

## DISCUSSION AND REPLY

### Hyperpycnal Discharge of Fluvial Sediment to the Ocean: Impact of Super-Typhoon Herb (1996) on Taiwanese Rivers: A Discussion

*Ho-Shing Yu*

*Institute of Oceanography, National Taiwan University, Taipei, Taiwan  
(e-mail: yuhs@ntu.edu.tw)*

#### Introduction

Submarine canyons are important pathways for terrestrial and shallow marine sediments transported to the deep-sea basins (Shepard 1981; Mulder et al. 2004). The Penghu and Kaoping submarine canyons on the southwestern Taiwan margin are no exception. Regarding the fate of hyperpycnal 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 South China Sea. Their conclusions were partly incorrect because they failed to recognize that the Kaoping and Penghu submarine canyons and the Penghu Channel are three distinct undersea features with different geological settings and hydrodynamic conditions.

#### Submarine Canyons on the Southwestern Taiwan Margin

On page 513, Milliman and Kao (2005) wrote: "On the southwestern side of the island, the Kaoping River empties directly into the Kaoping Canyon, which feeds into the Penghu Canyon system, which in turn leads into the South China Sea. The mouths of the Erhjen, Tsengwen, and Pachang rivers also are relatively close to the Penghu Canyon, and it therefore seems reasonable to assume that sediment discharged from all four rivers reaches this system and thereby ultimately the South China Sea (fig. 13)."

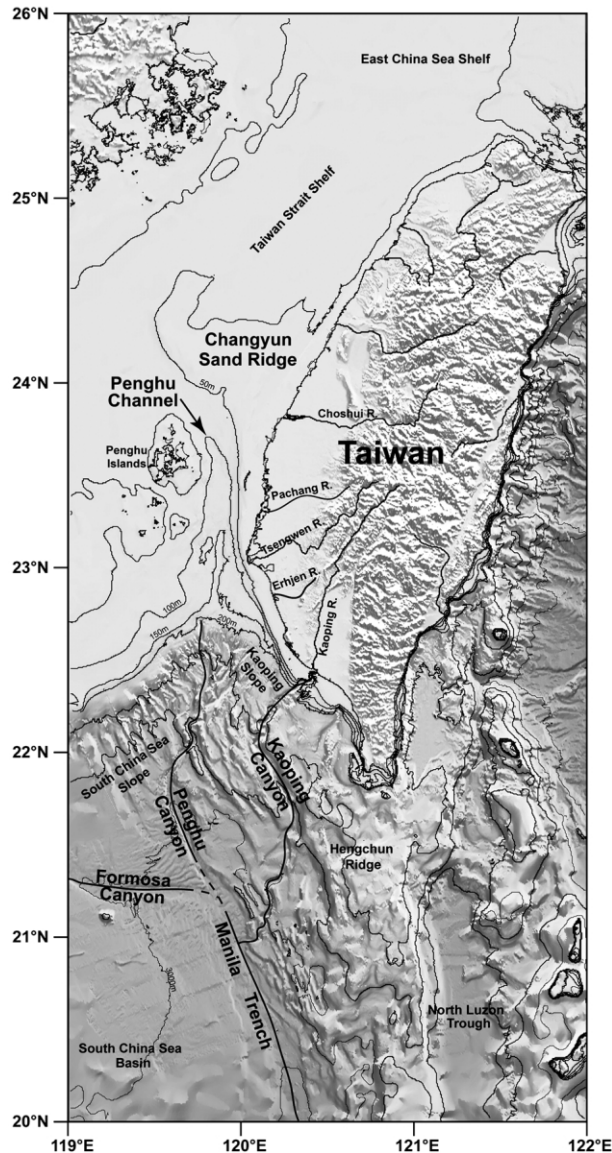
Their interpretations are misleading because they mistakenly considered the Penghu Channel to be the Penghu Canyon (their fig. 13). In addition,

they did not clearly locate the course of the Kaoping Canyon in their figure 13, leading to misinterpretation of the connection of the Kaoping Canyon to the Penghu Canyon. Figure 1 clearly shows that the Kaoping Canyon begins at the mouth of the Kaoping River, crosses the narrow shelf and broad slope region, and finally merges into the northern Manila Trench for a distance of about 260 km. Sediments from the Kaoping River are transported directly to the South China Sea via the Kaoping Canyon.

