

ECONOMIC POTENTIAL

Previous attempts at oil shale developments in Nova Scotia have historically been short-lived, uneconomic ventures that focused exclusively on hydrocarbon production: in Stellarton from 1852-1859 and 1929-1930 (Douglas and Campbell, 1942), in Antigonish (Big Marsh) around 1865 (Ells, 1909), and at McAdams Lake about 1890 (Neville, 1891). Further evaluations of oil shale potential have also led workers to conclude that shale oil yields are generally too low for commercial exploitation (Douglas and Campbell, 1942; Kendler, 1950; Macauley *et al.*, 1985; Naylor and Smith, 1986b, 1988a; Naylor, *et al.* 1987a). These workers have recognized that the economics of oil shale development must be enhanced through less expensive mining and retorting costs, higher oil yields and prices, additional use for the by-products of oil shale distillation, or use of the rocks and their products as a replacement or extender for imported commodities.

RECOMMENDED DIRECTIONS FOR OIL SHALE DEVELOPMENT

It is concluded that future investigations evaluating the potential of Nova Scotia oil shale should focus primarily on improvements in retorting technology and on a process for indirect use applications. In particular, these investigations should be directed toward the Stellarton oil shale since it represents the most attractive deposit in terms of yield (Fig. 18), quantity and potential for inexpensive surface (open-pit) mining. In New Brunswick, for example, the oil shale deposits are uneconomic on the basis of their oil yield alone (Macauley and Ball, 1982; Smith, 1985) but they are currently attracting attention because of their carbonate-rich character. The by-product potential that they offer is in shale oil recovery followed by co-combustion with high sulphur coal (from Minto, N. B.) during thermal power generation to reduce

