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PETROLEUM RESOURCE POTENTIAL IN THE PROPOSED AREA OF GWAII HAANAS/ SOUTH MORESBY NATIONAL PARK, BRITISH COLUMBIA

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SUMMARY

The proposed area of Gwaii Haanas/South Moresby National Marine Park Reserve includes the inter-island areas of the southern Queen Charlotte Islands archipelago and some 10 to 15 km of adjacent offshore areas of Hecate Strait and the Pacific Ocean. Petroleum geology studies of the region indicate that most of the proposed marine park area has low petroleum resource potential (rating categories 5, 6 and 7, Table 1, Fig. 5). The lack of significant oil or gas resource potential is due to the widespread over-maturation of potential petroleum source rocks and the limited distribution of potential reservoir strata.

Two small areas within the easternmost part of the proposed park area (in Hecate Strait) are considered to have moderate to high petroleum potential (rating category 3, Fig. 5). These areas occur along the Sandspit Fault, a major north- to northwest-trending Tertiary fault zone, located 10 to 15 km offshore. The enhanced petroleum prospectivity along the fault zone (and in areas to the northeast) is due to the presence of large anticlinal structures, thicker Tertiary reservoir sections and more favourable source rock conditions.

INTRODUCTION

A national marine park reserve is planned for the southern Queen Charlotte Islands area, British Columbia. Canadian Parks Service completed work in 1986 to define the South Moresby Marine Park area of interest and in 1988 this area became part of a comprehensive agreement for establishment of Gwaii Haanas/ South Moresby National Marine Park Reserve. The proposed marine park encompasses the inter-island areas of the southern Queen Charlotte archipelago and some 10 to 15 km of adjacent offshore areas of the Pacific Ocean and southwestern Hecate Strait (Figs. 1, 5).

Exploitation of mineral and energy resources is prohibited within Canada's national parks and, as a result, assessments of resource potential are considered before park boundaries are finalized. This open file report reviews the petroleum potential of the Gwaii Haanas/South Moresby marine park area. The study area for the petroleum assessment encompasses the southern Queen Charlotte Islands and adjacent parts of Hecate Strait and the Pacific Ocean (Fig. 1).

PREVIOUS WORK

Mineral Assessments

Mineral potential and other natural resources were considered in establishing the terrestrial portion of Gwaii Haanas/South Moresby National Park Reserve (South Moresby Resource Planning Team, 1983). An assessment of mineral, coal and geothermal resource potential of the marine park area was completed by Jefferson and Schmitt (1992). They identified large domains of high mineral potential within the proposed park area and recommended further studies and a more detailed mineral assessment.

Petroleum Assessments

An initial (unpublished) report on petroleum potential in the marine park area was prepared by Morrell and Fortier (1987). Subsequent accounts of petroleum potential were included in (unpublished) reports by Schmitt et al. (1987) and Dietrich et al. (1989), for the Pacific and Hecate Strait sectors of the park area, respectively. These initial assessments identified the petroleum potential as low in the Pacific offshore and variable (low to high) in the Hecate Strait area.

Petroleum Exploration

No onshore petroleum exploration wells have been drilled on the southern Queen Charlotte Islands. Nine wells have been drilled on Graham Island, north of the study area (Fig. 1). Shell Canada Ltd. drilled eight offshore wells in Hecate Strait and Queen Charlotte Sound in 1968 and 1969. The offshore wells drilled in southwestern Hecate Strait (within the study area) included Auklet G-41, Murrelet L-15 and Sockeye B-10 and E-66 (Fig. 3). No significant oil or gas accumulations were discovered in any of the onshore or offshore wells. The most encouraging hydrocarbon show encountered in the wells drilled to date occurred in the Sockeye B-10 well, which penetrated a 50 m section of oil-stained Tertiary sandstones. Marine seismic reflection data were collected in Hecate Strait by Shell Canada Ltd (in 1967-68) and Chevron Canada (in 1971) and in the Pacific sector of the study area by Texaco Canada Inc. (in 1972).

Petroleum companies holding principal interests in federal exploration permits located partially or wholly within the proposed park area include Shell Canada Ltd., Petro-Canada Resources, Chevron Canada Resources Ltd and Mobil Oil Canada (Fig. 5). No exploration permits exist on the Pacific side of the southern Queen Charlotte Islands.

A moratorium on offshore petroleum exploration in Hecate Strait and Queen Charlotte Sound was imposed by the federal government in 1971 and is still in effect. If the moratorium is lifted, petroleum companies are likely to undertake new seismic surveys and further exploratory drilling in Hecate Strait and Queen Charlotte Sound. Future exploration is unlikely to occur west of the Queen Charlotte Islands due to limited petroleum potential and adverse physical conditions (deep water, unstable seafloor slopes and earthquake hazards).

Geological Studies

Numerous papers have been published on geological and geophysical studies in the Queen Charlotte Islands region. Early publications included

