# Stratigraphic Correlation and Isopach Maps of Punjab Platform in Middle Indus Basin, Pakistan*

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## Abstract

Punjab Platform is the eastern part of Middle Indus Basin in Pakistan with Sulaiman depression and fold belt in the west, Sargodha High in North, and Pokhran High in the South. Subsurface geological reports and stratigraphic correlation of 19 onshore exploration wells of Punjab Platform completed by previous workers are incorporated in this paper to construct regional stratigraphic profiles and the isopach maps of prospective formations. During the Paleocene age, deposition center was located in southeast zone of Punjab Platform and thickness of strata increased from west to east. In Middle to Late Cretaceous age, deposition center was located in southeast zone and thickness of strata increased from 200 m in the northeast to 1350 m in the southwest. In Early Cretaceous, thickness of strata increased from 20 m in the west to 170 m in the east. In Jurassic age, deposition center was located in southwest and the thickness of strata increased from 10 m in northeast to 290 m in southwest. In Early Cambrian age the deposition center was located in eastern side of Punjab Platform and the thickness of strata increased from 40 m in the west to 800 m in the east. In Infra-Cambrian age, the deposition center was located in southeast zone of Punjab Platform and thickness of strata increased from 530 m in the west to 1130 m in the east. The locations of deposition centers for Ranikot (Paleocene) Khewra Sandstone (Cambrian) and Salt Range Formation (Infra-Cambrian) is similar which is southeast and the direction of sediments was from northwest to southeast.

Khewra Sandstone Formation is a proved reservoir in the Upper Indus Basin however shows were present in Salt Range Formation in Karampur-1 and Bijnot-1 wells with heavy oil which indicates a prospective zone in Punjab Platform of Middle Indus Basin for exploration in the future.

## Introduction

Punjab Platform (Latitude: 27N-29N, Longitude: 70E-72E) in Pakistan is the eastern part of Middle Indus Basin with Sulaiman depression and fold belt in the west, Sargodha High in north, and Pokhran High in the south. The Central Indus Basin is comprised of Punjab Platform, Sulaiman Depression, and Sulaiman Fold Belt units on the basis of the topography of the Indian Shield from east to west (Raza et al., 1989). Tectonically, the Punjab Platform

in Pakistan is the least affected part of the Indus Basin and is a broad monocline dipping gently towards the Sulaiman depression (Figure 1). The Punjab Platform extends eastward into India and is called the Bikaner-Nagaur Basin where India has discovered significant quantities of heavy oil in the Infra-Cambrian evaporite sequence called Hanseran Evaporite equal to Salt Range in Pakistan. The tectonic history of the Indian Plate is mainly related to two major events, Mesozoic rifting of Gondwanaland and Cretaceous-Tertiary Indian Plate collision with Eurasian Plate. Due to less effected stresses the strata of Punjab Platform may be in juxtapositions with normal faults and minor duplexes and contractional fans.

Outcrops of sedimentary rocks in Punjab Platform are not exposed on surface and are covered with thick alluvium deposits of clay, silt, and sand layers. Punjab Platform has been the target of petroleum explorations with more than twenty onshore exploration wells drilled in recent years. This area is also targeted due to recent discovery close to the border with neighboring India.

The purpose of this study is not only to establish the stratigraphic correlations of different wells in Punjab Platform but also to elucidate the source of sediments and depositional centers during different geological time periods. This helps in identifying the maximum thickness zones of prospective formations in Punjab Platform and the direction of sediments flow in the central Indus Basin during different geological periods.

## Stratigraphy and Sedimentary Fill

Subsurface geological data indicate the Precambrian basement rocks are comprised of granites, unfossiliferous metasediments, and metavolcanics. The oldest rocks encountered in Punjab Platform through drilling are Infra-Cambrian Salt Range Formation. Pre-Himalayan orogenic movements have resulted in prolonged uplifts/sea regression causing unconformities. As a result, several salt cored anticline structures are expected in the southern portion of this monocline (Qadri, 1995 and Humayun et al., 1991). Only the scattered outcrops of Precambrian shield rocks are present in Sargodha, Kirana, Shahkot, and Sangla Hill area (Shabih et al., 2005). The generalized stratigraphic sequence in the area which is inferred from the logs of exploratory wells (Figure 2) which is summarized below.

