Siberian Platform: Geology and Natural Bitumen Resources

By Richard F. Meyer and Philip A. Freeman

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Siberian Platform: Geology and Natural Bitumen Resources

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Summary: The Siberian platform is located between the Yenisey River on the west and the Lena River on the south and east. The Siberian platform is vast in size and inhospitable in its climate. This report is concerned principally with the setting, formation, and potential volumes of natural bitumen. In this report the volumes of maltha and asphalt referred to in the Russian literature are combined to represent natural bitumen. The generation hydrocarbons and formation of hydrocarbon accumulations are discussed. The sedimentary basins of the Platform are described in terms of the Klemme basin classification system and the conditions controlling formation of natural bitumen. Estimates of in-place bitumen resources are reviewed and evaluated. If the bitumen volume estimate is confined to parts of identified deposits where field observations have verified rock and bitumen grades values, the bitumen resource amounts to about 62 billion barrels of oil in-place. However, estimates of an order of magnitude larger can be obtained if additional speculative and unverified rock volumes and grade measures are included.

Introduction

The Siberian platform (fig. 1) is well defined physiographically. It is located by the Yenisey River on the west and the Lena River on the south and east. The Yenisey River separates it from the western East Siberian lowland. As is commonly the case, the drainage rather closely delimits the geology. Elevations of up to 200 m above sea level extend from the Western Siberia Lowlands to the Yenisey-Khatanga, Anabar-Lena, and Verkhoyansk basins (Dewdney, 1982). Much of the rest of the Siberian platform is covered by the East Siberian Plateau. This East Siberia Plateau consists of a series of dissected plateaus at elevations of 350-700 m, with isolated mountains to 1700 m. The Yenisey and Lena rivers, with catchment areas of 2.4 million km² each, drain north into the Kara and Laptev Seas, respectively. Just east of the Verkhoyansk basin in the marginal fold belt, the mean temperature is above freezing (0°C) for only five months, with a maximum of 15°C in July and a January mean of -50°C. Annual precipitation is 102 mm.

Three of the oil, gas, and bitumen provinces of Russia are found in eastern Siberia (Dickenshtyn, and others, 1983). The Yenisey-Anabar province coincides with the Yenisey-Khatanga and Anabar-Lena basins and the Lena-Vilyuy province with the Vilyuy basin, while the Lena-Tunguska oil and gas province incorporates the balance of the region.

Because the Siberian platform is vast in size and inhospitable in its climate, the geology is not fully understood. Table 1 is intended to help in the discussion of resources by indicating equivalences of nomenclature, no simple task. Figure 1 is a map of the area encompassed by the Siberian platform. In the discussion that follows, references to “feature x” refer to locations of the geologic features referenced in Figure 1. The geologic features within the basin outlines are shown in their approximate geographic locations. Of particular importance with respect to resources are the Aldan (feature D) and Anabar arches (feature K) and the Nepa-Botuoba (feature C) and Baykit (feature F) anticlines. No available maps locate these features in detail but neither are these point locations. In most Russian publications, maps regardless of scale or area, are reproduced page-size and usually without coordinates. However, rivers are commonly shown to indicate locations.

This report is concerned principally with heavy oil and natural bitumen. Heavy oil is defined as that oil with an API gravity[1] of 10-20 degrees. Natural bitumen includes all oil with API gravity of less than 10 degrees; the term includes oil called extra-heavy as well as oil sands (tar sands). Heavy oil also has a viscosity greater than 100 cP and natural bitumen has a viscosity that exceeds 10,000 cP. However, viscosity measurements are too seldom reported to permit their use for statistical purposes. In Russia heavy oil is generally termed high-viscous oil and has a density of 0.92-0.96 g/cm³ (15.8-22°API). Still heavier oil is termed maltha, which is viscous, has a density of 0.95-1.05 g/cm³ (3.3-17.4°API); it also is comprised of 40-65% oils and 35-60% asphalt and tar (resin). Asphalt has a density of 1.00-1.12 g/cm³ (10-(-3)°API), with 25-40% oils. Such chemical analyses are not routinely made on petroleum outside Russia. In this report quantities of maltha and asphalt are combined to represent natural bitumen.

Geology

The Siberian platform is an ancient structure, with its roots in Precambrian time. It is found in the northeastern part of the Eurasian plate (Simkin, and others, 2006). The Siberian platform thus stands as a buttress against the strong folding around its borders.

Gol’dberg, Lebedev, and Frolov (1981), leading geologists and geochemists of the Former Soviet Union, have predicted the prospective additional oil, natural gas, and bitumen resources of the Siberian platform on the basis of: (1) tectonic history; (2) distribution of regional seals in the cover rocks; (3) assessment of the oil, gas, and bitumen capability;(4) composition of the hydrocarbons

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[1] API gravity is computed as (141.5/sp g)-131.5 where sp g is the specific gravity of oil at 60 degrees Fahrenheit.

and bitumens; and (5) the times of generation and loss of those hydrocarbons and bitumens. Much of the following discussion follows their report.

