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Structural Styles of Crustal Shortening and Inversion Tectonics of the Eastern Margin of the Japan Sea

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The eastern margin of the Japan Sea is an active contraction zone between the Amurian and Okhotsuk Plates since late Pliocene. The zone was a rifted margin formed when Japan Sea opened mainly in early Miocene and now demonstrates unique structural style of incipient contractional deformation due to plate convergence. Detailed seismic profiling surveys of offshore areas as well as onshore geologic mapping in the eastern margin of the Japan Sea showed that three types of crustal deformation can be defined based on the difference of wavelength of folds which have been growing during the last two to three million years. The most widely developed shortening deformation is asymmetric anticlines 10 to 20 km wide. They are distributed in the zone up to 100 km wide and some of them were source area of earthquakes during the last one hundred years. The 2004 Mid-Niigata Prefecture earthquake occurred in one of the asymmetric anticlines about 15 to 20 km wide and the anticline can be interpreted as a fault-related fold of the source fault of the 2004 earthquake penetrating the upper crust down to its base. This fact indicates that the asymmetric anticlines 10 to 20 km wide are ramp anticlines above reverse faults cutting the upper crust and can be source areas of future earthquakes. The anticlines are generally underlain by Miocene rift sediments thicker than those in surrounding area, which indicates that the anticlines were caused by basin inversion due to reactivation of Miocene normal faults as reverse faults. The trend of the faults and anticlines changes from N-S to ENE-WSW, which reflects the variation of strike of normal faults bounding the rift basins. In sedimentary basins underlain by sediments thicker than 3 km, sediments have been deformed by folding of shorter wavelength less than several kilometers. The folds are interpreted as ramp anticlines above ramp and flat geometries of thrust systems in sedimentary basins. There are some gentle uplift zones more than 30 km wide. The Sado ridge is one of the uplift zones trending NNE-SSW parallel to the arc and many anticlines 10-20 km wide are concentrated on the uplift zone. The wide and gentle profile of the uplift zone suggests that the uplift reflects thickening of the lower crust. Similar uplift zones are observed onshore area, suggesting that shortening of lower crust occurs along several zones at different scale. These geologic structures along the eastern margin of the Japan Sea indicate that the shortening of the rifted margin has started in the wide zone and consists of different structural styles at different depths due to the change of physical properties.