OIL & GAS DEVELOPMENT COMPANY LIMITED

TENDER ENQUIRY NO. PROC-SERVICES/CB/EXPL-4722/2020

INTEGRATED SEQUENCE STRATIGRAPHIC STUDY OF LOWER GORU AND SEMBAR FORMATIONS IN SINJHORO EL AND ALLIED D&PLS FOR THE DELINEATION OF STRATIGRAPHIC/COMBINATION LEADS & PROSPECTS

Note:

Bid bond of **USD 8,000/- (US Dollar Eight Thousand Only)** must be submitted with the technical bid. Please see tender documents for further detail.

The master set of tender documents (services) uploaded on OGDCL website (www.ogdcl.com) is the integral part of this TOR.

TERMS OF REFERENCE (TOR)

FOR

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1. Introduction

1.1. Sinjhoro E.L covers an area of 1283.43 km^2 and is located geographically in the Sindh province of Pakistan. Geologically the area contains portion of the Southern Indus Basin known as Lower Indus Platform (Figure 1.4), which is located in Sanghar and Khairpur districts of Sindh Province, Pakistan.

1.2. The Lower Goru is the most prolific oil and gas bearing sandstone reservoir that is being explored for hydrocarbon in the Southern Indus Basin and the study area has extensively been explored for oil and gas since after the Khaskheli oil discovery in 1981. The area has many commercial oil and gas discoveries in Cretaceous age sandstone of the Lower Goru. Shales within the Lower Goru and Sembar Formation are the proven source in the study area. The combination of the intra-formational shale/sand sequences in Sembar Formation makes it a source of hydrocarbons and possible reservoir (mainly for shale gas and tight sand) as evident from the recent exploration activities with encouraging results in the area.

1.3. OGDCL operates Sinjhoro exploration license with more or less 10 D&P leases (Figure 1.5). Total 26 wells have been drilled so far, out of which 15 wells are hydrocarbon producers.

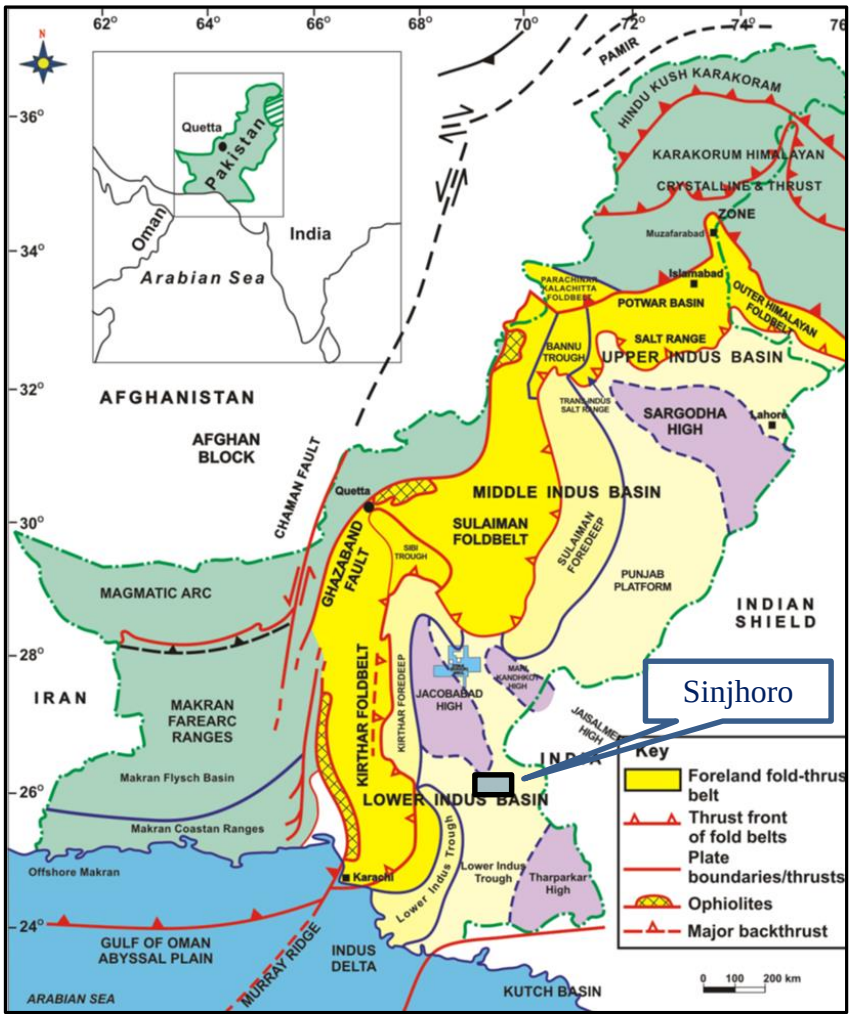

Figure 1.4. Basin outlines of Pakistan

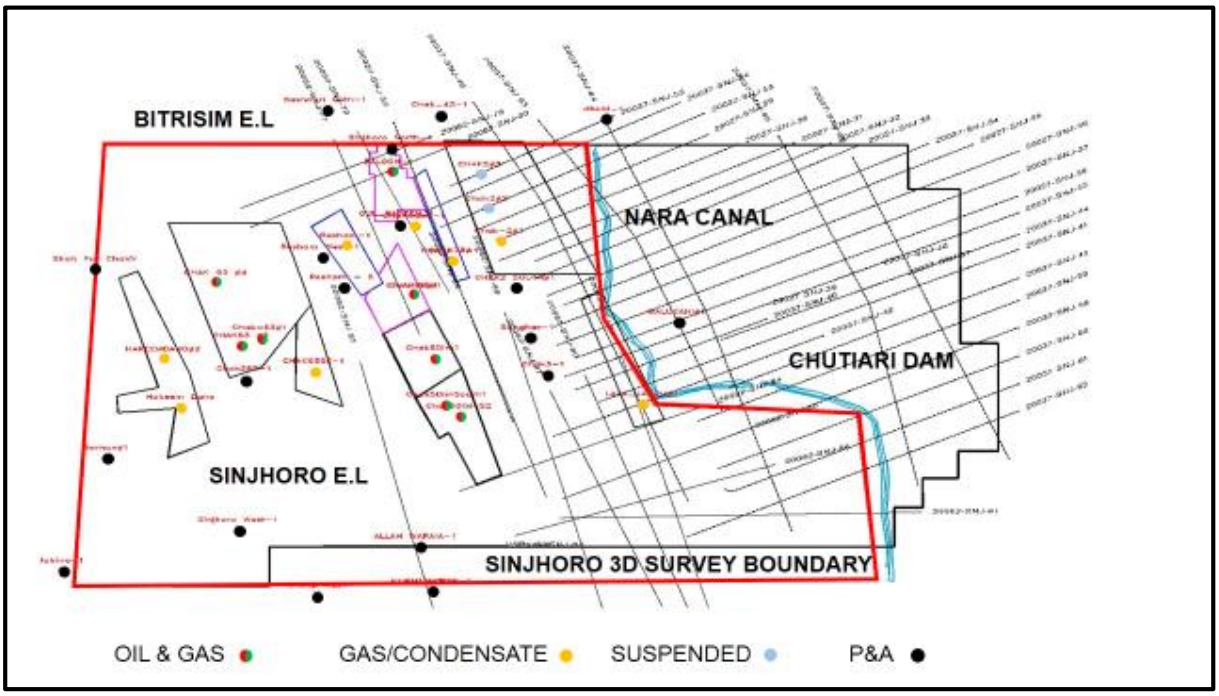

Figure 1.5. Base Map

2. Regional Geology

2.1. Tectonic

2.1.1. Geologically, the study area falls in the Thar Platform (Sindh Monocline) area of the Southern Indus Basin, which developed as result of Cretaceous rifting along the continental margin of the Indian Plate that led to the creation to numerous tilted fault block traps within the Lower Cretaceous section.

