

OGA Newdigate Seismicity Workshop – 3 October 2018

Summary and conclusion

On 3 October 2018, the Oil and Gas Authority (OGA) hosted a workshop on the Newdigate seismic events of April to September 2018. The workshop was chaired by the British Geological Survey (BGS) and comprised a review of the scientific analysis of the events and a consideration of whether they were natural or anthropogenic and, if anthropogenic, whether they were caused by oil and gas activity in the area.

Experts were invited from the BGS, Bristol, Edinburgh, Imperial College and Southampton universities, the Environment Agency (EA), geoscientists from the oil companies operating nearby oil and gas fields, South Eastern Water, the Surrey County Council, the Health and Safety Executive (HSE) and the Department for Business, Energy and Industrial Strategy (BEIS) (Annex 1: Attendees). Three presentations were made on the analysis of the events themselves and their geological context; one presentation on a possible causation mechanism linked to oil and gas activity; and two presentations on the scale and timing of nearby oil and gas activities. Rates of water abstraction by South Eastern Water and other commercial users were provided by the EA and posted on a wall map. Three break-out groups discussed seismicity, structural geology/petroleum engineering and regulation, followed by feedback and discussion (Annex 2: Meeting agenda and key questions).

The workshop participants concluded that, based on the evidence presented, there was no causal link between the seismic events and oil and gas activity although one participant was less certain and felt that this could only be concluded on “the balance of probabilities” and would have liked to see more detailed data on recent oil and gas surface and subsurface activity. It was agreed that the seismic event epicentres were well-resolved, with depths of 1.5 – 2km, and with some scatter deeper or shallower.

This document summarises how the conclusion was reached. A more detailed account of the seismic events and their cause is given in BGS Open Report OR/18/059.

Actions

It was agreed that:

- In the light of relatively sparse data availability, the industry should be encouraged by the OGA to make interpretations of in-situ stress measurements while drilling wells, and provide this information to the BGS Rock Stress data base;
- Although there was a general desire for additional seismometers to be added to the BGS National Network, it was also recognised that the current government funding for micro-seismic baseline monitoring is appropriately limited to areas where hydraulic fracturing is proposed;
- The Davis and Frohlich (1993) criteria provide a reasonable framework within which to assess in a general sense whether events might be anthropogenic.

However, the participants felt that these criteria also generate ambiguities. An alternative, more robust set of criteria, developed by academia, perhaps including a more quantitative assessment, would be desirable, especially in cases such as this where significant public interest is involved;

- That further information relating to surface activity at one of the oil and gas sites between 2016 and the seismic events should be provided to the OGA and distributed to the participants (this has since been provided, see note 1); and
- The OGA should look into improving the publicly available Petroleum Production Reporting System website information so that both re-injected produced water and water injected on a monthly basis from other sources are visible.

Summary of discussions

The central Weald has a low rate of background seismicity but events have been detected in the past (for example the 2005 Billingham events with similar depth). There is a higher rate of seismicity around the basin edges (e.g. the 2012 Chichester sequence and the 2007 Folkestone earthquake). Overall, seismicity patterns in the UK show relatively shallow seismicity in sedimentary basins, for example, a similar sequence of small events at 2 km depth was detected in 2001 near Manchester with no apparent cause. Deeper events are often recorded in harder/crystalline rock areas. It is important to note that smaller magnitude seismic events may have been undetected in the area because of the location of the BGS National Network stations (resolution completeness for magnitude 2.5+ UK-wide, and 3.5 pre-1970).

The event epicentres are now well-resolved, with the first event on 1 April 2018 occurring further west than later events in the sequence. Event depths of 1.5 – 2km fit most seismic analyses, but some events may be deeper or shallower. Epicentres are consistent with the north-east striking, south-dipping fault trend. First-motion polarities, S/P amplitude ratios, and full waveform centroid moment tensor inversion indicate right-lateral strike-slip movement along the Newdigate-Charlwood fault.

Fault mapping from surface geology is not reliable, but mapping of 2D seismic data indicates that it is unlikely that any fault directly links the Horse Hill 1 well with the Newdigate cluster of events (~three km away to the east). The Brockham Field is more distant (~10km to the north). Moreover, several faults running E-W perpendicular to the path between the oil wells and the epicentres separate the Brockham Field from the event locations. These faults are likely to be sealing, as evidenced by the fact that (i) they act as a seal for the oil at Brockham, (ii) they cause significant offset within the Portland units, and (iii) if they were not sealing, pressure changes caused by production at Brockham would be observed in the Horse Hill well. Therefore, these faults will act as barriers, meaning that pressure changes at Brockham would not be able to reach the event locations.

