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Geological Processes Affecting the Thermal Structures of Shallow Seafloor: An Example from offshore SW Taiwan

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Fluid migration pattern is important for understanding the structural features of a mountain belt and for hydrocarbon exploration. However, these patterns are difficult to measure on the seafloor. Using phase properties of the gas hydrates, we studied the fluid flow patterns offshore southwestern Taiwan. Seismic explorations in this region show wide spreading bottom-simulating-reflectors (BSR), which is interpreted as the bottom of the gas hydrate stability zone. It provides us an opportunity to study possible fluid flow patterns at several hundred meters sub-bottom depths of the marine sediments.

First, we used BSR-based geothermal gradient patterns to derive 1D vertical fluid flow models by analyzing the Péclet numbers. We found the regional fluid flow rates ranges from 6 cm/yr to 43 cm/yr, then we also discovered several prospect sites to examine the fluid migration pattern in the environs of active, passive and deformation front. Next, we forward 2D steady-state temperature fields of these sites to account for the topographic effects to compare with the BSR-based temperature. The discrepancy between the 2D conductive thermal model and the BSR-based temperature was interpreted as a result of fluid migration. And furthermore, we built 3D steady-state temperature fields, for comparing with BSR-based temperatures, to detail describe the regional temperature discrepancy with the structure evolution in 3D seismic data.

We discovered our interpreted fluid migration patterns are consistent with the regional structure. The BSR-based temperatures in Yung-An Ridge, which is in active margin, are higher than the conduction model near faults and chimney zones, we interpret that it is possible active dewatering inside the accretionary prism to allow fluid to migrate upward here. For the upper reach of Peng-Hu Canyon, which is across deformation front, we found the disequilibrium temperature field probably induced by the recently landslide. For the Formosa Ridge in passive margin, the BSR-based temperatures are colder than the theoretical model, especially on the flanks. We suggested that cold seawater is moving into the ridge from the flanks, cooling the ridge, and then some of the fluid is expelled at the ridge top. On the sum, the shallow temperature fields are strongly affected by 2D or 3D topographic effects, but we can still gain much information regarding fluid flow patterns through modeling. The new method we proposed will be helpful on assess the risk or value on energy exploration.