AUSGEO news ISSUE 78 June 2005

Australian Government
Geoscience Australia

WA rocked IN THE OLD DAYS

South and central west Western Australia experienced major earthquakes in prehistoric times

Dan Clark

New technology used to identify earthquake hotspots so that safer regional building codes can be developed has found evidence that many earthquakes comparable to the 1968 M6.8 Meckering event—the second largest onshore quake recorded in Australia—affected southwest Western Australia in prehistoric times.

Finding fault scarps in a wide open land

Since European settlement, most areas of Australia have not experienced the largest possible earthquake because large quakes occur in cycles of 20 to 40 thousand years or more on a given 'active' Australian fault. Our 100–200 year historic record of seismicity is therefore poorly suited to inform assessments of seismic hazard.

Finding active faults and trenching them is the only viable way to obtain data on the locations and recurrence intervals of large, destructive earthquakes. However, fault scarps are subtly delineated and difficult to recognise in the landscape, and the vastness of the Australian continent has limited the effectiveness of traditional methods to identify these features.

High-resolution digital elevation models (DEM) have recently emerged as an important tool for finding fault scarps. DEMs are well suited to reconnaissance over large or remote areas, and are also useful for defining and mapping areas of probable elevated earthquake hazard.

Thirty-three new Quaternary fault scarps

Examination of a 10-metre resolution DEM supplied by the Western Australian Department of Land Information (http://www.landmonitor.wa.gov.au) and selected Shuttle Radar Tomography Mission 3 arc-second DEM tiles (http://www2.jpl.nasa.gov/srtm/) has identified 33 previously unrecognised fault scarps of probable Quaternary age in the southwest and central west of Western Australia.

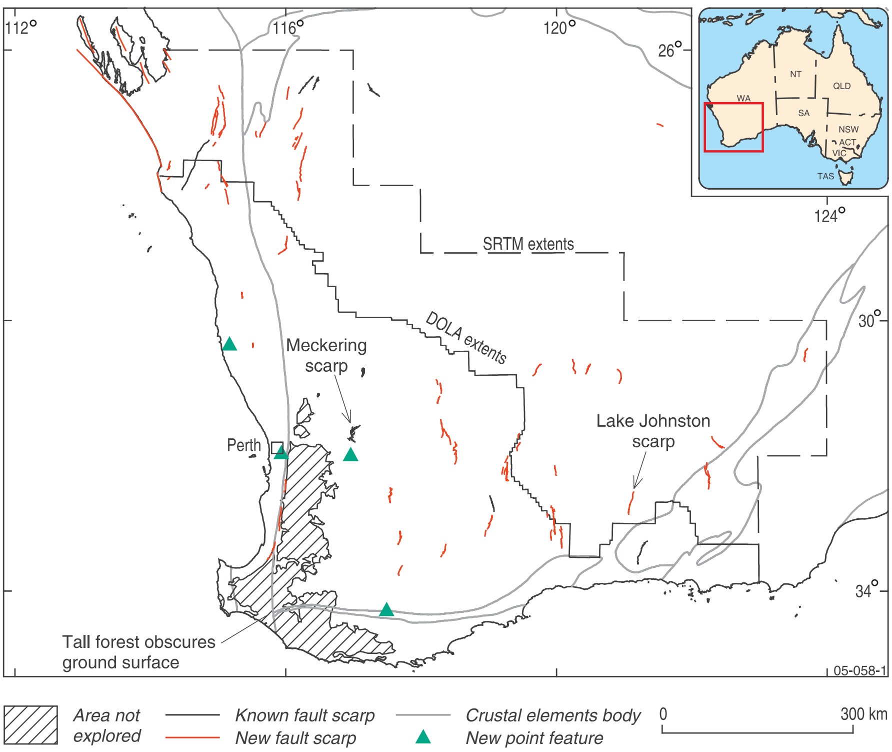


Figure 1. Map of Quaternary tectonic features within the study area (new features are in red).

This more than doubles, to 60, the number of Quaternary scarps known from this area (figure 1). The veracity of 17 of the scarps has been validated by ground truthing.

The new features are from about 15 kilometres to over 45 kilometres long, and from about 1.5 metres to 20 metres high. As the 1968 M6.8 Meckering scarp is 28 kilometres long and up to 2 metres high, some of the newly discovered features may have been associated with significantly larger earthquakes, or multiple earthquakes.

