Chapter R5

REGION 5 ASSESSMENT SUMMARY—NORTH AMERICA

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INTRODUCTION

Region 5 of the World Energy Assessment 2000 encompasses North America and includes the countries of Greenland, Canada, and Mexico, but excludes the United States. The region was divided into 86 geologic provinces (Klett and others, 1997). Thirteen of these provinces were assessed for undiscovered oil and gas resources (Region 5 Map). Assessed, but not all, provinces are labeled. These provinces range from long-established oil and gas producing areas , such as the Alberta Basin of Canada and the Villahermosa Uplift of Mexico, to frontier areas, such as the East Greenland Rift Basins of Greenland. As discussed in previous sections, the approach used in this assessment was to map the total petroleum systems (Region 5 Assessment Results Summary) in these provinces, define assessment units within the total petroleum systems, and assess the potential for undiscovered conventional oil and gas in each assessment unit.

TOTAL PETROLEUM SYSTEMS AND ASSESSMENT UNITS

East Greenland Province

Little is known about the East Greenland province, except for the intensely studied coastal area. Most of the province is covered by offshore ice all year. There is no petroleum production, but former oil accumulations are indicated by the presence of sandstones with pores now filled or lined with solid bitumen. The geologic data used to map the total petroleum system and assessment unit came from field studies along a narrow strip of land on the eastern coast. Combined with airborne and shipborne geophysical data collected offshore, the available information shows this province to be geologically analogous to the western Norwegian margin and North Sea (Haller, 1971; Birkelund and Perch-Nielsen, 1976; Larsen, 1990; Roberts, 1974; Talwani and Eldholm, 1977). Several pre-Late Jurassic rifting events affected relatively wide fault blocks on the East Greenland margin (Price and Whitham, 1997). During Late Jurassic rifting, the eastern margin was broken into smaller fault blocks that were rotated toward the west (Surlyk, 1978). Numerous north-south oriented basins have been interpreted to be present in the province, on the basis of offshore geophysical data (Larsen, 1990).

Studies along the eastern Greenland coast show that Upper Permian and Upper Jurassic rocks contain high-quality source rocks (Surlyk and others, 1984; Christiansen and others 1992). The Upper Jurassic source rock in Greenland is the age equivalent of the Kimmeridgian source rock that charged the large oil fields in the North Sea and off the Norwegian coast. The presence of good reservoir and seal rocks onshore Greenland and the expectation that they continue offshore, combined with the large exposed bitumen deposits, onshore, lead us to conclude that large oil fields may exist offshore. One total petroleum system (520001) was mapped in the East Greenland province, with one assessment unit (52000101) that was evaluated for undiscovered oil and gas.

Labrador-Newfoundland Province

Initial rifting in the Late Triassic to Early Jurassic in the Labrador-Newfoundland province, Canada, led to deposition of red beds, evaporites, and carbonates in local normal fault-bounded basins that included the Jeanne d'Arc Basin. The transition from arid, nonmarine depositional environments to shallow-marine evaporites was completed by the Early Jurassic. Rifting processes apparently ended and deposition from the Early to Late Jurassic (Kimmeridgian) was dominated by shallow marine shales and limestones deposited in an epeiric sea (Grant and McAlpine, 1990). The upper part of this shallow marine section includes the Egret Member of the Rankin Formation, the most important petroleum source rock in the province. The Egret Member is a Kimmeridgian-age carbonaceous and calcareous shale with marl interbeds. Another period of rifting occurred in the latest Jurassic and earliest Cretaceous as normal faulting was renewed and a thick sequence of siliciclastics was deposited. The basin-filling, coarse siliciclastic sediments, interbedded with shales, created isolated sand bodies that later became hydrocarbon accumulations (Sinclair and others, 1992; Taylor and others, 1992). One total petroleum system was mapped (521501) in the Jeanne d'Arc Basin and one assessment unit (52150101) that was evaluated for undiscovered oil and gas. A second total petroleum system and assessment unit were identified, but the entire province was not assessed.

