

# 1. INTRODUCTION

Cenozoic marine sequences deposited in the Tethys Ocean before its demise as a result of head on collision between Indo Pakistan and Eurasian Plates, are well exposed throughout the Indus Basin. Cenozoic sedimentary records of the Indus Basin exhibit a vivid change from Paleocene-Eocene marine sequences to non-marine littoral and terrestrial molasse-type deposits during Neogene and Quaternary. The Paleogene marine-strata in the Indus occur between the two major unconformities of the basin. In the Sulaiman Range, and in the Baluchistan Ophiolite and Thrust Belt, the Cenozoic-Mesozoic contact changes from an angular unconformity between Paleocene and older units, to a disconformity and overlap in the Kohat-Potwar-Salt Range region (Raza et al. 1989, Gee, 1989). In the Lower Indus Basin, the contact between the Paleocene and the Cretaceous is disconformable (Williams, 1959), however, it is transitional at places according to Hunting Survey Corporation (1961). Now the upper contact of marine Paleogene strata is also an unconformable with overlying Chitarwata Formation (Kazmi, 1995) of non-marine origin. This marine Paleogene sequence consists of four formations here given in ascending order: Dughan, Shaheed Ghat, Baska and Kirthar Formations. In this study Shaheed Ghat Formation is redefined.

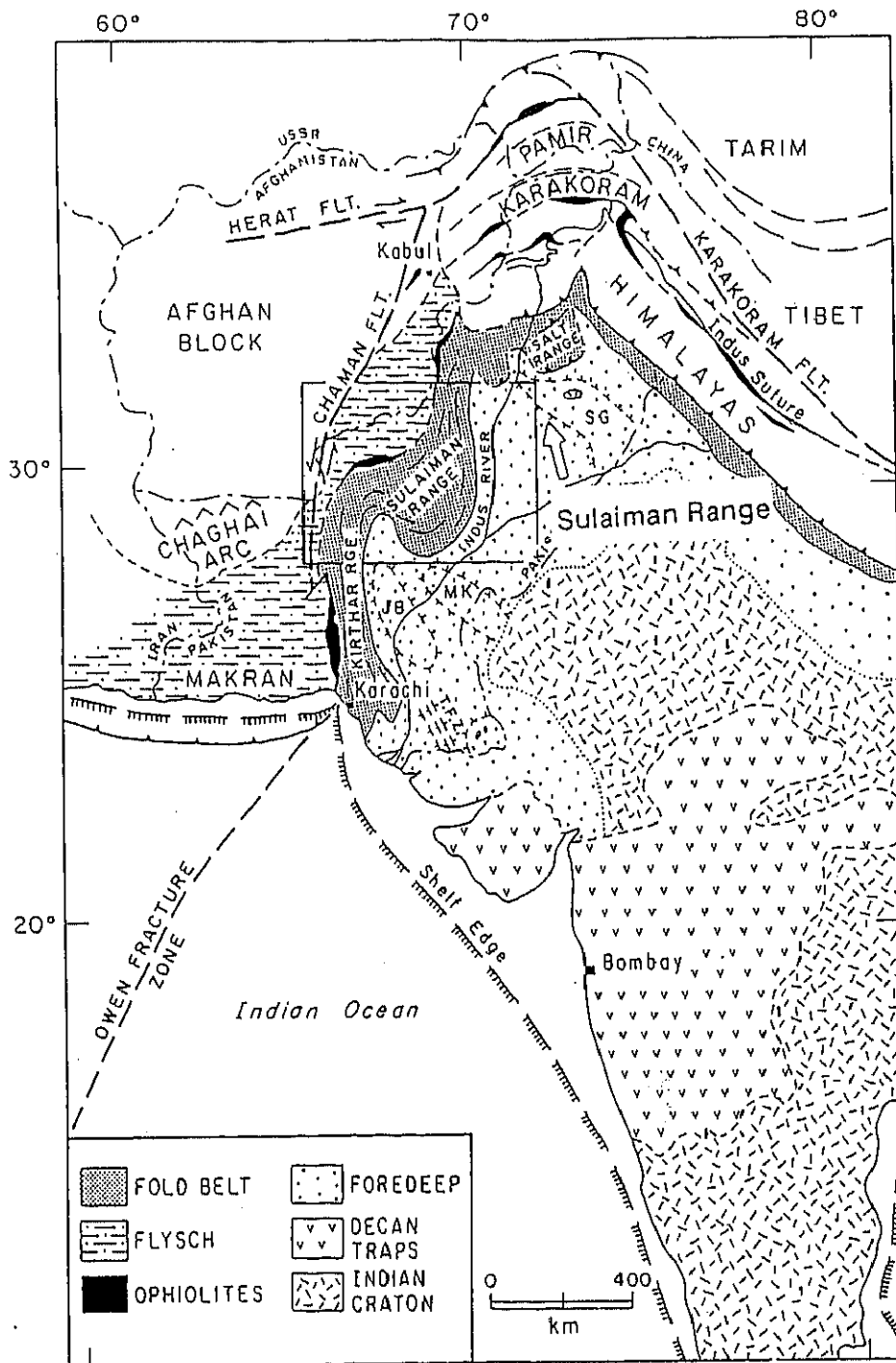
A comprehensive program in order to establish the Paleogene planktonic foraminiferal biostratigraphy for the Sulaiman Range, Southern Indus Basin,

