briefing note 398 July 2019

The 14 July 2019 Mw 6.6 Offshore Broome and Mw 7.3 Halmahera Earthquakes

By Paul Somerville

A magnitude Mw 6.6 earthquake occurred about 200 km west of Broome on 14 July 2019 (Figure 1). It is the second largest earthquake to have occurred in or near Western Australia in historical time. This earthquake was followed about 3.5 hours later by a magnitude Mw 7.3 earthquake in Halmahera, Indonesia (Figure 2). Both earthquakes occurred at shallow depths of about 10 km, and both had strike-slip focal mechanisms, which involve the horizontal movement of one side of the fault past the other side. This is presumably why no tsunami warning was issued (and none was observed) for either event, because tsunami generation requires uplift or subsidence of the sea floor, or some other form of volume change that could be caused by submarine landsliding or volcanic eruption. As described below, the focal mechanisms indicate that the earthquakes were caused by similarly oriented stress fields, but the large distance separating them suggests that their close time of occurrence was coincidental.

The Offshore Broome earthquake occurred at about 1:30 pm local time and was felt widely in Western Australia, from Esperance to Darwin. The duration of the shaking was consistently reported to be between 45 seconds and one minute. There are no known reports of structural damage, but there was some non-structural damage to ceilings, and objects fell from supermarket shelves in Broome and other towns. Based on these reports, it is likely that the peak ground accelerations were in the range of 2-10%g. Several people reported that the initial shaking was accompanied by a roaring noise. This may have been caused by the acoustic coupling of the compressional (P) waves, which are sound waves in rock, into the air. Although no tsunami warning was issued, the Shire of Broome announced just after 4pm that it would be closing Cable Beach, Town Beach, Entrance Point and Reddell Beach for the time being as a temporary precaution against any potential tidal surge.

The Halmahera earthquake occurred at about 4pm local time, and Indonesia's earthquake monitoring agency, the BMKG, estimated that 4000 people were exposed to "very strong" effects from the earthquake. It is reported that people were seen fleeing a building on the neighbouring island of Ternate, about 168 kilometres north-west of the epicentre. Ternate is the largest city in the province of North Maluku, and home to about 200,000 people. One person is reported to have been killed in southern Halmahera.

