Linking Onshore-to-Offshore Sediment Dispersal: Recent Understanding of Source-to-Sink System

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I briefly review a recent understanding of source-to-sink system and introduce some applications of its analysis. The source-to-sink system covers a suite of erosion, transportation, and deposition of sediments from catchment to deep-marine basin floor, and its analysis adopts both the sedimentological and morphological knowledge of any erosional-depositional system. Such a concept and approach have attracted increasing attention, especially from industries, to predict semi-quantitative characteristics in relationship between offshore sandstone distribution and onshore catchment evolution through geologic time.

Keywords: Source-to-sink system, Sediment dispersal, Linkage of offshore stratigraphy to onshore (paleo-)topography

The regulating function of discharge of turbidity currents by submarine canyons and channels

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Long-lived (> 1000s years) leveed submarine channels are common in submarine fans. The flow discharge of turbidity currents flowing inside the channel is required to be nearly constant for stabilizing submarine channel development; however, the cause of this steadiness of turbidity currents is unknown. Here we propose a possibility that self-accelerating process of turbidity currents inside submarine canyons and channels derive steadiness of flow volume rate of turbidity currents on the basis of numerical experiments. Turbidity currents occur at upstream ends of submarine canyons, and they grow up to large volumetric scales through the self-accelerating process in which flows increase their density by erosion of basal sediments. Our numerical experiments that used a model of turbidity currents considering conservation of turbulent kinetic energy revealed that there is a limit for currents to grow up because the increase of suspended sediments expenses turbulent kinetic energy in the currents. This limit of flow growth is related not to the initial sediment discharge but to geomorphological properties of submarine canyons. As a result, diversity in flow discharge of turbidity currents becomes smaller downcurrent, implying that the flow steadiness at the downstream end of submarine canyons can be attained by this effect. In addition to this effect, the overspilling process of turbidity currents in leveed channels has effect of negative feedback to the height of the submarine levees, which can also regulates flow discharge of currents.

Keywords: turbidity current, submarine channel, submarine fan

Submarine landslides and the trigger on the Kumano Basin

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Submarine landslides are indirectly visible, but they directly affect our society. Tsunamis might be excited mostly by an active fault movement on a seafloor, but some of the tsunamis could be excited by large submarine landslides in coastal areas in the 1952 Alaska Earthquake[1)] and the 2010 Haiti Earthquake[2)]. Some of the large tsunamis at convergent margins have been suspected as a result of submarine sliding[3)].
Underwater cables are cut suddenly by submarine landslides and related bottom currents. Such a cable cut accident damages economics[4)]. We have various observation data in the events, but we can not critically understand its trigger mechanism yet.
The trigger mechanism of submarine landsliding is thought to be earthquake shaking, pore pressure increment, slope steepening and so on[5)]. It is possible that uplift due to mud diapir could be responsible for slope steepening. The gas-related high-pressure could induce fluid escaping from deeper sub-seafloor toward seafloor and causes mud volcanism. We observed a gas-related submarine landslide example at off-Hachinohe[6)]. Some of the researchers challenged to understand the formation mechanisms using various soil mechanics experiments[7)]. However, we need more descriptive and also experimental studies to understand the formation mechanism. These attempts are the first step for a prediction of the submarine landslides.
In this June, Dr. Asada (chief scientist for the cruise), Prof. Moore and others challenged to survey what at the outer ridge of the Kumano Basin using *AUV Urashima* during the cruise YK15-10. This challenge was a series of difficulty caused by the Kuroshio Current, but finally the *Urashima* recovered dataset of topographic textures, sub-bottom profiling images, side scan sonar images, and bathymetric images in a submarine landslide area, as shown by Moore and Strasser[8)]. Based on these survey results, we conclude that
1) The submarine landslide might be critical state by a slope gradient of several degrees.
2) This slide was formed by one big slide (~1.0 x 1.0 x 0.03 km) and many small slope failures resulting turbidite layers covering on the wasted-mass.
3) This might not need any triggers for sliding (e.g. large earthquake).
4) In the wasted mass, we observed transparent dome-shaped bodies of ~several tens meters in the subbottom profiling images. These might result from fluid escaping and/or small mud volcanoes.
We further analyze in detail the Urashima's data to decipher the trigger mechanism and also formation process of the submarine landslides on the Kumano Basin.

