4TH LONDON GEOTHERMAL SYMPOSIUM AND
LAUNCH OF BRITGEOTHERMAL
13TH OCTOBER 2014

Enigmatic Geothermal Fluids of Northern England

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Acknowledgements

- **SUERC / University of Glasgow:**
  - Adrian Boyce
- **Newcastle University:**
  - David Manning, Andrew Waring, Patrick Orme, Jane Davis, Angela Sherry, Catherine Gandy, Aidan Doyle
- **National Nuclear Lab / Birmingham Univ:**
  - Nick Smith
- **British Coal:**
  - John Ellis
- **Coal Authority:**
  - Ian Watson
- **One North East:**
  - Chris Pywell, Mark Pearson
- **Lafarge Cement:**
  - Lloyd McInally

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Overview

- Since the renaissance of UK deep geothermal drilling at Eastgate (Co Durham) in 2004, saline geothermal fluids have been found which have enigmatic isotopic signatures
  - If it weren't for their salinity, you would think these were fresh, meteoric waters
- Comparison with data from the few saline springs in northern England reveals that this phenomenon actually occurs region-wide
- Possible explanations?

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Warning!

This will be a

boring presentation

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Geothermal Drilling in northern England – 2004 - 2014

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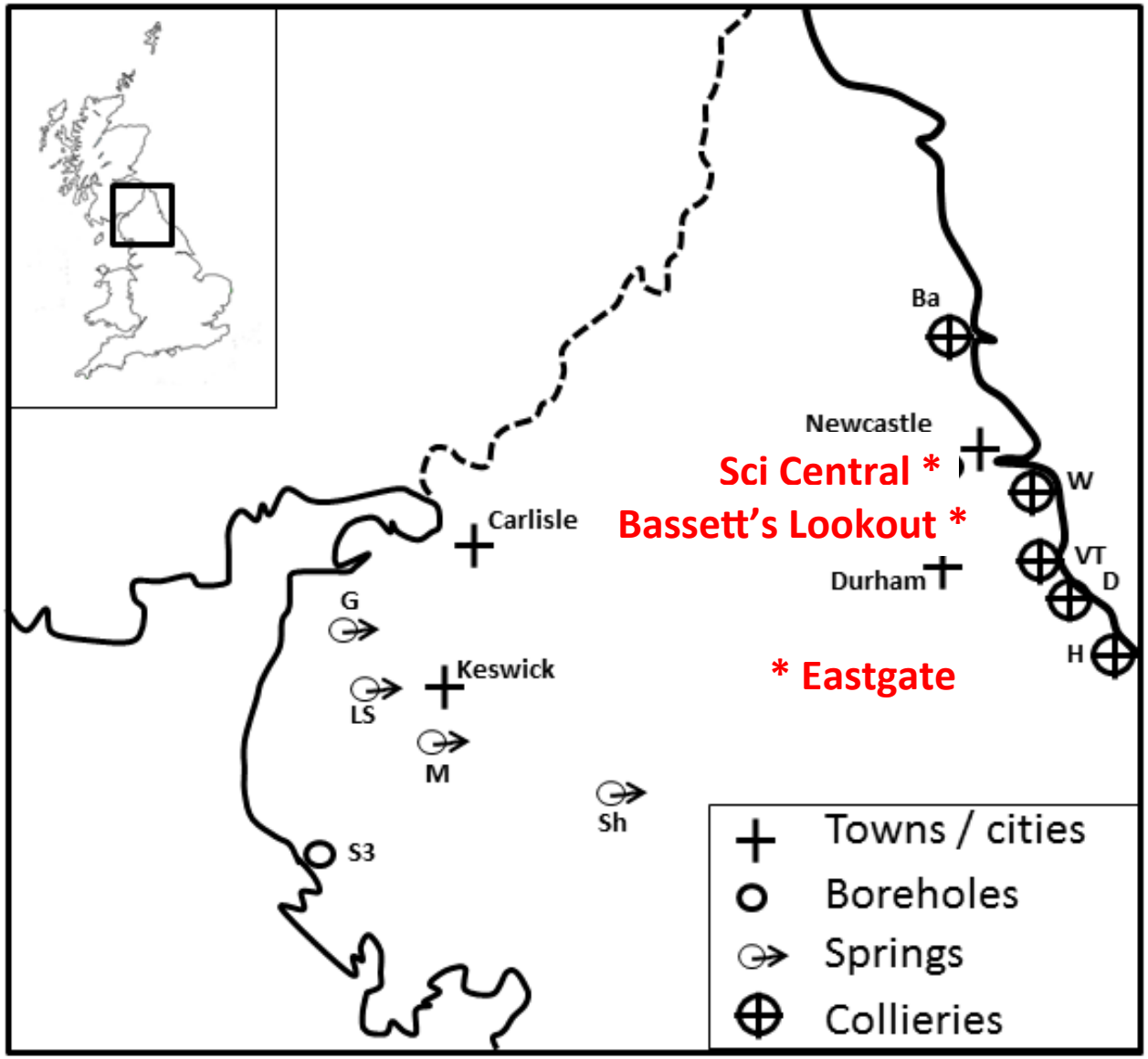
Sampling locations



