# SHALLOW GAS OFFSHORE TARANAKI NEW ZEALAND

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**Abstract**
Shallow gas has been observed on exploration seismic data in several locations offshore Taranaki. Detailed surveys in two areas, the Kora Prospect in the North Taranaki Bight, and the Moki Prospect in the South Taranaki Bight, show shallow gas features in the first 100 m subbottom. Data from these areas are of interest in studies of the genesis of shallow gas because there is strong evidence that this gas is originating from deeper reservoirs and is not shallow *in situ* biogenic gas. At both sites bathymetry, sidescan and single channel-boomer seismic surveys were carried out with line spacings of 150-200 m. At the Moki site, 24-channel high resolution multi-channel seismic surveys were also done. The shallow gas is evident as classical hazing of seismic records and enhancement of reflection amplitudes at some horizons. Sidescan shows highly reflective small patches on the seafloor which may be due to gas or to changes in the sediment properties. If overseas experience is any indication they could also be due to carbonate cementation or specialised types of shellfish. Hollows in the seabed are evident and, at Moki, gas venting into the water column has been observed. In both areas sharp boundaries of the gas related features coincide with shallow faults. At Moki, they also coincide with the position of faults mapped at depths of 1300 m or more; and at Kora faulting is known to extend from the near surface to reservoir levels. Although no samples of the gas are available, it seems probable that the shallow gas originates by migration up faults from the reservoir levels. With advance knowledge of the shallow gas both areas have been safely drilled.

## Introduction

Gas present within the first few hundred metres subbottom, i.e. shallow gas, is a potential hazard for drilling operations. Shallow gas is present in many hydrocarbon areas around the world, and the Taranaki Basin of New Zealand is no exception, although it is not considered to be an area of high risk in this regard. It is now standard practice in New Zealand for high resolution geophysical surveys to be carried out prior to any exploration drilling offshore to detect the prescence of any shallow gas shallow gas. Site surveys also provide information on other potential drilling difficulties such as shallow faulting, or infilled channels, in addition to providing information on the properties of the seabed which is particularly useful for anchoring and leg stability considerations.

Site surveys have been carried out at over 30 sites in the North and South Taranaki Bights during the last ten years, however most have not identified any shallow gas. At two locations, Kora in the North Taranaki Bight, and Moki in the South Taranaki Bight (Figure 1), gas is evident within the first 100 m subbottom, and also appears to be venting into the water column. Moki and Kora are the subject of this paper.

Site surveys were carried out at both sites by Buxton Tuder Waugh (BTW) Associates of New Plymouth (Farrant and Falconer, 1985; Falconer and Jackson, 1988). Moki was surveyed in 1984 for the then operator Tricentrol Exploration Ltd. The area was most recently operated by Petrocorp Exploration Ltd as Petroleum Mining Licence 38144. Kora is situated in Petroleum Prospecting Licence 38447 and was surveyed in 1988 for licence operator ARCO Petroleum N.Z. Inc.

The geophysical survey at each site collected information from bathymetry, 100kHz sidescan sonar, single channel boomer seismic, and some bottom grab samples. At Moki high resolution 24-channel sparker data was also obtained. The SYLEDIS positioning system was used. Equipment for the surveys was installed on supply boats. The multi-channel data was processed by GECO in Wellington. The remainder of the data was in analog form only. The author was field geophysicist and analysed the resultant data as a consultant to BTW Associates.

## Kora Area

The Kora site survey covered an area of approximately 11.5 sq. km. Some 1320 km of lines were surveyed, with a line spacing of 150 m in the north-south direction, and 500m in the east-west direction. For virtually all of the survey the Sea State was 5 or greater which degraded data quality, but drilling schedules meant that the survey had to be completed quite rapidly.

Figure 2 shows a representative cross-section in a SE-NW direction which illustrates all the major features of the shallow section of the site. Figure 3 is an E-W boomer seismic section which also illustrates typical features. Water

