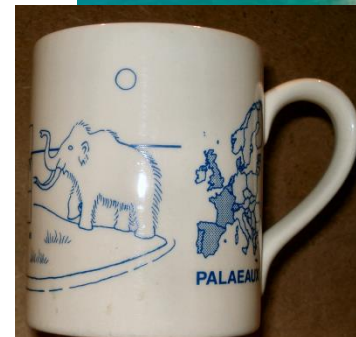
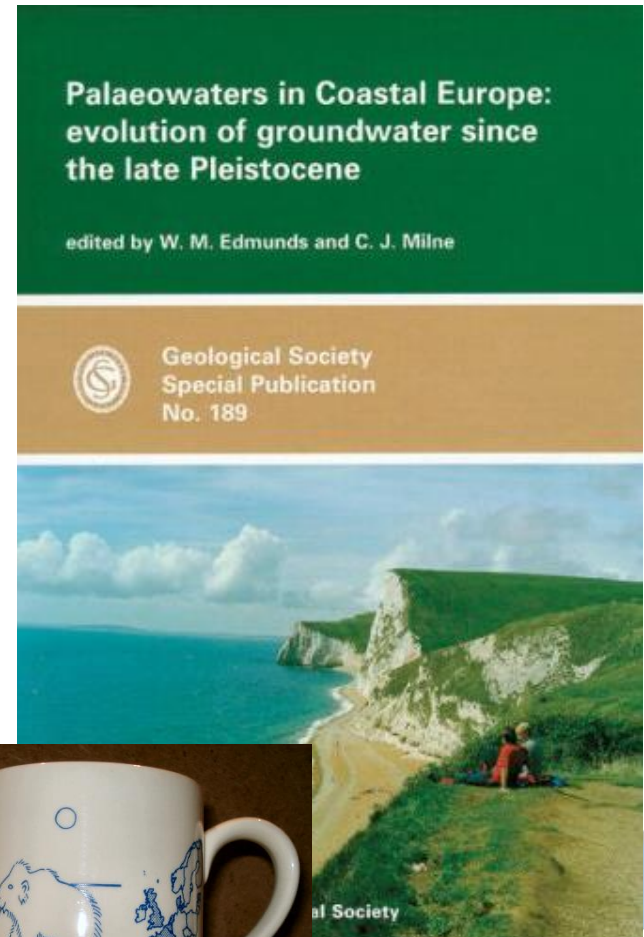
Gold

- This was basically about using hydrogeochemical methods for gold prospecting
- Analysis of gold at the ng/L level was a major analytical challenge
- The project was considered successful – but none of the participants became rich...



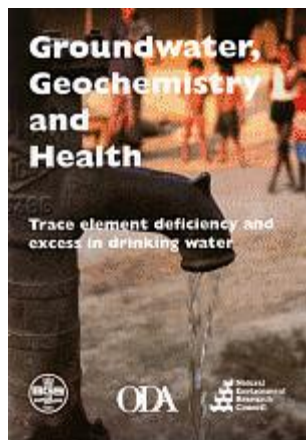
The Palaeaux project

- In the mid-90s Mike came up with the concept of a Europe-wide study of the hydrogeological and hydrogeochemical changes undergone by coastal aquifers during the sea-level rise at the end of the Ice Age
- EU partners from Portugal in the SW to Estonia in the NE enabled a ground-breaking synthesis of information
- This included palaeogeography, modelling and resource management and was published as a Geol. Soc. of London Special Volume



Geochemistry and health

- Developing from his work on trace elements, Mike became interested in their effects on health
- He published several papers on arsenic, fluoride, selenium etc. as well as a general overview



- However, he never managed to crack Balkan Endemic Nephropathy...

TRACE ELEMENTS IN GROUNDWATER AND THEIR SIGNIFICANCE IN TERMS OF HEALTH AND ENVIRONMENTAL PROTECTION

CONCENTRATIONS IN DILUTE, OXYGENATED GROUNDWATER AT pH 7

← TRACE ELEMENTS ————— | ————— MAJOR ELEMENTS →
 ————— INCREASING CONCENTRATION —————

1 ng l ⁻¹		1 PART IN TEN THOUSAND MILLION		1 μg l ⁻¹		1 mg l ⁻¹		
<0.00001	0.00001–0.0001	0.0001–0.001	0.001–0.01	0.01–0.1	0.1–1.0	1.0–10	10–100	>100
Nb	Cs	Rb	Li	P	Sr	Mg	Na	HCO ₃
Ru	Zr	La	Ba	B	F	K	Ca	
Rh	Mo	V	Cu	Br		Si	SO ₄	
Pd	Ag	Se	Mn	Fe			Cl	
In	Be	As	U	Zn			NO ₃	
Hf	Th	Cd	I					
Ta	Ce and REE	Co						
Re	Hg	Ni						
Os	Sc	Cr						
Ir	Sb	Pb						
Pt	Sn	Al						
Po	Te	Y						
Au	Tl							
	Bi							
	W							
	Ga							
	Ge							

