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REGIONAL CHARACTERIZATION AND RESOURCE EVALUATION OF PALEOCENE AND EOCENE COAL-BEARING ROCKS IN PAKISTAN

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ABSTRACT

Field work drilling, and other related studies carried out from 1985 to 1988 to assess the quantity and quality of the coal resources of southern Sindh. Sixty-eight holes drilled in the Lakhra/Jherruck, Thatta, and Indus East coal fields indicate that presently known and mined coal fields in southern Sindh are not isolated coal occurrences. Rather, much of southern Sindh, including the Thar Desert, is underlain by strata that contain coal beds.

More than 400 core and mine samples were collected for proximate and ultimate analysis and determination of major, minor and trace elements; also, lithologic logs were prepared from description of rock cuttings and core. Original coal resources of 1,080 million tones have been estimated for 7 out of 9 coal zones in parts of the Lakhra area, where coal-bed thicknesses range from a few centimeters to 5 m. In the Sonda/Jherruk area, 3,700 million tones of coal have been identified, the thickest coal bed intercepted being 6.3 meters. The apparent rank of the coal in these fields ranges from lignite A to sub-bituminous C. Averaged analytical results on an as received basis indicate the coal beds contain 28.4 % moisture, 18.3 % ash, 4.7 % sulfur, 25.2 % fixed carbon, 27.9 % volatile matter, and 33.1 % oxygen. Average calorific value for Lakhra coal samples is about 3,660 Kcal/kg, whereas that of Sonda/Jherruk samples is about 3,870 Kcal/kg. Geophysical logs were obtained for the drill holes, and cores and rock cuttings are available from the GSP for further study and reference.

The second phase of the project began in 1987 with surface exploration in the Salt Range coal field of Punjab Province, the Sor Range and Khost-Sharig-Harnai coal fields of Baluchistan, and the Makarwal and Cherat coal fields of NWFP. These are briefly discussed here.

INTRODUCTION

In spite of the obvious need to utilize coal as an alternate source of energy which could replace oil and gas in electricity generation and other industrial applications, very little attention has as yet been given to Pakistan's coal resources. These resources are distributed throughout the country in 25 known coal fields and occurrences (Fig. 1) and are reported to be 9.0 billion tones (Kazmi, 1990). Irrespective of the wide distribution of the coal deposits in Pakistan and their proximity to traditional markets, coal production (all from underground mines) has remained more or less static over the past 25 years and annual coal production in Pakistan is estimated to be 2-3 million tones (Kazmi, 1990; Pracha, 1990). Currently coal contributes less than seven percent of the country's commercial energy needs (Kazmi, 1990). The major market is the brick industry, which relegates coal demand to the uncertain swings of the construction industry. In view of lack of confidence in the expansion of domestic oil and gas production, and possible future increases in imported oil prices, the Government of Pakistan (GOP) has started taking an interest in promoting the use of indigenous coal in power generation and as an industrial and household fuel. Accordingly, the Seventh Five Year Plan (Planning Commission 1987) envisage that coal production will increase to a level of 7 million tones per year by 1992-93 and that a drilling program will be undertaken during the plan period sufficient to add 500 million tones of new resources in the measured category.

There is good reason to view the present GSP/USGS/USAID combined efforts to assess the coal resources of Pakistan as a major contribution to Pakistan's coal sector. Under the Coal Resource Exploration and Assessment Program (COALREAP), funds are being provided by the USAID to: (a) formulate and implement plans for GSP to explore, assess and expand the indigenous coal resource base of the country by conducting exploratory drilling and field studies that will provide descriptions, thicknesses and stratigraphic correlations of coal beds and coal-bearing intervals; (b) perform chemical analyses of core and mine samples for proximate and ultimate characterizations and determinations of major, minor and trace elements; (c) conduct regional studies which will result in a series of maps and reports that will address the regional geologic framework of the country's major coal-bering areas; and (d) improve the GSP's overall capabilities by improving the agency's support facilities, including the planning, training and publication capabilities of the Quetta headquarters and four regional offices.

