

Large earthquake in Victoria Australia - the first since 1840

USGS Solution

Date/Time: 2021 09 21 at 23:15:5 UTC or 2021 09 22 at 09:21 EST

Location: 37.49°S 146.36°E, 20 km NE of Woods point, Victoria Australia

depth: ~10.0 km

Magnitude Mw 5.9, ML 6.0

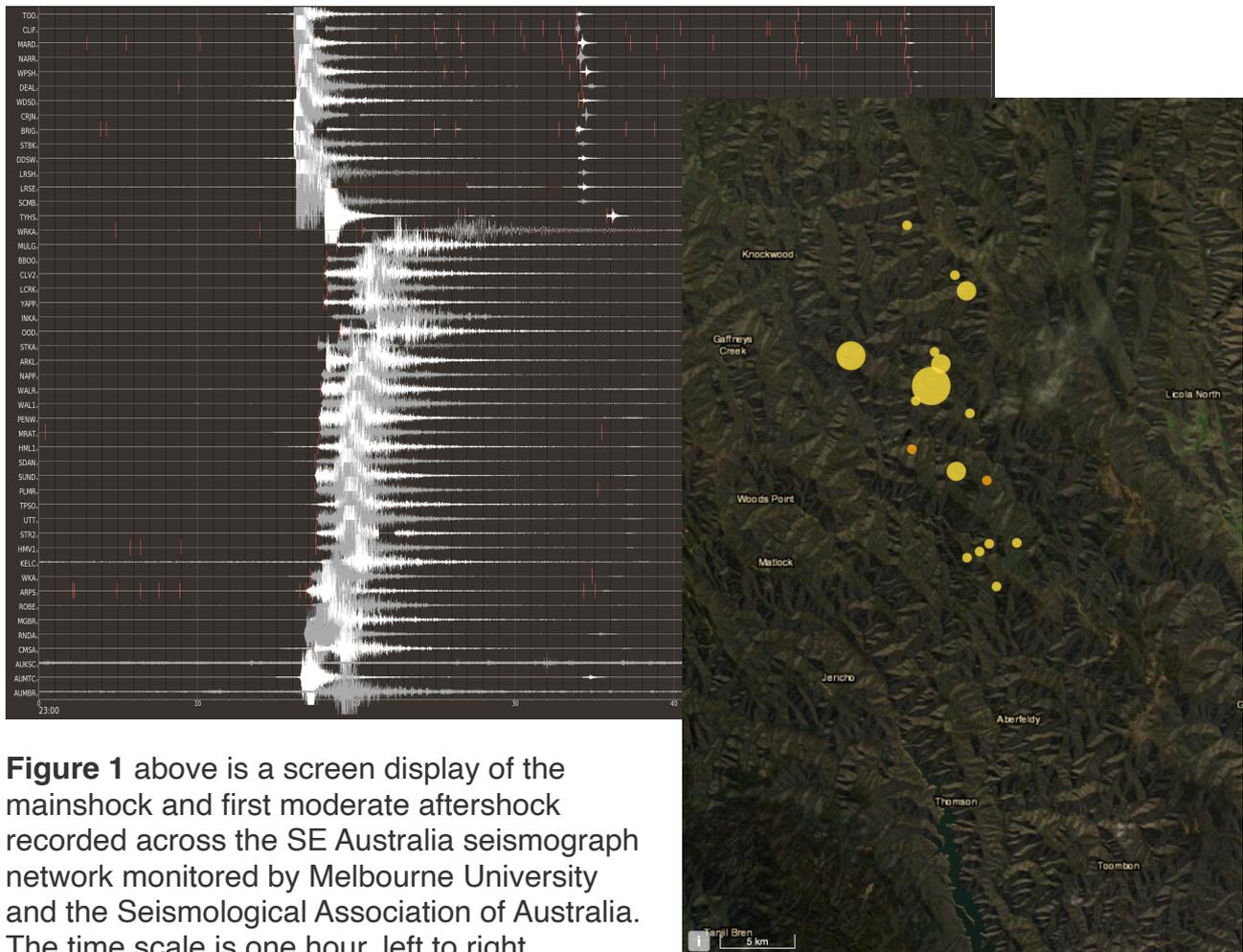


Figure 1 above is a screen display of the mainshock and first moderate aftershock recorded across the SE Australia seismograph network monitored by Melbourne University and the Seismological Association of Australia. The time scale is one hour, left to right.

Figure 2 The lower screen image shows aftershocks located in the first 3 days by Geoscience Australia, not far from Woods Point township and Thompson Dam at the bottom of the picture.