ESSENTIAL ELEMENTS
Cu Elements considered essential for human or animal health.
Sr Elements probably essential for health.

Non-essential elements.
Pb

TOXIC ELEMENTS
¹ Cd Elements considered to be toxic or undesirable in excessive amounts and for which maximum admissible concentrations (MAC) have been set by the CEC.
² V Other elements considered undesirable in excess but for which no statutory limit has been set by the CEC.

Chair of the WRI Working Group

- In 1992 Mike became Chair of WRI
- He had usually been involved before in the selection and setup of WRI symposium venues, but now he was *primus inter pares* which involved him in more admin
- ‘On his watch’ were two meetings far from Europe and the USA: WRI-8 in the far east of Russia (Vladivostok), and WRI-9 in New Zealand (Taupo)



2000–2015

- Palaeaux EU project replaced by Baseline-EU project
- Retirement from BGS (then mandatory at 60) in Oct 2001
- Appointment at Oxford University
- Arid zone work continues
- Oxford University MSc course director



Baseline-EU (aka BaSeLiNe)

- Building on the partnerships that had worked so well on Palaeaux, Baseline-EU ran from 1996–2006 and this time involved 25 reference aquifers in 12 different countries
- After considerable debate, baseline was defined as: **“The range of concentrations of a given element, species or chemical substance present in solution being derived from natural geological, biological, or atmospheric sources”**
- In addition to the hydrogeochemical science, the study recognised that policy and public awareness must be built into the overall synthesis



Oxford – Mike becomes an academic



‘Dominus Illuminatio Mea’
(The Lord is my Light)

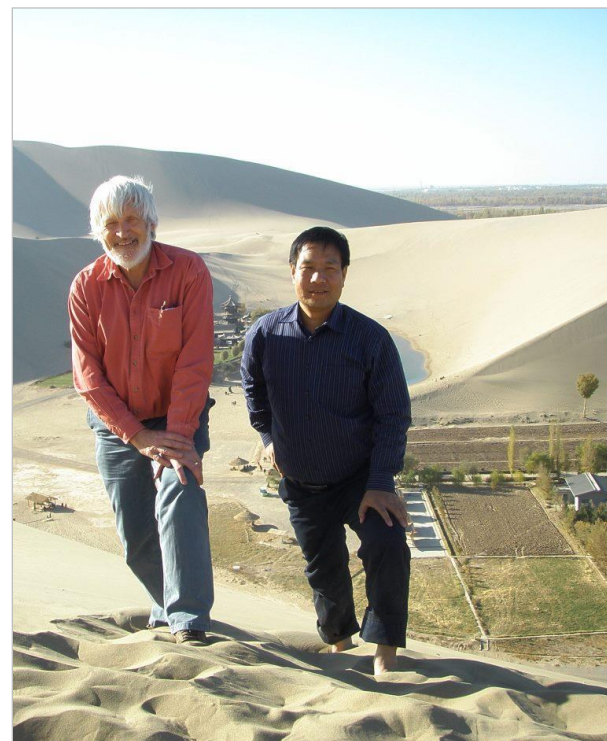


- Following retirement from BGS, Mike became Director of the Water Centre in the Dept of Geography at Oxford University
- He developed a new Master’s programme in Water Science, Policy and Management
- Interdisciplinary in design, it celebrated 10 years in 2014 with 220 alumni from 50 countries



The arid zone continued: 4

Mike moved his unsaturated zone work to China, where he also researched into the origin of the water in the lake and dune topography of the Badain Jaran desert



