Topographic induced flow variation and the trapping mechanism of sediment at the KPSC

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Abstract

This study investigates the variations of flow and associated water mass movements due to the influence of topographic effects in the Kaoping Submarine Canyon (KPSC), off southwestern Taiwan. The data used in this study are collected from multiple cruises of field observations using research vessel OR3. Instruments applied include ship-board ADCP、CTD、tow-ADCP, moored ADCP and vertical arrays of temperature loggers. Harmonic analysis of flow data shows that the Kao-ping Canyon is dominated by semi-diurnal M2 tide, although the sea level variation is diurnal dominated. EOF analysis of CTD profiles suggested that the first mode (semi-diurnal tide) can explain 88% of the variations. The amplitude tidal current increases downward with canyon depth. The major axis of tidal current aligns with canyon orientation (Figure 1). The water mass is moving around by the oscillation tidal current along the canyon. During flood, surface water flow to southeast, while bottom flow is up canyon. During ebb, surface water goes to northwest, while bottom flow is down canyon (Lin, 2006).

The vertical lifting of water mass has amplitude of 200m in the major part of the canyon. However, at the area of river mouth, analysis of flow data shows that the canyon head is not the channel for bottom layer water to climb up into the shallow bank or the river (perhaps the bottom water climb up over shelf at the turning of the canyon 5 km offshore). The water mass is also dominated by the oscillation M2 tidal current. There are 3 hours lag between sea level and flow. The maximum out canyon flow was found at the peak of flood, on the other hand, the up canyon flow was found at the low water (Wang, 2007). The low-pass of flow data 2004.13.13-20 indicate a counter clockwise rotation from surface down, which is explained due to bottom frictional effect. The bottom slope drives water upward creating vortex stretching can also be the causing of cyclonic circulation. The PVD of low-passed data indicates a landward up canyon flow. The landward transport is explained due the geostrophic pressure gradient of the alongshore flow at the edge of the shelf (Klinck, 1996). Mean flows from long term sbADCP data support the scenario of upwelling due to such left bounded flow. The up canyon mean flow may trap the sediments within the upper

canyon.

The Kaoping Canyon appears to act as a major sink for river borne trace metals. The distribution of coprostanol (Jeng et al., 1996) inputs from the past 20 years shows that the concentration is highest at the river mouth and decreases to 1% at the shelf break (about 50 km offshore). The coastal shallow water region is low due to dilution of clean sediment or degradation by biogenic process. However, the concentration remains high at the bottom of canyon 35km from the canyon head. The canyon is clearly a channel for material transport. The oscillating tidal flows provide a mixing mechanism of sediments along the canyon. The distance of movement is proportional to the time of excretion controlling by the tidal excursion distance and mixing rate. This source to sink pathway is a down canyon transport. Also, the southern bank of canyon is high of coprostanol deposition. Similar pattern was reported by Huh et al. (2007) that there was a striking feature of a pair of depositional lobes with sedimentation rates over 1 cm/yr flanking the KP canyon at the upper slope (200-600m) region. The depositional lobe is centered in the canyon axis at a locale where the channel turns and widens abruptly, with some topographic highs protruding the channel floor. Thery assumed that such a topographic setting may disperse the energy of fluvial plumes or turbidity flows, thus facilitating the spreading out and settling of fluvial sediment out of the water column.

Flow pattern shows that the river plume would move northward at ebb. The depocenter at the northern bank might be caused by river plumes that suspended fluvial sediment settle down at deep water and low flow velocity. However, the high sedimentation at the southern bank would not be direct deposition of plume sediments. It is likely form by resuspension of bottom sediments at flood, and deposited when tidal flow decreased. The bottom sediment in the canyon may push over shelf at the turning of the canyon into the shallow southern bank. Lower sedimentation rates were observed at the inner shelf region covered primarily by reworked sands. The muddy component of fluvial sediment cannot sustain strong tidal currents and wave activities and is preferentially transported down the canyon and offshore (Liu et al., 2002; Crockett and Nittrouer, 2004).

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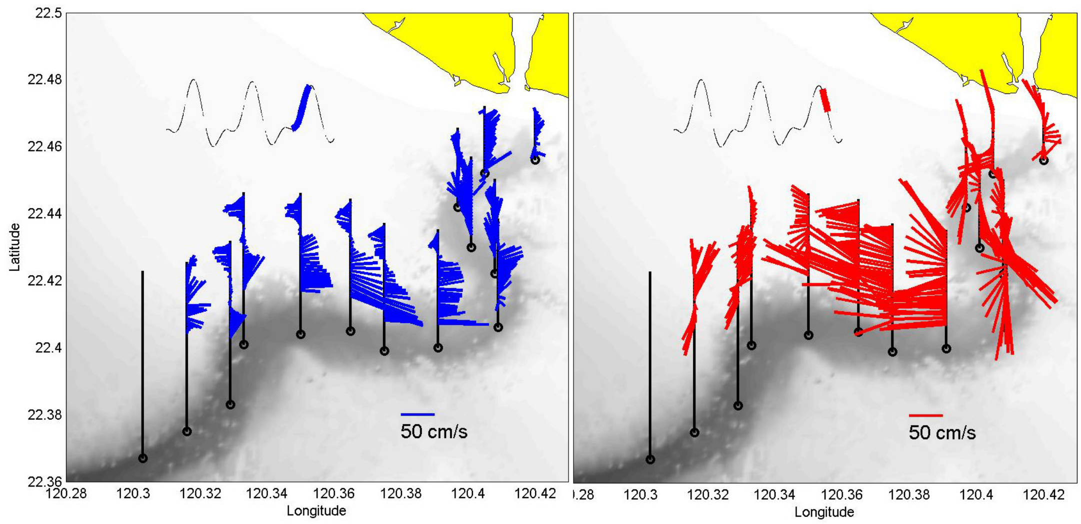

Figure 1. Stick diagrams of current along the Kaoping submarine canyon showing the typical flow of flood (left) and ebb(right). The data were collected by sbADCP during 4 day cruises repeated along the canyon axis. The flows during ebb (red) are down canyon while flood (blue) are up canyon which both are trapped by the topography of the submarine canyon regardless of the canyon axis. The flow patterns in the upper layer are more complicated which can be divided into sections according to the variations of canyon axis.