Pakistan, was taken by author as his research plan in the Institute of Geosciences, University of the Tsukuba, Japan. Initially, the western limb of the Zinda Pir Anticline along which marine sequence of Paleocene-Eocene age is excellently exposed was selected for biostratigraphic studies based on planktonic foraminifera. For the purpose of route geological mapping, section measurements and to get systematic samples, two field surveys were conducted between March 17 to 27, 1995, and in March 5 to 20, 1996. The results of this study were presented in the MS Thesis and later published (Warraich and Natori, 1997). Later on this project was expanded to the whole Sulaiman Range (Fig. 1) and a detailed field survey (May-June, 1997) for systematic sampling and other field measurements was carried out on three representative sections from the Sulaiman Range. These sections include the Rakhi Nala section, Zinda Pir east and Zinda Pir west sections.

### **1.1 Previous works**

A number of workers (Eames, 1952a; Nagapa, 1959; Butt, 1991) have published Cenozoic biostratigraphy of Pakistan, mainly based on larger foraminifera. Despite deep to open marine sequences of early Cretaceous to late Eocene age are widely and excellently exposed in the Kirthar and Sulaiman Ranges of the Southern Indus Basin, there is no published work available in the recent past over the planktonic foraminifera.

Haque (1956, 1959a, 1959) is the first Pakistani worker who did a pioneering effort to explore the use of bio-stratigraphically important group of



**Figure 1.** Regional tectonic setting of Pakistan showing the deposition of Paleogene marine sedimentary deposits distributed in fold and thrust belt of Pakistan formed as a result of the Indo-Pakistan and Eurasian Plate. Here the rectangular box indicates the position of the Sulaiman Range (Modified after Kazmi and Rana, 1982; Hamyon, 1991)

microfossils. Latif (1961, 1964) and Samanta (1973) both have studied the Paleogene planktonic foraminifera of the Rakhi Nala section in detail and attempted to establish the biostratigraphic framework of this area. Later, Dorreen (1974) has also discussed Paleocene-Eocene planktonic foraminifera from the Gaj River section (Kirthar Range) that lies to the southern part of Indus Basin. Recently, Jones (1997) while working for an oil company has discussed different aspects of the Cenozoic stratigraphy of the northern Sulaiman Range. However, for the last 30 to 40 years, no body has carried out a comprehensive and systematic work on the planktonic foraminiferal biostratigraphy that has now received world-wide recognition for the reliable and relatively precise and, high-resolution subdivision of Cenozoic strata. Therefore the present research was planned keeping the following objectives in mind.

## **1.2 Objectives**

The overall objectives of the present study are summarised as following.

- 1) The main objective of this study is to establish a detailed and high-resolution planktonic foraminiferal biostratigraphy for the Paleogen marine sequence of the Sulaiman Range, Southern Indus Basin, Pakistan.
- 2) Proper documentation, distribution and description of the planktonic foraminiferal fauna recovered from all three sections.
- 3) The position of the Paleocene-Eocene boundary in the Sulaiman Range based on the quantitative and qualitative analysis of both planktonic and benthonic foraminifera.

- 4) Analysis of the carbonate facies in order to interpret the depositional environment of the Paleogene sequence exposed in the studied areas.
- 5) Revision of the lithostratigraphic units mainly based on the careful field route mapping and thin section observations of the microfacies.
- 6) Finally, to establish a regional and interregional correlation between the biostratigraphic zones established herein this study with those of others established in other parts of the Southern Indus Basin, and with internationally established ones, respectively.

### **1.3 Study Areas**

In order to achieve the above mentioned objectives, three representative sections along which excellent exposures of the Paleogene marine sequences are exposed were selected from the Rakhi Nala and the Zinda Pir areas (Fig. 2).

