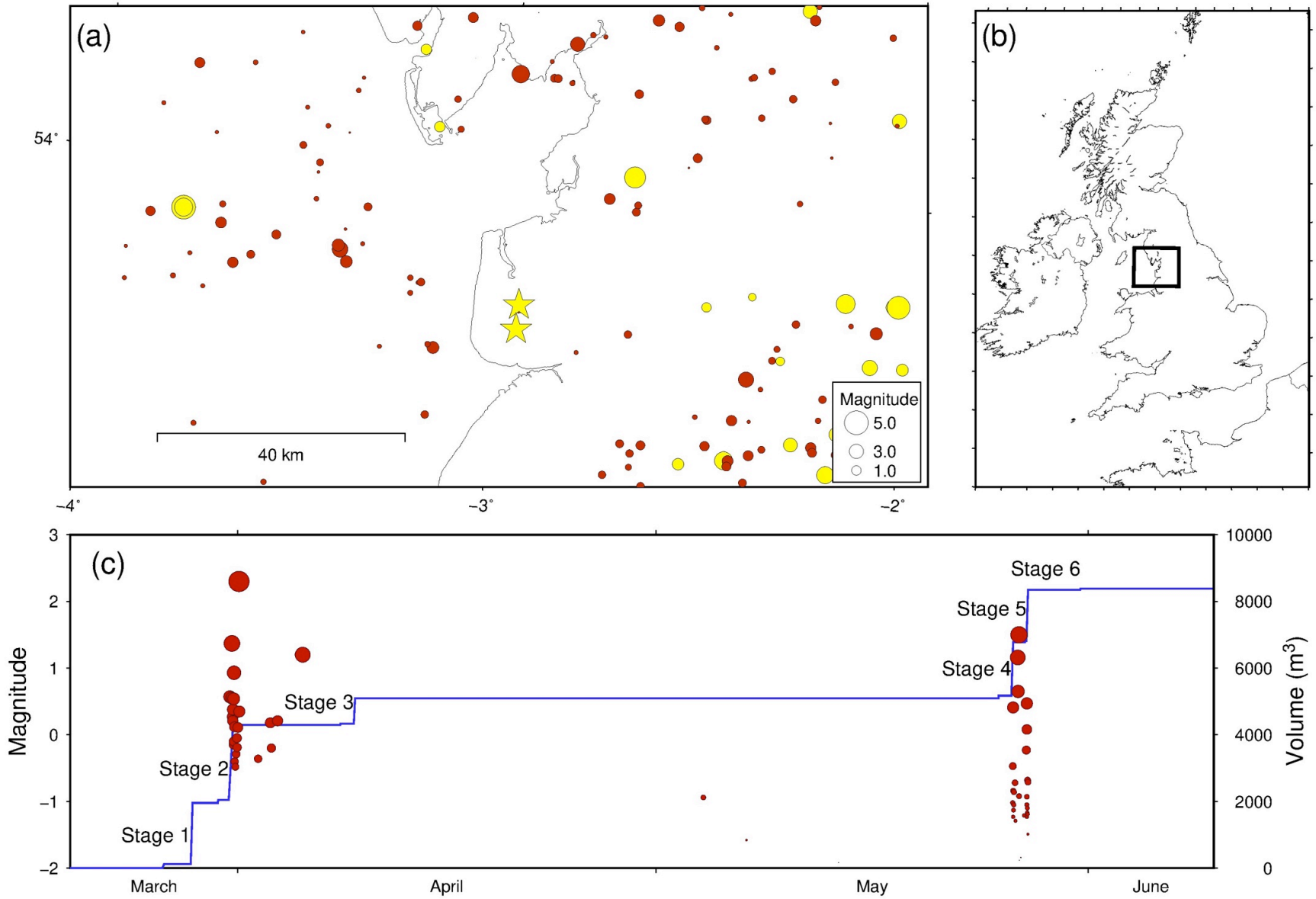
EQUIPT4RISK
Air · Water · Seismic

Seismicity Induced by Hydraulic Fracturing Operations at Preston New Road, Lancashire, 2018.