Here he worked mainly with Jinzhu Ma of Lanzhou University

Society awards



Whitaker Medal
(Geol. Soc. of London)
1999

William Whitaker,
1836 –1925



Meinzer Award
(Geol.Soc. of America)
2009

Oscar Edward Meinzer,
1876–1948



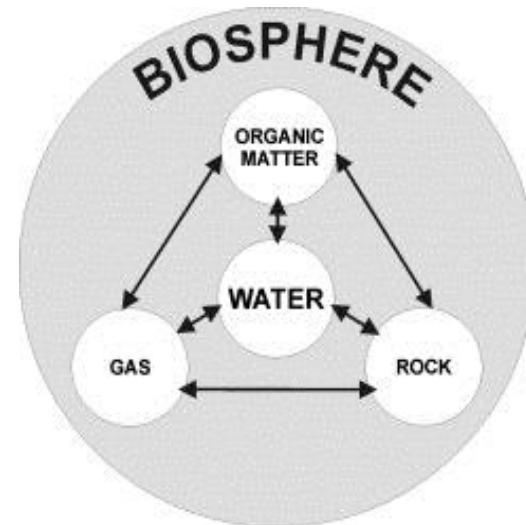
Vernadsky Medal
(Int. Assoc. GeoChem.)
2010

Vladimir I Vernadsky
1863–1945



Vladimir Ivanovich Vernadsky

- Fields of endeavour included: geology, crystallography, mineralogy, geochemistry, nuclear geology, biology, biogeochemistry – and for good measure, philosophy
- His ‘Biosphere theory’ is a forerunner of J Lovelock’s Gaia theory
- Mike researched into V.I.V. with the aid of a Russian postdoc and made the case for him as a pioneer of water–rock interaction



Applied Geochemistry 27 (2012) 1871–1886



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journal homepage: www.elsevier.com/locate/apgeochem



Review

Geochemistry of natural waters – The legacy of V.I. Vernadsky and his students

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^a School of Geography and the Environment, Oxford University, South Parks Road, Oxford OX11 9QA, UK

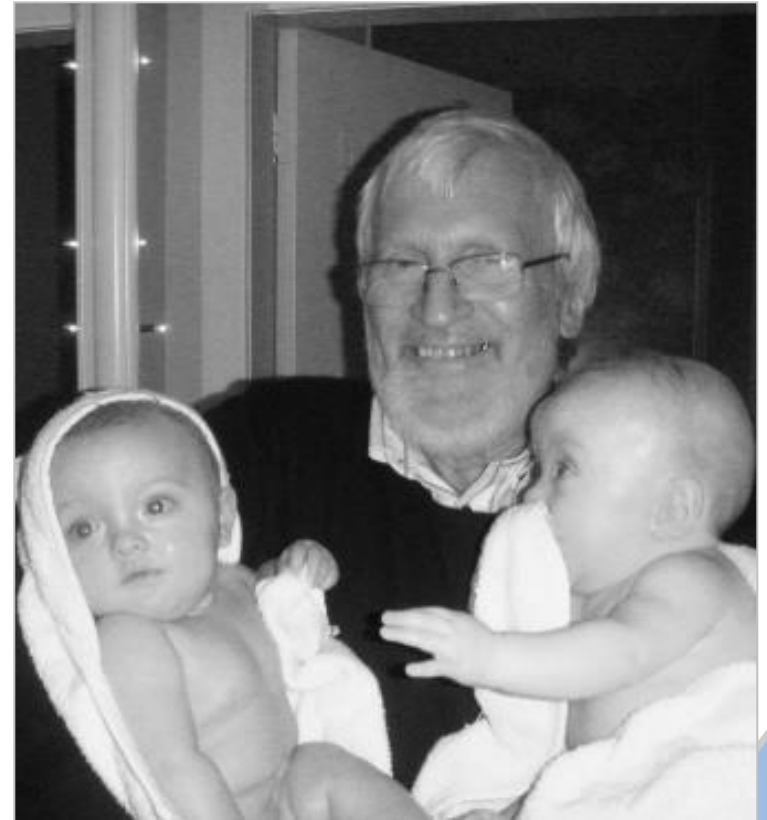
^b Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences (IGM SB RAS), pr. Koptyuga 3, Novosibirsk 630090, Russia



Mike vs Vladimir: beards and babes

Vladimir had the more impressive beard...

But Mike outdid him on the grand-children front!