Coal beds in Pakistan can be generally characterized as early Tertiary, lignite-A to sub-bituminous-C, lenticular bodies (generally less than 3 m thick) that are interbedded with clay or rock partings. These sediments were deposited in coastal or river flood plain environments along the western edge of the Indo-Pakistani subcontinent while it was drifting northward to its present position. Most of Pakistan coal beds are generally high in ash (7-33 %) and sulfur (2.5-6.5 %), on an as received basis (Warwick & Javed, 1990). Three major coal areas (Fig. 1) are known to exist in Pakistan; and

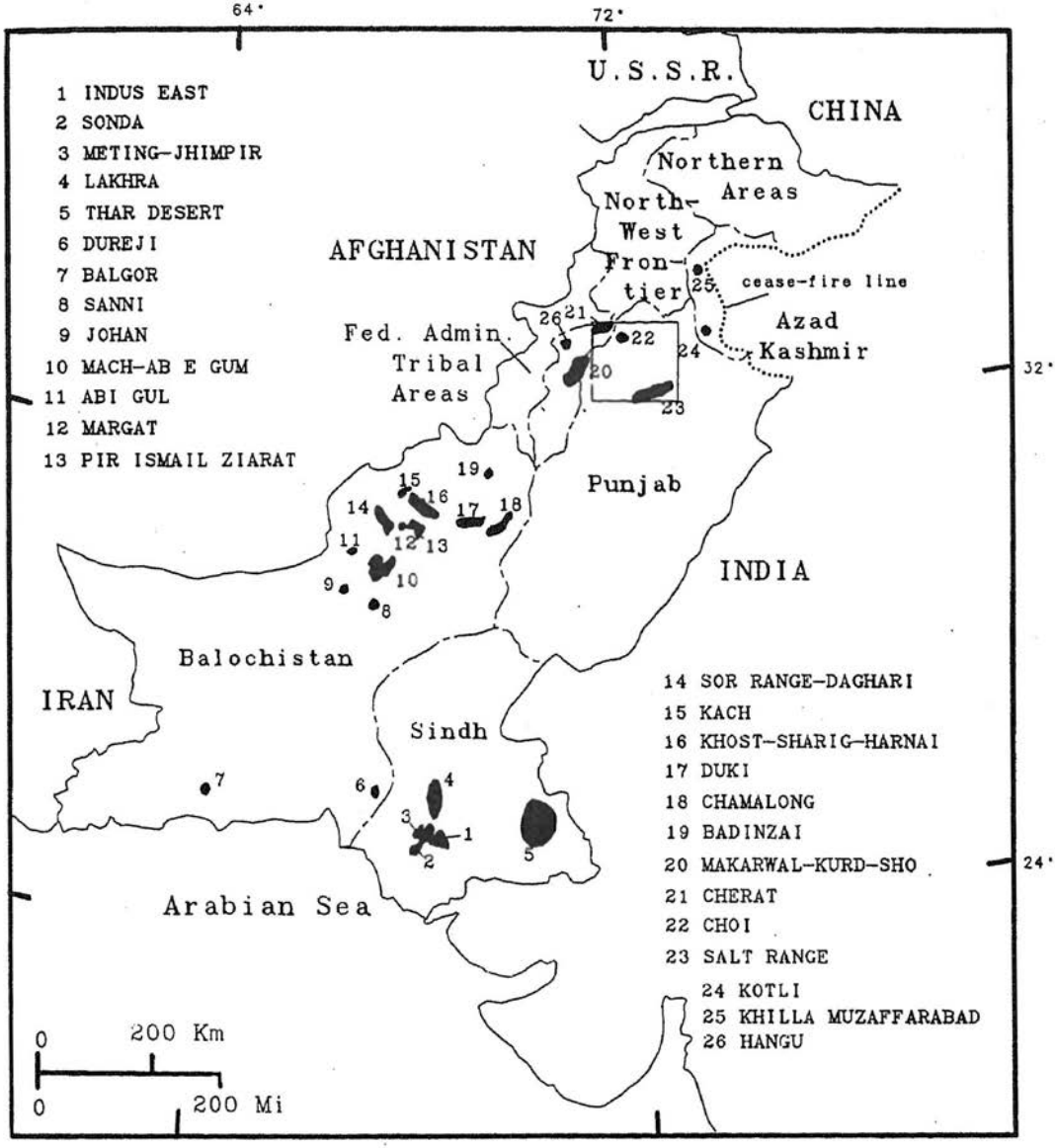

Fig. 1. Location of Pakistan coal fields and occurrences. Box shows Punjab Regional Framework area. Modified from Scheinfurth and Hussain, 1988.

these are located in southern Sindh , northern Baluchistan, and northern Punjab and adjacent areas. All these coal areas have been subjected to varying degrees of tectonic deformation, ranging from mild to intense.