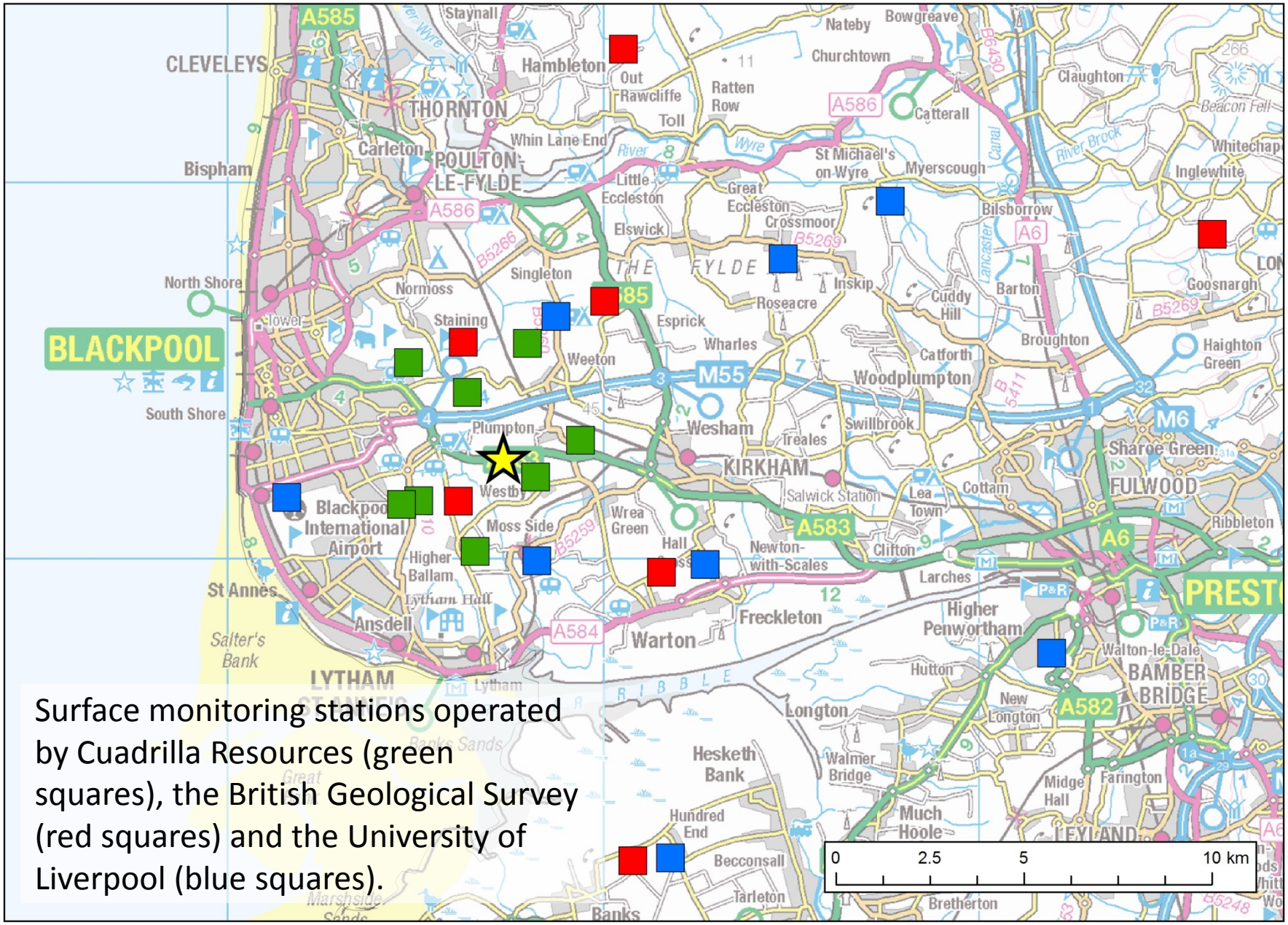
Brian Baptie, Richard Luckett (British Geological Survey)



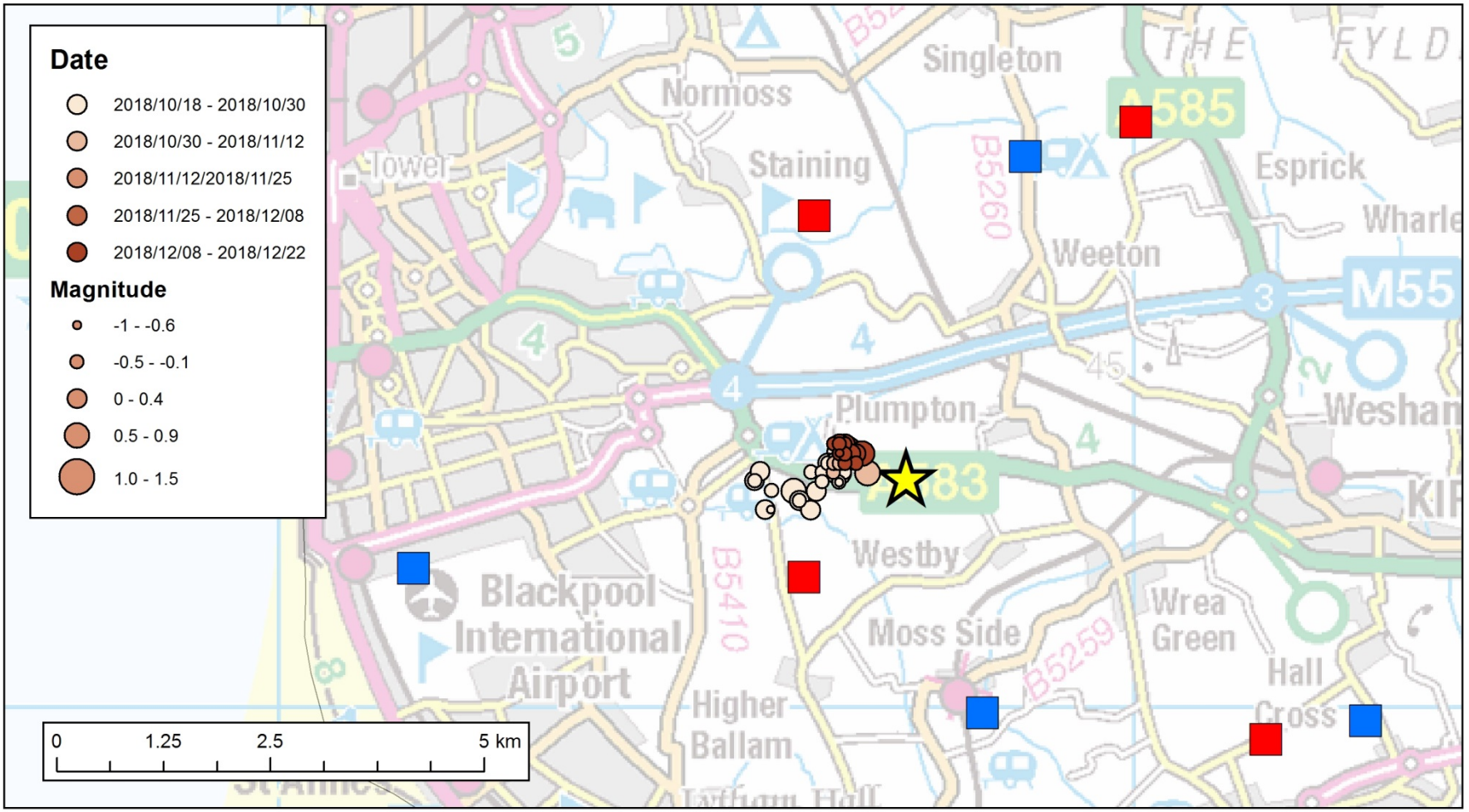
(a) Regional seismicity in northwest England. Yellow starts show the locations of the Preese Hall and Preston New Road sites. (b) geographic context. (c) Induced seismicity at Preese Hall (red circles, scaled by magnitude) and cumulative injected volume.

