OIL & GAS DEVELOPMENT COMPANY LIMITED

TENDER ENQUIRY NO. PROC-SERVICES/CB/EXPL-4464/2019

PROSPECTS DELINEATION THROUGH INTEGRATED SEQUENCE STRATIGRAPHIC STUDY OF LOWER GORU AND SEMBAR FORMATIONS IN SOUTHERN INDUS BASIN OF PAKISTAN

Note:

Bid bond of **USD 24,000/- (US Dollar Twenty Four Thousand Only)** to 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

PROSPECTS DELINEATION THROUGH INTEGRATED SEQUENCE STRATIGRAPHIC STUDY OF LOWER GORU AND SEMBAR FORMATIONS IN SOUTHERN INDUS BASIN OF PAKISTAN

1. <u>Introduction</u>

1.1. The study area is located geographically in the Sindh province of Pakistan and geologically the area contains portion of the Southern Indus Basin known as Lower Indus Platform (Figure 1.4), which is located in Ghotki, Sukkhur, Khairpur, Sanghar, Tando Allah Yar, Hyderabad and Tando Muhammad Khan 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. Six (06) OGDCL operated exploration licenses i.e. Thal, Khewari, Bitrism, Sinjhoro, Nim & Tando Allah Yar and several operated/non-operated D&P leases fall in the study area (Figure 1.5).

