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Hydrogeology education:
University courses, core skills and the role of IAH

Bruce Misstear
School of Engineering, Trinity College Dublin
Secretary General IAH

Talk outline

I will talk about:

- Some core aspects of hydrogeology education
- The role of universities
  - Postgraduate taught courses in UK and elsewhere
  - Threats to UK hydrogeology Masters programmes
- The role of organisations such as IAH
  - Training courses, educational aids, mentoring

Why do we need hydrogeologists?

- Of the 700 million people who don't have an improved water source, the majority will need to be supplied from groundwater
- Groundwater provides over 40% of all agricultural water
- Plenty of challenges for hydrogeologists in e.g. :
  - Evaluating impacts of changing climate and land use on groundwater resources and quality
  - Remediating polluted aquifers
  - Delineating groundwater protection schemes
  - Protecting groundwater-dependent ecosystems

- So the importance of groundwater and hydrogeologists should be obvious
- But is it obvious to policy makers and the funders of hydrogeology education?
  - Groundwater frequently does not feature explicitly in water management policies
  - The world-renowned hydrogeology Masters at Birmingham university was threatened with closure last year

- Paper from Canada says "*Demand for hydrogeology instruction has grown because of strong employment prospects for trained hydrogeologists and the growing recognition of groundwater in other disciplines*" (Gleeson *et al*., 2012)
- "*Hydrogeology has even been called recession-proof*" (Coontz, 2008)

Core knowledge

The top 15 most important hydrogeology topics for an undergraduate hydrogeology course, as identified in a survey of 68 academic hydrogeologists (from Gleeson *et al*., 2012)

Topic
Hydraulic conductivity/intrinsic permeability
Darcy's law and its applicability
Aquifers and confining units
Water table and mapping
Gradient and head
Water table
Hydraulic head
Specific yield and storativity
Wells and piezometers
Transmissivity
Specific discharge and average linear velocity
Primary and secondary porosity
Homogeneity and isotropy
Recharge and discharge areas
Steady flow in aquifers

10 pieces of advice from Siegel (2008)

1. Don't push the data farther than they can be pushed and be honest with respect to what can be done
2. Darcy's law needs to be understood at the 'gut' level
3. Potentiometric surfaces are different from the water table
4. Surface water is an 'outcrop' of the water table
5. Groundwater occurs in nested flow systems, separated by hydraulic boundaries
6. Groundwater chemistry is predictable from first principles
7. Chemical oxidation and reduction control many important groundwater and contaminant chemical compositions
8. As a working approximation, contaminant plumes should be considered narrow and no wider than a few times the width of the source at their heads
9. Contour using your head, and not your computer
10. Explore simple bivariate plots as an analysis tool.

- These core aspects of groundwater science are best taught in the university
  - Difficult to catch up on the science in the workplace
- Classroom learning should be supported by lab and field activities
- But hydrogeologists also need to learn about topics that are at the interface between groundwater science and other disciplines

Need to know about hydrogeology in relation to:

- Climate change
- Sustainable energy
- Integrated catchment management
- Sociological aspects of water development


WATER IS LIFE

Findings from recent Uganda study

Social challenges include

- Breakdown of improved water sources (hand-pumps)
- Inadequate operation and maintenance mechanisms
- Low involvement of women in water governance, including leadership roles in water user committees

Without an appreciation of these issues, the hydrogeologist's efforts are unlikely to be successful

- Poor roads and paths, and long distances, to access improved water sources
- Collection and payment of O&M fees
- Risks of assault / injury to women and children at the water source
- Need for better education

See Asaba *et al*. (2015), in Fagan *et al*. (eds) *Water is Life*. Practical Action Publishing

Hydrogeology education in Ireland

- Some undergraduate modules in Geology and Civil Engineering degree programmes
- No specialist Masters in hydrogeology
- There are Masters courses that contain modules with elements of groundwater, e.g.
  - Environmental Engineering at TCD and QUB
  - Environmental Science, TCD
  - Water, Waste & Environmental Engineering, UCD
  - Water Resources Engineering, NUI Galway (new)
- PhD research