Location	Amber	Red
Alberta	2.0	4.0
British Columbia	-	4.0
Illinois	2.0	4.0
California	-	2.7
Ohio	-	1.0
UK	0.0	0.5

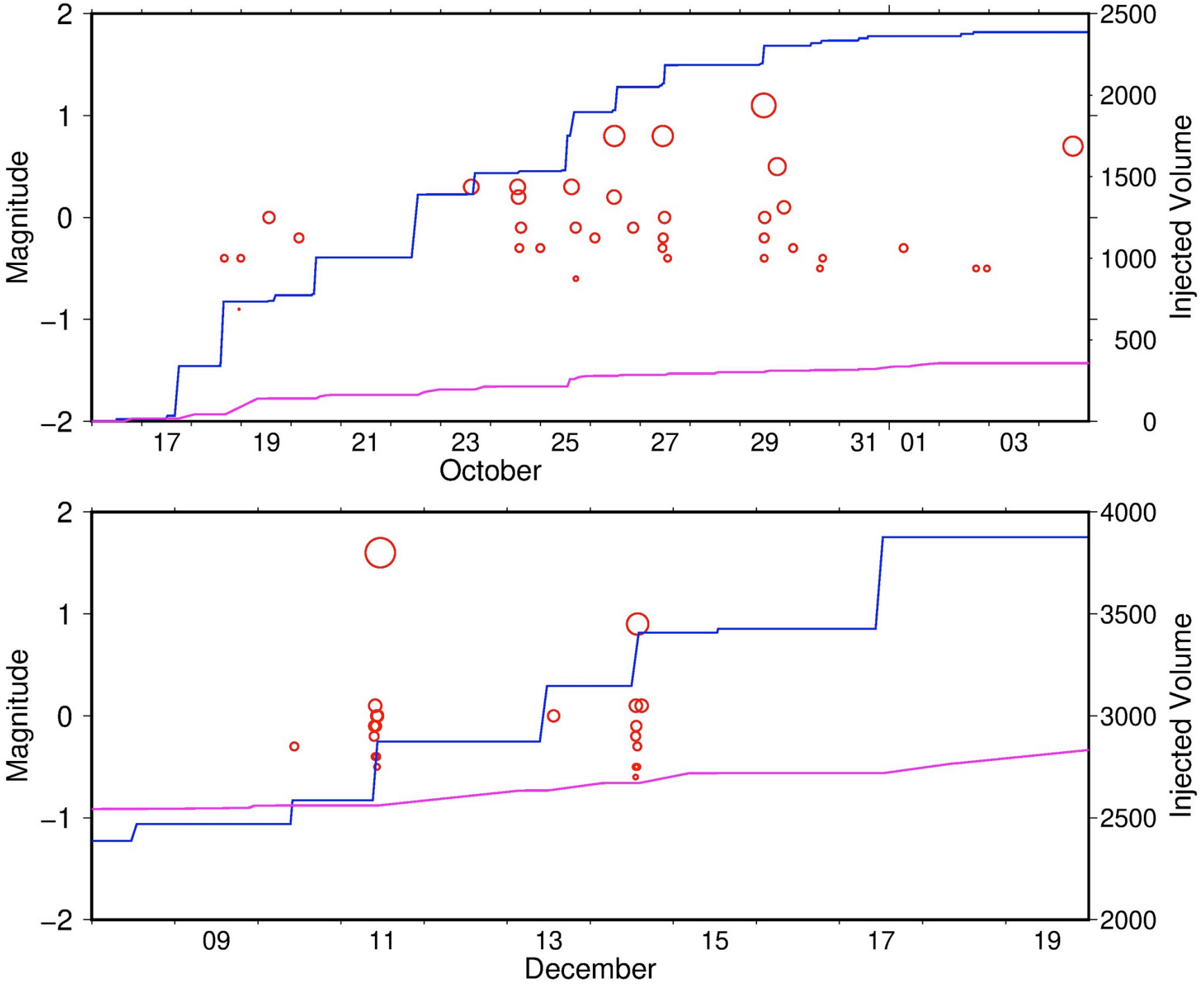
Magnitude thresholds for traffic light schemes implemented to mitigate seismic risk during hydraulic fracturing of unconventional hydrocarbon reservoirs.