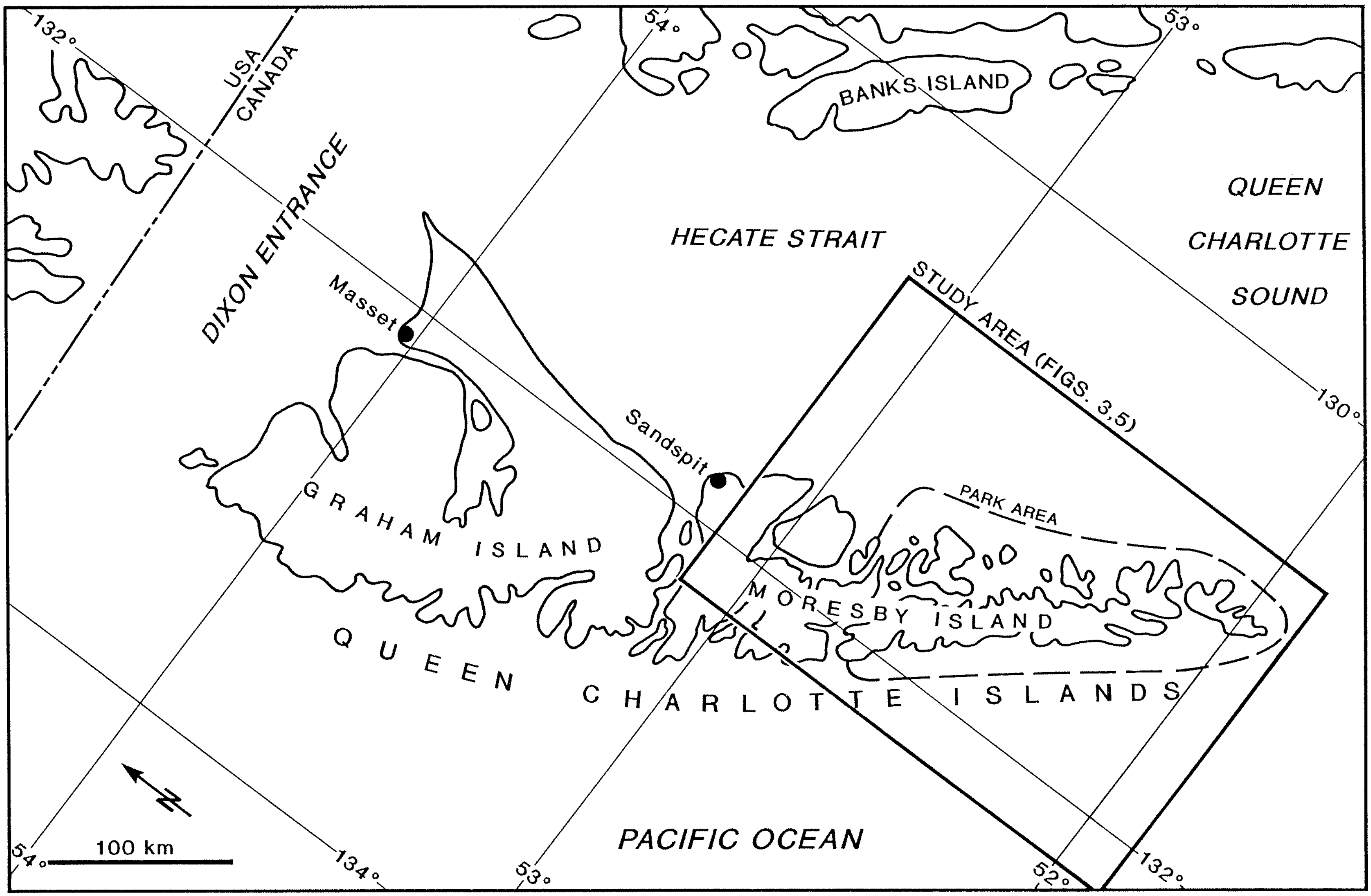

FIGURE 1. LOCATION OF MARINE PARK STUDY AREA

the onshore mapping of Sutherland Brown (1968) and onshore-offshore studies of Shouldice (1971) and Yorath and Hyndman (1983).

In 1987, an extensive basin analysis program in the Queen Charlotte Islands region was initiated through the Geological Survey of Canada's Frontier Geoscience Program (FGP). Much of the new data and interpretations from the FGP program have been published in papers (by various authors) in Geological Survey of Canada Current Research volumes (1988-1E, 1989-1H, 1990-1F, 1991-1A and 1992-1A), an FGP synthesis volume (Woodsworth, 1991), and a summary paper (Lewis et al., 1991). The FGP program included the acquisition of 1000 km of deep seismic reflection data in Hecate Strait and Queen Charlotte Sound (Rohr and Dietrich, 1990). Segments of some of the FGP seismic lines occur close to (but not directly in) the proposed park area.

Other important papers relevant to this petroleum assessment include the geochemical-based studies of Fowler et al.(1988), Hamilton and Cameron (1989), Vellutini et al. (1990) and Vellutini and Bustin (1990).

GEOLOGICAL SETTING

The Queen Charlotte region lies within the Insular Belt, on the westernmost edge of the North American continental plate. The region evolved in a continental margin setting through Mesozoic and Cenozoic time, with a depositional and structural history closely linked to plate margin tectonics. A diverse assemblage of Triassic through Tertiary sedimentary, volcanic and plutonic rocks are preserved in the Queen Charlotte Islands and adjacent Hecate Strait area. The following brief stratigraphic and structural summary is taken from Lewis et al. (1991), to which the reader is referred for more detailed information.

Triassic-Lower Jurassic

The oldest unit exposed on the southern Queen Charlotte Islands is the Triassic Karmutsen Formation, consisting of 4000 m of metamorphosed basic volcanic rocks (Fig. 2). The Karmutsen Formation has no petroleum source or reservoir potential and is considered as "basement" for petroleum exploration in the region. Conformably overlying the Karmutsen volcanic rocks are up to 1000 m of Upper Triassic-Lower Jurassic limestones and shales of the Kunga and Maude groups. The Karmutsen, Kunga and Maude rocks are volcanic arc and back-arc assemblages, all of which were deformed during a period of Middle Jurassic contractional deformation.

Middle-Upper Jurassic

Pre-Middle Jurassic rocks are unconformably overlain by several hundred metres of Middle Jurassic volcanic and volcaniclastic rocks of the Yakoun Group. Yakoun arc volcanism was succeeded by igneous intrusion of the Late Jurassic Burnaby Island Plutonic Suite (BIPS). Subsequent Late Jurassic uplift produced differential erosion/preservation of Yakoun and older rocks.

Cretaceous

Unconformably or nonconformably overlying Jurassic and Triassic rocks are up to 2000 m of Cretaceous strata, consisting of sandstone, conglomerate and shale of the Longarm Formation and Queen Charlotte Group (Fig. 2). Cretaceous sedimentary strata were deposited in marine shelf/slope environments during a period of relative tectonic stability. The coarse clastics at the base of the succession were deposited along northwest-aligned, northeastward-transgressing shorelines. Cretaceous (and older) rocks were deformed and folded during a late Cretaceous tectonic event, synchronous with local deposition of Upper Cretaceous volcanic rocks.

Tertiary

The Mesozoic succession is unconformably overlain by up to 6000 m of Tertiary volcanic and sedimentary rocks that comprise the fill of the Queen Charlotte Basin (Fig. 2). Tertiary basin formation began after a tectonic shift from convergent to transtensional plate margin interactions in the Late Eocene, leading to the development of fault-bounded subbasins. The Tertiary section includes up to 1000 m of (unnamed) Eocene-Oligocene volcanic and sedimentary deposits. Eocene-Oligocene deposition