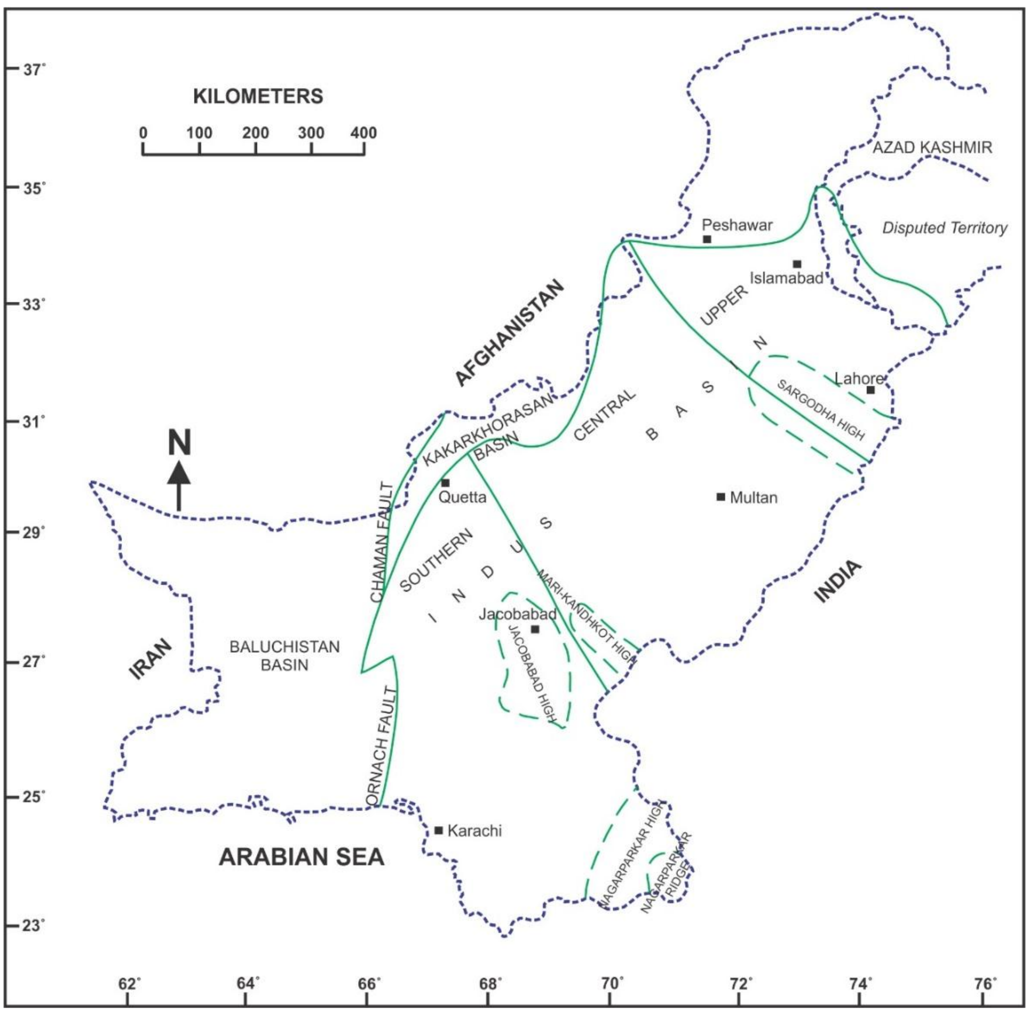

Figure 1.4. Basin outlines of Pakistan

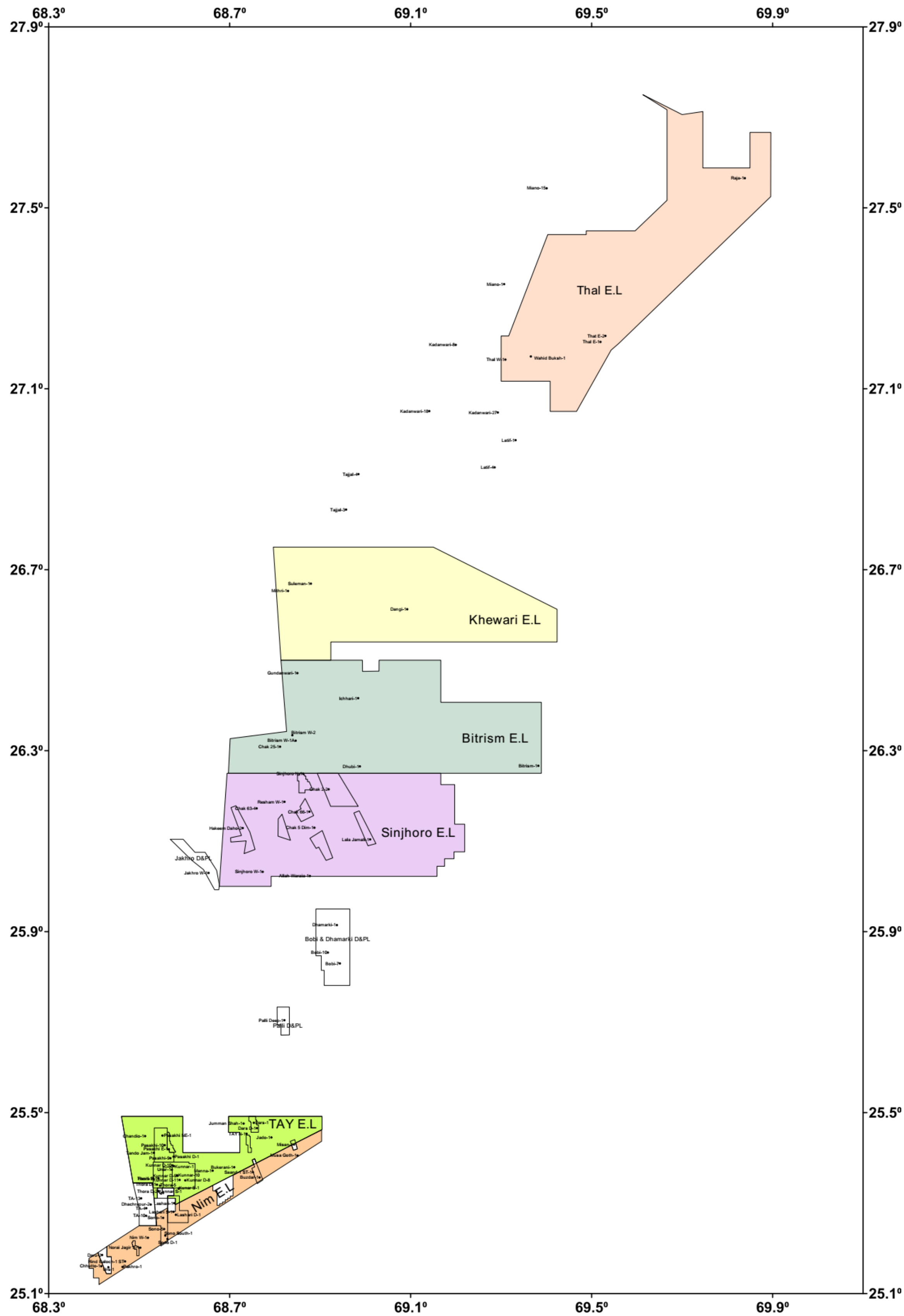

Figure 1.5. Base Map

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, Central Indus Basin and Lower Indus Basin (Figure 1.4).