In their assessments, Gol'dberg, Lebedev, and Frolov (1981) argue that the following geologic elements were important in hydrocarbon formation: (1) the great stability of the major structural elements that are distinguishable at all stages of development on the basement and in the lower cover beds; this stability would imply a constant position of the main zones for hydrocarbon generation, accumulation, and migration; (2) extensive development of volcanic trap magmatism; (3) accumulation of the greatest thickness of cover in Vendian and Early Cambrian time; (4) development of thick salt deposits in the Lower Cambrian rocks over a substantial part of the platform, and in Lower Devonian rocks in the northwestern and eastern areas; and (5) maximum subsidence of the crust below the salt of about 6.5 km and of the crust outside the limits of salt deposition of 2-3 km.

The formation of the sedimentary cover on the post-Lower Proterozoic Siberian platform had begun on a broad scale at the start of Upper Proteozoic Riphean time. At this point intense differential movements, both contractual and extensional, led to the creation of the principal structures, including the Anabar (feature K) and Aldan (feature D) arches, Nepa-Botuoba (feature C), and Baykit (feature F) anticlines, the Sayan-Yenisey (feature B) and Evenkiy (feature G) synclines, and such regional depressions as the Patom-Vilyuy (feature E), Yenisey-Khatanga (feature L), Teren-Dyupkun (feature H), and Lena-Anabar (feature A). In Riphean time the generation of the first hydrocarbon accumulations on the Siberian platform commenced. Unfortunately, these deposits largely were destroyed because of the lack of a regional cap-rock and the long period of denudation of the overlying sediments. Later in Riphean time, apparently only small amounts of natural gas were generated in areas of greatest subsidence.

Generation of present-day oil and gas accumulations took place in Middle to Late Cambrian time, when the Vendian and Lower Cambrian deposits, the most important generating complexes of the platform, had subsided to depths of 2.5 km. Bazhenova, Belyayeva, and Shumenkova (1982) estimated that during this period more than 800 million tons of oil and 900 trillion m^3 of gas were expelled from source rocks. The main negative areas were the Evenkiy (feature G) and Sayan-Yenisey synclines (feature B), the southern part of the Patom-Vilyuy depression (feature E), and the western, northern, and eastern folded margins of the platform. By then, hydrocarbon accumulations had formed in the Vendian and Lower Cambrian sediments below the salt and migration to the flanks of the positive structures, particularly the Nepa-Botuoba (feature C) and Baykit (feature F) anticlines had begun. In this area the thick Lower Cambrian salt deposits sealed the accumulations, whereas over the Aldan (feature D) and Anabar (feature K)arches the absence of the salt cap permitted loss of the light components and the start of heavy oil formation on the structural crests.

Differential subsidence of the platform continued throughout Late Cambrian, Ordovician, and Silurian time. During this time, oil, gas, and gas-condensate generating systems developed, but the lack of sealing beds allowed further degassing and heavy oil evolution over the Aldan (feature K) and Anabar (feature D) arches.

With initiation of the Devonian, the overall oscillatory subsidence of the platform changed to a regime in which the both favorable and unfavorable elements to hydrocarbon formation intensified. The distribution of these elements was little changed but large-scale intrusion of volcanic traps was introduced over the western platform and is described as the Tunguska structural-volcanic zone.

During Carboniferous, Permian, and Triassic time, structural evolution continued as during the Devonian. Over much of the platform little generation of new hydrocarbons took place but existing deposits were further transformed. In the Nepa-Botuoba anticline (feature C), gas-condensate fields with oil fringes developed and were preserved. In the Evenkiy syncline (feature G), intensive volcanic trap intrusion, accompanied by increases in vertical permeability of the sedimentary cover, caused destruction of heavy gas condensates and formation of light oil. Evidence of the condensate destruction takes the form of deposits of ozokerite and hatchettite.

On the east flank of the Aldan arch (feature D), adjacent to the platform margin, deposits of heavy oil continued to be generated. In the area of the Anabar arch (feature K) the existing heavy oil was metamorphosed into asphaltic bitumen. Natural bitumen now forms large deposits on the flank of the Anabar arch, and in other, smaller, parallel folds. Apparently the redistribution of oil beyond the boundary of the Lower Cambrian salt cap over the Anabar arch occurred during the post-Devonian period, and the natural bitumen deposits associated with the Anabar arch formed during the Middle and Upper Cambrian age.

The present day distribution of oil, gas, and bitumen in the Vendian-Lower Cambrian complex of major structural elements of the Siberian platform was essentially complete at the end of the Triassic. Substantial loss of natural gas due to vertical migration is typical of the Mesozoic and Cenozoic. Thick argillaceous Mesozoic sediments, rich in organic matter, accumulated in the large marginal depressions, the Yenisey-Khatanga, Anabar-Lena , and Verkhoyansk (fig 1). In the Anabar-Lena basin the narrow structures with steeply-dipping limbs, and the absence of cap-rock led to the loss of gas and to formation of predominantly oil accumulations in the Permian and Mesozoic sediments.

