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INITIAL GEOPHYSICAL AND GEOLOGICAL ASSESSMENT OF AN INDUSTRY 3D SEISMIC SURVEY COVERING THE JAPEX/JNOC/GSC MALLIK 5L-38 GAS HYDRATE RESEARCH WELL

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Abstract

An industry 3D seismic survey (Mallik 3D), covers 126 km^2 including Mallik 5L-38 and three industry exploration wells (Figure 1). The data was recorded in 2002 on Richards Island over a lake-covered, marine-inundated, permafrost terrain. The acquisition was optimized for deeper conventional hydrocarbons and thus limited shallow spatial resolution, fold, and frequency (60 Hz maximum). Shallow data gaps reach 700 ms while irregular permafrost ice creates complex static solutions, degraded velocity control, and energy transmission losses. Data volumes illustrated come from two processing flows including one intended to produce a near-true-amplitude output. The imaging quality of the Mallik 3D improves below about 700 metres, and the wide aerial coverage reveals the broader observations of geology and gas hydrate seismic expression.

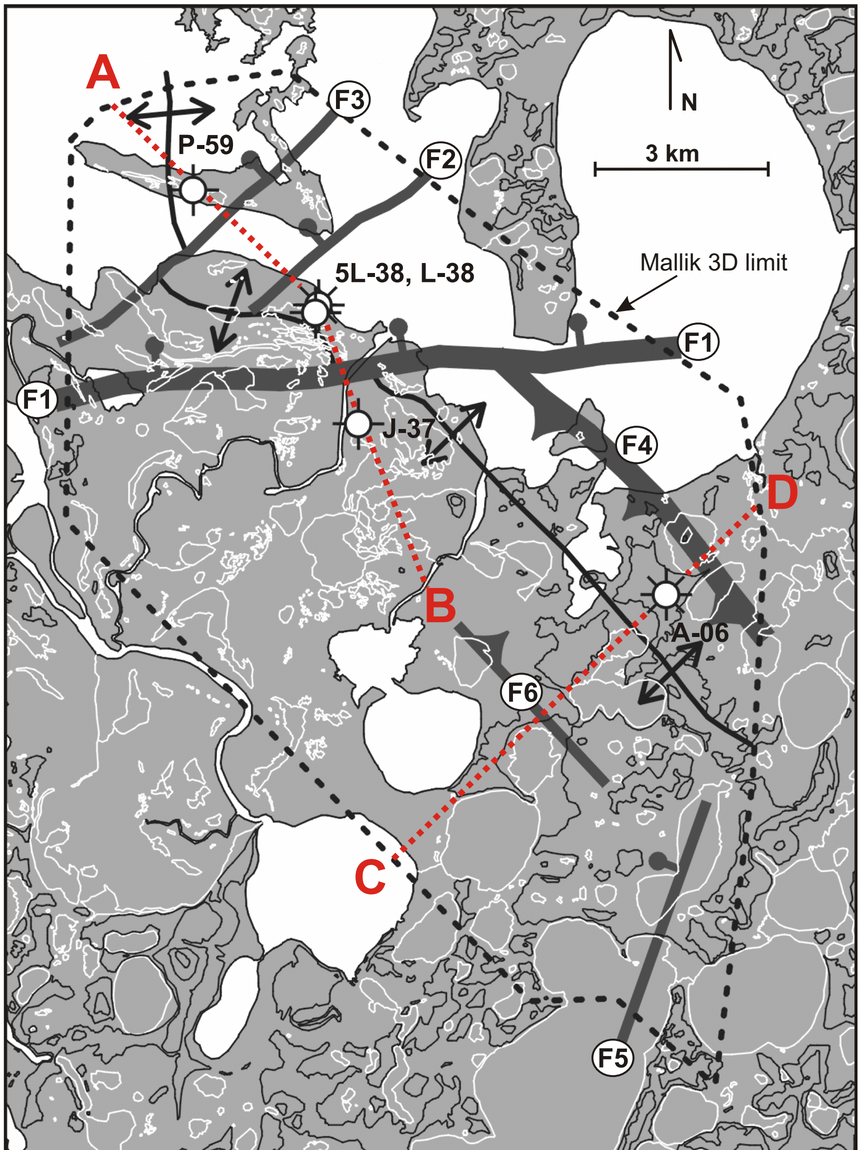

Figure 1. Map showing trace of the Mallik anticline and faults (F1 to F6) interpreted at seismic marker "G". Also shown are the location of Mallik area wells and seismic lines A-B and C-D seen in Figure 2. Overlain is culture data including marine shoreline, lakes, rivers and 100 foot elevation contours (thin dark lines). Note the general coincidence of lakes over fault F5 and southeast part of fault F4.

