

EARTHQUAKE DOUBLETS AND MULTIPLETS IN THE FIJI-TONGA-KERMADEC REGION

Sławomir Jerzy GIBOWICZ¹ and Stanisław LASOCKI²

¹ Institute of Geophysics, Polish Academy of Sciences
ul. Księcia Janusza 64, 01-452 Warszawa, Poland
e-mail: gibowicz@igf.edu.pl

² Department of Geophysics
Faculty of Geology, Geophysics and Environmental Protection
AGH University of Science and Technology
Aleja Mickiewicza 30, 30-059 Kraków, Poland

A b s t r a c t

We investigated all the pairs of shallow, intermediate and deep earthquakes in the Harvard CMT catalogue that occurred between 1977 and July 2003 at a centroid distance of less than 40, 60 or 90 km and within a time interval of 200, 300 or 450 days for small, medium and large events, respectively. For the Fiji-Tonga-Kermadec area the Harvard catalogue lists 1022 shallow, 410 intermediate and 633 deep earthquakes of moment magnitude from 4.9 to 8.0. The magnitude threshold, above which the catalogue is complete, is 5.3-5.4, and the number of earthquakes of magnitude above this value is 691 for shallow, 329 for intermediate and 476 for deep events, respectively. The proportion of earthquakes, however, associated with doublets and multiplets against the total number of earthquakes is approximately the same in both data sets and therefore all earthquake pairs were considered regardless of their magnitude. We found 208 pairs of shallow, 31 of intermediate and 92 of deep events with moment magnitude from 5.0 to 7.2.

To check whether these earthquakes in pairs are really coupled and not connected by chance, the possibility of their occurrence in an uncorrelated Poissonian catalogue was considered. It was assumed that in such a catalogue the inter-event time is exponentially distributed, the earthquake magnitude follows the Gutenberg–Richter relation, and the distribution of centroid distances between the events in pairs is controlled by its non-parametric kernel estimate. The probability of appearance of the observed proportion of doublets of shallow earthquakes in the Poissonian catalogue was found to be very low, 5.64×10^{-6} , confirming the non-random character of observed pairs. The low probability of occurrence in a semi-random

catalogue, created by randomising centroid locations in the actual dataset, indicates also high importance of the distance criterion used for a doublet specification. The time interval criterion is significantly less important, although the double events that occur shortly one after another are the least probable events to be uncorrelated.

In general, shallow earthquakes tend to form the pairs at smaller distances and within shorter time intervals than deep earthquakes. Both the distance and the time intervals do not depend on magnitude of involved events. The largest number of pairs of deep earthquakes is observed at a depth of about 600 km, and only a few pairs are found at a depth of 350-400 km. The proportion of deep events associated with doublets and multiplets against the number of all events increases also with depth. From comparison of focal mechanism of earthquakes in pairs, measured by the 3D rotation angle, it follows that deep earthquakes forming pairs have more diverse focal mechanism than shallow events. The rotation angle for three quarters of shallow earthquake pairs and only for about one third of deep earthquake pairs is smaller than 30 degrees.

Key words: Fiji-Tonga-Kermadec seismic region, earthquake multiplets, random catalogue, clustering test, focal mechanism, 3D rotation angle, fault rupture overlap.