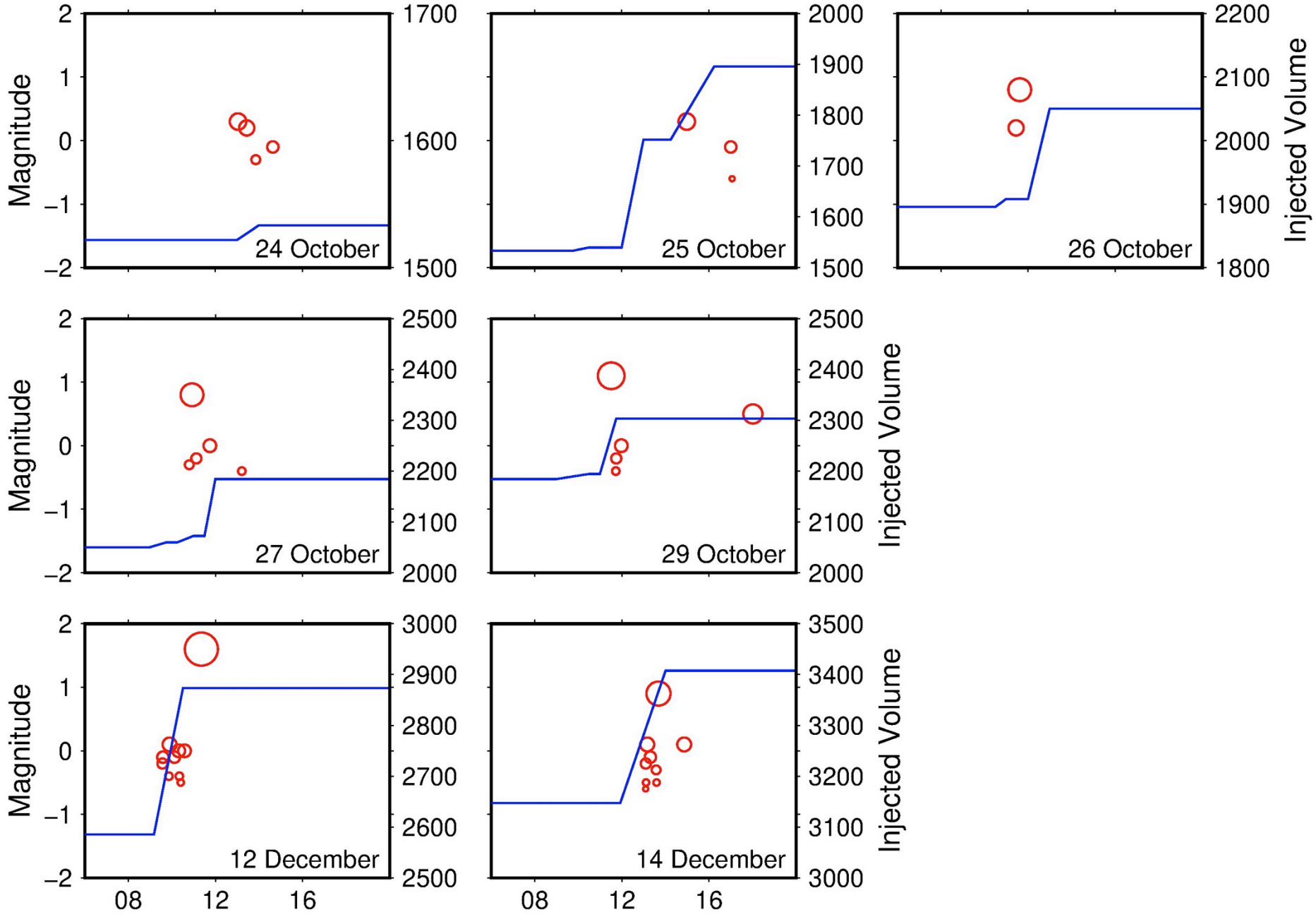


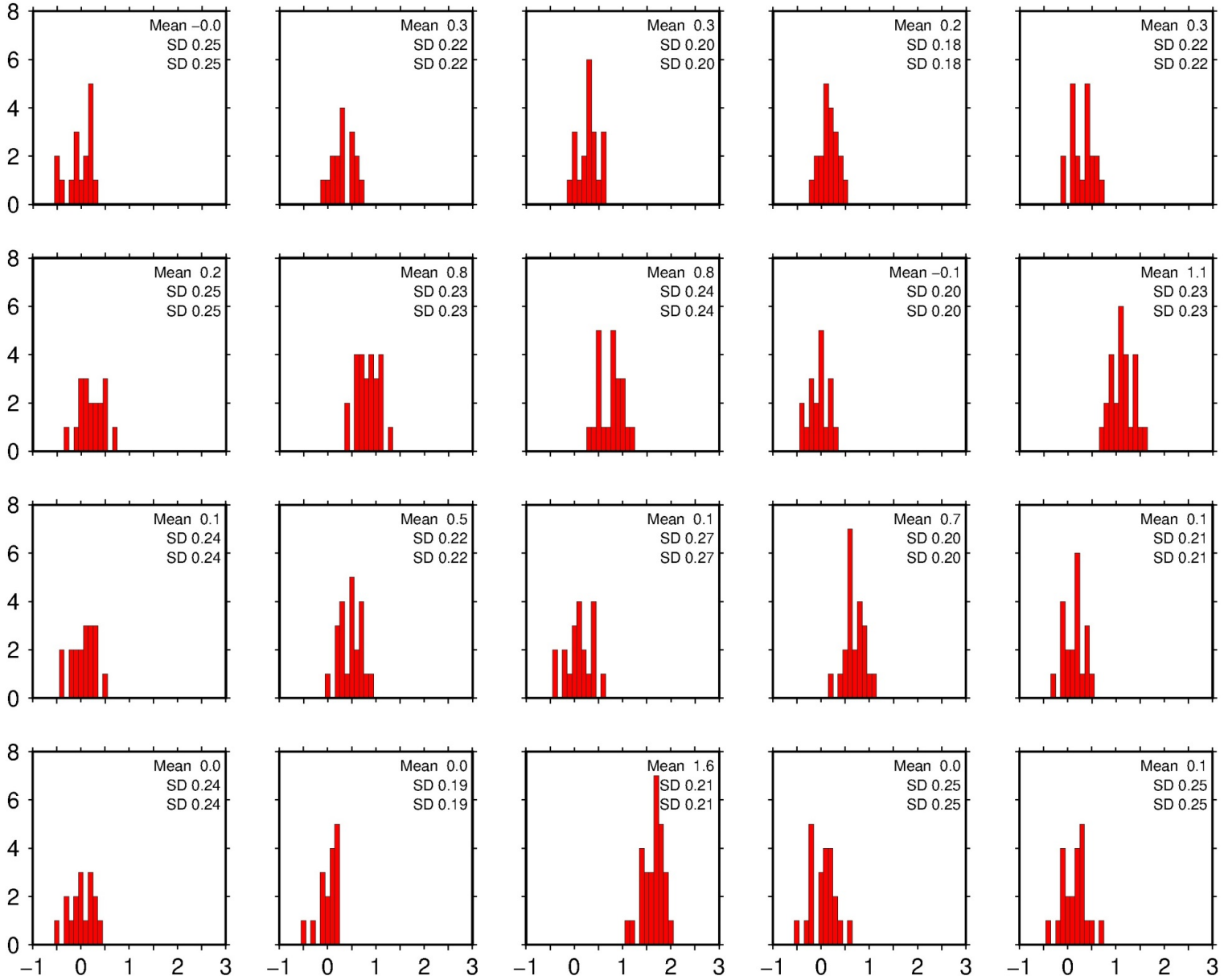
Surface monitoring stations operated by Cuadrilla Resources (green squares), the British Geological Survey (red squares) and the University of Liverpool (blue squares).



