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Trends In Seismicity in the CSG Producing Region of the Surat Basin in Queensland

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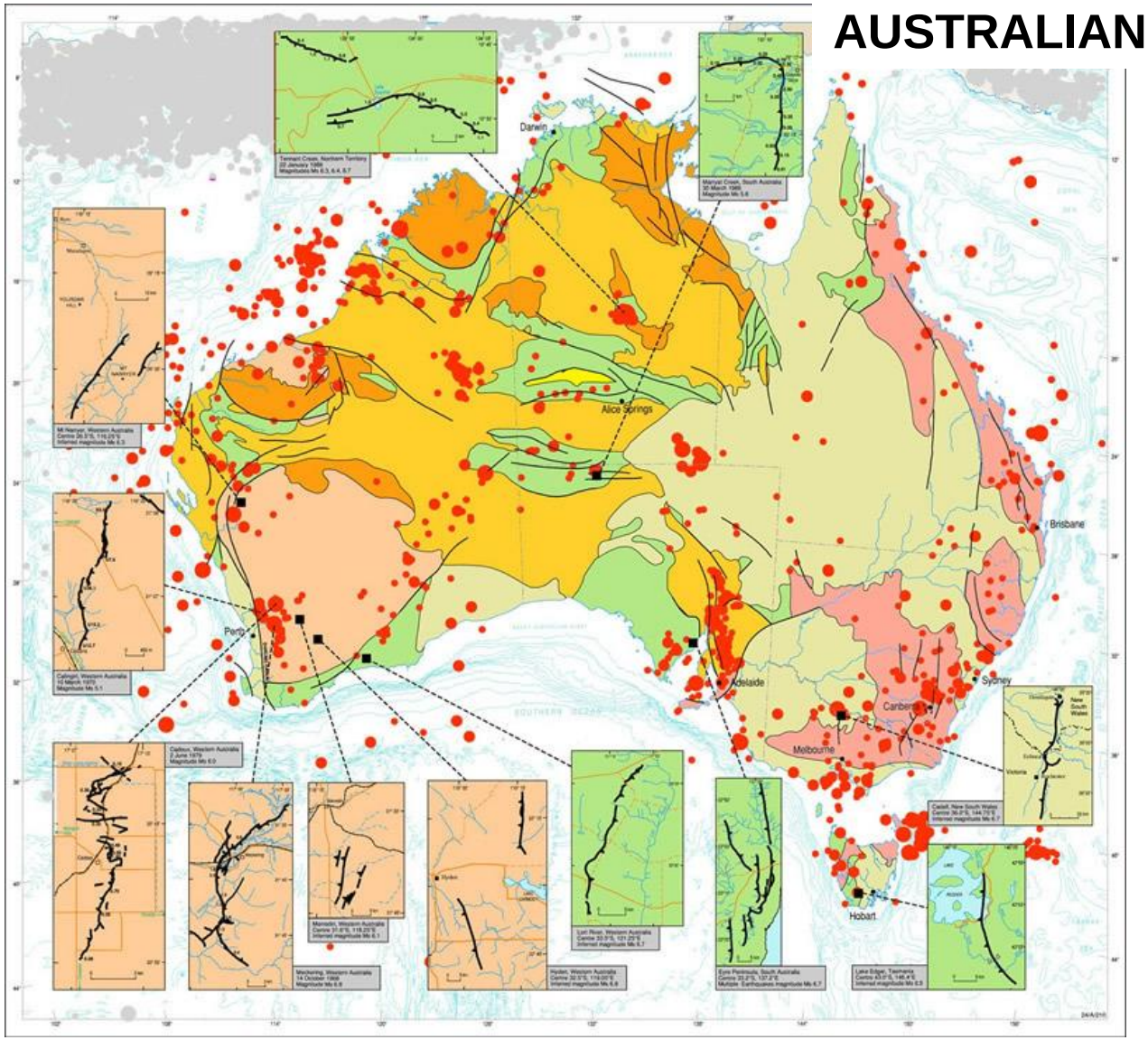
OUTLINE

- Introduction
- Historical seismicity:
  - Within the Australian Continent
  - Throughout Queensland
  - Surrounding the Surat Basin
  - Adjacent to CSG tenements
- Potential for anthropogenic seismicity
- Concluding remarks

