Kohat Plateau – A General Tectonic Study

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Abstract

The Kohat region in northern Pakistan area is one of the complex tilted plateau and also sometimes seems as "Cuesta" region with its complicated structural attribute, for example, moderate-steeper dip which may form asymmetrical structures due to large number of wrench-tectonic thrust/overthrust, rejuvenated and normal faulting. The study area (72ºN, 33º50'E and 72º30'N, 33º25'E) needs more concentration during Recent to Eocene time with regard to the structural changes seems to occur within different part of the region. The author tried to study the geological and geophysical results in general after the Indo-Eurasian collision during Paleogene time with stable Asia rotational wrenching that formed after the southwards lesser force vector from Tadjik Basin (east of Tibet) area controversial to northwards directed more vector forced Indian continent but especial emphasis has been made on the E-W structural trend with tight anticlines and wider synclines in the East of Kohat while even tight synclines in the western most part of Kohat Plateau. The collision also resulted in the west of Plate (the Pakistan territory), an N-S oriented series of deep seated left-lateral basement-effected faulting ranges while the east of Plate (the Indian Territory) contained E-W oriented right lateral Dauki and Haflong faulting system. A number of evidences for confirming the continued tectonics appeared during the study also with higher rate of earthquakes in the area. The author like other scientists have observed that detachments are present in Eocene formation indicates the compressional structure that gave risen to thrust faults, overturned folds. Such transpressional picture has been marked clearly in Kalabagh Fault area also.

The Kohat-Potwar plateau on the southern part of Himalayan and Karakoram orogenic belt is a result of compressional tectonics after Indo-Eurasian collision. The Kohat-Potwar plateau is bounded at north by Kalachitta Hills. The Salt Range and Trans-Indus Range marks the boundary at south. The western boundary is mark by Kurram-Parachinar Range. The River Indus separates the Kohat-Potwar Plateau by the Eastern side named as Potwar area and the Western side as Kohat area.

The study is based on selected five drilled-well data while Khushalgarh area maps, published literatures and field surveys and studies provided the authentic conclusion for the new structural setting. The unconformities predictions and stratigraphic chart helped to understand the geology and key to sequences and seismic stratigraphical study also. Three large scale unconformities have been marked; 1- Late Jurassic-Early Cretaceous, 2- Cretaceous-Paleocene, in Cretaceous the area emerged out of sea that was followed by erosion. The emergence was more intense south and east of the area witnessed by the absence of the Cretaceous section, and 3- Eocene-Miocene unconformities, Non-orogenic movements mainly caused by various cycles of uplift affecting pre-Eocene deposition. During the late Eocene, the area emerged out completely while the seawater withdraws from the area.

The geologic structural feature is difficult to tie with surrounded areas even after the seismic study. The most significant feature of the area is the correct geological division, and exact marking of the location. The geology of the area is different as compared to southern Potwar and westernmost Kohat Basin. The Kohat portion of upper Indus Basin is similar to Potwar area BUT the regional stratigraphy made difference between these two large basins. Both the basins have gone through

similar evolutionary history. The Potwar Plateau has subdued relief compared to Kohat Plateau having down-plunge geographic extension of Kohat Plateau.

The 2D seismic data interpretation is based on the seismic attributes, seismic configuration, seismic attributes and seismic pattern. The seismic data collected from both east and west part of the study area but western seismic section from western side has been shown for critical study due to importance o of rotational damages. The seismic reflection configuration is oblique-sigmoid type that indicated high-dip to moderate dip bedding pattern which in turn shows high energy to low energy depositional process. It has been marked in the seismic section that short pop-up structures have weak reflectors beyond 3 seconds. The increase of amplitudes between 2-3 seconds in the section suggests the possibilities of fractures or/and gas filled fractures and the dimming/weakening of amplitude refer has been difficult to analyze. In the central Kohat Plateau area, Tolanj anticlinorium have a flower structure. On this structure AMOCO had drilled a well in 80's. Although the westernmost part of the Plateau have number of fractures but identification of hydrocarbons at OGDC drilled well Chanda Deep at about 5100m (5,500bbl/13.37mcf) and MOL drilled in Tal Block, both have opened up the vast terrain of Kohat Plateau as highly prospective attraction. The seismic sections in the western part of study area shown a few diffractions also.