Three downhole velocity surveys tie to the Mallik 3D at Imperial Mallik J-37, P-59 and A-06. Anomalously elevated velocities at these locations infer gas hydrate thickness of 225, 105 and 135 meters respectively, in addition to the 116 m meters known at Mallik 5L-38.

The Mallik 3D lies within a regional fault zone (Taglu Fault Zone) which is at least 150 km long and on strike with a major hinge line of syn-tectonic Tertiary deposition into the Beaufort Sea Basin. The Mallik 3D structural interpretation indicates both compressional and extensional features. A major down-to-north normal fault (named F1, see Figure 1) strikes EW and divides the Mallik 3D into a north block

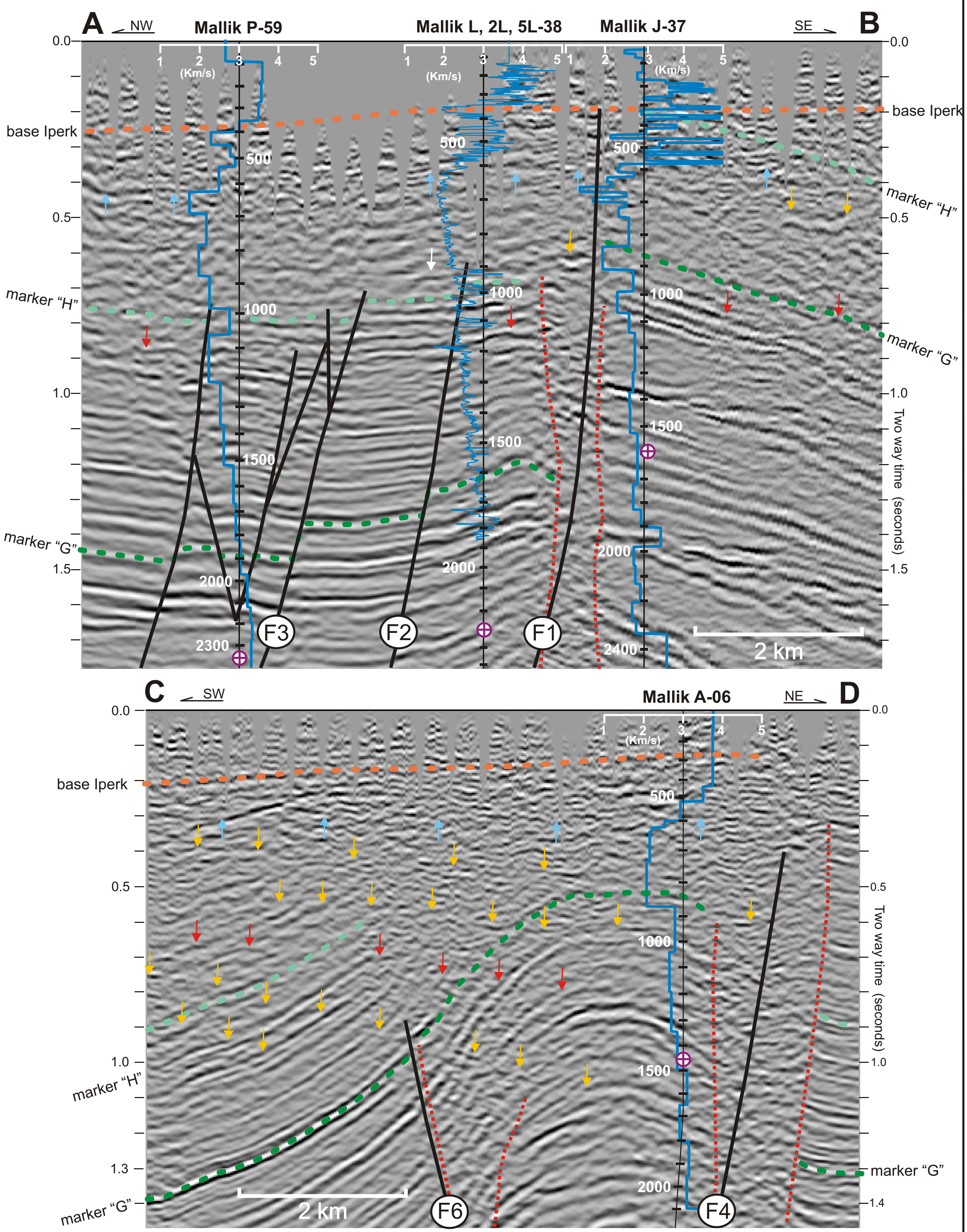

Figure 2. Interpreted Mallik 3D seismic lines A-B and C-D (location in Figure 1.). Overlain at Mallik area well locations are checkshots or VSP-corrected velocity curves, depth scales (m KB), and biostratigraphic datum (⊕). Blue arrows indicate base of ice-bonded permafrost and red arrows indicate weak seismic expression closest to the estimated base of methane hydrate stability. Vertical zones of amplitude /frequency /coherency "wash-out" are outlined with red-dashed lines. Yellow arrows indicate speculated seismic multiples, top GH energy, paleo-GH levels or diagenetic acoustic overprints possibly the legacy of deeper paleo-hydrate levels. Seismic data are from pre-stack time migrated processing.

containing Mallik wells 5L-38 and P-59, and a south block containing Mallik wells J-37 and A-06. The two southern block wells are drilled near the crest of a NW-striking thrust anticline. The major normal fault has apparent throw, near 5L-38, of 800 meters, interpreted on seismic at a level (marker "G", see Figure 2) deeper than the gas hydrate zones by about 700 m. Down-to-north offset of a biostratigraphic datum indicative of Middle-to-Late Eocene age strata is 705 m, between 5L-38 and J-37, and occurs about 600 m below the seismic correlation. Seismic character correlation across the fault is uncertain and is explained by changing stratal thickness, due to fault growth possibly through Late Eocene or Oligocene time, which would reduce fault throw upsection at the level of hydrate deposits of 5L-38, by several hundred meters. This implies the hydrate-hosting sediments in Mallik wells at 5L-38 and P-59, are younger and have a different geologic history than the sediments with inferred gas hydrate at Mallik J-37 and A-06.