2.1.2. The Indian Plate rifted from the Gondwanaland before 130 million years, travelled a distance of 5000 kilometers and collided with the Eurasian Plate in the north before 65 million years ago to 40 million years ago in Late Cretaceous to Mid Eocene age. The collision of the Indian Plate with the Eurasian Plate resulted in closing of the neo-Tethys and structuration that strongly influenced the deposition system of the Indus Basin as marine sedimentation replaced by fresh water environment.

2.1.3. The creation of the Indus Basin took place in Precambrian age. The sedimentary fill of Pre-Cambrian and Cambrian rest on the igneous and metamorphic basement of Gondawana landmass. There is erosion/non-deposition after Mid. Cambrian till Early Permian. Onset of marine sedimentation in Late Permian and westerly tilt of the platform suggest subsidence to the west. The rift expanded and continents separated. Mesozoic sediments show classic responses to the evolution of a continental margin. In the east, Jurassic marginal marine sediments overstep the more terrestrially influenced deposits of Triassic (Atlantic type-passive margin). In Mid-Late Cretaceous times regressive deposition was intensified because of the rifting of Indo-Pak plate took place along the NNW Precambrian lineament. The Indus Basin trends NE–SW for more than 1600 km with average width of 300 km and contains thick pile of Precambrian to Tertiary age sediments.

2.1.4. The paleo-topographic feature, the Pre-Cambrian Indian Shield, was the main feature that controlled the sedimentation in Indus Basin until the breakage of Pangea. The sedimentary cover over the basement thins

toward the Indian Shield in the east that crop out at surface in the Nagar Parkar area. The Indus Basin is subdivided in into three sub-basins i.e. Upper Indus Basin, Middle Indus Basin and Lower Indus Basin (Figure 1.4).

2.2. Southern Indus Basin (SIB)

2.2.1. The Southern Indus Basin (Figure 2.2.5) is located between the Sukkur Rift in the north and offshore Murray Ridge in the south. The Southern Indus Basin is further sub-divided into Sindh Monocline (Thar/Sindh Platform), Karachi Trough, Kirthar Fold Belt, Kirthar Foredeep and Indus Offshore.

2.2.2. The eastern part of the basin comprising the Sindh Monocline (Indus Platform/Thar Platform) is largely comprised of faulted and tilted blocks of Mesozoic rocks which form structural traps and contains small oil and gas fields. The northern margin of Southern Indus Basin comprise of Sukkur Rift Zone, which bears large anticlinal structures and contains the Kandhkot and Mari gas fields.

2.2.3. The Sindh Monocline (Thar/Indus Platform) is sloping monocline with sedimentary deposits of Mesozoic and Cenozoic age and is delineated in the west by the Lakhra Uplift and in the east by the Nagar Parkar High. Horst and graben structures in the strata below the Tertiary unconformity were developed on passive continental margin of the western side of Indian landmass due to extensional tectonics caused by anti-clockwise rotation of the Indian Plate during Cretaceous time that was tectonically unstable period with spreading rate of ~ 20-30 cm/year in 80 to 53 million years ago.

2.2.4. The main reservoirs in the Sindh Monocline are the Cretaceous Lower Goru sandstone. In the Karachi Depression, production is from Paleocene Ranikot Formation, in Kirthar Depression and Sukkur Rift Zone it is from Eocene SML/HRL.

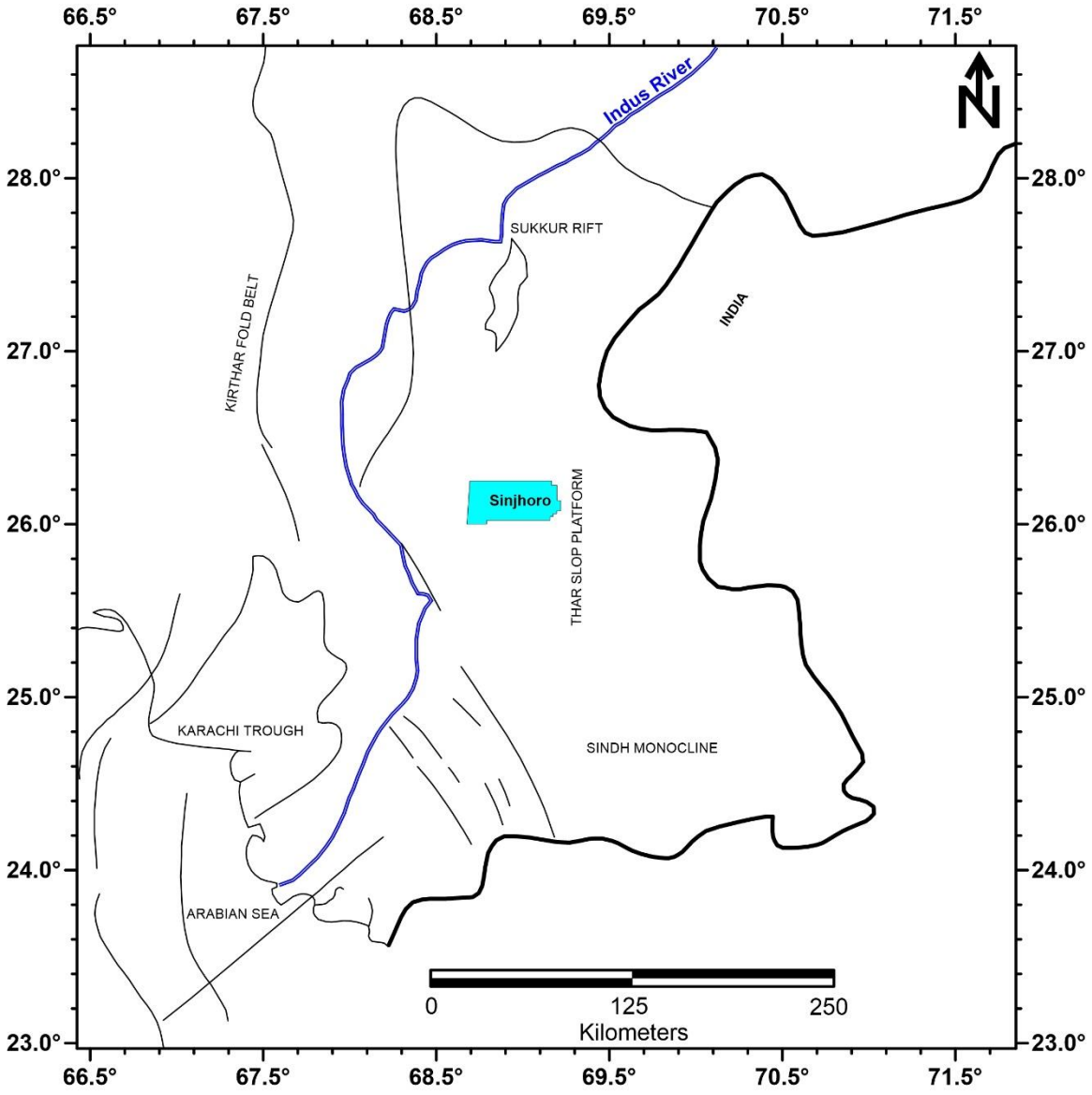

Figure 2.2.5. Southern Indus Basin map showing Sinjhoro E.L

2.3. Goru Formation

2.3.1. The Goru Formation is composed of marl and shale with very rare sandstone in the upper part called the Upper Goru while the lower part, also called the Lower Goru, comprises alternate beds of reservoir quality sandstone with good petroleum generation potential shales. The thickness of the Goru Formation is greatly and its thickness in the study area is about 1700 m, out of that 1400 m is Lower Goru whereas about 300 m is Upper Goru. It is pertinent to note that the gross thicknesses of producing sands i.e. Basal & Massive sands are +30 m and +500 m respectively.