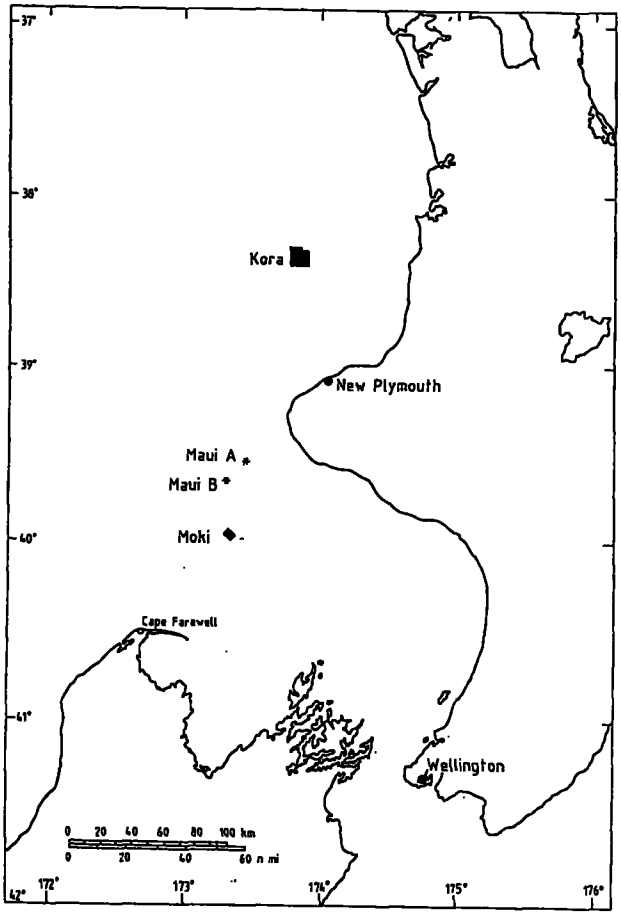


Figure1: Location diagram showing the areas surveyed at Kora and Moki. Maui-A is currently New Zealand's only offshore production site. Maui B platform installed early 1992.

depths in the survey area vary from 110 m to 140 m. The seabed is generally smooth, and consists of fine silty sand with some small broken shelly material. Several horizons are identifiable in the first 100 m subbottom, which was about the limit of penetration of the boomer system used. Horizon A marks the base of a shoreward thickening wedge of material which thins to zero across the site area. Other deeper horizons have a gentle northwestward dip, but Horizon C is an erosional unconformity. Two faults with offsets of less than 5 m offset Horizon C, but not the section above it.

Examination of the seismic reflection records identified areas where reflectors at Horizon C and below had enhanced amplitudes, and there was also a smaller area where there was a complete disruption of the seismic record (Figure 3). Both features are frequently associated with areas of shallow gas. Sidescan sonar images of the seafloor (Figure 4) showed a small area in which there were highly reflective patches which may be slight hollows (pock marks) or possibly gas venting into the water column.

When the areas of seafloor and seismic features are mapped they form a coherent pattern (Figure 5). One limit to the extent of the features appears to be the shallow faults which strike northeast. Figure 5 also shows contours of the depth to Horizon C and it is noticeable that the contours form a dome shape, with the gas features approximately centred on it.

The Kora prospect is associated with a volcanic plug, the top of which is at depths of over 1000 m. The discovery well, Kora-1, found oil on the flanks of the dome within the volcanics. Three subsequent Kora wells were less promising. There is no direct proof of shallow gas at the KORA area but the features seen on the seafloor and in the seismic records are very typical of shallow gas. The association of the shallow gas features with the location of the volcanic core is noticeable; the survey extends over 5 km from the centre of