During the Mesozoic and Cenozoic periods oil from synclines, which were filled with thick sequences of Upper Paleozoic, Mesozoic, and Cenozoic rocks, migrated laterally. Heavy oil and bitumen deposits were formed in the Vendian-Lower Cambrian formations on the north slope of the Aldan arch (feature D), in the Jurassic deposits on the southeast slope of the Anabar arch (feature K), and in the Permian on the north slope on the Aldan arch. These bitumen deposits differ from those developed in the pre-Devonian subsalt periods of migration and accumulation in that they are less variable in composition, with fewer asphaltenes, no metamorphosed varieties as a result of trap intrusions or hot springs, and with higher saturations, of up to 10-12wt% in Jurassic deposits.

The regions of preferential bitumen occurrence currently are the Aldan (feature D) and Anabar (feature K) arches and the Turukhan-Norilsk ridge (feature J). Stratigraphically, bitumen-bearing rocks include the Vendian-Lower Cambrian, Middle-Upper Cambrian, Permian, and Jurassic of the Anabar arch; the Vendian-Lower Cambrian of the Aldan arch; and the Lower and Middle Paleozoic of the southern part of the Turukhan-Norilsk ridge.

The Evenkiy syncline (feature G), central and northern parts of the Nepa-Botuoba anticline (feature C), and the Katanga saddle (feature M) are areas of conventional oil and gas deposits. In the Nepa-Botuoba anticline and the Katanga saddle the oil and gas deposits have been protected by the Lower Cambrian salt seal. The oil and gas in the Evenkiy syncline has been similarly protected on the south and by the Devonian salt on the north.

Gol'dberg, Lebedev, and Frolov (1981) conclude that the southern part of the Nepa-Botuoba anticline (feature C) and the Angara-Lena bench (feature A) are regions of concentration of mostly gas and gas condensate.

The Siberian platform (fig. 1) includes four types of basins, as defined by Klemme (1980a, 1984). Type I basins are found in the interior of the craton and include the Olenek and Tunguska basins. Type IIA basins are those on the margins of cratons. Here are included the Anabar-Lena, Angara-Lena, Irkutsk, Kansk, Verkhoyansk, Vilyuy, and Yenisey-Khatanga basins.

Type IIB basins are formed of rocks accreted to the craton margin and are represented by the Kuznets, Laptev, and Minusinsk basins (fig. 1). The Kuznets and Minusinsk basins are important coal-producing basins but are not known to include deposits of natural bitumen. They may perhaps belong more naturally with the young West Siberian platform rather to than the Siberian platform. Although the Laptev basin (fig. 1) has no known bitumen deposits, based upon seismic profiles, Vinogradov (1983) contends the geology and stratigraphic succession is remarkably similar to that of the Siberian platform. The Riphean is not expected to exceed one km in thickness. The Vendian-Middle Paleozoic complex should include domanik-type organic shale in the Vendian and Middle Devonian and marine and lagoonal carbonates and salt in the Middle and Upper Devonian. The complex is estimated to be 3 km in thickness. The Upper Paleozoic-Lower Cretaceous is probably comprised of about 3 km of marine and continental clastics and coal. Lastly, the Upper Cretaceous-Cenozoic complex may be 3-3.5 km thick in the trough (Ust'-Lena) along the mouth of the Lena river. With analogy to onshore, the rocks should be clastic, with plant fragments.

Lastly, there is a single type IIIB basin, the Baikal, comprised of strata accreted to the craton and rifted. Lake Baikal occupies a deep rift valley.

Resources

Numerous deposits of natural bitumen are found on the northern portion of the Siberian platform. Most are attributable to the absence of reservoir seals over previously-generated deposits of oil and gas.   Some heavy oil is known (table 3). In the following discussion the map location (fig. 1) is indicated by the number in parentheses after the deposit name.

The Siberian platform is characterized by sharply expressed structural elements in the sedimentary cover (Khalimov, and others, 1983). Large structural elements, the Aldan (feature D) and Anabar (feature K) arches,and the Turkhan-Norilsk (Yenisey) ridge (feature J), are distinguishable in the basement. The Aldan and Anabar arches have Precambrian crystalline basement exposed at the surface and the Turkhan-Norilsk (Yenisey) ridge has crystalline rocks younger than those in the preceding arches. In the structural depressions, over the platform, the basement is buried under sedimentary cover from 10-15 km thick. On the northwest and the northeast are the foreland depressions, the Yenisey-Khatanga and Tunguska basins, and the Sayan-Yenisey syncline, filled with Mesozoic rocks in the upper part of the section. In addition, there are numerous smaller structures. Oil and gas fields and natural bitumen deposits are associated to these smaller structures as described in the earlier section on geologic evolution of the platform. All the productive oil and gas fields are found in the Irkutsk, Angara-Lena, Tunguska, and Vilyuy basins but are mainly localized along the Nepa-Botuoba (feature C) and near Baykit (feature F) anticlines.

The Olenek (1) deposit, the most-studied and presumably the most important bitumen deposit on the Siberian platform and probably in all Russia, is located on a fold parallel to the Anabar arch (feature K) in the Olenek basin. Although rocks from Archean to Permian are present, the bitumen-saturated strata are of Upper Cambrian age. These are dolomite and limestone from 0-250 m in thickness. The carbonates are intensely fractured and also are cavernous in the upper part, to depths of 60-70 m. These rocks are transgressed by Permian clastics, which range in thickness from south to north from 60-85 m to 340 m, mainly because of the uneven Precambrian surface. The lower part of the Permian section is bitumen-free. The tops of sandy sections are impregnated with bitumen. Saturations vary from slight to 7wt%, but are most frequently 3-4wt%.

