Exploration Opportunities

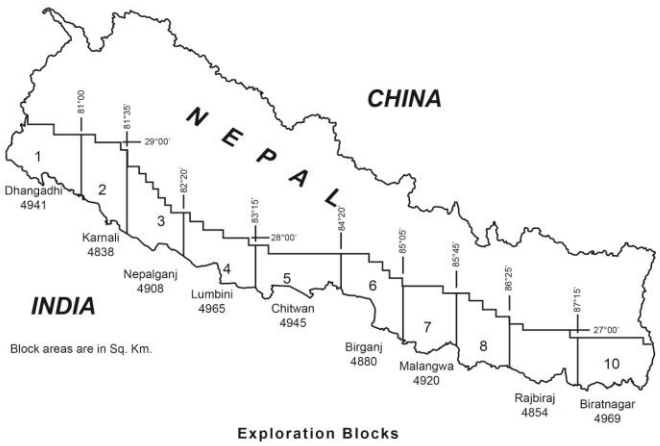
Petroleum Exploration Status in Nepal

Petroleum Exploration Promotion Project (PEPP)/ Department of Mines and Geology (DMG) has carried out geological, geochemical and geophysical studies in southern parts of the country with the technical and financial assistance of the IDA/World Bank.

The geological data includes regional to detailed surface geological mapping, stratigraphy, and structural studies at known oil and gas seeps and analysis of the major rock units to determine the quality of prospective reservoirs, seals and source rocks. The geophysical studies include gravity, aeromagnetic and seismic survey. The gravity survey provides Bouguer maps over the entire Terai area while the aeromagnetic survey provides comprehensive data over both the Terai and Siwalik fold belt. Over 5,000 line Km of multi-fold seismic data acquired since 1982 provides regional seismic coverage of most of the Terai and limited coverage in the Siwalik. A number of valuable geophysical interpretation reports exist in the PEPP/DMG.

Valuable information regarding the source rock distribution, their organic content and thermal maturity is also available. Similarly, the photogeological reports are study exists over the entire Terai and Siwalik fold belt. An exploratory test well was drilled in the seismically defined structure of the exploration Block No. 10. The data obtained from the drilling has created a valuable database for the exploration venture.

The petroleum oil and gas promising area lies in the Terai and Siwalik belts which have been divided into 10 exploration blocks, each of approximately 5,000 Sq. Km. in area (Figure 7). These blocks were opened for bidding exploration acreage in 1985 AD for the first time.



**Note: International Boundary in this map is not an authoritative boundary*

Figure 7: Lease Block Outline

History of Exploration

A series of geological, geochemical and geophysical works were carried out after the completion of the aeromagnetic and seismic reflection survey in a regional grid pattern by the Companies General de Geophysique (CGG) and Petro-Canada (over 3,000 line km).

Hunting Geology and Geophysics Ltd. (1985) conducted a photogeological study over 60,000 Sq. Km. area of the southern Nepal. It has been useful to establish the structures in the Siwalik belt.