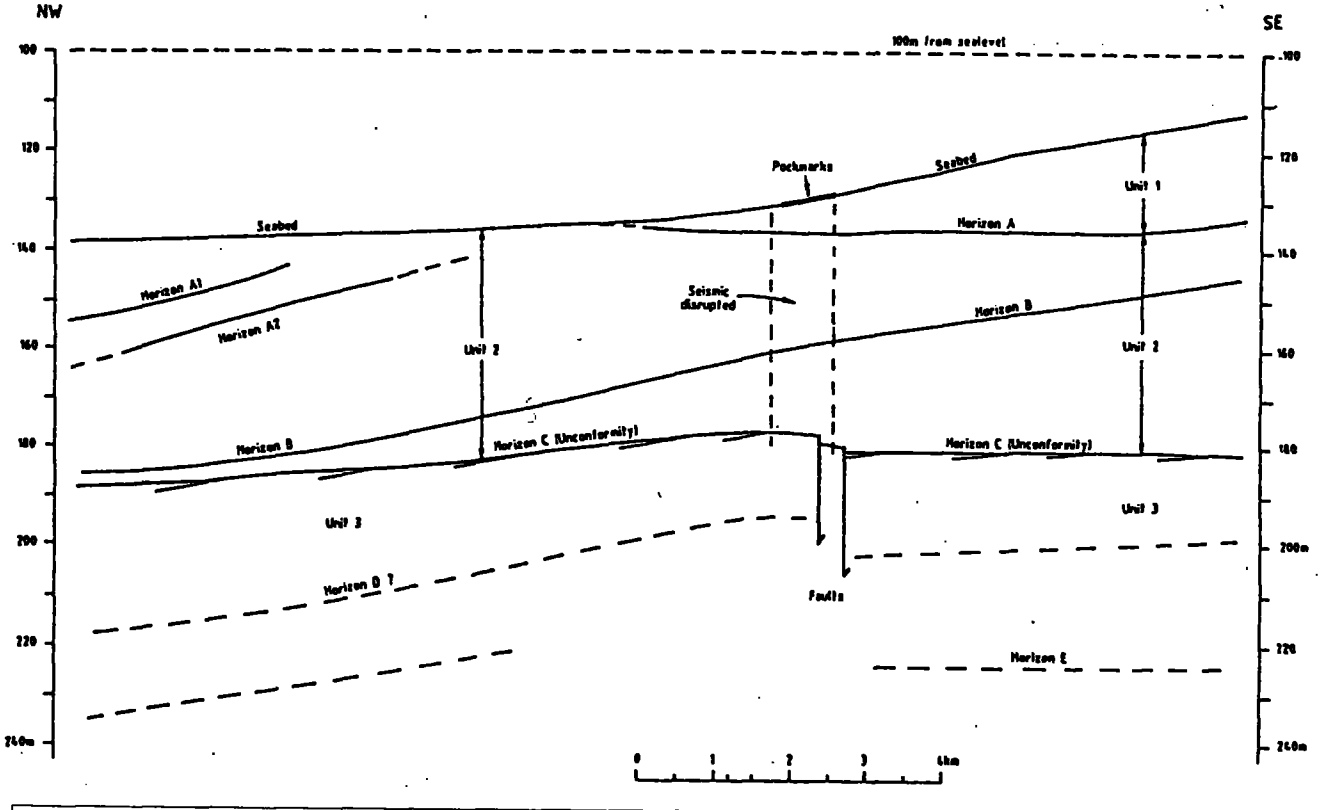


Figure 2: Cross-section through the Kora site, based on boomer seismic data.

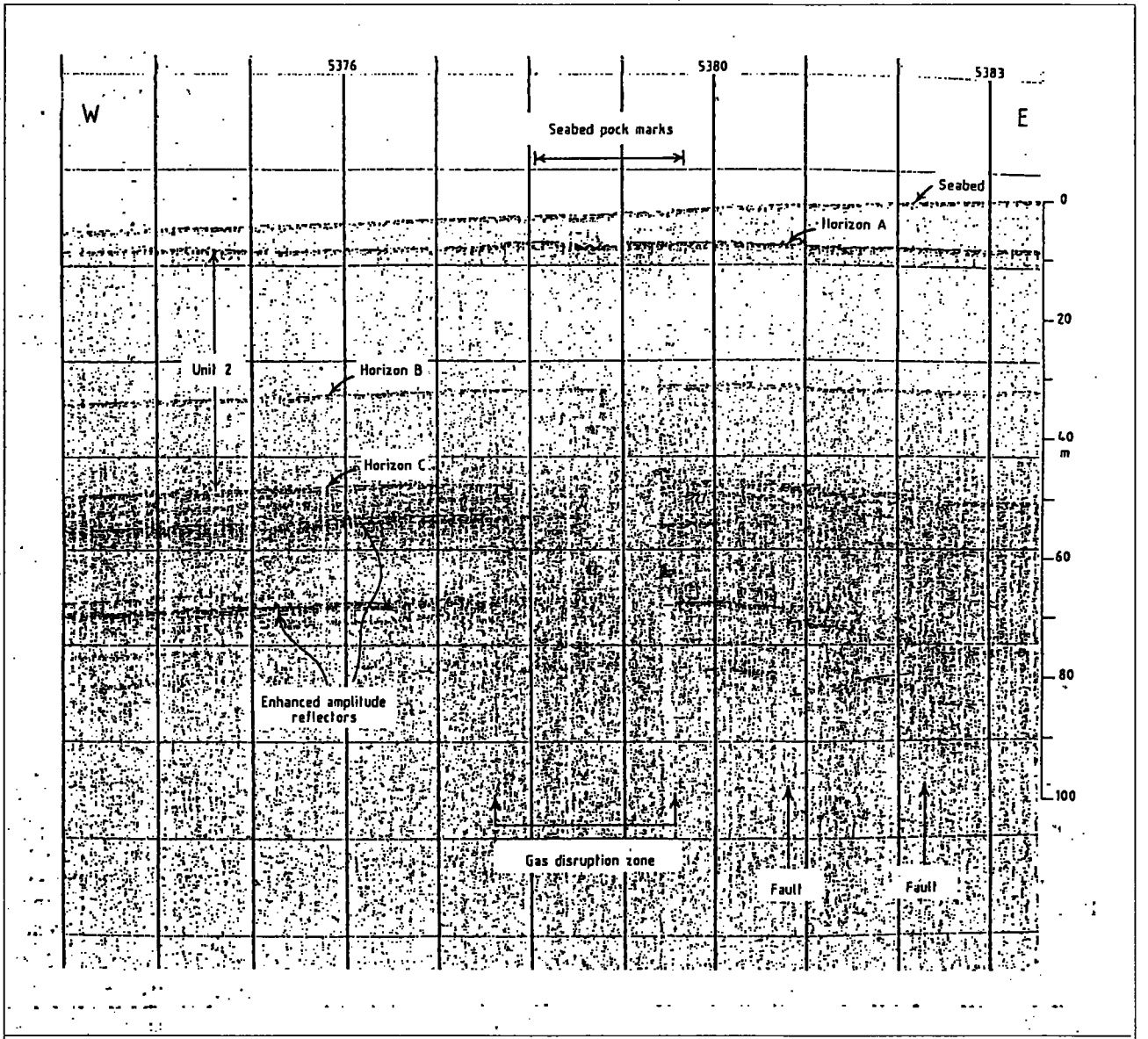


Figure 3: Boomer profile, Kora site.

the core and the gas features are only seen near the centre. The association with the shallow faults is interesting as it is known that faulting extends from near the surface to the reservoir depths.