2.2. Southern Indus Basin (SIB)

2.2.1. The Southern Indus Basin (Figure 2.2.6) 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.

2.2.5. Horst and graben structures (Figure 2.2.7), 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.

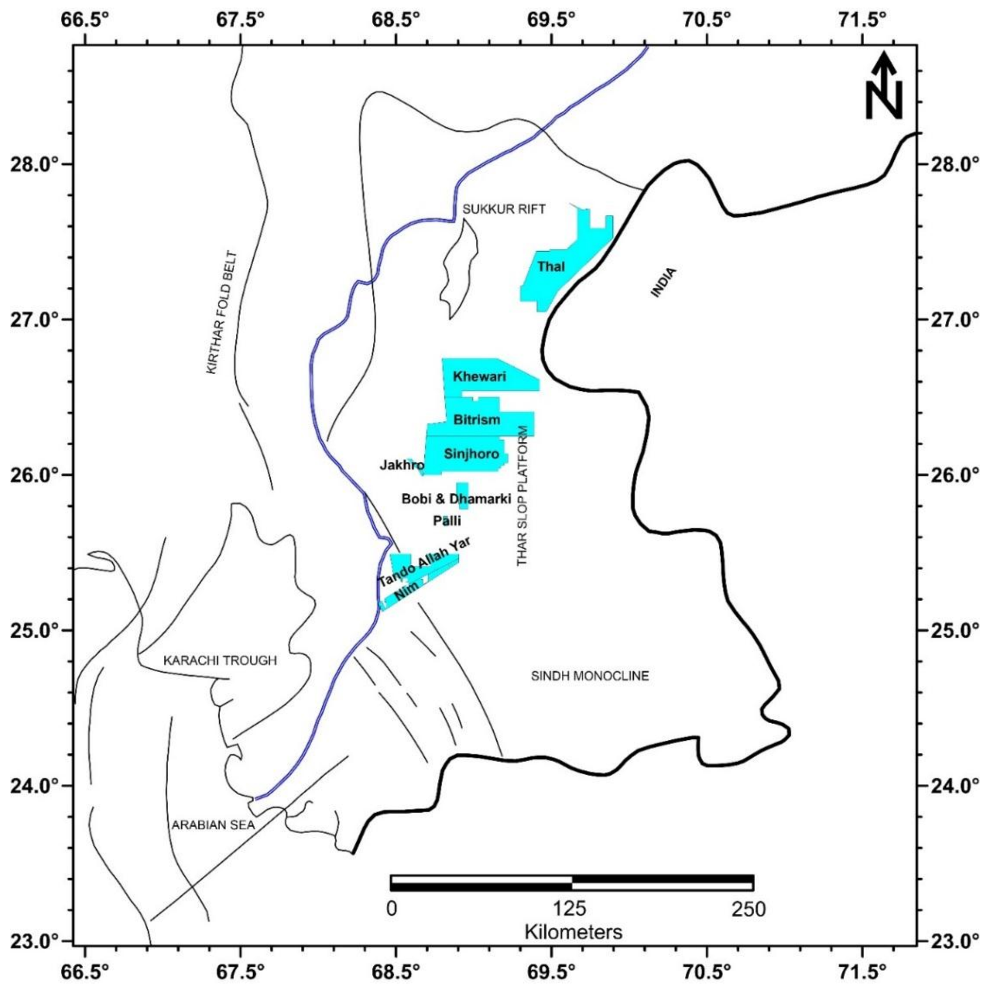

Figure 2.2.6. Southern Indus Basin map showing Exploration Licenses

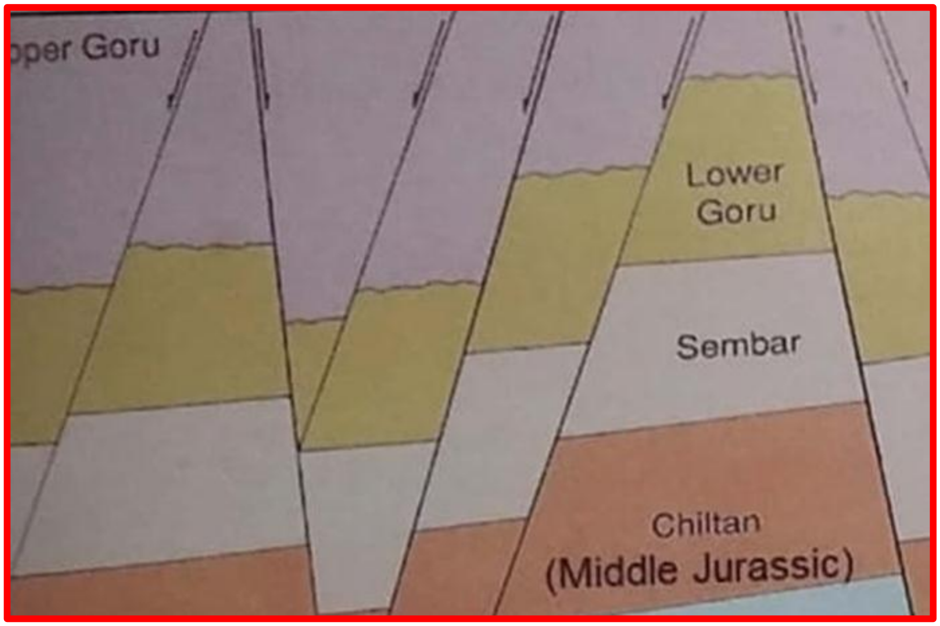

Figure 2.2.7. Typical host-graben structural geometry of Lower Goru reservoir

2.3. <u>Goru Formation</u>

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 varied as in type locality it is 536 m thick and in Quetta area the thickness is 70 m and up to 2700 m thickness has encountered in wells drilled for oil and gas.

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 north west 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).

AGE	Fm.	OGDCL			UTP		LASMO		OMV
CRETACEOUS	LOWER GORU	UPPER SANDS	"A" SAND	LAYER-1	UPPER SANDS	"A" SAND	SHALE OUT IN NORTH		SHALE OUT
			TURK SHALE	LAYER-2		TURK SHALE			
			"B" SAND	LAYER-3		"B" SAND			
			BADIN SHALE	LAYER-4		BADI SHALE			
			"C" SAND	LAYER-4		"C" SAND			
			JHOL SHALE			JHOL SHALE			
			"D" SAND			"D" SAND			
		UPPER SHALE			UPPER SHALE		"H" SAND (WITHIN UPPER SHALE)		NO SIGNIFICANT SAND BODY
		MIDDLE SAND			MIDDLE SAND		"G" SAND		"D" SAND
		LOWER SHALE			LOWER SHALE		"F" SAND (WITHIN LOWER SHALE)		"C" SAND
		BASAL SAND			BASAL SAND		"E" SAND		"B" SAND
		TALHAR SHALE			TALHAR SHALE		"D" SAND "C" SAND	WITH IN SHALE	
		MASSIVE SAND			LOWER BASAL SAND		"A" SAND		"A" SAND
		SEMBER			SEMBER		SEMBER		SEMBER

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.

3. Scope and Objectives of the Study

3.1. 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.

3.2. 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.

3.3. 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 study area.

