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Petroleum exploration in Nepal*

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ABSTRACT

The southern part of Nepal comprising of Terai plain and Churia foothills are the prospecting area for petroleum exploration. Geological, geochemical and seismic surveys are carried out during the last decade. Such investigations have indicated a fairly good source rocks in the Melpani and Swat formations of the Surkhet Group and also in the Gondwana and Lakharpata groups. Similarly, the reservoir and seal rocks are also adequately identified. The seismic survey confirms various kinds of traps. The oil generation, expulsion and migration are considered to have been contemporaneous with or to have post dated the formation of the traps.

His Majesty's Government of Nepal has designed a Production Sharing Contract with attractive work and fiscal terms including the "Seismic Option" and "No Ring Fencing" incentives. The promotional activities have resulted to conclude the petroleum agreements for exploration in Block 10 (Biratnagar) by Shell International (1986-1990) and Block 3 (Nepalgunj) and Block 5 (Chitwan) by Texana Resources Co., USA.

INTRODUCTION

Background

Nepal, a small Himalayan kingdom, lies in between China to the north and India to the south. The southern Nepal occupies some 20 to 40 km wide Terai plain (Indo-Gangetic plain) about a few hundred metres above sea level. The Terai and Siwalik area are in the foreland of Nepal Himalaya and are known for sedimentary basins with considerable thickness. This part of the country is the most accessible region in Nepal. Several sedimentary formations of the basin could have generated petroleum and located in a suitable structural traps. Thus, the Terai and Siwalik foothills are target areas for hydrocarbon exploration.

It is notable that oil and gas seeps have been observed to the north of the Main Boundary Thrust (MBT) in different parts of the country from the time immemorial. These seepages as in Dailekh, western Nepal were subjected to only the preliminary analysis in the sixties, whereas an extensive geochemical study was carried out in 1993.

Systematic petroleum exploration activities in Nepal began only in 1979. The Department of Mines and Geology (DMG) has conducted Airborne Magnetic Survey in 1978-79 over the Siwaliks and Terai belts of the country, covering an area of 48,000 km^2 with the help of IDA/World Bank. The survey has produced encouraging results. His Majesty's Government of Nepal has then established the "Petroleum Exploration Promotion Project" in 1982 to promote and monitor the exploration works in the kingdom.

Exploration History

A series of geological and geophysical works were carried out after the completion of the aeromagnetic survey followed by seismic reflection survey in a regional grid pattern by the help of Compagnie Generale de Geophysique (CGG) and Petro-Canada (over 3000 line km). Hunting Geology and Geophysics Ltd. conducted a photogeological study over an area of 60,000 km^2 in southern Nepal. Subsurface study of the Terai area has revealed favourable conditions for oil and gas accumulation, encouraging for further petroleum exploration in this region.

* Key Note Address

The Petroleum Exploration Promotion Project has divided the Terai and Siwaliks into 10 exploration blocks (Fig. 1), each of approximately 5,000 km^2 in area and opened it for exploration acreage in 1985 for the first time.

Shell Nepal B.V. carried out exploration works in eastern Nepal (Block 10) including geochemical study of some rock and seep samples. It has also acquired data of gravity and seismic survey (over 2000 line km) in close grid pattern. The company had drilled an exploratory well (total depth = 3520 m) to test the hydrocarbon potential of a seismically defined structure. Although the hole was dry and did not penetrate up to the basement, a valuable database for the exploration venture has been created.

GEOLOGICAL SETTING

There are four major rock units of exploration interest in Nepal. These are the Siwaliks, Surkhet, Gondwana and Lakharpata (Vindhyan) groups (Fig. 2).

Siwalik Group

The Siwalik Group (middle Miocene-early Pleistocene) comprises of Upper, Middle and Lower Siwaliks. The Upper Siwaliks are composed of conglomerate with subordinate sandstone and mudstone. The Middle Siwaliks consist of medium to coarse grained sandstone with interbeds of mudstone and siltstone. They contain coaly materials and plant fossils at places. The Lower Siwaliks are represented by fine grained sandstone with interbeds of red coloured mudstone, shale, siltstone and marl.

