Documenting the On-Going Processes Occurring within Modern Submarine Canyons: Offshore California

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Abstract

The gravity flow processes that occur within active submarine canyon channels are important components of the depositional systems that generated petroleum reservoirs. However, submarine canyon processes are understudied, as the axial channels within submarine canyons are challenging environments to survey and sample. Collecting physical data on conditions during gravity flow events has rarely been attempted. Thus, the potential analog value for understanding petroleum systems that could be achieved from the study of modern systems has not been realized. Conversely, these challenges also make submarine canyons interesting targets for new technology and technique developments, which is the primary mandate of the Monterey Bay Aquarium Research Institute (MBARI).

Over the last 15 years, MBARI has utilized a suite of robotic vehicles and novel sensors to study the dynamics of the on-going sediment transport processes occurring within submarine canyons. To date, over 200 remotely operated vehicle (ROV) dives have been conducted within eighteen submarine canyons along the California continental margin, ranging between La Jolla Canyon at the southern end and Eel Canyon at the northern end. On these dives more than 350 precisely-navigated vibracores have been collected using ROVs, which enables transects of closely spaced cores. These observations and surgically collected cores document complex coarse-grained facies associated with abrupt lateral and vertical changes that characterize the axial channel deposits. Nine canyons have been surveyed with an autonomous underwater vehicle (AUV) providing ultrahigh resolution multibeam bathymetry (vertical precision of 0.15 m and horizontal resolution of 1.0 m), which reveal the morphologies of the axial channels in unprecedented detail. Crescent-shaped bedforms (CSB) (wavelengths of 20 to 100 m and amplitudes of up to 2.5 m) have been discovered in Monterey, Carmel, Hueneme, Mugu, Dome, Redondo, and La Jolla Canyons. Although, the existence of the CSB was not previously recognized, as they are too small to be detected in surface vessel multibeam or seismic surveys, CSB appear to be a significant attribute of coarse-grained canyon floor deposits. CSB are only found in canyons which head near the shoreline, which implies they are receiving sediment from the present day long-shore transport cells. Repeat mapping surveys show that the positions of the CSB can change dramatically between surveys. Monitoring efforts in Monterey Canyon by MBARI and colleagues at the US Geological Survey also document that discrete gravity flow events occur at a sub-annual recurrence frequency that are capable of moving 700 kg objects. Recently, unique sensor packages capable of measuring conditions during sediment gravity flow events have been developed.

Some of the sensors are intentionally placed in the channel axis to record their orientation when they are transported down canyon during gravity flow events. In one case, an individual boulder-sized sensor traveled up to 9 km down canyon in as little as 57 minutes, recording both sliding and rolling motions. Collectively, these observations reveal the coarse-grained deposits that fill submarine canyons at a level of detail never achieved before and are starting to provide in situ observations on the physical conditions that generated them.