3.4. 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 eighty nine (89) wells is included in the study across the study area (Table 4.2). The well data includes conventional well logs, reports and any other available data. Total forty three (43) selected wells have 70 cores in different sands intervals of Lower Goru. Total nine (09) wells have TD in the Chiltan Formation while forty (40) have TD in the Sembar Formation. So the entire thickness of Sembar Formation has been penetrated in nine wells (09) while entire thickness of Lower Goru has been drilled in forty nine (49) wells. The study area is covered by approximately 6700 km^2 3D seismic. The contractor may identify the number of core and drill cuttings samples for lab analysis i.e. sedimentological, biostratigraphic etc. in order to carry out the study as mentioned in the study workflow. The technical proposal must include the name and required optimum numbers of laboratory tests. Optimum number of core/drill cutting samples tests would be used for meaningful study with mutual consultation of the company and contractor. The suggestions of company's professionals would be given due consideration in this regard.

S#	Well	Lower Goru Thickness (m)	Sembar Thickness (m)	TD (m)	Formation/ Zone at TD	Cores (Formation/Numbers/Interval, m)	VSP	Image Log
1	Wahid Bukhsh-1	1564.5	-	4122	Massive Sand	Massive Sand (1): 4003-4008.5		
2	Raja-1	1388	685.5	4004	Chiltan	Massive Sand (3): 2764-2773, 3037-3055	Yes	
3	Thal E-1	1560	20	4468	Sembar		Yes	
4	Thal W-1	1556.5	12.5	3984	Sembar	SABS (1): 3241-3250, Basal Sand (1): 3682-3685	Yes	
5	That E-2	1568	14	4465	Sembar	SABS (1): 3838.50-3847.5		
6	Dangi-1	1428	200	4153	Sembar		Yes	
7	Suleman-1	1108	665	4575	Chiltan	Massive (1): 3521-3530.5	Yes	
8	Mithri-1	1085.5	456.5	4250	Sembar	Massive Sand (2): 3398.5-3407.5, 3559-3568	Yes	
9	Ichhari-1	1025	-	3300	Massive Sand	Basal Sand (1): 2981-2986, Massive Sand (1): 3208-3210.5		
10	Dhubi-1	1100	-	3150	Massive Sand	Basal Sand (1): 2860-2869	Yes	Yes
11	Bitrism-1	1366	679	3690	Chiltan		Yes	Yes
12	Bitrism W-1A	1411	588	4210	Chiltan	Basal Sand (1): 2937-2946		
13	Gundanwari-1	1303	21	3750	Sembar		Yes	
14	Bitrism W-2	1408	32	3600	Sembar		Yes	
15	Chak 25-1	1395	-	3616	Sembar	Basal Sand (1): 2911-2920, Massive Sand (1): 3104-3113	Yes	
16	Chak 66-1	1027	-	3050	Massive Sand	Basal Sand (1): 2843-2852	Yes	Yes
17	Lala Jamali-1	1397	-	3400	Massive Sand		Yes	
18	Chak 63-4	1354	222	3550	Sembar	Massive Sand (1): 2974-2983		Yes
19	Chak 2-2	1327	-	3420	Sembar	Basal Sand (1): 2776-2785, Massive Sand (1): 2875-2884		Yes
20	Hakeem Daho-2	1025	-	3300	Massive Sand	Massive Sand (1): 3074-3083	Yes	Yes
21	Sinjhoro N-1	1428	20	3517	Sembar	Basal Sand (1): 2923-2932	Yes	
22	Allah Waraia-1	1307	22	3385	Sembar		Yes	
23	Sinjhoro W-1	1232	351	3870	Sembar	Massive Sand (1): 3145-3154	Yes	Yes
24	Resham W-1	1438	38	3500	Sembar	Basal Sand (1): 2881-2890, Massive Sand (1): 3019-3028	Yes	
25	Chak 5 Dim-1	1155	413	3600	Sembar			
26	Jakhro W-1	1168	40	3503	Sembar	Basal Sand (1): 2940-2949, Massive Sand (1): 3209-3218		
27	Bobi-7	798	-	2750	Massive Sand	Middle Sand (2): 2395-2404, 2453-2462, Basal Sand (2): 2691-2700, 2709-2718		
28	Bobi-10	1403	31	3286	Sembar			Yes
29	Dhamarki-1	898	-	2915	Massive Sand	Basal Sand (1): 2570-2579	Yes	
30	Palli D-1	1263	817.5	4050	Chiltan		Yes	Yes
31	Dars-1	222		2170	C&D Sand			
32	Jumman Shah-1	1409	789	3800	Chiltan		Yes	Yes