Subsurface operational activity at the Horse Hill 1 site included a flow test in 2016 of 1940 bbls of oil from the Portland and Kimmeridge zones combined, but then activity ceased until 3 July 2018 when the extended well test of the Portland began, long after the first seismic event on 1 April 2018. Although there are examples from other countries of production related induced seismicity, the Portland Formation has a completely different reservoir characteristic to these other reservoirs making

production-related induced seismicity (e.g. Groningen, Ekofisk) and a matrix compaction mechanism extremely unlikely.

There is no annular pressure evidence of impaired wellbore integrity in the Horse Hill 1 well because of the seismic events, nor evidence of migration of gas outside the wellbore between different zones. The strata are normally pressured and at formation pressures all gas is solution gas and there is no free gas.¹

Production at Brockham Field and flow testing at Horse Hill 1 well created pressure drawdown but the radius of influence is small (~200-1000m). There has been no hydraulic fracturing and the small injection of disposal fluid (March- July 2018 ranged between 22 and 79 m³/month) impact on pore pressures at Brockham field are not sufficient to conventionally re-activate a fault by reduction of normal stress on the fault plane.

Well-specific detail technical information is recorded by the Operator and reviewed by a number of bodies (including the Independent Well Examiner, the HSE and the OGA), but these reports are only available to the public after the lapse of the 4-year licence confidentiality period from Data Release Agents. Environmental permit application data and EA-approved permits are in the public domain, and newer permits have more detail on well design and groundwater risk. Approved Field Development Plans are published on UKOGL.org.uk after 6 years. Data available on Local Authority sites include that submitted for planning permissions and the EA publishes abstraction permits issued to water companies, golf courses and for other commercial use.

The OGA reports production data in the Petroleum Production Reporting System (PPRS) by Field, with monthly totals in the Open Data website pages. Monthly field Re-Injection information needs to be added to OGA website accessible data.

There was a general desire for additional seismometers to be added to the BGS National Network, but it was agreed that the current government funding for micro-seismic baseline monitoring is appropriately limited to areas where hydraulic fracturing is proposed. It was agreed that it would be an unreasonable burden on industry to fund

¹ Some questions were not answered during the event about activity at the Horse Hill site, and that information has since been made available: prior to the recent commencement of the Horse Hill 1 testing in 2018, there had been no sub-surface work at the Horse Hill site since 18 March 2016. Surface activity included the excavation of a nearby new cellar starting on 21 March 2018 using a JCB for a future well and the site was visited by tankers to remove rainwater collected above the impermeable layer. Well integrity tests were conducted by checking annular pressures on 5-6 April 2018. No pressure was detected in either annuli and pressure tests were satisfactory. A workover crane arrived on site on 25 June 2018 in preparation for flow testing and the well was re-entered on 3 July 2018 and the retrievable barrier was removed from the well to test the Portland Sandstone. No injection was done, but liquids were drawn out of the well using a downhole pump. On 17 August 2018, a 113ft interval in the well was perforated using a Geodynamics tool with 6 shots per foot and charges of 39gm. The modelled stressed rock penetration is 18 inches from this activity.

additional seismic monitoring for other oil and gas activity with no evidence of causality.

Two areas of further scientific study were identified: first, for academics to develop a UK specific scheme for assessing the likelihood of induced seismicity and second, the need for industry to support the BGS Rock Stress mapping by providing well-specific data to allow for better modelling of the subsurface stress regime and likelihood of fault reactivation.

The workshop concluded that the event epicentres were well-resolved, with depths of 1.5 – 2km although some events may be deeper or shallower. Participants concluded that, based on the evidence presented, there was no causal link between the seismic events and oil and gas activity although one participant was less certain and felt that this could only be concluded on “the balance of probabilities” and would have liked to see more data on nearby oil and gas surface activity over the past two years (see note 1).