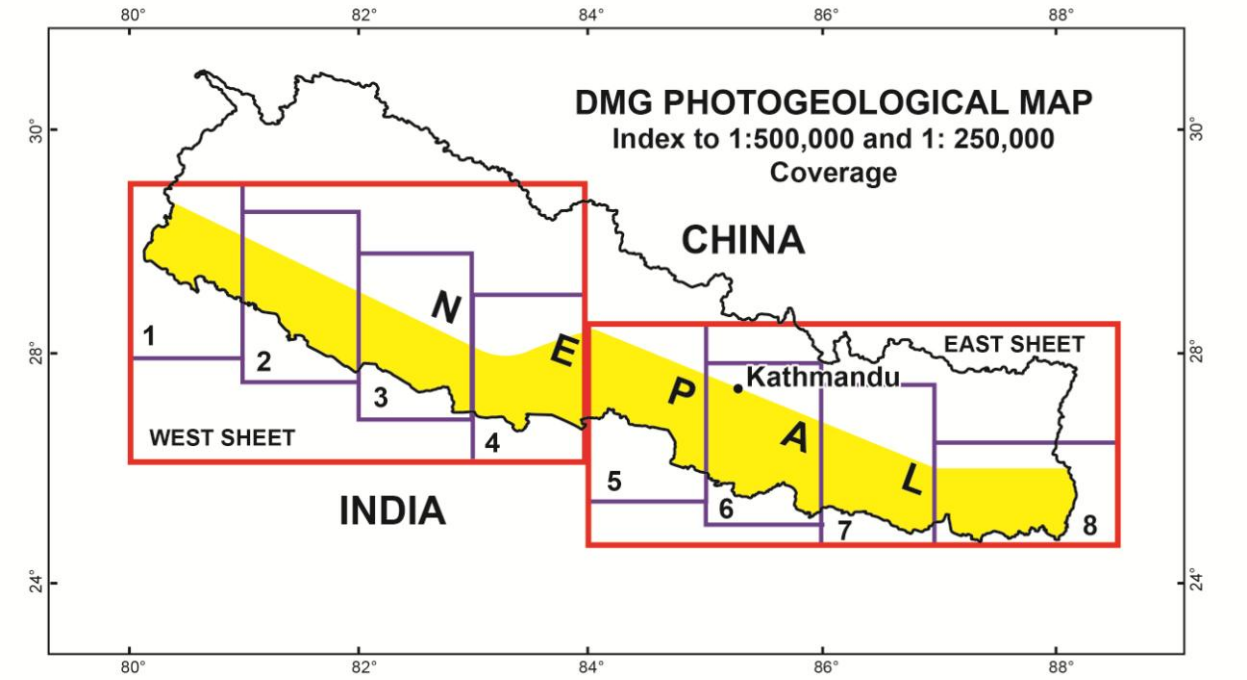


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Figure 8: DMG Photo Geological Survey

Shell Nepal B.V. (1986-90) carried out exploration works in Nepal (Block 10) including geochemical study of seep samples. It has also acquired gravity and seismic survey (over 2,000 line km) in close grid pattern. The company had drilled an exploratory well (TD 3520 m) to test the hydrocarbon potential of a seismically defined structure. The hole was dry and did not penetrate up to the basement. The result obtained from the drilling has created a valuable database for the exploration venture.

Since 1982-1992, over 5,000 Km of multi-fold seismic data has been acquired (Figure 9). The field survey provides regional seismic coverage of most of the Terai and limited coverage in the Siwaliks.

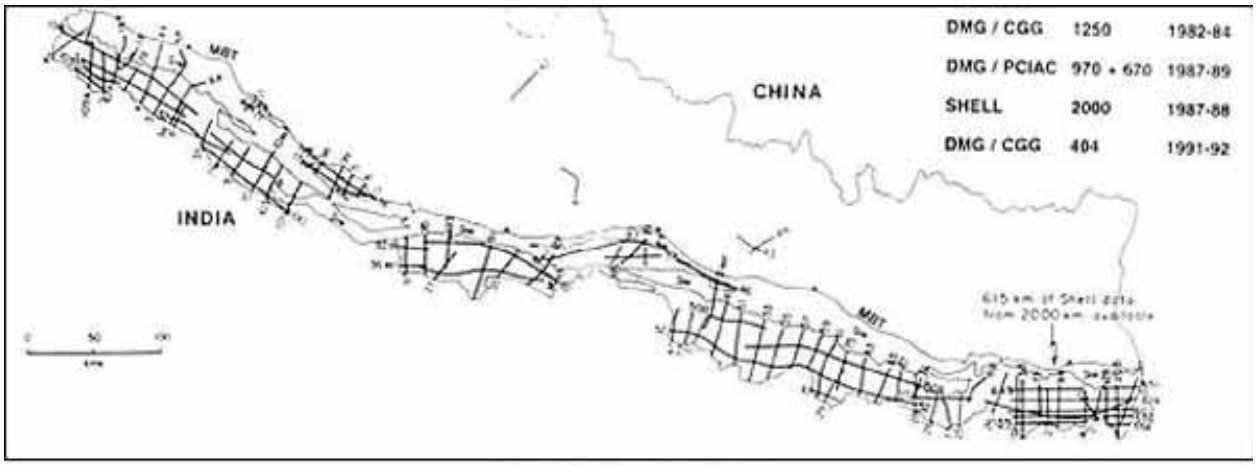

Figure 9: Seismic Index Map

The data has been processed and interpreted by different seismic service agencies. A number of valuable geophysical interpretation reports are available in the Kathmandu Data Centre.