Sindh Coal Exploration

An early program of sampling in coal mines was carried out by GSP and USGS personnel during the summer and autumn of 1985 (Simon et al., 1988) and a drilling plan for southern Sindh was developed by Schweinfurth et al. (1985). GSP initially drilled four USAID-funded holes in the Lakhra area in 1985 (L-series holes Figs. 1 & 2).

Further drilling by the Indus Valley Construction Co. Ltd. (IVCC), commenced in the Lakhra coal field (Figs. 1 and 2) in April 1986, and after expanding to the Sonda/Thatta area, was completed in May, 1987. Thirty-one holes were drilled during the first phase (Fig. 2). In the second phase of the drilling program, 13 more holes were drilled east of the Indus River (UAK 4-16 series, Fig.2). The result of these drilling programs, which covered about 46,600 hectares in the Lakhra area, 96,700 hectares in the Sonda area, and 48,000 hectares in the Indus East area, are discussed in the Landis et al. (1988), Thomas et al. (1988a), Schweinfurth & Husain (1988), and Thomas & Khan (1990). Another 20 holes (JK series, Fig. 2) were drilled in the Jherruk area of the Sonda coal field to investigate a 6 m thick coal bed that was intercepted (SanFilipo et al., 1989).

The coal deposits in Sindh Province (Fig. 1) are located in two stratigraphic horizons, the Paleocene Bara Formation and the Eocene Sohnari Formation. The Bara Formation is upto 940 m thick and is encountered at depths from 0 to 245 m in the Lakhra and Sonda coal fields. The Bara Formation contains at least 9 coal-bearing zones up to 35 m thick with individual coal beds up to 6.3 m thick (Ahmad et al., 1986; Schweinfurth & Husain, 1988; Kazmi et al., 1990; SanFilipo et al., 1990). The Sohnari Formation is up to 60 m thick and crops out in the Lakhra and Sonda areas (Outerbridge et al., 1990). It contains thin coal beds, generally less than 0.3 m thick. The Sonda coal beds range from a few centimeters to about 6.3 m thick and are generally thicker than those of the Lakhra area which range from less than 1 m to about 5 m thick. The main Sonda coal beds range from 115-300 m below the surface which is comparably deeper than at Lakhra, where the main coal beds are found at depths varying from 20 to 275 m below the surface (Schweinfurth & Husain, 1988).

The Sohnari Formation consists of siltstone, claystone, sandstone and coal and carbonaceous shale beds, and is lithologically similar to the Bara Formation (SanFilipo et al., 1990). Both the Sohnari and Bara Formations are near-marine, fresh- to brackish-water deposits. The marked difference between Lakhra and Sonda coal deposits is in their sulfur contents; the average Sonda coal sample contains less sulfur (2.6%) and