Evidence that at least the most recent events occurred during the Quaternary is typically provided by diversion of modern drainage, limited stream incision into a scarp, or disruption of Quaternary sediments.

Most of the scarps where a dip direction has been established by the DEMs show reverse displacement (compression) on the underlying fault (for example, figure 2). This, and the dominant northerly trend of the scarps, is consistent with our knowledge of the crustal stress field, which is thought to be oriented generally east–west and to be compressive.

The roughly uniform spatial distribution of the scarps (figure 1) is also consistent with uniformly distributed deformation across the Yilgarn Craton, which is an important constraint for crustal deformation models. Most of the newly discovered scarps are not associated with historic earthquakes (figure 3), suggesting that the focus for earthquake activity (i.e. crustal deformation) migrates over time and that large earthquakes are episodic within any given area.

Implications for intraplate seismic hazard

Information about the recurrence rates of large earthquakes associated with individual scarps is needed to improve the certainty of seismic hazard assessments for short return periods (e.g. the one-in-475 year event in the current hazard map, figure 4a). However, the fault scarps presented here identify 'earthquake-prone' regions (forming, in effect, an earthquake 'hotspot' map, as in figure 1) that could be used in further investigations.

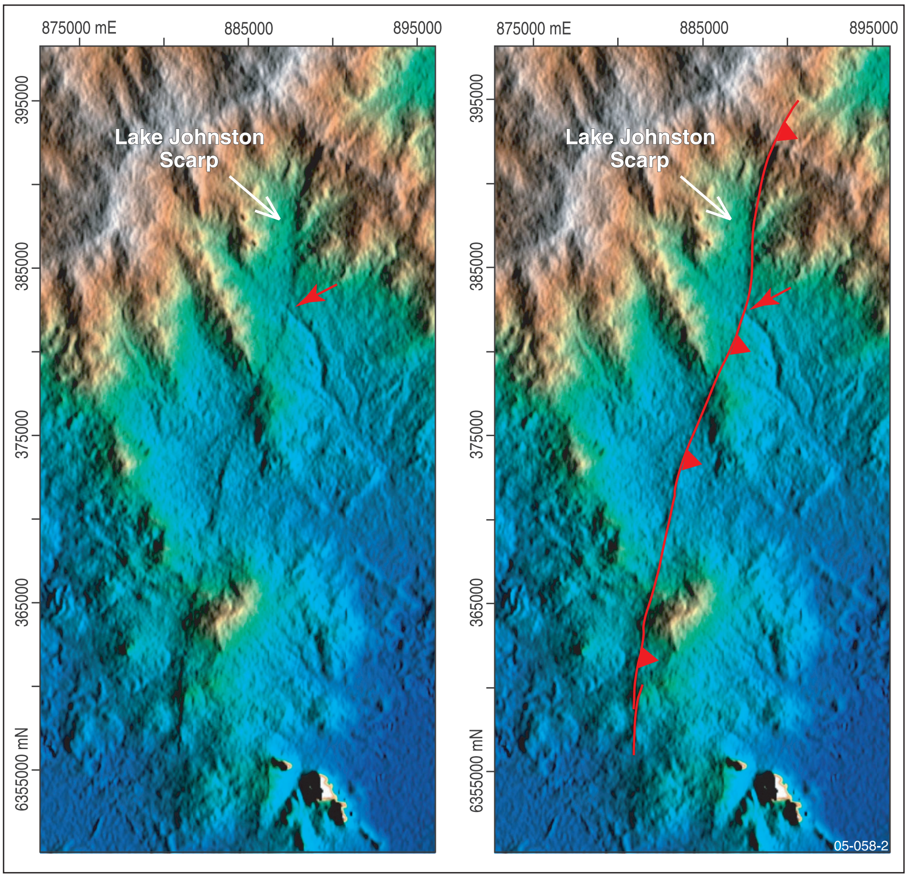


Figure 2. SRTM DEM over the 40 km long and up to 8 m high Lake Johnston scarp. Image on right shows interpretation of the fault. Red arrow marks a point where a stream has cut into the scarp. Illumination is from the east.