Bituminous sandstones are well-developed to the north, forming narrow, lenticular bodies up to 1 km in length. The saturated lenses are arranged en echelon and extend as much as 10 km, with widths of 3-12 km. These form a semi-circle of saturated rocks on the gently-sloping north and northeast sides of the Anabar arch (feature K) over an area of more than 250 km². Along the arch south of the Olenek deposit are two bitumen deposits, Kuoyka (14) and Sololisk (15), with reservoirs in Riphean and Lower Cambrian sandstones and dolomites. The total area of bituminous rocks, with thicknesses reaching 15 m, is over 800 km². Bitumen saturation is uneven, ranging from 1.2-10%.

On the east slope of the Anabar arch (feature K) are the Vendian-Lower Cambrian deposits which constitute the East Anabar (2) accumulation. These are fractured cavernous dolomites and limestones trending north-south for several km. Although up to 40 m in thickness, the saturations are low, from 0.2-2wt%, rarely 3wt%.

The Medvezh'ye (7) deposit is located on the northwest slope of the Anabar arch. There, natural bitumen, maltha, and asphalt saturate dolomites and limestones of Upper Cambrian and Ordovician age, both stratiform and lenticular. The zone is 17 km long by 5 km wide, with an effective thickness of 16m.

The Siligir-Markha (4) deposit is found on a small fold along the south flank of the Anabar arch (feature K). The fold is asymmetrical, the southwest limb is subtle but the northwest limb dips up to 9°. The Middle and Upper Cambrian limestones and dolomites are impregnated with maltha and asphalt. The rocks crop out in the northwestern part of the arch. A borehole in the deposit penetrated impregnated Riphean and Lower Cambrian sandstones and carbonates. Middle and Upper Cambrian rocks with 0.3-15wt% bitumen are thought to occupy an area of about 6000 km². However, the deposit has not been studied in detail.

The Rassokha (5) bitumen deposit is found on the north flank of the Anabar arch (feature K) in the zone of contact between Riphean sandstones and Lower Cambrian dolomites. The bitumens are maltha, the beds are 10-15 m thick, and the deposits are concentrated in the Riphean clastics. The saturated rocks are gently downwarped toward the Yenisey-Khatanga basin and cover about 250 km² at depths up to 50 m.

The Chun'ya (6) bitumen field, about 200 km² in the central portion of the Tunguska basin, is comprised of Middle and Upper Ordovician limestones with reservoir rocks a total of 8 m thick. The saturation is 0.2-3.6wt%.

The Turukhan (8) bitumen field is found in the area of the Turukhan-Norilsk ridge (feature J). Impregnations of maltha and asphalt are found in porous dolomites of Vendian, Lower and Middle Cambrian, and Lower Silurian age. The bitumens are in lenses and veins.

Other, unnamed bitumen deposits are found throughout much of the Tunguska basin, often bounded by trap rock. One of these deposits is analyzed as consisting of 82.28% carbon, 9,55% hydrogen, 5.01% sulfur, and 5.16% oxygen plus nitrogen.

The Chekurovka (3) and Bulkur (9) bitumen fields, covering an area of 800 km² are located in the extreme northeast edge of the Verhoyansk basin. The bitumens, most importantly maltha and asphalt, are confined to Vendian and Lower Cambrian strata. The occurrences are both stratiform and vein and the saturation is only 1.8wt%

A number of bitumen deposits are associated with the Aldan arch (feature D). In the Tuolba (10) deposit, on the west flank of the Tuolba high on the Aldan arch, heavy oil shows were found in basal sandstones and dolomites of Lower Vendian age at depths of 400-500 m. At the surface, Lower Cambrian carbonates 5-6 m thick, with saturations of 1.5-3wt% are present. The bitumen inclusions are of asphalt.

On the east flank of the Tuolba high, extensive surface occurrences of asphalt and maltha are present in Lower Cambrian carbonates. These rocks constitute the Amga (11) deposit, in which the thicknesses are 1.5-3 m, and saturations are no more than 1.5wt%.

The Sina (12) deposit on the Aldan arch (feature D) is composed of stratiform and vein bitumens in fractured Lower Cambrian limestones. Saturations are only 0.3-6.7wt%.

In the Baikal area some asphalt and heavy oil is known, but most of the bitumen is in the form of ozokerite, a waxy bitumen with a melting point above 50°C. It is of little commercial value although it is exploited in many places in Russia.