2.3.2. Reservoir sands of the Lower Goru were deposited on the passive continental margin on the western side of the Indian landmass resulted from the Indian Plate rifting from the Gondwanaland prior to Indian-Eurasian collision. The time of initiation of deposition of the Goru Formation is not exactly known due to poor faunal presence in the lower part. The presence of pelagic fauna shows deep-water marine environment while some zones show locally shallowing of the sea as indicated by presence of benthonic fauna. The Lower Goru shows deltaic, barrier bar, lower shore face to shallow marine environment of deposition.

2.3.3. Sands of the Lower Goru are major producers of hydrocarbon in the Sindh Monocline. The wells drilled in the area shows lateral facies change as the producing sands of the Lower Goru become shalier from east to west and the entire succession of the Lower Goru shale out in the west. Besides lateral facies change and differential erosion of strata at the Lower Goru top, the thickness of the strata varies and become thicker from south east to northwest direction.

2.3.4. Based on predominant lithologies, the Lower Goru is further subdivided into seven units i.e. Upper sands, Upper shale, Middle sand, Lower shale, Basal sand, Talhar shale and Massive sand. The Upper sand is further subdivided into four sand units of 'A' sand, 'B' sand, 'C' sand and 'D' sand with shale and marl/mudstone sequences in between. Different E&P companies have devised their own nomenclature schemes for alternate sand-shale sequences of the Lower Goru, which divides the Lower Goru into further sub-units based on the dominant lithology indicated by well logs signatures (Figure 2.3.5).

<table>
<tr><th>AGE</th><th>Fm.</th><th colspan="3">OGDCL</th><th colspan="2">UTP</th><th>LASMO</th><th>OMV</th></tr>
<tr><td rowspan="11">CRETACEOUS</td><td rowspan="9">LOWER GORU</td><td rowspan="7">UPPER SANDS</td><td>"A" SAND</td><td>LAYER-1</td><td rowspan="7">UPPER SANDS</td><td>"A" SAND</td><td rowspan="7">SHALE OUT IN NORTH</td><td rowspan="7">SHALE OUT</td></tr>
<tr><td>TURK SHALE</td><td>LAYER-2</td><td>TURK SHALE</td></tr>
<tr><td>"B" SAND</td><td>LAYER-3</td><td>"B" SAND</td></tr>
<tr><td>BADIN SHALE</td><td>LAYER-4</td><td>BADI SHALE</td></tr>
<tr><td>"C" SAND</td><td rowspan="3">LAYER-4</td><td>"C" SAND</td></tr>
<tr><td>JHOL SHALE</td><td>JHOL SHALE</td></tr>
<tr><td>"D" SAND</td><td>"D" SAND</td></tr>
<tr><td colspan="3">UPPER SHALE</td><td colspan="2">UPPER SHALE</td><td>"H" SAND (WITHIN UPPER SHALE)</td><td>NO SIGNIFICANT SAND BODY</td></tr>
<tr><td colspan="3">MIDDLE SAND</td><td colspan="2">MIDDLE SAND</td><td>"G" SAND</td><td>"D" SAND</td></tr>
<tr><td colspan="3">LOWER SHALE</td><td colspan="2">LOWER SHALE</td><td>"F" SAND (WITHIN LOWER SHALE)</td><td>"C" SAND</td></tr>
<tr><td colspan="3">BASAL SAND</td><td colspan="2">BASAL SAND</td><td>"E" SAND</td><td rowspan="3">"B" SAND
"A" SAND</td></tr>
<tr><td colspan="3">TALHAR SHALE</td><td colspan="2">TALHAR SHALE</td><td>"D" SAND "C" SAND WITH IN SHALE</td></tr>
<tr><td colspan="3">MASSIVE SAND</td><td colspan="2">LOWER BASAL SAND</td><td>"A" SAND</td></tr>
<tr><td></td><td colspan="3">SEMBER</td><td colspan="2">SEMBER</td><td>SEMBER</td><td>SEMBER</td></tr>
</table>

Figure 2.3.5. Nomenclature of Lower Goru

2.4. Sembar Formation

2.4.1. The Sembar Formation is the proven source of produced hydrocarbon in the study area that comprises of shale with interbedded siltstone and sandstone. The coarser arenaceous rocks/sands are increasing towards the eastern limits of the formation due to closeness of Indian Shield in the east. Eastward thinning of the Sembar Formation is possibly due to onlap and erosional truncation over the Indian Shield and the Kutch positive area while thinning in westward and northward direction is due to positive areas in those directions at the time of deposition and the distance from the provenance.

2.4.2. The Sembar Formation has been identified as a primary source rock for oil and gas producing fields in the Lower Indus Basin and particularly in the Thar Platform that has been thermally matured and generating

hydrocarbons since 65 million year ago and migrated updip. Hydrocarbon shows during drilling have also been reported in shales and sandstones of the Sembar Formation in numerous wells.

2.5. Petroleum Play

2.5.1. Horst and graben structures (Figure 2.5.2), rich organic shale of the Sembar and Lower Goru formations, porous/permeable sands of the Lower Goru and interbedded marl, shale and calcareous claystone of the Upper Goru provide the basic elements for petroleum system in the area. Faults provide migration pathways for the hydrocarbon generated in shales of the Sembar Formation to reservoir sands of the Lower Goru. Faults also provide lateral seal and trapping mechanism by juxtaposing non-reservoir rocks against reservoirs. The Cretaceous petroleum system is prevailing in the Lower Indus Basin. Various play types have been tested but majority of exploration success has come from sands of Lower Goru. In addition, stratigraphic-cum-structural play is also proven in some gas fields where a counter regional dip exists along highs and basinward shales are providing up-dip closure. In Sinjhoro, the major producing sands are Basal and Massive sands having porosity ranges from 10 - 24 % in the drilled wells. Generalized stratigraphic column of the area is shown in Figure 2.5.3. Twenty six wells have been drilled in the E.L, out of which fifteen are gas/condensate producers. The main reason behind the dry wells is either trap failure or reservoir quality.