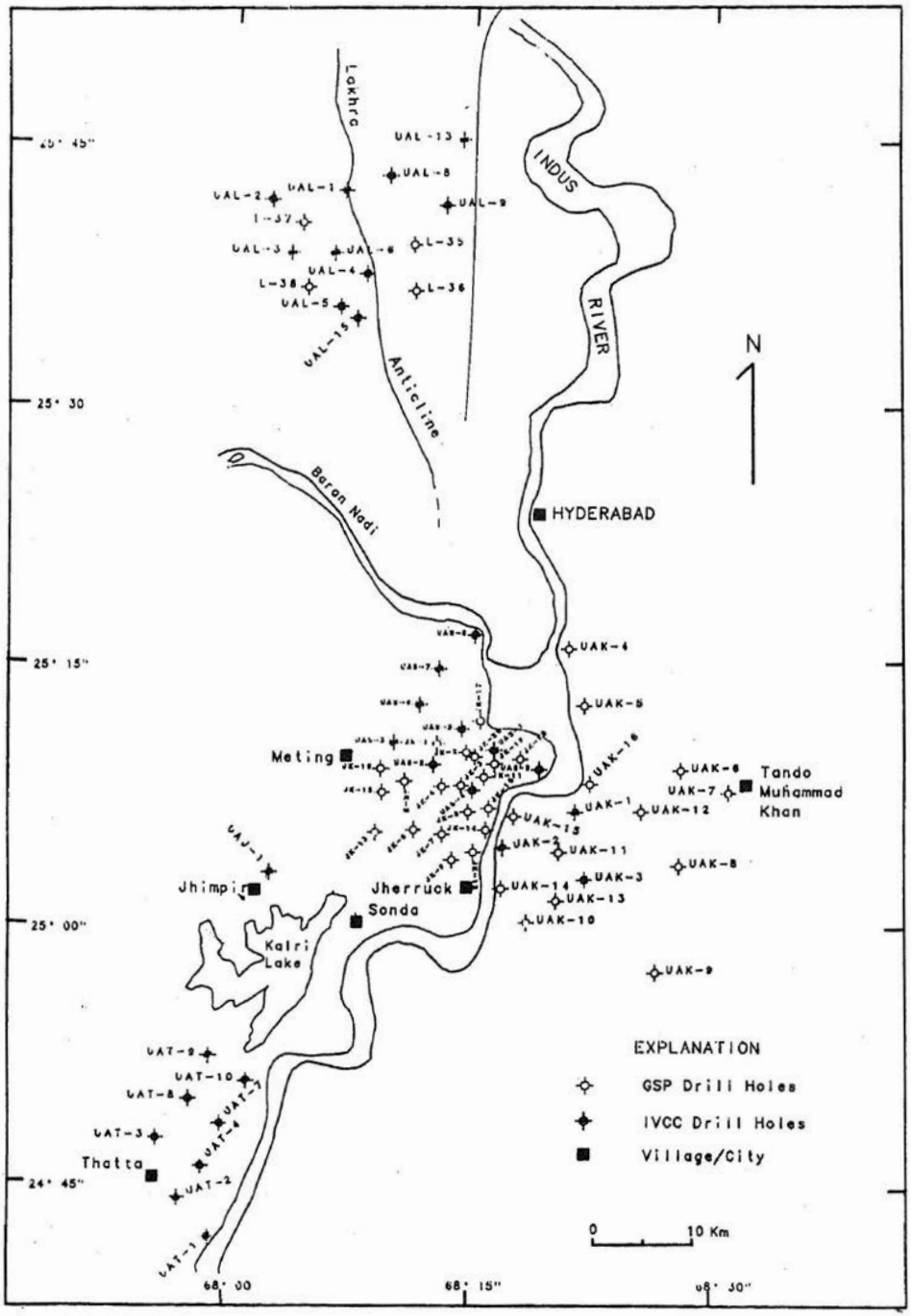

Fig. 2. Map showing COALREAP exploration drill holes in southern Sindh.

ash (15.4%) than the average Lakhra coal sample which contains 5.5 % sulfur and 19.1% ash, on an as received basis (Schweinfurth & Husain, 1988).

Coal samples from both the Lakhra and Sonda coal fields have the following average characteristics: 28.5% moisture, 28% volatile matter, 25.2% fixed carbon, 18.3% ash, 4.8% sulfur (on an as received basis). Average calorific value for Lakhra coal samples is 3,660 Kcal/kg, while that of Sonda samples is 3,870 Kcal/kg, on as received basis (Landis et al., 1988).

