COUNTRY NOTES

The following Country Notes on Oil Shale have been compiled by the Editors, drawing upon a wide variety of material, including papers authored by J.R. Dyni of the USGS, papers presented at the Symposium on Oil Shale in Tallinn, Estonia, November 2002, papers presented at the 26th Oil Shale Symposium in Golden, Colorado, October 2006, national and international publications, and direct communications with oil shale experts.

Australia

The total demonstrated oil shale resource is estimated to be in the region of 58 billion tonnes, of which about 24 billion barrels of oil is recoverable. The deposits are spread through the eastern and southern states of the country (Queensland, New South Wales, South Australia, Victoria and Tasmania), although it is the eastern Queensland deposits that have the best potential for economic development.

Production from oil shale deposits in southeastern Australia began in the 1860s, coming to an end in 1952 when government funding ceased. Between 1865 and 1952 some 4 million tonnes of oil shale were processed.

During the 1970s and early 1980s a modern exploration programme was undertaken by two Australian companies, Southern Pacific Petroleum N.L. and Central Pacific Minerals N.L. (SPP/CPM). The aim was to find high-quality oil shale deposits amenable to open-pit mining operations in areas near infrastructure and deepwater ports. The programme was successful in finding a number of silica-based oil shale deposits of commercial significance along the coast of Queensland. Ten deposits clustered in an area north of Brisbane were investigated and found to have an oil shale resource in excess of 20 billion barrels (based on a cutoff grade of 50 l/t at 0% moisture), which could support production of more than 1 million barrels a day.

Between 1995 and February 2002 the Stuart Deposit (located near Gladstone) was developed, firstly by a joint venture between SPP/CPM and Suncor Energy Inc. of Canada and then by SPP/CPM, following its purchase of Suncor’s interest. Further corporate restructuring took place when SPP became the holding company and CPM was delisted from the Australian stock exchange.

The Stuart project (found to have a total in-situ shale oil resource of 2.6 billion barrels and a capacity to produce more than 200 000 b/d) and incorporating the Alberta-Taciuk Processor (ATP) retort technology had three stages: The Stage 1 demonstration plant (producing a relatively light 42^{o} API gravity crude with 0.4 wt% sulphur and 1.0 wt% nitrogen) was constructed between 1997 and 1999 and produced over 500 000 barrels. The plant was designed to process 6 000 tonnes per stream day of run-of-mine (wet shale) to produce 4 500 bpsd of shale oil products. Stage 2 was to be scaled up by a factor of 4 to a commercial-sized module processing 23 500 tpsd and producing 15 500 bpsd oil products. It was envisaged that multiple commercial ATP units would come on stream during 2010-2013 processing up to 380 000 tpsd and producing up to 200 000 bpsd of oil products for a period in excess of 30 years.

To meet the needs of the market, the raw oil required further processing which resulted in ultra low-sulphur naphtha and light fuel oil. Shale oil has been certified as a feedstock for jet fuel production by the world's leading accreditation agencies and a long-term contract for the sale of naphtha to Mobil Oil Australia was in place. The light fuel oil was shipped to Singapore and sold into the fuel oil blending market.

Having committed itself to ensuring that the Stuart oil shale project had a sustainable development, SPP put various schemes into operation to achieve its stated environmental goals. One in particular launched in 1998 was a reforestation carbon dioxide sink. Some 250 000 trees were planted on deforested lands in Central Queensland. In September 2000, the first carbon trade in Queensland was announced. It was between SPP and the state government and was based on the reforestation trials.

In February 2004 Queensland Energy Resources Ltd. (QERL) acquired the oil shale assets of SPP and ran final plant trials at the demonstration facility. However, no production ensued and the Environmental Protection Agency regulated operations until the plant was closed in mid-2004. The facility is now on ‘care-and-maintenance in an operable condition’.

QERL continues to assess the possibilities for the future commercial operation of the Stuart project.

Brazil

The oil shale resource base is one of the largest in the world and was first exploited in 1884 in the State of Bahia. In 1935 shale oil was produced at a small plant in São Mateus do Sul in the State of Paraná and in 1950, following government support, a plant capable of producing 10 000 b/d shale oil was proposed for Tremembé, São Paulo.

Following the formation of Petrobras in 1953, the company developed the Petrosix process for shale transformation. Operations are concentrated on the reservoir of São Mateus do Sul, where the ore is found in two layers: the upper layer of shale (6.4 m thick), with an oil content of 6.4%, and the lower 3.2 m layer with an oil content of 9.1%. The company brought a pilot plant (8 inch internal diameter retort) into operation in 1982, its purpose being for oil shale characterisation, retorting tests and developing data for economic evaluation of new commercial plants. A 6 ft (internal diameter) retort demonstration plant followed in 1984 and was used for the optimisation of the Petrosix technology.