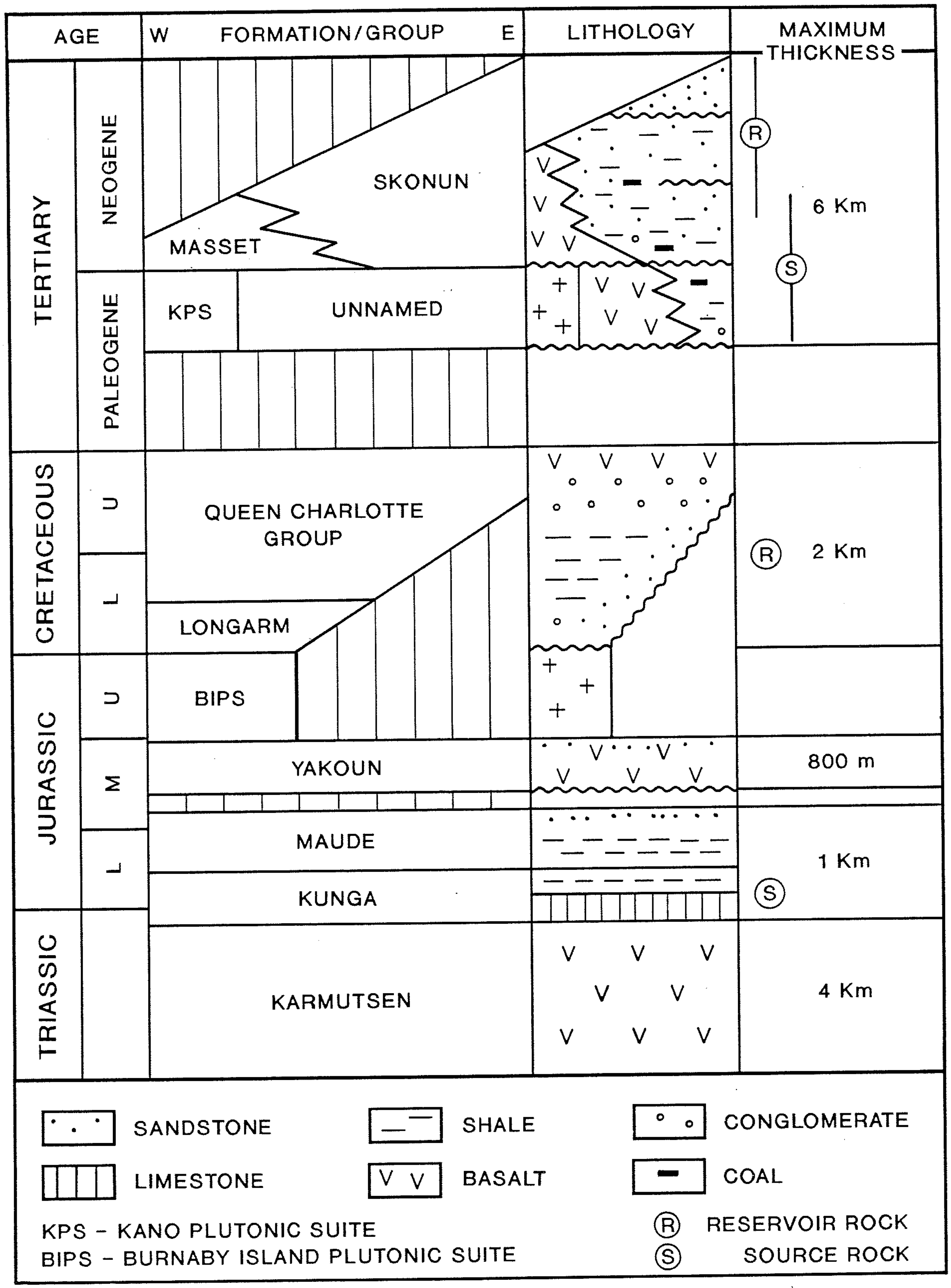

FIGURE 2. COMPOSITE STRATIGRAPHIC COLUMN

was coeval with local intrusion of plutons and associated dyke swarms of the Kano Plutonic Suite (KPS). Paleogene rocks are unconformably overlain by Neogene volcanic (Masset) and sedimentary (Skonun) rocks that attain cumulative thicknesses of up to 5000 m in offshore areas. A Late Neogene shift to transpressional Pacific-North America plate interactions resulted in local folding, fault inversions and uplift and erosion of parts of the Tertiary basin fill.

MORESBY PARK AREA GEOLOGY

The complex tectonic and magmatic history of the region produced highly variable distributions, thicknesses and thermal maturation levels of sedimentary strata (that may constitute petroleum source or reservoir rocks) within the region. A geological map of the study area (Fig. 3) illustrates generalized outcrop patterns, offshore isopachs of Tertiary deposits, major onshore and offshore faults and folds, and sites of local hydrocarbon shows and organic maturation measurements.

Onshore/Inter-island

With the exception of Skonun strata, all of the Mesozoic/Cenozoic units outcrop in the southern Queen Charlotte Islands. From southwest to northeast, the large-scale outcrop patterns outline northwest-trending belts of plutonic rocks, Triassic-lower Jurassic volcanic and sedimentary rocks and Tertiary volcanic rocks. Northwest-aligned belts of Cretaceous sedimentary and Yakoun volcanic rocks outcrop on northeastern Moresby Island. Variable outcrop patterns occur on the easternmost islands of the archipelago.

Major onshore and inter-island structural features include the northwest-trending Louscoone and Dawson Cove fault systems. The Dawson Cove Fault is a Mesozoic block fault, reactivated as a Tertiary contractional fault (Thompson et al., 1991). The Louscoone fault system consists of Tertiary dextral strike-slip faults (Lewis, 1991). The north end of the Louscoone fault system terminates obliquely against the Dawson Cove Fault.

Pacific Offshore

Projections of coastal outcrops and gravity and seismic data indicate that the narrow continental shelf and upper slope west of Moresby Island is underlain by Jurassic and Tertiary plutonic rocks and Karmutsen volcanic rocks (Riddihough and Hyndman, 1989). The igneous rocks are structurally truncated at the Queen Charlotte transform fault zone, located beneath the continental slope, some 5 to 10 km offshore (Fig. 3). The Queen Charlotte Fault marks the present day, right-lateral transform boundary between the Pacific and North American plates. Within the transform fault zone, sedimentary strata (up to 2 to 3 km thick) occur locally within narrow, fault-bounded basins (the synclinal axis of one such basin is illustrated in Fig. 3). West of the Queen Charlotte fault zone, a 2 to 5 km thick prism of folded sedimentary strata occurs beneath the Queen Charlotte Terrace (Chase et al., 1975; Davis and Seemann, 1981; Hyndman and Hamilton, 1991). The Queen Charlotte fault zone basins and sedimentary terrace occur beneath water depths of 500 to 2000 m and contain upper Tertiary and Quaternary turbidite deposits.

Hecate Strait

East of the Queen Charlotte Islands, Tertiary rocks thicken eastward into the Hecate Strait area (Fig. 3). The bulk of the offshore Tertiary succession consists of Miocene sedimentary strata of the Skonun Formation. The (western) erosional edge of Skonun strata occurs 2 to 10 km east of the Queen Charlotte Islands. A substantial portion of the Tertiary basin fill occurs within half-grabens, locally up to 6 km deep. The half-grabens and bounding extensional faults are northwest-, north- or northeast-trending.