The natural bitumen deposits listed in table 2 is misleading in its simplicity. The bitumen deposits (kirs, oil sands, tar sands) are common, widespread, and inadequately defined with bore holes. The English-language reports and accompanying resource estimates all represent translations of reports by Russian geologists. The amounts of bitumen are taken primarily from Gol'dberg's unpublished 1994 map. They represent reasonable estimates by a highly-experienced, competent geochemist, Gold'berg (1981) and the estimates by Gold'berg are based on field data. Not all deposits have been evaluated for resource content. Estimated volumes of bitumen in poorly known deposits made by a variety of other researchers (see summary section of table 2) are typically computed on the basis of a grade or percent weight of bitumen and a speculative estimate of volume of rock. Such estimates of bitumen resources may vary by orders of magnitude (table 2).

The estimates of Siberian platform total resources (see summary table 2) suggest a median estimate of perhaps 600 billion barrels. This is a substantial amount, even compared with Alberta, Canada. Even if this gross resource volume is present, the economic value to the Siberian resources suffers from the following mitigating factors: (1) the climate is extreme; (2) the area is remote and is essentially lacking in technological infrastructure; (3) the deposits are near-surface and relatively thin, requiring surface mining for exploitation; (4) bitumen saturations are low, usually under 5wt%; Russia still has very large oil reserves and enormous natural gas reserves. It is, therefore, unlikely that efforts will be made for large-scale bitumen exploitation until at least the middle of the present century.

Table 3 lists the few Siberian platform fields definitely known to have been productive of heavy oil. In addition, the table lists fields included in the report of the Lawyers' & Merchants' Translation Bureau (1950). It is not known which, if any, of these fields contained heavy oil, but it is likely that many did. Because they were drilled in the 1930s, most of them are in the areas where bitumen deposits are near the surface, providing clues to the presence of hydrocarbon deposits. These also are places where the salt seals had been removed so that conventional oil deposits, if not destroyed, would likely have been degraded to heavy oil. Heavy oil is known to be present in the Baikal basin in the vicinity of Lake Baikal.

At least 98 more recently discovered fields are known on the Siberian platform than are listed in table 3. These are mostly natural gas and gas-condensate fields and more than 40% of the total is located over the Nepa-Botuoba (feature C) and Baykit (feature F) anticlines, where the salt seals were preserved through time. The Yurubchenko-Tokhom oil, gas, and condensate field, (not listed in table 3) is located on the highest part of the Baykit anticline. It is the only giant field in the world with pools in Precambrian Riphean rocks (Bitner, and others, 1998). The field is divided into fault blocks with pay zones present not only in the Riphean carbonates, but also in clastics and carbonates of the Vendian. The field, covering an area of 13,000 km^2, produces from an eroded interval at the top of the Riphean. In 1982 a well in the field yielded oil from sediments 324 m below the erosion surface (Stenanenko, 1995).

Many of the oil gravity values of recently discovered fields and older fields are not in the public domain. The fields cited by Lawyers' and Merchants' Translation Bureau (1950) date as far back in time as the early 1930s and many of these, located in the northern parts of the Siberian platform, were likely heavy oil. At the time of this drilling the platform was very poorly known, indeed, and most of the wells were drilled near areas of bitumen deposits, a reasonable exploration approach. The few fields known to have heavy oil are in the area of bitumen deposits or else adjacent to Lake Baikal, where lumps of bitumen are found along the shore of the lake.

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The list of references is intended to enable more detailed study of the Siberian platform. Only a few are directly cited in this report. Other references are broad in scope, yielding information on all of Russia and Central Asia, that is, the Former Soviet Union.

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Table 1. Siberian Platform name equivalents

AAPG basin name	Basin type (Klemme)	Gol'dberg (1981)	Seregin and Sokolov (1977)	Age of strategraphic fill
Olenek (Sukhana)	I	Anabar arch	Sukhana	Paleozoic, Proterozoic
Tunguska (Lena-Tunguska)	I	Evenkiy (includes Turukhan-Norilsk ridge, Teren-Dyupkun depression, Baykit anteclise)	Tungusska	Mesozoic, Paleozoic, Proterozoic
Anabar-Lena	IIA	Anabar-Lena	Same	Mesozoic, Paleozoic, Proterozoic
Angara-Lena	IIA	Angara-Lena (includes Nepa-Botuoba anteclise, Angara-Lena benc)	Baikal-Lena	Paleozoic, Proterozoic
Irkutsk	IIA	(included with Angara-Lena)	Sayan-Yenisey	Mesozoic, Paleozoic, Proterozoic
Kansk	IIA	Sayan-Yenisey	Sayan-Yenisey	Mesozoic, Paleozoic, Proterozoic
Verkhoyansk	IIA	Pre-Verkhoyansk		Mesozoic, Paleozoic, Proterozoic
Vilyuy (includes Aldan-Maya)	IIA	Patom-Vilyuy (includes Aldan anteclise)	Lena-Vilyuy (includes Verkhoyansk)	Mesozoic, Paleozoic, Proterozoic
Yenisey-Khatanga	IIA	Yenisey-Khatanga (includes Khatanga saddle)		Permian-Cretaceous
Kuznets	IIB		Kuznets	Mesozoic, Paleozoic
Laptev	IIB		Laptev Sea	Cenozoic, Mesozoic
Minusinsk	IIB		Minusinsk	Mesozoic, Paleozoic
Baikal	IIIA	(included with Angara-Lena)	Baikal-Lena	Paleozoic, Proterozoic