Regional Hydrocarbon Occurrences

In the regional hydrocarbon occurrences, it is noteworthy that the Ganga Basin of Nepal is on a trend with the Potwar Basin to the west in Pakistan and the Assam Basin to the east in India (Figure 10). Both of which have similar geologic histories to Nepal and have proven to be hydrocarbon bearing with a long history of successful exploration and production operations.

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Figure 10: Regional Hydrocarbon occurrences Map

A number of wells are drilled in the Indo-Gangetic Plain all along the southern border of Nepal by Indian Oil Companies and have shown some positive results for hydrocarbon in the northern part of this Ganga Basin.

Occurrence of Oil and Gas Seeps

There are two areas of confirmed seeps in Nepal, both lying north of the Main Boundary Thrust (MBT). (Figure 3)

Muktinath gas seep: An active gas seep has been known since the beginning of historical times in the Muktinath region of northern Nepal. The seep emanates from Jurassic beds in the Tethys facies north of the MCT and for this reason it is thought to have no relation to petroleum possibilities in southern Nepal.

Dailekh oil and gas seeps: In the Dailekh region of western Nepal, at a location 30 Km north of the Main Boundary Thrust (MBT), is located a series of seeps which are of major importance in the exploration for hydrocarbons in Nepal. There are some 45 separate gas seepages, many of which have religious temples constructed over them. The gas seeps are continuously coming out up till now. The oil seeps are occasional and recorded during the rainy season.

The oil samples and several gas samples were obtained from seepages in the Dailekh area. These samples have been analyzed and indicate that this oil and gas has a geological origin from a mature source rock. Chromatograms suggest the oil samples represent light (mature) oil that has been severely biodegraded. The presence of C2 and higher molecular weight gases and their isotopic composition indicate the gases are thermogenic and derived either from a mature source rock or from the cracking of oil, rather than a shallow biogenic source. The proportion of higher homologies (C2 to C5) suggests that the gases were associated with oil. Combining the interpretation of the four analysis implies that the seeps originate at depth and are migrating rapidly to the surface along steep faults in the metamorphic rocks. The most likely ultimate source is a ruptured reservoir in non-metamorphic paleogene beds underlying the thrusted

metamorphic rocks at a shallow depth. These Paleogene beds might have some geological relation with the subsurface paleogene beds of the south lying Ganga Basin.

The Paleogene beds along with some other sediment are proved as source rocks in Potwar of Pakistan in the west and in Assam of India in the east. The geological conditions as in Potwar and Assam do exist in Nepal also. Therefore, Paleogene and other sedimentary formations in the subsurface of Terai and Siwalik are potential for the hydrocarbon exploration in Nepal. The natural seeps are the prospecting guide for oil and gas. The natural seeps are the prospecting guide during the search of oil and gas.

Structural Trapping Mechanisms

The principal play recognized in southern Nepal lies in the Surkhet Group with indigenous source, reservoir, and seal, and with a wide variety of potential trap types (Figure 11).