A major structure beneath Hecate Strait is the Sandspit Fault, a north to northwest-trending oblique-slip fault, subparallel to the Queen Charlotte and Louscoone fault systems. In many areas, the Sandspit fault forms the southwestern boundary of thick (> 2 km) Tertiary basin fill. The fault also forms a boundary between crustal blocks with contrasting (sub-Tertiary) density structures and thicknesses (Sweeney and Seemann, 1991).

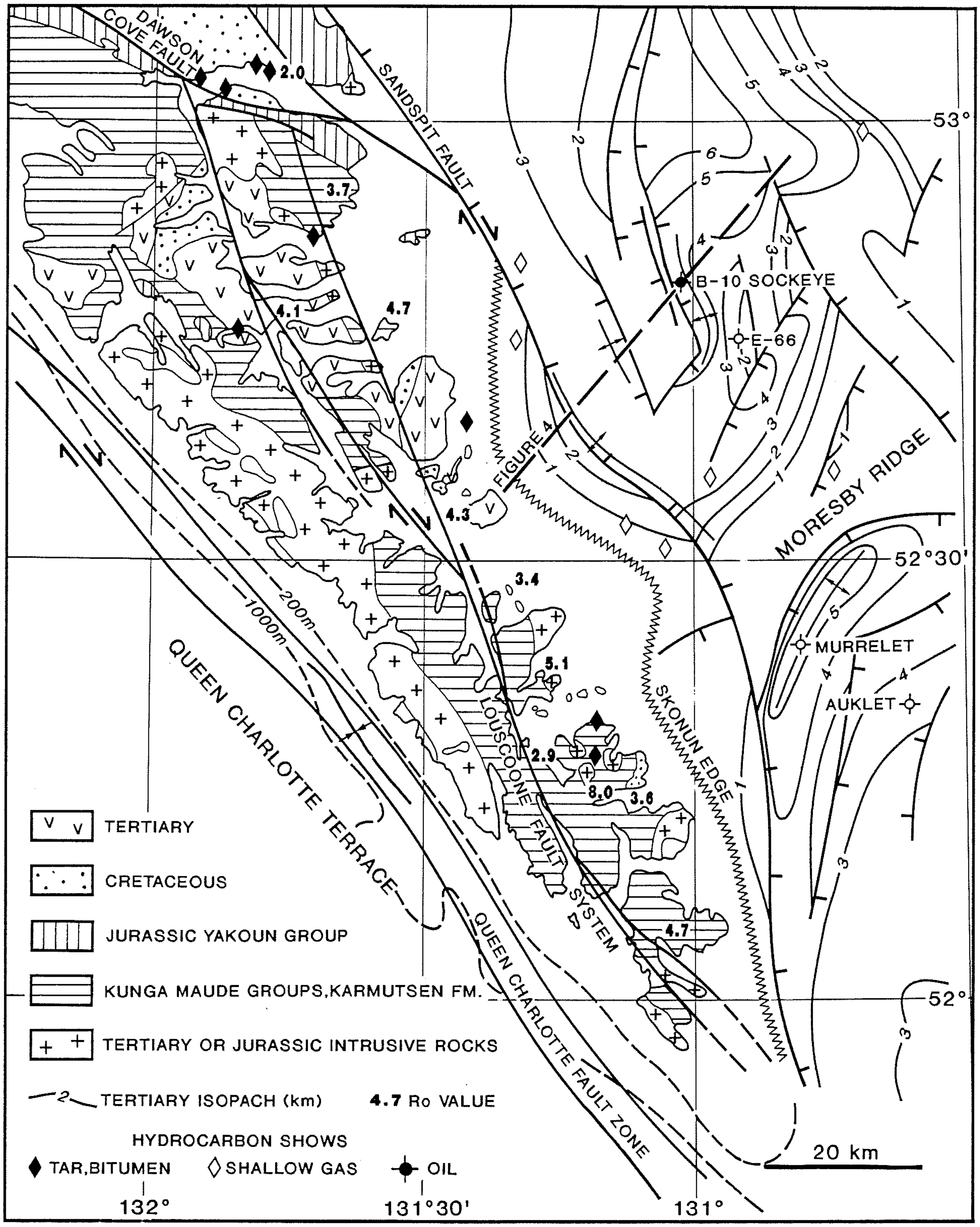

FIGURE 3. GEOLOGY OF MORESBY ISLAND - WESTERN HECATE STRAIT AREA

The Moresby Ridge is a northeast-trending asymmetric basement high, with northeast- and southeast-side fault margins. Similar to structural relationships observed onshore along the Louscoone fault system (Lewis, 1991), the development of northeast-trending, extensional structures in the Moresby Ridge area may be related to right-lateral shear on the Sandspit and other northwest-trending faults.

Other offshore structures include intra-Tertiary folds adjacent to the Sandspit and other faults. These folds are Pliocene inversion structures, associated with reverse fault reactivations of pre-existing extensional faults.

Interpretations of Tertiary and Mesozoic geology beneath southwestern Hecate Strait (derived from seismic data and outcrop projections) are illustrated in Figure 4. The northeastward thickening of Tertiary basin fill is accommodated by expansion of upper Eocene to Miocene sections across half graben-bounding faults (including the Sandspit Fault) and progressive basinward preservation and expansion of upper Miocene-Pliocene strata. Volcanic rocks occur in some (but not all) of the Tertiary half grabens. The Tertiary section contains unconformities of (?)Early and Late Miocene age. The Tertiary basin fill and underlying Mesozoic rocks are cut by numerous, variably dipping faults, with both extensional and contractional phases of displacement. Late Pliocene deformation produced folds, fault inversions and uplift and erosion. Tertiary strata have been eroded to progressively deeper stratigraphic levels in a southwesterly direction, with Eocene-Oligocene volcanic rocks occurring at or near the seafloor at the end of the cross-section. Outcrop and potential field data indicate that igneous intrusive rocks occur in abundance and at relatively shallow depths within the crustal block southwest of the Sandspit Fault (Sweeney and Seemann, 1989; Lyatsky, 1991).

PETROLEUM GEOLOGY

Reservoirs

Cretaceous and Tertiary sandstones and conglomerates are potential petroleum reservoirs in the southwestern Hecate Strait area. The best quality Cretaceous reservoir rocks occur in the basal transgressive facies (Fig. 2). Basal Cretaceous sandstones and conglomerates are up to 180 m thick, with porosity locally exceeding 15 % in outcrop on northern Moresby Island (Fogarassy et al, 1989). Paleogeographic reconstructions and projections of onshore trends indicate the Cretaceous transgressive facies was probably deposited (and locally preserved) within a southeast-trending belt extending from northern Moresby Island through the southwestern Hecate Strait area (Haggart, 1991, pers comm. 1992). The Sockeye B-10 well penetrated (?)Cretaceous sandstones below 4300m (Fig. 4). Although these sandstones have very low porosity, Cretaceous strata at shallower depths (in nearby areas) may have better reservoir qualities.