A 2 200 (nominal) tonnes per day, 18 ft (internal diameter) semi-works retort (the Iratí Profile Plant), originally brought on line in 1972, began operating on a limited commercial scale in 1981 and a further commercial plant - the 36 ft (internal diameter) Industrial Module retort - was brought into service in December 1991. Together the two commercial plants have a process capacity of some 7 800 tonnes of bituminous shale daily. The retort process (Petrosix) where the shale undergoes pyrolysis yields a nominal daily output of 3 870 barrels of shale oil, 120 tonnes of fuel gas, 45 tonnes of liquefied shale gas and 75 tonnes of sulphur. Actual daily output in 2005 was 3 040 barrels of shale oil, 80 tonnes of fuel gas, 31 tonnes of liquefied shale gas and 49 tonnes of sulphur.

The Ministry of Mines and Energy quotes end-1999 shale oil reserves as 445.1 million m^3 measured/indicated/inventoried and 9 402 million m^3 inferred/estimated, with shale gas reserves as 111 billion m^3 measured/indicated/ inventoried and 2 353 billion m^3 inferred/ estimated.

Canada

Oil shales occur throughout the country, with as many as 19 deposits having been identified. However, the majority of the in-place shale oil resources remain poorly known. The most explored deposits are those in the provinces of Nova Scotia and New Brunswick. Of the areas in Nova Scotia known to contain oil shales, development has been attempted at two - Stellarton and Antigonish. Mining took place at Stellarton from 1852 to 1859 and 1929 to 1930 and at Antigonish around 1865. The Stellarton Basin is estimated to hold some 825 million tonnes of oil shale, with an in-situ oil content of 168 million barrels. The Antigonish Basin has the second largest oil shale resource in Nova Scotia, with an estimated 738 million tonnes of shale and 76 million barrels of oil in situ.

Investigations into retorting and co-combustion (with coal for power generation) of Albert Mines shale (New Brunswick) have been conducted, including some experimental processing in 1988 at the Petrobras plant in Brazil. Interest has been shown in the New Brunswick deposits for the potential they might offer to reduce sulphur emissions by co-combustion of carbonate-rich shale residue with high-sulphur coal in power stations.

China

Between 2004 and 2006 China undertook its first national oil shale evaluation, which confirmed that the resource was both widespread and vast. According to the evaluation, it has been estimated that a total oil shale resource of some 720 billion tonnes is located across 22 provinces, 47 basins and 80 deposits. The shale oil resource has been estimated at some 48 billion tonnes.

Proved reserves of oil shale are estimated to be in the region of 36 billion tonnes.The major deposits are in Fushun in the north-eastern province of Liaoning, with a reserve of 3.6 billion tonnes and a Fischer Assay of 6%; Maoming in Guangdong, with 4.1 billion tonnes and 7%; Huadian in Jilin, with 0.3 billion tonnes and 10%; Longkow in Shandong with 0.1 billion tonnes and 14% and Nong An in Jilin with 16 billion tonnes and 4.5%.

The city of Fushun is known as the Chinese 'capital of coal'. Within the Fushun coalfield the West Open Pit mine is the largest operation of coal mining and is where, above the coal layer, oil shale from the Tertiary Formation is mined as a by-product.

The commercial extraction of oil shale and the operation of heating retorts for processing the oil shale were developed in Fushun between 1920 and 1930. After World War II, Refinery No. 1 had 200 retorts, each with a daily throughput of 100-200 tonnes of oil shale. It continued to operate and was joined by Refinery No. 2, restored in 1954. In Refinery No. 3 shale oil was hydrotreated for producing light liquid fuels. Shale oil was also open-pit mined in Maoming and 64 retorts were put into operation there in the 1960s.

At the beginning of the 1960s, 266 retorts were operating in Fushun's Refinery Nos. 1 and 2 and production peaked at about 23 million tonnes of oil shale (about 780 000 tonnes of shale oil). However, during the 1980s production had dropped to about 300 000 tonnes of shale oil and at the beginning of the 1990s the availability of much cheaper crude oil had led to the Maoming operation and Fushun Refinery Nos. 1 and 2 being shut down.

A new facility - the Fushun Oil Shale Retorting Plant - came into operation under the management of the Fushun Bureau of Mines. It at first consisted of 60 retorts producing 60 000 tonnes per year of shale oil to be sold as fuel oil, with carbon black as a by-product. By 2005 the total number of retorts stood at 120, each with a daily capacity of 100 tonnes of oil shale. In that year 180 000 tonnes of shale oil were produced. In 2006 it was expected that Fushun would again be expanded and operate 140 retorts. In addition to fuel oil some of the surplus retort gas with low heating value is used to produce steam and power. The shale ash is utilised in a 90 000 tonne/yr cement factory and a brick factory with an output of 60 million bricks per year.