Borehole	Eastgate No 1	Science Central	Bassett's Lookout
Date of sample	10th March 2006	7th July 2011	30th Nov 2004
Depth of sample	411m	1560m	170m
Temp. (°C)	27	38.5	12
pH	6.7	11.7	6.85
Total dissolved solids (TDS)	43,017	5,819	13,325
Calcium (ppm)	6,070	37.3	382
Magnesium (ppm)	69.8	< 0.1	307
Sodium (ppm)	9,630	1,166	4,690
Potassium (ppm)	720	110	91
Sulfate (ppm)	26	310	6,260
Bicarbonate (ppm)	67.2	1,435	1,032
Chloride (ppm)	29,280	966	4,360
δ^2H (‰ $_{SMOW}$) (of water)	-53.4 ± 0.5	n.d.	n.d.
$\delta^{18}O$ (‰ $_{SMOW}$) (of water)	-8.7 ± 0.06	n.d.	n.d.
$\delta^{18}O$ (‰ $_{V\text{-}SMOW}$) (of sulfate)	-3.9 ± 0.3	n.d.	n.d.
$\delta^{34}S$ (‰ $_{V\text{-}CDT}$) (of sulfate)	3.3 ± 0.3	n.d.	n.d.
Facies	Na-Ca-Cl	Na-Cl-HCO_3	Na-(Ca,Mg)-SO_4-Cl

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NE Colliery Brines

(Data: Coal Authority; Sheppard & Langley, 1984)

* = ppm

Colliery	Horden (-237m OD)	Dawdon (-442m OD)	Vane Tempest (-530m OD)	Westoe (-229m OD)	Horden pumped 30th Oct 2013	Dawdon pumped 21st Nov 2012	Bates pumped 12th Nov 2012
Grid ref	NZ 4772 4383	NZ 4435 5478	NZ 4550 5162	NZ 4426 5700	NZ 440 421	NZ 435 478	NZ 305 823
pH	6.4	7.2	6.1	6.5	6.5	7.5	7.4
TDS (ppm)	115,160	60,540	197,000	114,400	28,470	43,940	9,425
Calcium *	6,286	3,724	16,176	1,522	919	1,130	398
Magnesium*	1,482	705	2,673	2,772	570	690	436
Sodium*	36,150	18,650	54,434	38,800	9,200	13,800	2,010
Sulfate*	107	300	< 1	3,500	2,540	3,040	2,870
Bicarbonate*	n.d.	n.d.	n.d.	n.d.	335	469	959
Chloride*	71,100	37,000	122,000	67,800	12,600	21,900	2,530
δ^2H (‰ SMOW)	-51.4	-63.0	-36.7	-62.2	n.d.	n.d.	n.d.
$\delta^{18}O$ (‰ SMOW)	-7.2	-7.2	-4.9	-8.8	n.d.	n.d.	n.d.
Facies:	Na-Cl	Na-Cl	Na-(Ca)-Cl	Na-Cl-(SO_4)	Na-Cl	Na-Cl	