Postgraduate hydrogeology courses in Britain

- Typically one-year programmes: taught modules followed by research dissertation
- The number of courses has changed over the years:
  - 2 courses in 1970s and early 1980s
  - 5 courses by early 1990s
  - 3 courses at present
- Decline in courses mainly due to reduction in funding
  - UK Research Councils give priority to PhD research
  - Fees for Masters programmes are increasing in line with undergraduate fees
  - No government-backed loan scheme in place for masters students
- 4-year MEng and MSci ‘primary’ degrees have also had an impact

Hydrogeology Masters courses in Britain

Dates	University	Course
1965 – 2001	University College London	Hydrogeology (now run a Diploma course)
1972 – present	Birmingham	Hydrogeology
1987 – 1999	Newcastle	Groundwater Engineering
? – present	Newcastle	Hydrogeology and Water Management (includes “flexible learning” option)
1992 - c2002	Reading	Hydrogeology and Groundwater Quality
1992 – 1999	East Anglia	Hydrogeology
? – 2012	Leeds	Hydrogeology
2005 – 2012	Cardiff	Environmental Hydrogeology
? – present	Sheffield	Contaminant Hydrogeology
? – present	Strathclyde	Hydrogeology

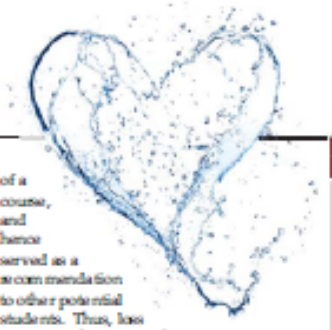
Bologna Declaration
(and several subsequent accords)

- Signed by European Ministers of Education in 1999
- Aim is for greater harmonisation in third-level education across Europe
- Two-cycle Bachelors/Masters degree – 3+2 model preferred
- Many universities in Europe now offer a 5-year Masters degree (4 years in UK)
- In Ireland, 5-year Masters is now the qualifying degree for CEng
- Masters-level primary degree programmes may lead to less demand for specialist 1-year Masters

Water, but not on the brain

WRITTEN BY BRUCE MISSTEAR

Hydrogeology taught master's courses are under threat, says Bruce Misstear*



For the past 40 years, taught master's courses in hydrogeology have played a vital role in the education of UK hydrogeologists, providing much of the ground water expertise for the Environment Agency, water companies, consultants, contractors, universities and research institutes. The taught master's programmes have also educated many hydrogeologists from outside the UK

of a course, and hence served as a recommendation to other potential students. Thus, loss of funding has far-reaching implications for the viability of a course.

Sheffield and an Applied Hydrogeology master's in Newcastle.

The UK Natural Environment Research Council (NERC), which previously funded a number of hydrogeology studentships, has withdrawn its support for such master's courses, and currently gives priority to funding of doctoral students. While funding of research students is clearly important, there is also a need to support applied taught master's programmes that produce well-rounded hydrogeologists with a broad skill-set in hydrogeology. The loss of funded studentships for taught master's degrees means that even the long-established and highly-regarded Birmingham course could be vulnerable in the future. Aside from the importance of funding *per se*, the award of studentships was an indicator of the status

tasks, in government agencies and consultancies, may then increasingly be carried out by unqualified staff, resulting in poor quality work. We may see a continuation of a modern trend whereby field-data collection and drilling are not properly prioritised, or supervised, with greater reliance being placed on desk-bound studies, including the application - or misapplication - of hydrogeological software.

We cannot rely on market forces alone to support taught master's programmes, as the industry is too fragmented. Government backing is essential to ensure the future of high quality hydrogeology education in this country.

* Bruce Misstear Hydrogeologist and Associate Professor, Trinity College Dublin

SOAPBOX CALLING!

Soapbox is open to contributions from all Fellows. You can always write a letter to the Editor, of course: but perhaps you feel you need more space?

