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Hydrocarbon Exploration in Himalayan Region – A Tough challenge with High Reward

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Summary

Rising of the mighty Himalayan range from the Tethys Sea due to collision of Indian plate with Eurasian plate created a huge subsurface treasure which probably, also includes abundant reserve of hydrocarbon. The present work is based on a class room study and group discussions on the reasons of possible high potential of hydrocarbon reserves in the Himalayans, the exploration efforts given so far and how the future strategy may be intensified based on the state of the art technology.

Keywords: *Tethys Sea, Laurasia, Gondwana, Radio acquisition system*

Introduction

During the major part of Mesozoic Era (251 to 65.5 million years ago) Tethys Sea separated the super continent of Laurasia in the north and Gondwana in the south (Fig 1). Continents of the Earth started taking the present shape when Gondwana began to break up in the early Jurassic (about 184 million years ago). During the Cenozoic Era, about 50 million years ago, the Indian Plate collided with Eurasian Plate (Klootwijk et al., 1979), buckling the crust and forming the Himalayan Range. The Tethys Sea was dominated by soft shell animals called Ammonites, when these animals died they got buried in the sediments of the Tethys Sea. As the Tethys Sea disappeared, those Ammonites got trapped in the sedimentary layers of shale and transformed into fossils. With passage of time, under pressure and temperature these fossils might have got converted to hydrocarbon. The occurrence of huge quantity of petroleum in the Middle Eastern countries shows the richness of aquatic animals in past eras, which died and decomposed to form hydrocarbon in the sediments of Tethys Sea. But the highly rugged terrain and logistics offer a very serious challenge in exploration program in the Himalayan Region (Fig 2).

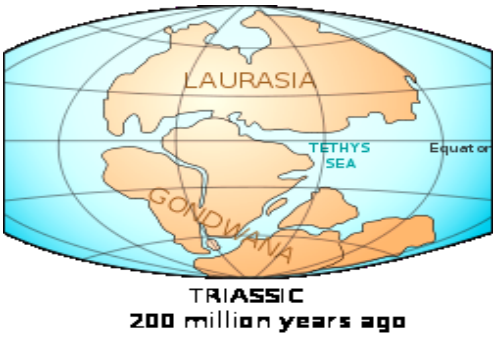

Fig 1: Continents and the Tethys Sea in Mesozoic Era (Source: Wikipedia, The Free Encyclopedia)

Fig 2: Highly rugged terrain and logistics offer a very serious challenge in exploration program in the Himalayas

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Himalayan Basin of India

The outer hill ranges or the foot hills of the Himalayan Mountain extend over a distance of more than 1500 km from Jammu in the west to Arunachal Pradesh in the east forming the Himalayan Foreland Basin (Fig 3) having a NW-SE trend. The northern and the southern limits of the basin are demarcated by two major faults namely the Main Boundary Thrust and the Himalayan Frontal Fault. The hill ranges form a series of WNW-ESE trending hills with intervening Valleys. These hills are mainly constituted of Tertiary rocks, the altitudes vary from 1800 to 2700 m. Beyond the southern slope of Himalayan Frontal Fault the area is plain having a cover of Alluvium. Total area of the basin is about 30,300 sq km. The basin is filled up with 5000 m to 6000 m thick Mio-Pliocene molassic sediments (Biswas, S. K. 1994). At some places the thickness of the sequences are of the order of 10 km. The oldest sequence belongs to Paleocene-Eocene time. Stratigraphically the area is presented by Tertiary sediments unconformably underlain by Early Cambrian to Precambrian rocks. According to the information available in the website of Directorate General of Hydrocarbon (DGH) the prognosticated resources of the basin are 140 MMT (O + OEG).

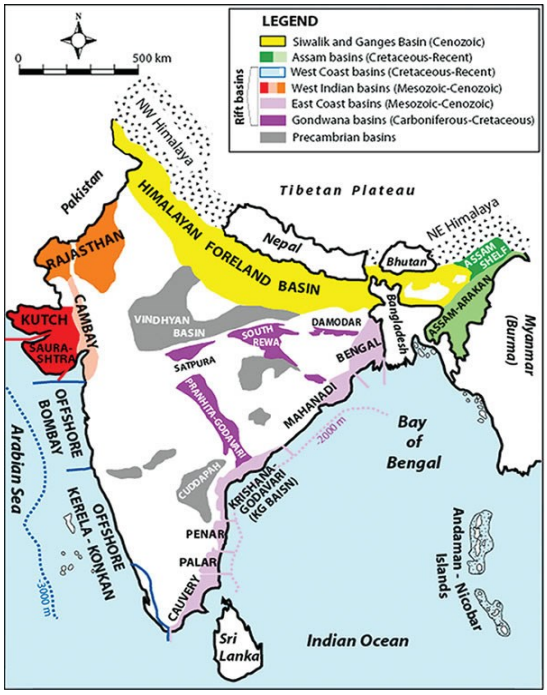

Fig 3: Location of Himalayan Foreland Basin (Source: www.geotimes.org)

Exploration Status in Himalayan Foreland Basin

Exploration work for hydrocarbon was started in the basin by the Petroleum Division of Geological Survey of India, Subsequently Oil and Natural Gas Corporation (ONGC), the national E & P Company of India has been carrying out detailed surveys and investigation since 1956. The work carried out by ONGC in the basin is summarized in the Table – 1. The exploration efforts by the ONGC in this basin have been continuous with varying intensity (Biswas, S. K., 1994). However, there is no commercial discovery of hydrocarbon till now.