Rocky Mountain Fold Belt and Alberta Basin

The Rocky Mountain Fold Belt and Alberta Basin provinces in western Canada developed on an open marine passive continental margin during Paleozoic through early Mesozoic time. The most common sediments deposited during this time were carbonate and shale resulting in seven different source rock units. Five of these source rocks were deposited in Middle Devonian, Late Devonian and Devonian-Mississippian time (Exploration staff, Chevron Standard Limited, 1979; Leenheer, 1984; Powell, 1984; Stoakes and Creaney, 1985; Clark and Philip, 1989; Creaney and Allan, 1990; Allan and Creaney, 1991; Feinstein and others, 1991; Creaney and others, 1994). The other two source rock units are of Middle Triassic and Early Jurassic age (Creaney and Allan, 1990; Allan and Creaney, 1991; Creaney and others, 1994; Riediger, C.L., 1994, 1997). The proximity of the source rocks to high-quality reservoir rocks resulted in significant petroleum accumulations in these two provinces. For rocks of this age range, four total petroleum systems (524301, 524302, 524303, and 524304) were mapped in parts of these two provinces and two assessment units in each system (52430101, 52430102, 53430201, 52430202, 52430301, 52430302, 52430401, and 52430402) were evaluated for undiscovered oil and gas.

Two tectonic events occurred during Late Jurassic and Late Cretaceous time that created a thrusted mountain range (Rocky Mountain Fold Belt) and a foreland basin (Alberta Basin) (R.A. Price, 1994). Rocks deposited in this foreland basin are mostly shale and sandstone. Carbonaceous shale and coal became the source rocks for large volumes of gas found in Lower Cretaceous sandstone reservoirs (Deroo and others, 1977; Welte and others, 1984). Organic-rich marine shales deposited during the Late Cretaceous form three source rocks that have generated significant volumes of oil and gas in the basin (Creaney and Allan, 1990; Allan and Creaney, 1991; Creaney and others, 1994). For rocks of this age range, two total petroleum systems (524305 and 524306) were mapped in parts of both provinces and five assessment units (52430501, 52430502, 52430601, 52430602, and 52430603) were identified, three of which (52430501, 52430601, and 52430602) were assessed for undiscovered oil and gas.

Williston Basin Province

The Williston Basin province is a cratonic basin located in north-central U.S. and south-central Canada (Kent and Christopher, 1994). Cambrian sandstone and shale are the oldest sedimentary rocks in the basin. Middle Ordovician through Lower Silurian deposits are composed primarily of carbonate and some evaporite rock. After a hiatus from the Middle Silurian through Early Devonian, cyclic carbonate and evaporite sedimentation became widespread. By the end of the Devonian, mainly dolomitic and evaporitic rocks with some red beds were being deposited. Mississippian rocks are predominately carbonate. Red beds are the most common rock type deposited during the Triassic in Saskatchewan and Manitoba. Jurassic strata reflect a change from restricted basin evaporites to more open marine shale and limestone grading into shale and sandstone toward the close of the period. Late Jurassic to Early Cretaceous uplift and erosion were followed by subsidence and flooding by the Cretaceous seaway and deposition of siliciclastic sediments eroded from the craton on the east.

Four source rocks, that have reached thermal maturity, occur in the Williston Basin in Upper Ordovician, Middle Devonian, Upper Devonian to Lower Mississippian and Mississippian rocks (Creaney and others, 1994; Osadetz and others, 1992). Although the deepest part of the basin is located in North Dakota and not included in this assessment, thermally mature portions of each source rock unit extend into Canada (Creaney and others, 1994). There has been much discussion in the literature regarding the relative importance of the Devonian to Mississippian Bakken Formation to the petroleum resources of the basin (Leenheer, 1984; L.C. Price, 1994; Price and LeFever, 1992, 1994; Meissner, 1978; Osadetz and others, 1992; Creaney and others, 1994; Burrus and others, 1996). Recent work suggests that most of the oil now produced from Mississippian reservoirs originated from the Mississippian Lodgepole Formation rather than the Bakken. These Mississippian oil accumulations are the most significant of the four total petroleum systems mapped in the Williston Basin. In each of the four petroleum systems (524401, 524402, 524403 and 524404) one assessment unit (52440101, 52440201, 52440301, and 52440401) was evaluated for undiscovered oil and gas.