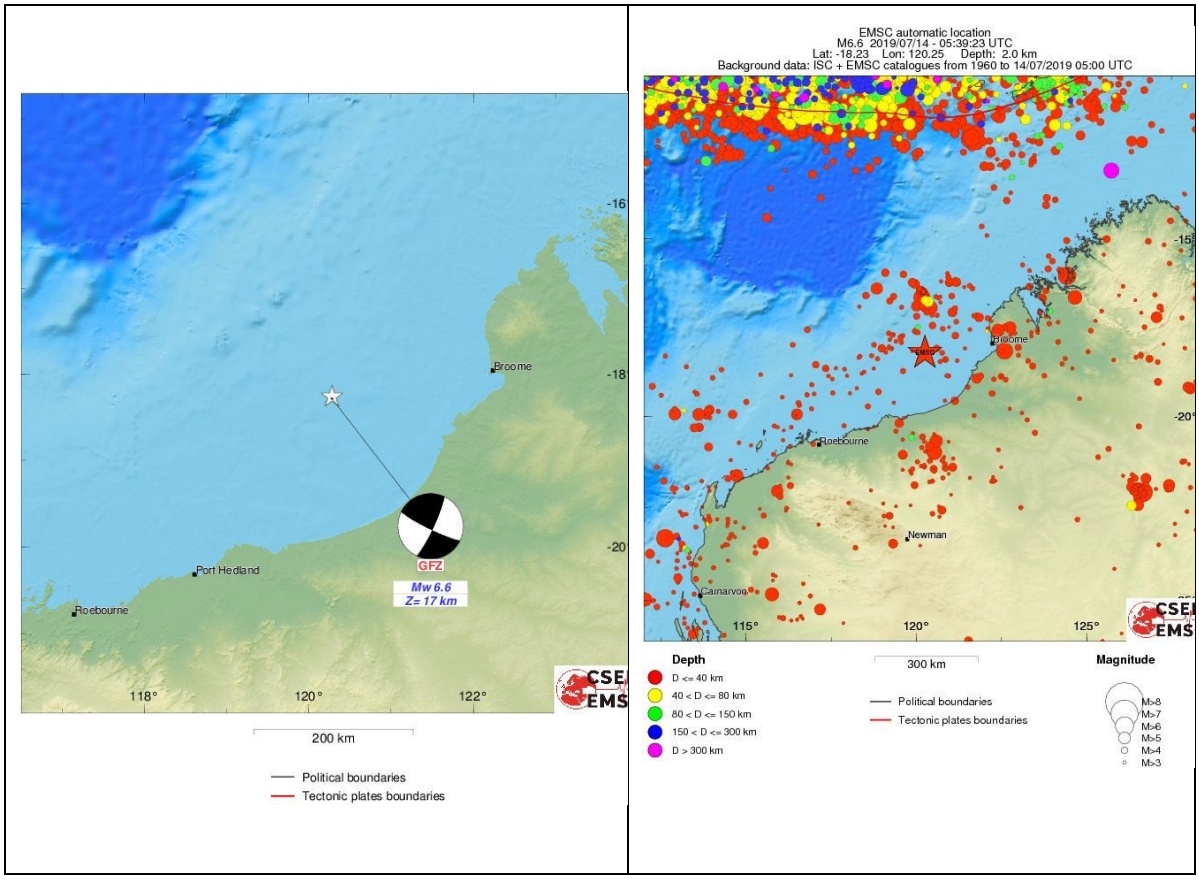

Figure 1. Left: The small white star shows the location of the Offshore Broome earthquake, and the beach ball shows a map view of the two possible fault planes, one oriented northeast and the other oriented northwest. Right: Historical earthquakes in northwestern Western Australia, showing the Offshore Broome earthquake as a red star. Source: European-Mediterranean Seismological Centre.

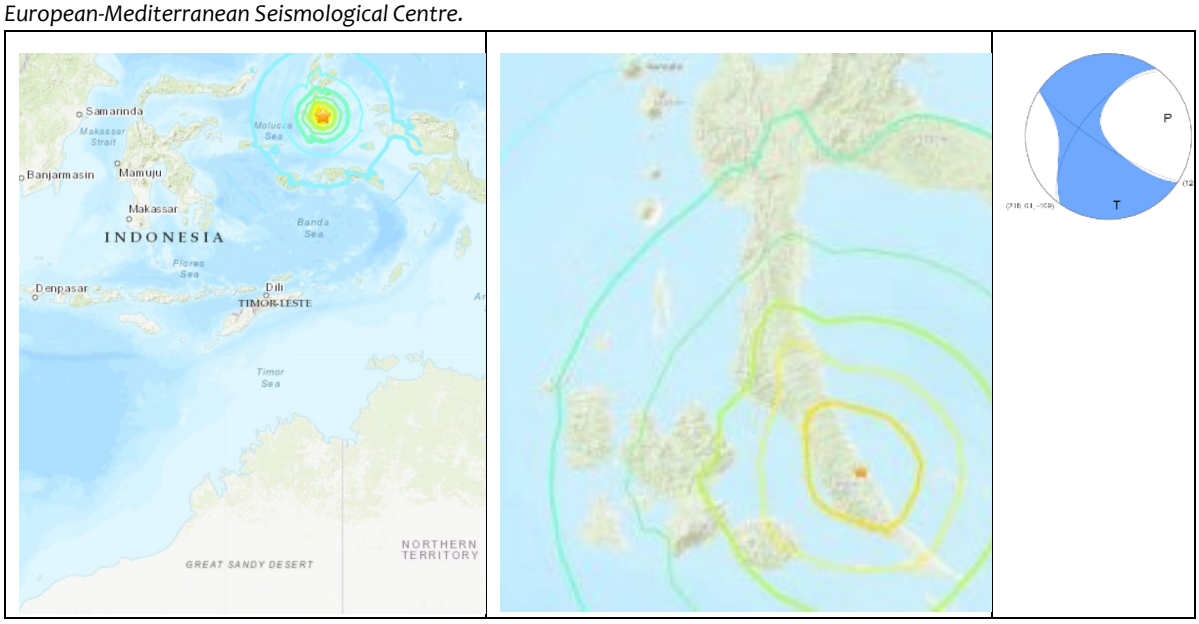

Figure 2. Left: Location map of the Halmahera earthquake. Centre: Detailed location map. Right: Focal mechanism showing possible northeast and northwest oriented fault planes. Source: USGS.

Causes of the earthquakes

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As shown in Figure 3, the Indo-Australian Plate is subducting (diving down beneath) the Sunda Plate along the Java Trench (western part of the map), because oceanic crust is thin and dense and easily subducts. However, the Indo-Australian Plate is colliding with the Sunda Plate in the Timor region (eastern part of the map), because in this region the Indo-Australian plate consists of thick, buoyant continental crust that cannot be subducted. Consequently, the part of the Indo-Pacific plate that is subducting beneath the Sumatra Plate is moving to the northeast at a higher rate than the part that is colliding with Timor. This causes strike-slip earthquakes, like the Offshore Broome earthquake, to occur along the Western Australia Shear Zone, as shown by the numerous offshore earthquakes with a northeast-southwest alignment on the right side of Figure 1. The focal mechanism of the earthquake, shown on the left side of Figure 1, indicates faulting on either a northeast or northwest oriented fault plane; the northeast plane is consistent with the northeast orientation of the Western Australia Shear Zone in Figure 3. In either case, the earthquake was caused by local crustal shortening in a north-south direction and extension in an east-west direction.

Unlike the Offshore Broome earthquake, which occurred within the Indo-Australian Plate, the Halmahera earthquake occurred within the Sunda Plate, and was caused by the collision of those two plates in Timor. As for the Offshore Broome earthquake, the focal mechanism of the Halmahera earthquake, shown on the right side of Figure 2, indicates faulting on either a northeast or northwest oriented fault plane. In either case, the earthquake was caused by local crustal shortening in a north-south direction and extension in an east-west direction, due to the plate collision shown in Figure 3.

