

Experimental study of "supercritical-flow plane bed" formed by density currents

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Plane bed is a smooth and flat bedform, which is formed in various environments. Parallel lamination which is a sedimentary structure formed by plane bed is a common feature of sedimentary rocks. It is frequently observed in lower to middle part of turbidites as Bouma's Tb division. It has been known that plane bed can be formed by subcritical unidirectional flows. However, this study implies that plane bed can also be formed by supercritical conditions. As a result of flume experiments of density flows, plane bed was produced by a supercritical density flow that shows very high Froude number (> 4). This discovery may suggest that previous estimations of paleo-hydraulic conditions of parallel lamination should be reconsidered.

Experimental density flows were produced by mixtures of salt water (1.01-1.04 in density) and plastic particles (1.5 in density, 80 microns in diameter). Salt water and plastic particles are analogue materials of mud water and sand particles respectively. Acrylic flume (4.0 m long, 2.0 cm wide and 0.5 m deep) was submerged in an experimental tank (6.0 long, 1.8 m wide and 1.2 m deep) that was filled by clear water. Inclination of the flume was fixed during experiments. A weir (10 cm long) was set at downstream end of the flume to keep basal sediments. Mixtures of salt water plastic particles were injected from a hose at upstream end of the flume. Ratio of saltwater and plastic particles and flow discharge were maintained constant during each experiment. Features of bedforms were observed when the flume reached equilibrium condition. The experimental conditions range 1.5-4.2 in densimetric Froude number and 0.2-0.8 in Shields dimensionless stress.

As a result of the flume experiments, plane bed was formed under the condition of supercritical flow regime that was not recognized in previous studies. Plane bed was stable against physical disturbances and well reproduced in experiments. Although number of experimental runs is insufficient to examine stability field of this bedform, a typical condition to form the supercritical flow plane bed was 4.2 in densimetric Froude number and 0.8 in Shields stress. This condition is distinctively different from formative conditions of plane bed of the upper flow regime.

The supercritical flow regime plane bed could be a new type of bedforms. Established theories of bedform stability predict that plane bed is unstable in supercritical flow regime, so that another factor that was not incorporated in previous theories should be considered to understand the origin of this supercritical flow plane bed. For example, the supercritical flow plane bed was formed under the condition where sheet flow (traction carpet) is dominant, whereas plane bed of upper flow or lower flow regimes is formed under the condition where bedload and suspended load are dominant process in sediment transport. Also, density currents instead of open channel flows were used in this study. We suggest that these could be factors to be considered in future studies.

Keywords: turbidity current, bedform, flume experiment, plane bed

Long-term migration and deposition of dumped sediment on the Kashima Coast

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It is important to understand offshore sedimentation processes for predicting long-term morphological changes in the nearshore zone. In this study, we investigated the whereabouts of sediments, which were dumped into the sea in large amounts in the past on the Kashima Coast, by dating radiocarbon ages of shells contained in the seabed to understand the offshore sedimentation processes. The older-than-normal shells specially contained in the dumped sediments were used as tracers, because the sediments were derived from excavating the ground. We estimated the amount and the history of depositions, caused by dumping sediments, in some depths of water. The result confirmed that the dumped sediments were deposited on offshore seabed, which had potential to migrate onshore, and would influence the morphological changes in the nearshore zone.

Keywords: dumped sediment, Kashima Port, the Kashima Coast, offshore, sedimentation rate, radiocarbon dating

Progradation rate of the Soc Tran coast, Mekong delta, related to the winter monsoon fluctuations

