THE GEOLOGY OF NEW BRUNSWICK OIL SHALES, EASTERN CANADA

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ABSTRACT

The stratigraphy, mineralogy, organic geochemistry and organic petrology of three oil shale deposits are discussed. Interpretations are based upon lithologic logs of drill core, bedrock mapping, and inorganic and organic determinations. The interrelationship of the identified oil shale lithotypes and lithostratigraphic units is one of facies change.

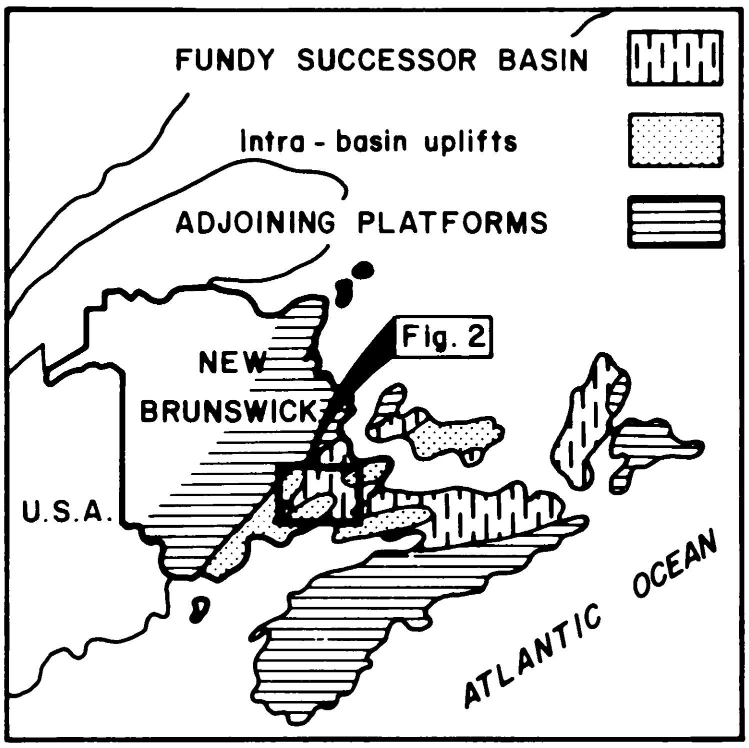

Fig. 1. Major tectonic elements of Atlantic Canada

1. INTRODUCTION

The oil shales in New Brunswick (Figure 1) are found in the Albert Formation which is of upper Devonian to lower Mississippian age. Rocks of the Albert Formation are exposed around the margins of the Moncton Sub-basin (Figure 2), a ccmponent basin of the major tectonic Fundy Successor Basin. The Sub-basin is bounded on the south by the Caledonia Uplift and to the northwest by the Kingston Uplift. The oil shales are best developed along the southern margin of the Sub-basin where the three deposits discussed herein are located.

2. REGIONAL GEOLOGY

The Mississippian rocks of New Brunswick lie in angular unconformity on a basement of pre-Middle Devonian and Precambrian rocks deformed by the late Lower Devonian Acadian Orogeny. These

