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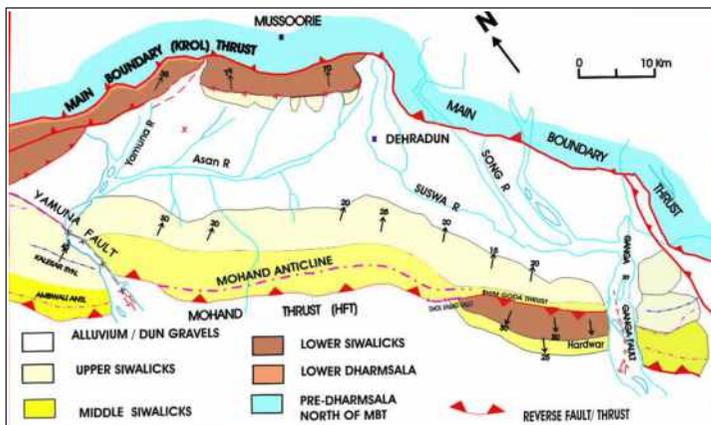


**GEOLOGICAL FIELD TRIP TO MOHAND SECTION, DOON VALLEY, UTTARAKHAND**

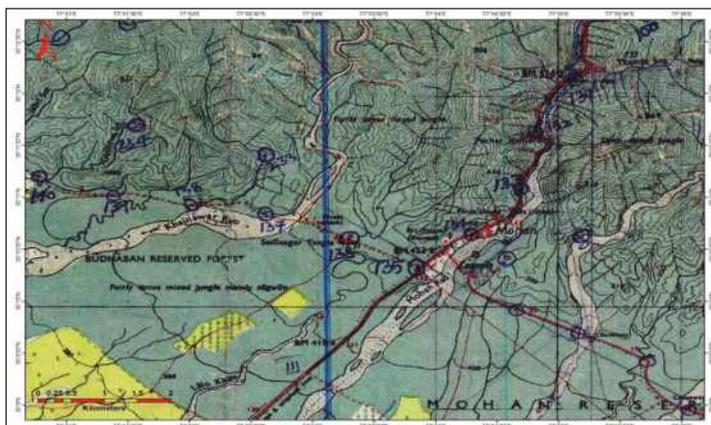
Curious eyes minutely observe variation of sedimentary facies. Mohand is where an exploratory well drilled by ONGC six decades back. A report by Arun Kumar Singhal, Chief Editor, DEW as member of the APG-I geological field trip to Mohand Section, Uttarakhand



# Geological structures of Mohand analysed



Geological map of Doon Valley (after Riverman et al, 1983, Philp 1996.)  
Source: Remote Sensing Lab.



Toposheet of the area showing Mohand Rao and Khajawar Rao

**The Himalayan Foreland:**

If one views the Himalayan Foreland it is a typical Foreland Basin formed as a result of continent to continent collision located in the North Western part of India encompassing J&K, Punjab, Himachal Pradesh, Uttarakhand and Uttar Pradesh.

**The Mohand Section, Uttarakhand:**

Taking a closer look at the geology around the Doon valley, the Uttarakhand foothills lie between Yamuna and Ganga rivers with the Mohand structure here consisting of en-echelon anticlines with a common northern limit. It is faulted against the alluvium by the concealed Mohand Thrust.

The foothill belt mainly exposes Tertiary rocks except in Solan and Jammu where pre-Cambrian limestone are exposed as inliers. A major line of dislocation designated as the Main Boundary Thrust (MBT) represents the junction between the Lesser Himalayan tract and Foothills. The MBT while not a continuous line but occurs in the shape of a sinuous line with pronounced re-entrants viz the Jhelum syntaxis, Punjab re-entrant and the Dehradun re-entrant. The focus for hydrocarbons in the Himalayan Foothills has been on the Tertiary group of rocks. The Tertiary belt is of varied width and the structure exposed in its length are quite diverse.

