

## Tectonic geomorphology, earthquakes and solid methane hydrate in the southernmost Toyama Trough, Japan Sea

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Sea bottom exposure of a sherbet hydrate was not unusual as famous as in the Hydrate Ridge along the Oregon coast of United States. During the NT06-19 cruise Leg2 of R/V Natsushima and Hyper-Dolphin at the sea area southwest offing the Sadogashima Island in the central Japan Sea, a fantastic outcrop of exact crystalline methane hydrate was discovered and observed as exhumation of the world's largest scale by the submersible investigation. It means that tectonic activity and related methane plume of this area is so active that formed a hydrate dome with a conduit topped by such an outcrop.

Accoding to the results of visual observation utilizing Hi-Vision TV camera and sub-bottom profiling by the ROV, all mounds were covered by an acoustically transparent layer composed of semi-consolidated massive mud chaotically intercalated by thin seams of carbonate crust and their fragments. The transparent layer becomes thick in depression and thins out toward hilly place. Crystalline hydrate seated 1.0-1.5 m below sea bottom and massive hydrate layer occurs 3.0-3.5 m below sea level. Consequently it is probable that the hilly topography surrounding the pit crater can be called as a hydrate dome similar to a salt dome.

The Kita-torigakubi (K) spar, the Joetsu (J) knoll and the Umitaka (U) spar characterizes tectonic geomorphology of the southernmost Toyama Trough as well as the submarine canyons. The U spar is formed as an asymmetrical anticline controlled by a N-S trending, Miocene normal fault, that was changed into a reverse fault by the early middle Pliocene. The north and south tips of the U spar are cut by the NE-SW trending anticlines, J knoll and K spar. The anticline topped by J knoll shows southeastward vergence, while the K spar is regarded as the young leading edge of northwestward vergent thrust seets.

The Joetsu-type of massive hydrate demonstrates that the upwelling of methane gas from the reservoir toward the seafloor is quite vigorous in the area and that such a pit crater was shaped quite recently. Moreover, because of its high buoyancy, methane hydrate might rise up through the upper limit of stability and emerge onto the sea surface, if, for example, a large earthquake were to occur. In 1987, a midium sized earthquake (M5.9) occurred right west of the J knoll, whose epicenters at the main and after shocks are deep enough, ranging from 20 to 30 km, to show the genetic relationship with the seismogenic belt along the eastern margin of Japan Sea.