Acceleration of low average earthquake rupture velocity (Vr) yields strong ground motions

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Many destructive earthquakes occur in slowly deforming regions away from plate boundaries. As these earthquakes occur less frequently than those located near to plate boundaries, relatively few observations have been made in the deadly 'near-field', or the nearest tens of kms from the epicenter. Earthquakes in areas of the crust which rarely experience earthquakes are thought to be strong, with fast ruptures, high amounts of released stress, and stronger than average ground shaking. Here we show that this model is at least sometimes, not correct. The Mw=6.2 Christchurch earthquake of February 22, 2011 occurred in a low-strain rate region approximately 140km from the plate boundary and produced at least 2.2g accelerations in the near-field. Previous work has suggested that aftershocks in the sequence have higher static stress drops than those measured elsewhere. Numerical experiments have shown that stress drop is proportional to rupture velocity (Vr). In this study, we use a back projection approach to show that the rupture velocity of the event was variable, starting slowly before reaching a maximum of ~0.9 * shear-wave velocity (Vs) near the end of the rupture process, when the rupture was within about 2km of the ground surface and Vs is substantially less than at the origin depth. This result has implications for estimates of source parameters, including the rapidly developing field of dynamic rupture modeling. The effect also provides a dynamic example of the rupture process of shallow buried thrust faults, in which overlying sediments halt the rupture within a few km of the surface.