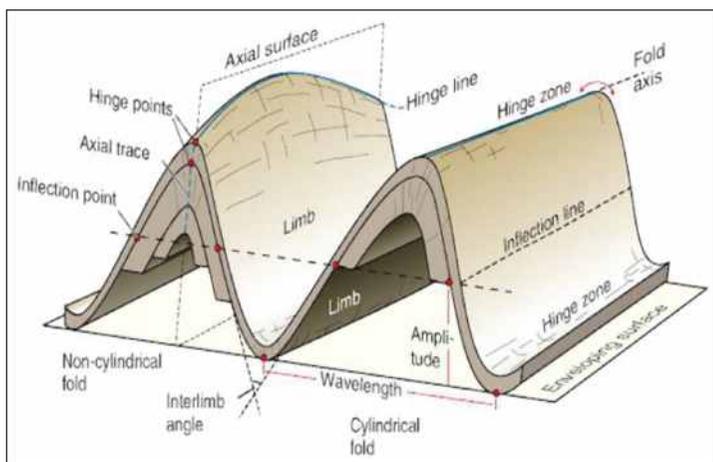
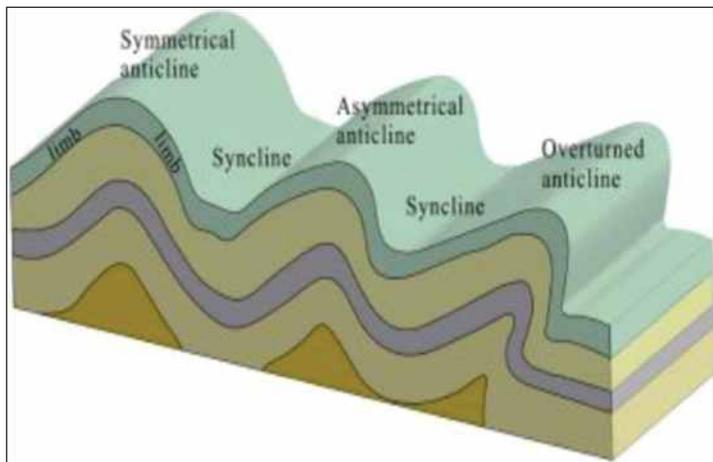
It has been documented that the majority of the world's oil reserves reside in Mesozoic and Tertiary rocks. The State of Uttarakhand covers part of the exposed Tertiary belt and considerable thickness of prospective Tertiary sediments are envisaged beneath the Pre-tertiary cover to the North of the MBT. In addition to this there is a probability of a

Palaeogene wedge extending below the Tarai plains which may also be a prospect for future exploration. The Mohand sector displays Up-Thrust Tertiary Play.