Owing to high crude oil prices and favourable economic factors it is planned to further increase production capacity and a project to build an ATP retort capable of processing 6 000 tonnes per day is planned.

The production of oil shale has long been a by-product of Chinese coal mining. In the Longkow mining area the Bureau of Mines has a project to build a plant designed to process 2 million tonnes of oil shale, producing 200 000 tonnes of shale oil. A feasibility study has been approved by the Shandong Provincial Development Committee and following the utilisation of Fushun-type retorting to begin with, it is planned to use fluidised-bed combustion for producing power and ash suitable for building products.

A similar project is planned for Huadian in Jilin Province but with Petrosix technology being used. A prefeasibility study was approved by the China National Development and Reform Commission in late-2003 and the scheme is now at the feasibility stage.

It is planned to utilise oil shale once again in the Maoming retort in a fluidised-bed combustion process for the production of power.

China's high level of oil imports is influencing the country to further consider the development of its oil shale resource. It is possible that reserves in Uromqi Xinjiang, Yongden Gansu, Yilan, Heilongjiang etc will be utilised in the near future.

China possesses a wealth of knowledge regarding oil shale and the Petroleum University is assisting with a feasibility study on the Khoot oil shale deposit in Mongolia.

In 2005 the China National Oil Shale Association was established.

Egypt (Arab Republic)

Oil shale was discovered during the 1940s as a result of oil rocks self-igniting whilst phosphate mining was taking place. The phosphate beds in question lie adjacent to the Red Sea in the Safaga-Quseir area of the Eastern Desert. Analysis was at first undertaken in the Soviet Union in 1958 and was followed by further research in Berlin in the late 1970s. This latter work concentrated on the phosphate belt in the Eastern Desert, the Nile Valley and the southern Western Desert. The results showed that the Red Sea area was estimated to have about 4.5 billion barrels of in-place shale oil and that in the Western Desert, the Abu Tartour area contained about 1.2 billion barrels.

The studies concluded that the oil shale rocks in the Red Sea area were only accessible by underground mining methods and would be uneconomic for oil and gas extraction. However, the Abu Tartour rocks could be extracted whilst mining for phosphates and then utilised for power production for use in the mines. Additionally, although in both areas power could be generated for the in-place cement industry, the nature of the shale as a raw material would not be conducive to the manufacture of high-quality cement.

In view of the depletion of Egyptian fossil fuel reserves, a research project was implemented during 1994-1998 on the 'Availability of Oil Shale in Egypt and its Potential Use in Power Generation'. The project concluded that the burning of oil shale and its use as fuel for power production was feasible, but only became economic when heavy fuel oil and coal prices rose to significantly higher levels. Many recommendations of a technological and environmental nature were made and economic studies continue. A 20 MW oil shale pilot plant for power generation in Quseir was recommended as part of a first step towards the exploitation of Egyptian oil shale.

Estonia

Oil shale was first scientifically researched in the 18th century. In 1838 work was undertaken to establish an open-cast pit near the town of Rakvere and an attempt was made to obtain oil by distillation. Although it was concluded that the rock could be used as solid fuel and, after processing, as liquid or gaseous fuel, the 'kukersite' (derived from the name of the locality) was not exploited until the fuel shortages created by World War I began to impact.

The Baltic Oil Shale Basin is situated near the north-western boundary of the East European Platform. The Estonia and Tapa deposits are both situated in the west of the Basin, the former being the largest and highest-quality deposit within the Basin.

Since 1916 oil shale has had an enormous influence on the energy economy, particularly during the period of Soviet rule and then under the re-established Estonian Republic. At a very early stage, an oil shale development programme declared that kukersite could be used directly as a fuel in the domestic, industrial or transport sectors. Moreover, it was easily mined and could be even more effective as a combustible fuel in power plants or for oil distillation. Additionally kukersite ash could be used in the cement and brick-making industries.

Permanent mining began in 1918 and has continued until the present day, with capacity (both underground mining and open-cast) increasing as demand rose. By 1955 oil shale output had reached 7 million tonnes and was mainly used as power station/chemical plant fuel and in the production of cement. The opening of the 1 400 MW Balti Power Station in 1965 followed, in 1973, by the 1 600 MW Eesti Power Station again boosted production and by 1980 (the year of maximum output) the figure had risen to 31.35 million tonnes.

In 1981, the opening of a nuclear power station in the Leningrad district of Russia signalled the beginning of the decline in Estonian oil shale production. No longer were vast quantities required for power generation and the export of electricity. The decline lasted until 1995, since when production levels have varied but generally are less than half of those of the early 1980s.

