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Inverse analysis of hydraulic conditions of turbidity currents

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A new method to estimate hydraulic conditions of turbidity currents from ancient turbidites is proposed here. This method of inverse analysis is based on downstream variation in thickness and granulometric characteristics of turbidites. It has been known that characteristics (grain size, internal sedimentary structure and bed thickness) in individual turbidites drastically change in vertical and downstream direction, and this spatial variation of turbidite characteristics can be regarded as an indicator of spatio-temporal change in hydraulic conditions of turbidity current such as velocity and sediment concentration. However, hydraulic conditions of turbidity currents have been rarely measured because these currents occur only in subaqueous environments so that it is quite difficult to observe directly.

In this study, firstly, the detailed variation of characteristics in individual turbidites is investigated in the Otadai Formation, the Pleistocene Kazusa Group distributed in the Boso Peninsula. As a result, grading and non-grading intervals in individual turbidites are clarified based on grain-size analysis. Non-grading intervals can be interpreted as deposits from quasi-steady turbidity currents.

Secondly, a numerical model of quasi-steady mixed grain size turbidity currents is established. We assumed that sediments in turbidity currents are composed of 5 classed sand and 1 classed silt mixtures. One-dimensional three-equation model and Exner equation were employed. Hiding effect in the basal active layer of sediments is considered in this model.

To confirm precision of model, inverse analysis of simulated turbidite is carried out. Boundary condition of simulated turbidite is U = 1 m/s, h = 360 m,T_{max} = 5000 s. The result of inverse analysis of simulated turbidite is U = 1 m/s, h = 340 m,T_{max} = 4500 s. As the result of inverse analysis of simulated turbidite, it was suggested that hydraulic condition of turbidity currents can be successfully reconstructed by inverse analysis method established in this study.

Finally, an inverse analysis of ancient turbidites in the Otadai Formation is carried out to estimate paleo-hydraulic condition of the turbidity current. The result of inverse analysis suggests that the turbidite in the Otadai Formation deposited from a quasi-steady turbidity current that was 0.9 m/s in flow velocity, 495 m in flow thickness, and 1995 s in flow duration time.

Although it is necessary to improve the forward modeling of turbidity currents containing mix-sized sediments and validation of the results of inverse analysis, numerical inverse analysis will become an important method for the turbidite sedimentology and reconstruction of paleoenvironment.

Keywords: turbidity current, turbidite, inverse analysis, paleo-hydraulic condition, grain-size distribution, the Otadai Formation