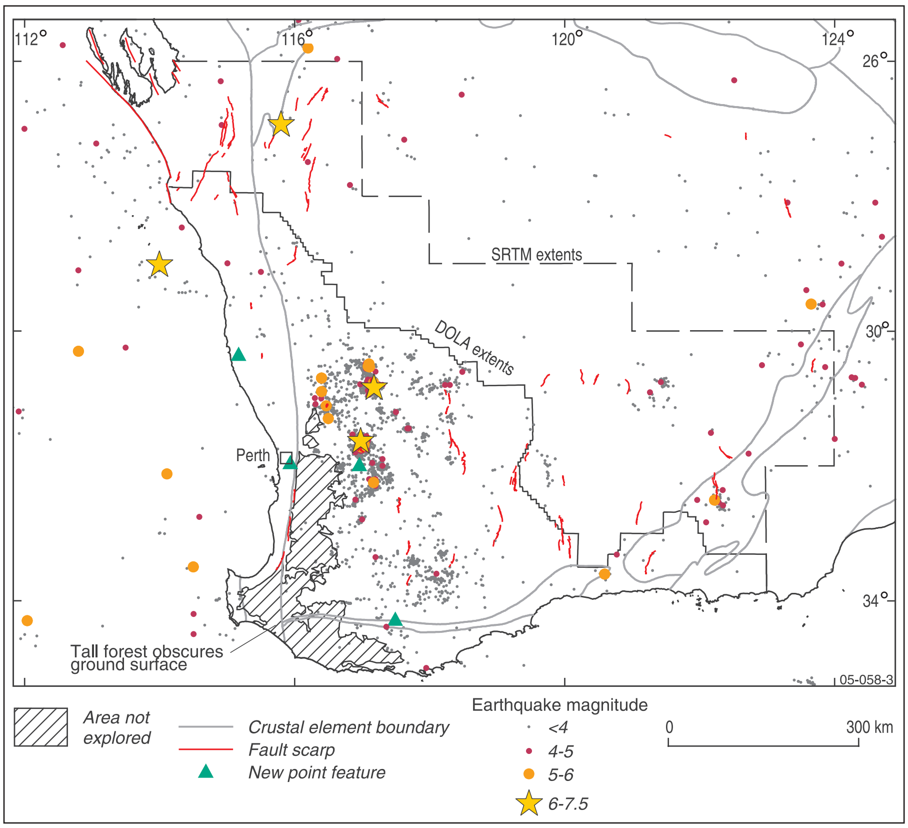


Figure 3. Comparison of Quaternary scarps and earthquake epicentres. Note that most scarps are not associated with earthquakes.

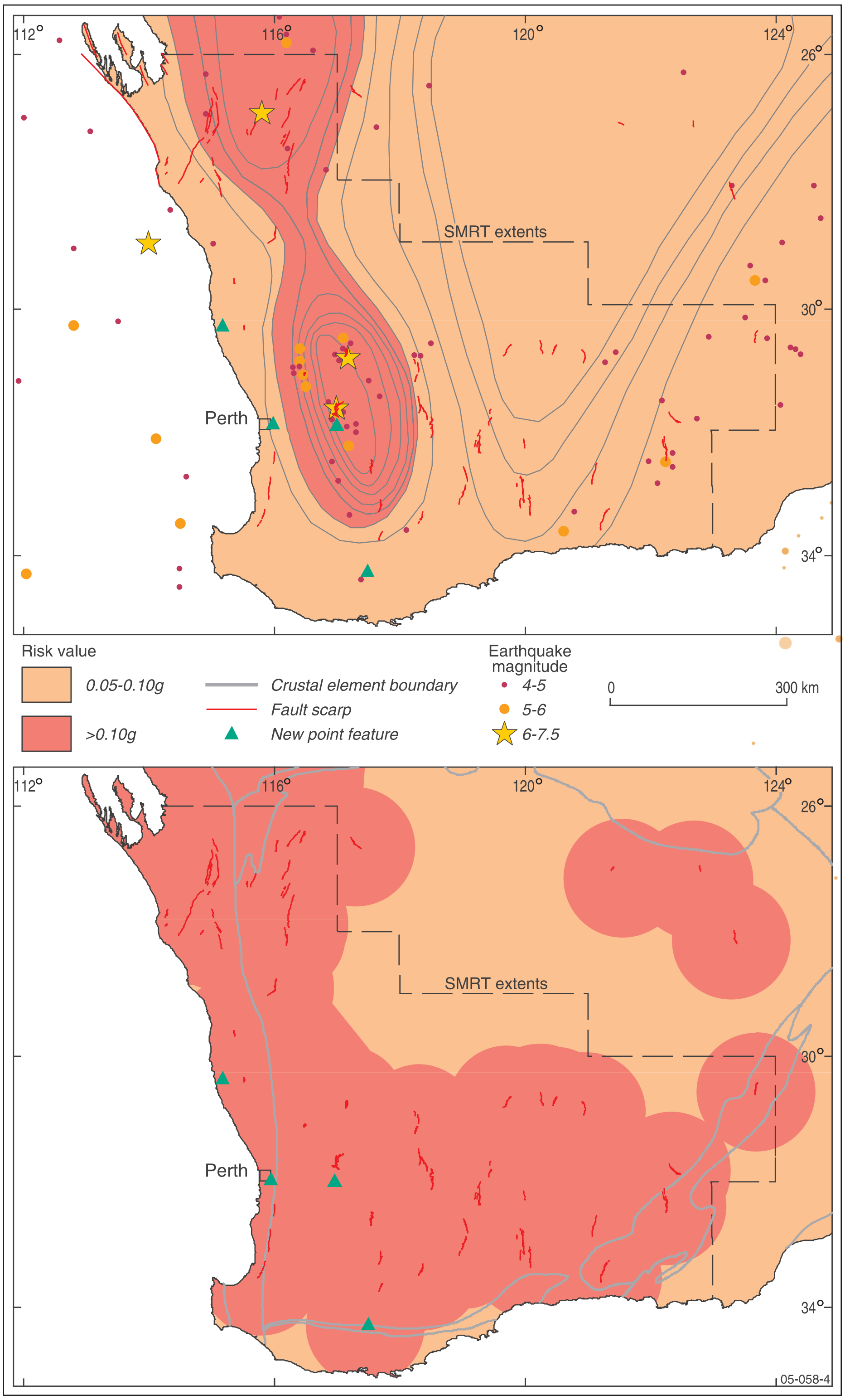
The hotspot map may be suitable for immediate application to hazard assessments for longer return periods, such as the tens of thousands of years scale required for dam siting and design.