If you can write it entertainingly in 500 words, the Editor would like you.

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uld be of print rule of thumb, r a few hundred uld do.

will always be given al contributions. tributor may not often than once per every 12 months).

> IF WE REACH THE POINT WHERE INSUFFICIENT HYDROGEOLOGISTS ARE GRADUATING WITH HIGH-QUALITY MASTER'S QUALIFICATIONS TO SUPPLY THE JOB MARKET, THE IMPLICATIONS FOR THE PROFESSION WILL BE SERIOUS
> Bruce Misstear

"The loss of funded studentships for taught masters means that even the long-established and highly-regarded Birmingham course could be vulnerable in the future."

- MSc Hydrogeology at University of Birmingham was threatened with closure last year
- Huge outcry from hydrogeological community
- The course has had a reprieve:
  - An email from the university (15/2/2016) says they will "continue to deliver the MSc Hydrogeology programme with improved delivery effectiveness", but that they will "disinvest in Hydrogeology research"

North America

- Numerous Masters programmes
- Often 2 years duration
- Many offer an MS in Hydrology or similar, with significant 'groundwater hydrology' options
- See NGWA website for list of masters programmes in North America

USA examples:

Arizona
California (Davis)
Nevada
Ohio
Penn State
Stanford
Texas
Wisconsin

Canadian examples:

British Columbia
Toronto
Waterloo

Courses in continental Europe

There are several postgraduate hydrogeology courses in continental Europe which are taught through English:

- Germany, **Tübingen**: Applied Environmental Geoscience (2 years)
- Holland, **UNESCO-IHE Delft**: Hydrology and Water Resources (18 months)
- Holland, **Utrecht**: Environmental Hydrogeology (2 years)
- Sweden, **Stockholm University**: Hydrology, Hydrogeology and Water Resources (2 years)

PhD programmes

- Many hydrogeologists obtain their hydrogeology education through PhD programmes
- Can be attractive option for a student, especially if funding available
- Also, PhD is essential for academic career
- But can a PhD programme offer the same all-round hydrogeology education as a taught MSc?
  - In some countries, doctoral programmes do include substantial taught course components

Role of IAH

- Education Working Group prepared report in 2014 to enhance IAH role in education
- But an organisation like IAH can only be a facilitator – does not seek to replace core role of universities

WG recommendations:

a) Develop a separate *Education and Training* banner on the IAH website home page;
b) Prepare a list of hydrogeology degree courses available internationally, with links to course information from the IAH Education web pages;
c) List short courses, field courses and webinars organized by national

Many of these depend on improvements to the IAH website

f) Compile an international panel of experts who would potentially be willing to contribute to short courses organized and run by national chapters;
g) Prepare IAH-branded educational materials (lectures, illustrations, etc) and making these available for download from the website;
h) Develop short thematic papers on key strategic topics to help IAH increase the awareness of groundwater issues amongst policy makers and water managers, and the wider public.

International Association of Hydrogeologists
the World-wide Groundwater Organisation

Search

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Members Login

Education

General Public

Groundwater - the hidden resource. In this area you can find out more about the importance of groundwater.

Perhaps thinking about a career or study in hydrogeology or a groundwater-related subject? We provide some encouragement.