**Pre-Cambrian:** Kazmi (1964) introduced the name “Kirana Group” for unfossiliferous Precambrian metasediments and metavolcanics which are exposed in the form of small hillocks between Sargodha and Shahkot in Punjab. The exposed Late Proterozoic basement rocks is largely comprised of pink and grey granites, with dolerite and gabbro intrusions which is known as Nagar Parkar Igneous complex of Sindh, Pakistan (Kazmi and Khan, 1973). Since the boundary of Infra-Cambrian is not well defined, the age of Salt Range Formation is considered as Precambrian in the literature (Ibrahim, 1977).

**Cambrian:** The Cambrian sequence in Punjab Platform consists of four main lithostratigraphic units; Bhaganwala, Jutana, Kussak, and Khewra Sandstone however in Suji1, only Khewra Sandstone is encountered. The Cambrian rocks apparently conformably overlie the Salt Range Formation of Precambrian age and are unconformably overlain by Permian strata (Kazmi and Abbasi, 2008).

**Triassic/Jurassic:** Triassic formation is mostly missing in Punjab Platform except in Sarai Sidhu well in which a limited Triassic sequence is

encountered. Samanasuk/Chilton L.st, Shinawari S.st, and Datta S.st are encountered in Suji-1 however Jiwanwala (Jiw)-1 well documents only Shinawari Formation. The thickness of Jurassic increased from Suji-1 to Jiw-1 where it drilled more than 400 m indicates that further drilling in Jiw-1 well may expose thicker Jurassic sequence in the east. Jurassic sediments are of marine limestone, shale, and sandstone with subordinate dolomite and ferruginous beds (Figure 2). They form a part of platform cover in the entire Indus Basin.

**Cretaceous:** Cretaceous rocks extensively cover the Indus platform and the foredeep region, indicated by several discovery wells (Kazmi and Abbasi 2008). The Upper Cretaceous formations such as Upper Goru and Lower Goru S.st are proved reservoirs. A thin bed of Lumshiwal S.st is encountered in Suji-1 which is equivalent to Goru (S.st) in Jiw-1 which may be due to a depositional break (Qadri, 1995). This is confirmed due to absence of Goru Formation around Jacbabad-Khair Pur High. The Lower Cretaceous unit, Sember Formation, is encountered in several wells spread over the Indus platform (Qadri 1995). Sember consists of black shale interbedded with siltstone and nodular, argillaceous limestone.

**Paleocene/Eocene:** Dunghan L.st and Ranikot S.st formations of Paleocene are well defined in Punjab Platform. The thickness of Paleocene increased in southeast direction from Karampur to Marot-1. This may be due to the collision between the western margin of Indian Plate and Afghan Block. The resulting structural unrest is reflected in the fluctuating depositional environment and variation of thickness of Paleocene formations in different part of sedimentary basin.

**Recent Deposit:** The Punjab Platform area is covered with thick alluvium comprising of clay, silt, and sand layers on the surface.

## Methodology

The geological reports and stratigraphic correlation charts of Punjab Platform are integrated to construct stratigraphic profile in this study. The list of wells of Punjab Platform used for this study is given in Table 1. The other objective is to determine the depocentres of prospective formations from the 19 exploration wells located in the Platform.

The isopach maps of Ranikot, Goru, Sember, Chilton/ Samanasuk, Khewra, and Salt Range formations of Paleocene, Cretaceous, Middle Cretaceous, Early Cretaceous, Jurassic, Cambrian, and Infra-Cambrian age respectively are constructed with Surfer software.