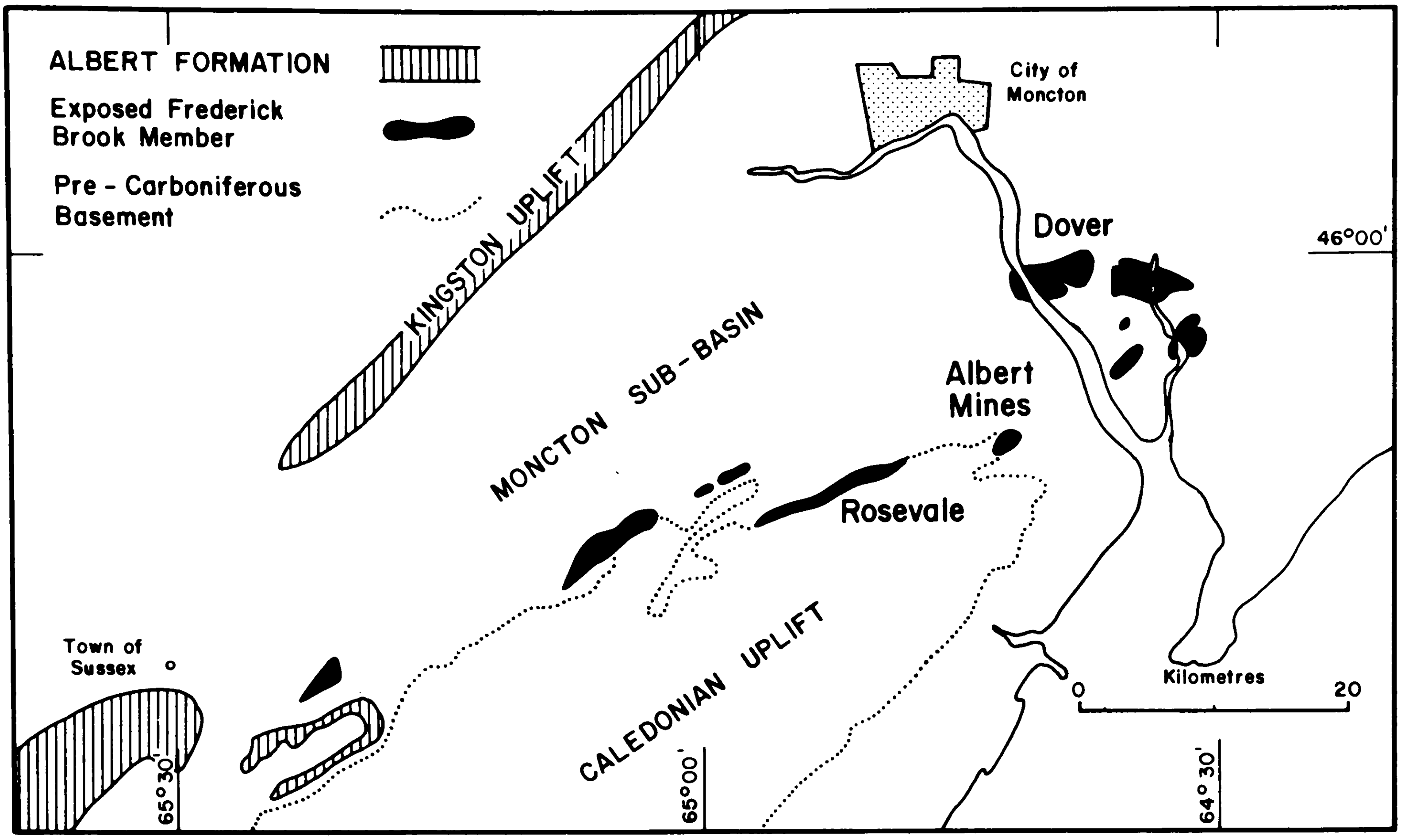

Fig. 2. Distribution of the Albert Formation within the Moncton Sub-basin

rocks provide an effective basement for hydrocarbon and oil shale potential.

The Carboniferous sediments of Atlantic Canada consist predominantly of terrestial clastics deposited in a series of connected intermontain basins within the Fundy Successor Basin.

The basal unit of the Mississippian in New Brunswick is the Horton Group which consists of basal and uppermost red units, the Memramcook and Moncton Formations, respectively, with a medial grey sequence. The grey sequence, the Albert Formation, contains the oil shale interval.

The Albert Formation includes: a lower unit of sandstone, siltstone, shale and conglomerate, the Dawson Settlement; the medial Frederick Brook consisting of oil shale, limestone, calcareous shale and siltstone; and the uppermost Hiram Brook consisting of siltstone, shale and calcareous sandstone. A local salt-bearing zone, the Gautreau evaporite, occurs within the Hiram Brook. Macauley _et al_. (1984) indicate that coarser grained clastics of the Round Hill are found as facies equivalents to all members of the Albert Formation.

The complex interrelationships of these rock units within the Albert Formation has resulted in their being treated herein as facies (Figure 3). This avoids the problems of interbedding members and of the necessary inclusion of considerable non-representative lithology within many of the members. This sequence represents a complex of alluvial-fluvial-deltaic-lacustrine environments. The oil shales themselves were deposited within shallow lacustrine environments at isolated locations.