Find out more

Professionals

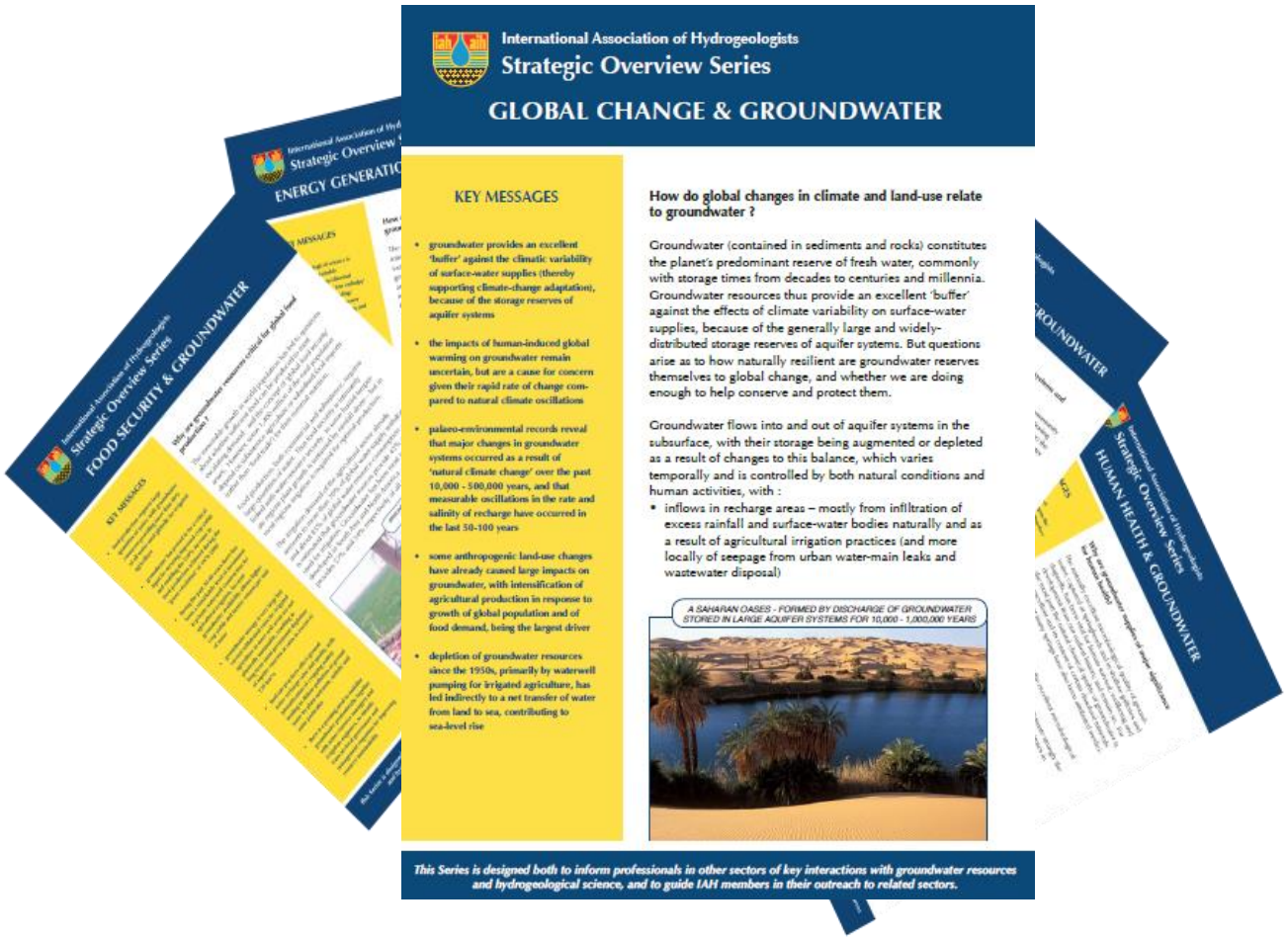
Working in the field of hydrogeology/groundwater related matters and seeking specialised information or professional development?

The day-to-day efforts of IAH and our members range from dealing with the basic and relatively unchanging principles of hydrogeology – the way that groundwater occurs and moves beneath our feet – through to highly-specialist scientific investigations of topical and complex subjects. This area aims to encourage and harness such knowledge, and to stimulate further research.

Find out more

Webpages are in preparation…….