#### **1.3.1 Rakhi Nala**

Rakhi Nala (29° 59'N latitude and 70° 03' E longitude) exhibit undisturbed and very well exposed Paleocene-Eocene marine successions, is easily accessible through the Dera Ghazi Khan-Quetta road. It lies on the easternmost flank of the Sulaiman Range. All four Paleogene formations are typically exposed in this section (Fig. 3). Apart from the route geological mapping and section measurements, 143 samples were collected systematically.

### 1.3.2 Zinda Pir Anticline

The Zinda Pir Anticline is a long and narrow anticlinal structure which runs approximately north-south and is separated from a very complex folded belt of the Sulaiman Range by a narrow syncline in the west (Fig. 2). The eastern limb is relatively steep and buried under the alluvial deposits of the Indus River system. The crestal area is broad and gentle, and is dislocated by very small oblique faults.

The study area is situated in the Dera Ghazi Khan district of the Punjab Province. It lies at the 30° 25'N latitude and 70° 29' E longitude and is covered by the 39 J / 7 and 39 J / 11 (1: 50,000 scale) topographic sheets of the Survey of Pakistan. The approach to the area is very difficult, so that it has been neglected despite the excellent surface exposures. It can be approached through the road running from Dera Ghazi Khan towards Taunsa Shareef, then taking a dirt road from the Kamar Pull to a small village Haft Ghat. From Haft Ghat, it is approached either by walking or by a four-wheel jeep, as it is very rough terrain without any proper road.

Along both sides of the Zinda Pir Anticline, all four formations: Dunghan, Shaheed Ghat, Baska and Kirthar Formations are well exposed. For this study, route geological mapping and section measurements were carried out along both sides of the anticline and results of which are summarized in Figure 4. For biostratigraphy and facies analysis 97 and 132 samples suitable horizons were systematically collected from western and eastern limbs of the anticline, respectively.