The Siwalik Group is characterised by thick folds and repeated thrusts. The Siwalik sediments are overlain by the Recent to Quaternary fluvial deposits in the Terai plain. The Siwaliks unconformably overlie sub-basins comprising of early Tertiary to Proterozoic sediments and rocks of the Indian Shield. The most of these pre-Siwalik sediments are exposed to the north of the Main Boundary Thrust (MBT) in Nepal Himalaya . In the north, these rocks are in contact with the Midland Group along the Main Boundary Thrust. However, some slices of pre-Siwalik rocks are also found to the south of the Main Boundary Thrust within the Siwaliks of eastern Nepal.

The surface geology of the Siwalik Group indicates thick and multi-channels of sands of reservoir quality and are expected to continue into the subsurface. There is sufficient shale especially in the lower part of the section (Lower and Middle Siwaliks), which provides good quality seals. A few pockets of coal are present, but the source rocks have not been reported from the Siwaliks.

Surkhet Group

The Surkhet Group (late Cretaceous-early Miocene) is subdivided into three formations. The Melpani Formation at the base is composed of white, grey, ferruginous quartzitic sandstone and grey to dark grey shale with basal conglomerate. The coaly materials, bivalve, gastropod, coral, echinoid and vertebrate remains are quite common. The Swat Formation is reprersented by grey to dark grey shale with foraminiferal limestone (*Nummulite beaumonti*, *Asilina papillata*) and coquina. The uppermost part, the Suntar Formation, consists of green and greenish grey sandstone and purple shale with occasional marl. The vertebrate bone fragments and wood trunks are also common.

The Surkhet Group outcrops in the southern part of western Nepal. The "Unnamed Formation" of Palaeogene age is interpreted as its lateral equivalent in the Raxaul and Puranpur wells in India. The thickness of the "Unnamed Formation" is estimated to be 1,000 m in the Lumbini area of Gandak depression. It contains potential source rock and seal in the Swat Formation, reservoir in the Melpani and Suntar formations. Some sands of the Melpani Formation bear hydrocarbon.

Gondwana Group

The Gondwana Group (late Palaeozoic to early Cretaceous) outcrops in the Lesser Himalaya of eastern, central and western Nepal. This group is characterised by the presence of sandstone, conglomerate, diamictite, shale and coaly materials. The plant fossils and invertebrates are found at Tansen and Barahakshetra.