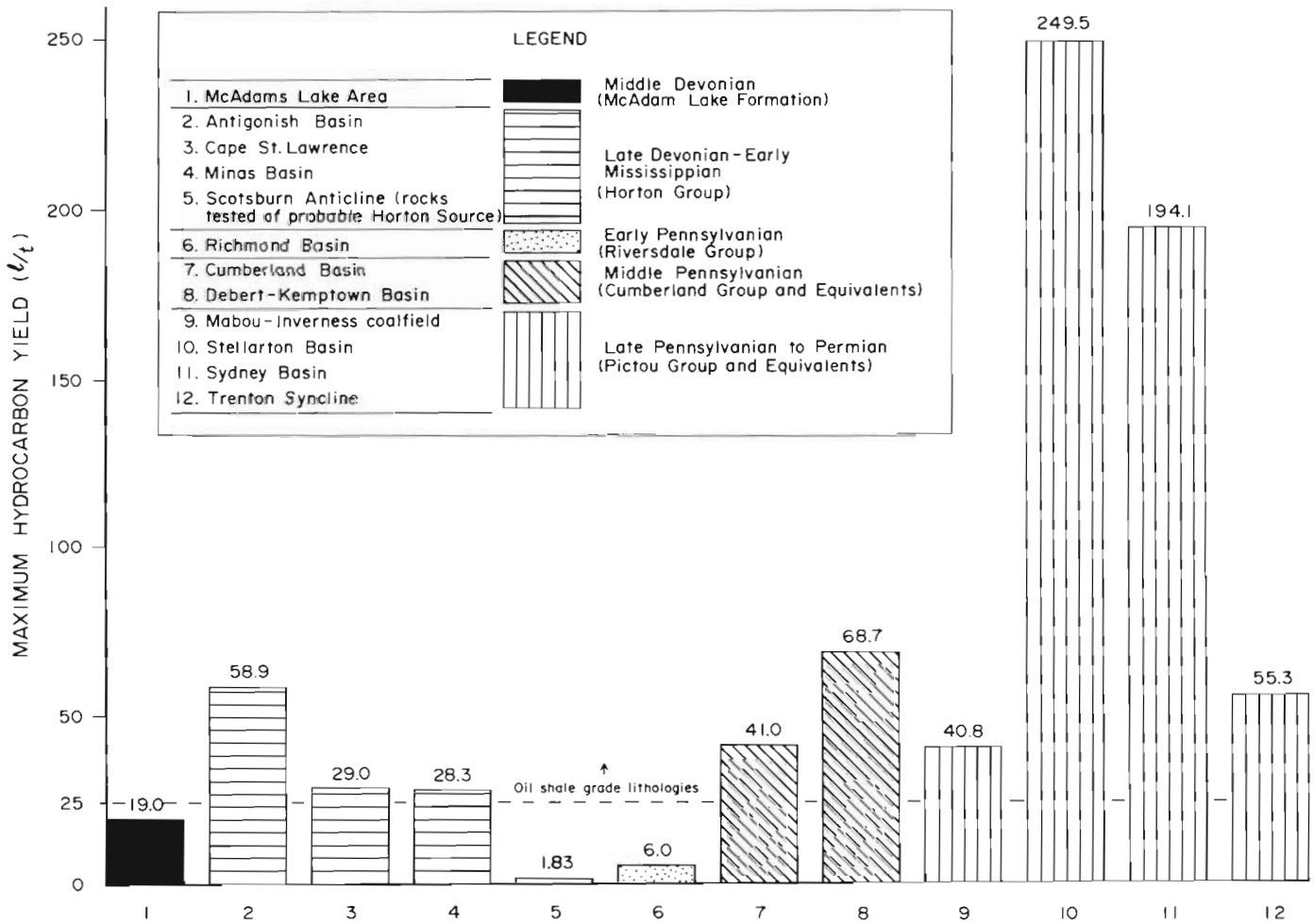


Figure 18. Maximum hydrocarbon yields obtained from rocks in 12 areas of Nova Scotia reported to contain oil shale. The dashed line indicates the lower limit of oil yield, 25 l/t, at which rocks are considered to be of oil shale grade.

sulphur emissions (Macauley *et al.*, 1985). Although the co-combustion process is not suited to the silicate-rich Stellarton oil shale, it serves to illustrate the type of innovative approach required to develop an otherwise uneconomic resource.

Retorting Technology

Effort has been directed toward improvements in retorting technology, principally with Stellarton oil shale, at the Technical University of Nova Scotia, Halifax. Flynn (1926) investigated the effects of heating oil shale under different conditions (variable retorting rates, progressive heating, variable size fractions or lumps, retorting with steam, and retorting under pressure and vacuum). His work demonstrated that the heating rate during pyrolysis has a considerable effect on the pyrolysis products: fast rates yield the greatest quantity of liquid product but lower quality oil; slow rates give lower yields but higher quality oil with lower specific gravity. Rockwell (1985) has studied the treatment of oil shale by heavy liquid separation and (Wilfley) tabling, conventional flotation and oil agglomeration/brine flotation for the purpose of concentrating the organic component and thereby increasing hydrocarbon yields. Rockwell's (1985) experiments indicated that crushing/grinding followed by heavy liquid separation provided the most favourable results. In particular, oil shale samples crushed to size fractions of 0.250 - 0.600 mm and 0.150 - 0.250 mm followed by heavy liquid separation generated higher Fischer Assay values than initial values obtained from raw crushed oil shale (i.e. crushed to 2.36 mm, the standard crushed size for the ASTM D3904-80 Fischer Assay method; ASTM, 1984). The other methods of treatment showed only limited success in producing higher yields.

Also related to improvements in oil shale retorting technology are the studies of flash hydrolysis of coal being carried out at the Ontario Research Foundation. In this process, coal is rapidly pyrolyzed in the presence of hydrogen at high temperatures and pressures of up to 10.34 MPa (Starzomski, 1987). Flash hydrolysis application to oil shale or oil shale/coal mixtures offers potential for better quality and yields of liquid products (Starzomski, 1987).

Indirect Use Applications

Potential indirect or substitute-extender uses of

oil shale, with a value-added component to enhance the economics of utilization, have been investigated. These replacement-extender applications include: utilization of waste products as industrial materials commodities, ammonia recovery, co-processing to enhance or extend resource utilization, and replacement for imported products.

Waste and By-product Residue

One indirect application of oil shale follows combustion to generate electricity and involves use of the co-processed oil shale and coal ash to produce industrial materials. Some effort has been directed toward investigating the use of Stellarton oil shale as raw material for concrete by Kendler (1950) and Haw (1958) and as additives for paint and rubber products by Kendler (1950). In Stellarton, a candidate for this scheme is oil shale bed 58 which overlies the Acadia seam. Recent drilling by Pioneer Coal Ltd. has identified a coal resource area accessible through open-pit mining (Smith *et al.*, 1989b).

Use of oil shale ash in brick and cement production was successfully carried out in the German oil shale industry (Macauley and Ball, 1982) and oil shale ash is currently used by cement producers in the USA, USSR and China (Knutson *et al.*, 1989).