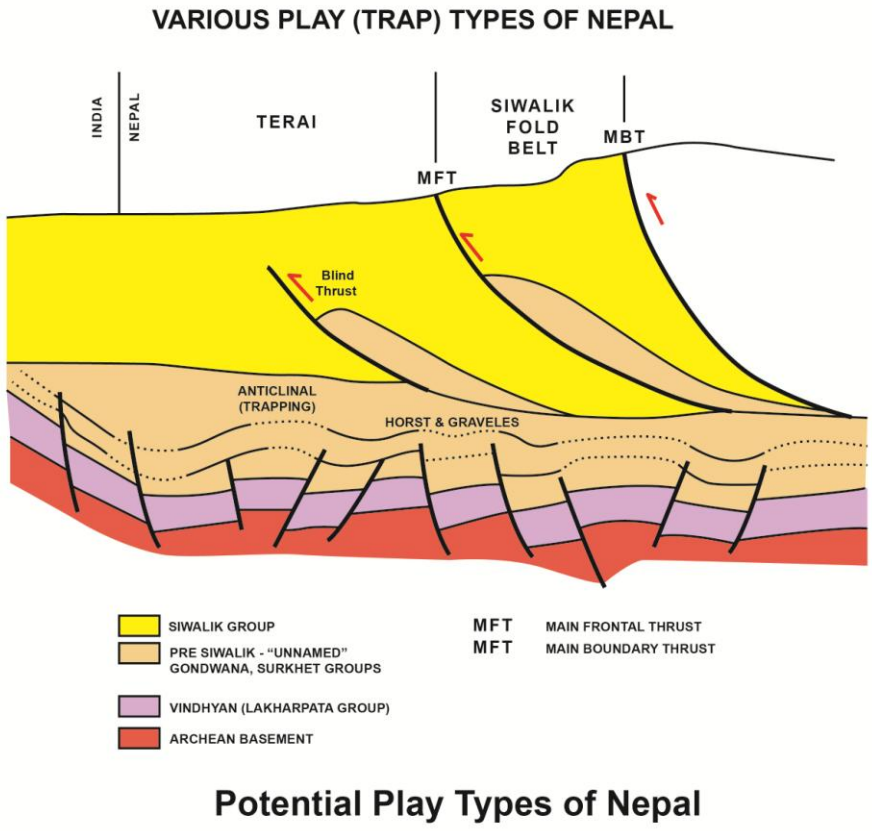

Figure 11: Potential Play Types of Nepal

The Paleogene rock unit is the imputed source for the Dailekh oil and gas seep area of western Nepal. It is also considered to be a source rock in the Terai and the Siwalik of the southern Nepal. Secondary plays, alluded to above, embrace the lower Siwaliks, the Gondwana and possible Upper Vindhyan reservoirs.

The regional seismic grid over most of the Terai and part of the Siwalik Fold Belt has allowed identification of a number of different structural leads (Figure 12). It has allowed identification of a number of different structural traps.

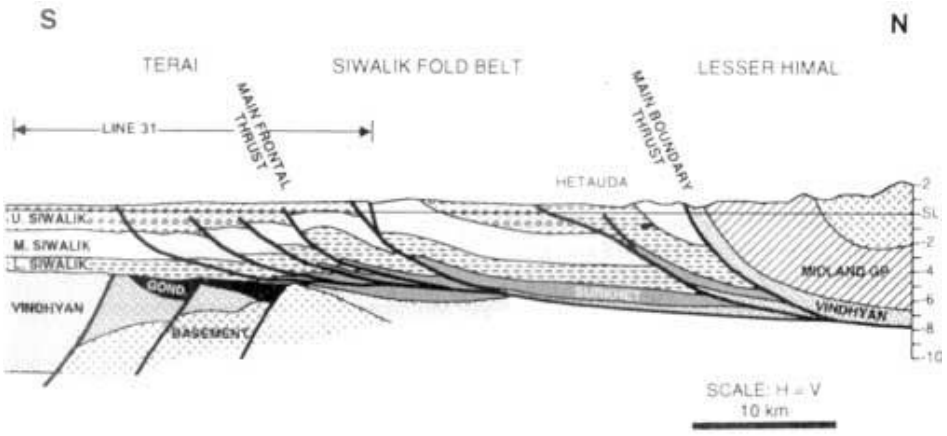

Figure 12: Structural Cross-Section across Terai, Siwalik and Lesser Himalaya

On the other hand, Shell acquired their 2000 Km detail grid in Block 10, they were able to identify numerous prospects and leads not previously seen on the regional grid (Figure 13). This same phenomenon is expected to be generally true in the remainder of Nepal because of the similarity in geologic history.

The trapping mechanisms include anticlines and thrust faults developed in the Siwalik Fold Belt and "blind" thrusts developed under the Terai ahead (south) of the Main Frontal Thrust. In addition, under the Terai we can expect structural closures associated with basement controlled faults, graben edge folds and fault closures, draping over pre-existing highs, and stratigraphic traps caused by reservoir pinch out, facies changes, permeability barriers etc.