In the first 2 days there were more than 100 discernible aftershocks few of which have been located but the locations outline a 20 km long NNW/SSE fault parallelling the major geological lineaments in the region (see the Geological Map below from the Victorian Geological Survey).

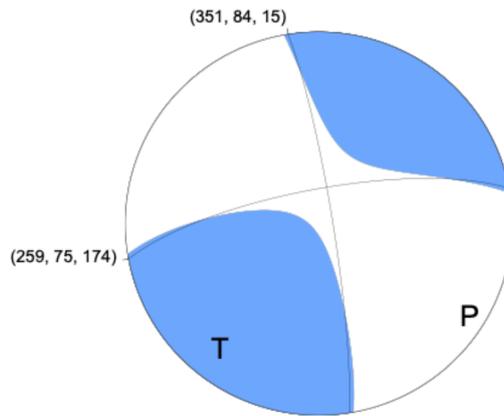
The moderately intense aftershock sequence indicates a shallow rupture, which may well have propagated to the surface. Exactly at what depth fault rupture initiated cannot be determined using just the national or state seismographic networks, the nearest station at 70km, too far from the fault to resolve a depth. The various moment tensor solutions used 12.0, 17.7 and 21.5 km and all are probably too deep. In south-east Australia, few aftershocks follow an earthquake at about 20km deep.

Catalog	Tensor	Magnitude	Depth	% DC	Source
✓ US		5.9 Mww	21.5 km	82 %	US ¹
US		5.8 Mwb	12.0 km	79 %	US ¹

Figure 3 & 4 Moment tensor solutions from the USGS

W-phase Moment Tensor (Mww)

Moment	8.675e+17 N-m
Magnitude	5.89 Mww
Depth	21.5 km
Percent DC	82%
Half Duration	1.91 s
Catalog	US
Data Source	US ¹
Contributor	US ¹



Nodal Planes

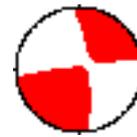
Plane	Strike	Dip	Rake
NP1	259°	75°	174°
NP2	351°	84°	15°

Principal Axes

Axis	Value	Plunge	Azimuth
T	9.061e+17 N-m	14°	216°
N	-0.832e+17 N-m	74°	12°
P	-8.230e+17 N-m	6°	124°

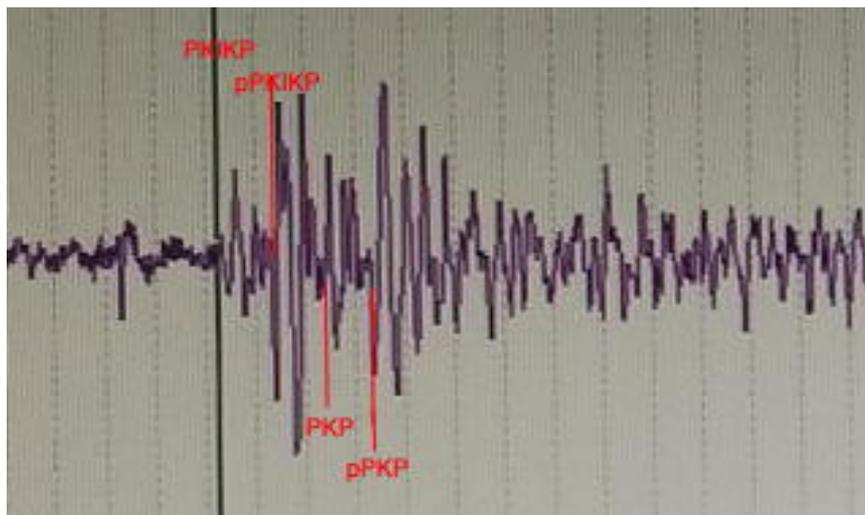
Figure 5 Quick CMT Solution (Columbia University)

Date: 2021/ 9/21 Centroid Time: 23:15:56.6 GMT
Lat= -37.47 Lon= 146.27
Depth= 17.7 Half duration= 2.2
Centroid time minus hypocenter time: 3.3
Moment Tensor: Expo=24 0.280 2.110 -2.390 -2.150 0.662 -9.150
Mw = 5.9 mb = 0.0 Ms = 5.9 Scalar Moment = 9.69e+24
Fault plane: strike=354 dip=78 slip=6
Fault plane: strike=263 dip=85 slip=168



Mechanism The mechanism on all 3 moment tensor solutions agree, left-lateral strike slip on a North/South fault (or its orthogonal plane) but the meridional plane is the same direction as the aftershock trend and the pre-existing geological fault strike direction.