A schematic hazard map (figure 4b) for a return period equivalent to the average recurrence interval for large earthquakes on a typical WA intraplate fault is based on the new DEM data. The map was created by constructing areas of potentially damaging ground-shaking around each scarp and basing their size on the Meckering event.

However, it must be stressed that because recurrence information exists for only a handful of scarps in Australia, and the return periods obtained vary from tens to hundreds of thousands of years, an exact return period cannot yet be set for figure 4b. Furthermore, it might be expected that ground-shaking would be significantly more intense than 0.1 g proximal to a scarp in the event of a large earthquake.

Acknowledgments
We thank the WA Department of Land Information and the contributors to the SRTM dataset (most notably NASA) for providing their data.

For more information, phone Dan Clark on +61 2 6249 9606 (email dan.clark@ga.gov.au).



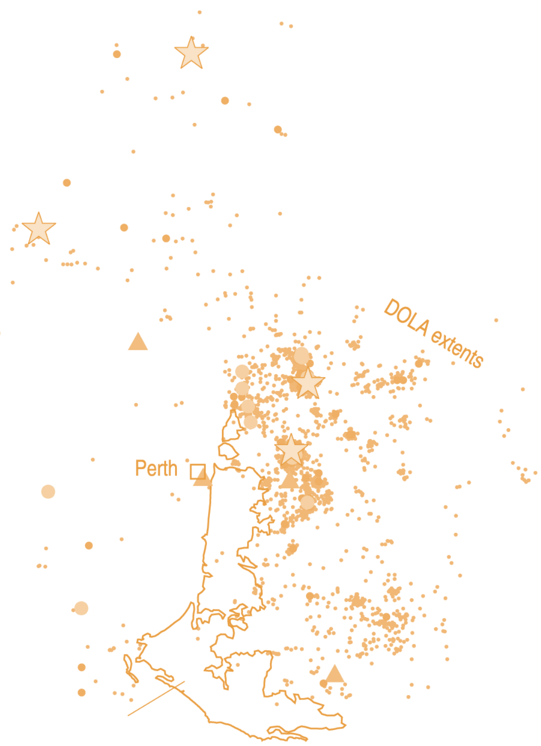


Figure 4. Earthquake hazard maps. a) Current hazard map with contours of ground acceleration as a proportion of g for a one-in-475 year event. b) Schematic hazard map for a return period equivalent to the average recurrence interval for a large earthquake on an Australian intraplate fault.