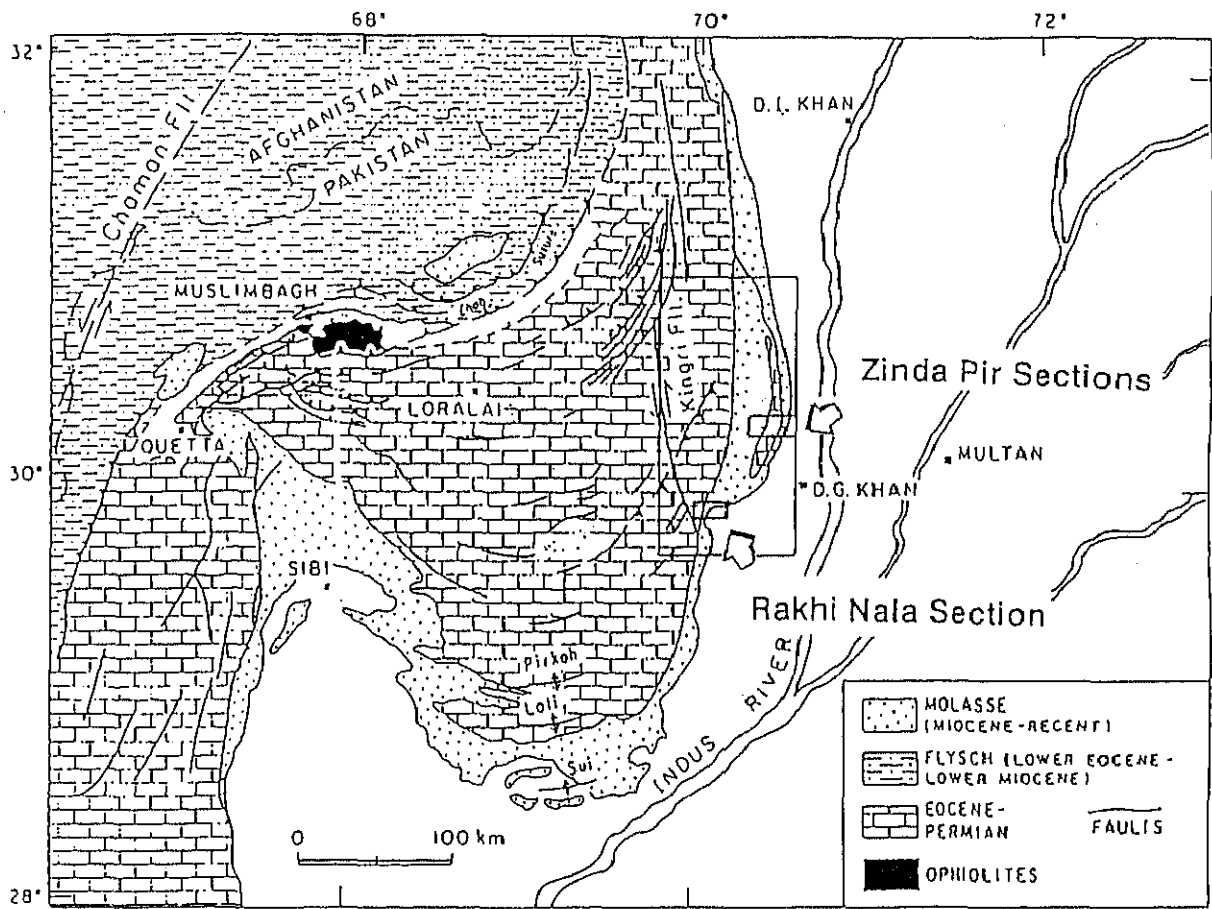
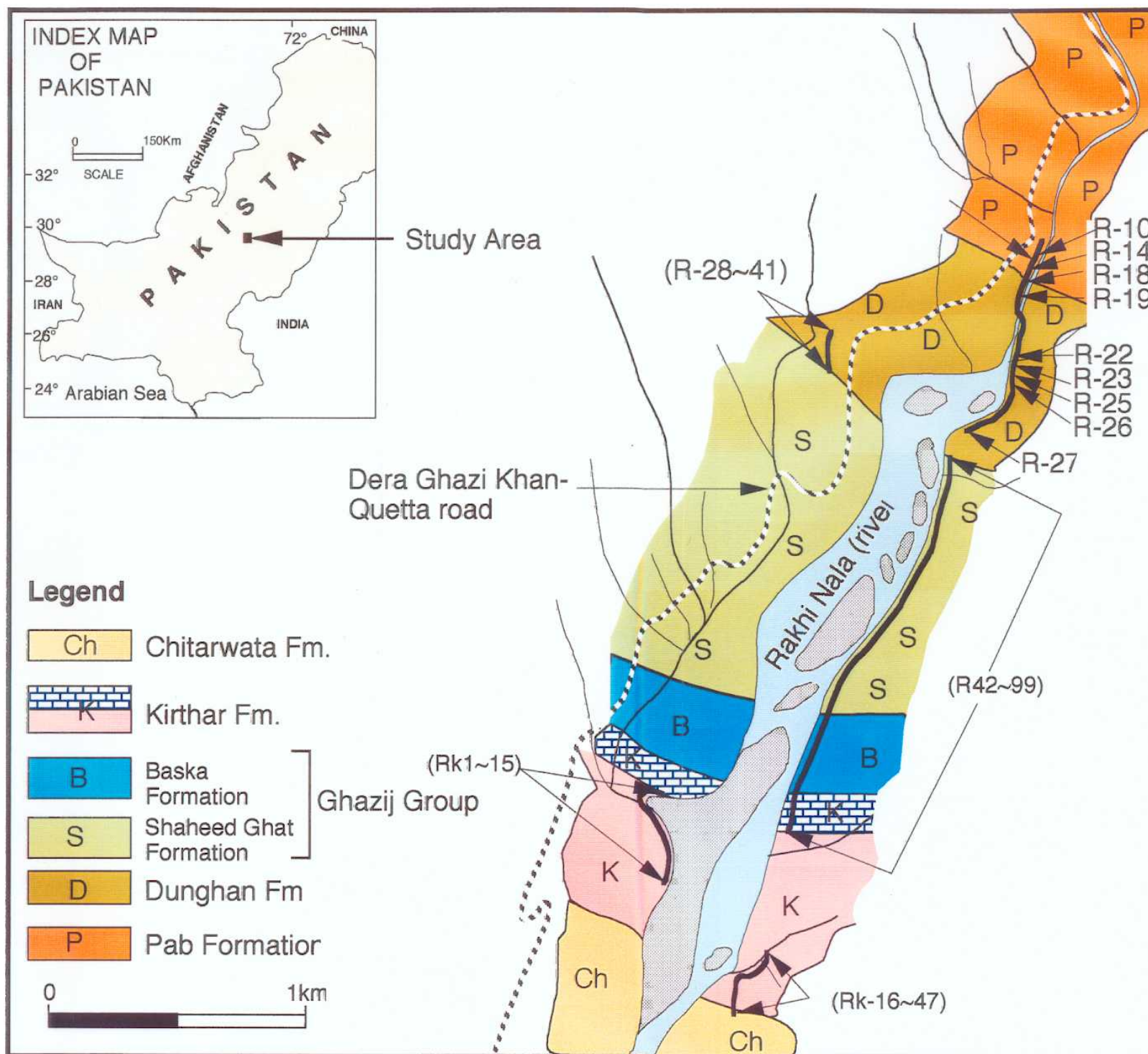
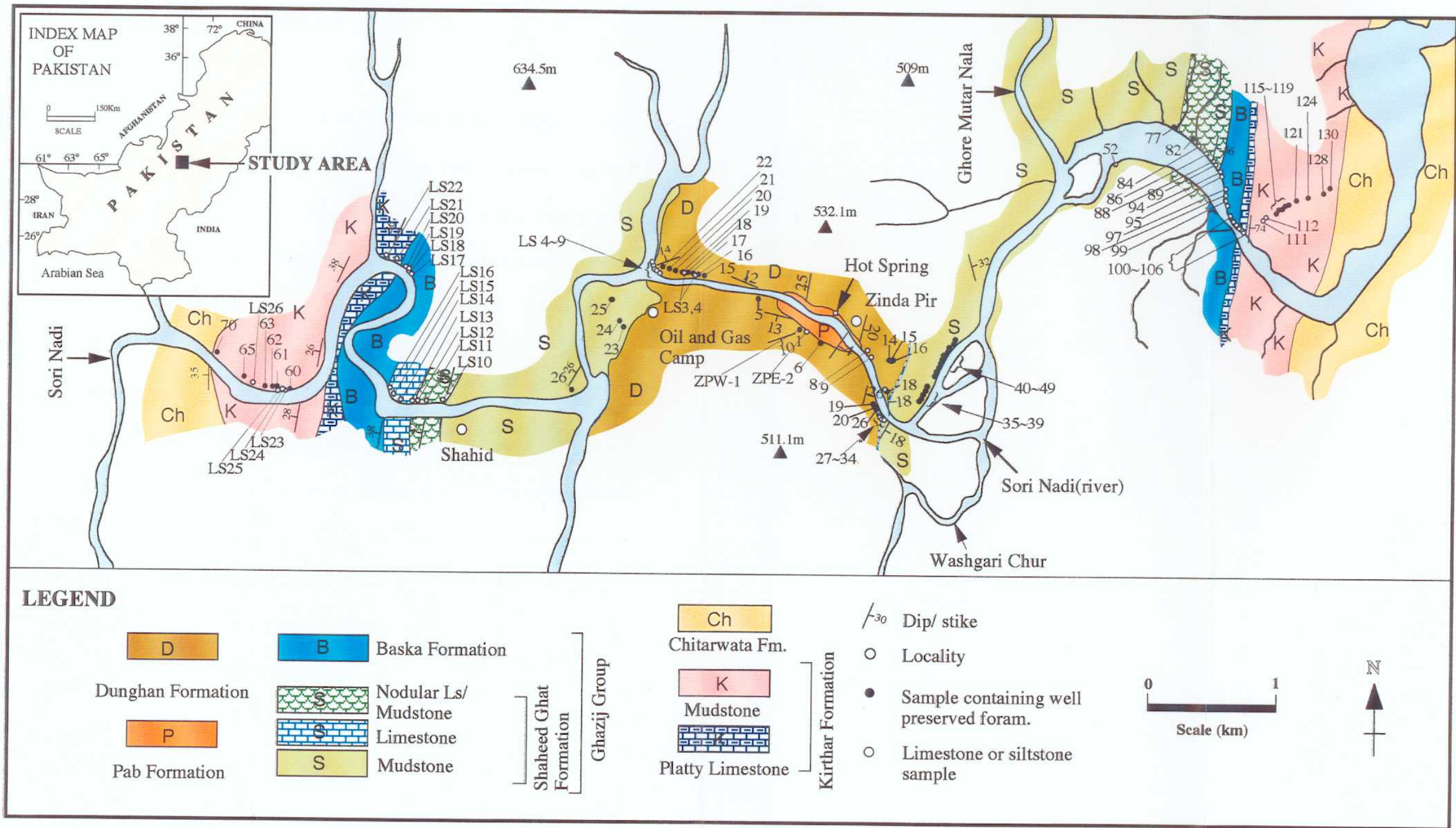


Figure 2. The geological map of the Sulaiman Range showing the locations of the Rakhi Nala section and the Zinda Pir Anticline (Modified after Kazmi and Rana 1982; Hamyon et al., 1991)



**Figure 3.** Route geologic map showing distribution of Paleogene sequence exposed along the Rakhi Nala (river), Sulaiman Range, Southern Indus Basin, Pakistan.





**Figure 4.** Route geological map of the Zinda Pir Anticlin showing lithostratigraphic units and sample locations, along the Sori Nadi, eastern Sulaiman Range, Southern Indus Basin, Pakistan.