S#	Well	Lower Goru Thickness (m)	Sembar Thickness (m)	TD (m)	Formation/ Zone at TD	Cores (Formation/Numbers/Interval, m)	VSP	Image Log
33	TAY N-1	217	-	1720	Upper Shale	B Sand (1): 1510-1519	Yes	Yes
34	Dars D-1	1180.5	12.5	3388	Sembar			
35	Unar-1	1218	591.5	4100	Chiltan	Massive Sand (1): 2924-2933		
36	Chandio-1	1293	-	3660	Sembar		Yes	
37	Jado-1	1086	91	3000	Sembar			
38	Pasakhi E-1	1168	583	4176	Chiltan			
39	Kunnar S-1	1133	2.69	3349.69	Sembar		Yes	
40	Tando Jam-1	1360	18	3530	Sembar		Yes	
41	Manna-1	1057.5	27	3440	Sembar	Massive Sand (1): 3104-3108.25	Yes	Yes
42	Hanif-1	1391	114	3350	Sembar	Basal (1): 2775-2784	Yes	Yes
43	Kunnar-1	318	-	2202	Upper Shale	A Sand (1): 1954-1962, C&D (2): 2020-2028, 2078-2084	Yes	
44	Kunnar-10	215.35	-	2114	Upper Shale			
45	Kunnar D-8	1286	23	3433	Sembar		Yes	
46	Kunnar D-9	1352	635	3910	Sembar			Yes
47	Kunnar D-10	1223	483	3800	Sembar			
48	Kunnar D-11	1294	24	3338	Sembar			
49	Kunnar S-1	1133	8	3355	Sembar		Yes	
50	Lashari-1	490	-	2550	Upper Sand	A Sand (1): 2086-2095	Yes	
51	Lashari D-1	1070	19	3302	Sembar			
52	Lashari S-1	182.9	-	2253.9	B Sand	A Sand (3): 2073-2082, 2082-2091, 2091-2100, B Sand (1): 2145-2153		
53	Dhachrapur-2	1153	502	3975	Sembar		Yes	
54	Pasakhi-9	114.96	-	2130	C&D Sands			Yes/SHDT
55	Pasakhi-10	171.83	-	2150	Badin Shale			
56	Pasakhi D-1	1065.5	601.5	4160	Chiltan	Basal Sand (1): 2860-2869	Yes	
57	Pasakhi NE-1	1622	155	3782	Sembar			
58	Sono-1	161	-	2322	B Sand	A Sand (4): 2163-2171.5, 2183-2192, 2192.6-2201.6, 2201.6-2205.6	Yes	
59	Sono-5	62	-	2300	B Sand			
60	Sono D-1	1256	28	3510	Sembar		Yes	
61	Sono S-1	250	-	2450	Upper Shale			
62	TA-4	185	-	2344	C&D Sand	Upper Sand (5): 2174-2183, 21832192, 2192-2210.5, 2244-2261, 2275-2290.5	Yes	
63	TA-10	151	-	2400	Badin Shale	A Sand (1): 2255-2264	Yes	
64	TA-13	205	-	2525	C&D Sand	Upper Sand (1): 2324-2333	Yes	
65	Thora-5	80	-	2040	B Sand			
66	Thora E-1	207	-	2173	C&D Sand	A Sand (1): 1960-1969		
67	Thora D-1	1059	499	3906	Sembar	Massive Sand (1): 3180-3183		
68	Thora D-2	1020	22	3400	Sembar	Massive Sand (1): 3039-3048		
69	Norai Jagir E-1	1332	16	3450	Sembar			