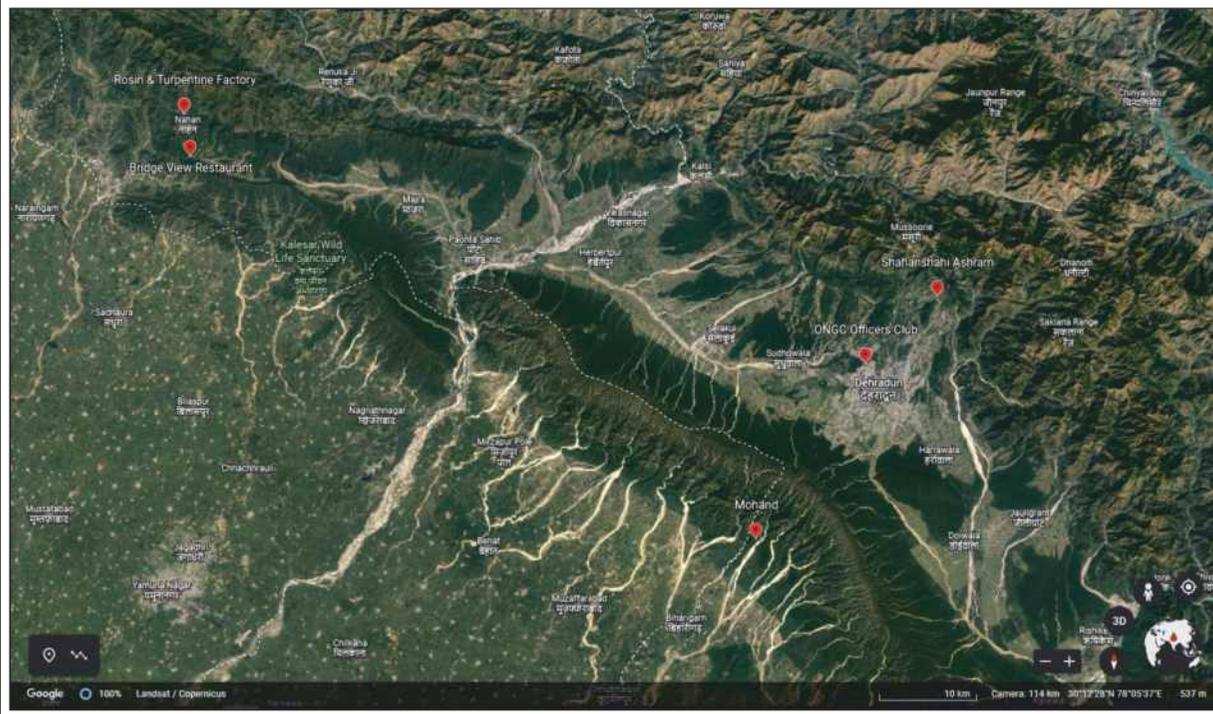
One notices, a major part of Uttarakhand covers the Himalayan Foreland Basin. Exploratory efforts were therefore initiated in this basin during the inception of ONGC, however, despite concerted exploratory efforts with exploratory and structural wells drilled in the Mohand sector in early nineteen sixties, commercial success has eluded so far.

From geological point of view, the Up-thrust Tertiary Play - Mohand area encompasses the foothill belt of Dehradun and Haridwar. A major part of the area is covered by the Doon Valley alluvium and is interpreted to overlie Tertiary and pre-Tertiary sequence of rocks. The Himalayan Frontal Thrust (HFT) is locally called the Mohand thrust dips towards the North-East. The Bhimgoda Thrust (BGT) situated on the eastern side of the frontal Shivalik range dips towards South bringing the Lower Shivaliks overriding the Upper Siwaliks.

The Lower, Middle and Upper Siwaliks



Folds



Google map of the area showing Mohand Ridge and Himalayan Frontal Thrust (HFT)



Geological field trip members with faculty at the Middle Siwalik, Khajawar Rao section, Mohand.

are exposed in the area apart from the Doon Gravels. The most prominent structure in the area is therefore the Mohand anticline, which is an anticline ridge and consists of a series of en-echelon anticline features. It is faulted against alluvium by the concealed Mohand Thrust. Several features of the re-entrant make it attractive for the search of hydrocarbons viz stratigraphic favourability for presence source facies rocks capable of generating hydrocarbons besides availability of reservoir sequences, cap rocks (good shale and clay bands exist which can act as cap rock) and favourable locales for entrapment.

The source facies would include the Pre-Tertiary sequences encountered in well Mohand-1 and the known marine Sabathu sequences, which are seen on either side of the Doon entrant. The Sabathu's have proven their generation potential in sourcing hydrocarbons in the Potwar of Pakistan.

Keeping in view the aforesaid, an understanding of the area suggests that it holds promise for hydrocarbons and require further exploratory inputs to completely realize the potential of the up-thrust, sub-thrust and Paleogene wedge prospects.