The WME top-ten first-author papers: 1

1. Edmunds W M, Guendouz A H, Mamou A et al. (2003) Groundwater evolution in the Continental Intercalaire aquifer of southern Algeria and Tunisia: trace element and isotopic indicators. ***Applied Geochemistry*** 18, 805–822.
2. Edmunds W M and Smedley P L (2000) Residence time indicators in groundwater: the East Midlands Triassic sandstone aquifer. ***Applied Geochemistry*** 15, 737–752.
3. Edmunds W M, Bath A H and Miles D L (1982) Hydrochemical evolution of the East Midlands Triassic Sandstone aquifer, England. ***Geochimica et Cosmochimica Acta*** 46, 2069–2081.
4. Edmunds, W M and Bath, A H (1976) Centrifuge extraction and chemical analysis of interstitial waters. ***Environmental Science & Technology*** 10, 467–472.
5. Edmunds W M, Ma, Jinzhu, Aeschbach-Hertig W et al. (2006) Groundwater recharge history and hydrogeochemical evolution in the Minqin Basin, North West China. ***Applied Geochemistry*** 21, 2148–2170.
6. Edmunds W M, Andrews J N, Burgess W G et al. (1984) The evolution of saline and thermal groundwaters in the Carnmenellis Granite. ***Mineralogical Magazine*** 48, 407–424.
7. Edmunds W M, Shand P, Hart P et al. (2003) The natural (baseline) quality of groundwater: a UK pilot study. ***Science of the Total Environment*** 310, 25–35.
8. Edmunds W M, Carrillo-Rivera J J and Cardona A (2002) Geochemical evolution of groundwater beneath Mexico City. ***Journal of Hydrology*** 258, 1–24.
9. Edmunds, W M and Gaye, C B (1994) Estimating the spatial variability of groundwater recharge in the Sahel using chloride. ***Journal of Hydrology*** 156, 47–59.
10. Edmunds W M and Wright E P (1979) Groundwater recharge and palaeoclimate in the Sirte and Kufra basins, Libya. ***Journal of Hydrology*** 40, 215–241.



The WME top-ten first-author papers: 2

No.	Subject	Co-author nationality	Journal
1	Groundwater evolution, residence time	Algeria, Tunisia, UK	Appl. Geochem.
2	Trace elements, residence time	UK	Appl. Geochem.
3	Groundwater evolution, residence time	UK	Geochim. Cosmochim. Acta
4	Laboratory technique development	UK	Env. Sci. & Tech.
5	Recharge, groundwater evolution	China	Appl. Geochem.
6	Evolution of saline g'waters in granite	UK	Mineralogical Magazine
7	Baseline water quality	UK	Sci. of Total Env.
8	Groundwater evolution, residence time	Mexico	J. Hydrology
9	Recharge	Senegal	J. Hydrology
10	Recharge, palaeoclimate	UK	J. Hydrology

Main preoccupations: groundwater quality, residence time, sedimentary aquifers

Others: recharge, palaeoclimate, hard rock aquifers, technical developments

40% of co-authors international

Good-quality journals



Activities outside work

- Four children
- Six grandchildren
- Gardening/allotment
- Cacti
- 'Sustainable Blewbury'
- Wells for India
- Opera, singing in choirs
- The 'great outdoors'



Wells for India

Bringing water and dignity to the poorest people of rural Rajasthan



Ten secrets of Mike's success

1. Good ideas
2. Good at getting funding to pursue them
3. Successful at delivering on projects – finishing as well as starting
4. Talent spotting for new staff (but only room for one boss!)
5. Great networker
6. Linguistic strengths
7. Excellent at synthesising a wide range of data
8. Artistic abilities – a good eye for presentation of data and publicity
9. Optimism – definitely a 'glass half full' person
10. Good relationship with his staff



Farewell

The church in Blewbury was packed full for Mike's funeral service, and many tributes were paid

His grave is marked by a sarsen stone found in a local stream during the construction of the 'Mike Edmunds memorial bridge' by Sustainable Blewbury

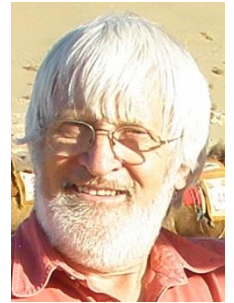
The inscription reads "*There is a time to close the books of science and dream*"

I think that Mike would have been pleased to have a sarsen – not only is there the Stonehenge connection, but they are formed in groundwater and are high in titanium, so have a hydrogeochemical dimension too!





Wyndham Michael Edmunds 1941–2015



My thanks to:

Kathy Edmunds, Adrian Bath, David Kinniburgh,
John Mather, Chris Milne, Paul Shand
and Pauline Smedley