## Results and Conclusions

Stratigraphic Correlation Profile (Figure 3) is based on the subsurface geological information of wells as highlighted in Table 1 indicates that the Mesozoic and Tertiary rocks are thinning toward the basement high. Further, the lithology is changing from marine calcareous sediments to terrigenous sandy units, however, there appears to be no drastic change in the thickness of the Tertiary and Mesozoic strata in the west. Two prominent unconformities can be observed in well data at bottom of Miocene and Permian. This may be due to pre-Himalaya orogenic movements which caused uplifting/sea regression in the area. The thickness of Paleocene formations is decreasing towards Fort-Abbas well but in Cretaceous Period, thickening

of formations is towards Bahu-1.

## Isopach Maps and Location of Depocentres

Isopachs of Ranikot Sst, Goru Sst, Sember Shale, Chilton/Samanasuk Limestone, Khewra Sst, and Salt Range Formation in Punjab Platform are shown in Figure 4 which indicates the position of their respective depocentre. Paleocene formation is almost encountered in all wells and the depocenter was located in southern part of Punjab Platform and the direction of sediment flow was north to south until Middle Cretaceous the depocentre was southwest as indicate in Goru isopach map. In Early Cretaceous, the direction of sediment flow was southwest to northeast. Sember Shale of Early Cretaceous age was encountered in the western part of Punjab Platform is approved source rock in Middle Indus Basin of Pakistan. During Jurassic Period, the depocentre was southeast of Punjab Platform. The thickness of Chilton Formation of Jurassic age increased in eastern part of Punjab Platform. In Cambrian and Precambrian ages, the depocentres were in southeastern part of the platform which shows the direction of sediments flow was from northwest. The Goru, Chilton, and Khewra formations are approved reservoirs in the study area.

## References


Humayun, M., R.J. Lillie, and R.D. Lawrence, 1991, Structural interpretation of Sulaiman folds belt and foredeep, Pakistan: Tectonophysics, v. 10, p. 299-324.

Ibrahim, S., 1977, Memoir 12: Geological Survey of Pakistan, Quetta.

Kazmi, A.H., and I.A. Abbasi, 2008, Stratigraphy and Historical Geology of Pakistan: National Centre of Excellence in Geology, University of Peshawar, Peshawar, Pakistan, 210 p.

Kazmi, A.H., 1964, Report on the geology and ground water investigations in Rechna Doab, West Pakistan: Geological Survey of Pakistan, Record 10/3, 26 p.

Kazmi, A.H., and R.A. Khan, 1973, The report on the geology, mineral and water resources of Nagar Parker, Pakistan: Geological Survey of Pakistan, Information Release 64, p. 1-33.

Qadri, I.B., 1995, Petroleum Geology of Pakistan: Pakistan Petroleum Limited, 212 p.

Raza, H.A., R. Ahmed, S.M. Ali, A.M. Sheikh, and N.A. Shafique, 1989, Exploration performance in sedimentary zones of Pakistan: Pakistan Journal of Hydrocarbon Research v. 1/1, p. 1-7.

Riaz, A.S., M.A. Jamil,, J. McCann, and M.I. Saqi, 2003, Distribution of infracambrian reservoirs on Punjab Platform in central Indus Basin of Pakistan: SPE/PAPG Annual Technical Conference and Oil Show 2003, Islamabad, Pakistan.

Shabih, M.S., A.A. Khan,, A.W. Qureshi, and M.R. Adnan, 2005, A new move toward interactive well-seismic data calibration by adjusting interval velocity: SPE/PAPG Annual Technical Conference 2005, Islamabad, Pakistan.

Wandrey, C.J., B.E. Law, and H.A. Shah, 2004, Sembar Goru/Ghazij composite total petroleum system, Indus and Sulaiman-Kirthar geologic provinces, Pakistan and India: U.S Geological Survey Bulletin, Report #B 2208-C, 23 p.

