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Balanced cross sections based on geometry of folds in the source area of the 2004 Mid-Niigata Prefecture earthquake

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The 2004 Mid-Niigata Prefecture earthquake (Mj=6.8) occurred on 23 Oct 2004 by rupture of a reverse fault. Its source area is located in the Shin'etsu fold-thrust belt in Neogene rift basins, where many active folds and faults have been growing during the period of the last a few million years. The earthquake occurred in one of the anticlinoria composed of middle Miocene to early Pleistocene sediments trending in the NNE-SSW direction, 80 km long and 15-20 km wide. The rupture area was about 30 km long and 15 km wide in the middle to southern part of the anticlinorium. The late Pliocene to early Pleistocene Uonuma Group is the youngest marine sediments in the anticlinorium and has been uplifted several hundred meters during the period of the last 1 million years. The vergence of the anticlinorium changes along its strike. The northern and southern parts have east vergent profiles accompanying estdipping reverse faults along the eastern margin of the anticlinorium. In contrast, the middle part of the anticlinorium shows a west vergernt profile bounded by eastdipping reverse faults along the western margin. The earthquake occurred in the northern half of the southern part of the anticlinorium that consists of tight folds in the middle and open folds in the eastern part of the anticlinorium. The Muikamachi fault bounding the eastern margin of the southern part of the anticlinorium is obscure near the source area. The thrust fault under the anticlinorium in the source area was inferred using balanced cross-section method. The present and depositional morphology of the base of the Uonuma Group were constructed from the geologic structure and paleoenvironmental data provided by geological maps and previous geologic studies of this area. Then the fault that can restore the depositional morphology of the Uonuma Group was deduced from the present morphology of the folded Uonuma Group. Layer-parallel slip was applied to the hanging wall as deformation style. The depth of the base of the fault was assumed to be 15 km, because the depths of the aftershocks of the 2004 earthquake were roughly shallower than 15 km. The inferred fault consists of deeper steep and upper gentle parts with a large bend. The tight folds in the middle of the source area can be attributed to the bend. In contrast, it is inferred that the thrust fault under the anticlinorium to the south of the source area has not bend because of the simple asymmetric anticlinorinal profile. The lateral change of fold geometry shows the change of fault geometry under the anticlinorium, which presumably defined the rupture area of the earthquake.

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