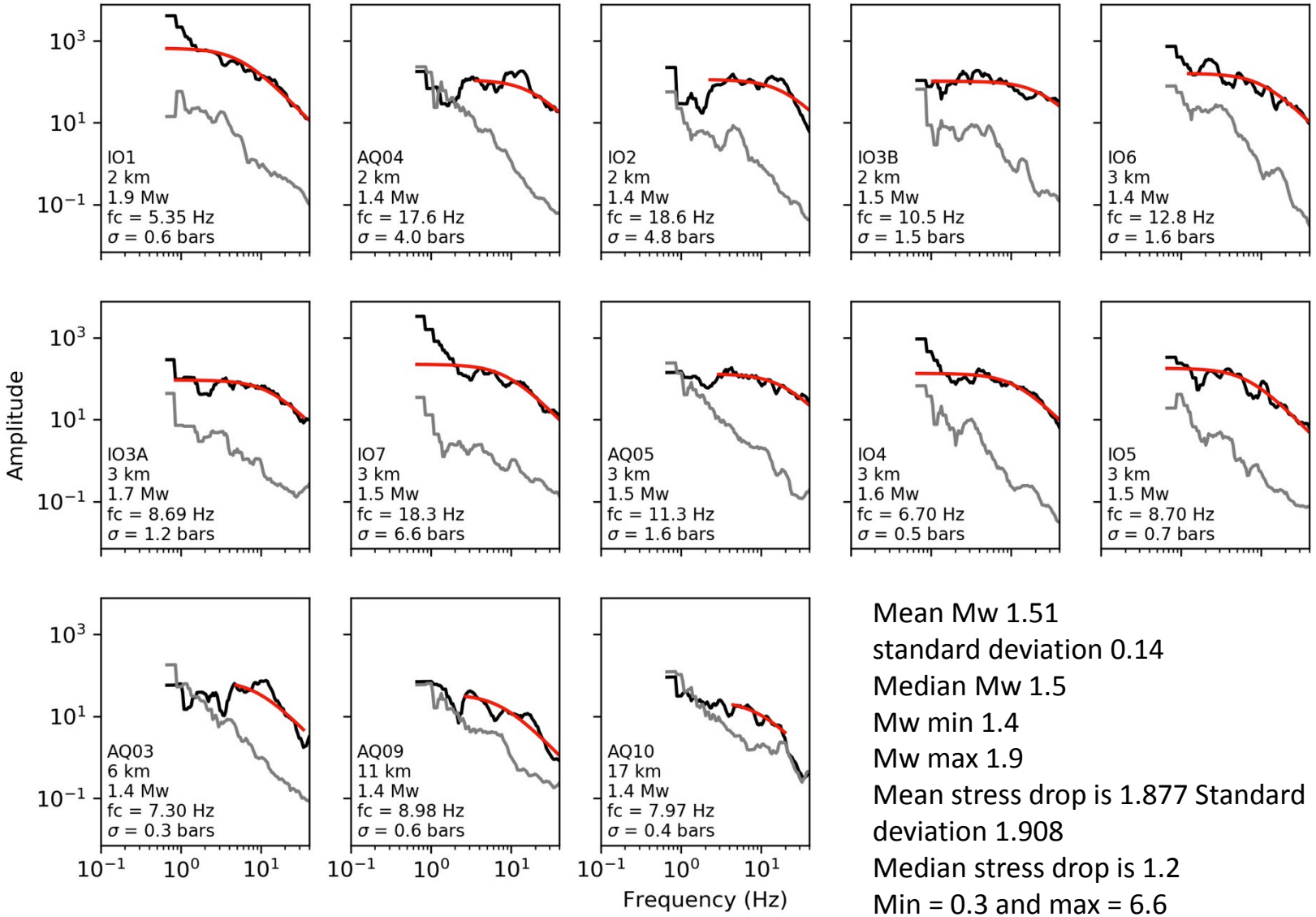
Circles show earthquakes detected by the surface seismic monitoring network during operations. Events move from west to east corresponding to different stages of hydraulic fracturing in the horizontal well PNR-1.