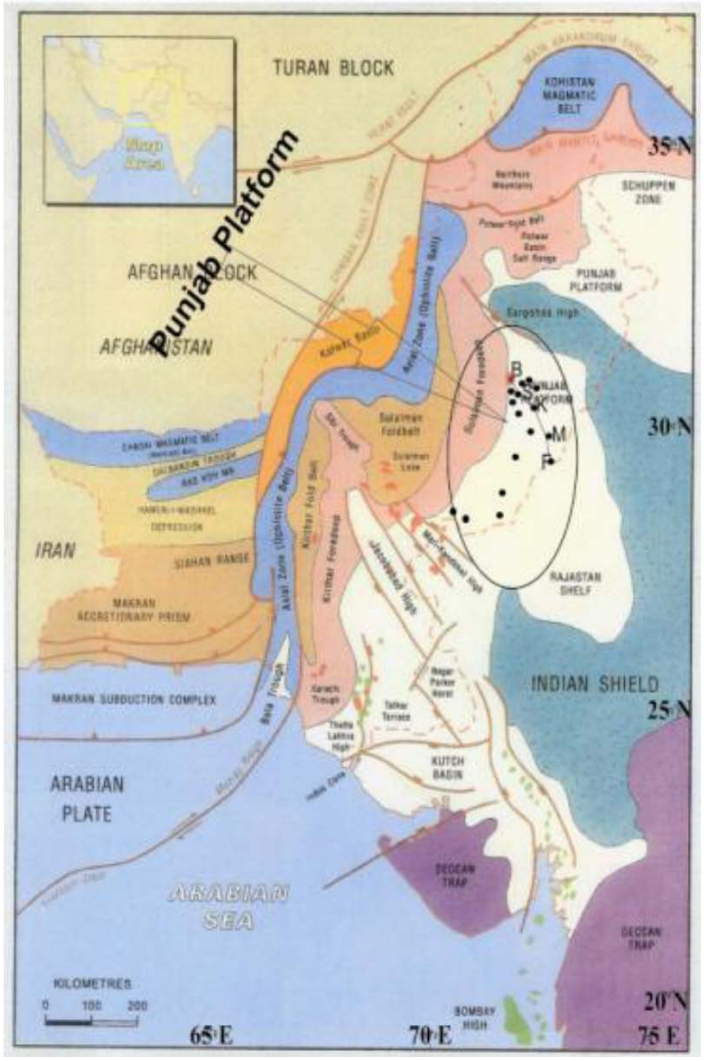


Figure 1: Location and tectonic set up of Punjab Platform.