#### **Geological Field trip to Mohand Section:**

To study the geology of the area and expose it to the young geologists, a group of seasoned geoscientists and geoscience students and researchers visited on April 16, 2022 the Khajawar Rao and Mohand Rao in Mohand Section of the Uttarakhand Shivaliks around the Doon valley as part of a geological

field excursion organised under the aegis of the Association of Petroleum Geologists-India (APG-India). The group had a curious eye to observe variation of sedimentary facies, sedimentary processes, provenance, landscape evolution, surface processes, and paleoclimates during the field visit. The Mohand region of the Shivalik has always attracted geoscientists since an exploratory well drilled here six decades back by India's national oil major ONGC in search of hydrocarbons.

The field trip flagged off by Dr. Ravi Mishra, Executive Director, Exploration & Development Directorate, ONGC and Vice President of APG-India. The trip was led by Prof. Dr. Pradeep Srivastava and Dr. Anil Kumar as faculty members. Dr. Srivastava is a field specialist in quaternary geology and a professor at the IIT Roorkee, while Dr. Anil Kumar is Scientist 'D', Wadia Institute of Himalayan Geology, Dehradun with field specialisation in quaternary geology, sedimentology and luminescence dating.

The field trip was also participated by Dr. Ravi Mishra, Executive Director, Exploration & Development Directorate, ONGC, Mr. Rajesh Sharma, Group General Manager-Frontier Basin, ONGC, Mr. Arun Kumar Singhal, Chief Editor, DEW Journal, Mr. Jayanta Sarkar, CGM, E&D Directorate, ONGC and Secretary, APG India besides others.

The participants comprised a mix of geology experts from the industry and academia, senior office bearers of APG-India, representatives from the oil & gas and service companies, scientists from the Geological Survey of India, besides geology students and