Magnitude
Injected Volume
2
1
0
−1
−2
2500
2000
1500
1000
500
0
17
19
21
23
25
27
29
31
01
03
October
Magnitude
Injected Volume
2
1
0
−1
−2
4000
3500
3000
2500
2000
09
11
13
15
17
19
December


Magnitude
Injected Volume
24 October
25 October
26 October
27 October
29 October
12 December
14 December
08
12
16

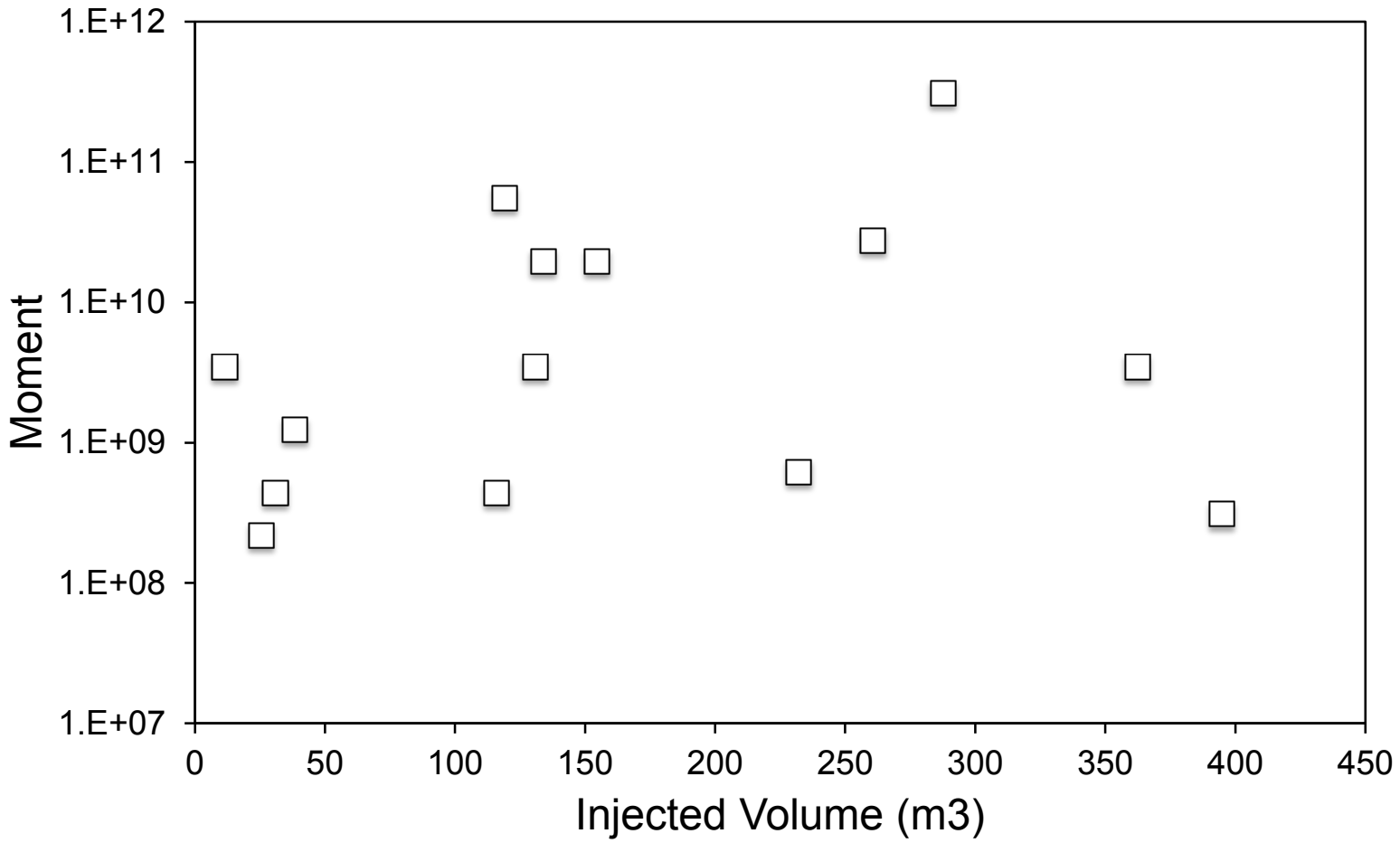


Histograms showing local magnitudes calculated at each station for events with ML > 0.

