Tectonically active sediment dispersal system in SW Taiwan margin: from mountain top to deep sea trench floor

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Abstract

The sediment dispersal system in SW Taiwan margin consists of two main parts: the subaerial drainage basin and the offshore receiving marine basin. In plan view, this sediment dispersal system comprises five units: (1) the Kaoping River drainage basin, (2) the Kaoping Shelf, (3) the Kaoping Slope, (4) the Kaoping Submarine Canyon and (5) the Manila Trench in the northernmost South China Sea. The Kaoping River drainage basin is a small (3650 km^2), tectonically active and overfilled foreland basin, receiving sediments derived from the uprising Central Range of Taiwan with a maximum elevation of 3952 m. The Kaoping Canyon begins at the mouth of the Kaoping River, crosses the narrow Kaoping Shelf (~10 km) and the Kaoping Slope, and finally merges into the northern termination of the Manila Trench for a distance of ~260 km. The SW Taiwan margin dispersal system is characterized by a direct river-canyon connection with a narrow shelf and frequent episodic sediment discharge events in the canyon head.

In a regional source to sink scheme, the Kaoping River drainage basin is considered the primary source area, the Kaoping Shelf being the sediment bypass zone and the Kaoping Slope being the temporary sink and the Manila Trench being the ultimate sink of the sediment from the Taiwan orogen. It is inferred from seismic

data that the outer shelf and upper slope region can be considered as a line source for mass wasting deposits delivered to the lower Kaoping Slope where small depressions between diapiric ridges are partially filled with sediment or empty.

At present, recurrent hyperpycnal flows during the flood seasons are temporarily depositing sediments mainly derived from the Kaoping River in the head of the Kaoping canyon. On the decadal and century timescales, sediments temporarily stored in the upper reach are removed over longer timescales probably by downslope eroding sediment flows within the canyon. Presently, the Kaoping Canyon serves as the major conduit for transporting terrestrial sediment from the Taiwan orogen to the marine sink of the Manila Trench. Seismic data indicate that the Kaoping Canyon has been eroding the Kaoping Slope intensely by presumed hyperpycnal flows and transporting sediments from the canyon head to the middle and lower reaches of the canyon. The middle reach is a sediment bypass zone while the lower reach serves as either a temporary sediment sink or a sediment conduit, depending on relative prevalence to deposition or erosion during canyon evolution. Contrast differences in channel gradient and travel length between the Kaoping and Amazon sediment dispersal systems suggest that the Kaoping River-Canyon system is an active sediment dispersal system for transporting terrestrial materials to the deep sea. The fate of the Kaoping River sediment is the northern Manila Trench.

Introduction

Source-to-Sink studies focus on examination of variations of a sediment discharge passing through morphodynamic units of sediment dispersal systems, revealing relevant climate, tectonics and sea-level changes and linkage between terrestrial source and marine sink, and towards a better understanding of a history of global change (MARGINS, 2004). Active convergent continental margins are considered focused study areas where much terrestrial sediments were brought in and deposited in adjacent marine closed basins, such as the type localities of the Fly River and adjacent Gulf of Papua and the Waipaoa River System on the east coast of the North Island, New Zealand.

The fold-and-thrust mountain belt of Taiwan in an arc-continent collision setting has been frequently cited as one of the few modern examples of ongoing tectonically active regions (Lallemand and Tsien, 1997; Byrne and Liu, 2002). Taiwan is characterized by high erosion rates (3-6 mm yr^{-1}) resulting mainly from heavy rainfall caused by frequent typhoons and large earthquakes (Dadson et al., 2003; Galewsky et al., 2006). In addition, many rivers in Taiwan are characteristic small, mountainous rivers, supplying large amount of sediments to the adjacent coastal sea commonly during flood events (Milliman and Syviski, 1992). Therefore, the climatic and tectonic conditions of Taiwan are favorable for generating large amount of sediments to be delivered to the coastal seas by hyperpycnal flows. Lately, link between terrestrial sediment source from the rising Taiwan orogen and the adjacent coastal sea sink has received much attention. For example, Dadson et al. (2005) pointed out that small mountainous rivers draining the tectonically active island of Taiwan commonly discharge suspended sediments to the coastal seas at hyperpycnal concentrations, typically during typhoon-related floods. Concerning the fate of hyperpycnal sediment discharge from rivers in southwestern Taiwan, Milliman and Kao (2005) postulated that the Kaoping and Penghu submarine canyons serve as sediment conduits for transporting parts of sediments derived from southwestern Taiwan to the adjacent South China Sea. Galewsky et al. (2006) discussed the tropical cyclone triggering of sediment discharge in Taiwan and concluded that orographic effects localized heavy rainfall over the southwestern slopes of the Central Range triggering high sediment discharge on the Kaoping River.

Similar to the Fly River/Gulf of Papua System, a modern developing foreland basin, the SW Taiwan margin is a developing foreland basin and receives much terrestrial sediments derived from the uprising Central Range in the southern Taiwan (Covey, 1984; Yu, 2004; Chiang et al., 2004). However, the river-canyon connection setting is different from that of Fly River/Gulf of Papua system. The sediment dispersal system in southwestern Taiwan foreland basin such as active sedimentation spanning various source to sink environments, characterized by a very narrow shelf with a river-canyon connection, can be compared to those of the Fly River/Gulf of Papua System and sediment dispersal systems in passive margins as well.

References

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