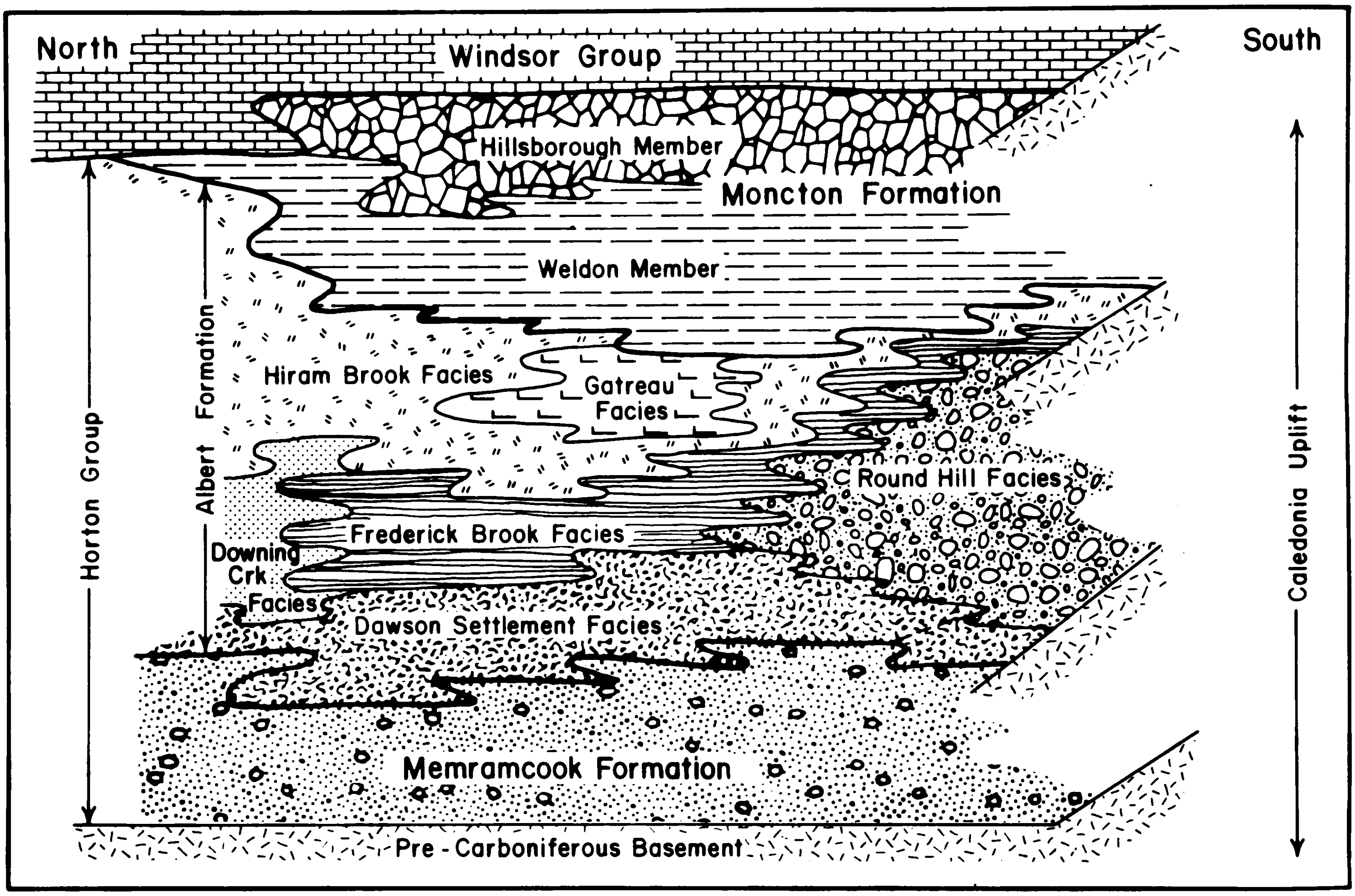

Fig. 3. Internal stratigraphy of the Horton Group (after Carter and Pickerill, 1985)

3. STRATIGRAPHY

ALBERT MINES DEPOSIT

As a result of detailed examination of drill core, from the Albert Mines oil shale deposit (Figure 2), Macauley et al. (1982)

recognized that the oil shales are composed of three marlstone lithotypes; laminated marlstone (maximum kerogen content), clay marlstone and dolomite marlstone (grading to dolostone). The lithotypes are interlaminated, interbedded and intergradational. They are defined by variations in the relative abundances of their three major components: dolomite (including calcite and siderite), clay (mostly montmorillonite-illite) and kerogen. In addition, the quartz and feldspar contents modify the three primary lithotypes, particularly the dolomite marlstone. The dominance of each lithotype within specific stratigraphic intervals allows subdivision of the Frederick Brook facies within the Albert Mines deposit (Figure 4). The upper unit consists of all three lithotypes and is underlain by the Albert Mines zone, which is dominated by laminated marlstone, and is itself underlain by a clay marlstone unit. Dolomite marlstone predominates in the lowermost unit.

