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Implications of mass transport deposit for gas hydrate-bearing seismic chimneys in the Ulleung Basin, East Sea, Korea

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The Ulleung Basin, located between Korea peninsula and Japan islands, is a well-known site for gas hydrate research. Geophysical studies using 2D/3D multi-channel seismic survey and well log data have identified several seismic signatures indicative of gas hydrate. Among those seismic indicators of gas hydrate, this study mainly focused on the seismic chimney structures associated with gas hydrate and their origin.

Seismic interpretations and well log analysis shows that there are a number of seismic chimneys in the Ulleung Basin, and they are classified into two different types. Type-I is a mound-like feature with transparent or chaotic internal reflection pattern, consisting of mobilized homogeneous mud and fracture-filling gas hydrates. In contrast, Type-II is pipe-like feature with vertically stacked distorted reflectors. This type has fracture-filling gas hydrate without any sediment remobilization.

From the 3D seismic interpretation, this study shows the relationship between the flow process of a large-scale mass transport deposit (MTD) and the occurrence of seismic chimneys. The seismic interpretation shows that the MTD moved from the south to north, and formed a lateral shear surface. Based on the flow process of the MTD, study area was laterally classified into two zones: (a) flow zone and (b) shear zone. The flow zone is subdivided into Zone-1A and Zone-1B. Zone-1A is characterized by tilted blocks at the lower part of the MTD. In contrast, Zone-1B consists of chaotic internal reflections without distinctive tilted blocks. Therefore, we interpreted that Zone-1A is more efficient to move the trapped fluid/gas under the MTD because the tilted block and related internal faults has higher permeability within the mass transport deposit.

In the aspect of spatial distribution, Type-I were only observed at the Zone-1A and showed similar geometries and distribution pattern to the tilted blocks in plan view. Therefore, we suggest that the fluid migration through the tilted blocks and the related internal faults was one of the important factors to make the fluidization and sediment remobilization of Type-I. On the other hand, Type-II seismic chimneys mostly appear along the zone boundaries or faults. Furthermore, the circular geometries of Type-II in plan view indicate that they result from rapid fluid migration through the fracture swarms. Thus, we suggest that the fault or zone-boundaries induced by either mass transport deposit or fault reactivation provided the primary migration pathway to the focused fluid flow, forming Type-II seismic chimneys.