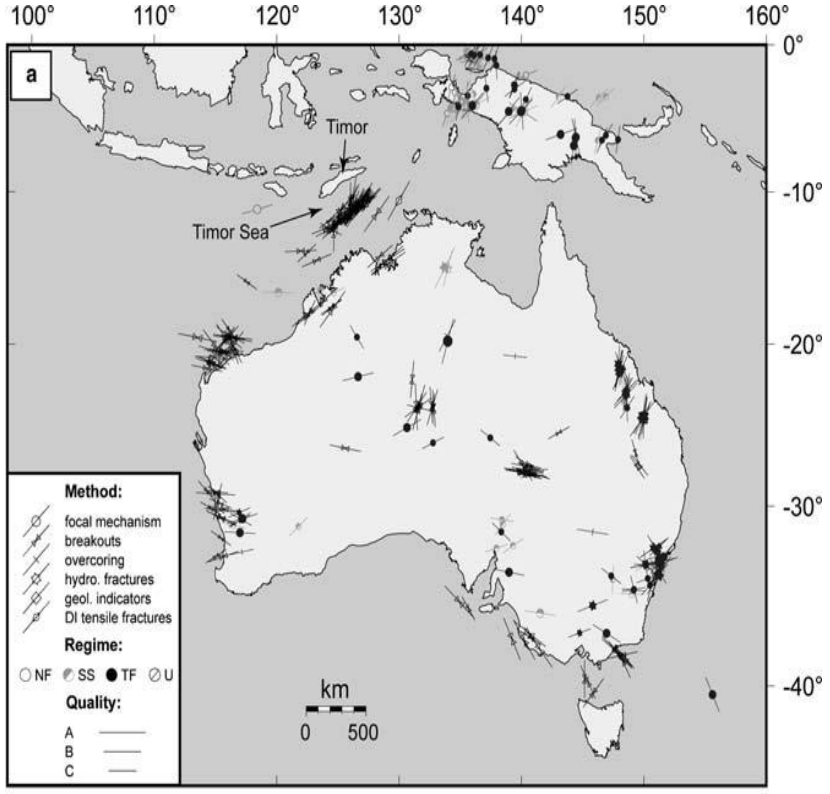
AUSTRALIAN SEISMICITY (1)



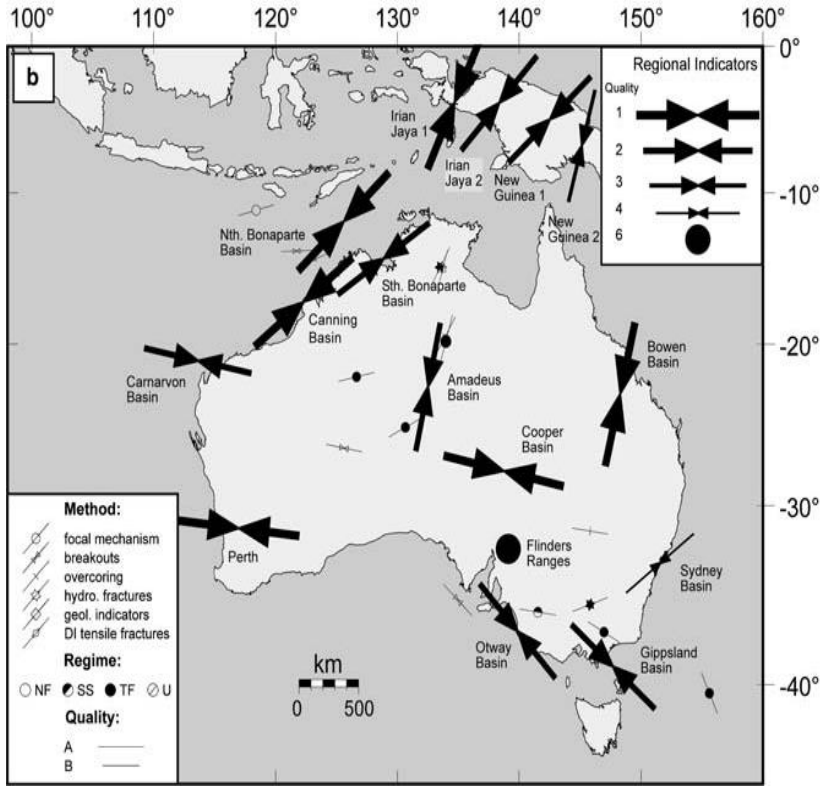
- Approximately two M>5 earthquakes per year
- "Great" earthquakes (M>7) have occurred in South and Western Australia
- 20 earthquakes have caused property damage or exceeded M=6
- The 1989 M=5.6 Newcastle earthquake resulted in 13 fatalities and AU$4B insured losses
- Seismicity rate amongst the highest for stable continental regions