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A unique sediment transport system caused by monsoons characterizes the South China Sea coast of the Mekong delta, southern Vietnam. In summer, under the relatively weaker southwesterly monsoon, sediments supplied from the flooded river is deposited and stored on the coast. These sediments are then drifted northwestwards by the longshore current driven by the stronger northeasterly winter monsoon. Mud is further transported to the end of the South China Sea coast, forming the prominence of the Camau Peninsula. Thirteen optically-stimulated luminescence (OSL) ages of cheniers and radiocarbon ages of a sediment core were obtained for the reconstruction of the progradation of the Soc Tran coastal plain, southwestern part of the Mekong delta. From this, we found remarkable changes of the progradation rate, which are thought relevant to fluctuations in the winter monsoon strength. The OSL ages are younger than 2770 yr, and become younger seawards concordantly with the coastal progradation that cheniers document. The sediment core, drilled in the inter-ridge swale between two chenier ridges of 1370 +/- 70 yr and 600 +/- 30 yr, reaches the basement at -20 m relative to the mean sea level. The core shows a regressive delta succession, of which radiocarbon ages become younger upwards from 4790-4640 BP (4850-4700 yr) to 1530-1420 BP (1590-1510 yr). These radiocarbon ages support estimates of OSL ages obtained in cheniers landwards, which contemporaneous of the subaqueous delta deposits in the succession. The progradation rate of the Soc Tran coast have changed drastically; it was 8 m/yr, 31 m/yr, and 5 m/yr during periods of 2770-1370 yr, 1370-590 yr, and 590 yr to present, respectively. The rapid progradation during 1370-590 yr did not form cheniers, resulting in an extensive inter-ridge swale. Cheniers are generally formed in relations to erosion of muddy coast. The chenier distribution and drastic changes in progradation rate were resulted from fluctuations in relative importance of longshore sediment removal to seaward sediment accretion. The architecture and chronology of beach ridges in the Tra Vinh coastal plain, northeast of the Soc Tran, also suggest similar fluctuations in the longshore sediment transport. The dominance of the longshore sediment transport after 590 yr is thought caused by the strengthened winter monsoon, which is possibly related to the beginning of the Little Ice Age.

Uplift history of the Kunlun Mountains based on provenance of coarse fraction of fluvial sediment since 8Ma

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Tarim Basin is located to the north of Tibetan Plateau. At present, Tarim Basin is characterized with very dry climate and the Taklimakan desert is located in the central part of the basin. In previous studies, the desertification of Tarim basin is interpreted as having been triggered by the uplift of Tibetan Plateau (e.g. Zheng et al., 2000, DH Sun et al., 2011). However, the linkage between the two has not yet been proved. The major reason is the difficulty in constraining the timing of the tectonic activity relative to the onset of desertification.

In this study, we tried to extract the tectonic information from the fluvial sequence, which is well dated by magnetostratigraphy. To extract the tectonic information, we conducted the provenance study of quartz, which is common mineral and resistant to weathering, in the coarse fraction of the fluvial sediments.

For the provenance study of quartz, we used Electron Spin Resonance (ESR) signal intensity of quartz and crystallinity index (CI) of quartz. ESR signal intensity of quartz reflects the age of mother rock (Toyoda and Naruse, 2002), whereas CI of quartz reflects physical condition of its formation such as temperature and rate of crystallization (Murata and Norman, 1976). In her study of modern river sediments in the Tarim basin, Isozaki (2009 MS) suggested that quartz in coarse fraction (>63 μ m) of river sediments reflects bedrock geology of the catchment area based on ESR signal intensity and CI of quartz.

We applied this method to the fluvial sequence. Firstly, we identify the provenance changes of river sediments using ESR signal intensity and CI. Second, we interpret the provenance change as the change of mother rocks exposed in the catchment area by comparing the river sediments ESR and CI data with those of pebbles contained in intercalated conglomerates. Finally, we reconstruct tectonic uplift history from the change of mother rocks exposed in the catchment area.

We conducted field survey at Yecheng section in the southwestern Tarim Basin. Fluvial to alluvial deposits with occasional intercalations of eolian sediments deposited between 7.6Ma to 1.8 Ma are continuously exposed along the Yecheng section (Zheng et al., 2010; Tada et al., 2010). We sampled 27 river sediments (9 sandstones and 18 conglomerate matrix) and 21 clasts in conglomerates in 63-500 μ m fraction to measure ESR signal intensity and CI of quartz.