Ammonia Recovery

Another indirect use of oil shale involves recovery of ammonia gas during the pyrolysis process to produce ammonium sulphate, an ingredient of fertilizer. Ammonium sulphate yields of 4.3-20.5 kg/t have been reported for various Stellarton oil shale beds (Ells, 1909; Flynn, 1926) and up to 19.0 kg/t for oil shale sampled from the Big Marsh deposit at Antigonish (Ells, 1909). In the Scottish oil shale industry ammonium sulphate, as well as paraffin wax, were produced as by-products of shale oil extraction; ammonium sulphate production was considered to be one of the principal sources of profit from the distillation process (Ells, 1910).

Co-processing and Enhancing

Macauley *et al.* (1985) suggested that the co-

processing of the Stellarton Oil Coal seam and underlying boghead shale-rich oil shale (bed 45) offers potential for exploitation. The potential offered by this scheme is the recovery of oil and gas through distillation of the oil shale-coal mix, followed by electric power generation through burning of the residue. Coal would offer some contribution to the overall liquid yield (see Table 6 for a summary of hydrocarbon yield testing results for selected Stellarton coals). Stellarton oil shale bed 45 was mined from 1852-1859 for use in gas making, as a mix for coal, as an enricher in the manufacture of illuminating gas and for distillation. The project was abandoned when cheaper conventional crude oil was discovered in Pennsylvania in 1860 (Douglas and Campbell, 1942).

This study indicates that the high hydrocarbon yields and calorific values obtained from the cannel shale of Stellarton oil shale bed 22 also offers the potential for shale oil recovery followed by combustion of the residue for electrical generation. This potential is particularly attractive since the cannel shale-bearing oil shale bed overlies a bed of claystone currently mined, by open pit methods, for use in brick manufacture; the oil shale is stripped away from the underlying claystone and set aside as waste. The cannel shale

was mined for its shale oil yield in 1930 by Torbanite Products Limited. The project was abandoned when the company's plant burned down late in 1930 (Messervey, 1930; Douglas and Campbell, 1942).

Numerous other oil shale beds within the Stellarton Basin and oil shale occurrences elsewhere in the Province, all associated with coal, could offer a similar potential. Such occurrences include petroliferous limestone of Cumberland Basin and Sydney Basin, cannel shale of the Mabou-Inverness coalfield and boghead shale of the Trenton Syncline.

Replacement and Substitution

Shale oil may be used as a replacement for the conventional petroleum additive in asphalt. This potential use of oil shale is currently being investigated using oil shale from the western USA (Colorado) by the New Paraho Corporation. Recent reports indicate that use of shale oil improves pavement resistance to moisture damage and binder embrittlement (Lukens, 1989) which is particularly important in freeze-thaw climates such as here in Nova Scotia.

Table 6. Summary of laboratory test results for selected coal seams from the Stellarton Basin (see Appendix 1.10b for details of the results). TOC = Total Organic Carbon Content.

ANALYSIS				
COAL SEAM		OIL YIELD (l/t)	TOC (WT%)	HYDROGEN INDEX (H.I.)
Sixfoot	Range n	107.7-142.0 2	50.6-65.3 2	209-300 2
Widow Chis. B	Range n	75.7 1	65.6 1	153 1
McLeod	Range n	2.9-158.5 28	1.6-60.2 28	123-386 28
Foord	Range n	42.7 1	27.6 1	153 1
Cage	Range n	36.2-124.3 3	27.1-74.8 2	173-213 2
Oil Coal	Range n	6.2-101.2 5	7.3-54.6 5	104-207 5

STELLARTON OIL SHALE POTENTIAL

Multiple Use Applications

The oil shale at Stellarton is ideally located when considering the potential multiple uses discussed above. Figures 19 and 20 show that the Stellarton oil shale is situated within 10 km of coal-fired electric generating plants, concrete ready-mix plants and an asphalt plant.

Implications for Coal Resource Exploration

An immediate use for oil shale from the Stellarton Basin lies in the ability to recognize distinct oil shale beds within sections of the Stellarton Formation that are separated by 1-2 km. The oil shale beds make excellent stratigraphic markers and hence are useful for section correl-

ation. As well, the association of some oil shale beds with coal seams within the Stellarton Formation has been used as a guide to coal exploration (Naylor *et al.*, 1986). In particular, lake (oil shale) to swamp (coal) paleo-environmental trends within the Stellarton Basin have applications in exploring for undiscovered coal (Naylor and Smith, 1988b).

