Remote triggering of earthquakes in intraplate Australia

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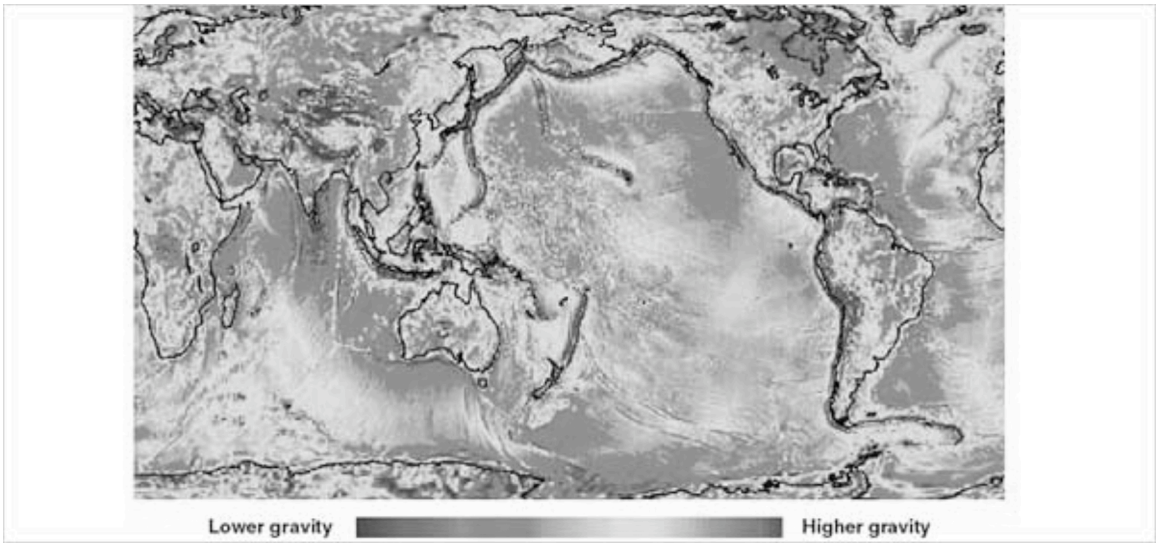
Introduction

As early as the 1960s, Professor Sam Carey, University of Tasmania, had a student investigate the correlation of distant earthquakes with great earthquakes on the then 'Pacific Ring of Fire'. Ambraseys (1970) documented progressive step-by-step faulting on the North Anatolian Fault starting in 1939, each earthquake seemingly triggering the next earthquake to the west. Despite many observations of such occurrences worldwide, there was not general agreement that remote triggering existed (Wikipedia) until the magnitude M 7.3 Landers earthquake struck California on 28 June 1992 (http://www.data.scec.org/chrono_index/landersq.html). Nearby faults experienced triggered earthquakes (up to M 6.4), and minor surface rupture.

Hough and others (2003) report on observations of large earthquakes within North America triggering other earthquakes way beyond the source area out to perhaps 2000 km and within a few hours or days of the triggering event. They suggest that remotely triggered earthquakes occur preferentially in regions of recent and/or future seismic activity and that therefore, faults are at a critical stress state in only some areas.

Analogous observations of triggering in Australia have been observed over the last few decades and are reported here for the first time in response to the paper by Hough and others (2003). They do not always support the possibility suggested by Hough and others (2003) that the triggered events may be limited to areas of past or future seismic activity.

The 2004 Great Sumatran earthquake caused remarkable gravitational changes (tectonic movements) throughout the world detected for the first time by satellites of the Gravity Recovery and Climate Experiment, or Grace.



Gravity fluctuations (less than one-thousandth percent of the Earth's total gravity) detected by Grace and published by Kenneth Chang in Science.

The Australian experience

Observations have been made over the last four decades of remote triggering of earthquakes in Australia by some large intraplate earthquakes and great earthquakes on the Australian Plate boundary though never published. Here are two:

- The 1988 Tennant Creek earthquake sequence consisted of three large earthquakes in a 12 hour period on 22 January 1988. Their magnitudes were Mw 6.3, 6.4 and 6.7, equivalent in energy release to one Mw 6.8 event and together they produced a 35 km long surface fault (Jones and others, 1991). Hardly 5 days had passed when three earthquakes between magnitude ML 4.6 and 5.0 occurred near Marble Bar WA about 1300 km to the west of Tennant Creek. Another week later a magnitude ML 5.7 earthquake occurred in WA at Doubtful Bay about 1000 km NW of Tennant Creek. On 10 March an ML 4.3 earthquake occurred near Katherine NT about 600 km to the north, all the while a prolific sequence of aftershocks was shaking Tennant Creek.
- On 23 May 1989 a great magnitude Mw 8.2 earthquake fractured the Macquarie Ridge along the Pacific/Australian plate boundary. This earthquake was felt 2000 km away at Hobart, Tasmania in southeast Australia. Reports of the shaking were still being phoned in from Tasmania as the pen on an analogue short-period seismograph in Canberra traced out the coda of 20s period surface waves, when seismologists had an unexpected call from southern Queensland that an earthquake (presumed to be the earthquake) had been felt in the pub in Hungerford, 3000 km from Macquarie Island. It turned out that a magnitude ML 4.0 earthquake had occurred near the town whilst the surface waves were still passing through. Within five days a magnitude Ms 5.7 earthquake struck Katajuta in the Northern Territory and aftershocks at Tennant Creek NT intensified starting with a magnitude ML 5 earthquake on 11 June. On 26 June a magnitude 4.4 earthquake occurred in the Flinders Ranges SA.