Table 2. Bitumen resources of Siberian Platform. (OOIP – original oil in place)

Geological province	Basin type (Klemme)	Field name	Prospective OOIP (10^6bbl)	Reference
Olenek	I	Arga Sala		Meyerhoff and Meyer (1987)
Olenek	I	Olenek, Central (Sololisk, Kuoisk)		Meyerhoff and Meyer (1987)
Tunguska	I	Chun'ya	2,835	Goldberg (unpub. map and 1981); Central Intelligence Agency (1985); Khalimov, and others (1983)
Tunguska	I	Siligir-Markha	12,600	Goldberg (Unpub. Map; 1981; 1994);Beskrovnyy , and others. (1981); Janisch (1981);Khalimov, and others (1983)
Anabar-Lena	IIA	Anabar, East	5,355	Goldberg (Unpub. Map; 1994)
Anabar-Lena	IIA	Anabar, Middle	3,465	Goldberg (Unpub. Map; 1994)
Anabar-Lena	IIA	Anabar, North		Fane (1985)
Anabar-Lena	IIA	Kuoyka	2,835	Goldberg (Unpub. Map; 1994)
Anabar-Lena	IIA	Munsk		Fane (1985)
Anabar-Lena	IIA	Nordvik	2,205	Goldberg (unpub. map)
Anabar-Lena	IIA	Olenek	13,860	Goldberg (Unpub. Map; 1981; 1994); CIA (1985); Khalimov, and others (1983)
Anabar-Lena	IIA	Udzhinsk		Fane (1985)
Vilyuy	IIA	Aldan		Meyerhoff and Meyer (1987)
Vilyuy	IIA	Amga (Resource includes Sina & Tuolba)	15,750	Goldberg (Unpub. Map; 1994)
Vilyuy	IIA	Ingilisk		Fane (1985)
Vilyuy	IIA	Sina		Goldberg (Unpub. Map; 1994)
Vilyuy	IIA	Sinsk		Fane (1985)
Vilyuy	IIA	Tuolba		Goldberg (Unpub. Map; 1994)
Vilyuy	IIA	Yunsk		Fane (1985)
Yenisey-Khatanga	IIA	Koti Maimechen		Fane (1985)
Yenisey-Khatanga	IIA	Medvezh'Ye	630	Goldberg (Unpub. Map; 1994)
Yenisey-Khatanga	IIA	Rassokha	2,205	Goldberg (Unpub. Map; 1994)
TOTAL			61,740	
		Other Resource Assessments		
Olenek	I	Arga Sala	75,000	Meyerhoff and Meyer (1987)
Olenek	I	Olenek, Central	75,000	Meyerhoff and Meyer (1987)
Olenek	I	Olenek, Central (Sololisk, Kuoisk)		Fane (1985)
Tunguska	I	Siligir-Markha	13,000	Fane (1985)
Tunguska	I	Siligir-Markha (Aykhal)	150,000	Meyerhoff and Meyer (1987)
Anabar-Lena	IIA	Anabar, North		Fane (1985)
Anabar-Lena	IIA	Munsk		Fane (1985)
Anabar-Lena	IIA	Olenek	20,000	Meyerhoff and Meyer (1987)
Anabar-Lena	IIA	Udzhinsk		Fane (1985)
Angara-Lena	IIA	Olenek	100,000-900,000	Fane (1985)
Vilyuy	IIA	Aldan	315,000	Meyerhoff and Meyer (1987)
Vilyuy	IIA	Ingilisk		Fane (1985)
Vilyuy	IIA	Sinsk		Fane (1985)
Vilyuy	IIA	Tuolba		Fane (1985)
Vilyuy	IIA	Yunsk		Fane (1985)
Yenisey-Khatanga	IIA	Koti Maimechen		Fane (1985)
Yenisey-Khatanga	IIA	Rassokha		Fane (1985)

