Evaluating Fold-Thrust Structures and Hydrocarbon Potential in the Western Marwat-Khisor Ranges and Sheikh Badin Hills, North Pakistan

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The Marwat-Khisor mountainous belt of the Himalayan frontal ranges is a south-vergent fold-thrust strap that protrude south to southeastward into the northwestern Punjab foredeep. It is characterized by east-west to northeast trending parallel to en echelon, plunging structures mostly asymmetric to overturned and dominantly southeast vergent. The frontal foothills of the Khisor Range and Sheikh Badin Hills encompass the latest partially emergent thrust fault named Khisor and Sheikh Badin Frontal Thrust. The outcrop appearance and its extrapolation to the subsurface of the structural fabrics proposes a thin-skinned structural configuration for the progression of the Marwat-Khisor Range where the cushion surface for the frontal ramp being sited within the Jhelum Group rocks of Cambrian age at an estimated depth of 4~5 km. The structural enhancement of the Himalayan frontal ranges is primarily attributed to tectonic processes originating from the north and transferring southward. This tectonic mechanism is observed along a disconnected surface at the base of the Cambrian Khewra Sandstone. Along this décollement horizon the thrust sheet comprising the Khewra Sandstone is exposed at the surface and juxtaposed to the sediments lying south-eastward and belonging to the Punjab foredeep. Thrust tectonics often initiate subsequent to the deposition of molasse sediments, as these rocks become involved in the latest phase of thrust faulting. The forefront of the Khisor Range represents the newest and most dynamic zone of tectonic activity in the northwestern segment of the Himalayas, with geological disturbances progressing towards the southern axis. In the region near Dhupsari, the boundary of the Khisor Thrust delineates the northwestern edge of the

Punjab foredeep, predominantly consisting of marine sediments from the Permian to Triassic periods. The geologic succession observed in the area under investigation shows substantial similarities to the stratification seen in the Surghar and Salt ranges, albeit with a few distinct variations. The Khisor Range's Permian sequence is made up of rock layers from the Nilawahan and Zaluch groups. Overlying the Nilawahan Group is the Sardhai Formation and at the base of the Zaluch Group lies the Amb Formation. The Sardhai Formation has been measured to be over 40 meters thick, mainly composed of blackish-gray to black, carbon-rich shale. In contrast, the base of the Amb Formation is characterized by a dark gray, carbon-rich, and calcareous shale with a thickness exceeding 20 meters. The configuration of the structural forms and the stratigraphic sequence within the Khisor Range point to the northwestern Punjab foredeep being a promising zone for hydrocarbon resources, given the considerable thickness of carbon-rich shale strata in both levels, making them potential sources of hydrocarbons. The study area also contains other prerequisite parameters imperative for the building of a hydrocarbon kitchen, such as a trapping system along with a reservoir, seal, and overstrained horizons.