Are cold seep locations controlled by topography or gas hydrate distribution? A view from the Kerch seep plumbing system in the Black Sea

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Cold seeps seem to develop preferentially at or near the crests of ridges or other local topographic highs (e.g. Johnson et al., 2003; Klaucke et al., 2006; Greinert et al., 2010). Although conclusive reasons for this widespread phenomenon have not been offered it implies that topography is a primary control on the distribution of cold seeps. It has been suggested that free gas migrates laterally along the base of the gas hydrate stability zone or within the hydrate stability towards the crest of the structure. Recent high-resolution surface (deep-towed sidescan sonar) and subsurface (Chirp, high-resolution 3D-seismic) data of the Kerch seep and plumbing system in the Black Sea challenge this view.

The Kerch seep site is located in 890 – 940 m water depth south of the Kerch Strait in the northern Black Sea, and consists of three individual seafloor mounds with an elevation of about 1 to 10 m from the surrounding seafloor and covering an area between 0.03 to 0.2 km². A remarkable feature of these seeps is the fact that one seep developed on the crest of a levee, one on the flank, and one in the channel bed (Fig. 1).

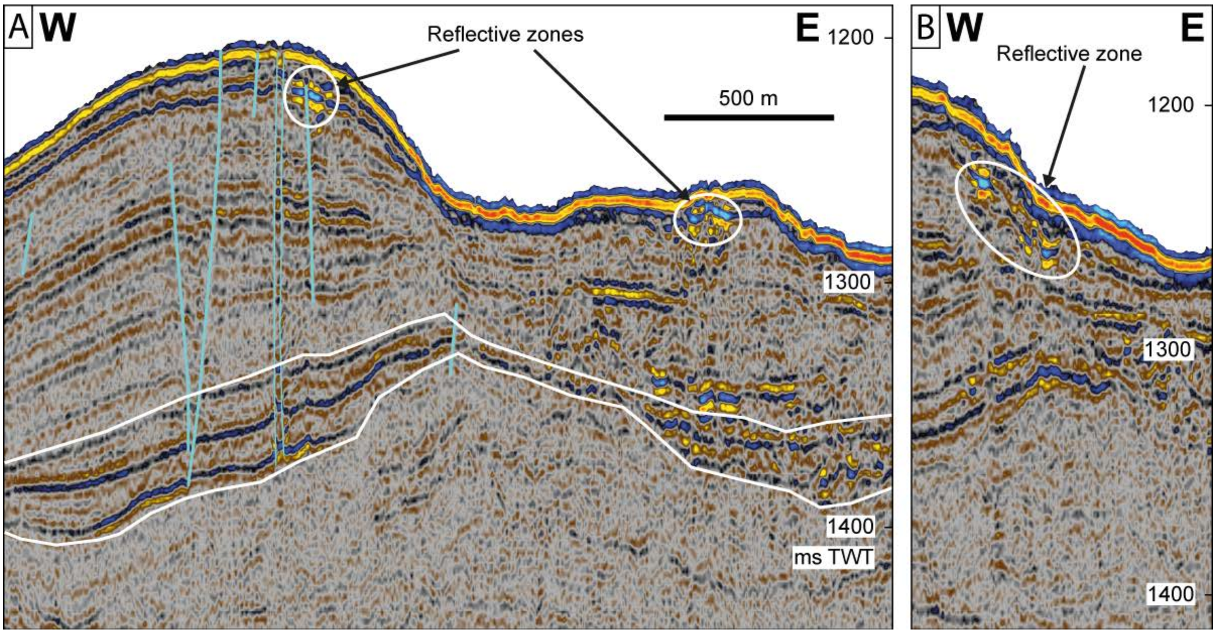

Fig. 1: Shallow subsurface of the Kerch seep site highlighting the development of three individual seeps on top of a levee (A), on the levee-flank (B), and in the channel sediment bed (A). The base of the channel-levee system is highlighted by high-amplitude reflections. Reflective zones in shallow depth indicate free gas accumulations. The levees show numerous subvertical faults (blue lines).

Each of the seeps is currently active as evidenced by gas bubble streams (flares) escaping into the water column at the margins of the mounds. Individual gas accumulations are present in shallow depths of about 5-10 m below the seafloor (Fig. 1). 3D seismic data and coherency maps show the presence of numerous sub-vertical faults on the levees with lateral extensions of up to 1000 m, which often can be traced down below the base of channel deposits (Fig. 1). A BSR is not visible in the seismic data, but the presence of gas hydrates has been confirmed for the mounds in shallow depth (Römer et al., 2012). The faults in the levees are post-depositional and some act as migration pathways for rising gas through the GHSZ towards the seafloor as evidenced by reflector pull-ups. However, other faults in the close vicinity do not appear to have acted as a fluid conduit. As for the seep in the coarse-grained channel bed: intermediate gas accumulations indicated by bright spots in channel sediments (Fig. 1) are expected. Faults in the channel sediments are not imaged due to a chaotic seismic character of the deposits, but we expect the presence of weak zones and fractures that favor focused fluid ascent towards the seafloor. Vertical reservoir connectivity and permeability should, in our view, result in a much wider seafloor expression of the seep.

In the area of the Kerch seep site the base of the gas hydrate stability zone coincides with high amplitude reflection packages at the base of the levee succession. Differences in pressure build-up in this intermediate reservoir govern the location of seeps at the surface rather than topography. The actual source of the gas has not been imaged but lies much deeper.

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