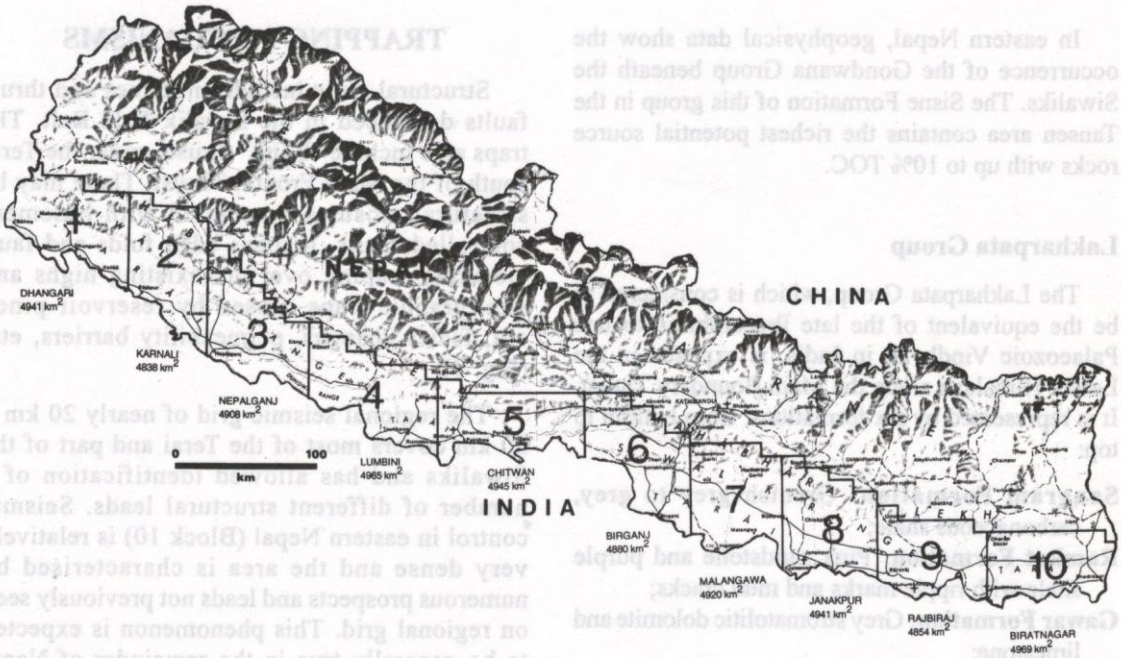

Fig. 1: Lease block outline

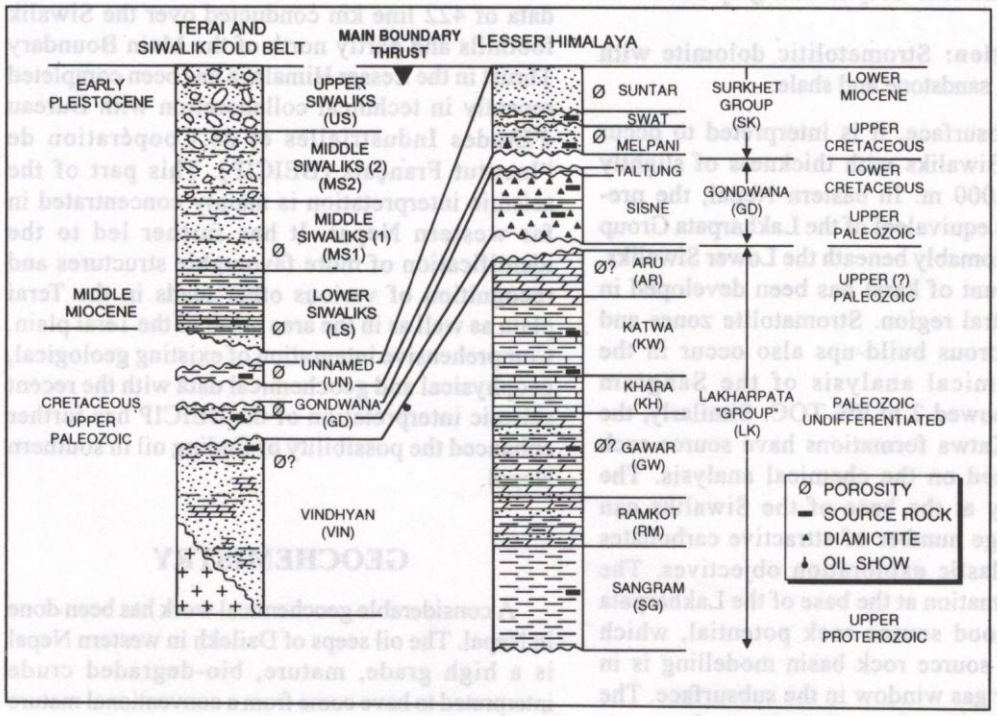

Fig. 2: Stratigraphic diagram of central - southern Nepal

In eastern Nepal, geophysical data show the occurrence of the Gondwana Group beneath the Siwaliks. The Sisne Formation of this group in the Tansen area contains the richest potential source rocks with up to 10% TOC.

Lakharpata Group

The Lakharpata Group, which is considered to be the equivalent of the late Precambrian to late Palaeozoic Vindhyan in India, is exposed in the Lesser Himalaya along the Main Boundary Thrust. It is represented by six formations, from bottom to top:

Sangram Formation: Grenish grey to grey, carbonaceous shale;
Ramkot Formation: Pink sandstone and purple shale with ripple marks and mud cracks;
Gawar Formation: Grey stromatolitic dolomite and limestone;
Khara Formation: green grey and purple shale and limestone;
Katuwa Formation: Grey to dark grey shale with limestone;
Aru Formation: Stromatolitic dolomite with limestone, sandstone and shale.

In the subsurface, it is interpreted to occur beneath the Siwaliks with thickness of slightly more than 5,000 m. In eastern Nepal, the pre-Siwalik rocks equivalent of the Lakharpata Group occur unconfiomably beneath the Lower Siwaliks. A small amount of karst has been developed in the west central region. Stromatolite zones and small non-porous build-ups also occur in the Group. Chemical analysis of the Sangram Formation showed 7 to 9% TOC. Similarly, the Gawar and Katwa formations have source rock potential based on the chemical analysis. The unconformity at the base of the Siwaliks can provide a large number of attractive carbonates as well as clastic exploration objectives. The Sangram Formation at the base of the Lakharpata Group has good source rock potential, which according to source rock basin modelling is in the oil and/or gas window in the subsurface. The Gawar and Katuwa formations have also some source rocks potential.

