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Assessment of heat flow in the Ulleung Basin, East Sea (Sea of Japan) and its relationship with the depth of gas hydrate stability zone

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The Ulleung Basin is one of three major basins in the East Sea (Sea of Japan), which occupies the southwestern part of the sea. it is believed to form through back-arc extension from the late Oligocene to middle Miocene. Marine heat flow studies have been conducted since 1960s, however, the scarcity of location and the reliability of data does not allow one to figure out heat flow distribution in the basin or to estimate the background heat flow from the asthenoshpere. According to previous studies, the heat flow in the basin varies from 51-157 mW/・. However, there is no obvious correlation between the heat flow values and major topographical features of the basin. This raises an important question as whether the data obtained over several decades instruments represent the true background heat flow when considering the basin formation history. In June 2007, gas hydrate consisted of 99.9% methane was recovered for the first time in the Ulleung Basin several meters below the seafloor (mbsf). In the following month, using a Ewing-type marine heat probe we conducted marine heat flow survey at 10 new sites (HF01-10; Fig. 1. Left) including sites where bottom simulating reflectors were clearly detected in high-resolution seismic profile. According to the new measurements, the geothermal gradient ranges from 103-137 mK/m and

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in-situ thermal conductivity 0.82-0.95 W/m · K. The corresponding heat flow (84-130 mW/·) appears to increase towards the center of the basin. Volcanic sills/flows emplaced within sediment do not seem to play a role as heat flow anomaly source. The validity of each heat flow measurement can then be tested by comparing the lower boundary of gas hydrate stability zone with the BSR depth. BSR depth was detected at 12 sites more among existing heat flow measurements based on densely-spaced high-resolution reflection seismic profiles obtained by Korea Institute of Geoscience and Mineral Resources. While there is little correlation between the two values in the existing heat flow data, in the new measurements, the estimated depth to the base of GHSZ (153-181 mbsf) is slightly shallower, but correlates fairly well with the BSR depth. We argue that the BSR depth may be a more reliable approach to estimate the background heat flow in the Ulleung Basin so far than the existing heat flow values. From the BSR depth, the background heat flow of the Ulleung Basin can be estimated as approximately 120 mW/m^2 at 2500 m and 80 mW/m^2 at 1000 m (Fig. 1. Right).

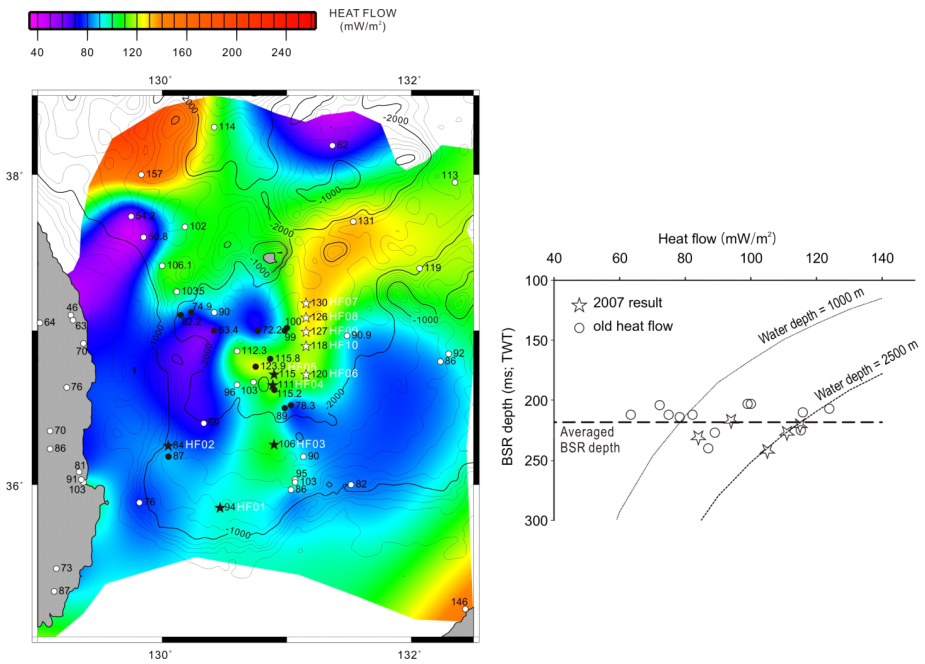

Fig. 1. (Left) Gridded map of heat flow in the Ulleung Basin produced after combining our new measurements of 2007 with existing data. The open circles and starts represent the location of heat flow measurement where seismic survey did not find BSR. The solid symbols denote heat flow locations where BSR was identified in the seismic sections. The star symbols represent the location of new measurements. There is still no obvious correlation with major topographic features. (Right) Plot of heat flow vs. BSR depth in the Ulleung Basin. The circles represent the existing data and the star symbols the new data. The BSR depth does not vary much in the Ulleung Basin (< 30 m), in contrast to the heat flow value. Using a BSR depth model, one can estimate the predicted heat flow for given BSR depth. Dashed and dotted curves represent the empirical relationship based on Ryu et al. (2004) between heat flow and BSR depth for depth of 2500 and 1000 m, respectively. The observed heat flow values do not vary according to the empirical relationship. The horizontal dashed line is an averaged value of BSR depth data in two-way travel time. From the intersection between the empirical relationship and averaged depth of BSR, one can predict heat flow based on BSR information.