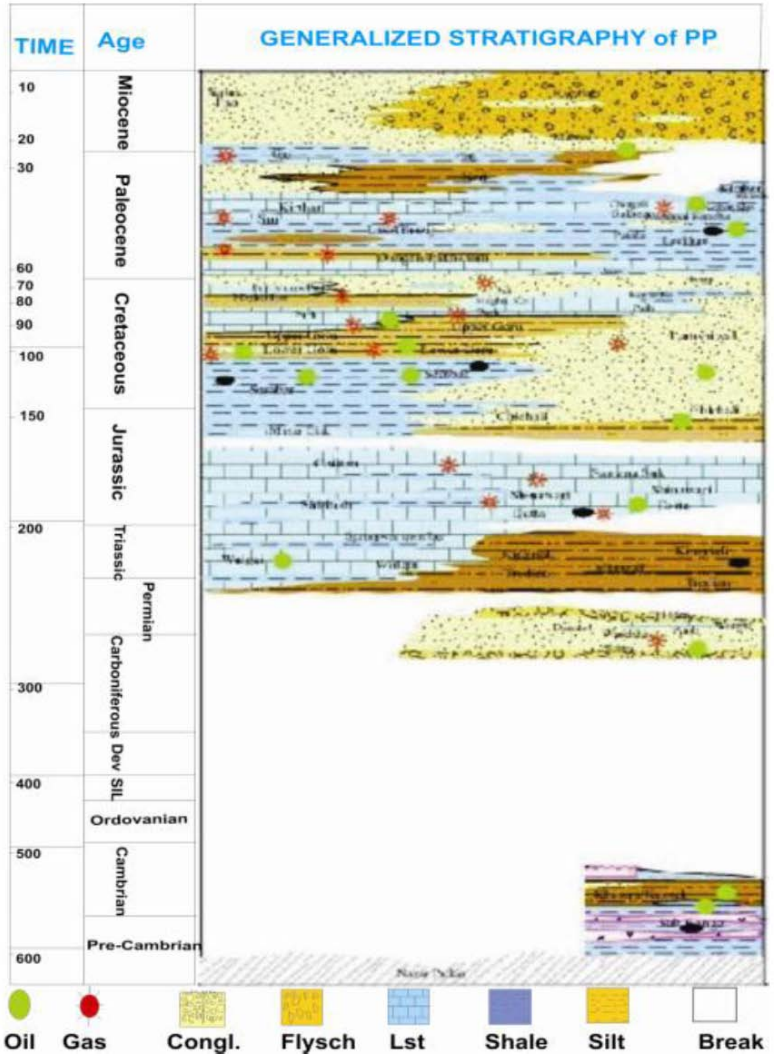


Figure 2: Stratigraphy of Punjab Platform (modified from Wandrey et al., 2004).