Dr. Anil Kumar



Dr. Pradeep Srivastava



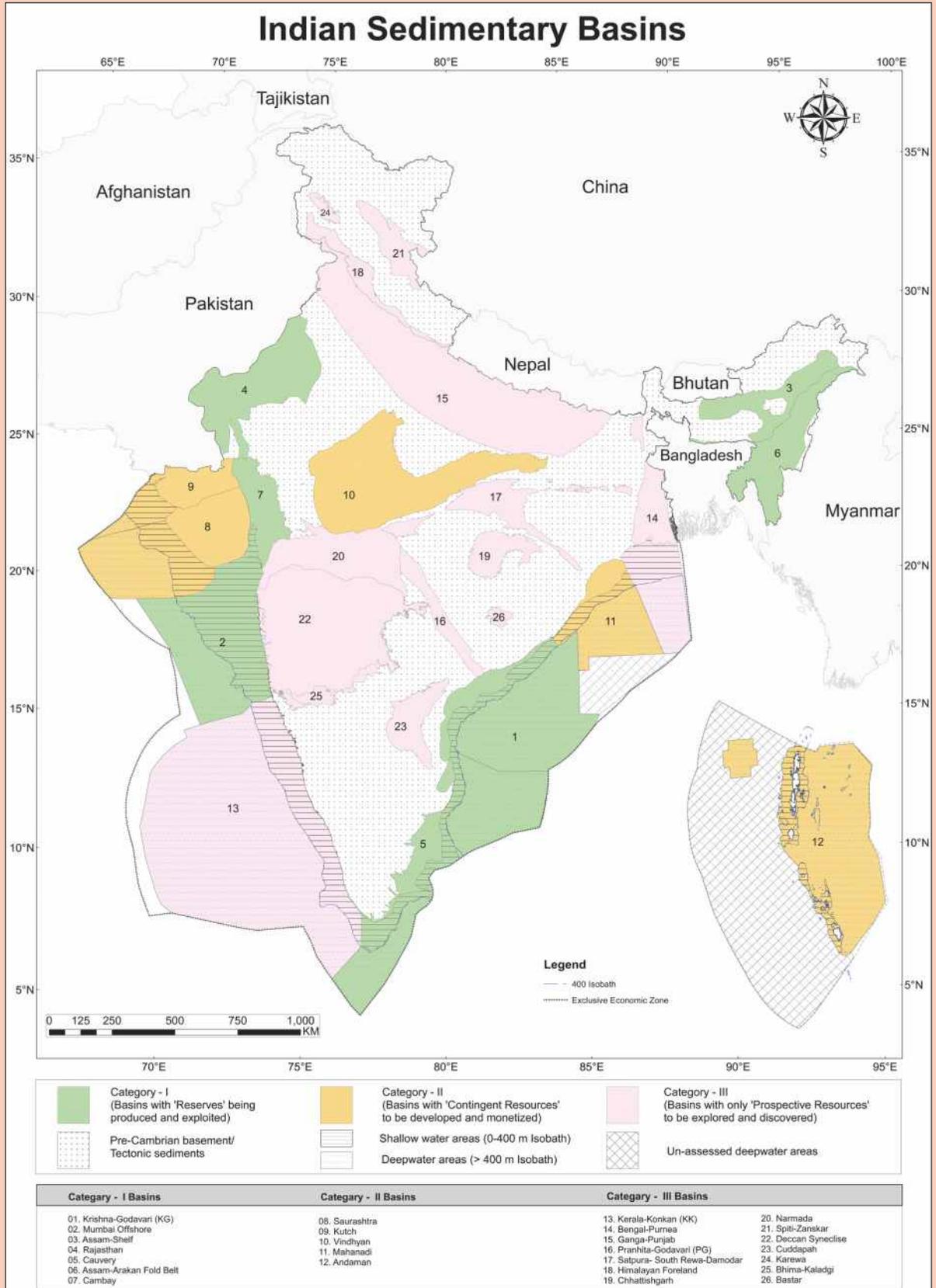
Dr. Ravi Mishra



L to R: Mr. Jayanta Sarkar, CGM, E&D Directorate, ONGC and Secretary, APG India, Dr. S K Mahanti, former Group General Manager (Geology), ONGC, Mr. Rajesh Sharma, Group General Manager-Frontier Basin, ONGC, Dr. Anil Kumar, field trip faculty, Mr. Arun Kumar Singhal, Chief Editor, DEW Journal during the field visit.



Middle Siwalik and upper Siwalik contact at Mohand Rao



## Sedimentary Basins & Himalayan Geology

There are 26 sedimentary basins in India, covering a total area of 3.4 million sq. km. The area is spread across onland, shallow water up to 400 meter water depth and deepwater farther up to Exclusive Economic Zone. These basins are divided into three categories based on maturity of hydrocarbon resources as under:

- Category-I: Basins, which have reserves and already producing.
- Category-II: Basins, which have contingent resources pending commercial production
- Category-III Basins, which have prospective resources awaiting discovery

The Himalayan Mountain Chain extending over a distance of more than 2000 km is traditionally subdivided into the following

1. The Siwalik Foothills of the Sub-Himalaya constituted of the Neogene-Quaternary molassic deposits of the Siwalik Group.
2. The Lesser Himalaya exposing from the outer to the inner parts
  - the Palaeogene sediments juxtaposed against the Siwalik Group in south along the Main Boundary Fault and against the Proterozoic rocks in north along the MBT,
  - isolated Early Cambrian, Early Permian and Late Cretaceous outliers over the Proterozoic rocks,
  - crystalline thrust sheets and
  - windows of Proterozoic/ Palaeogene rocks within the crystalline/Proterozoic rocks along the antiformal valleys.
3. The Higher Himalaya consisting of the crystalline thrust sheets with the Vaikrita Thrust Sheet (=Main Central Thrust, Bhargava and Bassi, 1994) occupying the highest tectonic level. The Vaikrita Thrust Sheet known by different names (e.g. Salkhala in Kashmir, Thimphu in Bhutan) extends through out the Himalaya.
4. The Tethyan Himalaya made up of the Neoproterozoic-Eocene succession resting as detached synclinoria over the Vaikrita Crystalline or its strike equivalents, commonly and loosely termed as Central Crystallines. The main synclinoria often referred to as basins, from west to east are: Kashmir; Chamba-Bhadarwah-Tandi; Spiti-Zaskar; Kinnaur-Kumaon; Nepal; Sikkim-Bhutan and Arunachal.
5. The Indus-Tsangpo Suture Zone representing rocks associated with the Suture between the Indian and Asian plates. Synclinorium: The Spiti Valley, located north of the Pir Panjal Range, exposes an excellent section of Neoproterozoic-Cretaceous rocks in the Tethyan Himalaya of Himachal Pradesh. The Spiti Tethyan rocks towards NW through the Lahaul Valley extend into the Zaskar area where Paleocene-Eocene sequences are also preserved. The Spiti-Zaskar synclinoriums approximately occupies an area of 22,000 sq km. (Source: DGH)

