Flume experiments for Froude supercritical flow submarine fan: morphology and grain size distribution

*Kenya Ono[1], Hajime Naruse[2], Kazuki Kikuchi[2], Qifeng Yao[2], Zhirong Cai[2], Shunsuke Watanuki[1], Koji Ohata[2], Sojiro Fukuda[2,3], Kazushi Nakata[2], Miwa Yokokawa[4]

1. INPEX Corporation, 2. Kyoto University, 3. University of Hull, 4. Osaka Institute of Technology

The Froude supercritical flow bedform has been commonly recognized as the upstream migratiing bedwaves in modern submarine fans. Also, in successions exposed at outcrops, we are able to interpret those bedforms by the dominance of scour and fill structures. These observations demonstrate their wider distribution than the previous recognition, which implies that the Froude supercritical flows significantly affect the depositional process on the submarine fan setting. However, their influence on the architecture and the grain size distribution in a lobe-complex scale remain uncertain. Thus, to understand the internal and external characteristics of supercritical bedforms by density flows, we started the first series of experiments using a 2D flume to observe the channel lobe transition zone (CLTZ), and then examined the sedimentary structures and detailed grain size segregation caused by the hydraulic jump of CLTZ. As the second phase of the experimental series, we expanded the setting into a 3D flume to observe the bedforms over the single lobe and grain size distribution. In each experiment, a surge of the turbidity current was generated by opening the valve for five seconds over a four-meter long tank, repeated by more than a hundred flows. We used the ten-centimeter wide flume for a 2D experiment and open flume (three-meter wide) for the 3D experiment. Sediment used in these experiments has broad grain size distribution, ranging from silt fine to medium sands.

The result of the 2D experiment showed that the occurrence of hydraulic jumps significantly controlled the resultant geomorphology and grain size segregation of deposits. Hydraulic jumps occurred sequentially from CLTZ forming the cyclic steps in one-meter long-wavelength after thirty surge-flows. The mean of grain-size segregation was controlled by those hydraulic jumps. The fraction of fine-grained sediment was significantly decreased at around the locations of hydraulic jumps.

The 3D experiment reproduced the single lobe structure from CLTZ after fifty surge-flows. The lobe is composed of one to two-centimeter high, and a few to ten-centimeter long multiple lobate sediment waves, also with local scour surfaces. The grain size distribution of the lobate deposit exhibits a similar trend with the 2D experiment. After more than a hundred surge-flows, however, the lobe evolves into the aggradational and flat-surfaced lobe only with grain-size segregation inside the channel-lobe transition, implying that the sediment waves were transitional features over the evolution of the single lobe.

The morphological similarity between the experimental results and observations of sediment wave, as well as CLTZ deposits exposed in the outcrops and modern sea floor, suggests that the Froude supercritical flow plays a similar role also in natural environments. Both experimental and ancient deposits show amalgamated stratigraphy but with the dominant erosional features. Also, our study demonstrates the Froude supercritical flow fan initiated from CLTZ is dominated by transitional structures such as the sediment waves exhibiting the autogenetic evolution.

Keywords: Froude supercritical flow, Submarine fan, Hydraulic jump