Image source: Geoscience Australia

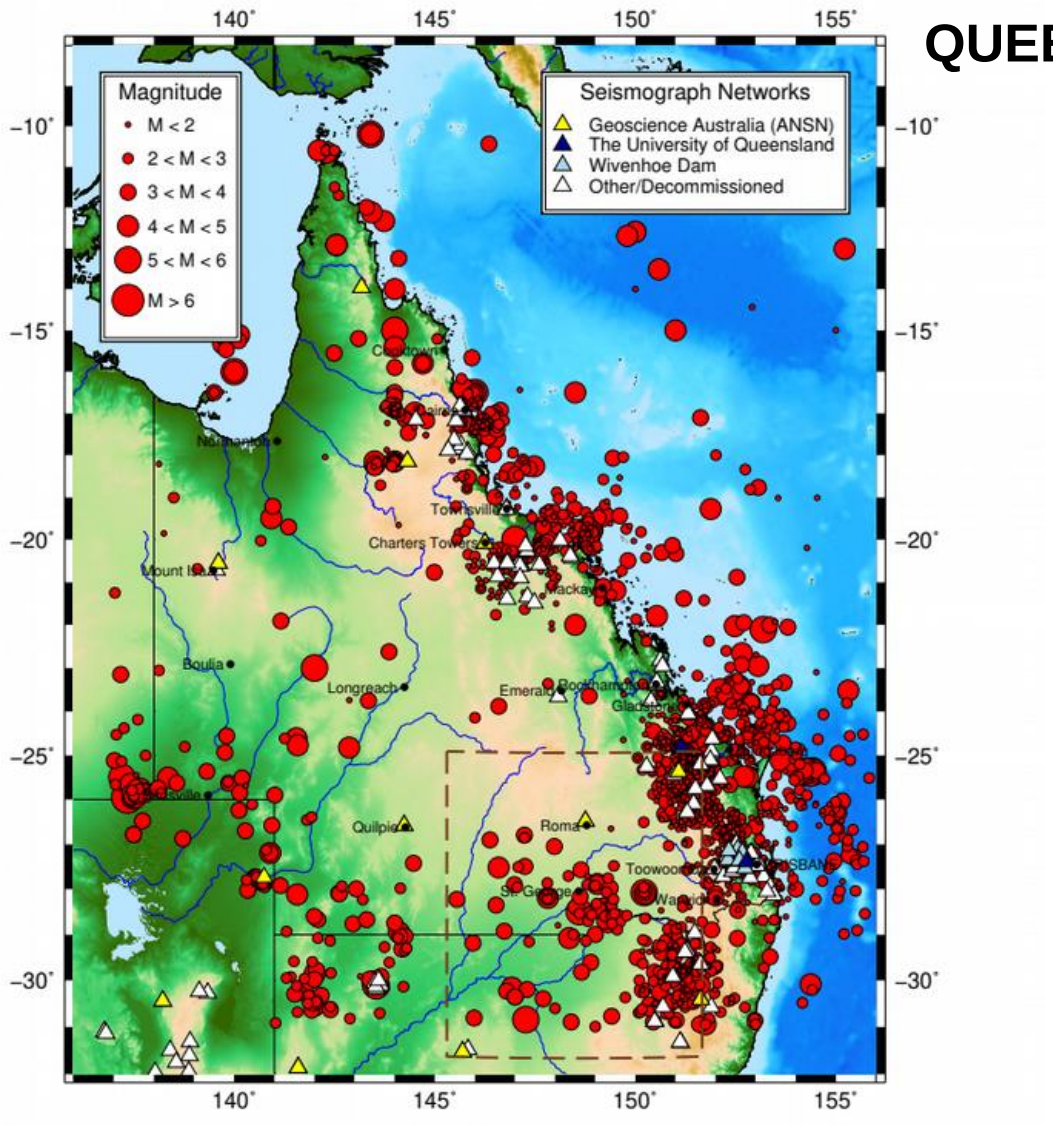
AUSTRALIAN SEISMICITY (2)



- Generally the continent is in a compressive state
- Tectonic stress directions vary across the continent from N-S to E-W
- Within Queensland, the principal stress direction is N14ºE
- Tectonic seismicity predominantly reactivates ancient fault structures



Hillis, R.R., Sandiford, M., Reynolds, S.D. and Quigley, M.C. (2008) Present-day stresses, seismicity and Neogene-to-Recent tectonics of Australia's 'passive' margins: intraplate deformation controlled by plate boundary forces, in *The Nature and Origins of Compression in Passive Margins*, Geological Society, London, Special Publications **306**, 71-90.