Tertiary strata consist of interbedded sandstone, conglomerate, shale and coal, deposited in a wide range of environments, including alluvial fan, fan delta, delta-plain, and tidal-shelf settings (Higgs, 1991). Tertiary sandstones and conglomerates with reservoir potential are volumetrically more abundant than Cretaceous reservoir strata. Skonun sandstone beds are up to tens of metres thick and have excellent porosity (20 % to 35%) and fair to good permeability (30 to 300 md) above 2000 m depth. Porosity within the Skonun and older Tertiary sandstones decreases progressively with depth, to average values of 10% to 20% between 2000 m and 3000 m and less than 10% below 3000 m. The low porosity and permeability in Tertiary sandstones and conglomerates below about 3000 m depth significantly reduces reservoir potential.

Source Rocks

Upper Triassic-Lower Jurassic limestones and shales within the Kunga and Maude groups (Fig. 2) contain abundant Type I and II organic matter (up to 11 % TOC) and (under suitable maturation conditions) have good to excellent oil source potential (Macauley, 1983; Vellutini et al., 1990). The Neogene Skonun Formation and (unnamed) Paleogene strata contain numerous coal beds, with fair to good gas and oil source potential (Fowler et. al., 1988; Vellutini et. al. 1990). Shales within the Tertiary succession contain small to moderate amounts of Types II and III organic matter (up to 2.5 % TOC) and have fair gas and oil source potential (Vellutini et. al., 1990).

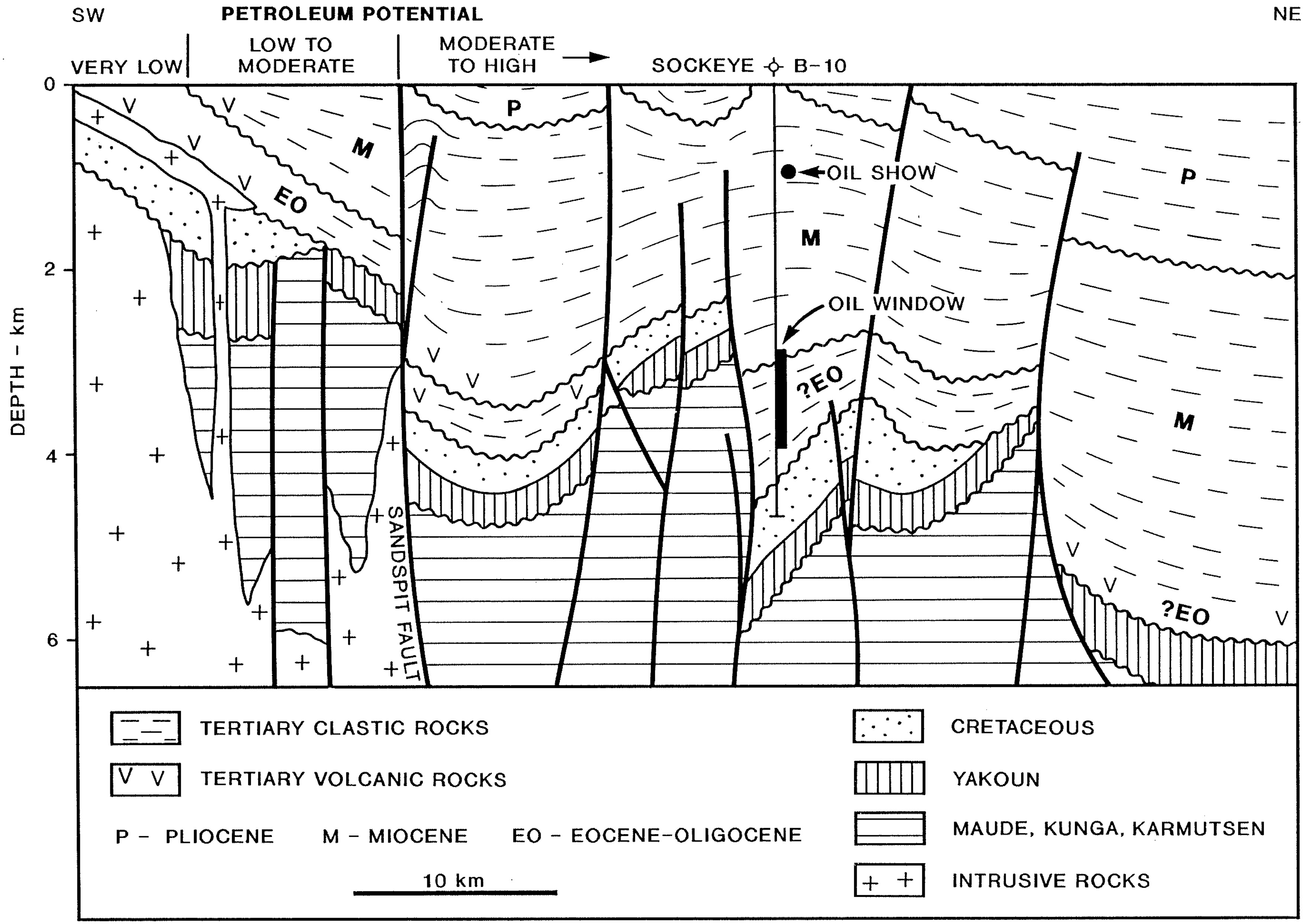

FIGURE 4. GEOLOGICAL CROSS-SECTION, WESTERN HECATE STRAIT

Onshore bitumen and tar occurrences (Fig. 3) were sourced from Upper Triassic-Lower Jurassic and Tertiary strata (Fowler et. al., 1988; Hamilton and Cameron, 1989; Snowdon et al., 1989). Most of the onshore oil shows appear to be associated with local oil generation associated with igneous-related heating. There is some geochemical evidence that suggests the oil show in the offshore Sockeye B-10 well (Figs. 3, 4) was sourced from Jurassic Kunga Group strata (M.G. Fowler, pers. comm., 1991). Shallow gas occurrences within Quaternary sediments beneath Hecate Strait (identified from seismic records; Fig. 3) were probably sourced from Tertiary strata (Barrie, 1988).