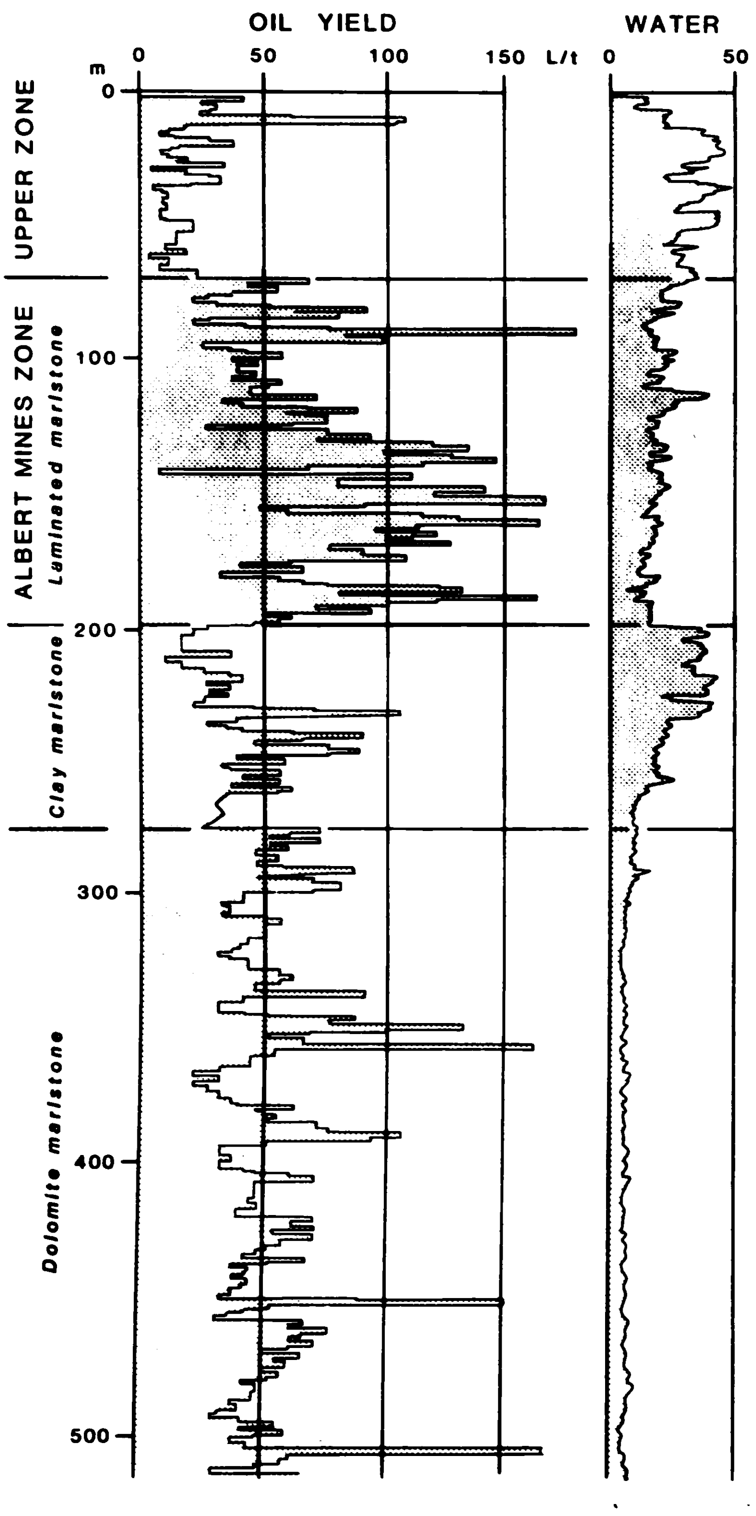

Fig. 4. Shale oil - water yield log

The Round Hill facies is seen as representing alluvial fans flanking the margin of the Caledonia Uplift. The Hiram Brook and Dawson Settlement facies represent the more distal fluvial-deltaic finer grained and in part equivalent rock units of the Round Hill. These coarser grained, noncarbonate and organically "dry" rock units represent periodic influxes of clastics into the shallow lacustrine related environments represented by the oil shales themselves.

DCVER DEPOSIT

The stratigraphy of the Dover-St. Joseph area (Figure 2) is similar to that of the Albert Mines area with the absence of the Round Hill facies and the addition of a unit labelled the Downing Creek facies (Wright, 1982). The Downing Creek encompasses sections of shales, siltstones, sandstones and carbonates in which minor oil shales are present, essentially, the same as Hiram Brook-Dawson Settlement facies but containing oil shales in insufficient quantity and quality to be defined as Frederick Brook facies.

Structurally the deposit is less complex than that at Albert Mines, a factor which could be advantageous for development. Stratigraphically both deposits exhibit the complex interdigitation of several facies.