TRAPPING MECHANISMS

Structural traps include anticlines and thrust faults developed in the Siwalik Fold Belt. The traps also include "blind" thrusts under the Terai south of the Main Frontal Thrust. There may be structural closures associated with basement controlled faults, grabens edge folds and fault closures, draping over pre-existing highs and stratigraphic traps caused by reservoir pinch out, facies changes, permeability barriers, etc. (Fig. 3).

The regional seismic grid of nearly 20 km x 30 km covers most of the Terai and part of the Siwaliks and has allowed identification of a number of different structural leads. Seismic control in eastern Nepal (Block 10) is relatively very dense and the area is characterised by numerous prospects and leads not previously seen on regional grid. This phenomenon is expected to be generally true in the remainder of Nepal because of the similarity in geologic history.

Similarly, interpretation of seismic reflection data of 422 line km conducted over the Siwalik foothills and partly north of the Main Boundary Thrust in the Lesser Himalaya has been completed recently in technical collaboration with Bureau d'Etudes Industrielles et de Coopération de l'Institut Français (BEICIP). This part of the seismic interpretation is mainly concentrated in far western Nepal. It has further led to the identification of more favourable structures and recognition of various other leads in the Terai plain as well as in the area north of the Terai plain. Comprehensive integration of existing geological, geophysical and geochemical data with the recent seismic interpretation of the BEICIP has further enhanced the possibility of finding oil in southern Nepal.

GEOCHEMISTRY

A considerable geochemical work has been done in Nepal. The oil seeps of Dailekh in western Nepal is a high grade, mature, bio-degraded crude interpreted to have come from a conventional mature source rock. The wet gas from the same area is considered to have a similar source. These

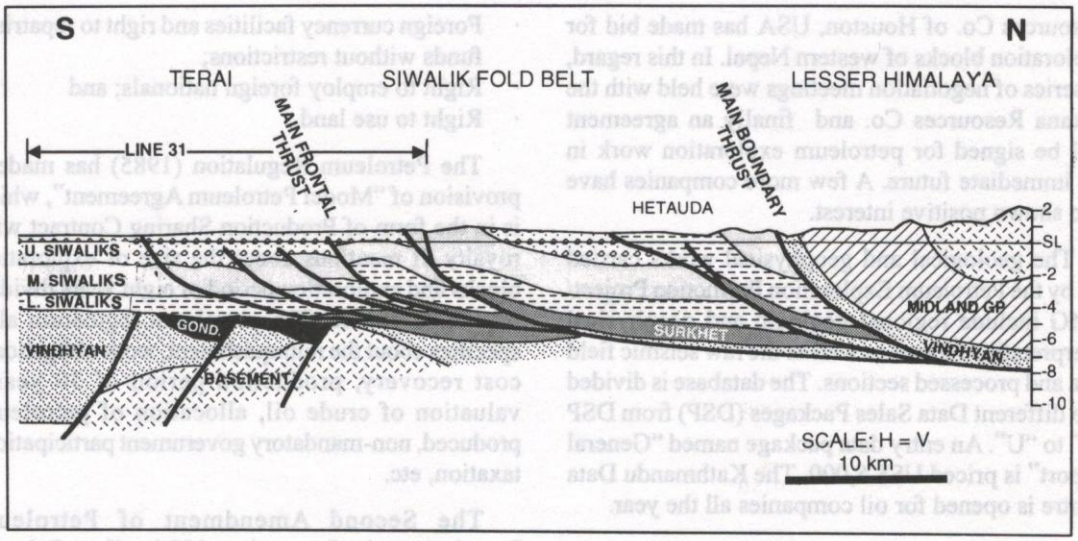

Fig. 3: Structural cross-section across Terai, Siwaliks and Lesser Himalaya

hydrocarbon seeps occur in fault trend from metamorphic rocks indicating that source rocks are buried below the thrusts and are mature expelling hydrocarbons.

Source rock maturity basin modelling indicates that the Suntar, Swat, Melpani and Gondwana formations fall within the oil window, whereas the Lakharpata Formation is located within the gas generating window. The oil generation, explulsion and migration are considered to have been contemporaneous with or to have post dated the formation of the traps.