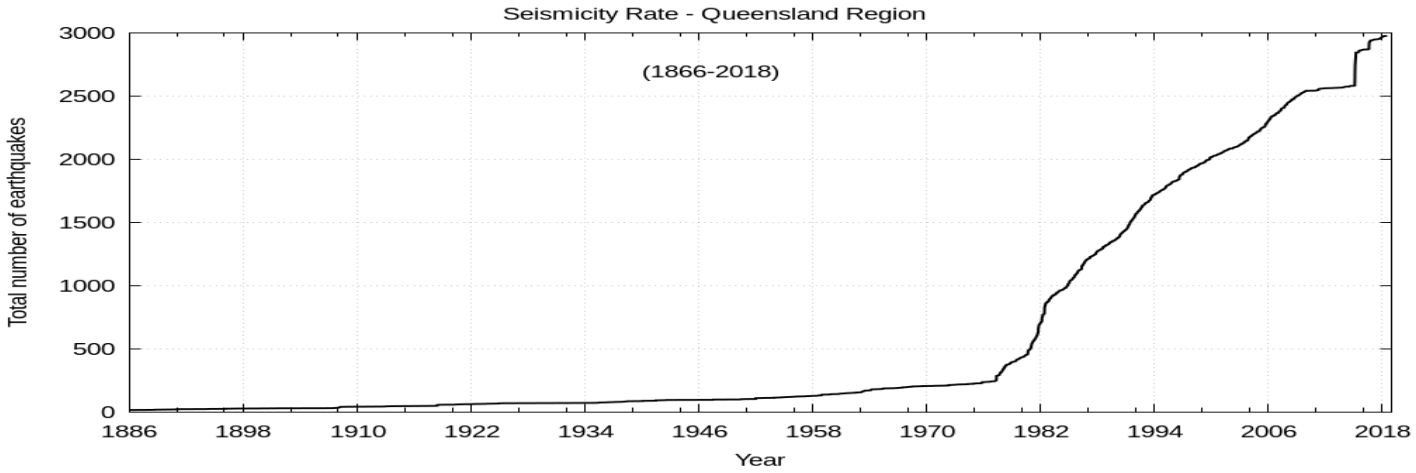


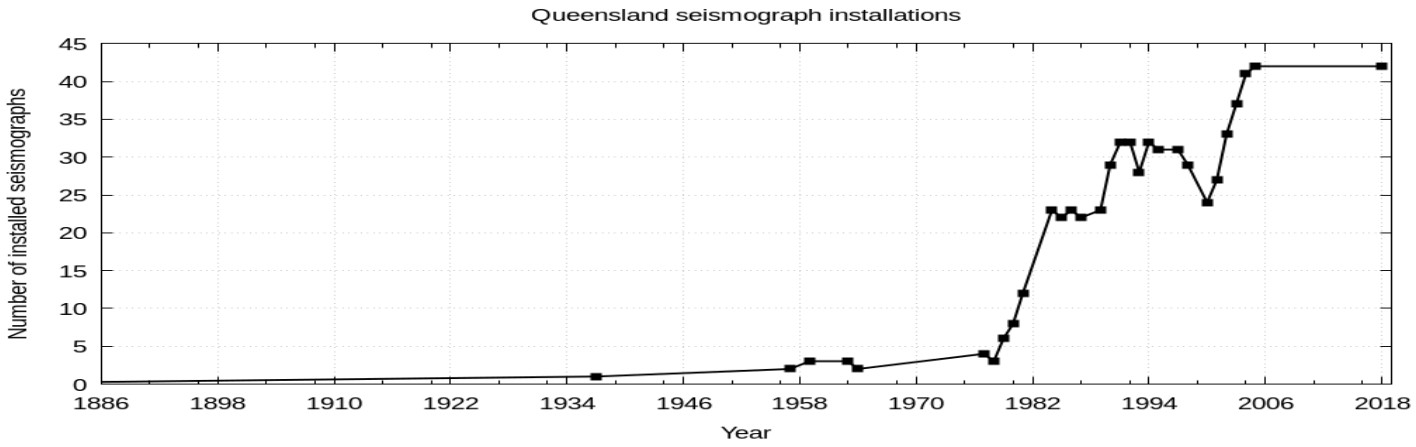
QUEENSLAND SEISMICITY (1)

- Earthquakes of moderate intensity (M>5) have been reported since 1866
- Largest recorded event: 1918 M=6 Gladstone earthquake:
  - Felt area exceeding 3 million km^2
- Central Burnett region currently the most seismically active:
  - M>5.5 earthquakes in 1883 and 1935 near Gayndah
  - 2015 M=5.2 Eidsvold earthquake the most recent
    - Aftershocks still occurring in 2019

