Transition of turbidity current suggested from massive sandstone layer with multiple inversely-graded units

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In the submarine-fan sequence of the Pleistocene Otadai and Umegase Formations of the Kazusa Group in the Boso Peninsula, there are many thickly bedded massive sandstones which are predominant in the proximal area deposited during lowstand. Sedimentation mechanism of the massive sandstones remained unsolved, although it has been explained by a high-density turbidity current model (Lowe, 1982). However, it may exist as a transient basal part of a more dilute flow (e.g. Kneller & Buckee, 2000). In fact, a highly concentrated suspension prior to the final settling is suggested by a series of evidence such as a grading pattern indicative of settling from a highly concentrated uniform suspension, floating mud clasts without any distinct imbrication, and syndepositional flow deformation and dewatering structures. Recently, a number of massive turbidite layers with multiple inversely-graded units (MIGU) have been found. Sedimentary structures, grain fabric, and their lateral change over various scale demonstrate the four divisions; (1) megaflute like scour-and-fill, (2) nearly horizontal MIGU, (3) massive part with erosional base, and (4) graded part with traction current structures, in ascending order.

(1) Megaflute like hollows are filled with two different sediments as fine gravels or sediments similar to those in MIGU capped by darker fine-grained films.

(2) Multiple inversely-graded units, each of which is less than several centimeters thick with thin basal layer of well-sorted very fine-grained sands rich in heavy minerals, are stratified nearly horizontal but shifted upstream on each very low-angle erosional plane. The grains show significant a(p)a(i) imbrications inclined 15 to 20 degrees at the base and more than 30 degrees in the upper part of each unit. These textural characteristics are common in those due to upstream migration of antidunes.

(3) Massive division, composed of fine- to medium-grained sand with 5 to 15 % mud, lacks any distinct internal structures other than diffuse bandings. Despite an ungraded grain-size, heavy mineral content increases downward as estimated from magnetic susceptibility data. Rapid deposition is suggested by dewatering structures and by cut-and-fill structures with partly oversteepened erosion surface into the MIGU, as well as high density suspension inferred from rip-up clasts and pumice fragments in the upper part of the division.

(4) Normally graded division, less than 20 cm thick, showing parallel and ripple laminations, is comparable to Bouma(1962)'s Ta to Td divisions. This division occasionally displays convolute laminations involving the upper part of the massive division.

For several traced beds over 10 kilometers, MIGU can be found in the area of at least 7.5 km, although it is more or less eroded almost everywhere by the massive division.

The gravity flow over a place of deposition of the turbidite with MIGU might thus be changed as follows;

(1) Fully turbulent flow, probably under the head of the gravity flow, erodes megaflute hollows and passes without deposition.

(2) Still powerful lower part of the flow with increasing concentration transports most of the grains, but small amount of grains began to deposit on the bed forming bedforms under antidune regime. The megaflute hollows trap these grains especially larger grains as a lag deposit. During the upstream migration of antidunes, fine sand and heavy minerals are concentrated when the trough of the antidune passes. Repeated upstream passing of the crests with aggradation by settling grains may result in the MIGU.

(3) Highly concentrated suspension flow erode and fill the MIGU, and deposits rapidly unsorted sediments which are mobile even after the deposition due to entrapped fluid and lubricant clay. Fine grains rich in heavy minerals in MIGU are eroded and mixed into the flow.

(4) Waned and less concentrated flow entraining the surface material of still fluidized sand mass will leave laminated deposits.