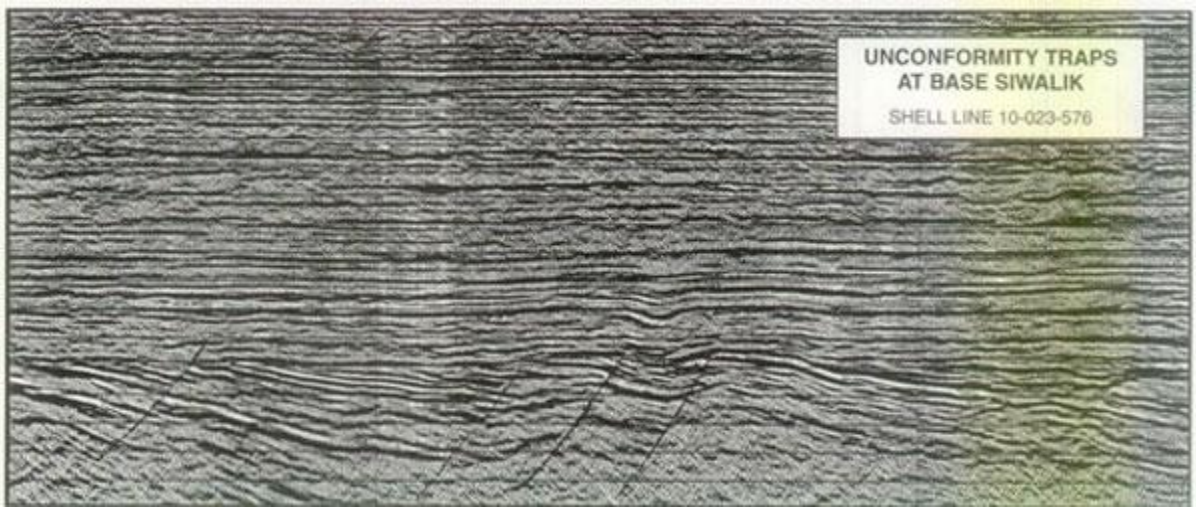

Figure 13: Seismic Expression of Unconformaty Traps

The limited seismic lines in Siwalik foothills indicate major folds and thrust faults with substantial potentially prospective pre-Siwalik which is supported by gravity survey and also by surface geology.

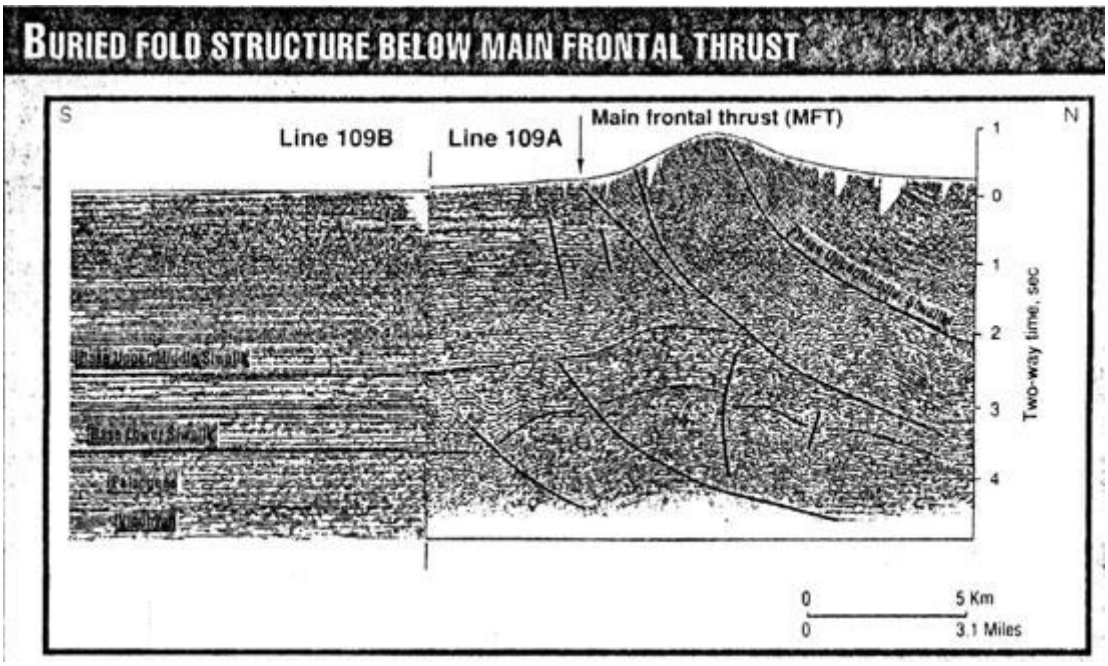

Figure 14: Buried fold structures below Main Frontal Thrust (MFT)

Source Rock Maturity Basin Modeling

A considerable geochemical work has been done in Nepal. The oil seep of Dailekh in Western Nepal is a high grade, mature, biodegraded crude interpreted to have come from a conventional mature source rock. These hydrocarbon seeps occur in fault trend from metamorphic rocks indicating that source rocks are buried below the thrusts and expelling hydrocarbons.