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Cumbrian saline springs

(Data: Neil Cooper / NNL)

Site	Manesty	Lorton (Stanger)	Shap Spa	Gilcrux
Grid reference	NY 2517 1847	NY 1412 2719	NY 5777 0972	NY 1210 3833
Date sampled	26th July 2011	29th June 2011	29th June 2011	26th July 2011
pH	6.62	6.78	7.75	6.93
Temp. (°C)	12.3	14.2	11.6	20.1
TDS	1,675	21,775	7,170	2,291
Calcium (ppm)	244	2,081	1,256	n.d.
Magnesium (ppm)	9.5	197	4	n.d.
Sodium (ppm)	369	5,453	1,138	n.d.
Potassium (ppm)	5.6	194	38	n.d.
Sulfate (ppm)	24.2	1.56	93	n.d.
Bicarbonate (ppm)	75.6	182	102	n.d.
Chloride (ppm)	920	14,304	3,734	n.d.
δ^2H (‰ $_{SMOW}$)	-43.67	-45.51	-56.20	n.d.
$\delta^{18}O$ (‰)	-6.16	-6.78	-8.56	n.d.

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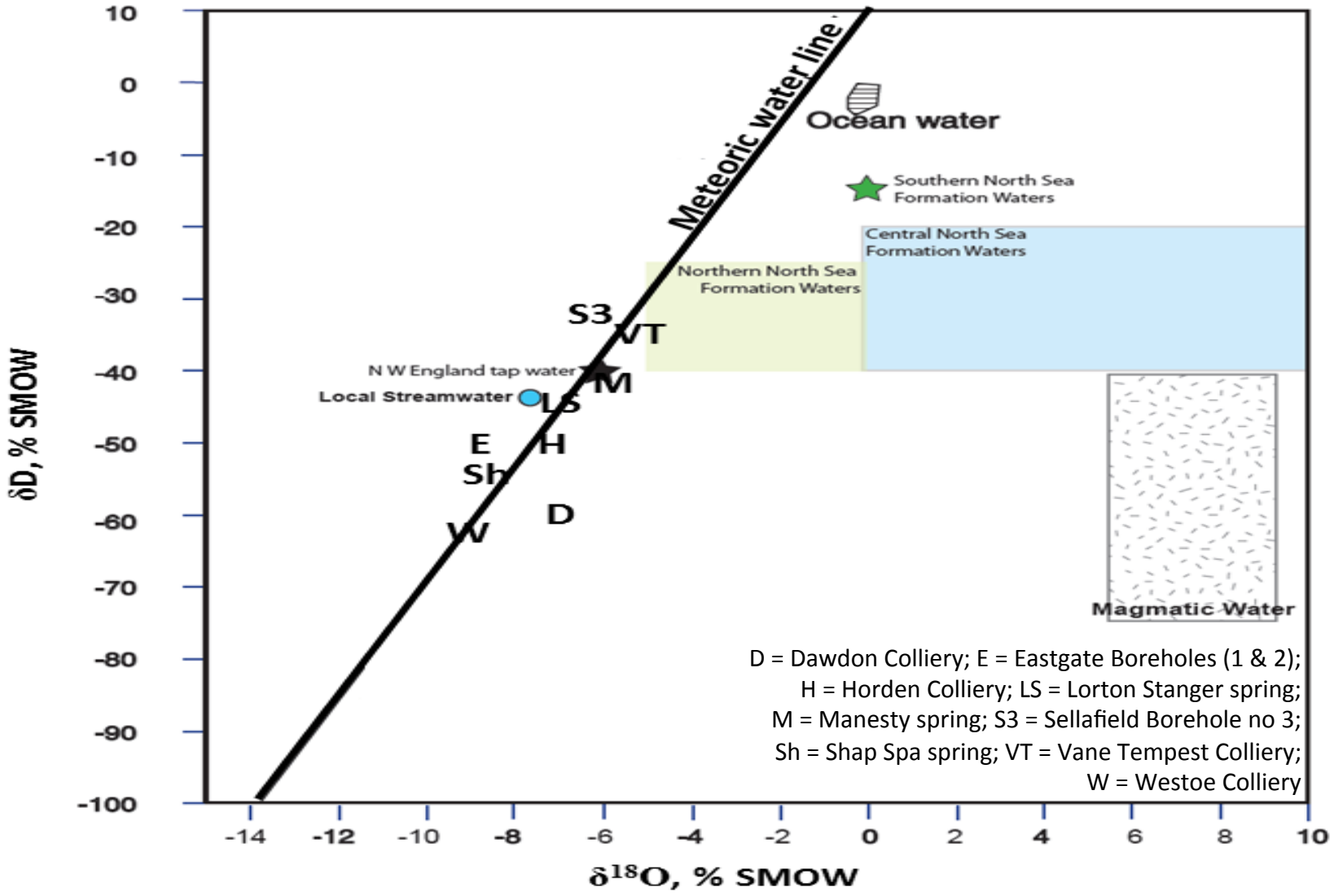
Sellafield Borehole 3