S#	Well	Lower Goru Thickness (m)	Sembar Thickness (m)	TD (m)	Formation/ Zone at TD	Cores (Formation/Numbers/Interval, m)	VSP	Image Log
70	Nim W-1	1302	51	3510	Sembar		Yes	
71	Pakhro-1	1318	43	3692	Sembar		Yes	
72	Rind Baloch-1 ST	99	-	2358	Badin Shale	A Sand (1): 2225.15-2231.65	Yes	
73	Saand-1 ST-1	1268	-	2651	Massive Sand	B Sand (1): 1406-1406.7	Yes	
74	Chhutto-1	1271.5	24	3820	Sembar	Massive Sand (1): 3520.5-3522.9		
75	Daru-2	191	-	2642	Badin Shale	A Sand (1): 2472-2481, B Sand (1): 2550-2559		
76	Urs-1	1343	-	3810	Massive Sand	Basal Sand (1): 3423-3432, Massive Sand (2): 3563-3572, 3650.5-3659.5		
77	Musa Goth-1	84	-	1252	C&D Sands	B Sand (1): 1170-1179		
78	Misan-1	951	-	2111	Basal Sand	B Sand (1): 1164-1173		
79	Bukerani-1	787	-	2451	Lower Shale			
80	Buzdar-1	265	-	1553	Upper Shale	B Sand (1): 1301-1310	Yes	
81	Latif-1	1142	-	3520	B (OMV)			
82	Latif-4		-	3500				
83	Tajjal-3	870	-	3800	B (OMV)			
84	Tajjal-4	926	-	3835	B (OMV)			
85	Kadanwari-8	945	-	3423				
86	Kadanwari-18	1070	-	3545	C (ENI)			
87	Kadanwari-27	998	-	3535	C (ENI)			
88	Miano-1	1577	173	4030	Sembar			
89	Miano-15	1185	-	3455	B (OMV)			

Table 4.2. Summary of Selected 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 Stratigraphic 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:

5.4. To undertake detailed core description of selected 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.

5.5. 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.
- 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 previous/existing interpretation.
- 5.7.2. Review of data quality to ensure that all vintages can be balanced to common datum prior to interpretation.
- 5.7.3. Ensure that data is available to make effective tie between wells and seismic.
- 5.7.4. Establish format if data is to be exported.
- 5.7.5. Ensure that data can be fully loaded & made accessible on workstation.
- 5.7.6. Ensure that interpretations already available with OGDCL can be gridded and exported for further use.

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

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

5.7.9. 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 4^{th} 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.

Project setup

5.10. 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 company will be available at company site during project set up and data loading/QC.

Biostratigraphy

5.11. 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 biozonation of the Cretaceous age Lower Goru and Sembar Formation. OGDCL strongly suggest undertaking quantitative palynology as the prime discipline.

Sedimentology

5.12. Sedimentological analysis and petrographical results will include interpretation and facies analysis based on the drill cutting, core descriptions and petrographical 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

5.12.1. The core descriptions and petrographical 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 and the well logs.

Conventional Wireline Log and FMI Analysis

5.12.2. 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

5.12.3. 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

5.13. Full integration of all available well logs, biostratigraphic and sedimentological data is to be used to generate an integrated high-resolution (up to 4^{th} 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:

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

5.13.2. Establishment of regional litho-stratigraphic and chronostratigraphic correlation.

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

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

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

5.13.6. Paleontological data analysis and carrying out biostratigraphic control.

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

Seismic Interpretation

5.14. Structural interpretation on 4-5 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 all the 3D seismic data sets. 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 (in any) would also be required from contractor.

5.15. 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:

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

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

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

5.15.4. 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.

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

5.15.6. 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.

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

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

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

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

5.15.11. Development of 6-8 regional geo-seismic sections illustrating the shelf to basin variations as well as their Wheeler diagrams.

5.16. 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 through VC.

Phase-III

5.17. 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.