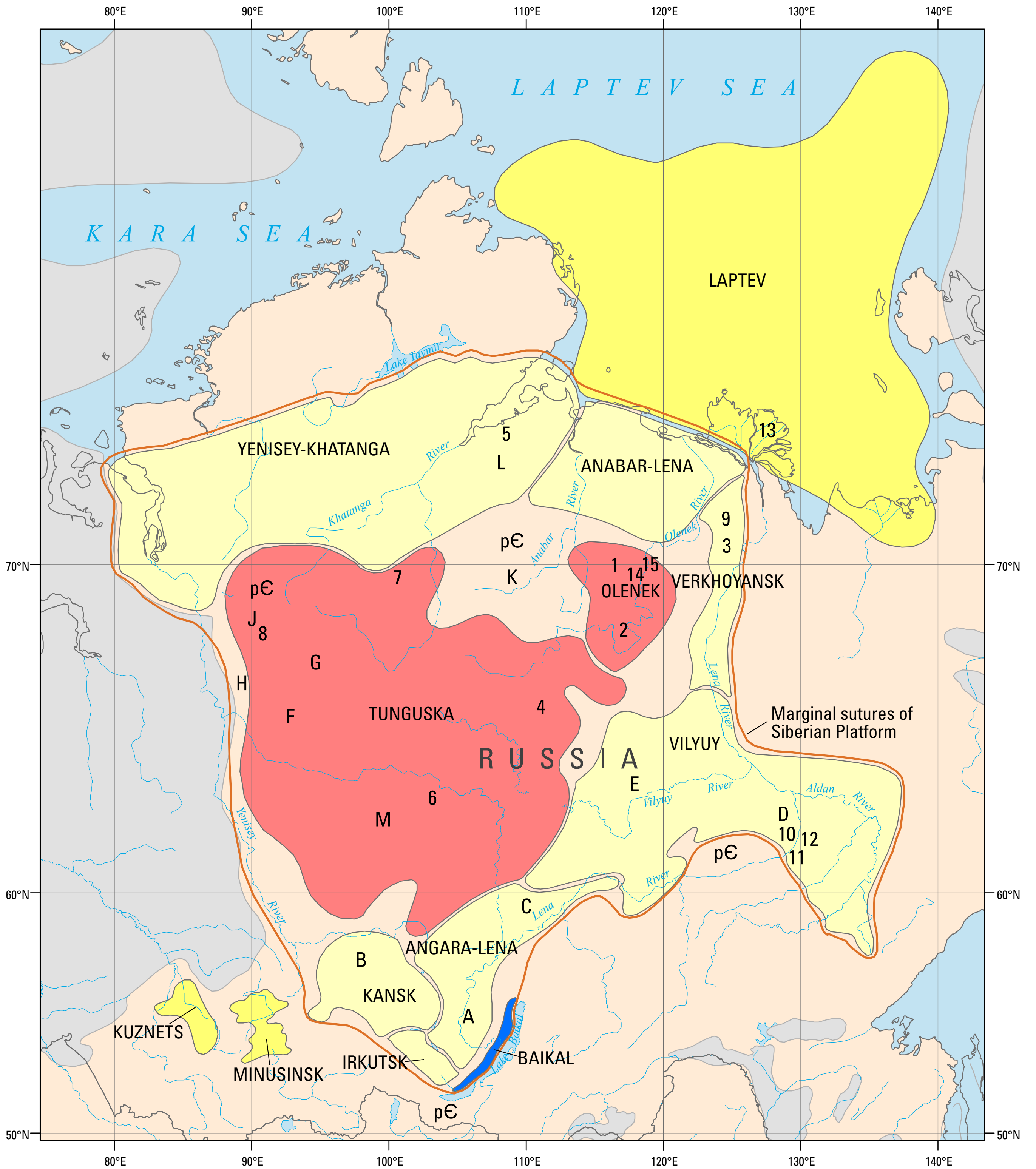
Table 2. Bitumen resources of Siberian Platform – cont.

Platform Bitumen Resource Summaries

	Prospective OOIP (10^6bbl)	Reference
Siberian platform	701,300-801,300	Medaisko (1989)
Siberian platform	91,753	Gol'dberg (1981)
Siberian platform	598,500	Starosel'tsev
Siberian platform	647,000	Meyerhoff and Meyer (1987)
Siberian platform	729,000	Meyerhoff and Meyer (1987)
Siberian platform	61,740	This report

Table 3. Oil fields of the Siberian Platform
CO – conventional oil, HO – heavy oil, ? indicates uncertainty

Geological province	Basin type (Klemme)	Oil type	Field name	Prospective OOIP (10^6bbl)	OOIP discovered (10^6bbl)	Reference
Olenek	I	CO?	Arga Sala			Lawyers' & Merchants' (1950)
Tunguska	I	CO?	Sukhaja Tunguska			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Anabar			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Belaja			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Chaidakh			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Ilia			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Koshevnikove salt dome	6,300		Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Kotui			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Olenek			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	CO?	Olenek			Lawyers' & Merchants' (1950)
Angara-Lena	IIA	CO?	Baikal-Sayan area wells			Lawyers' & Merchants' (1950)
Angara-Lena	IIA	CO?	Kempendzai area wells			Lawyers' & Merchants' (1950)
Verkhoyansk	IIA	CO?	Verkhoyansk ridge wells			Lawyers' & Merchants' (1950)
Vilyuy	IIA	CO?	Amga			Lawyers' & Merchants' (1950)
Vilyuy	IIA	CO?	Eve Tas			Lawyers' & Merchants' (1950)
Vilyuy	IIA	CO?	Namana			Lawyers' & Merchants' (1950)
Vilyuy	IIA	CO?	Soljanka			Lawyers' & Merchants' (1950)
Vilyuy	IIA	CO?	Tuolba			Lawyers' & Merchants' (1950)
Vilyuy	IIA	CO?	Ust' Maia			Lawyers' & Merchants' (1950)
Yenisey-Khatanga	IIA	CO?	Diavolskaja			Lawyers' & Merchants' (1950)
Yenisey-Khatanga	IIA	CO?	Dudinka			Lawyers' & Merchants' (1950)
Yenisey-Khatanga	IIA	CO?	Karaul			Lawyers' & Merchants' (1950)
Yenisey-Khatanga	IIA	CO?	Tigan			Lawyers' & Merchants' (1950)
Yenisey-Khatanga	IIA	CO?	Ust' Port			Lawyers' & Merchants' (1950)
Kuznets	IIB	CO?	Domes unnamed			Lawyers' & Merchants' (1950)
Minusinsk	IIB	CO?	Anticlines and domes unnamed			Lawyers' & Merchants' (1950)
Baikal	IIIA	CO?	Barguzin			Lawyers' & Merchants' (1950)
Baikal	IIIA	CO?	Selenga			Lawyers' & Merchants' (1950)
Baikal	IIIA	CO?	Taikhoi			Lawyers' & Merchants' (1950)
Anabar-Lena	IIA	HO	Anabar, East (Vostochno-Anabar)	12,000		Meyerhoff and Meyer (1987)
Anabar-Lena	IIA	HO	Nordvik		1,000	Meyerhoff and Meyer (1987)
Anabar-Lena	IIA	HO	Nordvik salt dome			Meyerhoff and Meyer (1987)
Vilyuy	IIA	HO	Sredne-Vilyuy			Meyerhoff and Meyer (1987)
Yenisey-Khatanga	IIA	HO	Tigan-Yuzhno			Meyerhoff and Meyer (1987)
Yenisey-Khatanga	IIA	HO	Tigan-Yuzhno			Meyerhoff and Meyer (1987)
Baikal	IIIA	HO	Baykal		1,000	Meyerhoff and Meyer (1987)
Baikal	IIIA	HO	Cape Tolstoy			Meyerhoff and Meyer (1987)
Baikal	IIIA	HO	Sarankhur			Meyerhoff and Meyer (1987)