Figure 6 Analogue seismogram Depth phases PKIKP, pPKIKP and pKP and pPKP recorded at a distance of ~150 degrees at station Valandovo (VAY) in North Macedonia indicate the rupture commenced at a depth of 3.6 ± 0.6 km. The order of PKP and PKIKP may be reversed when its exact distance is computed but the depth doesn't change. In the part of the seismogram reproduced, the vertical dotted lines are 1s apart and an average crustal velocity of 6.5km/s was adopted.



Geology The Geological map and superposed epicentres of the mainshock and nine aftershocks (from the Geological Survey of Victoria) suggests that the Fiddlers Green Fault is a candidate source for the earthquake. Under a principal stress direction of NE/SW compression, left-lateral strike-slip motion on this fault would be expected.

Damage Surprisingly very little damage was reported. An URM parapet wall of a 2-storey building in Melbourne 100km from the epicentre collapsed into the street. There seem to have been no horizontal restraints or ties. It's a wonder it didn't collapse in a storm. There was no damage in Woods Point, 15km from the epicentre with a population of 37, a former mining town which was rebuilt in 1939 after a destructive bushfire. There were no landslides, nothing much to report.

Brief History This is the largest earthquake recorded in Victoria (and NSW) since European settlement. The previous largest earthquakes in the modern instrumental [period was the November 1982 Wonnangatta Victoria earthquake, ML5.6. The most damaging earthquake in Victoria was the July 1903 Warrnambool earthquake, ML 5.3. In the pre-instrumental period the largest earthquake in this region occurred on 30 August 1869 at 4:50am EST, the centre of the felt area near Mt Hotham.

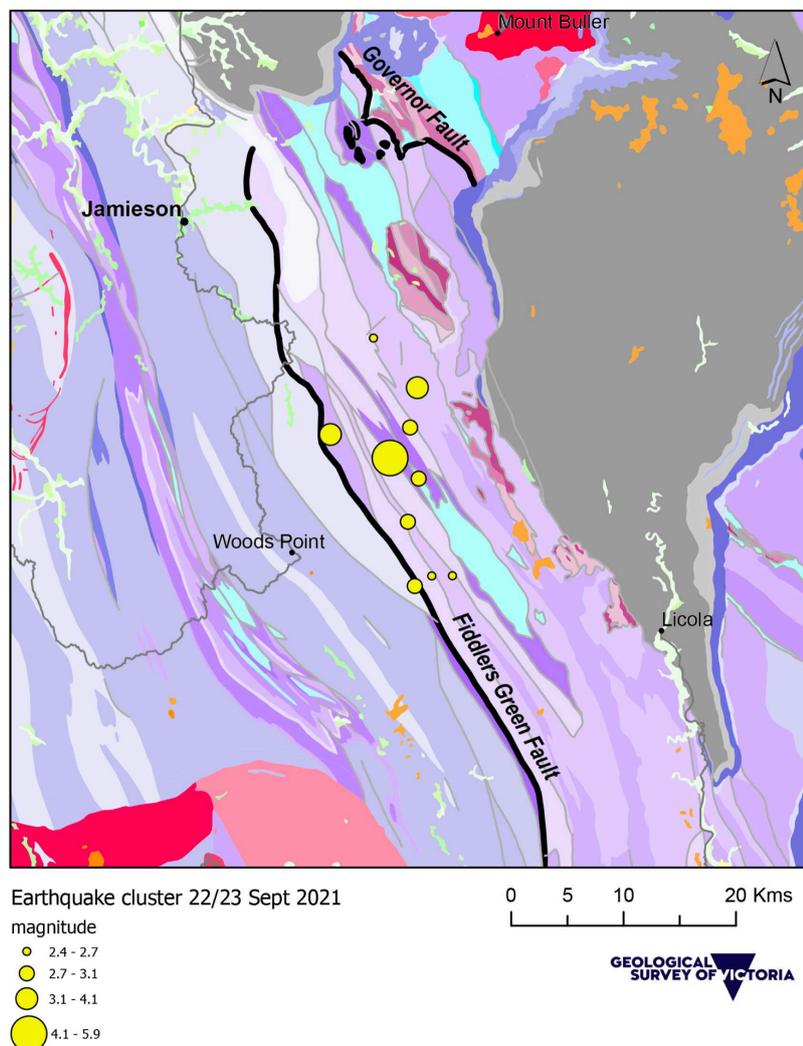


Figure 7 Geology in the epicentral region of the September 2021 earthquake, Victoria

Acknowledgment Gary Gibson and David Love are thanked for so diligently managing the seismograph network and server.

Kevin McCue and Cvetan Sinadinovski
SAA members