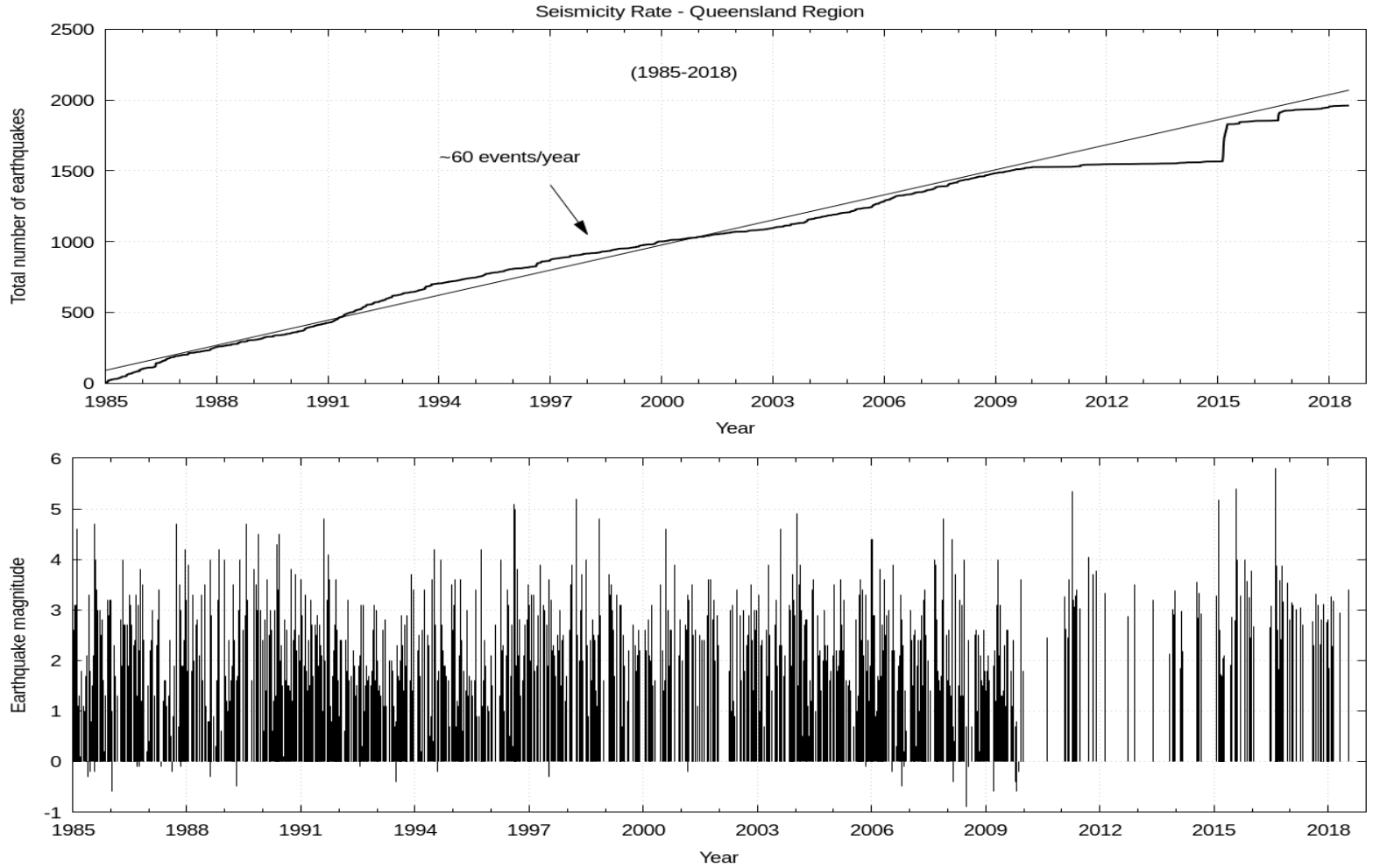
QUEENSLAND SEISMICITY (2)

- Multiple government, university and private entities have operated seismographs in the State
- Spatial and temporal variability of seismicity in Queensland largely reflects the timing and location of seismograph installations – not increased earthquake activity
- The record of M>3.5 earthquakes since 1985 is considered largely complete for Eastern Queensland





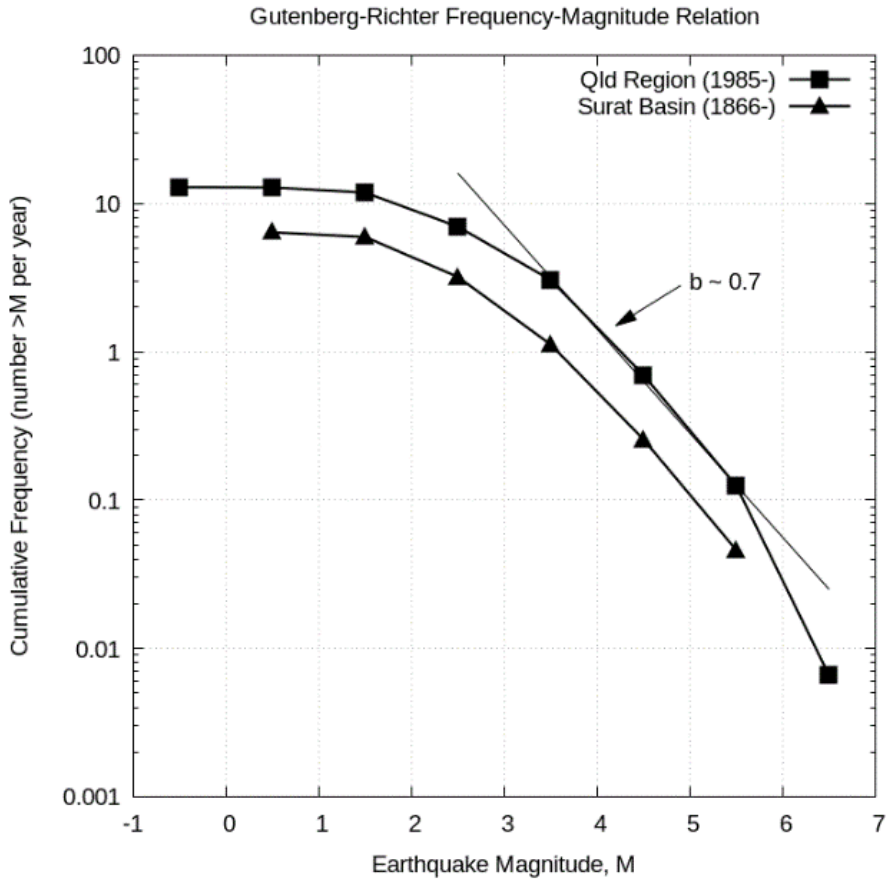
QUEENSLAND SEISMICITY (3)