researchers.

The field trip addressed interesting geological curiosities of the young geologist (student) by the faculty and subject expert.

Speaking to DEW Journal on the objective of the field trip, Prof. Dr. Pradeep Srivastava said, "the Himalayas are a fold and thrust belt and our focus precisely on knowing how these folds and thrust are formed and how they grow. In other words, the aim of this field trip is three-pronged-first, the young geologists and students will be shown what the mountain front looks like. Secondly, how the mountain front grows and third, how and at what rate it can grow. Also, we are examining and showing to young geologists





Jayanta Sarkar

how sand bodies evolved in any rock system in fluvial driven systems behave in the past and how sediment bodies evolved vertically”.

All these three features he emphasised can be shown here in the Mohand section. Being the youngest phase of building mountain ranges and

evolving, it provides an opportunity for the young geologists to study these features on the ground during this field trip. The Mohand anticline was formed around 6000 years to the present day, how the mountain front in the Garhwal Himalaya formed and how the anticlines geometry can be mapped.

Geologists, world-over too, are constantly studying the lateral variability of the mountain range here. So this is indeed a very important aspect being showcased by Prof. Srivastava added.

In addition to the above, the oil industry experts also studied the geological features of the region from their point of view.

The field trip studied delineating the Quaternary signatures of tectono-climatic evolution of the Himalaya and its foreland; building the syn and post-collision landscape using archives; understanding the sedimentary pattern and basin evolution of pre- Himalayan sedimentary basins. A close study of sedimentary rock classification, type of source material, environment of deposition and process deposition was taken up.

On the geology of the region, Dr.Ravi Mishra, Executive Director, E&D Directorate, ONGC and Vice President, APG-India stated, the Doon Valley, which is an inter montane valley, extends 80 km in length and spreads 20 km in average width. There are two prominent transverse faults, called Ganga and Yamuna faults, occurring at the eastern and western extremities of the valley. The Re-entrant is bound to the north by the Main Boundary thrust (MBT) that separates Pre-Tertiary rocks of the Lesser Himalayas from that of Cenozoic sediments of the Outer Himalayas. The MBT passes through Kalsi, Rajpur and just west of Rishikesh to the south. Himalayan frontal thrust (HFT) bounds it in the south that passes through Mohand.

The Middle Siwalik, he said, is exposed here on the right bank of Khajnawar Rao with sequences overriding the present-day gravel beds along the Himalayan Frontal

Thrust. The thrust contact with Siwalik makes an asymmetrical anticline that exhibits gouged rock at the thrust contact where no bedding plane is distinguishable, though, on a fresh chip, one can easily identify salt and pepper texture, which is due to the presence of quartz and feldspar (salt) and lithic fragments (pepper) and moving upstream, one can start deciphering the bedding structure and change in dips from north to south.