(Data: Bath et al. 2006)

Stratigraphic unit	Sherwood Sandstone	Carboniferous Limestone	Borrowdale Volcanic Group
Depth	1,106	1,539	1,668
TDS	188,000	135,000	177,000
Calcium (ppm)	2,520	2,610	2,910
Magnesium (ppm)	686	537	489
Sodium (ppm)	71,600	49,300	65,100
Potassium (ppm)	327	292	539
Sulfate (ppm)	4,910	4,740	3,340
Bicarbonate (ppm)	55	184	< 5
Chloride (ppm)	108,000	77,700	104,000
$\delta^{2}H$ (‰ $_{SMOW}$)	-32	-42	-32
$\delta^{18}O$ (‰ $_{SMOW}$)	-5.1	-5.8	-5.9
Facies:	Na—Cl	Na—Cl	Na—Cl

δ^2H versus $\delta^{18}O$



D = Dawdon Colliery; E = Eastgate Boreholes (1 & 2);
H = Horden Colliery; LS = Lorton Stanger spring;
M = Manesty spring; S3 = Sellafield Borehole no 3;
Sh = Shap Spa spring; VT = Vane Tempest Colliery;
W = Westoe Colliery

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Geothermometry

Site	Na (ppm)	Na (molal)	K (ppm)	K (molal)	Estimated temperature when last at equilibrium (°C)
Eastgate No 1	9,630	4.19E-01	720	2.39E-02	**173.2**
Science Central	1,166	5.07E-02	110	3.65E-03	**190.4**
Bassett's Lookout	4,690	2.04E-01	91	3.02E-03	**94.3**
Manesty	369	1.61E-02	5.6	1.86E-04	**82.8**
Lorton (Stanger)	5453	2.37E-01	194	6.45E-03	**126.0**
Shap Spa	1138	4.95E-02	38	1.26E-03	**122.4**
Horden pumped	9,200	4.00E-01	514	1.71E-02	**153.4**
Dawdon pumped	13,800	6.00E-01	935	3.11E-02	**166.3**
Bates pumped	2,010	8.74E-02	94	3.12E-03	**142.2**

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Origins … ?

- Recharge during Cenozoic to Recent uplift
- High concentrations of solutes derived by:
  - high-temperature rock-water interaction in the radiothermal granites and / or
  - 'freeze out' from overlying permafrost that surely formed in this region during cold periods?
    - Modelling of permafrost thickness at Eastgate suggests it may have reached 250m thickness in the Devensian Cold Stage
    - This is almost the same as the remnant thickness of Carboniferous cover above the Weardale Granite there
    - Hence freeze-out processes could have expelled saline waters from almost the entire sedimentary cover into the granite
    - Given that the lowermost Carboniferous is limestone-rich, this would also explain the observed relative enrichment of calcium in the Eastgate brines

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Thank you