A modeling study was conducted for three widely separated locations in southern Nepal using a numerical technique, which calculates a one dimensional model of the evolution of sediment compaction and hydrocarbon generation. Input parameters to the model include the thickness, age and lithology of the rocks, a description of the source organic matter and the current and past heat flow or temperature parameters.

Models were constructed for eastern (Biratnagar-1), central (Lumbini) and western (Dhangadi) Nepal. The Shell Biratnagar-1 well was used to calibrate the model for eastern Nepal (Figure 15). In addition, outcrop information and subsurface seismic data were also used. An example of the output is given in Figure below which is the burial depth versus maturity plot for Lumbini, central Nepal. It is clear from this Figure that the Suntar, Swat, Melpani and Gondwana units fall within the oil window, whereas the Lakharpata unit falls within the gas generating window, respectively.

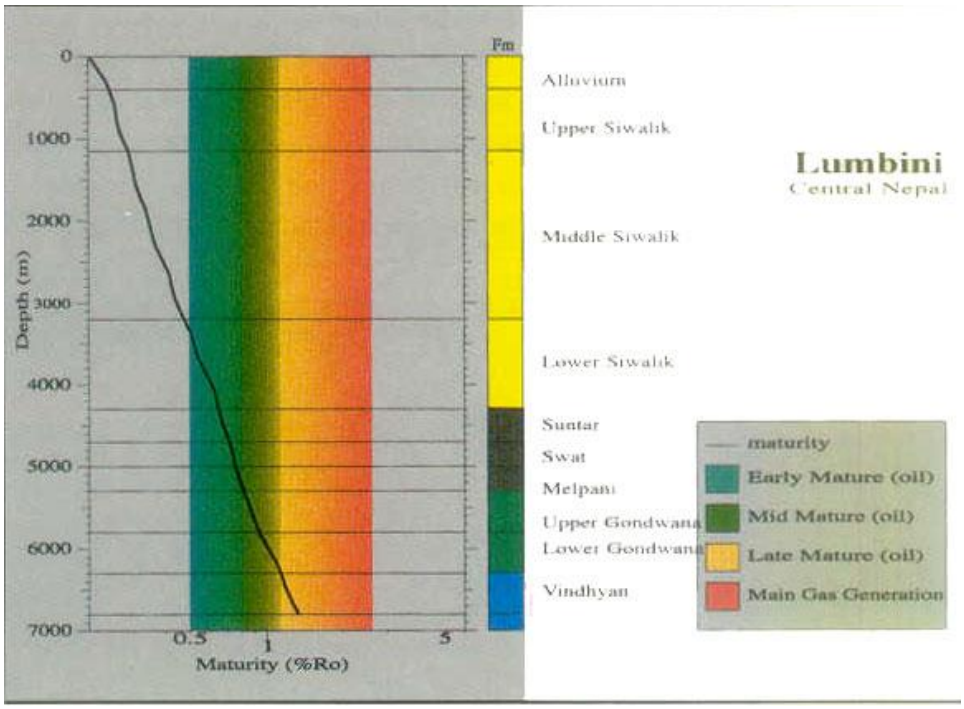

Figure 15: Burial Depth vs. Maturity Plot, Lumbini, Central Nepal

Data Sales Packages

The geological and geophysical works carried out by the Petroleum Exploration Promotion Project, DMG meets the international standard of oil industry. The database contains over 5000 Km of multi-fold seismic reflection data and a number of valuable geophysical as well as geological reports including an update well data (Figure 9).

The data base is divided into 21 different Data Sales Packages (DSP) from "A" to "U". A General Report, which is a summary document, is available at a price of US$ 5,000.00 per copy. It covers the general aspects of the technical hydrocarbon potential, the fiscal terms and work obligations expected for operations in Nepal. The document contains sufficient detail for a company to make an informed decision about the hydrocarbon potential of the country and furthermore contains a working economic model on 3.5" diskette (either in Excel or Lotus 1 2 3) suitable for cash flow sensitivity analyses. Purchase of the General Report is a pre-requisite for companies wishing to purchase other data, visit the Kathmandu Data Centre or to lodge a formal bid for exploratory lands