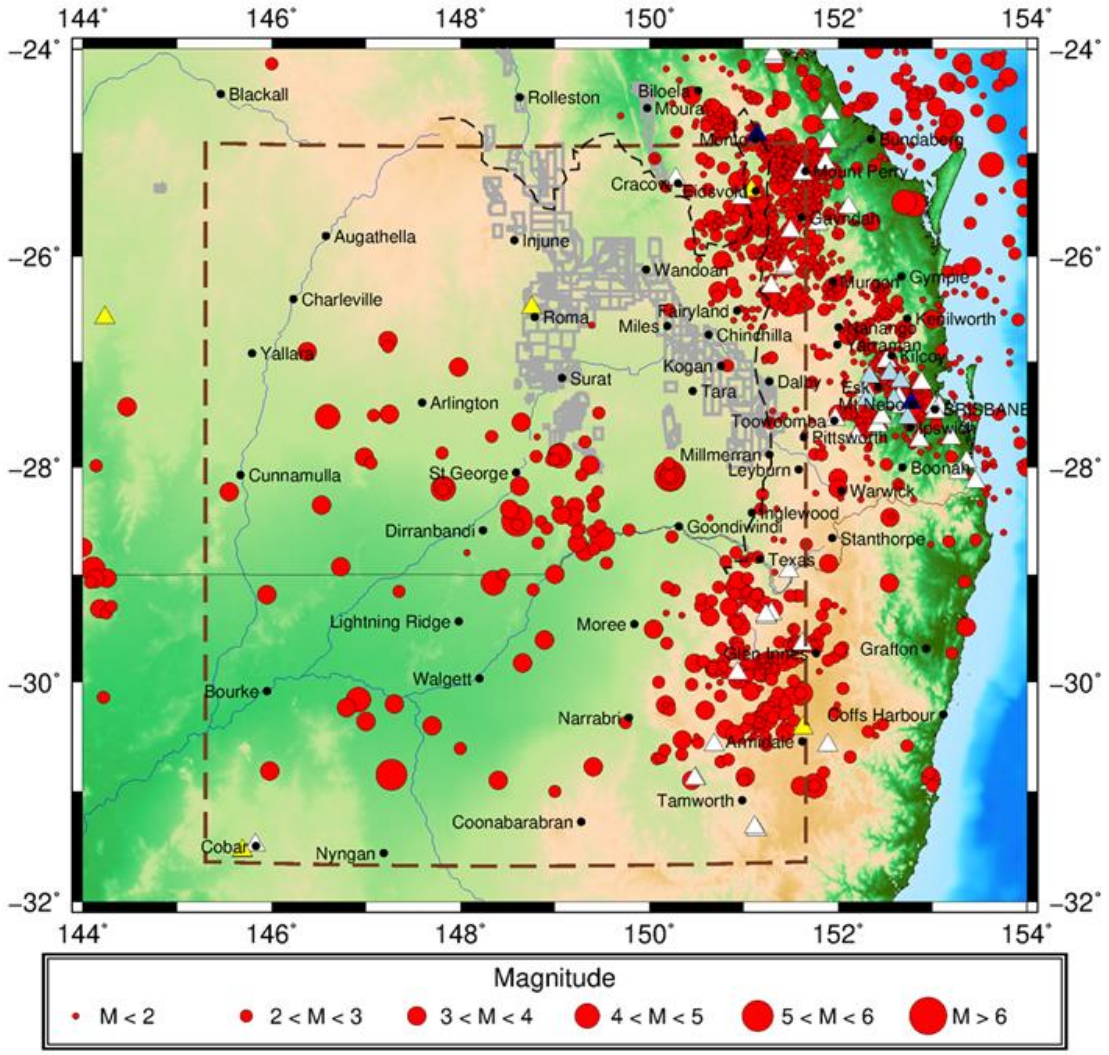
- Since 1985, the State experiences approximately 60 recorded earthquakes per year
- An apparent reduction in seismic rate from 2010-2015 reflects a reduction in the number of operating seismographs
- The step increase in seismic rate in 2015 is attributable to three M>5 earthquakes and their associated aftershocks

QUEENSLAND SEISMICITY (4)

- Frequency-Magnitude distributions for Queensland regions demonstrate a lack of detection of M<3.5 earthquakes
- Approximately 10 “felt” earthquakes (M>2.5) are recorded each year
- Potentially damaging (M>5) earthquakes occur approximately every 5-10 years
- Seismicity within the Surat Basin region largely follows the same trend as the rest of the State



