



Orientation damage in the Christchurch cemeteries generated during the Christchurch earthquakes of 2010

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The intensity scales determined the damage caused by an earthquake. However, a new methodology takes into account not only the damage but the type of damage "Earthquake Archaeological Effects" EAE's, and its orientation (e.g. displaced masonry blocks, impact marks, conjugated fractures, fallen and oriented columns, dipping broken corners, etc.). It focuses not only on the amount of damage but also in its orientation, giving information about the ground motion during the earthquake.

In 2010 an earthquake of magnitude 6.2 took place in Christchurch (New Zealand) (22-2-2010), 185 casualties, making it the second-deadliest natural disaster in New Zealand. Due to the magnitude of the catastrophe, the city centre (CBD) was closed and the most damaged buildings were closed and later demolished. For this reason it could not be possible to access to sampling or make observations in the most damaged areas. However, the cemeteries were not closed and a year later still remained intact since the financial means to recover were used to reconstruct infrastructures and housing the city. This peculiarity of the cemeteries made measures of the earthquake effects possible. Orientation damage was measured on the tombs, crosses and headstones of the cemeteries (mainly on falling objects such as fallen crosses, obelisks, displaced tombstones, etc.). 140 data were taken in the most important cemeteries (Barbadoes, Addington, Pebleton, Woodston, Broomley and Linwood cemeteries) covering much of the city area.

The procedure involved two main phases: a) inventory and identification of damages, and b) analysis of the damage orientations. The orientation was calculated for each element and plotted in a map and statistically in rose diagrams. The orientation dispersion is high in some cemeteries but damage orientation S-N and E-W is observed. However, due to the multiple seismogenic faults responsible for earthquakes and damages in Christchurch during the year after the 2010 earthquake, a more detailed correlation of the ground acceleration and the damages is being carried out.

The orientation of the damage is not usually recorded after an earthquake; however, it can provide information on the orientation of the peak ground acceleration. Thus, when an earthquake occurs, the analysis of the damage orientation can provide information about the seismic source.