The total Estonian in-place shale oil resource is currently estimated to be in the region of 16 billion barrels and at the present time continues to play a dominant role in the country's energy balance. However, many factors: economic, political and environmental are all having an effect.

In the years following independence, the oil shale industry was privatised and is now open to the forces of free market competition; production of oil shale has been shown to be economically viable up to a crude oil price of US$ 30 but with prices in excess of this level, new mining projects have become feasible; the country’s accession to the European Union has brought compliance with many directives, especially the emissions trading directive. Estonia has ratified the various climate change and pollution control protocols of recent years but must increasingly address the air and water pollution problems that nearly a century of oil shale mining has brought. Many investment programmes have been launched in an attempt to reduce the environmental effects of oil shale.

In 2005 14.6 million tonnes of oil shale were produced, among them the billionth tonne. Imports amounted to 0.2 million tonnes, 10.9 million tonnes were used for electricity generation, 0.7 for heat generation and 2.8

million tonnes were processed for shale oil and coke production. Production of shale oil was 345 000 tonnes, 222 000 tonnes were exported, 8 000 tonnes were utilised for electricity generation and 98 000 for heat generation.

The historical ratio of underground mining to open-cast (approximately 50:50) is tending to move away from open-cast production as the bed depths increase – the exhausted open-cast areas are gradually being recultivated and reforested. The Government has decreed that the share of renewables in electricity production will increase to 5.1% by 2012. Additionally, both the Long-term Development Plan for the Estonian Fuel and Energy Sector and the Estonia Forestry Development Programme 2001-2010 both state that the share of biofuels will increase. However, although the country possesses low-pollution peat and biofuels resources, they are limited and therefore oil shale is likely to remain central to the energy balance in the next decade.

Ethiopia

The existence of oil shale deposits in Ethiopia has been known since the 1950s. Although surveys were undertaken, no projects were proceeded with owing to high mining costs and lack of funding.

The resource, estimated to be 3.89 billion tonnes, in the northern province of Tigray is considered to be suitable for open-cast mining.

France

Oil shale was irregularly exploited in France between 1840 and 1957 but at its highest (1950), output only reached 0.5 million tonnes per year of shale. During its 118 year life, the Government imposed taxes and duties on foreign oil, thus preserving the indigenous industry.

In 1978 it was estimated that the in-place shale oil resources amounted to 7 billion barrels.

Germany

The German oil shale industry was developed in the middle of the 19th century and during the 1930s and 1940s the development of retorted oil contributed to the depleted fuel supplies during World War II.

Today the only active plant is located in Dotternhausen in southern Germany, where Rohrbach Zement began using oil shale in the 1930s. At the beginning of 2004, Holcim, a Swiss cement and aggregates company acquired Rohrbach Zement. The oil shale from this area has a low energy content, a low oil yield and a high ash content but by using a complex process the complete utilisation of both the oil shale energy and all its minerals can be accomplished and incorporated into the manufacture of cement and other hydraulic binding agents. A small part of the oil shale is directly used in a rotary kiln for cement clinker production as fuel and raw material. Most of the oil shale, however, is burnt in fluidised-bed units to produce a hydraulic mineral cement component while the heat of this process is used simultaneously to produce electricity.

A minimal quantity of oil shale is produced for use at Holcim's Dotternhausen cement plant. In 2005 and 2006 production amounted to 284 000 and 320 000 tonnes respectively.

In 1965 it was estimated that Germany's in-place shale oil resources amounted to 2 billion barrels.

India

Although oil shale, in association with coal and also oil, is known to exist in the far northeastern regions of Assam and Arunachal Pradesh, the extent of the resource and its quality have not yet been determined.

Currently oil shale, recovered with coal during the mining process, is discarded as a waste product. However, the Indian Directorate General of Hydrocarbons has initiated a project designed to assess the reserve and its development.

Indonesia

Faced with declining reserves of oil and gas, Indonesia has accelerated its research into identifying, and possibly utilising, its oil shale resources.

The Center for Geo Resources is currently engaged on surveying and preparing an inventory of occurrences. To date, three main prospective oil shale areas have been found, two on the island of Sumatera and one on Sulawesi.

