High heat flow anomaly associated with fluid discharge on the bottom of Lake Biwa

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Fluid discharge on the bottom of Lake Biwa has been observed around the deepest part of the lake (Kumagai et al., 2021). Visual surveys with AUV and ROV revealed venting of muddy fluid and bubbles on the lake bottom. Acoustic images of plumes rising through lake water, probably gas bubbles, were detected by echo sounders. These observations indicate the existence of upward fluid flow through bottom sediments, which should transport heat advectively and may affect the surface heat flow distribution. Tentative measurement of heat flow on the lake bottom was made in 2010 and anomalous high heat flow (high temperature gradient) was detected at a station in the vicinity of fluid discharge sites.

We recently started a more systematic survey of heat flow distribution as part of a research project for comprehensive study of fluid discharge activity in Lake Biwa and its relation to the subsurface structure. We conducted closely-spaced measurements mainly in the vicinity of a site where prominent venting activity has been reported, around 35°20'N, 135°06'E, in November 2020, May 2021, and November 2021 with R/V Hakken (NPO Biwako Trust). Vertical temperature profiles in bottom sediment were measured by penetrating a 3-m long sensor probe.

A problem in heat flow measurement in Lake Biwa is influence of bottom water temperature (BWT) variation. Temporal variation of BWT is very large even in the deepest part of the lake and may exceed 1 K, which significantly disturbs temperature profiles in surface sediments. We evaluated influence of BWT variation using a long-term record of BWT at a station about 8 km north of our target area. We found extremely high heat flow, e.g., over 200 mW/m^2, can still be detected with the 3-m long probe, though it is difficult to determine the heat flow value without information on the past BWT variation around the measurement site.

Results of the three expeditions in 2020 and 2021 showed that heat flow is highly variable in the area with fluid discharge activities. Very high heat flow, probably higher than 200 mW/m^2, was measured at three sites, while heat flow is not high at other sites even within about 50 m of the high heat flow sites, though the measurements were made at different times. It indicates that upward fluid flows through sediments are local and sparsely distributed and/or highly variable with time. Long-term monitoring of temperature profile in surface sediment would enable us to estimate the fluid flow rate and its time variation.

Keywords: heat flow, Lake Biwa, fluid discharge, heat transport, bottom water temperature variation

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