Without direct sampling it is not possible to say whether the shallow gas would have originated at shallow depths through biogenic decay, or would have a deeper hydrocarbon source. However, the association of gas features with the centre of the reservoir volcanic plug, and with the faults, points to a deep hydrocarbon source rather than a shallow biogenic source. It therefore seems probable that the shallow gas features seen in the Kora site survey are associated with hydrocarbon gas generated at reservoir depths of more than 1000 m. The gas still is migrating to the surface, through the sediment section or preferentially up faults.

## Moki Area

The data discussed here is for the Moki-2 site. The Moki-2 well was drilled in 1985, subsequent to the site survey. The Moki-1 well, drilled in 1983, was located approximately 2 km to the north. Both wells had oil and gas shows. A third well (Maui-4) was drilled in 1969, approximately 10 km southwest of Moki-2 and also had oil and gas shows. The site survey work in 1984 involved work throughout the Moki-Maui-4 area but shallow gas only was found in the vicinity of the Moki-2 well.

The Moki-2 site survey extended over an area of approximately 4 km x 6 km with a line spacing of 200 m in one direction and 1000 m in the other. Prior to the site survey it was known from exploration seismic data that there were shallow gas anomalies at the Moki-2 site. In addition to surveying the shallow gas hazard the site survey multi-channel data was obtained to see if it would be possible to get useful seismic data to depths of 1000 m or so within the gas zone.

Figure 6 shows a multi-channel record across the shallow gas zone which illustrates several features typical of the site survey data. A distinct zone of disruption in the seismic records is evident and it extends to the seafloor. Anomalies in the reflectivity of the seafloor can be seen in the disrupted zone. In a wider area than the disrupted zone there are enhancements of horizons at approximately 45 m and 100 m subbottom, and these have phase changes associated with them. The boomer data, with penetration to approximately