Annex 1: Workshop attendees

- Mike Stephenson - Director of Science Technology, BGS Keyworth
- Brian Baptie - Head of Seismology, BGS, Edinburgh
- Richard Luckett – Seismologist, BGS, Edinburgh
- Andy Chadwick – Structural Geologist, BGS, Keyworth
- Stephen Hicks – Postdoctoral Research Fellow in Passive Source Seismology, University of Southampton
- James Verdon - Lecturer in Applied Geophysics for the School of Earth Sciences, University of Bristol
- Julian Bommer - Senior Research Investigator (Seismic Hazard & Risk), Imperial College London
- Jon Fuller – Consultant Reservoir Engineer for Horse Hill Developments Ltd
- Andrew Hollis – Consultant Petroleum Engineer for Angus Energy
- Jamie Burford – Petroleum Engineer /Geoscientist for HHDL
- Stephen Jenkins – Surrey County Council
- Tony Almond – Health and Safety Executive
- Simon Dawson- Environment Agency –Technical Specialist, Geophysics, Geoscience Operations Team, National Permitting Service
- Dick Selley – Emeritus Professor of Petroleum Geology, Imperial College London
- Stuart Haszeldine – Professor of Carbon Capture and Storage, University of Edinburgh
- Stuart Walters – Senior Policy Advisor, BEIS
- Toni Harvey – Head of Onshore Exploration and Production, OGA
- Mark Quint – Senior Geoscientist, OGA
- Simon Toole – Advisor, OGA
- Tom Wheeler – Director of Regulation, OGA
- Kelsey Ward – Geoscientist, OGA
- South Eastern Water were invited but did not participate in the Workshop

Annex 2: Meeting agenda and key questions

10:30 – 10:35	Tom Wheeler - Welcome and set scene
10:35 – 10:45	Mike Stephenson – Set out goal of meeting
10:45 – 11:00	Introductions round table
11:00 – 11:10	Brian Baptie - BGS report summary
11:10 - 11:20	Stephen Hicks - focal mechanism
11:20 - 11:30	Mark Quint – Seismic Structure Mapping
11:30 - 11:40	Stuart Haszeldine - interpretation
11:40 - 11:50	Andrew Hollis – Brockham field activity
11:50 - 12:00	Jon Fuller – Horse Hill activity
12:00 – 13.00	Break out groups
13.00 – 13.30	Report back, outcome and next steps
13.30 – 14.30	Lunch and discuss Science Research Questions

Questions regarding seismicity:

- Establish the historical, regional seismicity in the Weald
- Comment on resolution / accuracy of earthquake locations and depths for the Newdigate cluster.
- Comment on the focal mechanism of the 18 August earthquake
- Comment on the suitability of Davis and Frohlich and any other schemes that assess likelihood of induced seismicity
- Attempt to jointly apply the Davis and Frohlich criteria

Questions regarding structural geology/petroleum engineering:

- Establish the main features of the structural geology in the region
- Establish the activities and precise timing of the activities at Horse Hill and Brockham
- Comment on well bottom pressure in relation to structural geology and cause of the earthquakes
- Are there Science Research Questions that should be considered?

Questions regarding regulation:

- What practices could be improved and communication- is there a need for any guidance?
- What things (reporting, detection capability, data availability) could be improved?

Documents received as evidence to consider at the 3 October Workshop:

1 Brian Baptie, [The Newdigate Earthquake Sequence, 2018](#)

2 Andy Chadwick, [UK stress slides](#)

- 3 Stephen Hicks, [Interim technical report on the 2018 Surrey earthquake sequence](#)
- 4 James Verdon, [2018 Newdigate Earthquake Swarm: Induced or Not?](#)
- 5 Julian Bommer, [Integrity of Hydraulic Fracturing Wells During Earthquakes](#)
- 6 Horse Hill Development Limited, [Operational summary of activity at Horse Hill 1 wellsite](#)
- 7a Angus Energy, [Production & Injection Summary 2018](#)
- 7b Angus Energy, [Southern UK Earthquakes report](#)
- 7c Angus Energy [Maps](#)
- 8 Environment Agency, [EA permits for water abstraction table](#)
- 9 Richard Selley, [The Impact of the Newdigate Earthquakes on the Adjacent Population & Environment Report](#)
- 10 Stuart Haszeldine, [Weald basin earthquakes induced OGA Workshop Haszeldine Cavanagh Oct 2018 slides](#)
- 11 OGA, [Regional Subsurface Seismic Analysis slides](#)
- 12 OGA, [Map of nearby production, published induced seismicity and the Davis and Frohlich 1993 criteria slides](#)
- 13 Surrey County Council, [Seismic activity in Surrey, the BGS and quarry sites in Surrey email](#)