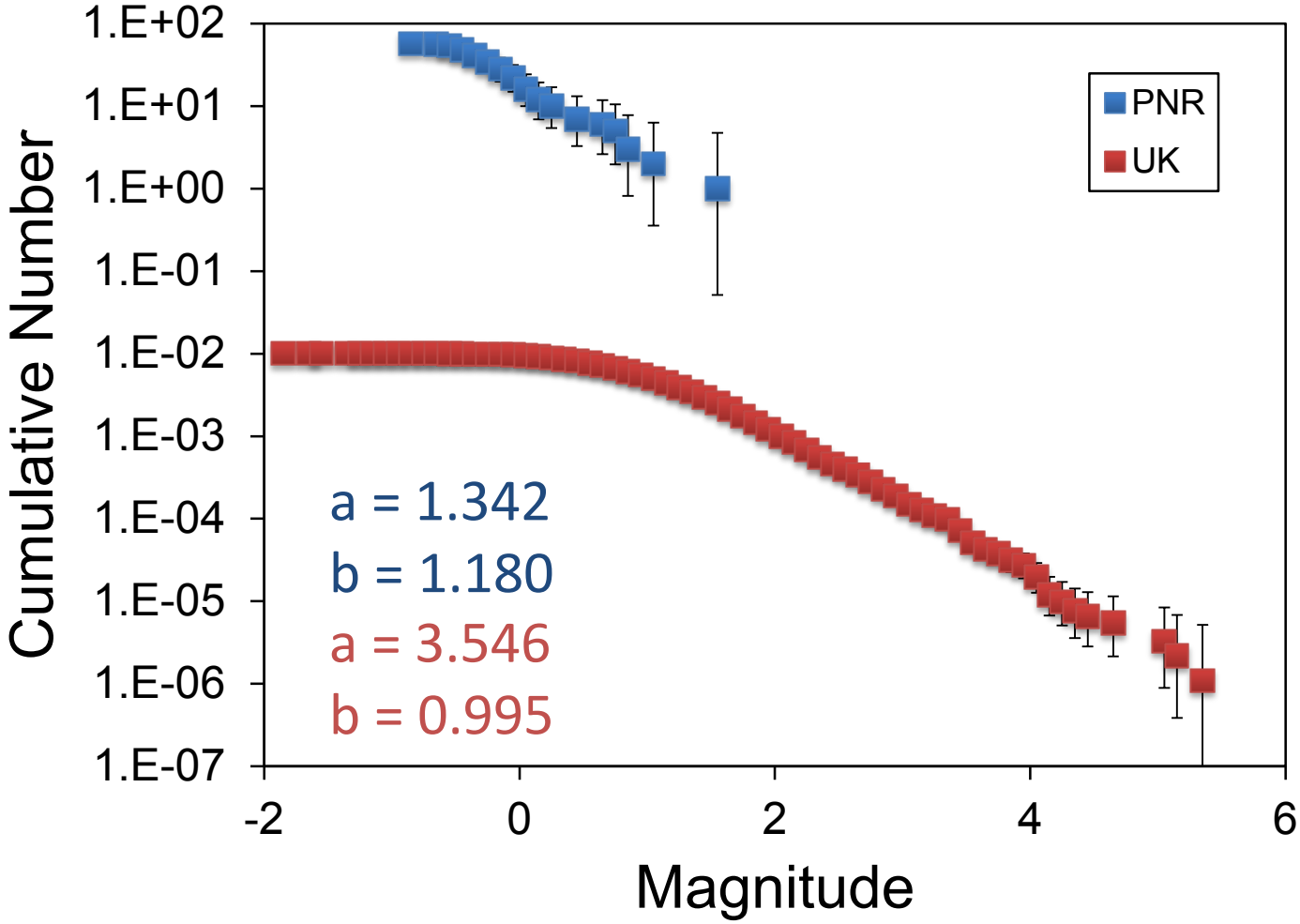


Mean Mw 1.51
standard deviation 0.14
Median Mw 1.5
Mw min 1.4
Mw max 1.9
Mean stress drop is 1.877 Standard deviation 1.908
Median stress drop is 1.2
Min = 0.3 and max = 6.6

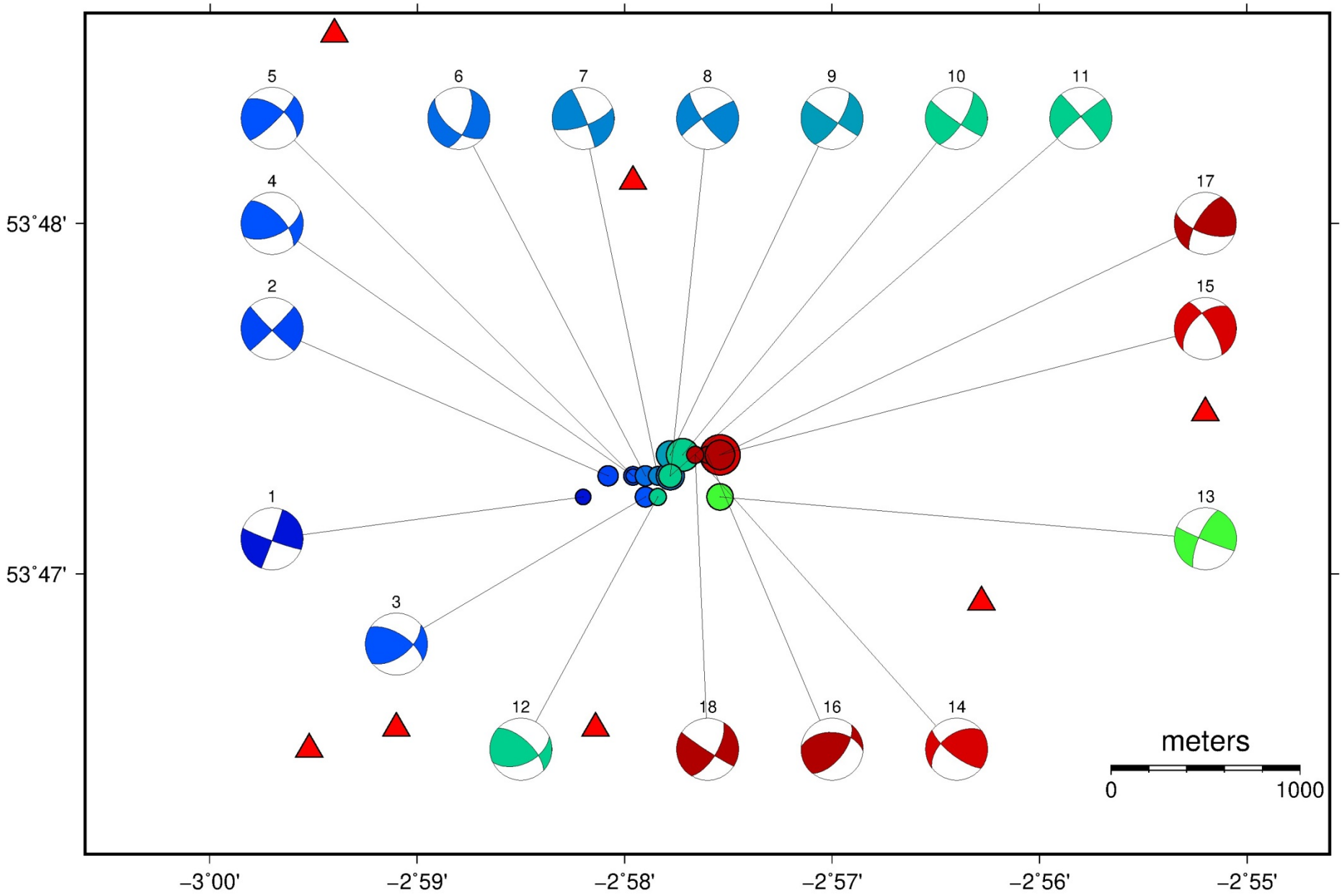
Moment magnitude for the largest event (1.5 ML)