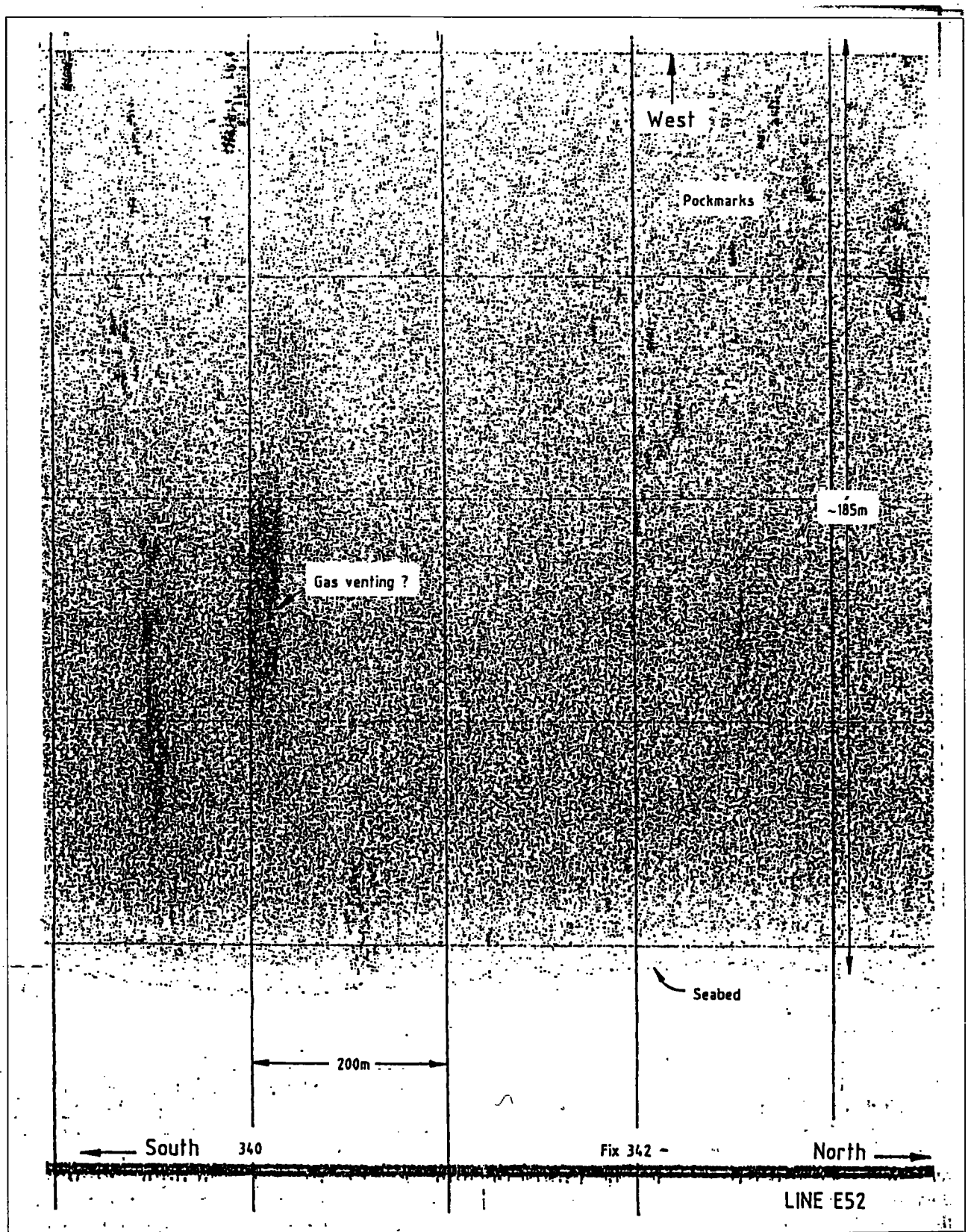


Figure 4: Sidescan sonar data, Kora site.

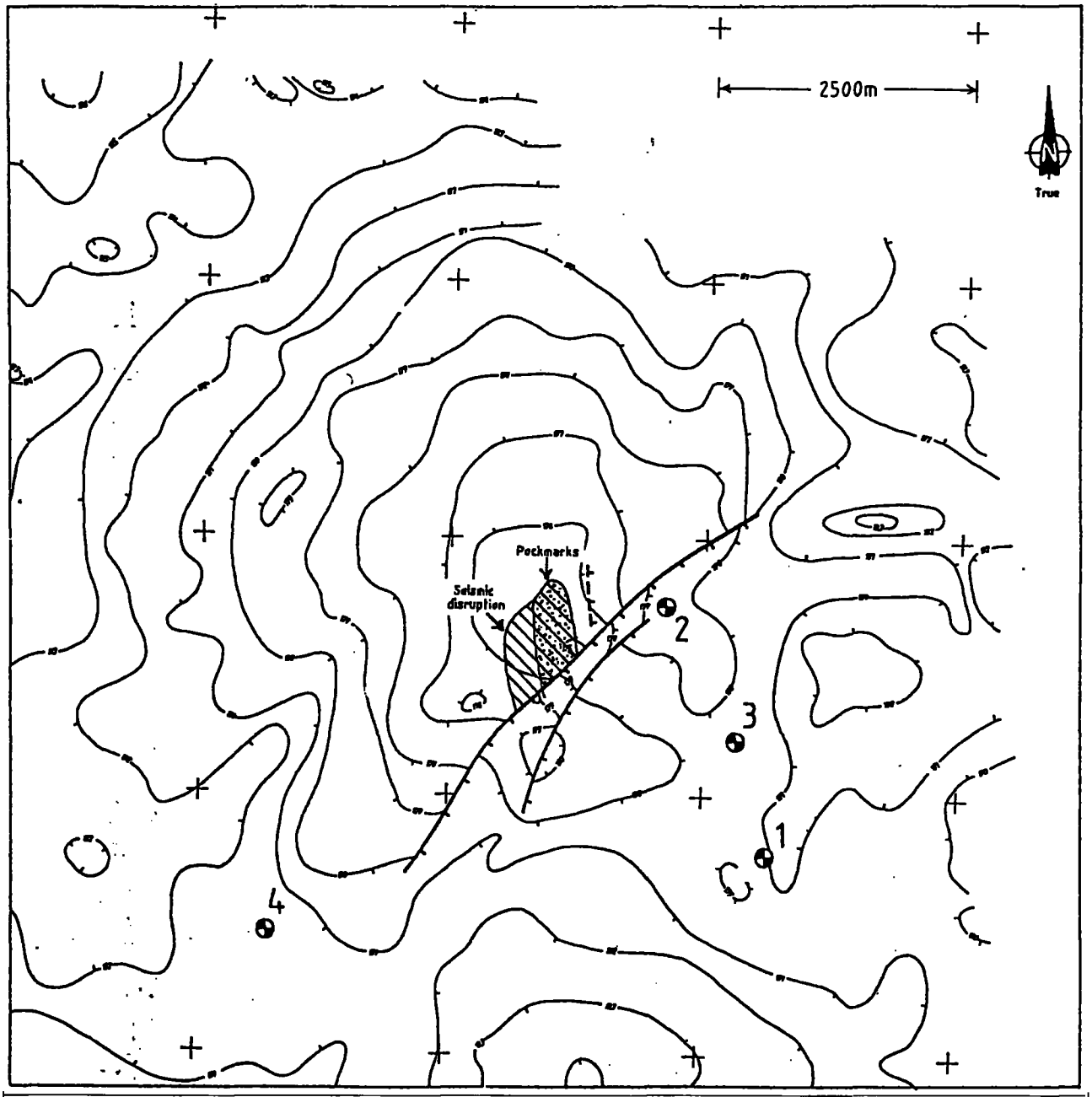


Figure 5: Kora site. Shallow gas features, and contours and faults on Horizon C which is approximately 50-60 m subbottom. The four Kora drill-sites are also shown.