Strategic Overview Papers



https://iah.org/knowledge/learning-resources

Mentoring

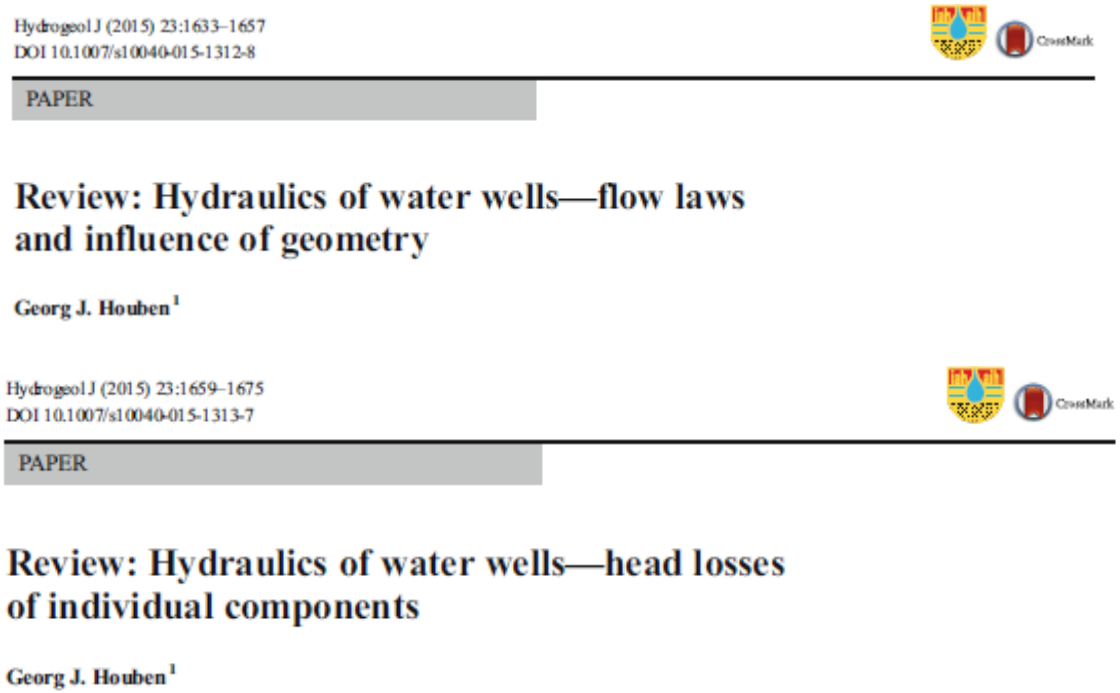
To quote from the IAH website, the scheme can potentially help members in three areas:

- the scientific – providing advice and technical knowledge on various topics within the many strands of hydrogeological science;
- career options and pathways – providing guidance on job types and locations, CVs, interviews, networking, courses and training openings;
- practical experience – case studies, local hydrogeological knowledge of specific regions or aquifer types, volunteering to undertake short assignments.

https://iah.org/knowledge/mentoring

Hydrogeology Journal

- The main purpose of Hydrogeology Journal is to publish research articles
- In 2013 the journal introduced a new type of review paper called Foundations
- The aim here is to allow authors to review some of the basic principles of hydrogeological science in a depth that is beyond that possible in most textbooks (Post, 2013)



Hydrogeol J (2015) 23:1633–1657
DOI 10.1007/s10040-015-1312-8

PAPER

Review: Hydraulics of water wells—flow laws and influence of geometry

Georg J. Houben[1]

Hydrogeol J (2015) 23:1659–1675
DOI 10.1007/s10040-015-1313-7

PAPER

Review: Hydraulics of water wells—head losses of individual components

Georg J. Houben[1]



National chapters play a key role e.g through conferences, technical seminars, short courses, field trips, etc




Conclusions

- University hydrogeology courses should aim to give students a good grasp of the fundamentals of groundwater science
- Secondary objective should be to cover topics at the interface between hydrogeology and other disciplines
- Specialist Masters courses have a key role in hydrogeology education – but these courses are under threat, at least in UK
- Organisations like IAH can aid life-long learning through short courses, webinars, educational papers, mentoring, etc