During the recent decades ONGC has intensified seismic data acquisition program for sub surface imaging of this complex basin. But due to highly rugged terrain and difficult logistics it is a tough challenge for the seismic crew in areas like those shown in Fig 2 & 4. Field logistics are extremely important in these types of areas due to the difficulty in equipment mobilization, complexity of the field operation and the time constraints to finish the acquisition during the winter-spring seasons. With traditional cable-based recording system it is not possible to cost effectively deploy enough stations for proper imaging.

GEOLOGICAL SURVEYS	
Semi-detailed mapping	99,163.5 Km^2
Special studies	1,931 Km^2
Reconnoitory traversing	300Lkm
AEROMAGNETIC SURVEYS	45,000 Km^2
GRAVITY MAGNETIC SURVEYS	30,079 Stations
SEISMIC SURVEYS	
Refraction	3510.29 GLK
Reflection CDP	2578.97 GLK
EXPLORATORY WELL	
Number of wells drilled	15
Meterage	61,304.35 m
STRUCTURAL WELLS	
Number of wells drilled	8
Meterage	6,239.25 m

Table – 1. Exploration Status in Himalayan Basin (Source: DGH website)

Fig 4: Field logistics are extremely important in this type of terrain of Himalayan Foreland Basin

The Right Acquisition technology for Himalayan Basin

Extensive 3D seismic survey to cover the entire basin with high station-density for high quality sub surface imaging is necessary to assess the actual hydrocarbon potential of foot Himalayan hills. The job is highly challenging and capital intensive, at the same time may turn out to be highly rewarding. The ideal seismic acquisition system for the Himalayan Foreland Basin should be able to leverage numerous advances in wireless transmission and advanced data storage facilities. Now a days, for a standard 3D seismic survey, cables and various other ground equipments supporting cable-based data transmission weigh 25 tons or more (Hollis et al, 2005). Weight of the equipments directly contributes to the cost and speed of the survey. To overcome the limitations of cable-based architecture in the hilly terrain Radio transmission architecture with state of the art support of helicopter-dropping of equipments and crew members for speedy mobilization, use of dismountable shot hole drilling rig and radio transmission of the acquired data to the field processing system of the Base camp for real time quality control is to be deployed.

Hollis et al (2005) showed receiver layout with Radio Acquisition System and Conventional Cable System with Radio based Extension (Fig 5), which are suitable for inaccessible hilly terrain regions. Depending upon the size of the survey and the logistics, a combination of the above two may be utilized. But for the extreme terrain each receiver station should have an independent bi-directional communication path to the recording unit and there would be no telemetry cables interconnecting stations (Fig 6).

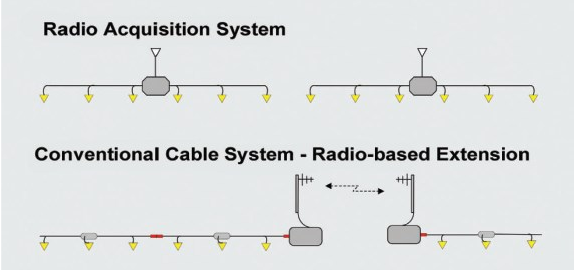

Fig 5: Radio Acquisition System and Cable System with Radio-based Extension.

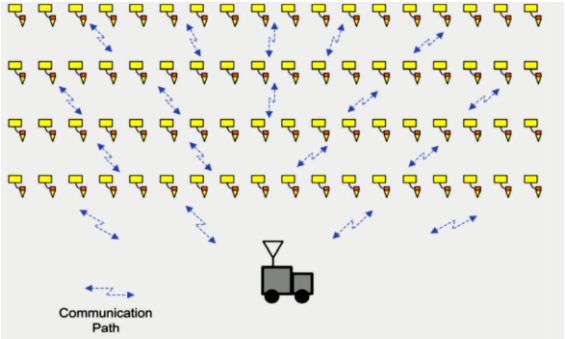

Figure 6: 3D Survey layout with only Radio Transmission (after Hollis et al)

Conclusions

Detailed sub-surface mapping of the Himalayan Foreland Basin can not be accomplished by 2D surveys or by conventional 3D surveys on selectively accessible areas. The entire basin needs to be covered with high station-density 3D seismic acquisition to properly image prospective targets at all basin depths and for this, state of the art radio transmission systems are to be deployed so that the area of extremely rugged terrain also can be covered. A serious well planned effort to explore this basin may bring a very high reward.

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