Onshore maturation data indicate that potential Upper Triassic-Lower Jurassic source rocks in the southern Queen Charlotte Islands (south of the Dawson Cove Fault) are overmature with respect to petroleum generation windows (Vellutini and Bustin, 1990; Orchard and Forster, 1991). Most vitrinite reflectance measurements of organic matter (Ro values, Fig. 3) are above 3.0 % Ro, beyond the gas preservation limit. The high levels of organic maturation in the southern Queen Charlotte Islands resulted from high heat flow associated with Jurassic and Tertiary plutonism and volcanism. In contrast to the overmature state of Mesozoic strata onshore, data from the four offshore wells in the study area (Auklet, Murrelet and Sockeye B-10 and E-66, Fig. 3) indicate a substantial portion of the Tertiary sedimentary basin fill is characterised by immature to mature levels of organic maturation, with maturation gradients largely reflecting burial-related heating (Yorath and Hyndman, 1983; Bustin et al., 1990; Bustin, pers comm., 1992). Maturation data from the Sockeye B-10 well (the deepest of the four wells) indicate the present day oil window occurs within Tertiary strata, at depths from about 2700 to 3700 m (Fig. 4).

Traps

Although specific petroleum prospects cannot be mapped from available data in the study area, a range of possible trap types is apparent from surface mapping and seismic profiles. Broad anticlines are common within Cretaceous strata and locally encompass potential reservoir rocks (Lewis and Ross, 1991). Steeply dipping faults and unconformity surfaces are common throughout the Mesozoic succession and varied types of fault-block and sub-crop traps may occur. Onshore, in the area of the Dawson Cove Fault, fault blocks have been identified where Cretaceous reservoir strata unconformably overlie Kunga-Maude (potential source rock) strata (Thompson et al., 1991). Similar fault blocks containing juxtaposed Mesozoic reservoir and source rock sections probably occur locally beneath Hecates Strait. Offshore, structures within the Tertiary basin include basement-cored fault blocks, rollover structures and detached inversion folds (Rohr and Dietrich, 1990; Fig. 4). Structural-stratigraphic traps in Tertiary clastics may be associated with updip onlap or facies changes within half-grabens/grabens or along dipping unconformities or uplifted basin margins.

Seals

Cretaceous or Tertiary shales and/or volcanic rocks may provide seals for potential petroleum traps. Impermeable fault zones may also contribute to (updip) trap sealing. The upper Miocene-Pliocene section of the Tertiary basin fill contains a high percentage (> 50%) of porous and permeable strata, and may be less likely to contain adequate trap seals.

PETROLEUM POTENTIAL

The petroleum potential in the marine park area was assessed qualitatively, based on interpretations of areal distributions of potential petroleum reservoirs, traps and source rocks. A critical element in the assessment was the interpretation of source rock maturation conditions. As previously discussed, potential Mesozoic source rocks are overmature (at surface) across the southern Queen Charlotte Islands. Projections of surface maturation trends (Vellutini and Bustin, 1989) indicate that Mesozoic source rocks may occur with maturation levels within the oil/gas window beneath parts of central Hecate Strait. Observed and interpreted geological differences across the Sandspit Fault also suggest possible variations in maturation conditions between the northeast and southwest parts of the study area.

Assessment Categories

Areas of (estimated) moderate to high, low to moderate, low and very low petroleum potential were identified in the study area (Fig. 5). The numbers assigned to each area (3, 5, 6 and 7) are part of a numerical rating scheme used in the Moresby Park mineral resource assessment and petroleum/mineral assessments of other park areas (Table 1). The boundaries between areas of close numerical rating (eg. 5 and 6) are approximate, as petroleum potential is perceived to increase or decrease gradationally.

Moderate to High Potential

The areas of moderate to high petroleum potential (category 3, Table 1) encompass the Sandspit Fault and areas to the east, excluding the Moresby Ridge (Fig. 5). Skonun reservoir sections occur within large structures, including rollover anticlines and inversion folds adjacent to the northeast side of the Sandspit Fault. Cretaceous strata are present within some fault blocks below the Tertiary basin and may locally have reservoir potential. Sections of potential Tertiary source rocks are known to be within the oil window and similar favourable maturation conditions may occur locally in Mesozoic (Kunga and Maude Group) source rock sections. The oil show in the Sockeye B-10 well indicates post-Miocene oil generation and vertical migration of Kunga-sourced oil (Fig. 4). The overmature state of Mesozoic strata beneath the Sockeye half-graben suggests the source area for the B-10 oil show may have occurred in a nearby (less deeply buried) horst block. Shallow gas occurrences in Quaternary sediments in the area of the Sandspit Fault (Fig. 3) indicate recent migration of (Tertiary-sourced?) gas.

Low to Moderate and Low Potential

On the east side of the marine park, areas of low to moderate and low petroleum potential (categories 5 and 6, Table 1) occur southwest of the Sandspit Fault and along Moresby Ridge (Fig. 5).

The Moresby Ridge, a basement-cored high with a thin cover (< 1 km) of Tertiary strata, is rated as low to moderate potential. Southwest of the Sandspit Fault, Skonun reservoir sections are less than 2 km thick and structural dips are uniformly basinward, with no potential for large structural traps. Some limited potential exists for Tertiary-sourced oil or gas to occur within stratigraphic traps created by updip (southwest-directed) onlap or facies transitions within the Tertiary section. Reservoir rocks and structural traps are likely to occur locally in Cretaceous sections but potential Mesozoic source rocks are probably overmature.

On the west side of the marine park, areas rated as low to moderate potential (category 5) encompass the Queen Charlotte fault zone and adjacent sedimentary terrace (Fig. 5). Structural and/or stratigraphic traps may occur within local basins containing turbidite sandstones. Deep marine mudstones may contain some petroleum source potential, but the types and thermal maturation conditions of organic matter are unknown.

Very Low Potential

The areas of very low potential (category 7, Table 1) are west of the Skonun erosional edge and east of the Queen Charlotte fault zone (Fig. 5). These areas are underlain by igneous plutons, basement volcanic rocks or (thermally) overmature Mesozoic sedimentary strata. Cretaceous reservoir rocks may locally be present but the extremely high levels of thermal maturation all but preclude preservation of any significant petroleum accumulation.

CONCLUSIONS

The proposed Gwaii Haanas/South Moresby marine park (Fig. 5) encompasses areas which, for the most part, are considered to have minimal potential for petroleum resources (rating categories 5, 6 and 7, Table 1). The largest part of the proposed park area is rated as very low potential (category 7).