Mercator Projection
Mapscale at equator 1: 46 400 000

Basin outlines from Sedimentary Provinces of the World-HydroCarbon Productive and Nonproductive, compiled by Bill St. John, The American Association of Petroleum Geologists, CD-ROM datapage GIS mapping file. AAPG©1996, Basin outlines reprinted by permission of the AAPG whose permission is required for further use.

Figure 1. Map of sedimentary basins in the Siberian Platform, Russia. Key of deposit locations is on facing page. Approximate locations of geologic features referred to in text are labeled as: A, Angara-Lena bench; B, Sayan-Yenisey syncline; C, Nepa-Botuoba anticline; D, Aldan arch; E, Patom-Vilyuy depression; F, Baykit anticline; G, Evenkiy syncline; H, Teren-Dyupkun depression; J, Turukhan-Norilsk ridge; K, Anabar arch; L, Khatanga saddle; and M, Katanga saddle. Diagram on facing page shows Klemme basin architectural form and geological basin type for Siberian Platform basins.

EXPLANATION:

Siberian sedimentary basins by Klemme basin classification

- I
- IIA
- IIB
- IIIA
- Basins outside platform

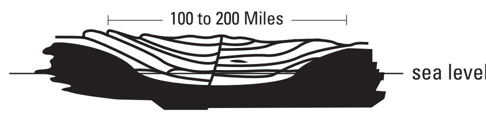
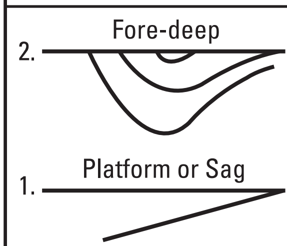
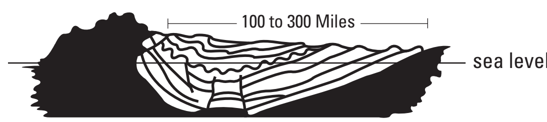
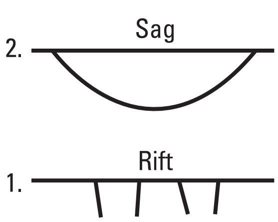
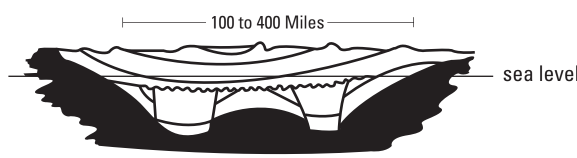
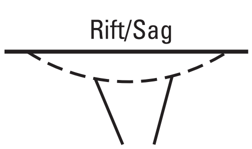
pЄ Precambrian cystalline terrain

DEPOSIT LOCATIONS:

1 Olenek
2 East Anabar
3 Chekurovka
4 Siligir-Markha
5 Rassokha
6 Chun'ya
7 Medvezh'ye
8 Turukhan
9 Bulkur
10 Tuolba
11 Amga
12 Sina
13 Ust'-Lena trough
14 Kuoyka
15 Sololisk

INSET MAP:

KLEMME BASIN CLASSIFICATION:

SEQUENTIAL BASIN ARCHITECTURAL FORM	GEOLOGICAL BASIN TYPES
	**I. CRATON INTERIOR BASINS** 
	**II. CONTINENTAL MULTICYCLIC BASINS** A. CRATON MARGIN - Composite 
	B. CRATON Accreted Margin - Complex 
	**III. CONTINENTAL RIFTED BASINS** A. CRATON AND ACCRETED ZONE RIFT 

Modified from St. John and others, 1984