# Dinoflagellate cysts from the JAPEX/JNOC/GSC Mallik 2L-38 gas hydrate research well

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**Abstract:** Sparse occurrences of organic-walled dinoflagellate cysts were recorded from the JAPEX/JNOC/GSC Mallik 2L-38 gas hydrate research well, Mackenzie Delta area, Northwest Territories, Canada. Some of the recorded taxa are indicative of a Paleocene–Eocene age, while others are considered to be of Cretaceous origin. Because the deepest parts of the section are correlated to the Oligocene Kugmallit Sequence, all the dinoflagellate cysts are interpreted to be reworked. According to this interpretation, the total absence of in situ marine dinoflagellate cysts suggests that the studied samples were deposited under nonmarine conditions, most likely within a fluvial system.

**Résumé :** Des kystes peu abondants de dinoflagellés aux parois organiques sont présents dans le puits de recherche sur les hydrates de gaz JAPEX/JNOC/GSC Mallik 2L-38 foré dans la région du delta de Mackenzie, Territoires du Nord-Ouest, Canada. Certains taxons rencontrés remontent au Paléocène–Éocène, alors que d'autres seraient originaires du Crétacé. Lorsque les parties les plus profondes de la section sont mises en corrélation avec la Séquence de Kugmallit de l'Oligocène, tous les kystes de dinoflagellés sont interprétés comme ayant été remaniés. D'après cette interprétation, l'absence totale de kystes de dinoflagellés marins en place laisse supposer que les échantillons étudiés ont été déposés dans des conditions non marines, fort vraisemblablement dans un système fluvial.

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## INTRODUCTION

This is a contribution to the ongoing research program on methane hydrate with financial support from JNOC (Japan National Oil Corporation) and ten oil, gas, and electric companies in Japan. The program also received operational and scientific support from the Geological Survey of Canada and the United States Geological Survey.

Dinoflagellate cysts are organic-walled microfossils that provide biostratigraphic controls for marine strata of middle Triassic to Quaternary sedimentary rocks worldwide. Dinoflagellate cyst occurrences have been reported from a variety of marine settings ranging from estuaries and deltas to open marine conditions, and therefore are useful for detecting marine intervals in marginal settings. The aim of this study is the determination of the geological age, as well as the depositional environment, of the section penetrated by the JAPEX/JNOC/GSC Mallik 2L-38 gas hydrate research well in the Mackenzie Delta, Northwest Territories, Canada.

## MATERIAL AND METHODS

Twenty-two samples were obtained for this study. These included 15 core samples from the 892.51–949.21 m interval (from cores no. 14, 15, 18, 20, 23 and 24) (all depths were measured from kelly bushing [8.31 m above sea level]. Seven other samples were obtained from the 150–1150 m interval and were selected from drill cuttings that were studied primarily for free gas analysis. The seven cuttings samples were chosen because they are relatively rich in mud and/or shale (more than 50%). In this study, a single sample from the Iperk Sequence, 10 from the Mackenzie Bay Sequence, and 11 from the Kugmallit Sequence were obtained according to the stratigraphic subdivision devised by Dallimore et al. (1999) and Jenner et al. (1999). The core-sample depth is indicated by the mean depth in metres of each sampled interval.

The samples were processed using a standard palynological procedure which employs HCl and HF to eliminate mineral contents. To obtain higher concentrations of pollen, spores, and algal microfossils, the organic residues were weakly oxidized by acetolysis or by Schulze's reagent (a mixture of $KClO_4$ and $HNO_3$). The core samples were processed at the GSC, Calgary, and the cuttings samples were processed at the JAPEX Research Center, Chiba, Japan.

## RESULTS

The results of the dinoflagellate cyst study are shown in Table 1. Seven samples (from 150 m, 900 m, 921.39 m, 944.32 m, 941.61 m, and 949.21 m) were barren of dinoflagellate cysts and other algal microfossils. The other fifteen samples, from the Mackenzie Bay and Kugmallit sequences, yielded very few dinoflagellates and/or other algal microfossil specimens. The identified dinoflagellate taxa belong to two groups. The first group includes *Apectodinium homomorphum*, *Cordosphaeridium fibrospinosum*, *Glaphyrocysta divaricata*, *Glaphyrocysta exubarens*, *Lentinia serrata*, and several others. The reported stratigraphic ranges of these taxa fall within a Paleocene to Eocene interval (Eaton, 1976; Williams et al., 1993). This group occurred exclusively in the upper part of the Kugmallit Sequence between 945.21 and 948.16 m depth. The second group consists chiefly of *Chatangiella* spp., *Coronifera* sp., *Cribroperidinium edwardsi*?, *Exochosphaeridium phragmites*, *Luxadinium propatulum*, *Pseudoceratium* spp., and *Subtilisphaera* sp. These taxa are interpreted to have been derived from Middle to Upper Cretaceous strata. The latter group was recorded from a relatively long interval within the section, ranging through the Mackenzie Bay and Kugmallit sequences.

A few other organic microfossil taxa were recorded, including *Pterospermella* spp., *Tasmanites* spp., and *Micrhystridium* spp. These specimens are not age diagnostic. In addition, specimens of 'ovoid cyst' of Ioannides and McIntyre (1980) were common and occurred in the 500 m and 750 m sample interval of the upper part of the Mackenzie Bay Sequence.