Israel

Sizeable deposits of oil shale have been discovered in various parts of Israel, with the principal resources located in the north of the Negev desert. Estimates of the theoretical reserves total some 300 billion tonnes, of which those considered to be open-pit mineable are put at *only* a few billion tonnes. The largest deposit (Rotem Yamin) has shale beds with a thickness of 35-80 m, yielding 60-71 l of oil per tonne. Generally speaking, Israeli oil shales are relatively low in heating value and oil yield, and high in moisture, carbonate, and sulphur content, compared with other major deposits. Following tests in a 0.1 MW pilot plant (1982-1986), a 1 MW demonstration fluidised-bed pilot plant was established in 1989. In operation since 1990, the generated energy is sold to the Israeli Electric Corporation, the low-pressure steam to an industrial complex and a considerable quantity of the resulting ash used to make products such as cat litter which is exported to Europe.

Although during the early 1990s proposals for shale oil extraction were put forward, the crude oil price was not high enough to justify financial viability. With the current higher global crude oil price, the project has been seen to be economically possible.

During 2006, A.F.S.K. Hom-Tov, an Israeli company presented a scheme to the Ministry of National Infrastructures for the manufacture of synthetic oil from oil shale. The method would entail combining bitumen (from the Ashdod refinery, 80 km north of the proposed plant at Mishor Rotem in the Negev Desert) with the shale prior to processing in a catalytic converter. It has been suggested that the resultant oil, totalling up to 3 million tonnes/yr, could be piped back to Ashdod for refining. Additionally, the remaining shale rock, containing some residual fuel, could be utilised in a new power plant in the south of the country.

Oil shale is already being mined by companies accessing the phosphate reserves underlying the rock.

Whilst the Government is encouraging development of the oil shale resource, particularly in-situ underground techniques, it is mindful of the environmental concerns.

Jordan

There are about 24 known occurrences, which result in Jordan having an extremely large proven and exploitable oil shale resource. Geological surveys indicate that the existing shale reserves cover more than 60% of the country and amount to in excess of 50 billion tonnes.

The eight most important deposits are located in west-central Jordan and of these, El Lajjun, Sultani, and the Jurf Ed-Darawish have been the most extensively explored. They are all classified as shallow and most are suitable for open-cast mining, albeit some are underlain by phosphate beds. One more deposit, Yarmouk, located close to the northern border is thought to extend into Syria and may prove to be exceptionally large, both in area and thickness. Reaching some 400 m in thickness, it would only be exploitable by underground mining.

The naturally bituminous marls of Jordan are generally of quite good quality. The oil content and calorific value vary quite widely between deposits but research has shown that 20-30% of the original thermal content remains in the retorted residue, thus providing a source of fuel for the production of heat or electricity. Additionally, it has been shown that the levels of sulphur and mineral content would not cause technological or environmental problems.

During the past two decades the Government has undertaken a number of feasibility studies and test programmes. These have been carried out in co-operation with companies from Germany, China, Russia, Canada and Switzerland. They were all intended to demonstrate utilisation through either direct burning or retorting. All tests proved that burning Jordanian oil shale is very stable, emission levels are low and carbon burn-out is high. Furthermore, research on catalytic gasification was undertaken in the FSU, with positive results. Solvent extraction of organic matter was the subject of a joint study by the Jordanian Natural Resources Authority and the National Energy Research Center.

The eventual exploitation of Jordan's fuel resource to produce liquid fuels and/or electricity, together with chemicals and building materials, would be favoured by three factors - the high organic matter content of Jordanian oil shale, the suitability of the deposits for surface-mining and their location - away from centres of population but having good transport links to potential consumers (i.e. phosphate mines, potash and cement works).

In recent years the price of crude oil has not been high enough to justify the financial commitment of developing Jordanian oil shale. The National Resources Agency proposed that it should continue to monitor both technological advances and the economic aspects of prospective projects. However, the Government now considers that owing to the rapid increase in demand for electricity, the prospective grid connections between countries in the region and significantly higher oil prices, the required investment is not only becoming feasible but should be pursued through joint ventures and BOT projects.

The Ministry of Energy and Mineral Resources (MEMR) stated in its 2005 Annual Report that a study on the future strategy of the nascent industry would be financed by the US Trade Development Agency. The 2006 study was due to address the question of the shale oil being utilised directly for electricity generation or sent for distillation.

In November 2006 Eesti Energia of Estonia announced that the company had been awarded the right to explore 300 million tonnes of the El Lajjun reserve. A study to establish whether the construction of a shale oil facility would be feasible and mutually beneficial is estimated to take 18 months.

Early in 2007, it was reported that Petrobras of Brazil had signed an MOU with the MEMR to study the economic viability of using the company's Petrosix process on the oil shale of the Attarat Umm Ghudran deposit.

Kazakhstan

At the beginning of the 1960s successful experimentation was carried out on a sample of Kazakhstan's oil shale in the former Soviet Republic of Estonia. Both domestic gas and shale oil were produced. It was found that the resultant shale oil had a low-enough sulphur content for the production of high-quality liquid fuels.