On their own these events would not have rated a mention but taken together and shortly after a significant earthquake, one intraplate (b in table 1) , the other interplate (a in table 1) it seems clear that they were triggered in some way by the earlier event. An example of a great earthquake that did not trigger intraplate earthquakes (c in table 1) is also tabulated below.

Table 1 Triggering and triggered earthquakes in Australia

Date	Origin Time	Lat º	Longº	M	Distance	P%	Place
Tennant Ck earthquake (a)							
1988 01 22	0036	-19.81	133.98	6.3			Tennant Creek NT
1988 01 22	0357	-19.83	133.98	6.4			Tennant Creek NT
1988 01 22 T	1205	-19.84	133.99	6.7			Tennant Creek NT
1988 01 28	0146	-21.05	119.60	4.8	1510		Marble Bar WA
1988 01 28	0149	-21.05	119.60	4.6	1510		Marble Bar WA
1988 01 28	0156	-21.05	119.60	5.0	1510	2	Marble Bar WA
1988 02 06	0523	-16.18	124.51	5.7	1085	<1	Doubtful Bay WA
1988 03 10	1415	-14.64	130.71	4.3	675	12	Katherine NT
Macquarie Is earthquake (b)							
1989 05 23T	1054	-52.34	160.57	8.3			Macquarie Island
1989 05 23	1208	-28.84	143.98	4.0	2950	7	Hungerford Qld
1989 05 28	0255	-25.25	130.65	5.7	3920	<1	Katajuta NT
1989 06 11	1452	-19.86	133.94	5.0	4280	10	Tennant Creek NT
1989 06 26	1118	-31.48	138.58	4.4	2925	>70	Flinders Ranges SA
Balleny Islands earthquake (c)							
1998 03 25	0312	-62.88	149.71	8.0			Balleny Is

T is the triggering event. M is magnitude, either Mw or ML. P is the probability (%) based on logNc/yr = 5.3 – M (McCue, 1993) that an event of this magnitude would (a) happen in the time period since the triggering event within this distance from Tennant Creek or (b) that it would occur anywhere in Australia in the time period after the Macquarie Island event. Case (c) no triggered events were observed.

Discussion

Analogous observations of triggering in Australia have been observed over the last few decades and are reported here for the first time in response to the paper by Hough and others (2003). Only one of the thirteen large plate-boundary earthquakes in the Australian region triggered earthquakes in intraplate Australia. No large earthquakes have since occurred in the triggered–event region, nor have smaller earthquakes been limited to those areas. Triggered earthquakes in Australia do not support the possibility suggested by Hough and others (2003) that the triggered events may be limited to areas of past or near future seismic activity and that therefore, faults are at a critical stress state in only some areas. The triggered events at Tennant Ck were as she would have predicted.

References

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Appendix: Great earthquakes in the Australian region since 1980

Source	Year	Mo/Day	Time	Lat	Long	Depth	Ms	M Msource
PDE	1980	07 17	194223.20	-12.525	165.916	33 N	7.9	8.0 UKBRK
PDE	1989	05 23	105446.32	-52.341	160.568	10 G	8.2	8.0 MSBRK
PDE	1995	04 07	220656.89	-15.199	-173.529	21 G	8.0	8.1 MSBRK
PDE	1996	02 17	055930.55	-0.891	136.952	33 N	8.1	8.2 MwHRV
PDE	1998	03 25	031225.07	-62.877	149.527	10 G	8.0	8.8 MeGS
PDE	1998	11 29	141031.96	-2.071	124.891	33 N	7.7	8.3 MeGS
PDE	2000	06 04	162826.17	-4.721	102.087	33 N	8.0	8.3 MeGS
PDE	2000	06 18	144413.31	-13.802	97.453	10 G	7.8	8.0 MeGS
PDE	2000	11 16	045456.74	-3.980	152.169	33 N	8.2	8.2 MSBRK
PDE	2000	11 17	210156.49	-5.496	151.781	33 N	8.0	8.2 MSBRK
PDE	2004	12 23	145904.41	-49.312	161.345	10 G	7.7	8.1 MwHRV
PDE	2004	12 26	005853.45	3.295	95.982	30 G	8.8	9.0 MwHRV
PDE	2005	03 28	160936.53	2.085	97.108	30 G	8.4	8.6 MwHRV