ROSEVALE DEPOSIT

Southwest of the Albert Mines deposit and paralleling the north flank of the Caledonia Highlands, there is an elongate exposure of the Albert Formation at Rosevale (Figure 2). Lateral and vertical lithofacies changes have been noted (Brown and Whaley, 1986). In particular the higher shale oil yielding zone(s), the Albert Mines zone equivalent, is depositionally discontinuous over the exposed trend of the Albert Formation. This lateral lensing phenomenon, while only confirmed at Rosevale, is consistent with what would be expected from the vertical stratigraphy of the Albert Formation as mapped at Albert Mines and Dover. Rosevale provides greater lateral exposure of the Albert Formation, thus permitting the observation of lateral facies changes.

4. ORGANIC GEOCHEMISTRY

ALBERT MINES DEPOSIT

The oil and water yield assays from the Albert Mines deposit provided the initial recognition of the oil shale zones which make-up the Frederick Brook facies (Figure 4). The Albert Mines zone typically exhibits high shale oil yields and moderate water yields whereas the clay marlstone zone exhibits low shale oil yields and high water yields. These variations are attributable to differences in the zones' respective kerogen and clay contents. The underlying dolomite marlstone zone exhibits cyclical shale oil yields and low water yields. These observations lead to correlations with organic and inorganic mineral content and ultimately to the development of the depositional models presented herein.

Detailed chemical studies of extracts, kerogen and kerogen-pyrolyzates indicate that essentially all of the organic matter in the Albert Mines deposit has a similar algal component, lamalginite (Kalkreuth and Macauley, 1984). Lamalginite, Type I algal matter, is typical of continental lacustrine deposits which in this case has undergone moderate catagenetic alteration. Hydrocarbons in the form of bitumen and heavy oil products have been generated and migration has occurred within the oil shale. The kerogen, bitumen and heavy oil products are at the stage where some lighter hydrocarbon generation has occurred. No major amount of light gravity oil appears to have been generated; consequently most of the potential yield is still available to the oil shale retort.

Shale oil yields vary with the zone of the deposit but current estimates of reserves in place stand at 762.5 x 10^6 tonnes of oil shale yielding 269.4 x 10^6 barrels of shale oil.

DOVER DEPOSIT

Kerogen in the better quality oil shale beds, in which total organic carbon exceeds 5%, is a Type I lamalginite. As kerogen content decreases, the ratio of lamalginite to matrix bituminite also decreases. The variable organic content of the Dover area oil shales parallels the complex facies relationships observed. These oil shales are thermally only marginally mature, having generated bitumen and possibly a heavy oil component retained within the source beds. The lesser maturity has resulted in the generation of a heavier, slightly more aromatic oil than that recovered at Albert Mines.

Current estimates of reserves within 100 metres of the surface for the Albert Mines zone equivalent stand at 26.6 x 10^6 tonnes of oil shale yielding 14.2 x 10^6 barrels of shale oil from oil shales yielding in excess of 85 litres/tonne.

ROSEVALE DEPOSIT

Rock-Eval pyrolyses of Rosevale core samples indicate that the better quality oil shales derive their organic content from Type I algal material. The poorer quality oil shales, many tending to siltstones, in part derive their organic content from plant detritus. Essentially the same findings as at Dover, with similar implications for low thermal maturity of the oil shales.

A zone equivalent to the Albert Mines beds has been identified and in part delineated. Current estimates of reserves within 100 metres of the surface for the zone stand at 4.4 x 10^6 tonnes of oil shale yielding 2.8 x 10^6 barrels of shale oil from oil shales yielding in excess of 100 litres/tonne.

5. CURRENT DEVELOPMENT POTENTIAL

Until recently, interest in the oil shales of New Brunswick had been aimed solely at potential liquid hydrocarbon production. However, there is interest in maximizing the utilization of indigenous resources for the generation of electricity. In conjunction with the Federal Department of Energy, Mines and Resources, the New Brunswick Electric Power Commission is evaluating the fluidized bed co-combustion of oil shale and high sulphur New Brunswick coal. Carbonates from the oil shales will combine with the sulphur from the coal to reduce sulphur dioxide emissions by 90%. A 20 megawatt circulating fluidized bed coal-oil shale-limestone co-combustion unit has been constructed and is now being commissioned. This technology has necessitated renewed evaluation of the oil shales of the province with the requirement that not only the hydrocarbon content of the oil shales be assessed but that their carbonate and clay content also be determined.

6. CONCLUSIONS

Vertical and lateral variations within the Albert Formation are its hallmark - they are to be expected. The geological variations affect both the organic and inorganic mineralogy of the oil shales and must be taken into account in any economic evaluation. Hydrocarbon content of the oil shales is an important evaluation criterion, however, in light of the currently anticipated development process for the oil shales, their inorganic mineral content must also be determined during the evaluation procedure.

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