Gulf of Mexico Provinces

In the southern Gulf of Mexico, a stable Late Jurassic tectonic setting developed after a period of extensional tectonics that began in the Late Triassic. This period of tectonism involved three general phases: (1) Late Triassic to Middle Jurassic continental rifting, (2) Middle Jurassic to early Late Jurassic opening of the Gulf of Mexico Basin, and (3) Late Jurassic regional subsidence (Salvador, 1991a,b). Several large grabens developed, with sedimentary sections varying from Upper Triassic nonmarine red beds to Middle Jurassic salt deposits, the latter of which are widespread in the Gulf of Mexico. The cessation of extensive salt deposition coincided with the opening of the Gulf of Mexico Basin, which resulted in a greater influx and deepening of marine waters. This tectonic setting remained stable from Late Jurassic through the Tertiary (Peterson, 1983). A marine transgression in Late Jurassic time, resulted in the deposition of a major source rock (Guzman-Vega and Mello, 1999). In general, the Upper Jurassic strata are dark-gray to black limestone, argillaceous limestone, calcareous shale, and dark shale that originated in various shelf, ramp, and basin settings (Salvador, 1991b). These depositional settings continued into the Early Cretaceous but by mid-Cretaceous, the important carbonate buildups of the Tuxpan and the Yucatan platforms were well developed (McFarlan and Menes, 1991). The Yucatan platform and extensions to the west continued to be a site of carbonate platform and slope sedimentation through the Late Cretaceous (Sohl and others, 1991), and similar carbonate sedimentation continued into the Paleocene along the Yucatan platform (Galloway and others, 1991).

The Cretaceous and Paleocene carbonates that were deposited in various platform margin, ramp, and basinal settings are the principal reservoir rocks in the Gulf of Mexico Basin provinces (Enos, 1977, 1985). The remainder of the Tertiary sedimentary sequence provided the overburden necessary to generate and mobilize the petroleum that charged these reservoirs (Guzman-Vega and Mello, 1999). On the east side of the southern Gulf of Mexico, salt movement formed traps; whereas on the western side, traps formed on carbonate reefs and in debris flows (Enos, 1977, 1985).

In summary, the 100 million years of tectonic and depositional stability between the late Jurassic and the Paleocene in this region led to development of the excellent source and reservoir rocks, whereas the Tertiary sedimentation that followed provided the overburden rock to create salt movement that formed traps and mature the underlying source rock. One total petroleum system was mapped (530501) and seven assessment units (53050101, 53050102, 53050103, 53050104, 53050105, 53050106, and 53050107) were used to evaluate the undiscovered oil and gas.

ASSESSMENT RESULTS

The assessment results for Region 5 are summarized in the Region 5 Assessment Results Summary. Note that, in the case where the TPS boundary extends beyond the boundary of the assessed province, a portion of the resource has been allocated to that adjacent province, but the adjacent province has not been assessed.

SIGNIFICANCE OF ASSESSMENT

This assessment shows that the greatest to least potential for large undiscovered oil and gas fields in Region 5 is as follows: Greenland, Mexico, and Canada.

The potential for large oil fields in the East Greenland province is high. The presence of areas that contain exposed, bitumen-filled sandstone, interpreted to be remnants of large petroleum traps onshore, is encouraging evidence for the existence of similar sized accumulations offshore. Issues related to the presence of year-around offshore ice in this province appear to be the most serious obstacles to exploration.

In the southern Gulf of Mexico, the Saline-Comalcalco Basin and the Villahermosa Uplift have considerable potential for large fields. The potential for large fields is mostly offshore in water depths of as much as 2000 m, and mainly in carbonate debris flow reservoirs. Several large oil fields have already been discovered in carbonate debris flow and turbidity current reservoirs in the offshore on the

Villahermosa Uplift. The thermally mature Upper Jurassic source rock is a more than adequate charge for all the undiscovered traps.

Analysis of the sizes and numbers of pools discovered through time in Canada, for the defined assessment units, suggest that significant numbers of pools and volumes of conventional oil and gas remain to be found. The sizes of individual pools, however, are unlikely to be large. These results, at the assessment unit level, indicate relatively mature exploration.

It should be pointed out that two assessment units that contain large known reserves and potentially large undiscovered volumes of natural gas were identified but not assessed because of their continuous (non-conventional) nature. These two units are the Mannville Continuous (Basin-Center) Gas (52430502) and the Upper Cretaceous Eastern Shallow Gas (52430603) assessment units (Continuous Resource Map). It is also likely that coal bed methane will add significant reserves to Western Canada in the future. Finally, mention must be made of the huge bitumen deposits in the Alberta Basin. These were not assessed because they are also non-conventional.

Note: A minimum pool size of 0.5 million barrels of oil for oil pools and 3 billion cubic feet of gas for gas pools was chosen for AU in western Canada. Due to rounding, the minimum oil-pool size appears as 1 million barrels in the assessment results tables.

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