Analysis of ground motions in Grenoble valley and simulation for the Laffrey2005 earthquake (M2.8)

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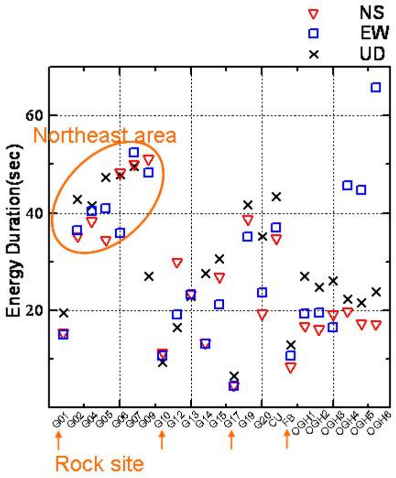
In 2005 Laffrey event of Mw=2.8 occurred in the south of the Grenoble valley, and yield a lot of observed weak motion records with very long duration. The observed long duration could not be reproduced by Emanuel (2006) in his simulation. In order to understand the cause of this extraordinary long duration we extract duration and energy information of observed ground motions based on the method of Husid (1969) for three earthquakes, namely, Laffrey, Vallroncine 2005 (Mw4.4), and Lancey 2003 (Mw2.9) and compare with those of simulated waveforms by Emanuel (2006). We then try to improve matching with records by tuning up the ground structure.

We found that long durations are observed at a line-shaped array in the northeast part of the valley despite of their relatively small energy during Laffrey earthquake (see attached figure). We also found that in Laffrey and Lancey long duration is controlled by components up to 3 Hz, while in Vallrocine it is up to 2 Hz. The same is true for energy so this is probably due to their source magnitude difference. When we check correlation between the duration and basin depth, we found that only the UD component observed during Vallrocine showed positive correlation. As for the comparison between observation and simulation for Laffrey both durations and amount of energy are smaller in the simulation than those in the observation. The difference is especially noticeable for sites called G02 to G07 in the northeast part of the valley as shown in the figure. The differences between observation and simulation exist even at several rock side stations, and so we need to tune up both the basin structure and the surrounding rock formation.

Then, parametric study was performed using Laffrey as the target for re-examination of the ground structure of the Grenoble basin. The analysis area was set to be a rectangular box of 37.5km (EW) by 30km (NS) with the depth of 10km, and theoretical calculation up to 2Hz was performed with the three-dimensional finite difference code, GMS, developed by Aoi and Fujiwara of National Research Institute for Earthquake Science and Disaster Prevention (1998). The same model as Emanuel (2006) with a 125m x 125m grid digitization was used for the basin model with additional grids of 7.5km in the northern and southern ends for boundary absorbing layers.

Since the initial model based on Emanuel (2006) was insufficient in amplitude at several rock sites, we calculate the responses of a model with the 100m thick weathered layer with the S-wave velocity Vs of 1.5 km/s. As a result, at the rock sites amplitude became large to some extent, and duration was also extended, although the improvement was not so remarkable. In addition, energy at the basin sites became smaller than the initial model. Then, the model with Vs inside the basin to be 0.8 times with the weathered layer in the surrounding medium was built, and comparison with an initial model was performed. As a result, we found that the durations are improved in both basin sites and rock sites but that in terms of energy significant improvement was not found.

Through these parametric studies it turned out that the duration and energy at observation sites in the northeast part of the basin are always much less than the observation. The layer thickness of the structure in a basin is assumed to be proportional to the basin depth in our calculation. The above-mentioned simulation result shows that it is necessary to assume one or more layers with smaller Vs on the surface in the northeast part of the basin. This is in agreement with the recently reported result of Tsuno et al. (2007) in which 25m of layers with Vs~200 m/s may exist based on the microtremor array observation in the CUMPUS area located in the northeast part of the Grenoble basin. Thus, it is necessary to re-examine the basin model focused on the northeast part of the Grenoble basin in order to reproduce observed records with higher precision.


NS
EW
UD
Northeast area
Energy Duration(sec)
60
40
20
G01
G02
G04
G05
G06
G07
G09
G10
G12
G13
G14
G15
G17
G19
G20
CU
FB
OGH1
OGH2
OGH3
OGH4
OGH5
OGH6
Rock site

Laffrey