The country's only well, drilled by SHELL in 1989 in eastern Nepal (Block 10) was abandoned after penetrating a section of predominately Tertiary molasses. However, the most convincing evidence of the existence of hydrocarbon in Nepal can be proved with the presence of oil and gas seeps. In the regional hydrocarbon occurrences, it is noteworthy that the Ganga and Purnea basins of Nepal have similar geological histories to the Potwar basin at the west in Pakistan and the Assam basin at the east in India, both of which have proven to be hydrocarbon bearing with a long history of successful exploration and production operations. Hence, the existing seeps and other technical data lead us to believe that there are hydrocarbon potentialities in Nepal.

Promotional Programme

The first round of bidding with Promotional Campaign was held in 1985. As a result, Shell International B.V. and Triton Energy Corp. jointly acquired the Block 10, Biratnagar in eastern Nepal and carried out exploration works up to 1990.

Several works were carried out to enhance the technical database since 1990. In this series, additional seismic survey was conducted in the far western Terai and its adjoining Siwalik foothills. Similarly, Source and Seal Study project has been completed. The result of this study has great value in the assessment of hydrocarbon potential of Nepal.

In recognition of the nature of exploration risk and the underdeveloped infrastructure, His Majesty's Government of Nepal has designed a Production Sharing Contract, which has attractive work, and fiscal terms that are competitive with most countries in the world. A second amendment of the Petroleum Regulations offers "Seismic Option" and "No Ring Fencing".

After the introduction of more attractive work and fiscal terms such as 'Seismic Option' and 'No Ring Fencing' and addition of new technical data base, some international oil companies have shown more interest or renewed their interest for petroleum exploration work in Nepal. Recently, Texana

Resources Co. of Houston, USA has made bid for exploration blocks of western Nepal. In this regard, as series of negotiation meetings were held with the Texana Resources Co. and finally an agreement will be signed for petroleum exploration work in the immediate future. A few more companies have also shown positive interest.

The geological and geophysical works carried out by the Petroleum Exploration Promotion Project/ DMG include regional geologic and geophysical interpretation reports as well as the raw seismic field data and processed sections. The database is divided into different Data Sales Packages (DSP) from DSP "A" to "U". An entry data package named "General Report" is priced US$ 5,000. The Kathmandu Data Centre is opened for oil companies all the year.

Petroleum Legislation

The principal law governing the petroleum operations is the Nepal Petroleum Act (1983) which is supplemented by Petroleum Regulation (1982) with first amendment in 1989 and second amendment in 1994. The Act allows the HMG/ Nepal to enter into an agreement with international oil companies for petroleum exploration and production.

The Act grants rights and obligations to contractors who are parties to petroleum agreements including:

- Right to export entitlements of petroleum;
- Exemption from all taxes and fees except a royalty of not less than 12.5%, an income tax at 50% of net income, annual surface rentals, and miscellaneous fees of general application;
- Exemption from customs duties on imported goods;
- Foreign currency facilities and right to repatriate funds without restrictions;
- Right to employ foreign nationals; and
- Right to use land.

The Petroleum Regulation (1985) has made a provision of "Model Petroleum Agreement", which is in the form of Production Sharing Contract with royalty. It mentions about the size of exploration blocks and exploration period of eight years divided into three phases. The petroleum regulation also specifies about the relinquishment, work obligations, cost recovery, production period of 30 years, valuation of crude oil, allocation of petroleum produced, non-mandatory government participation, taxation, etc.

The Second Amendment of Petroleum Regulations in September 1994 offers Seismic option, No Ring-fencing of blocks, designation of Secretary, Ministry of Industry as a signatory to the contract and delegates Project Chief, Petroleum Exploration Promotion Project, as "One Window Shopping" for all petroleum operations in Nepal.

CONCLUSIONS

The petroleum exploration activities carried out till now fairly indicates the presence of source, seal and reservoir rocks together with the various traps. The oil and gas seepages are the indications of oil and gas generation and migration.

It is envisaged that with the economic liberalisation policy of the Government and new seismic options and attractive fiscal terms available, His Majesty's Government is very much hopeful that many international oil companies will feel Nepal an attractive frontier for petroleum exploration.