Beginning in early 1998 and lasting until end-2001, a team funded by INTAS (an independent, international association formed by the European Community to preserve and promote scientific co-operation with the newly independent states) undertook a project aimed at completely reevaluating Kazakhstan's oil shales. The resultant report testified that Kazakhstan's oil shale resources could sustain the production of various chemical and power-generating fuel products.

The research undertaken concluded that the occurrence of oil shale is widespread, the most important deposits having been identified in western (the Cis-Urals group of deposits) and eastern (the Kenderlyk deposit) Kazakhstan.

Further deposits have been discovered in both the southern region (Baikhozha and the lower Ili river basin) and the central region (the Shubarkol deposit).

In excess of 10 deposits have been studied: the Kenderlyk Field has been revealed as the largest (in the region of 4 billion tonnes) and has undergone the greatest investigation. However, studies on the Cis-Urals group and the Baikhozha deposit have shown that they have important concentrations of rare elements (rhenium and selenium), providing all these deposits with promising prospects for future industrial exploitation.

The in-place shale oil resources in Kazakhstan have been estimated to be in the region of 2.8 billion barrels. Moreover, many of the deposits occur in conjunction with hard and brown coal accumulations which, if simultaneously mined, could increase the profitability of the coal production industry whilst helping to establish a shale-processing industry.

The recommendations made to INTAS were that collaboration between the project's participants should continue and further research undertaken on a commercial basis with interested parties, as a precursor to the establishment of such an industry.

Mongolia

Mongolia possesses large mineral deposits which, owing to the country's political isolation during most of the 20th century, remain largely undeveloped. Some mining operations were established prior to 1989 with the help of the Soviet Union and Eastern European countries but following the breakup of the USSR, Mongolia's move to a free economy and the Minerals Law being passed in 1997, the potential is being recognised.

Numbered amongst the indigenous minerals are oil shale deposits from the Lower Cretaceous Dsunbayan Group, located in the east of the country. Exploration and investigation of the deposits began as long ago as 1930 but it was only during the 1990s and with the help of Japanese organisations that detailed analyses began. Twenty six deposits were studied and found to be associated with coal measures. Historically, Mongolia's coal has been mined as a source of energy, with the shale being left untouched. However, the study ascertained that the oil shales are 'excellent' potential petroleum source rocks, particularly the Eidemt deposit.

During 2004, Narantuul Trade Company, the owner of the Eidemt deposit was investigating the possibilities of developing the field's potential with the aid of international cooperation.

It was reported in late-2006 that China University of Petroleum had signed a contract to undertake a feasibility study on the Khoot oil shale deposit.

Morocco

Exploitation of oil shale in Morocco occurred as long ago as 1939, when the Tangier deposit was the source of fuel for an 80 tonnes/day pilot plant which operated until 1945. A preliminary estimate of this resource has been put at some 2 billion barrels of oil in place.

During the 1960s two important deposits were located: Timahdit in the region of the Middle Atlas range of mountains (north central Morocco) and Tarfaya in the south west, along the Atlantic coast. The total resource has been estimated at 42 billion tonnes for the former and 80 billion tonnes for the latter. Oil in place has been estimated at 16.1 billion barrels for Timahdit and 22.7 billion barrels for Tarfaya.

Morocco's total resource is estimated at some 50 billion barrels in place, a level which ranks the country amongst the world leaders in respect of in-place shale oil.

During the 1970s and 1980s, the Office National des Hydrocarbures et des Mines (ONHYM), with the assistance of companies in the USA, Europe, Canada and Japan, undertook research and testing of more than 1 500 tonnes of Timahdit and 700 tonnes of Tarfaya oil shale. Within Morocco, some 2 500 metric tonnes of Timahdit oil shale were tested in an 80 tonne capacity pilot plant. In 1985-1986 the Moroccan experience led to ONHYM developing its own process called T^3, a semi-continuous surface retorting method based on the utilisation of two identical retorts operating in tandem according to two modes: retorting mode and cooling mode.

The technical and economic feasibility studies have resulted in Morocco acquiring a large amount of information – a database which can be used for future projects. With the current need to look at developing alternative sources of liquid fuels, the ONHYM has stated that any pilot plant should be followed by a demonstration phase during which the commercial evaluation of by-products should also be undertaken.

Nigeria

Research has shown that the southeastern region of Nigeria possesses a low-sulphur oil shale deposit. The reserve has been estimated to be of the order of 5.76 billion tonnes with a recoverable hydrocarbon reserve of 1.7 billion barrels.

Russian Federation

In excess of 80 oil shale deposits have been identified in Russia.

The deposits in the Volga-Petchyorsk province, although of reasonable thickness (ranging from 0.8 to 2.6 m), contain high levels of sulphur.

