Formation process of submarine massive sandstones: Study based on grain fabric analysis using deep-learning image segmentation

*Sayo Ishii[1], Hajime Naruse[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

This study examined the dominant process of sediment transport and their variation depending on the sedimentary environments in submarine fans by analyzing grain fabric of massive sandstones. The massive deposits of sediment gravity flows are common in channel-filling or proximal lobe deposits in submarine fans, and recent studies suggested that their formation processes can be distinguished from characteristics of grain fabrics. This study sampled the massive sandstone beds from the submarine channel-fill, crevasse splay, and frontal splay deposits in the Upper Cretaceous Himenoura Group distributed in the Kamiamakusa City, Kumamoto Prefecture, southwest Japan. Images of the polished cross sections of the massive sandstones were taken by a flat bed scanner, and were analyzed by the machine-learning model using the convolutional neural network to investigate directional distributions of major axes of sand particles. As a result, three types of grain fabric were recognized in massive sandstone beds, which are characterised by upward-increasing trend of imbrication angle (Fabric Type 1), homogeneously low imbrication angle (Fabric Type 2), and imbrication angle oscillating vertically (Fabric Type 3). On the basis of comparison with results of existing flume experimental studies, Fabric Type 1 is interpreted as product of deposition from debris flows. Fabric Type 2 exhibits a typical feature of the grain fabric of low concentration turbidites. Fabric Type 3 can be interpreted as structures formed by multiple surges of debris flows or hybrid flows of debris flows and turbidity currents. The occurrence of these fabric types strongly depended on the depositional environments. Massive sandstones exhibiting Fabric Type 3 were dominated in submarine channel-fill deposits, while sandstones of Fabric Type 2 preferentially occurred in the crevasse splay deposits. Sandstones showing Fabric Type 1 was mainly observed in the frontal splay deposits which were formed in the regions downstream of the channels and crevasse splays. These results indicate that the debris flows and/or the gravity flows with two-layered structure of debris flow and turbidity current were dominated in the submarine channel environments although the spill-over flows from the submarine channel were mainly composed of turbidity currents. In contrast, it is considered that the debris flows were deposited as the massive sandstones in the frontal splay which located in the downstream end of the channel. Thus, it is implied that not only turbidity currents but also high-concentration gravity flows such as debris flows and two-layer hybrid flows should be fully taken into account in modeling the formation of submarine fans. In the future, it will be necessary to analyze submarine fan deposits in other regions and ages, accumulate data, and examine the effects of two-layer hybrid flows and/or debris flow on the formation of submarine fan by laboratory experiments and numerical simulations.

Keywords: Massive Sandstones, Submarine Fan, Grain Fabric