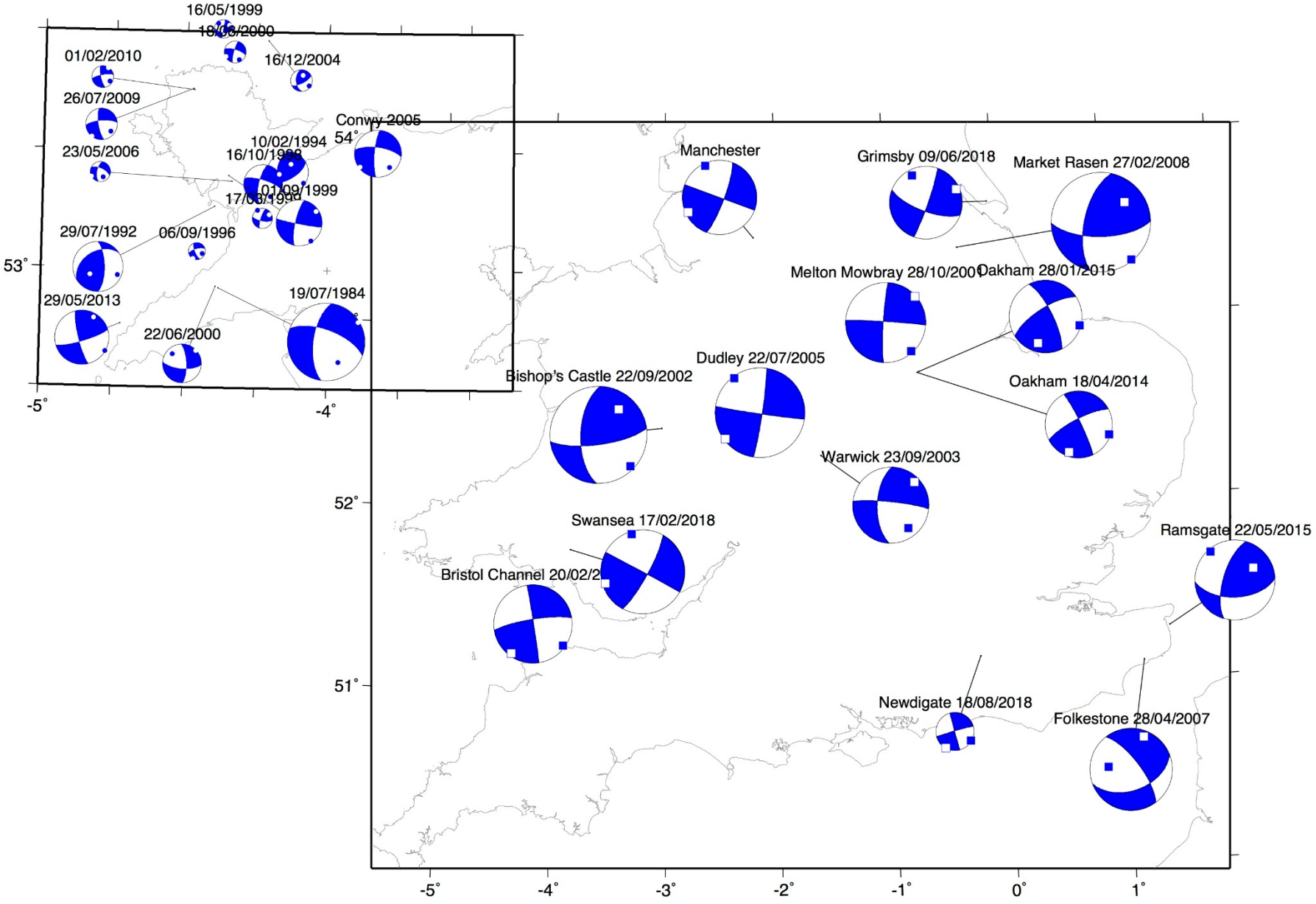
Seismic moment of largest event in stages with induced seismicity versus the injected volume of fluid for that stage.



Frequency magnitude distributions for the Preston New Road events (blue squares) and tectonic earthquakes in the UK (red squares). The rate for instrumentally recorded tectonic earthquakes has been scaled to the same source area and time period as the PNR events.



Focal mechanisms from first motion polarities and P/SH amplitude ratios calculated using HASH.



Focal Mechanisms for tectonic earthquakes.

Conclusions

- Events located using only the surface monitoring network show seismicity migrating from west to east corresponding to operations.
- Seismicity occurs mainly during periods of injection with few trailing events.
- Some evidence to suggest that the largest events occur later in each stage.
- Magnitude uncertainties are approximately 0.25 ML.
- No clear relationship between injected volume and seismic moment.
- Focal mechanisms agree well with those for regional tectonic earthquakes and expected orientation of the regional stress field.