



Development of the shale diapir-controlled Fangliao Canyon on the continental slope off southwestern Taiwan

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Abstract—Fangliao Canyon is one of several major canyons on the continental slope off southwestern Taiwan. This paper evaluates the canyon morphology and its formative processes and origin using multichannel seismic reflection profiles and bathymetric data. Fangliao Canyon is a small canyon around 10 km wide and 60 km long, an order of magnitude smaller than the large canyons of the world. This canyon can be divided into two morphologically contrasting parts: the upper canyon, a relatively straight part beginning at the shelf edge and ending approximately at the 600 m isobath, and the lower canyon, consisting of two segments separated by a rising linear ridge (shale diapir) and extending downslope to about the 1000 m isobath where its mouths lack submarine fans. Seismic profiles and bathymetric data provide evidence of submarine erosion forming the upper canyon and the uplift of a shale diapir controlling the formation of the lower canyon. In the upper canyon, truncation of parallel flat-lying strata and sliding/slumping features on the canyon walls are indicative of downcutting and lateral widening of the canyon. In the lower canyon, the shale diapir uplifted the slope strata and protruded through the overlying slope sediments, producing a ridge rising from the sea floor. Here the steep flanks of the shale diapir become the walls of the steep-sided canyons. The interaction of these sedimentary and tectonic processes on the continental slope off southwestern Taiwan forms the present Fangliao Canyon.

Introduction

The continental slope off southwestern Taiwan has several canyons. From northwest to southeast, these canyons are the Penghu, Kaohsiung, Kaoping and Fangliao (Fig. 1). They have been known for more than 60 years. None of them are well understood because of insufficient data acquired by modern marine geophysical and geological techniques. For example, the sedimentary processes in these canyons are poorly known because no sediment cores from the canyons are available for sedimentologic analyses. A general geological review of these canyons was given by Yu and Liu (1994).

Fangliao Canyon (named after the coastal town; Yu and Wen, 1991) cuts the shelf edge about 20 km south of the coastline (Fig. 1). Until now, only one published paper has specifically dealt with the Fangliao Canyon (Yu and Wen, 1991). Based on limited bathymetric data and 3.5 kHz echograms across Fangliao Canyon, Yu and Wen (1991) failed to recognize branching of the lower canyon into two segments formed by a north-south trending diapiric intrusion. As a result, their conclusions on the morphology and origin of the Fangliao Canyon were only partly correct.

This paper describes the morphology of the Fangliao Canyon in detail, relates the morphology to local uplift of the shale diapir, and then discusses the origin of the canyon using newly acquired bathymetric data and multichannel seismic reflection profiles.

Geological Setting

Physiography

Taiwan, a mountainous island, is formed by the Late Cenozoic collision of the Luzon arc with the Chinese

margin (Ho, 1986; Teng, 1990). Off its southwestern coast, Taiwan has a narrow (20 km) shelf which is the natural seaward prolongation of the Coastal Plain Province and the southern Central Range of the island. The shelf extends from the southern tip of the island northwestward, where it merges into the broad Taiwan Strait shelf. The shelf edge ranges from 60 to 170 m in depth. The shelf has a general northwest-southeast trend, which changes to a north-south direction parallel to the coast at the southern tip of the island (Fig. 1). The continental slope extends seaward from the shelf break to the 3000 m isobath, where it grades into the abyssal plain of the South China Sea (Fig. 1). This slope varies in gradient from 3 to 16° (Chen, 1983). The continental slope can be divided into upper and lower slopes at approximately the 1000 m isobath. Submarine canyons including the Fangliao Canyon and channels occur mainly on the upper slope (Yu and Wen, 1992). The slope also changes from the general northwest trend to a north-south trend, curving gradually along the southwestern coast of the island.

Stratigraphy

The geological framework of the region in southwestern Taiwan, including offshore areas, was established during Pliocene-Quaternary (Covey, 1984). In Pliocene the offshore area of southwestern Taiwan was a deep marine environment which became shallow marine and nearshore depositional environments as the arc-continent collision in Taiwan propagated southward in Pleistocene and Quaternary. The arc-continent collision in the Taiwan orogen resulted in the formation of a foreland basin filled with orogenic sediments up to