A large number of low mountain ridges have noticed in the studied area confirming the presence of Eocene detachments having continuous sequences of shale in Middle Eocene. And thus, large numbers of duplex structure also have been marked in the area. The Kohat and Kuldana Formations are the only representatives of the Middle Eocene in the Kohat Plateau. Relative to Potwar, the Salt-Range facies in Kohat area are more basin-ward and affected by the Early to Middle Eocene during the early stages of the Himalaya orogeny. The surface outcrops and subsurface conclusive interpretation study revealed the infrastructure of the area. The geological study showed that the region is Salt-effected based thin-skinned and Basement-effected based, detachment formed thick-skinned with weak/broken upper ductile multi-fractured Incompetent Package (Miocene age) with detachment line and with the strong lower viscous table Competent Package (Eocene age). The upper zone above Eocene Incompetent package is more damaged as compared to the lower zone below Eocene Competent package. The north and northwestern area of Kohat have more tight and deformed structures as compared to the south and southeastern areas due to rotational activity. The whole Kohat region like Potwar is composed of imbricate wrench faults and these imbricate faults are gentle in the Potwar area while steeper in the Kohat area. The eastern part of the Kohat Plateau formed duplex structure in Kohat Formation. The western part of the area has more tectonic damages as compare to east part of Kohat region. Middle Eocene is better developed in Kohat Plateau. The northern areas of Pakistan mostly contain thin wedged shale of about 50-150 m thick deposits of Kuldana Formation from presumably Late Eocene while probably Middle Eocene age. In some northwestern of Kohat Plateau areas, this formation found as outcrop in isoclinals folded form sometime parallel to MBT (Main Boundary Thrust). The Lower Eocene (Chorgali Formation) is active but damaged more in western part of Kohat area, which also proves the rotational direction of the continent towards northwest from southeast and also the steep dips and throws of wrench faulting system in the area supports the statement. The main best source rock for the oil/gas accumulation available in the study area is Patala Formation and also Kuldana Formation.
In Hazara District, the Kuldana Formation consists of multi-cored Marls, Calcareous conglomerates and red Sandstone is also common. In Kalachitta and northern Potwar, it consists of greenish grey to brown silty gypsiferious shale. In Kohat, this formation is composed principally of brownish red calcareous, silty clays with thin beds of sandstone near the top. It is exposed in the southern Hazara and northern Rawalpindi areas extending through northern Potwar and Kalachitta to Kohat area. It reaches about 150 meter (500ft) in Hazara and northern Potwar. The presence of fauna gastropods, fresh water bivalves and other fossils indicates that the formation was deposited in a transitional environment with probably more marine fresh water influence. In the Potwar, Kalachitta and Hazara areas, it overlies about 66 meter whereas in Kohat area conformably underlain by the Jatta Gypsum. In most areas, it is firmly overlain by the Middle Eocene Kohat Formation except in southern Hazara and Kalachitta where the Early Miocene Murree Formation unconformably overlies the Kuldana. Based on stratigraphical evidences the age is interpreted to range from Early Eocene to Early Middle Eocene.

The Kohat formation is consisting of light grey to cream colored massive to nodular Limestone with marl and also green shale. In some areas, this formation may appear as "Reservoir Rock". The Kohat Formation was found with three members, namely; 1- **Kaladhand Limestone Member:** The basal member, which consists of light grey, hard, dense thin-bedded limestone with thin shale beds especially in the lower part. This unit becomes more massive from east to west, 2- **Sadkal Shale Member:** The middle unit consists of greenish grey calcareous shale and light grey limestone with

abundant Foraminifera (Nummulites). It is mostly found in the northwestern Kohat area where shale nature is well developed and 3- **Habib Rahi Sandstone Member:** The upper member is composed cream colored, hard, dense, thick bedded to massive limestone that is fractured and bracciated in the top few meters. The formation is restricted to Kohat, northern Potwar and Kalachitta upto180 meter (590ft) of thickness. A rather shallow marine environment due to little continental influence has been marked in the area.

In the western part of area the drilled Kahi-1 well have Panoba Shale (Eocene) exposed. The well was drilled unto Jurassic formation. In the eastern of Kahi-1, Sumari-1 was drilled where thickness of Patala Shale of Paleocene has been increased toward east. At NE of Kohat Plateau Tolanj-01 was drilled where Kohat Limestone of Eocene age is exposed. The well shows the repetition of Eocene rocks due to the formation of faults. At southern Kohat, Shakardarra-01 was drilled where Pliocene sediments are exposed. Shakardarra-01 limestone (Cretaceous) is absent in the section.

Lockhart Limestone (Paleocene) is not encountered in Sumari-1 well. The Chichali formation (Cretaceous) is missing in Tolanj-1. In the SW of Kohat, Kundi-X1 well was drilled unto Eocene rocks at about 6000m while in the rock of Kohat, the Eocene is exposed. This shows that in the north and northwestern region of the Kohat Plateau, Eocene rocks are exposed while in the southern region Pliocene and recent materials are exposed. The thickness of Paleocene-Eocene rocks varies dramatically from East to West.

The Kohat Plateau should be study with reference to hydrocarbon exploration especially oil/gas searching due to large available prospecting approach, structural styles and off course, some of discoveries proved this statement also. The wrench faulted imbricate structured Kohat Plateau area is broad ~200km and gently dip of about <3° with overthrust complex belts have been interpreted with unreliable broader group length 2D seismic data acquired from different exploration companies previously and thus, it is recommended to have 3D approaches to understand at least the proper structure of the area. It is clear that 2D-Time Migration suffices in delineating targets on such imbricate structures due to sideswipe energy gathering and this can be clear by 3D migration in the seismic section. It is in fact, also important to have good quality of seismic acoustic impedance, wave signals in the seismic expression, seismic inversion for velocity/density ratio. The AVO, synthetic seismic and 3D modeling can also give better result if examine them time to time during different test. Although, this should be consider that statements here given are not final and thus should study with more approaches and facts.

Keywords

Amplitude attributes 2D seismic diffraction

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