## DISCUSSION AND CONCLUSIONS

All the recorded dinoflagellate specimens from the Mallik 2L-38 well are considered to be of Eocene age or older. If the deepest part of the section is correlated with the Oligocene Kugmallit Sequence, as indicated by Dallimore et al. (1999) and Jenner et al. (1999), then all of these dinoflagellate cysts indicate sediment reworking. According to this interpretation, the total absence of in situ marine dinoflagellate cysts suggests that the studied samples were deposited under nonmarine conditions, most likely within fluvial systems. The high numbers of cuticles and other membranous tissues from higher-order plants, which were observed throughout the palynological residues in this study, also supports this interpretation, as these components are known to be abundant in sediments exclusively deposited in the nonmarine realm (Batten, 1996).

The similarity between the Paleocene–Eocene cyst group and the assemblages reported from the Taglu Sequence (Early to Middle Eocene) in the western Beaufort Sea (Dietrich et al., 1989) have led to the interpretation that the specimens in the Mallik 2L-38 well section may have been reworked from the Taglu Sequence. According to Ioannides and McIntyre (1980), their 'ovoid cyst' was common in the 'Interval A' of the Campanian Caribou Hills outcrop along the Mackenzie River. The same morphotype was found in the upper part of the Mackenzie Sequence at the Mallik 2L-38 locality and may have been derived from the Upper Cretaceous strata in the provenance area.

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**Table 1.** Dinoflagellate cysts from the JAPEX/JNOC/GSC Mallik 2L-38 gas hydrate research well.

| ← upsection | | Depths of formation contacts after Dallimore et al. (1999) and Jenner et al. (1999) | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 346 m | | | | | | | | | | 926.5 m | | | | | | | | | |
| **Dinoflagellate cysts (Marine palynology)** | **Sequence** | **Iperk** | **Mackenzie Bay** | | | | | | | | | | **Kugmallit** | | | | | | | | | |
| **JAPEX/JNOC/GSC MALLIK 2L-38** | **Sample depth in m** | **150 ctg** | **500 ctg** | **750 ctg** | **892.5 cc 14** | **896.7 cc 15** | **897.3 cc 15** | **900 ctg** | **900.6 cc 15** | **903.8 cc 18** | **905.7 cc 18** | **921.3 cc 20** | **935.7 cc 23** | **937.3 cc 23** | **944.3 cc 24** | **945.2 cc 24** | **946.2 cc 24** | **947.6 cc 24** | **948.1 cc 24** | **949.2 cc 24** | **970 ctg** | **1050 ctg** | **1150 ctg** |
| | **Sample Core no.** | | | | | | | | | | | | | | | | | | | | | | |
| | | barren | | | | | | barren | | | | barren | | | barren | | | barren | | barren | | barren | |
| **Paleocene - Eocene cysts** | | | | | | | | | | | | | | | | | | | | | | | |
| *Apectodinium* | *homomorphum* | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Cordosphaeridium* | *fibrospinosum* | | | | | | | | | | | | | | | | | | 1 | | | | |
| *Deflandrea* | sp. indet. | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Glaphyrocysta* | *divaricata* | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Glaphyrocysta* | *exubarens* | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Hystrichokolpoma*? | sp. | | | | | | | | | | | | | | | 1 | | | | | | | |
| *Lentinia* | *serrata* | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Spiniferites* sp. cf. | *pseudofurcatus* | | | | | | | | | | 1 | | | | | | | | | | | | |
| **Cretaceous cysts** | | | | | | | | | | | | | | | | | | | | | | | |
| *Chatangiella* | spp. | | 1 | | | 1 | | | | | | | | 2 | | | 1 | | 1 | | | | |
| *Circulodin*ium? | sp. | | | | | 1 | | | | | | | | | | | | | | | | | |
| *Coronifera* | sp. | | | | | | | | | | | | | 1 | | | | | | | | | |
| *Cribroperidinium* | *edwardsi* ? | | | | | | | | | | | | | | | | | | 1 | | | | |
| *Exochosphaeridium* | *phragmites* | | | | | | | | | | | | | | | | 1 | | | | | | |
| *Isabelidinium* | spp. | | 1 | 3 | | | | | | | | | | 1 | | | | | | | | | 2 |
| *Luxadinium* | *propatulum* | | | | | | | | | | | | | 2 | | | | | | | | | |
| *Oligosphaeridium* | spp. | | | | 1 | 1 | | | | | | | 1 | 2 | | | | | | | | | |
| *Palaeoperidinium* | sp. | | | | | | | | | | | | | 2 | | | | | | | | | |
| *Pseudoceratium* | sp. | | | | | 1 | | | | | | | | 5 | | | | | | | | | |
| *Spinidinium* | sp. | | | | | | | | | | | | | 1 | | | | | | | | | |
| *Subtilisphaera* | sp. | | | | | | | | | | | | | 1 | | | | | | | | | |
| **Other algal microfossils** | | | | | | | | | | | | | | | | | | | | | | | |
| 'ovoid cysts' of Ioannides and McIntyre (1980) | | | 49 | 36 | | | | | | | | | | | | | | | | | | | |
| *Pterospermella* | spp. | | | | | | | | | 1 | | | | 1 | | | | | | | | | |
| *Tasmanites* | spp. | | | | | | | | 1 | | | | | | | | | | | | | | |
| *Micrhystridium* | spp. | | | | | | 1 | | | 1 | | | | | | | | | | | 1 | | |

cc – core sample; ctg – cuttings sample

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