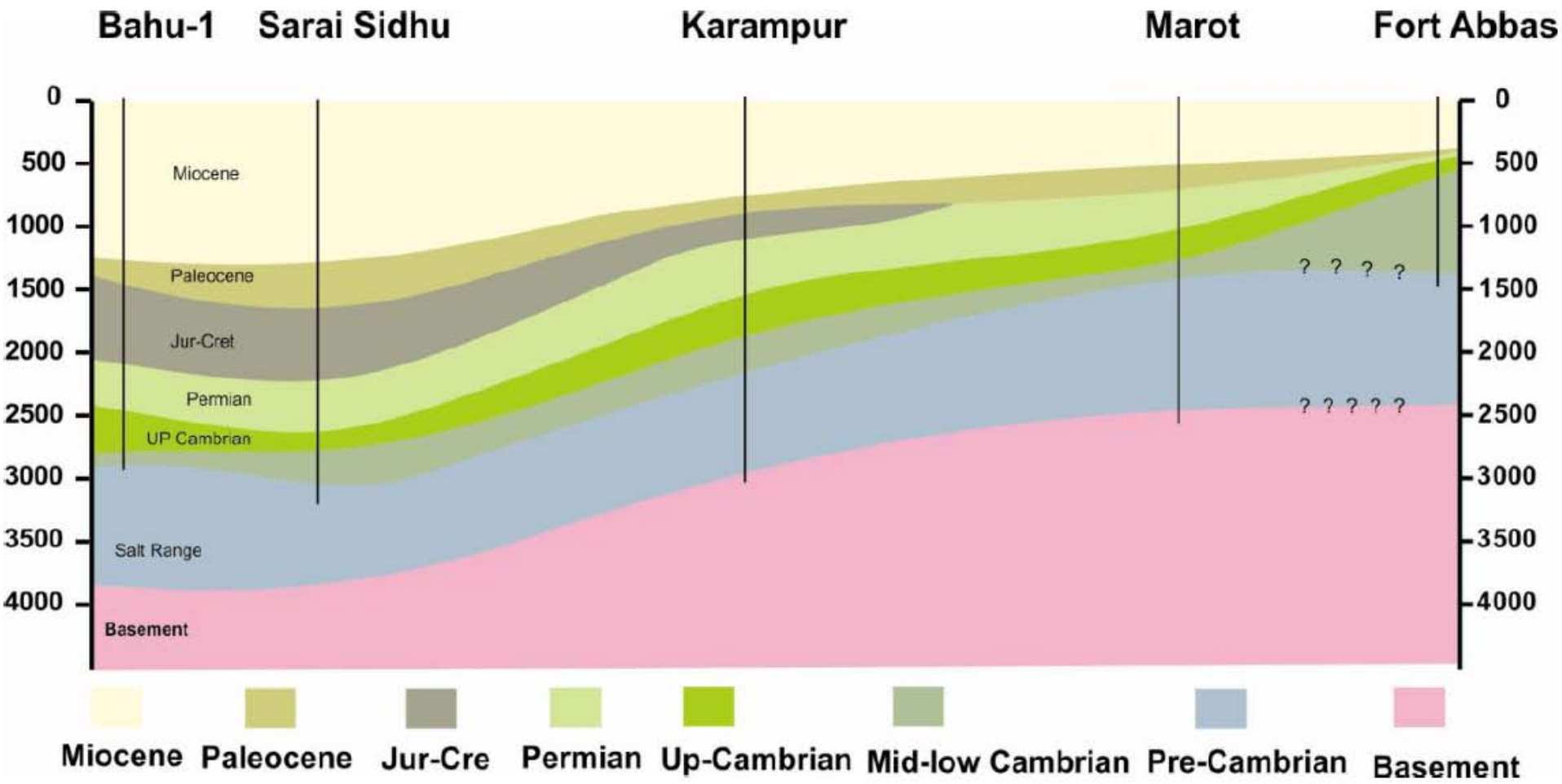


Figure 3: Stratigraphic Correlation Profile.

