Crustal velocity analysis using travel time inversion

Yoshinari Nakajima[1]; Eiichiro Nishiyama[2]; Eiichi Asakawa[3]; Ryuji Kubota[2]; Tomoyuki Tanaka[1]; Junzo Kasahara[4]; Azusa Nishizawa[5]; Kentaro Kaneda[6]

[1] JGI; [2] Kawasaki Geol. Eng.; [3] JGI, Inc.; [4] JCSS; [5] Hydrogr. & Oceanogr. Dep., JCG; [6] HODJ

There are two methods to analyze crustal velocity structure using travel time of OBS records. One is forward modeling, the other is tomographic inversion. Forward modeling is the best way to construct layer structures, but it is very time-consuming because it is an interactive process. The tomographic inversion, even though it requires travel time picking, is very fast and robust, because it is a mathematical batch process. We report here work by tomographic inversion.

The software used for tomographic inversion is tomo2d (Korenaga et al., 2000). Tomo2d has the capability not only of inversion of refraction travel times, but also joint inversion of refraction and reflection travel times. This software can analyze the depth of reflectors such as the Moho discontinuity. But, in this case, the identification of reflection phases is important and careful picking of reflection times is required. The method of travel time computation used by tomo2d is a hybrid of the graph method and ray-bending method. The graph method finds out the fastest ray path quickly without falling into a local minimum, and then the ray-bending method re-fines this ray-path with more accuracy.

Tomographic inversion is a non-linear process. It needs an initial velocity model, and computes travel times, then updates the velocity model to minimize the difference between computed time and picked time. The result may depend on the initial velocity model. We tested several initial models, with or without a sedimentary layer, with steep or moderate gradient of crustal velocity. It was found that the initial velocity gradient did not affect to final result. Setting a sedimentary layer in the initial model is preferable, if reliable information is available. Even if no sedimentary layer is set, the velocity of middle to lower part of crust can be analyzed without any distortion.

In this work, the grid size of the velocity model is 500m in the horizontal direction, and in the depth direction it is variable from under 100m shallow to several hundred meters in the deeper parts. The offset range of picked travel times is from several km to more than 100 km. First, the shallow part was analyzed using picked travel time data with offsets less than 20km, and then the analysis proceeded to deeper parts step by step using data with longer offset. A checkerboard test was also carried out to estimate the reliability of the inversion result.