Exceptions to the lower potential ratings occur in Hecate Strait (10 to 12 km northeast of Lyell and Kunghit islands) where the proposed eastern park boundary locally extends northeast of the Sandspit Fault zone, encompassing small areas rated as having moderate to high petroleum potential (category 3). In these areas, petroleum accumulations may exist within Tertiary sandstones or

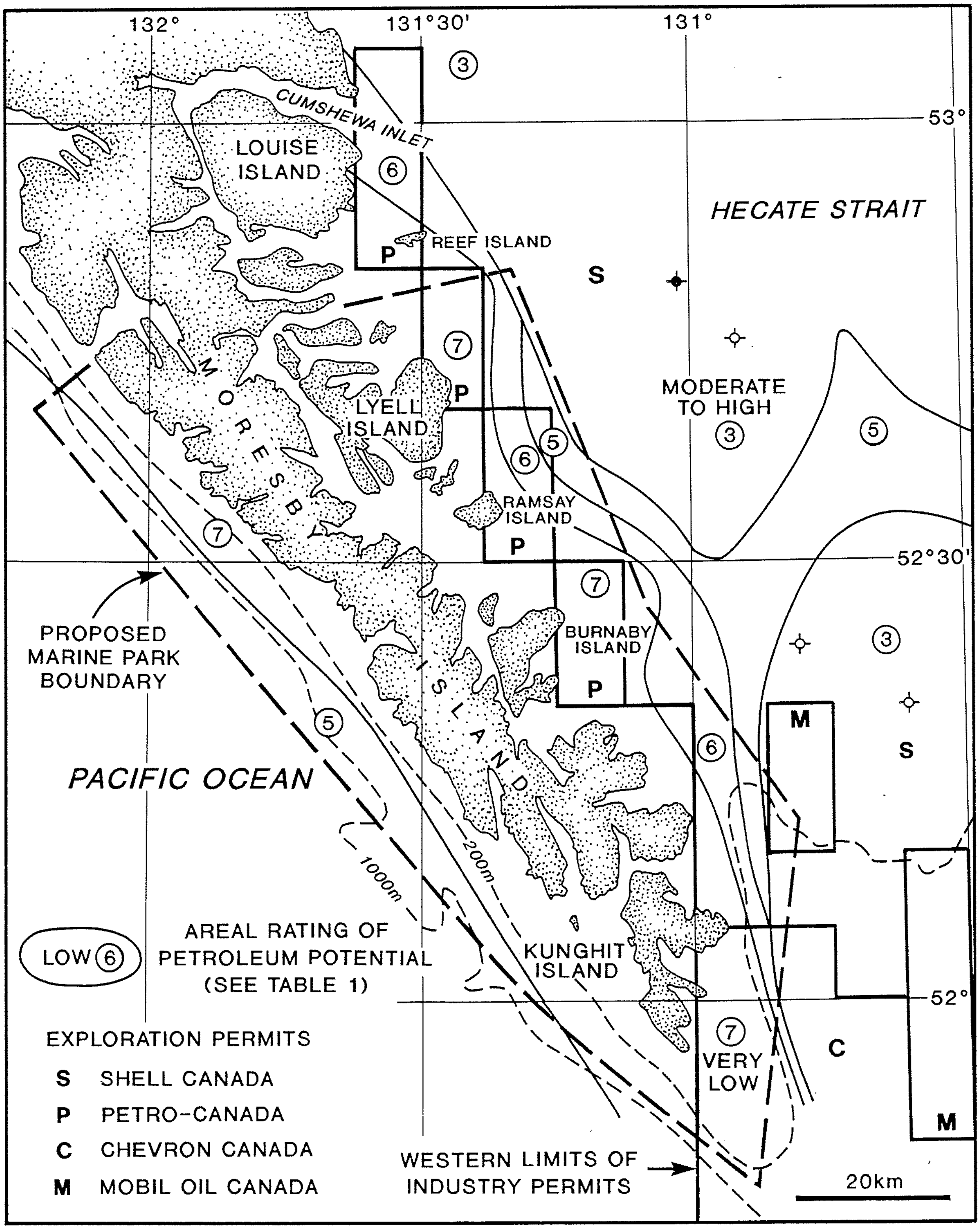

FIGURE 5. PETROLEUM POTENTIAL, MORESBY MARINE PARK AREA

Table 1. Explanation of numerical rating categories (adapted from Scoates et. al., 1986; Jackson and Sangster, 1987; Jefferson and Schmidt, 1992)

Number	Petroleum Potential	Criteria
1	Very High	- Geological environment is very favourable - Significant accumulations[1] are known - Presence of undiscovered accumulations very likely
2	High	- Geological environment is very favourable although significant accumulations may not have been discovered - Presence of undiscovered accumulations is likely
3	Moderate to High	- Between moderate and high potential - Reflects greater uncertainty[2]
4	Moderate	- Geological environment is favourable - Presence of undiscovered accumulations is possible
5	Low to Moderate	- Between low and moderate potential - Reflects greater uncertainty
6	Low	- Some aspects of the geological environment are favourable but a critical factor(s) may be missing - Presence of undiscovered accumulations is unlikely
7	Very Low	- Geological environment is unfavourable - Presence of undiscovered accumulations is very unlikely

[1] An "accumulation" is an oil and/or gas field of a size that could be developed
[2] Uncertainty results from insufficient data

conglomerates in fault-bounded anticlinal structures.

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REFERENCES

Barrie, J.V., 1988: Surficial geology of Hecate Strait, British Columbia continental shelf. Geological Survey of Canada, open file 1682.

Chase, R.L., Tiffin, D.L. and Murray, J.W., 1975: The western Canadian continental margin; in Canada's continental margin and offshore petroleum exploration (C.J. Yorath, E.R. Parker and D.J. Glass, eds.), Canadian Society of Petroleum Geologists, Memoir 4.

Davis, E.H. and Seemann, D.A., 1981: A compilation of seismic reflection profiles across the continental margin of western Canada. Geological Survey of Canada, open file 751.

Dietrich, J.R., Morrell, G.R. and Fortier, M., 1989: The petroleum resource potential of the Moresby east side marine park area, Queen Charlotte Islands, British Columbia. Geological Survey of Canada, unpublished report.

Fogarassy, J.A.S., Barnes, W.C. and Higgs, R., 1989: Sedimentology and petroleum reservoir potential of the Cretaceous Queen Charlotte Group. Programs and Abstracts, Exploration Update 89, Canadian Society of Exploration Geophysicists and Canadian Society of Petroleum Geologists.

Fowler, M.G., Snowdon, L.R., Brooks, P.W. and Hamilton, T.S., 1988: Biomarker characterization and hydrous pyrolysis of bitumen from Tertiary volcanics, Queen Charlotte Islands, British Columbia, Canada. Organic Geochemistry, v. 13.

Haggart, J.W., 1991: A synthesis of Cretaceous stratigraphy, Queen Charlotte Islands, British Columbia; in, Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.). Geological Survey of Canada, Paper 90-10.