100 m, show the same features as the multi-channel data. Some small bright spots and other disruptions are seen deeper in the section, but these are mostly point type features rather than features over a wide area.

Hollows are evident on the seafloor in echo sounder records (Figure 7). They are only 1 to 2 m deep, with diameters of up to a few hundred metres. On some records there are plumes above the hollows which may be gas bubbles within the water column. Sidescan sonar records show reflective patches on the seafloor which may be slight hollows, gas bubbles or changes in seabed reflectivity due to changes in sediment properties or biological colonies such as clams or tube worms which elsewhere in the world are seen associated with gas seeps.

When all the different seafloor features are mapped, they all lie within the zone of subbottom disruption identified in the seismic data (Figure 8). The coincidence of features points to a common origin. When the shallow features (i.e. those within the top 100 m subbottom) are superimposed on faults mapped at 1400 m subbottom one boundary of the gas features correlates with a fault. The two sets of data were mapped independently. Faults are known to extend from near the surface to the reservoir depths of Moki-2.

As at the Kora field there is no direct sampling evidence of gas seepage through the seafloor at Moki-2, but all the features seen are typical of gas features seen elsewhere. The gas may be biogenically produced at shallow depths, but the correlation with the deep faulting strongly suggests that the gas is hydrocarbon gas migrating up faults from the reservoir depths.

The Moki-2 well was drilled right through the centre of the shallow gas zone, although only after extensive discussion of the shallow gas data, and consideration of whether the exploration objectives could be met by drilling outside the gas zone. First a small pilot hole was drilled to a depth of approximately 500 m, with careful monitoring of returns.