SURAT BASIN SEISMICITY (1)

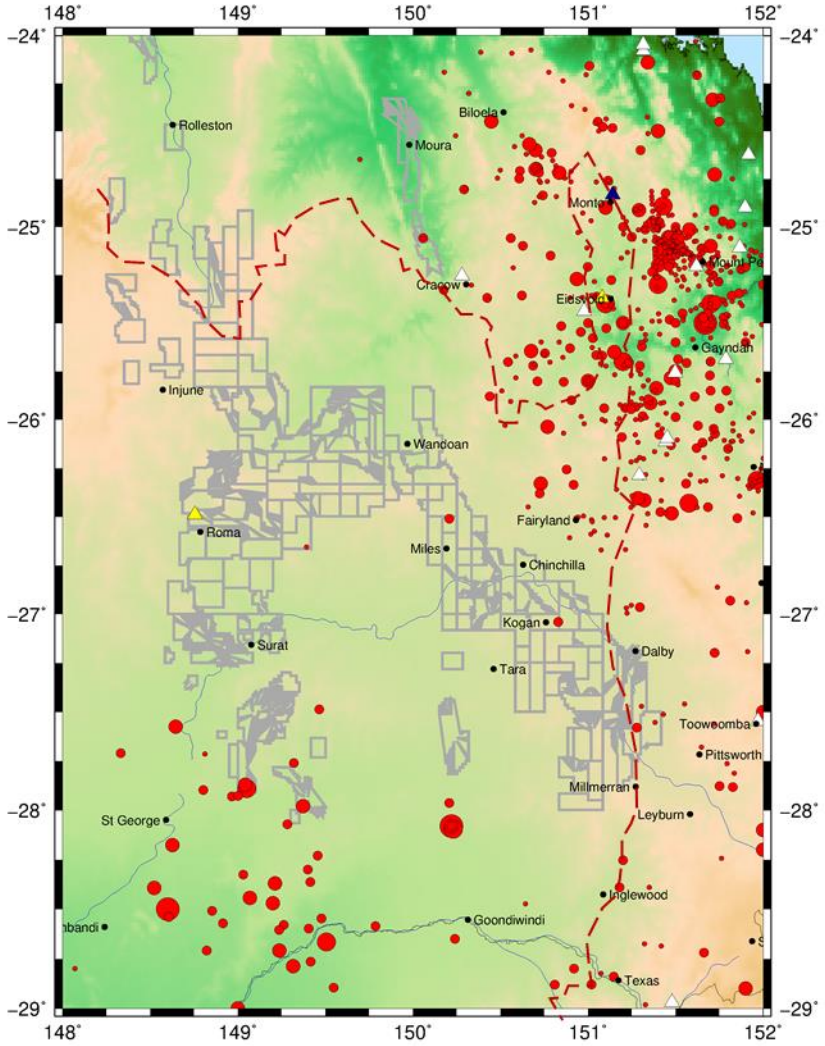


- Approximately 16 “earthquakes” recorded per year
- 44 earthquakes recorded with M>3.5
- Seismograph installations primarily to the East of the Basin
- Higher seismicity regions:
  - In the N-E Central Burnett region
  - In the S-E New England fold belt region
- Small magnitude 2<M<4 earthquakes have been reported “felt” throughout the Surat Basin region

SURAT BASIN SEISMICITY (3)

Year	Month	Day	HHMM	Sec	Latitude	Longitude	Depth (km)	Magnitude (ML)	Locality
1965	6	3	2159	56.9	-28.08	150.22	28	5.3	GOONDIWINDI
1954	9	19	1037	6	-28.5	148.6	10	5.3	ST. GEORGE AREA
2015	2	15	1557	9	-25.146	151.436	12.5	5.17	EIDSVOLD
1961	5	16	652	47.7	-30.85	147.27	10	5	NW OF COOLIBAH, NSW
1938	6	27	2238	47	-30.1	151.6	10	4.7	ARMIDALE-GUYRAAREA, NSW
1910	11	24	2252	42	-25.7	151.2	10	4.7	MUNDUBBERAAREA
1977	3	5	604	12.25	-28.096	150.231	33	4.6	N OF GOONDIWINDI
2008	2	13	2157	29.36	-27.523	146.593	10	4.4	"MOORO" STATION
2005	12	28	2054	56.27	-28.197	147.82	29	4.4	"BOGONG" STATION
1980	9	4	2105	44.79	-29.126	150.937	12	4.3	ASHFORD, NSW
1970	8	8	1605	53	-29.08	148.35	10	4.3	W OF MUNGINDI, NSW
1991	9	24	436	52.68	-27.89	149.051	8	4.1	"THOMBY" STATION
1964	3	25	614	37.9	-25.3	151.4	8	4.1	N OF MUNDUBBERA
1891	1	5	334	0	-25.4	151.1	10	4.1	EIDSVOLD REGION
2008	6	9	137	31.55	-30.16	146.921	20	4	S OF BREWARRINA, NSW
2007	8	25	606	54.79	-26.431	151.576	2	4	"DANGORE" STATION
1985	8	12	702	10.15	-28.666	149.506	0	4	BOOMI, NSW

