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Subsurface Seismic Structure of the Nascent Ridge Vent Site, Makran Deformation Front, Offshore Pakistan

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In 2007, a wide range of geophysical and geological data was collected along the Pakistan segment of the Makran accretionary prism. The main scientific goal of the offshore campaign was to identify, map, and characterize recent or presently active fluid vent sites at and beneath the seafloor. The extremely thick sedimentary cover of the subduction complex was hoped to help pin down the influence of sedimentation on the nature of venting and provide a solid basis to compare resulting seepage with other, largely differing vent systems such as in the Black Sea or at the West-African Margin.

High-resolution seismo-acoustic data from the vicinity of the proto deformation front in approximately 3000 m water depth show uniform seismic layering in the subsurface. This is interpreted to indicate undisturbed hemipelagic, predominantly turbiditic sedimentation. At the estimated depth of the base of gas hydrate stability zone, high reflection amplitudes hint to the presence of trapped gas in the strata. The high-amplitude package is a single, clear, negative-polarity reflector towards the flanks of the fold, but becomes a set of elevated reflector segments and chaotic high-amplitude patches towards the crest. The depth of the anomaly below seafloor decreases by several hundred meters to a depth which is thought to be within the gas hydrate stability zone. The reflection polarity of the feature varies locally below the crest between negative, undefinable, and positive, the latter indicating a physical cause other than free gas presence. We attribute this to elevated gas hydrate concentration in the lower part of the stability zone. The structure exhibits 3D topography with vertical steps of several tens of meters within short lateral distances, as well as a chimney-like amplitude drop of relatively small extent.

The sediment above the high-amplitude anomaly appears to be fractured, and displays acoustic turbidity in a large portion of the area. Acoustic and visual observations during the cruise documented free gas in the water column, the existence of which might indicate unknown mechanisms of free gas migration through the gas hydrate stability zone. Our data reveal the fine subsurface structure of this rare phenomenon on a few meters' scale, adding to a successful explanation of the feature.