The result revealed three rapid increase of ESR signal intensity at 6.6Ma, 5.2Ma, and 4.0Ma, and rapid increase and decrease at 3.5Ma and 3.0Ma. Comparison with conglomerate clasts data suggests the provenance change during 7.6Ma to 3.5Ma can be explained by the exposure of Mesozoic and Paleozoic sandstones, which was caused by the uplift of leading edge of the Kunlun mountains. The provenance change between 3.5Ma to 3.0Ma can be explained by the exposure of weakly metamorphic rocks, which was caused by the rapid uplift of leading edge of the Kunlun mountains. The provenance change after 3.0Ma can be explained by the exposure of gneiss and granite, which was caused by the further uplift of leading edge of the Kunlun mountains.

In summary, the provenance changes at the Yecheng section are affected by the uplift history of leading edge of Kunlun mountains since 8Ma. Comparison with previous data about onset of desertification in Tarim Basin suggests that the uplift activity including the leading edge of the Kunlun mountains could affect the eolian dust and desert formation in the Tarim Basin after 8Ma.

Keywords: Tarim Basin, Uplift, Provenance study, Quartz, Desertification

Historical transition in chemistry of detrital chromian spinels in the Cretaceous Yezo and Kuji Groups, northern Japan

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Tectonic histories of sedimentary basins in the Cretaceous Japan arc have been assessed to understand the response of the Asian continental margin to the oblique subduction of the Paleo-Pacific (i.e. Kula or Izanagi) Plate beneath the Asian continent during the Early Cretaceous and that subducted orthogonally in the Late Cretaceous. In the Cretaceous Yezo Group in Hokkaido, northern Japan and the Kuji Group in the Kitakami Massif in northeastern Honshu, sandstone petrography and chemistry of detrital chromian spinel grains were performed to assess the tectonic environmental change during the Cretaceous period on the basis of provenance analysis.

Results of sandstone petrography suggest that the material of clastic rocks was derived from areas of a Cretaceous volcanic belt (Rebun?Kabato Belt) and from a Jurassic accretionary complex (Oshima - North Kitakami Terrane), which was intruded by Cretaceous granite, adjacent to the depositional basin. The compositions of detrital chromian spinels in these sediments are very diverse and mainly derived from tholeiitic and intra-plate basalts showing high-TiO₂ (>about 1.0 wt%) and island arc basalts with moderately low-TiO₂ (1.0 > TiO₂ > 0.5 wt%) and high -Cr#. Latter chromian spinels can be considered as a record of island arc activity including high Mg-andesite. Because adequate source rocks of the spinels are elusive near the basin, these rocks are believed to have been disturbed by Cenozoic tectonics and eroded and covered by newly formed volcanic and sedimentary rocks.

Comparison of chemical composition of the chromian spinels among studied areas of the Yezo and Kuji Groups indicates that chromian spinels with very low-TiO₂ (<0.5 wt%) prevail in the Lower Cretaceous (Aptian-Albian). In contrast, chromian spinels showing moderately low TiO₂ predominated in the late Cretaceous (Cenomanian-Santonian). This clear difference suggests the change of oceanic plate motion around Japan arc promoted the change of source rock assemblage and the arc volcanic activity in late Cretaceous time. Thus the chemical characteristics of detrital chromian spinels of the Yezo and Kuji Groups give the key to clarify the interaction between the swaying of young and hot plate and development of the Cretaceous island arc in eastern Asian margin.

Keywords: Yezo Group, Kuji Group, Cretaceous, heavy mineral

Sedimentological studies on dynamics of radioactive cesium in the Abukuma River system

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We studied the stratigraphic variation of radioactive cesium (¹³⁴Cs, ¹³⁷Cs) in the sediments from Iino-dam. A maximum peak of cesium concentration at the depth of 7cm is corresponding to the flooding caused by the torrential rains in September 2011. The maximum concentration at the depth of 12cm was caused by the 3.11 accident. Several top-level maximums are believed to be due to heavy rainfall in May, June and July 2012. Hydrological dynamics of radioactive materials are interpreted to be deeply associated with the sedimentological processes of fine-grained materials.