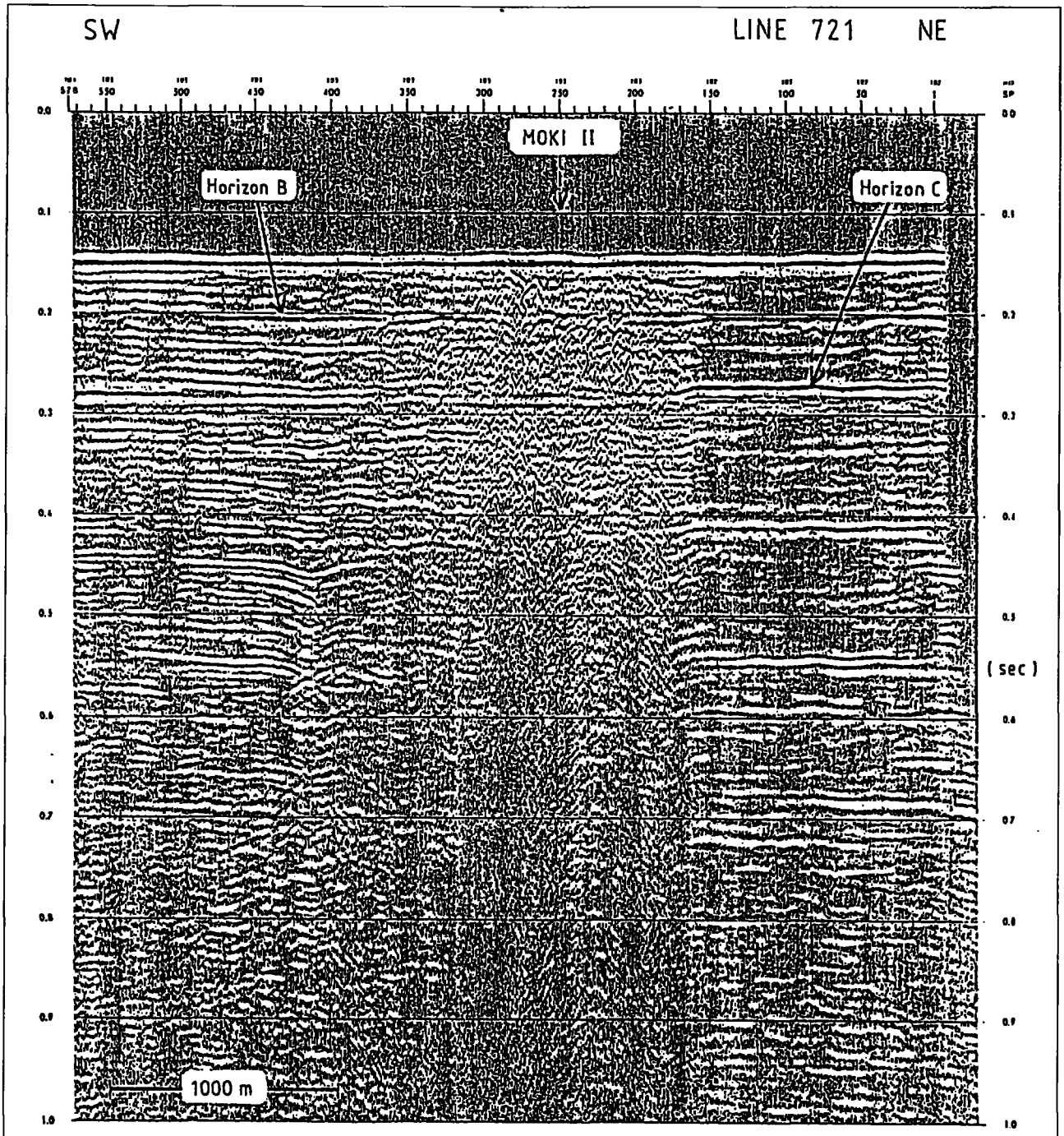


Figure 6: Moki-2 site; 24-channel sparker data showing gas disruptions of the seismic section, and enhanced amplitudes and phase changes on reflectors.

No gas was detected, and the primary hole was subsequently drilled without any problems. The pilot hole did encounter problems with hole collapse, and it is tempting to speculate whether the gas has had an impact on sediment properties.

## Conclusions

Site surveys at the Moki-2 and Kora prospects show features typical of shallow gas. These features include disruption of seismic reflection data, enhancement of amplitudes of reflection horizons, pock marks and other highly reflective patches on the seafloor, seafloor hollows, and probable gas venting into the water column. There is no direct sample evidence of the origin of the gas, but the relationships of the gas to known hydrocarbon prospects, and the fact that in both areas the gas is associated with faults which extend from the near surface to the reservoir depths, strongly suggests that the gas seen within the top 100 m subbottom is hydrocarbon gas which originated at depth and is still migrating to the surface.

The knowledge of the gas features obtained in the site surveys prior to the well-drilling, allowed detailed planning for the drilling operations, and both sites were safely drilled. In the case of the Moki site, directly through the shallow gas zone. In addition to the safety aspects of the site survey, the data obtained could also be used for foundation studies if production is subsequently developed at these locations.