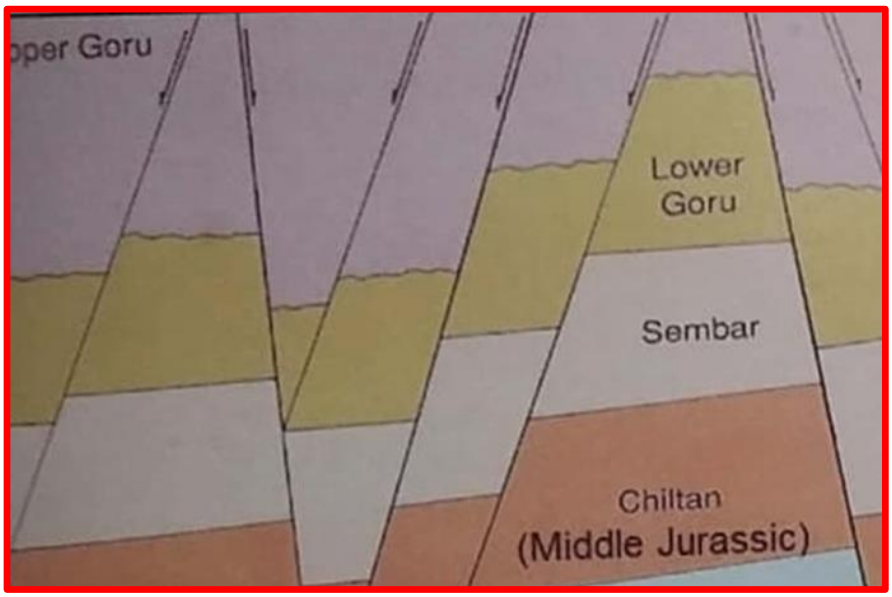

Figure 2.5.2. Typical horst-graben structural geometry of Lower Goru reservoir

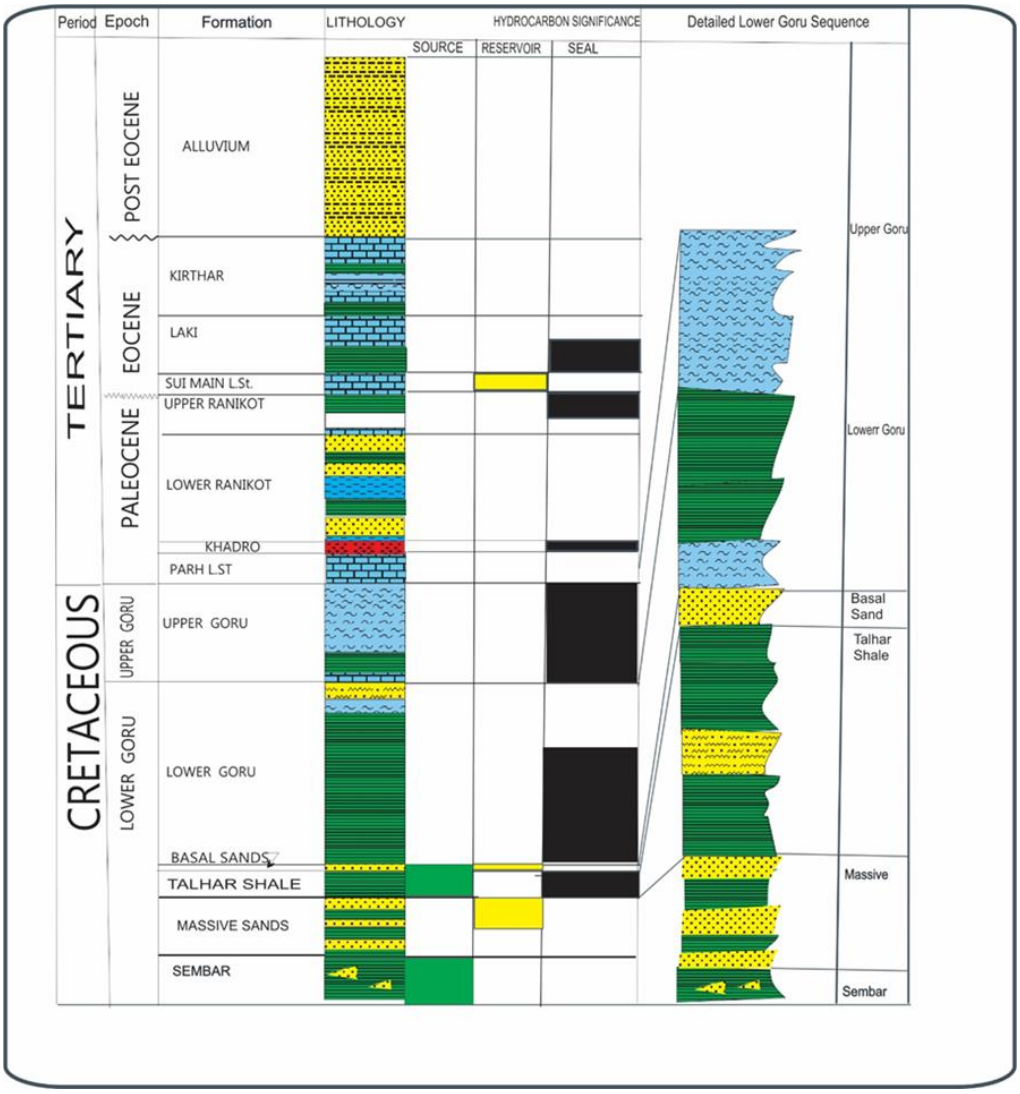

Figure 2.5.3. Generalized Stratigraphic Column of Sinjhoro Area

3. Scope and Objectives of the Study

3.1. OGDCL as an operator of Sinjhoro block intends to perform comprehensive sequence stratigraphy based on well logs, reprocessed 3D seismic volume, geological and geophysical data. The integration of previous work with addition of new data from Sinjhoro block would provide to a regional depositional model, facies trend for Lower Goru and Sembar sequences in order to identify and explore stratigraphic/stratigraphic-cum-structural entrapment in Sinjhoro block.

3.2. Integrated sequence stratigraphic analysis helps in the prediction and distribution of sedimentary facies in space & time with identified risk of drilling stratigraphic/combination plays in new or previously explored areas for hydrocarbon. Integrated sequence stratigraphy study would also enable us to recognize stratigraphic traps/prospects in matured explored area where potential for larger structural traps has almost exhausted.

3.3. The study may provide ideas of suitable area for petroleum exploration based on prediction of sedimentary facies distribution and high-resolution global and regional stratigraphic correlations using stratigraphic units defined by their genesis. The integrated interpretation of all available datasets i.e. geological & geophysical would also enable the sub-division of the stratigraphic column of the wells into sequences, systems tracts and sedimentary cycles on a grid of key regional lines with objective of defining plays and trap types for more detailed analysis.

3.4. The primary objective of the study is to construct a high resolution sequence stratigraphic framework (tectonic setting, facies, nature of contacts, stratal terminations, depositional trends, stratal geometries, depositional elements and depositional systems) with the help of biostratigraphy, core data and stacking patterns from wells data integrated with seismic data to understand sea level changes, system tracts, parasequences and depositional environment to identify subtle stratigraphic/combination leads/traps, characterizing and predicting occurrences of reservoir rocks in the Lower Goru and Sembar formations across the Sinjhoro area with special emphasis on Basal and Massive sands as these are producing sand bodies in the study area.

3.5. The study may be organized into levels of basin, play and prospect focus. The essential ingredients for the petroleum system may be verified by examining the basin as a whole and then play and prospect level. Tectonostratigraphic framework and basin history may be studied as it determines the fill, stratigraphic sequences and potential for generating and trapping hydrocarbons. In order to analyze the basin fill, seismic data may be combined with identified paleo-environmental, chronostratigraphic, and sequence stratigraphic interpretations of lithologic and biostratigraphic data. Different sequence stratigraphic models at different levels and chronostratigraphic charts (wheeler diagrams) on selected transects may be developed. A geological model may be built and then volumetrics, technical risk and confidence/ranking assessed for a range of models and prospects.

4. Dataset

4.1. Total twenty six (26) wells is included in Sinjhoro block (Table 4.2). The well data includes conventional well logs, reports and any other available data. Total (17) wells have cores in different sands intervals of Lower Goru. Total (09) wells have TD in Sembar Formation. So the entire thickness of Lower Goru has been drilled in (09) wells. The study area is covered by approximately 952 km^2 3D and more than 400 L Kms 2D seismic data is available outside the 3D boundary. 2D seismic data would be used where necessary and recommended upon by mutual agreement.