SEISMICITY AND CSG TENEMENTS (1)



- Approximately 25 earthquakes (M=0.7 to M=3.8) have been recorded “adjacent” to current CSG assets, all prior to 2007
- Record of small magnitude (M<3) earthquakes likely underestimates the natural rate due to a lack of seismograph installations or monitoring campaigns in this region
- Reasonable to assume that a few tectonic micro-earthquakes (M=1) occur each year
- None of these reported earthquakes are attributable to CSG-related activities

SEISMICITY AND CSG TENEMENTS (2)

Year	Month	Day	HHMM	Sec	Latitude	Longitude	Depth (km)	Magnitude (ML)	Locality
1977	7	21	1644	04.18	-26.336	150.917	21	2.4	"DURAH" STATION
1978	3	24	0427	55.43	-26.037	150.769	8	3.1	AUBURN RANGE
1981	5	10	1439	37.39	-26.33	150.73	19	3.8	MONOGORILBY DISTRICT
1984	12	18	0052	58.53	-26.507	150.932	13	1.2	FAIRYLAND
1988	3	5	0949	10.22	-26	151.081	5	1.5	BROVINIA
1989	2	2	2057	22.83	-26.575	151.036	9	1	FAIRYLAND
1990	12	8	1341	58.17	-26.381	150.724	8	2.5	BARAKULA
1991	2	7	1140	17.34	-26.03	150.526	8	1.6	"COONDARRA" STATION
1992	3	21	2237	53.17	-26.609	150.895	0	1.8	"COORANGA" STATION
1992	3	22	1750	03.36	-26.595	151.11	12	0.9	FAIRYLAND
1992	3	24	2108	40.42	-26.503	150.944	0	1.6	FAIRYLAND
1992	3	29	0032	05.99	-26.526	151.024	7	1.4	FAIRYLAND
1992	3	29	0838	15.69	-26.497	150.974	9	1.1	FAIRYLAND
1992	4	6	1730	28.32	-26.505	151.093	5	0.9	FAIRYLAND
1992	8	10	0328	26.15	-26.671	151.075	8	0.3	N OF JANDOWAE
1993	1	8	1527	43.53	-26.516	151.02	0	1.5	FAIRYLAND
1994	5	14	1608	57.84	-26.257	150.878	0	2.3	"WYCHIE" STATION
1994	6	5	1620	11.83	-26.45	150.658	8	0.9	ELGIN VALE
1995	2	1	1833	52.41	-26.59	151.016	10	0.7	FAIRYLAND
2000	7	23	1233	58.93	-26.07	150.86	7	1.6	MONOGORILBY
2001	5	11	1232	49.50	-26.511	150.208	30	2.2	KOWGURAN
2004	2	17	0937	31.95	-26.007	151.098	10	1.6	MONOGORILBY
2005	3	14	1303	00.00	-27.04	150.83	5	2.2	KOGAN
2006	10	10	2342	38.53	-26.202	151.094	4	1.3	S OF ALLIES CREEK
2007	10	18	1548	35.41	-26.021	150.978	10	1.2	"NEW DURAH" STATION

POTENTIAL FOR ANTHROPOGENIC SEISMICITY ?

- Induced seismicity within the Australian continent:
  - Associated with large-scale hydraulic fracturing during development of a HDR geothermal energy reservoir
    - Approx. 36000 micro-events M<1 in two hydraulic stimulation campaigns
  - Six cave mining related events in central NSW, the two largest (M=3.8 and M=4.7) resulted in temporary suspension of operations
  - Micro-seismicity correlated with water reservoir impoundment; significantly higher potential than the global average

- ***Hypothetically***, 3 possible risk factors for CSG-related induced seismicity:
  - Managed acquifer recharge
  - Subsidence associated with gas and water abstraction
  - Hydraulic fracturing

- Currently no geological, tectonic or operational indications that CSG operations in the Surat Basin may induce significant, damaging seismicity

CONCLUDING REMARKS

- There are no sound global analogues for the CSG operations in the Surat Basin
- The detection of future small (M<3.5) seismic events in the Basin is largely constrained by the locations of available seismograph installations
- In the broad area of the CSG operations, 25 seismic events (M=0.3 to 3.8) have been recorded, all prior to 2007
- Whilst large-scale water injection, and gas and water abstraction are hypothetical risk factors, no seismic events in this study are attributable to CSG operations
- Based upon available baseline evidence, a small number of “felt” tectonic earthquakes are likely to occur during the 40+ years of gas activities in the region
- Current seismographic instrumentation installed in the region is insufficient to *definitively* locate their source

Acknowledgements

For further information about Surat Basin seismicity, please contact:
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