Implications for Petroleum Exploration

Finally, the occurrence of oil shale and organic-rich shale in Nova Scotia may have significant implications for hydrocarbon exploration. Especially important are those occurrences contained in Horton (Antigonish Basin, Cape St. Lawrence area and Minas Basin), Cumberland (Cumberland Basin) and Pictou (Mabou-Inverness coalfield, Stellarton Basin,

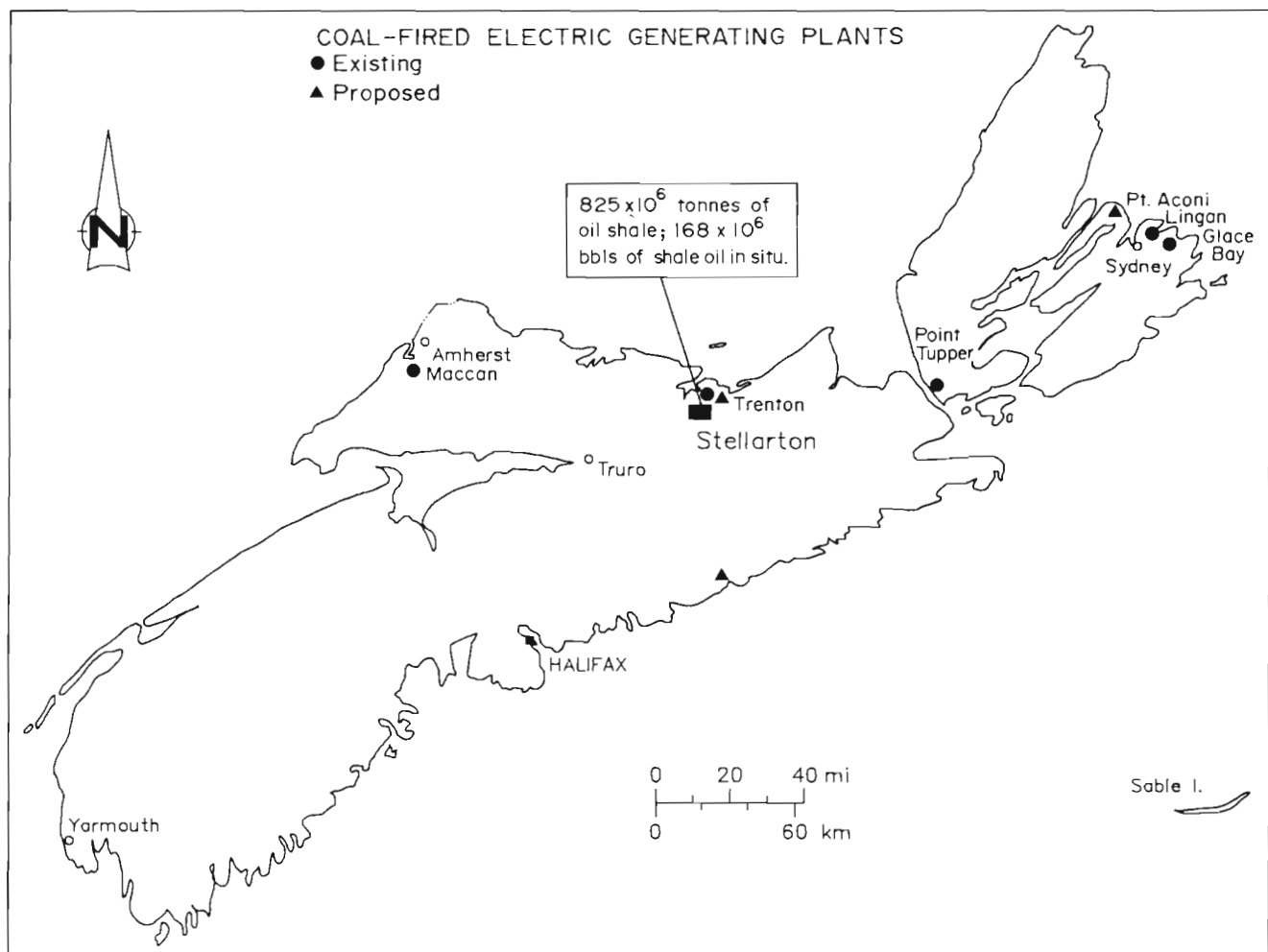


Figure 19. Location of the Stellarton oil shale resources relative to existing and proposed coal-fired electric generating plants.