Chak 66 NE-1	Chak 63-4	Chak 63-3	Chak 63-1	Chak 63 SE-1	Chak 3-1	Chak 2-3	Chak 2-2	Chak-2-1	Barhun-1	Baloch-1	Allah Waraia-1	4.2. The contractor may identify the	
31.49	33.38	29.78	29.81	31.79	30.16	35.76	33.67	33.11	32.54	37.18	31.82	**KB (m)**	
1410	1354	1460	+1058	1150.5	+1020	1099.5	+1375	+934	1335	1382	1307	**Lower Goru Thickness (m)**	
-22	226.5	+139	-	-	-	-	-	-	+86	+38	+22	**Sembar Thickness (m)**	
3435	3550	3465	3000	3201.5	3050	3198.5	3400	3050	3600	3463	3385	**TD (m)**	
Sembar	Sembar	Sembar	Massive	Massive	Massive	Massive	Massive	Massive	Sembar	Sembar	Sembar	**Formation/Zone at TD**	
600 – 2298 2302 - 3436	612 - 2086 2372 - 3566	2069 - 3459	611 - 3053	625 - 3192	611 - 3047	601 - 3198	607 - 2186 2198 - 3399	604 - 3050	610 - 3601	580 – 2291.6	2270 - 3386	**DT_Compressional**	
No	2400 - 3552	2071-3468.5	1772 – 1998 &1934-3006	2750 - 3201	611-1884	No	2198 - 3419	604 - 2034	2880 - 3593	No	No	**FMI**	
2500 - 3438	1700 - 3550	2800 - 3466	2675 - 3005	2700 - 3200	2700 - 3048	No	2700 - 3419	2750 - 3050	2785 - 3601	2750-3462.5	2600-3379	**Bulk Density**	
2500 - 3434	2400 – 3552.5	2800 - 3466	2650 - 3002	2700 - 3192	2700 - 3048	2650 - 3198	2700 - 3415	2750 - 3050	2799 – 3600	2750 – 3462.5	2594 - 3387	**Resistivity (Deep & Shallow)**	
600 - 2298 2302 - 3436	612 - 3552	2069 - 3459	502 – 1793 1934 - 3004	625 - 3192	611 - 3047	601 - 3198	607 - 2195 2198 - 3419	604 - 3050	610 - 3601	2300 – 3461.5	2270 - 3386	**Gamma Ray**	
2500 - 3438	1700 - 3550	2800 - 3466	2675 - 3005	2700 - 3200	2700 - 3048	No	2700 - 3419	2750 - 3050	2785 - 3601	No	2600-3379	**Neutron Porosity**	
2500 - 3434	2400 – 3552.5	2065 - 3466	502 – 1793 2650 - 3002	2700 - 3192	2199 - 2454	2650 - 3198	607 – 2195 2198 - 3419	2750 - 3050	2785 - 3601	2750 – 3462.5	2600 - 3387	**Caliper**	
2954-2957	2974-2983	2980-2984.6	2840-2849	2995-3004		2770-2779	2875-2884	2776-2785	2785-2794	3133-3142			**Depth** **Core**
Massive	Massive	Massive	Basal	Massive		Basal	Massive	Basal	Basal	Massive			**Formation**
		yes	yes		yes	yes			yes	yes	yes	yes	**Check shot**
													Deviation Surveys
Geochem , Sediemntology & RCA reports available	RCA report Available	RCA report available	Biostraigraphy, sedimentology, Geochem & RCA reports available	Geochemical & RCA reports Available		RCA reports available	RCA reports available	Biostratigraphy, sedimentology, Geochem & RCA reports	Biostratigraphy, sedimentology & Geochem & RCA reports available				**Others (Ditch cuttings & RCA reports etc.)**

Sinjhoro West-1	Chak 25C-1	Sinjhoro North-01	Sanghar-1	Resham-02	Resham-01	Malukani-01	Lala Jamali-01	Hakeem Daho-2	Hakeem Daho-1	Gulbadin-1	Chak-7A-1	Chak 66-1
32.60	33.85	38.68	22.87	36.69	32.55	32.82	27.09	34.27	32.79	-	33.60	31.93
1232	1340	1428	+1364	+1128	+1070	+1414	+1397	+1032	1050	1399	+1016	+974
+351	+24	+20	-	-	-	-	-	-	-	+39	-	-
3870	3360	3517	3333	3200	3050	3301	3400	3300	3210	3419	3050	2997
Sembar	Sembar	Sembar	Massive	Massive	Massive	Massive	Massive	Massive	Massive	Sembar	Massive	Sembar
613 – 2277.5	592 - 3369	580 - 3522	625 - 3326	619 - 2078 2750 - 3182	619 - 1989 1998 - 3052	610 - 3301	551 - 3377	625 - 3311	599 - 3159	600 - 3455	585- 2104	621 - 2019 2025 - 3052
2295 - 3586	No	No	No	No	No	No	2650 - 3360	2350 – 3305	No	No	604 - 2101	2025 - 3053
2220 - 3590	2210 - 3370	2864 - 3521	2666 - 3339	2741 - 3204	1959 - 3059	2591 - 3302	2630 - 3404	2350 - 3311	2788 - 3158 2975 - 3216	2700 - 3456	2679 - 3060	2025 - 3053
2214 - 3590 3546 - 3879	2187 - 3369	2830 - 3522	2675 - 3336.5	2735 - 3204	1959 - 3059	2577 - 3303	2644 - 3403	2350 - 3311	2799 - 3199 3025 - 3212	2700 - 3456	2681 - 3056	2025 - 3048
613 - 3590	592 - 3369	580 - 3522	625 - 3336.5	619 - 2078 2741 - 3204	619 - 3054	610 - 3303	551 - 3403	625 - 3311	599 - 3159	600 - 3455	606 - 3052	621 - 2019 2025 - 3052
2220 - 3590	2210 - 3370	2864 - 3521	2666 - 3339	2741 - 3204	1959 - 3059	2591 - 3302	2630 - 3404	2350 - 3311	2788 - 3158	2700 - 3456	2679 - 3060	2025 - 3053
2214 - 3590 3546 - 3879	2210 - 3370	2864 - 3521	2675 - 3336.5	2741 - 3204	1959 - 3059	2591 - 3302	2644 - 3403	2795 - 3311	2788 - 3158	2700 - 3456	2681 - 3056	2025 - 3048
3145-3154 / 3056-3065 / 3047-3056		2923-2932		2870.5- 2879.5	2835-2844			3074-3083			2821-2830	2843-2852
Massive / Talhar / Talhar		Basal		Basal	Basal			Massive			Basal	Basal
yes	yes	yes			yes	yes	yes	yes	yes		yes	yes
Biostratigraphy, Sedimentology & RCA reports available		RCA reports Available		RCA reports available	Geochemical & RCA reports Available			RCA reports available			Geochemical & RCA reports Available	Biostratigraphy, sedimentology, Geochem & RCA reports available

													30 side wall cores	Talhar & Massive			
Resham West-1	31.41	1438	+38	3500	Sembar	199 - 2019	No	2024 - 3510	2024 - 3510	199 - 2019 2049 - 3511	2024 - 3510	2024 - 3510	2881-2890	Basal	yes		
													3019-3028	Massive			
													3298-3307	Massive			

Table 4.3. Summary of Wells

5. Study Workflow

The contractor has to define the workflow and phases of the course of study in its technical bid document. OGDCL intend to conduct the study in four (04) phases:

Phase-I

5.1. It will comprise a visit of contractor to OGDCL head office Islamabad, Pakistan to collect all available wells/seismic data and to inspect cores and collect core and flush cuttings samples for laboratory analysis in order to establish comprehensive geological and seismic database for the study.