Milliman and Kao (2005) suggested that the Kaoping Canyon feeds into the Penghu Canyon System, a suggestion that is not supported by the bathymetric chart in the northern South China Sea (fig. 1). The Penghu Canyon is located along the intersection of the South China Sea Slope on the Chinese margin and the Kaoping Slope on the Taiwan side (fig. 1). This N-S-trending axial canyon is about 240 m deep at the head below the Taiwan Strait Shelf, increasing to about 3200 m deep at its mouth, before merging gradually into the Manila Trench (Yu and Hong 2006). The head region receives sediment derived from the Taiwan Strait Shelf to the north. Tributary canyons and gullies on both slopes of the Taiwan and China margins feed into the upper reach of the Penghu Canyon. The Penghu Canyon serves as a major longitudinal transport route of the marine basin off SW Taiwan, delivering sediments derived from the Taiwan Strait Shelf and the Taiwan and Chinese margins to the South China Sea (Yu and Hong 2006, fig. 8).

On the other hand, the Penghu Channel is located north of the Penghu Canyon, with its head between the Penghu Islands and western Taiwan at depth of about 80 m (fig. 1). This channel extends southward for about 110 km to its mouth near the shelf break of the Taiwan Strait Shelf at a water

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**Figure 1.** Bathymetric chart showing the two major submarine canyons on the southwestern Taiwan margin. Bathymetric data from the bathymetry data bank at the National Center for Ocean Research (NCOR), National Taiwan University, were used to generate this bathymetric chart off southwestern Taiwan. The Web site of the data bank of NCOR is <http://www.ncor.ntu.edu.tw>. The Kaoping Canyon is about 260 km long, extending from its head immediately near the mouth of the Kaoping River, crossing the narrow shelf and broad slope region, and finally merging into the northern end of the Manila Trench. The Penghu Canyon is about 180 km long and begins below the shelf break of the Taiwan Strait Shelf, extending along the intersection of the Kaoping Slope and the South China Sea Slope in a nearly N-S direction and finally merging into the northern end of the Manila Trench. The Penghu Channel, bounded by the Penghu

depth of 200 m. It is a funnel-shaped channel with a width of about 40 km in the north and about 80 km in the south. On the basis of detailed bathymetric mapping, Huang and Yu (2003) emphasized that the Penghu Channel and the Penghu Canyon are two distinct undersea features, not a continuous sea valley.

The Penghu Channel is regarded as a scour furrow of erosional origin, probably formed by northward-flowing tidal currents coming from the South China Sea. There are persistent northward flows in the Penghu Channel, and detailed oceanographic observations were carried out in the 2000s (e.g., Jan and Chao 2003; Jan et al. 2004; Wang et al. 2004; Lin et al. 2005). These hydrodynamic studies indicated that the currents in the Penghu Channel are essentially barotropic and characterized by strong semidiurnal tides and mean flows. The mean current is uniform, with an average northward velocity of up to 100 cm/s. Lin et al. (2005) reported a short-term current velocity measurement at the northern tip of the Penghu Channel (119°50'E, 23°52'N), showing continuous northward flows from the Penghu Channel into the Taiwan Strait (fig. 1).

Surface cored sediments of the Penghu Channel floor are characterized by gravels and sands, with a progressive decrease in grain size to the north (Huang and Yu 2003). Combining hydrodynamic conditions and sediment characteristics along the Penghu Channel, I suggest that the Penghu Channel can be regarded as a sediment conduit, transporting sediment northward by the strong north-flowing currents from the South China Sea. Therefore, sediments delivered by four major rivers in southwestern Taiwan—the Pachang, Tsengwen, Erhjen, and Kaoping—may not be transported southward via the Penghu Canyon to the South China Sea but rather northward instead.

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Islands to the west and the southwest coast of Taiwan to the east, is characterized by a funnel-shaped sea valley. This channel is a scour furrow and is completely unrelated to the Penghu Canyon genetically (Huang and Yu 2003; Yu and Hong 2006).

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