Stacked data of the Mallik 3D indicate data contamination which might potentially confuse gas hydrate interpretation, these include: 1.) energy reverberations generated from impedance at air/ground, top/base ice-bonded permafrost, intra-permafrost taliks, and at the base-Iperk sequence, and; 2.) Amplitude and frequency degraded zones (wash-outs) caused by lake-controlled near-surface conditions creating signal attenuation. Wash-outs are observed as deep as one second two-way-time, and are directly beneath and spatially coincident with the outline of specific lakes.

Anomalous seismic energy from suspected gas hydrate is evident in the Mallik 3D. Observed are numerous, mostly weak, discontinuous, near-horizontal seismic energy or amplitude changes which appear to cut across or be superimposed on dipping primary geologic reflectors. The two-way-time range to expect seismic evidence of the theoretical base of methane hydrate stability is estimated between 825 and 1035 milliseconds. Pronounced amplitude "blanking" is apparent on near-true-amplitude processed data above levels within this time range. Throughout much of the Mallik 3D, where primary reflectors are dipping, there are commonly several near-parallel energy levels interpretable as being near the base of gas hydrate stability, unlike the classic seismic expression on marine data which exhibit a single bottom-simulating reflector.

Other observations of gas hydrate interest include: 1.) apparent east dip of suspected base-hydrate energy into the anticlinal fold in the southern part of the Mallik 3D; 2.) subsurface positions of certain major faults appearing to underlie the general trend of lakes at surface and 3.) Major faults exhibiting a generally vertical zone of amplitude/frequency degradation and/or chaotic seismic nature around them in the subsurface.