5.2. Although the main course of study will be undertaken at contractor facilities in their head office. However, this phase will comprise the contractor's Biostratigrapher, Sedimentologist, Petrophysicist, Sequence Stratigrapher and Geophysicist visit to OGDCL office to review the data in order to establish the required dataset for the study. For this purpose, access will also be provided to OGDCL storage facilities to undertake sampling of drill cuttings and cores for analysis.

5.3. A description of the principal activities for each discipline is presented as follows:

Sedimentology/Biostratigraphy/Well Logs

Main tasks will include:

To undertake detailed core description of all available conventional cores to aid both construction of a series of depositional models and generation of the sequence stratigraphic scheme. During this phase, geologists/ Sedimentologist from OGDCL will participate in the core review and QC to facilitate the transfer of skills/technology and ideas.

5.4. SEM (Scanning electron microscope) and CT scan analysis of core samples should be done for the reservoir quality evaluation

5.5. Other relevant data will be reviewed and a dataset will be defined for subsequent study/analysis. The dataset required to achieve the stated objectives might include the following:

5.5.1. Suite of available well logs (digital or hard copy formats) for interpretation of high resolution sequence stratigraphic study

and detailed Petrophysics of Lower Goru is needed to define reservoir pinch out.

5.5.2. FMI, if available.

5.5.3. Available well reports, mud logs and composite logs.

5.5.4. Access to conventional cores/drill cuttings for analyses for description.

5.5.5. Petrographic data, if available.

5.5.6. Biostratigraphic and Chronostratigraphic breakdown of formations.

5.5.7. Conventional core analysis and relevant SCAL data, if available.

The Sedimentologist will also complete the following:

5.5.8. Review of all available stratigraphic reports and charts.

5.5.9. Review and analysis of available zonation schemes and correlations panels.

5.5.10. Review and analyses of available well logs and composite log data.

5.6. Following the contractor's team visit to OGDCL, a list of data and Samples of required core/well cuttings intervals for analysis will be prepared. OGDCL will make shipment of these samples and data to the contractor's base.

Geophysics

5.7. Main tasks will include:

5.7.1. Review of existing interpretation.

5.7.2. Review of data quality to ensure that 3D and 2D of all vintages can be balanced to common datum prior to interpretation.

5.7.3. Establish format of data to be exported.

5.7.4. Ensure that data can be fully loaded & made accessible on workstation.

5.7.5. Ensure that interpretations already available with OGDCL can be gridded and exported for further use.

5.7.6. Review of seismic data tied with wells to establish resolvable order of stratigraphic sequences.

5.7.7. Identification and mapping of key sequence stratigraphic surfaces, need to be mapped.

5.7.8. Review of all VSP data (hard/soft)

5.8. Detailed report of key findings would be submitted by the contractor followed by a presentation to OGDCL management on conclusion of the Phase-I.

Phase-II

5.9. This phase will comprise a program of high-resolution (up to 4th order) sequence stratigraphic analysis based on biostratigraphic, Chronostratigraphic, sedimentological, well logs data & seismic data analysis and interpretation. The dataset of the analyses will provide a basis for defining and predicting sequences that will form an integral and essential part for the subsequent phases of the study.

5.10. If required, the contractor should develop a new sequence stratigraphic terminologies

Project setup

5.11. The project will be setup by the contractor at the start of the project incorporating projection and datum details as per company requirements. All available well and seismic data will be loaded and QC. A team of two relevant professionals from the OGDCL will be available at contractor's office during project set up and data loading/QC.

Biostratigraphy

5.12 The facies of the reservoir horizons suggests that the biostratigraphic emphasis be placed on quantitative palynology, with volumetric micropaleontology and semi-quantitative nannopalaeontology run on a targeted dataset defined by the palynological results, where it is deemed that there will be sufficient recovery of these fossils in order to establish a viable biostratigraphic sub-division and bio zonation of the Cretaceous age Lower Goru and Sembar Formation. OGDCL strongly suggest undertaking quantitative palynology as the prime discipline. However, where core is available then preference should be given to core data.

Sedimentology

5.13 Sedimentological analysis and petro graphical results will include interpretation and facies analysis based on the drill cutting, core descriptions and petro graphical studies generated during phase-I of the study, and will be augmented by detailed sedimentological interpretation of available FMI logs through selected key intervals.

Facies Analysis

5.13.1 The core descriptions and petro graphical results generated during phase-I would provide the primary database for generation of the depositional model and interpretation of candidate stratal surfaces. Facies analysis will initially be based on the cored intervals, with subsequent extrapolation into uncored sections using calibration between the cores, FMI and well logs.

Conventional Wireline Log and FMI Analysis

5.13.2 An understanding of the lithological, facies and mineralogical characteristics of the reservoir horizons provides a basis for interpolation of the facies analysis and reservoir quality interpretations beyond the cored intervals. Core to log correlation will be undertaken to furnish facies breakdown and lithogical

interpretation of the uncored intervals based on well log signatures and the constructed depositional models. This methodology will provide correlation basis for the generation of detailed facies information throughout the studied interval and subsequent mapping. Wherever possible, this interpretation will be constrained by relevant biostratigraphic data and other relevant information.

Depositional modelling, Correlation and Integration

5.13.3 The final phase of the sedimentological work programme is to use all the available data to generate a detailed depositional model (or models) and to provide a series of high quality correlations of selected wells based on sequence stratigraphic principles.

Integrated High Resolution Sequence Stratigraphic Framework

5.14 Full integration of all available well logs, biostratigraphic and sedimentological data is to be used to generate an integrated high-resolution (up to 4th order) sequence stratigraphic framework in order to understand reservoir geometries, distribution and quantity. In combination, the sedimentological and biostratigraphic analysis produces a high resolution, high confidence sequence stratigraphic scheme that is inductive/data driven (not model driven) and can be used to better understand, and act as a powerful tool for future exploration. The main tasks will include:

5.14.1 Identify basin fill dynamics (Paleobathymetry-Paleo-topography) and establishment of the factors governing deposition in the area.

5.14.2 Establishment of regional litho-stratigraphic and chronostratigraphic correlation.

5.14.3 Establishment of eustatic cycles and relative sea level changes during basin development and fill.

5.14.4 Identification of depositional sequences viz. unconformities, sequence boundaries, transgressive and regressive sequences.

5.14.5 Recognition of highstand/lowstand system tracts, shelf margin system tracts and maximum flooding surfaces within depositional sequences.

5.14.6 Paleontological data analysis and carrying out biostratigraphic control.

5.14.7 Integration of biostratigraphic, sedimentological and well log data for depositional environments and sequence stratigraphic analysis.

Seismic Interpretation

5.15 Structural interpretation on 5 key horizons (top of Lower Goru, top of Basal Sand, top of Massive Sand, top of Sembar and top of Chiltan) will be available on 3D/2D seismic data set. Infill fault and horizon interpretation, where existing interpretation is sparse, and their smoothing/conditioning may be required for structural modelling. Interpretation on additional structural horizons,

stratigraphic horizons/segments as required for entire integrated sequence stratigraphic framework would be carried out by the contractor. Interpretation on 2D seismic profiles would also be required from contractor.

