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Tidal Motion in Submarine Canyons—A Laboratory Experiment

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ABSTRACT

The reasons for the large-amplitude tidal motion observed in oceanic submarine canyons have been explored with a laboratory experiment. A barotropic tide was forced in a stratified tank, containing continental shelf-slope topography into which a narrow canyon was incised. Large-amplitude tidal motions were observed in the canyon; it is shown that these were forced by the large horizontal pressure gradient existing on the continental shelf near the canyon head. Another significant feature of this experiment was that internal waves inside the canyon were partially reflected from the open boundary at the mouth of the canyon, like sound waves from the open end of an organ pipe. This enabled energy to propagate down the canyon in the form of leaky modes.

The character of the flow in the canyon was strongly dependent on the ratio of bottom slope α to ray (or characteristic) slope *c*. For α/*c* Lt; 1 the stratification had little effect on the motion, and the largest displacements were nearly barotropic and occurred near the canyon head; for α/*c* ≈ 1 the motion was baroclinic and had the same pattern at all depths. For α/*c* > 1 the energy propagated down the canyon in the form of leaky modes; because of reflection at the bottom, large amplitudes may occur near there in some cases.

The analysis also suggests a mechanism for the large amplitudes of high-frequency internal waves observed in submarine canyons. For a narrow canyon, wave motion in the canyon will be forced at the mouth by the pressure field of an incident wave from the deep sea, plus that of the wave reflected from the eternal continental slope; this will result in a wave with up to twice the amplitude (and hence four times the energy) inside the canyon.

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