5.18. 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.

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

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

5.21. Preparation of final draft report with conclusions and recommendations

Phase-IV

5.22. The contractor will provide draft copy of the report and deliver a detailed presentation to OGDCL management within two weeks after completion of phase-III.

5.23. Final report and deliverables will be provided within 2½ months after phase-III completion.

5.24. The contractor will incorporate the inputs/suggestions/ amendments/changes proposed by the company.

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 backups/data of the software (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 2½ months after completion of the Phase-III. On completion of the study, the bidder will give a presentation of results to OGDCL in head office 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. Volumetric evaluation, quantitative risk assessment/maps for key areas of prospectivity/prospect inventory and its 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:

"PROSPECTS DELINEATION THROUGH INTEGRATED SEQUENCE STRATIGRAPHIC STUDY OF LOWER GORU AND SEMBAR FORMATIONS IN SOUTHERN INDUS BASIN OF PAKISTAN"

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 week 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 14 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)	: 1½ months
Main Project (Phase-II & III)	: 10 months
Final Presentation, Final Report Review and Deliverables (Phase-IV)	: 2½ months
Total Time	: 14 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 5.16.

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. <u>General Terms</u>

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 ten (10) OGDCL geoscientists will participate in the study The contractor should propose a workable program (duration and time in the technical proposal) for the involvement of 10 professionals from Exploration Department of OGDCL (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 the OGDCL.

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 OGDCL. 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 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.

11. <u>Technical Evaluation Criteria</u>

11.1. 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 11.2.1. 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.

11.2. The bidders are required to strictly follow the sequence of technical evaluation criteria (Table 11.2.1) and submit the technical proposals accordingly. The financial proposals of the bidders obtaining less than 80 marks in the technical evaluation will not be opened. The technical evaluation will be based on the following criteria:

Table 11.2.1. 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	≥ 10 projects = 30 marks 08 - 09 projects = 25 marks 06 - 07 projects = 21 marks
2.	No of professionals assigned for the project with relevant experience (please provide detailed CVs)	Total ≥ 12 professionals = 35 marks ≥ 06 professionals with ≥ 15 years of experience & ≥ 06 professionals with ≥ 10 years of experience Total ≥ 10 professionals = 30 marks ≥ 05 professionals with ≥ 15 years of experience & ≥ 05 professionals with ≥ 10 years of experience Total ≥ 08 professionals = 25 marks ≥ 04 professionals with ≥ 15 years of experience & ≥ 04 professionals with ≥ 10 years of experience
3.	Relevant qualification of the professionals	03 PhD + 09 BS/MS = 15 marks 02 PhD + 08 BS/MS = 13 marks 01 PhD + 07 BS/MS = 11 marks
5.	Time to complete the study	= 14 months = 10 marks 14 - 16 months = 07 marks
6.	Skill/technical transfer plan	Mandatory
7.	Experience in similar geological environment (subject to the provision of client satisfaction report)	> 05 project = 10 marks 04 - 05 project = 07 marks
Total		100 marks

11.3. 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.

11.4. 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 11.2.1.

12. Financial Evaluation Criteria

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

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

12.3. The potential bidder will submit financial proposal as per financial proposal bid format provided in Table 12.3.1.

Table 12.3.1. Financial Bid Format for Comparison of Financial Bids		
S#	**Study Project**	**Total Lump Sum Cost (US $) inclusive of all applicable taxes duties and Levies etc except Provincial Sales Tax/ ICT Tax on Services in Pakistan**
1.	**Prospects Delineation Through Integrated Sequence Stratigraphic Study of Lower Goru and Sembar Formation in Southern Indus Basin of Pakistan as per TOR**	

12.4. 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.

13. Amount of bid bond:

Bid Bond /Bid Security amounting to US 24,000/- (US Dollar Twenty Four Thousand Only) to be attached with technical bid. Please see master set of tender documents (services) for further details.

14. Bid Validity:

The Bid shall remain valid and open for acceptance for a period of 180 days from the specified date of technical bid opening.

Note:-

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