On the basis of opposite dips in Middle Siwalik units, an anticlinal fold is observed caused due to Himalayan Frontal Thrust. The Holocene crustal shortening rates due to anticline formation can be deduced here by looking at dated uplifted river terraces. This spot therefore serves well where one can carry out structural mapping of bedding planes, joint planes and fault planes and also prepare lithology by observing the variation of sedimentary facies exposed along a part of Middle Siwalik along Khanjavar Rao, Dr.Mishra pointed out.

The Mohand Rao, on the other hand, sees a sharp contact between Upper Siwalik conglomerate facies with Mudstone facies of Middle Siwalik and changes in sedimentary environments can be observed. Also observed here are angular unconformity between Holocene conglomerate facies and sequences of Upper and Middle Siwaliks, Dr.Mishra said.

Dr.Mishra also said, APG-I through its various efforts has tried to disseminate knowledge and sow the futuristic ideas towards the growth of Geosciences and contributing to petroleum E&P industry. Our efforts have been widely hailed in providing a seed bed for nucleating ideas and prompting the future trends.

The geological features here, therefore, evoke an interesting geological curiosity ever since the only exploratory well drilled in the area so far is Mohand-1, which penetrated the exposed Mohand anticline, which is a thrust related anticlinal fold formed within Middle Siwalik.

Earlier, Mr. Jayanta Sarkar, Secretary, APG-India and



General Manager-E&D Directorate, ONGC briefed the participants on the aims and objectives of APG-India. APG India, he stated, is a forum which brings together Petroleum Geologists on one platform to discuss, deliberate and plan ways and means to support worthwhile educational and scientific programs or projects related to geosciences. It focuses on advancement of the science of Petroleum Geology and promotion of technology for exploration and production in an economically and environmentally sound manner.

He also informed APG-I organise periodical geological field excursions around the country to study geological features of the hydrocarbon bearing structures. The present Geological Field Trip to the Mohand Section of the Doon valley, Uttarakhand, was in line with the many field excursions organised by APG-I since its inception in year 2000.

He called for the young geoscience students and researchers to be a part of APG-I by being its members to avail chance to study the geological features during field visits, a rare opportunity.

**The legendary Mohand Deep Well No.1:**

As part of the geological field trip the group visited "Mohand Deep Well No.1" an exploratory well drilled by ONGC in 1964 on the Mohand anticline on the outskirts of Dehradun. This well though did not produce hydrocarbons has provided a wealth of geological information to geoscientists though, it now lies in total neglect, buried under thick bushes, unnoticed and only cited in the geological reportage. The place is a heritage site from the geological point of view.

Explaining the features of Mohand-1 Well to the members of the geological field trip, Mr. Rajesh Sharma,

Group General Manager (Geology), Frontier Basin, ONGC stated, the well was one of the earliest well that ONGC took up exploration in the Himalayan region drilled to a depth of 5264 meters before being terminated. After drilling through the Middle Siwaliks the well encountered the Mohand thrust and entered the Middle Shivalik range again followed by the Lower Siwaliks, Dharamsala and Pre-tertiary sediments. Palynological studies have identified the age of the Pre-Tertiary in the interval 4594 m to 5053 to be younger than Triassic. This has not been conclusively proved. The two horizons tested gave only saline water he pointed out. Mr. Sharma also informed ONGC having drilled two structural well on this anticline to ascertain the hade of the thrust.



Mr. Rajesh Sharma

While considerable exploratory inputs were expanded in this sector until late eighties, with the area being geologically mapped bringing out broad features including Mohand anticline, the geoscientists are still far away from any conclusive opinion of whether or not the region holds hydrocarbons. Possibly, the area requires more exploratory inputs to still better understand the potential of the area. With hopes, the geoscientists keep revisiting this area periodically!

It is time ONGC develop the site of the famous Mohand Deep Well No.1 as a remnant of the past that not only holds great history but toil for oil in the initial days post independence when India initially, indigenously began search for hydrocarbons. [dewjournal.com](http://dewjournal.com)



Members of the Geological Field Trip at Mohand Deep Well No.1 location