Extraction began in this area in the 1930s, with the oil shale being used to fuel two power plants, but the operation was abandoned owing to environmental pollution. However, most activity has centred on the Baltic Basin where the kukersite oil shale has been exploited for many years. In 2002 the Leningradslanets Oil Shale Mining Public Company produced 1.12 million tonnes. Following June 2003 all shale mined was delivered to the Estonian Baltic power station with the resultant electricity delivered to UES (Unified Energy System of Russia). However, production ceased at the

Leningradslanets Mine on 1 April 2005. It has been reported that the Russian-owned company, Renova, plans to build its own shale oil producing plant. Although design work has yet to begin, oil shale production restarted on 15 January 2007, with the 50 000 tonnes per month being stored.

Until 1998, the Slantsy electric power plant (located close to the Estonian border, 145 km from St Petersburg) was equipped with oil shale fired furnaces but in 1999 its 75 MW plant was converted to use natural gas. It continued to process oil shale for oil until June 2003, since when its main activities have been electrode coke annealing and the processing of coals and natural gas oil components.

In 1995 a small processing plant operated at Syzran with an input of less than 50 000 tonnes of shale per annum. Although the accompanying mine has now closed, a group of about 10 miners are producing in the region of 10 000 tonnes per year. Using the Syzran plant the oil shale is being processed for the manufacture of a pharmaceutical product. Investment is being sought for a new plant capable of processing 500 tonnes per day. The mine would be re-opened with the intention of perpetuating the production of pharmaceutical products. To this end a business plan has been issued.

Sweden

The huge shale resources underlying mainland Sweden are more correctly referred to as alum shale; black shale is found on two islands lying off the coast of south-eastern Sweden. The in-place shale oil resource is estimated to be 6.1 billion barrels.

The exploitation of alum shale began as early as 1637 when potassium aluminium sulphate (alum) was extracted for industrial purposes. By the end of the 19th century the alum shale was also being retorted in an effort to produce a hydrocarbon oil. Before and during World War II, Sweden derived oil from its alum shale, but this process had ceased by 1966, when alternative supplies of lower-priced petroleum were available; during the period 50 million tonnes of shale had been mined.

The Swedish alum shale has a high content of various metals including uranium, which was mined between 1950 and 1961. At that time the available uranium ore was of low grade but later higher-grade ore was found and 50 tonnes of uranium were produced per year between 1965 and 1969. Although the uranium resource is substantial, production ceased in 1989 when world prices fell and made the exploitation uneconomic.

Thailand

Some exploratory drilling by the Government was made as early as 1935 near Mae Sot in Tak Province on the Thai-Burmese border. The oil shale beds are relatively thin, underlying about 53 km^2 in the Mae Sot basin and structurally complicated by folding and faulting.

Another deposit at Li, Lampoon Province is small, estimated at 15 million tonnes of oil shale and yielding 50-171 l of oil per tonne.

Some 18.6 billion tonnes of oil shale, yielding an estimated 6.4 billion barrels of shale oil, have been identified in the Mae Sot Basin, but to date it has not been economic to exploit the deposits. In 2000 the Thai Government estimated that total proved recoverable reserves of shale oil were 810 million tonnes.

Turkey

Although oil shale deposits are known to exist over a wide area in middle and western Anatolia, they have received relatively little investigation. The total reserve of oil shale has been estimated to be in the region of 3-5 billion tonnes, with proved reserves put at 2.2 billion tonnes. Of this latter figure, the geologic reserve is put at 0.5 billion tonnes and the possible reserve at 1.7 billion tonnes. Four major deposits: Himmetoğlu, Seyitömer, Hatildağ and Beypazari have been studied in detail and found to vary quite widely in quality. Study is required of each individual reserve to establish the suitability of use. However, it is already considered that in general Turkish oil shale would be most profitably used to supplement coal or lignite as a power station fuel, rather than for the recovery of shale oil.

United States of America

It is estimated that nearly 74% of the world's potentially recoverable shale oil resources are concentrated in the USA. The largest of the deposits is found in the 42 700 km^2 Eocene Green River formation in north-western Colorado, north-eastern Utah and south-western Wyoming. The richest and most easily recoverable deposits are located in the Piceance Creek Basin in western Colorado and the Uinta Basin in eastern Utah. The shale oil can be extracted by surface and in-situ methods of retorting: depending upon the methods of mining and processing used, as much as one-third or more of this resource might be recoverable. There are also the Devonian-Mississippian black shales in the eastern United States. The Green River deposits account for 70% of US shale oil resources, the eastern black shales for 9%.