The total estimated original coal resources, by reliability category and in millions of tones, as estimated by SanFilipo et al. (1988), are: Lakhra-measured and indicated, 540; inferred, 510; and hypothetical, 30; Sonda-measured and indicated, 500; inferred, 2,520; and hypothetical, 680. The Lakhra coal field is estimated to contain 1,080 million tones; 3,700 million tones of coal resources are present in the Sonda area. About 470 million tones, or nearly 60% of the resources in Sonda are in beds 0.75 m thick or greater. Water and oil well drilling in the Thar Desert of Sindh suggests thick (up to 17 m) coal beds in the subsurface at depths less than 250 m (Fig. 1) (SanFilipo et al., 1990).

Baluchistan Province Coal Fields

The coal fields of Baluchistan (Fig. 1) are generally located in the northern part of the province, and contain sub-bituminous to bituminous, lenticular coal beds up to 2.3 m thick in several zones in the middle part of the Eocene Ghazij Formation which ranges from less than 1000 m to more than 2500 m in thickness. Paleocene rocks are apparently devoid of coal beds in Baluchistan (Shah, 1990).

Limited activities carried out in the coal fields of Baluchistan include structural and stratigraphic investigations in the Sor Range and Khost-Sharig-Harnai area (Fig, 1), and collection of stratigraphic sections and microfossil samples from outcrop and drill core (Brouwers et al., 1990). a limited number of coal samples have been analyzed from the various fields in Baluchistan and summarized by Warwick & Javed (1990).

Punjab and North-West Frontier Province Coal Fields

The major thrust of coal exploration in the Punjab has generally been limited to the Salt Range coal field (Fig, 1). Several COALREAP USGS/GSP geologists, however, have been working in the Makarwal, Choi, and Cherat areas of Punjab and NWFP (Fig, 1), and preparation of reports on these areas is underway.

Paleocene sediments in the Salt Range coal field (Fig, 1) were deposited disconformably over Precambrian to Cretaceous (Gee, 1989). Coal deposits in the Salt Range occur in the Paleocene Patala Formation and have been described by Warwick &

Shakoor (1988), Warwick & Husain (1990), Warwick & Javed (1990), Warwick et al., (1990), and Wardlaw et al., (1990). Average thickness of the coal beds is 0.43 m and thicknesses range from 0.1 to 2.13 m. The rank of the coal beds ranges from high volatile C to B bituminous (Landis et al., 1971; Ghaznavi, 1988; and Warwick et al., 1990). Forty-four coal samples collected from the salt range coal have an average ash yield of 24.2%, average sulfur content of 5.3%, and an average calorific value of 4,972 Kcal/kg (Warwick et al., 1990). A preliminary estimate of the total tonnage for the Salt Range area is 235 million metric tones, not including carbonaceous shale deposits (Warwick & Shakoor, 1988).

In the Makarwal coal field, the coal-bearing strata are within the Hangu Formation of Paleocene age. These sediments are overlain by younger Tertiary rocks that extend 5,000 m in total thickness (Danilchik & Shah, 1987). Thickness of the coal beds ranges from < 1m to 2 m (Danilchik & Shah, 1987). Makarwal coal beds, which are ranked as high-volatile B and C bituminous (Landis et al., 1971; Ghaznavi, 1988), have an average ash yield of 11.2%; they contain 40.2% fixed carbon, 5.14% sulfur, and have calorific values of 6248 Kcal/kg (on values on an as received basis and from Warwick & Javed, 1990).

A Permian coal bed from near the contact of the Warcha and Tobra Formations is being mined on a very limited basis near the town of Buri Khel in the western part of the Salt Range (Fig, 1). The maximum thickness of the coal bed encountered near Bari Khel is about 1 m (Warwick & Shakoor, 1988). Several unsuccessful attempts have been made by GSP to drill and test the extension of the Permian coal deposits into the subsurface of the Punjab Plains, south of the Salt Range. The drill holes, however, did not reach the target depth which was more than 1000 m.

Azad Kashmir Coal Fields

The sediments in the Azad Kashmir coal fields, which are mainly located in the Kotli area (Fig. 1), are similar to the Paleocene Patala Formation of the eastern Salt Range (Warwick & Javed, 1990). About 26 coal samples, collected for coal quality analyses and chemical characterization, indicate that the average ash yield is 29.2% and average sulfur content 3.3% (Ahmed, 1981; Shah & Bhutta, 1988). Average thickness of the coal beds is about 0.6 m.

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