5.16 Seismic interpretation would comprise of structural and stratal terminations etc. on all available 2D/3D seismic data and evaluation, generation of time & depth maps to be used to establish the detailed seismic stratigraphic sequence model for Lower Goru and Sembar formations. Seismic interpretation will be undertaken at contractor facilities in their head office. Delivery format of the data will be discussed in phase-I. The Chronostratigraphic and sequence stratigraphic framework established from biostratigraphic and sedimentological analysis and interpretation will be used to mark/interpret sequences on seismic. During this phase, professionals from OGDCL will participate to QC, supervise and assist in picking horizons and sequences. The main tasks will include:

5.16.1 Reflection termination configurations and facies variations based on seismic character.

5.16.2 Calibration and integration of well logs, FMI, drill cutting, cores data and analyzed results with those from seismic.

5.16.3 To tie the seismic data with some global sea level curve otherwise develop local curve matching with seismic sequences of the area.

5.16.4 Mapping of key sequence stratigraphic surfaces (sequence boundaries, transgressive surfaces and maximum flooding surfaces) on seismic grid and develop high-resolution sequence stratigraphic framework at various biozone levels with the help of the well logs.

5.16.5 Recognition/marking of system tracts e.g. highstand (HST), falling stage (FSST), lowstand (LST)/shelf margin (SMST) and transgressive (TST) system tracts etc.

5.16.6 Identification and mapping of possible geobodies like channels, isolated sand bodies, basin floor fans, turbidites etc. with their reservoir quality, High Amplitude Reflectors Packets (HARP), prospects identification & evaluation.

5.16.7 Construct regional transects to know the extent of key horizons and sequences.

5.16.8 Identification and capture of relevant seismic geometries of depositional sequences and bounding unconformities.

5.16.9 Identification of top, lateral, bottom seals and the reservoir quality associated with different geometries.

5.16.10 Development of sufficient number of regional geo-seismic sections illustrating the shelf to basin variations as well as their Wheeler diagrams.

5.17 The contractor would submit draft report for Phase-II entailing all the details of the workflow, methodology and output of Phase-II. Phase-II of the study would be concluded with a presentation by contractor.

Phase-III

5.18 This phase is the final integration stage when all elements of previous phase are integrated to come up with an overview of the integrated sequence stratigraphy of Lower Goru and Sembar formations across the study area.

5.19 To carry out time to depth conversion of seismic interpretations using best possible/suitable methods as per SOPs. Preparation of time maps, depth maps, isopach maps, gross depositional environment (GDE) maps, common risk segment (CRS) maps of each sequence/system tract/zone of interest.

5.20 To integrate all the available and interpreted data to generate detailed depositional models (both 2D and block diagrams) at different sequences.

5.21 To identify sweet spots with ranking, prospects delineation with ranking, volumetric and risk mitigation.

5.22 Preparation of final draft report with conclusions and recommendations

Phase-IV

5.23 The contractor will provide draft copy of the report and deliver a detailed presentation to client within one week after completion of phase-III.

5.24 Final report and deliverables will be provided within one month after completion of phase-III.

5.25 The contractor will incorporate the inputs/suggestions/ amendments/changes proposed by the client.

5.26 Based on the outcome of the study provide post mortem anlaysis of all the dry wells of the Sinjhoro Block

6. Deliverables

6.1. A report (hard & soft copy) including in detail, all aspects of the study with independent opinions, interpretation/findings, identified stratigraphic/combination leads/prospect with risk assessment, ranking and recommendations on the further work plan on the area. The contractor will provide the project complete backup data (digital, readable, editable) compatible with Petrel and DSG, DS Petrophysics, ARCMAP, CorelDraw) on which the study/interpretation was conducted after completion of the study.

6.2. The deliverables will be provided within one month after completion of the Phase-III. On completion of the study, the bidder will give a presentation of results to client in Islamabad.

6.2.1. Integrated high-resolution sequence stratigraphic framework for Lower Goru and Sembar Formation based on all available data i.e. well & seismic.

6.2.2. High resolution biostratigraphic and paleo-bathymetric summary table.

6.2.3. Well summary tables showing formation tops, sequence stratigraphic tops, thicknesses, depth (meter and milli-seconds), hydrocarbons shows, reservoir quality, net sand and shale volumes of each well (MS excel format).

6.2.4. Well composite logs of 1:500 scale showing log curves, FMI logs, formation tops, sequence stratigraphic tops, geological age (numerical), facies, lithology, grain size and sedimentary structures, biostratigraphy, petrographic slide pictures, core images and core details, depositional environments, hydrocarbons shows, reservoir quality, net sand and shale volumes of each well.

6.2.5. Well correlation panels along and across depositional strike and other directions, wherever appropriate.

6.2.6. Depositional environments and facies maps of each system tract in the resulting sequence stratigraphic framework.

6.2.7. Seismic facies maps of each system tract in the resulting sequence stratigraphic framework.

6.2.8. Sequence stratigraphy interpretation/surfaces and depositional architecture on seismic data based upon regional sequence stratigraphic model.

6.2.9. Regional geo-seismic sections illustrating the shelf to basin variations in sequences and system tracts.

6.2.10. Chronostratigraphic charts/wheelers diagram, against some key seismic section passing through wells illustrating major depositional variations.

6.2.11. Time and depth maps of each formation tops (page size 36x36 inches) with proper scale and legend.

6.2.12. Time and depth maps of each sequence stratigraphic surfaces at (page size 36x36 inches) with proper scale and legend.

6.2.13. Grids/surface (digital) of paleobathymetry at each possible level.

6.2.14. Play fairway maps, isopach maps, gross depositional environment (GDE) maps, seismic facies maps and common risk segment (CRS) maps of reservoir units to highlight potential prospective areas (page size 36x36 inches).

6.2.15. Provide stratigraphic and structural trap maps of all potential reservoir candidates of the block along with volumetric evaluation, quantitative risk assessment and resultantly prospect inventory & its ranking. Fault seal analysis should be undertaken on main faults to determine whether these breach stratigraphic and structural traps prior to prospect ranking.

6.2.16. A comprehensive report (pdf and/or MS word) covering the methodology, discussion on interpretation and results with support of figures, enclosures & models.

6.2.17. Digital copy (editable) of well correlation panels in a software compatible with Petrel/DSG/DS Petrophysics.

6.2.18. Digital copy of all mapping data (grids, shapefiles/databases, mxd) compatible with Petrel/DSG/ArcMap.

6.2.19. All drawings and sketches digital files compatible with Corel Draw X4.

6.2.20. All the final deliverables will be provided in a digital format compatible with Petrel/DSG.

6.2.21. The contractor will supply 04 hard copies of report and 04 soft copies in good quality portable hard drives. The final report may be named as:

“INTEGRATED SEQUENCE STRATIGRAPHIC STUDY OF LOWER GORU AND SEMBAR FORMATIONS IN SINJHORO EL AND ALLIED D&PLS FOR THE DELINEATION OF STRATIGRAPHIC/COMBINATION LEADS & PROSPECTS”

7. Data Collection/Inputs

7.1. For data collection, a team of experts of each discipline from consulting firm will visit OGDCL head office in Islamabad.

7.2. The team will review and scrutinize the data during their stay in Islamabad. They will provide report about the quality of available data. All the expenses for this visit will be the sole responsibility of the consulting firm.

7.3. The newly acquired data during the study time or any additional/replacement data, if any, will be provided to the contractor to refine their work as specified by the OGDCL or the contractor.

7.4. Data collection must start within two weeks with a kick-off meeting at OGDCL head office after signing the contract.

7.5. All geological, geophysical, drilling, production testing, well logs, drill cuttings and core required for the study will be available to the contractor free of charge. Such material will be the property of OGDCL. The contractor will treat all data and information supplied by OGDCL and those acquired during the study with utmost confidentiality. All such material will be returned back to OGDCL at the completion of the study.