Oil distilled from shale was burnt and used horticulturally in the second half of the 19th century in Utah and Colorado but very little development occurred at that time. It was not until the early 1900s that the deposits were first studied in detail by the US Geological Survey and the Government established the Naval Petroleum and Oil Shale Reserves, which for much of the 20th century served as a contingency source of fuel for the nation's military. These properties were originally envisioned as a way to provide a reserve supply of oil to fuel US naval vessels.

Oil shale development had always been on a small scale but the project that was to represent the greatest development of the shale deposits was begun immediately after World War II in 1946 - the US Bureau of Mines established the Anvils Point oil shale demonstration project in Colorado. However, processing plants had been small and the cost of production high. It was not until the USA had become a net oil importer, together with the oil crises of 1973 and 1979, that interest in oil shale was reawakened. In the latter part of the 20th century military fuel needs changed and the strategic value of the shale reserves began to diminish.

In the 1970s ways to maximise domestic oil supplies were devised and the oil shale fields were opened up for commercial production. Oil companies led the investigations: leases were obtained and consolidated but one by one these organisations gave up their oil shale interests. Unocal was the last to do so in 1991.

Recoverable resources of shale oil from the marine black shales in the eastern United States were estimated in 1980 to exceed 400 billion barrels. These deposits differ significantly in chemical and mineralogical composition from Green River oil shale. Owing to its lower H:C ratio, the organic matter in eastern oil shale yields only about one-third as much oil as Green River oil shale, as determined by conventional Fischer assay analyses. However, when retorted in a hydrogen atmosphere, the oil yield of eastern oil shale increases by as much as 2.0-2.5 times the Fischer assay yield.

Green River oil shale contains abundant carbonate minerals including dolomite, nahcolite, and dawsonite. The latter two minerals have potential by-product value for their soda ash and alumina content, respectively. The eastern oil shales are low in carbonate content but contain notable quantities of metals, including uranium, vanadium, molybdenum, and others which could add significant by-product value to these deposits.

After many years of inactivity, interest was revived in the oil shale sector in 2004. A committee was formed by the Office of Naval Petroleum and Oil Shale Reserves and prepared two reports: 1) Strategic Significance of America's Oil Shale Resource, vol. I, Assessment of Strategic Issues and vol II, Oil Shale Resources, Technology and Economics and 2) America's Shale Oil, A Roadmap for Federal Decision Making.

The increasing price of petroleum has encouraged the Government to initiate steps toward the commercial development of the Green River oil shale deposits through the issuance of RD&D oil shale leases. In 2005, nominations for 160-acre tracts of public oil shale lands in Colorado and Wyoming were sought from private companies by the Bureau of Land Management (BLM). By September 2005, 19 applications for leases had been received - ten in Colorado, eight in Utah, and one in Wyoming. After a review of these nominations, five leases were granted in Colorado in late 2006; one lease in Utah received provisional approval (April 2007) and the Wyoming application was denied. All of the successful applicants for the Colorado leases propose to develop *in-situ* technologies for the recovery of shale oil, whereas the Utah lease applicant plans to use a surface retort. Industry interest in surface mining of oil shale in Colorado appears to be minimal, in view of the problems of possible large-scale environmental degradation of the oil shale lands.

The RD&D leases were issued for a term of 10 years with a possible five-year extension, providing that evidence of diligent pursuit of production of shale oil in commercial quantities is shown. If commercial production is achieved, a preference right for additional acreage of as much as 4 960 acres of oil shale lands may be granted. The RD&D leases include specific requirements of permitting, and monitoring and mitigation of environmental impacts.

Since 1996 Shell Frontier Oil & Gas has been developing a new technique for extracting the oil by in-situ heating of the rock in the Piceance Creek Basin. Shell's patented In-Situ Conversion Process (ICP), which is more environmentally benign and uses less water than conventional methods, involves heating the rock containing the kerogen until it yields a liquid hydrocarbon. In order to trap the oil prior to removal and refining, a barrier of ice between the heated rock and the surrounding area is created by the circulation of a chilled, compressed liquid.

In November 2006, Shell announced that the US BLM had awarded the company three leases on land in the Piceance Creek Basin to conduct further RD&D. This work will begin once the necessary State, air and water permits have been granted.

The estimated total resource of Green River oil shale in the three-state area amounts to about 1.5 trillion barrels of in-place shale oil. Although recoverable shale oil resources have been estimated to be as high as 800 billion barrels, no definitive study has yet been made to substantiate this figure.

By way of enhancing the publicly-available body of knowledge, the US Geological Survey is preparing a database with information taken from the Green River Formation prior to its closure in 1996 and is also acquiring new data and maps. The Office of Naval Petroleum and Oil Shale Reserves announced early in 2007 that the US could be producing oil from shale on a commercial basis in northwest Colorado by 2015.