Sydney Basin and Trenton Syncline) Group strata. The presence of hydrocarbon shows and accumulations within such strata or age equivalents elsewhere the Maritimes (Moncton Basin, Minas Basin, Antigonish Basin, Lake Ainslie area, Cumberland Basin and Stellarton

Basin) suggests that the strata may have acted as regional petroleum source rocks (Naylor *et al.*, 1987a; Naylor and Smith, 1988a). The regional source rock potential of the areas studied in this project is currently part of an investigation by McMahon (in prep.).

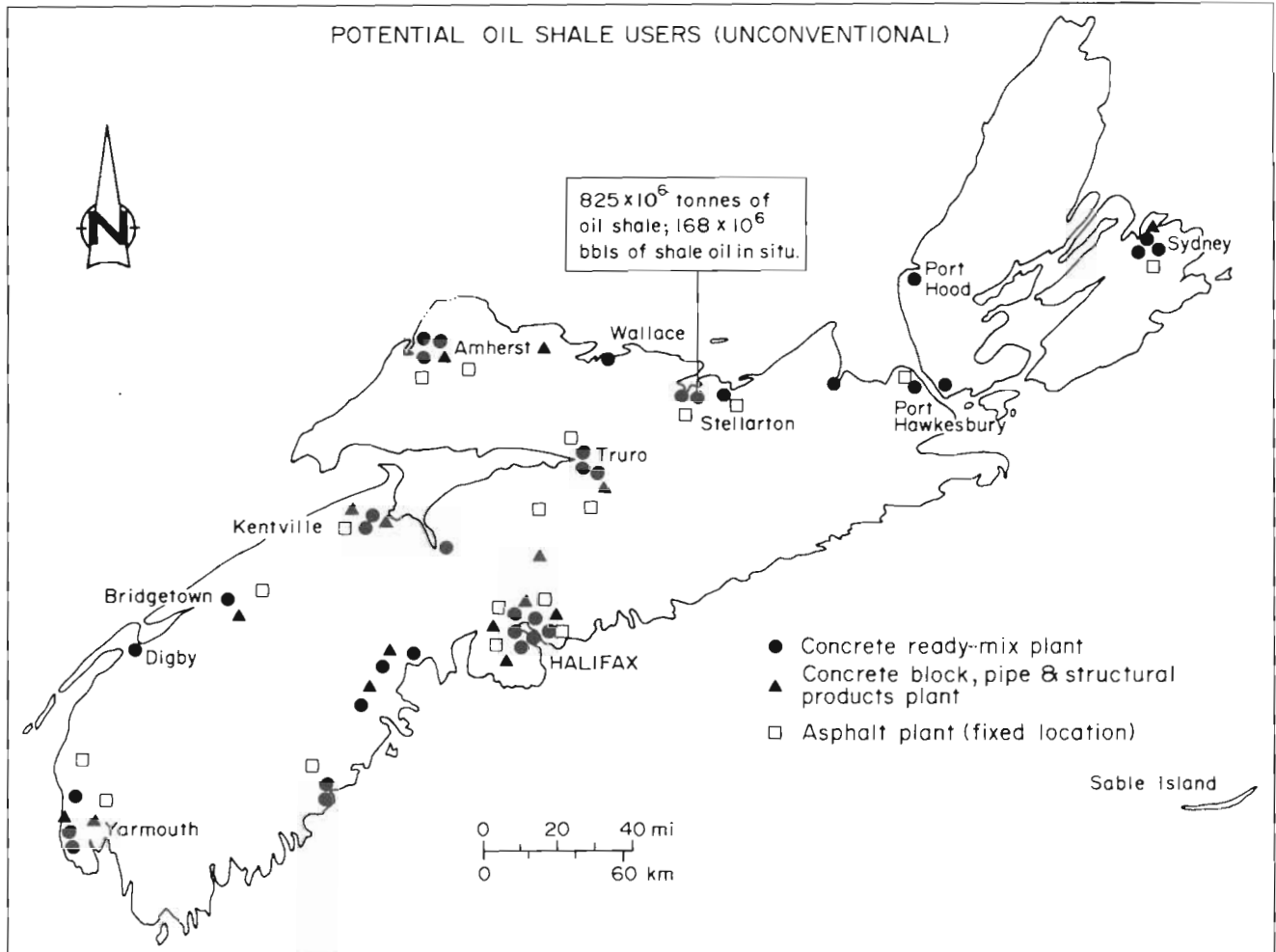


Figure 20. Location of the Stellarton oil shale resources relative to existing concrete ready-mix plants, concrete block, pipe and structural products plants, and asphalt plants.