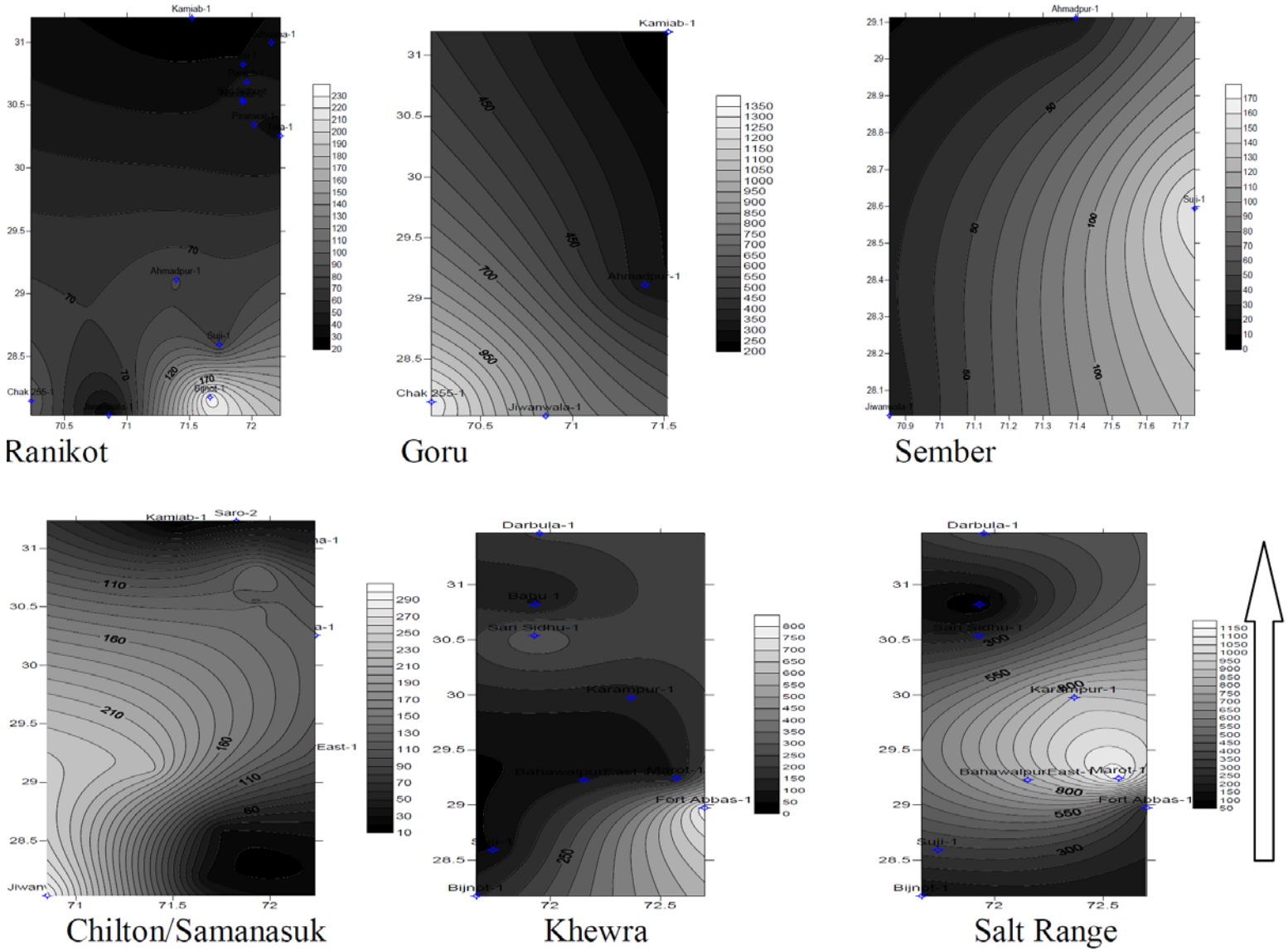


Figure 4: Isopach maps of various formations. Arrow indicates north direction.

| Sr. No. | well name | Long | Lat | SR | KH | SS/CH | SM | GO | RK |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ahmadpur-1 | 71.3942 | 29.112 | - | - | 224 | 19 | 317 | 81 |
| 2 | BahawalpurEast-1 | 72.152 | 29.2286 | 817 | 93 | 113 | - | - | - |
| **3** | **Bahu 1** | **71.9303** | **30.8227** | **50** | **89** | **129** | **-** | **-** | **31** |
| 4 | Bijnot-1 | 71.6661 | 28.1761 | 140 | 141 | 29 | - | - | 230 |
| 5 | Budhuana-1 | 72.1575 | 30.9958 | - | - | 56 | - | - | 34 |
| 6 | Chak 255-1 | 70.2316 | 28.1474 | - | - | - | - | 1306 | 101 |
| 7 | Darbula-1 | 71.9507 | 31.4694 | 406.5 | 210 | - | - | - | - |
| 8 | Fort Abbas-1 | 72.6982 | 28.9754 | 251 | 797 | - | - | - | - |
| 9 | Jiwanwala-1 | 70.8532 | 28.032 | - | - | 294 | 22 | 856 | 27 |
| 10 | Kamiab-1 | 71.5203 | 31.1936 | - | - | 15 | - | 201 | 21 |
| 11 | Karampur-1 | 72.3663 | 29.9771 | 906 | 120 | - | - | - | - |
| 12 | Marot-1 | 72.5698 | 29.2442 | 1143 | 99 | - | - | - | - |
| 13 | Nandpur-2 | 71.9291 | 30.523 | - | - | 134 | - | - | 43 |
| 14 | Panjpir-1 | 71.9594 | 30.6841 | - | - | 129 | - | - | 45 |
| 15 | Piranwal-1 | 72.0173 | 30.3448 | - | - | 127 | - | - | 40 |
| 16 | Sari Sidhu-1 | 71.9277 | 30.5393 | 222 | 306 | 103 | - | - | 42 |
| 17 | Saro-2 | 71.8259 | 31.2321 | - | - | 24 | - | - | - |
| 18 | Suji-1 | 71.7398 | 28.5952 | 332 | 50 | 31 | 161 | - | 76 |
| 19 | Tola-1 | 72.2311 | 30.2556 | - | - | 121 | - | - | 39 |

Table 1: List of wells used in this study. SR, KH, S/CH, SM, GO, and RK indicate Salt Range, Khewra S.st, Samanasuk/Chilton, Sembar shale, Goru, and Ranikot respectively. The highlighted wells are used for stratigraphic profile construction.