8. Project Timeline

8.1. The contractor shall have to complete the study within 06 months. The project time will start within two weeks of award of contract with kick off meeting at OGDCL head office. The contractor should submit a detailed work plan in the form of Gantt chart along with the technical proposal. The project time breakup is mentioned below;

Data Review/collection (Phase-I)	: ½ months
Main Project (Phase-II & III)	: 4½ months
Final Presentation, Final Report Review and Deliverables (Phase-IV)	: 01 months
Total Time	: 06 months

9. Presentation and Reports

9.1. The contractor should submit a detailed weekly progress report accompanied with updated Gantt chart on first day of the week to OGDCL.

9.2. Detailed draft reports for Phase-I and II of the study would be submitted to OGDCL as mentioned in section 5.8 and 5.17.

9.3. On completion of the study, the contractor will send digital copy of draft final report to OGDCL. After final presentation and incorporating the inputs/suggestions/amendment/changes of the company, the contractor will provide four (04) copies of the final report (hard, soft & digital/editable).

9.4. The Final report will include in detail, all aspects of the study with the conclusions and recommendations derived from the entire study.

9.5. The contractor has to supply OGDCL with a copy of project backups (readable/editable) of each phase after their completion for loading/working on OGDCL workstation system. The contractor will supply final copy of the complete project (readable/editable) at the completion of the project.

9.6. The contractor will provide all the final work done on good quality portable hard drives.

9.7. The contractor would arrange to deliver the final presentation at OGDCL House, Islamabad within two weeks after conclusion of Phase-III of the project at their own expenses.

10. General Terms

10.1. The consultancy services will be engaged for completion of the task as required in scope of work.

10.2. The contracted firm will provide the required services as per terms of reference/scope of work etc.

10.3. The contractor will also provide a detailed workflow of the project along with Gantt chart.

10.4. Manager (Exploration–South East) from OGDCL will supervise the project. If at any stage the company is not satisfied with the work done by the contractor, the company may ask for correction or redo of that work.

10.5. During the course of study, total seven (07) client's geoscientists Sedimentologist (01), paleontologist (01), two (02) geologists and three (03) geophysicists) will participate in the study The contractor should propose a workable program (duration and time in the technical proposal) for the involvement of seven (07) professionals (each participant for two weeks' time to QC, supervise and review in the study at each milestone). Also, contractor should propose the stage and time in Gantt chart when these professionals' participation can be of utmost benefit. The contractor will be bound to take all necessary measures to facilitate the client's participation process. Any delay due to visas, air tickets etc. will be accommodated by the contractor, however total cost of travelling and lodging will be borne by client.

10.6. Transportation/shipment cost, in all respects, of samples and supporting data/material/reports/magnetic tapes etc. for the study from Pakistan to contractor office abroad will be borne by Client. Transportation/shipment cost, in all respects, of samples and supporting study data/material/reports/magnetic tapes etc. from contractor office to OGDCL office, Islamabad, Pakistan will be borne by the contractor.

10.7. Companies with international experience and proven excellent reputation having technical expertise and international experience in different types of complex sedimentary basin analysis will be preferred.

10.8. The bidder should be able to perform the work as per international oil industry standards. The bidder should indicate the hardware, software and study center/location to be used for the proposed study.

10.9. The bidder must be able to complete the proposed study within the stipulated period.

10.10. An organizational structure of the proposed study group along with CVs of professionals and detailed methodology indicating work details and workflow schedule is required from the bidders with benchmarks in the technical portion of the bid. It is mandatory that all technical professionals conducting the study should be from the CVs provided.

11. Key References:

Ahmad et al. (2018). Risk and resource assessment approaches for stratigraphic and combination traps and customized risk models, Published and presented in PAPG/SPE Annual Technical Conference, Pakistan.

Ahmad et al. (2010). Play Fairway Analysis and CRS Mapping within a Sequence stratigraphic Framework: Screening Tools for Geological Risk Constrained Exploration, PAPG/SPE Annual Technical Conference, Pakistan.

Ahmad et al. (2007). Exploration of Subtle Stratigraphic Traps Lower Goru Play Fairway Pakistan, Geological Society – Petroleum Group Conference Emerging Plays – Australasia London, 17-19 July, 2007.

Ahmad et al. (2004). Sequence Stratigraphy as Predictive Tool in Lower Goru Fairway, Lower and Middle Indus Platform, Pakistan. PAPG Annual Technical Conference.

Technical Evaluation Criteria

12.1. For final bid evaluation, 70 % weightage will be given to technical evaluation and 30 % to financial evaluation. The technical bids will be evaluated as per criteria given in Table 12.2.1. The lowest bidder will attain the maximum marks in financial evaluation and other would be ranked on sliding scale. The marks obtained in technical and financial evaluation will then be summed and the contract will be awarded to the bidder obtaining maximum marks.

12.2. The bidders are required to strictly follow the sequence of technical evaluation criteria (Table 12.2.1) and submit the technical proposals accordingly. The financial proposals of the bidders obtaining less than 70% marks in the technical evaluation will not be opened. The technical evaluation will be based on the following criteria:

Table 12.2.1. Technical Evaluation Criteria

S#	Description	Allocated Marks
1.	No of G&G projects involving integrated sequence stratigraphy completed during the last 05 years by the contractor with client satisfaction report.	≥ 10 projects = 30 marks 08 - 09 projects = 25 marks 06 - 07 projects = 21 marks < 06 projects = 0 marks
2.	No of professionals assigned for the project with relevant experience (please provide detailed CVs)	Total ≥ 07 professionals = 35 marks ≥ 04 professionals with ≥ 15 years of experience & ≥ 03 professionals with ≥ 10 years of experience Total ≥ 05 professionals = 28 marks ≥ 03 professionals with ≥ 15 years of experience & ≥ 02 professionals with ≥ 10 years of experience
3.	Relevant qualification of the professionals	02 PhD + 05 BS/MS = 15 marks 01 PhD + 04 BS/MS = 12 marks
4.	Time to complete the study	= 06 months = 10 marks 06 - 07 months = 07 marks
5.	Skill/technical transfer plan	Mandatory
6.	Scope of work/ Workflow/methodology	Mandatory
7.	Experience in extensional tectonic regime in clastics depositional,environment with client satisfaction report.	> 05 project = 10 marks 04 - 05 project = 07 marks
Total		100 marks

12.3. In technical evaluation, the bidder scoring equal to or more than (≥) 70 % marks in each category and equal to or more than (≥) 80 % marks in total will be declared as technically qualified.

12.4. The successful bidder/contractor will be bound to deploy the same number of professionals with relevant years of experience as per technical evaluation criteria Table 12.2.1.

13. Financial Evaluation Criteria

13.1. Financial Bids of only those bidders will be opened who has been declared as technically responsive.

13.2. Financial Bids of the technically non-responsive bidders will be returned un-opened.

13.3. The potential bidder will submit financial proposal as per financial proposal bid format provided in Table 13.3.1.

Table 13.3.1. Financial Bid Format for Comparison of Financial Bids

S#	Study Project	Total Lump Sum Cost (US $) inclusive of all applicable taxes duties and Levies except PST/ICT on services in Pakistan
1.	INTEGRATED SEQUENCE STRATIGRAPHIC STUDY OF LOWER GORU AND SEMBAR FORMATIONS IN SINJHORO EL AND ALLIED D&PLS FOR THE DELINEATION OF STRATIGRAPHIC/COMBINATION LEADS & PROSPECTS as per TOR	

13.4. 40 % of the quoted price as per financial proposal will paid at conclusion of Phase-II of the project against verified invoices while the remaining 60 % payment will be made at completion of the project in all respects against verified invoices.