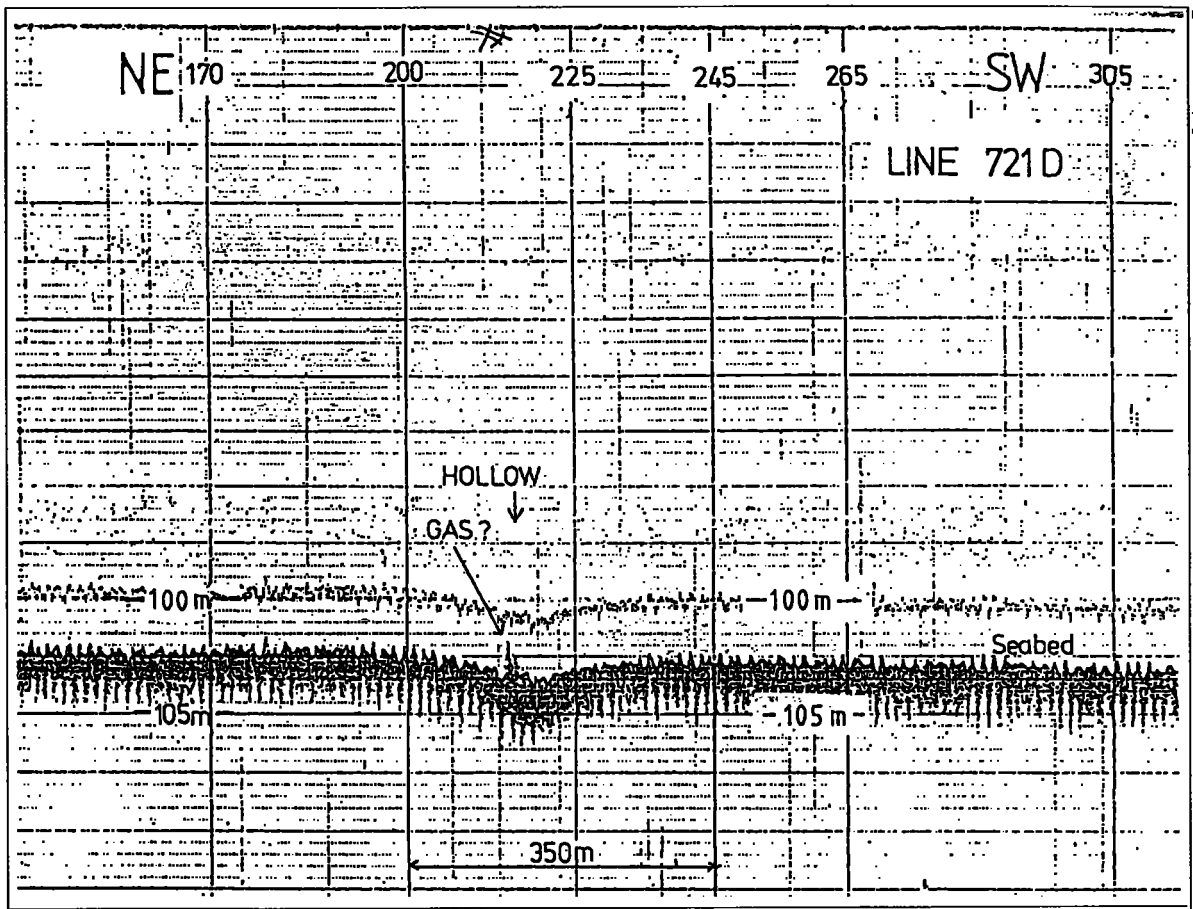


Figure 7: Moki-2 site. Profile showing a hollow and possible gas plume in the water column above it.

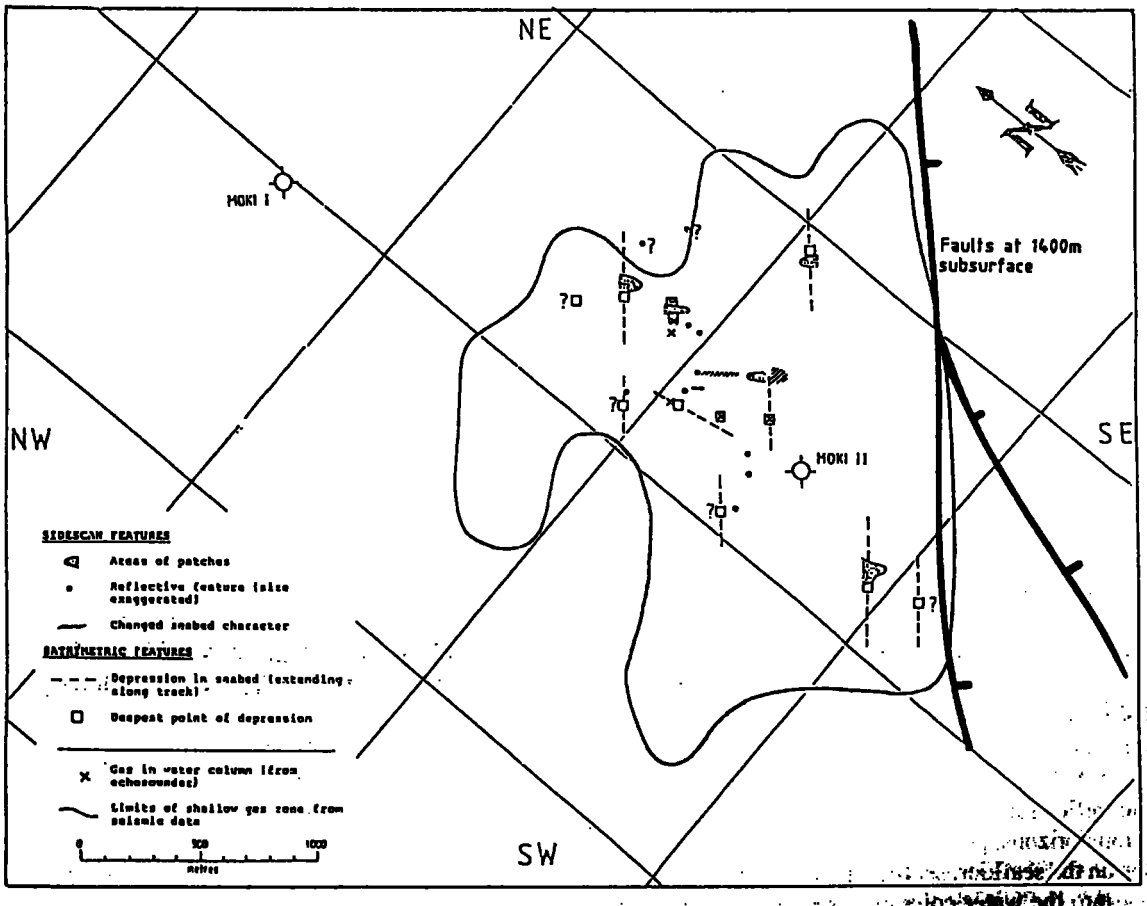


Figure 8: Moki-2 site. Seabed features, and the area of disruption and enhanced amplitudes in the top 100 m from seismic records. Faults at a depth of 1400 m subbottom are superimposed.

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