Hamilton, T.S. and Cameron, B.E.B., 1989: Hydrocarbon occurrences on the western margin of the Queen Charlotte Basin. Bulletin of Canadian Petroleum Geology, v. 34, no. 4.

Higgs, R., 1991: Sedimentology, basin-fill architecture and petroleum geology of the Tertiary Queen Charlotte Basin, British Columbia; in, Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.). Geological Survey of Canada, Paper 90-10.

Jackson, G.D. and Sangster, D.F., 1987: Geology and resource potential of a proposed national park, Bylot Island, Northwest Territories. Geological Survey of Canada, Paper 87-17.

Jefferson, C.W. and Schmidt, H.R., 1992: Assessment of mineral resource potential, Phase I, in the proposed area of Gwaii Haanas/South Moresby National Marine Park Reserve. Geological Survey of Canada, open file 2480.

Lewis, P.D., 1991: Dextral strike-slip faulting and associated extension along the southern portion of the Louscoone Inlet fault system, Queen Charlotte Islands, British Columbia. Geological Survey of Canada, Current Research, Paper 91-A, Part A.

Lewis, P.D. and Ross, J.V., 1991: Mesozoic and Cenozoic structural history of the central

Queen Charlotte Islands, British Columbia; in Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.). Geological Survey of Canada, Paper 90-10.

Lewis, P.D., Haggart, J.W., Anderson, R.G., Hickson, C.J., Thompson, R.I., Dietrich, J.R. and Rohr, K.M., 1991: Triassic to Neogene geologic evolution of the Queen Charlotte region. Canadian Journal of Earth Sciences, v. 28.

Lyatsky, H.V., 1991: Regional geophysical constraints on crustal structure and geologic evolution of the Insular Belt, British Columbia; in Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.). Geological Survey of Canada, Paper 90-10.

Macauley, G., 1983: Source rock-oil shale potential of the Jurassic Kunga Formation, Queen Charlotte Islands. Geological Survey of Canada, open file 921.

Morrell, G.R. and Fortier, M., 1987: Potential for hydrocarbon resources underlying the proposed South Moresby marine park and adjacent areas. Canada Oil and Gas Lands Administration, unpublished report.

Orchard, M.J. and Forster, P.J.L., 1991: Conodont colour and thermal maturity of the Late Triassic Kunga Group, Queen Charlotte Islands, British Columbia; in, Evolution and Hydrocarbon Potential of The Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.). Geological Survey of Canada, Paper 90-10.

Riddihough, R. and Hyndman, R.D., 1989: Queen Charlotte Islands margin; in The Eastern Pacific Ocean and Hawaii (E.L. Winterer, D.M. Hussong and R.W. Deckers, eds.), The Geology of North America, v. N.

Rohr, K.M. and Dietrich, J.R., 1990: Deep seismic survey of Queen Charlotte Basin. Geological Survey of Canada, open file 2258.

Schmitt, H.R., Jefferson, C.W., Morrell, G.R. and Fortier, M., 1987: South Moresby marine park proposal, non-renewable resource assessment - Phase I, west half. Geological Survey of Canada, unpublished report.

Shouldice, D.H., 1971: Western Canadian continental shelf; in The future petroleum provinces of Canada (R.G. McCrossan, ed.). Canadian Society of Petroleum Geologists, Memoir 1.

Snowdon, L.R., Fowler, M.G. and Hamilton, T.S., 1989: Oil in the Queen Charlotte Basin. Programs and Abstracts, Exploration Update 89, Canadian Society of Exploration Geophysicists and Canadian Society of Petroleum Geologists.

South Moresby Resource Planning Team, 1983: South Moresby land use alternatives. British Columbia Ministry of Forests, 249 p.

Sutherland Brown, A., 1968: Geology of The Queen Charlotte Islands, British Columbia. British Columbia Department of Mines and Petroleum Resources, Bulletin 54.

Sweeney, J.F. and Seemann, D.A., 1989: Gravity measurements over the Burnaby Island pluton, Queen Charlotte Islands, British Columbia. Geological Survey of Canada, Current Research Part H, Paper 89-1H.

Sweeney, J.F. and Seemann, D.A., 1991: Crustal density structure of Queen Charlotte Islands and Hecate Strait, British Columbia; in Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.). Geological Survey of Canada, Paper 90-10.

Thompson, R.I., Haggart, J.W. and Lewis, P.D., 1991: Late Triassic through early Tertiary evolution of the Queen Charlotte Basin, British Columbia, with a perspective on hydrocarbon potential; in Evolution and hydrocarbon potential of the Queen Charlotte Basin, British Columbia (G.J. Woodsworth, ed.). Geological Survey of Canada, Paper 90-10.

Vellutini, D., Bustin, R.M. and Goodarzi, F., 1990: Source rock potential of Mesozoic and Tertiary strata, Queen Charlotte Islands, British Columbia. Bulletin of Canadian Petroleum Geology, vol. 38, no. 4.

Vellutini, D. and Bustin, R.M., 1990: Organic maturation of Mesozoic and Tertiary strata, Queen Charlotte Islands, British Columbia. Bulletin of Canadian Petroleum Geology, v. 38, no. 4.

Woodsworth, G.J. (ed.), 1991: Evolution and hydrocarbon potential of the Queen Charlotte Basin, British Columbia. Geological Survey of Canada, Paper 90-10.

Yorath, C.J. and Hyndman, R.D., 1983. Subsidence and thermal history of the Queen Charlotte Basin. Canadian Journal of Earth Sciences, v. 20.

ADDENDUM

Coal Bed Methane

Some potential for coal bed methane resources may occur in coal-bearing Tertiary strata within the Queen Charlotte Basin (Jefferson and Schmidt, 1992; M. Dawson, pers. comm. 1992). At maturation levels of about 0.9 to 1.6% Ro, Tertiary coal beds may contain (recoverable) methane gas. The offshore Sockeye B-10 well (Figs. 3 and 4) penetrated numerous coal beds (1 to 3 m thick) in lower Miocene and Oligocene strata below 2000m. The well encountered at least one gas show (gas cut mud) from a coal-bearing zone at 3900 m depth (Shell Canada well history report, 1968).

In southwestern Hecate Strait, the most prospective area for coal bed methane may occur between the Sandspit fault and the Skonun Formation erosional edge (Fig. 3). In this area, relatively high rank (above 0.9% Ro) Tertiary coals may be present at shallow depths (above 2000 m).

As with estimates of conventional oil/gas potential in the Moresby park area, there is insufficient data to quantify possible coal bed methane resources. In terms of the petroleum assessment categories (Table 1), the resource potential for coal bed methane is rated as very low (category 7) for areas west of the Skonun edge and low to moderate to low (categories 5 and 6) for areas east of the Skonun edge (Fig. 3).