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Keywords: Submarine slide, Nankai trough, Mud volcano

Sedimentary process of event deposits along the southern Ryukyu forearc and the southern Ryukyu Trench

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We conducted piston coring with bathymetric and sub-bottom profiling surveys, along the southern Ryukyu forearc and the southern Ryukyu Trench, for understanding sedimentary process of event deposits in this area. Our final objective is to explore the recurrence record of large tsunami and earthquake archived as deep-sea event deposits along the Ryukyu arc.
Many event deposits considered as turbidites, including many biogenic carbonate-rich very fine-medium sand layers are identified in the piston cores, recovered from a submarine fan located in the southwest of Ishigaki Island. The averaged intervals of the turbidites from two cores recovered from different part of the fan are estimated to be 500–1000 years.
The cores obtained from the forearc basin are intercalated by turbidites including biogenic carbonate-rich very fine-coarse silt, and massive clay layers with gray color almost composed of lithic fragments. The latter sections are possibly originated from the Taiwan region. Lower part of one core recovered from the deepest part of the forearc basin in the south of Ishigaki Island is composed of carbonate-rich very coarse- very fine sand layers considered to be attributed to subaqueous debris-flow. The piston cores obtained from the Ryukyu Trench floor, the coring sites locate behind the natural levee of the channel, are composed of gray silty clay intercalated with numerous coarse silt layers. Most of the coarse layers are <1 cm in thickness.
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Keywords: earthquake, Ryukyu forearc, Ryukyu Trench , turbidite, subaqueous debris-flow

Formation of a gravelly sand bar in the Yahagi River, central Japan, inferred from a Ground Penetrating Radar (GPR) survey

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GPR survey is useful for interpreting subsurface structures and revealing formation of fluvial bars. GPR profiles of fluvial bars are characterized by inclined-, horizontal-, trough-shaped reflectors, and set of multiple reflectors bounded by channeled-shaped surface, which represent downstream-migrating foreset of a bar and lateral accretion of a side bar, dunes, bedload sheet, and secondary channel scours and fills, respectively. We conducted a GPR survey of a gravelly sand bar in the Yahagi River, central Japan, which is 725 m long and 160 m wide, to clarify the three-dimensional architecture of the bar deposits. The survey was carried out in January 2015 using 250-MHz antennas. Obtained GPR profiles showed upward accretion of the inner part of the bar, chute channel incision and fill, and lateral accretion of the bar. The formation history of the bar deposits may present changes in bed load transport associated with recent disturbance, including dam constructions and dredging operations.

Keywords: the Yahagi River, gravelly sand bar, ground-penetrating radar (GPR) survey

Paleoweathering condition in the Middle Miocene and the Pliocene in Setouchi Province: Geochemical composition of fluvial muddy sediments

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The Middle Miocene to Pliocene fluvial sediments, which are distributed in Setouchi Province, are characterized by the finer sediments had been used as a high quality resource of ceramics. In general, finer sediments are suitable for examination of the paleoweathering condition, because their chemical compositions show representative value of paleoweathering degree reflecting their wide catchment area at that time. The geochemical composition is a result of the complicated influence of paleoweathering condition and fluvial processes involved in hydrodynamic sorting. This study examine geochemical variations within the fluvial muddy sediments of the Middle Miocene Tokiguchi Porcelain Clay Formation and the Pliocene Iga Clay Formation in order to assess the paleoweathering condition considering hydrodynamic sorting.
The sedimentary environments of the each formation are considered to be deposition in lake-pond and floodplain environments with partly channel and natural levee. The muddy sediments in the Middle Miocene were collected from three mines in the Gifu Prefecture and those in the Pliocene were taken from two mines in the Mie Prefecture. Then the geochemical analysis were made using XRF and ICP-MS.

The Middle Miocene sediments display clear negative linear trends between SiO_2 and other major elements, which is result of quartz dilution by effective hydrodynamic sorting. On the other hands, the Pliocene sediments have relatively high concentrations of Na_2O and CaO. Almost samples, furthermore, have positive correlation between SiO_2 and Na_2O, CaO and K_2O. Those results are caused by its sandy nature with richness of feldspar grains led by less hydrodynamic sorting and relatively felsic source rock in the Pliocene sediments.
On the A-CN-K diagram, the Middle Miocene sediments show high weathering ratio (CIA value: 79-93). The Pliocene sediments, meanwhile, can be divided into highly CIA value (80-94) and low CIA value group (70-75). The grain size effect (Al_2O_3/SiO_2) to the chemical weathering index is unclear in the Middle Miocene sediments and obvious in the Pliocene sediments. Moreover, ΣREE, which is generally higher in clay sized sediments than the parent rocks, in the Middle Miocene sediments are higher than those in the Pliocene sediments.

Also, the Middle Miocene sediments are characterized by the clear hydrodynamic sorting effect and high chemical weathering ratio. The Pliocene sediments, whereas, show bimodal chemical weathering ratio and the less hydrodynamic sorting. These results indicate that the variety of weathering degree in provenance and/or source rock composition. Additionally, typical geography probably affected the formation of faces variation in finer and coarser sediments, which made weathering variation along the basin.

Keywords: weathering , geochemical composition, Miocene, Pliocene, Setouchi Province, fluvial sediments