As shown in Figure 3, the Western Australia Seismic Zone extends onshore in the vicinity of Dampier. The largest earthquake known to have occurred in historical time in Western Australia is the Mw 7.25 Offshore Geraldton earthquake of 11 November 1909. The location of that event is shown in the bottom left corner of Figure 3; the Ms of 7.8 is the surface wave magnitude. The Mw 5.58 1968 Meckering earthquake had a marginally lower magnitude that the Offshore Broome event, and practically destroyed the town of Meckering. The Offshore Broome earthquake is also larger than the 1941 Mw 5.52 Meeberrie earthquake.

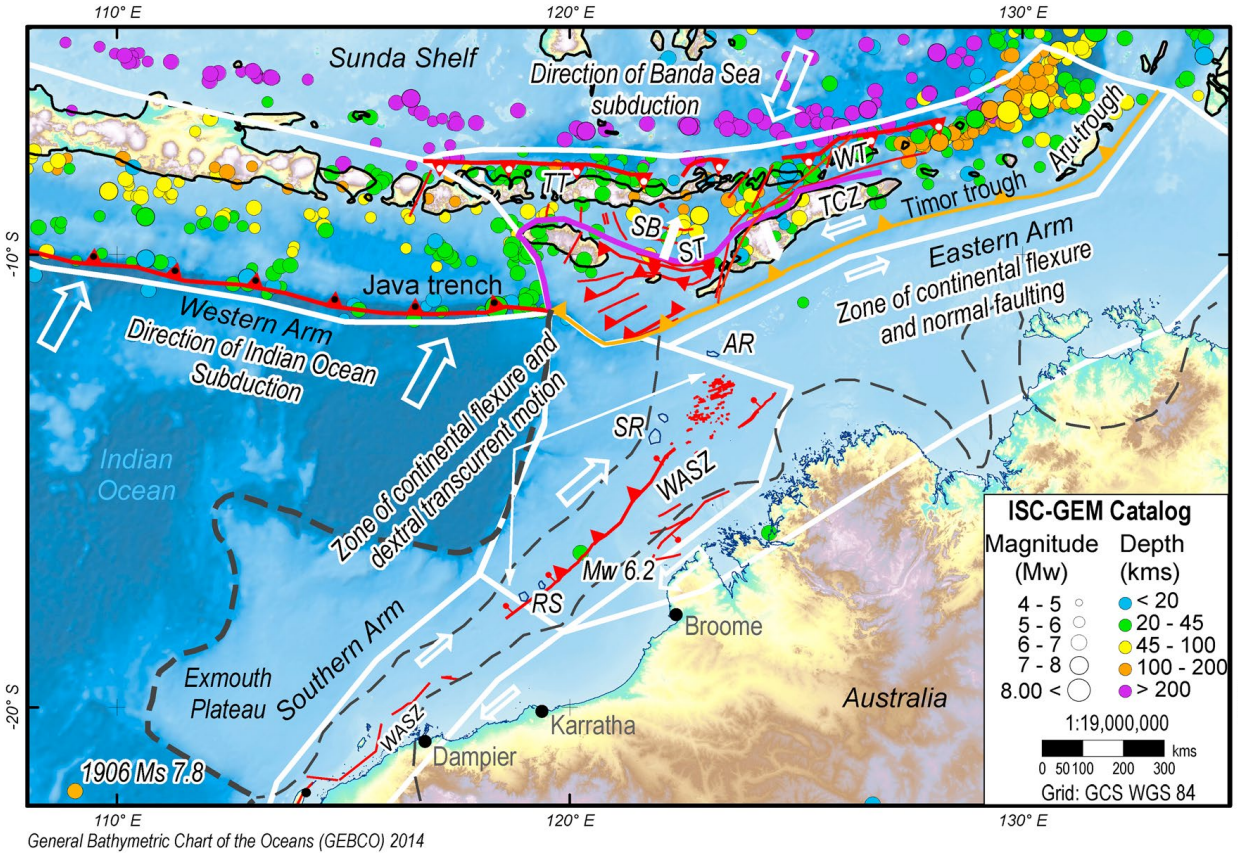

Figure 3. Tectonic map of northwestern Western Australia showing the locations of the Western Australia Shear Zone (the zone outlined by white lines; mapped faults shown by red lines). The Offshore Broome earthquake occurred near the eastern edge of the zone, southeast of the letters "RS" (Rowley Shoals). The purple line, which lies just north of Timor, shows the edge of Australian continental basement. The Indonesian islands are located on the Sunda Plate to the north, and Australia is located on the Indo-Australian plate to the south. Source: Hengesh & Whitney, 2016.

Reference

Hengesh, J. V., and B. B. Whitney (2016). Transcurrent reactivation of Australia's western passive margin: An example of intraplate deformation from the central Indo-Australian plate, Tectonics, 35, 1066–1089, doi:10.1002/2015TC004103.