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Geology and combustion perspectives of Pakistani coals from Salt Range and Trans Indus Range

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ABSTRACT

Abundant availability of low rank coals in some developing countries has a great potential for socio-economic development. Pakistan, as a developing country, has taken a number of initiatives some of which are at an advanced stage. Thus, a critical study of regional and local geology of Salt Range and Trans Indus Range coals located in the Kohat–Potwar geologic province is presented in this paper. Permian coal is the oldest coal, which is located in the Western Salt Range in limited quantity while Palaeocene coal is the younger coal and it is mined from the Hangu and Patala formations. The Palaeocene coal is available in abundance and is mined in the Eastern and Central parts of the Salt Range and Trans Indus Range.

Additionally, this study presents the thermo-chemical analyses of the coal samples collected from thirty coal mines of Salt Range and Trans Indus Range. The samples were analyzed for ash composition, ash fusion temperatures (AFT), proximate analysis, ultimate analysis and calorific value from two different Labs, i.e. SGS Pakistan and Changsha University of Science and Technology (CUST), China. The average AFT of the samples analyzed is >1350 °C, which reveals that the coal is non-slagging. On average the coal has low slagging index, medium fouling index, good combustion characteristic parameters and indices. The coal samples have high ash (14–50%), ultra-high sulfur (3.3–11.1%), low moisture (3–10%), high volatile matter (VM, 24–41%), low carbon (23–57%) with low to medium gross calorific value (GCV, 10.2–25.7 MJ/kg).

The data gathered from an extensive campaign is compared with the already published data. The study has provided a knowledge on utilization of coal reserves to meet the projected energy demand in Pakistan as well as in other developing countries.

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1. Introduction

The world has huge reserves of coal and prices are lower, in comparison to oil and gas. Depletion time of coal reserves is much >100 years, which is approximately three times bigger than oil and gas. Thus, coal being sustainable energy source will become energy substitute for oil and gas in future (Shahriar and Topal, 2009; Wolela, 2007). Coal-fired plants continue to be the largest source of electricity generation all over the world and share of coal in the world power generation mix is >40% (Burnard and Bhattacharya, 2011; WCA, 2014; Widera et al., 2016). However, the share is declining due to exploitation of the renewable resources. In Pakistan, power generation policy has recently shifted the interest from oil and gas to coal based power generation (National Power Policy, 2013). At present, the share of coal in power generation of Pakistan is <1% (Punjab's Initiative for development of Coal Fired Power Projects, 2014). The share of coal in the Pakistan energy mix could be increased considerably using low grade coals such as sub-bituminous ones in Salt Range, Trans Indus Range in Punjab and Baluchistan, and lignites in Thar and Lakhra (Sindh). These low grade local coals are of high potential for economic power generation for Pakistan. Furthermore, the coals can be blended with better quality imported coals for higher performance and compliance with environmental regulations.

One feasible method for small to medium scale power production is fluidized bed combustion (FBC). This technology is flexible enough to utilize low grade and noncompliant quality coal while maintaining low emissions of sulfur oxides (SO_x) and nitrogen oxides (NO_x) (Koornneef et al., 2007; Findlay and Probert, 1993).

In the literature, geological aspects and combustion perspectives of Pakistani coals have not been fully investigated. The regional geologic studies of the coal-bearing areas in Northern Pakistan were conducted under Potwar Regional Framework Assessment Project (PRFAP) and the assessment of coal resources for Pakistan was done under Coal Resources Exploration and Assessment Program (COALREAP), a joint

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study by US Geological Survey (USGS) and Geological Survey of Pakistan (GSP) (Warwick and Wardlaw, 2007). Latest work on regional geology, local geology, coalfield stratigraphy and coal resources of Salt Range and Trans Indus Range has been done by "Snowden" for Mines and Minerals Department of Punjab in Pakistan (Coal Resource Report, Snowden, 2012). The study has confirmed that there are 500 million tons of coal reserves in Salt Range and Trans Indus Range (Power generation projects in Punjab, 2012).

Daood et al. (2014) performed the combustion test of Thar lignites in pilot scale facility and examined the emissions of the coal like NO_x, CO, CO_2 and SO_2 with slagging and fouling analysis of ash samples at different combustion conditions. Zaidi (1995) studied the coal reactivity and char formation for the five coals collected from Lakhra, Sindh, Sore-Range & Sharigh, Baluchistan, Makarwal, Punjab in Pakistan and Sin Kiang in China. Iqbal et al. (2006) investigated four coal samples from Islamkot, Thar parker and studied the effect of particle size on peak and burn out temperatures and increase in VM on removal of inherent mineral. Naveed et al. (2013) investigated the coal of Eastern Salt Range (Chakwal) and recommended the coal for gasification. However, the work on Salt Range and Trans Indus Range coal is very limited.

This study focuses on the geology, coal field stratigraphy and combustion perspectives of the coals from the Salt Range and Trans Indus Range. It will help engineering community, government and private sector to make decisions for the investment in design, engineering and installation/setup of coal mines and small to medium size coal-fired power plants. It will help to exploit indigenous coal resources of Punjab in particular and of Pakistan in general to produce cheap electricity as compared to oil-fired power plants and to bridge the gap between demand and supply of electricity for better economic growth.

2. Geology

Pakistan region under study is showing on geological map (Fig. 1). The Salt Ranges and Trans Indus Ranges are situated in Kohat–Potwar geologic province, which is bounded by the Parachinar-Murree fault in the north, the Kurram fault in the west and the Jhelum fault in the east. Indus geologic province is located on the south of the Salt Range (Warwick and Wardlaw, 2007). The Kohat–Potwar geologic province is characterized by regional geological structures (Fig. 2). The mountains of Kohat and Potwar Plateau falls are known as Sub-Himalayas. The Himalayan orogeny is the outcome of collision between the mighty Eurasian Plate drifting southward with the Indo–Pak Plate drifting northward. The collision started somewhere in Eocene (<55 million years ago). Both the plateaus are separated by Indus River (Wandrey et al., 2004). Structurally, these plateaus are fold and thrust belts. In the north they are bounded by Main Boundary Thrust (MBT), while in the south these are bounded by Main Frontal Thrust (MFT) (Jaswal, 1990). Depositional record of the Kohat–Potwar geologic province is known from late Proterozoic to Holocene.

The Salt Range as rightly said 'THE MUSEUM OF GEOLOGY' extending about 250 km east–west and about 7–8 km north–south is the most southern part of the Himalayan orogeny. It is exposed along the Main Frontal Thrust (MFT). The ramp-like structure dipping north, verging south on the Indo–Pak Plate seems to be responsible for the Salt Range thrust (a part of MFT). On the east, the Salt Range terminates along the Jhelum Fault and in the west it terminates with the Kalabagh Fault and further it runs in north-south direction (Sameeni, 2009).

2.1. Stratigraphy

Coal of Salt Range and Trans Indus Range is found at three different stratigraphic horizons, i.e. rocks of Permian age, Hangu and Patal formations of Palaeocene age. However, the age range of stratigraphic units of the Salt Range is from Precambrian to Quaternary (Fig. 3). Permian coal is the oldest one, which is located in the Western Salt Range and is limited in quantity. Palaeocene coal is younger and is extracted from Hangu and Patal formations, and it is available in abundance.

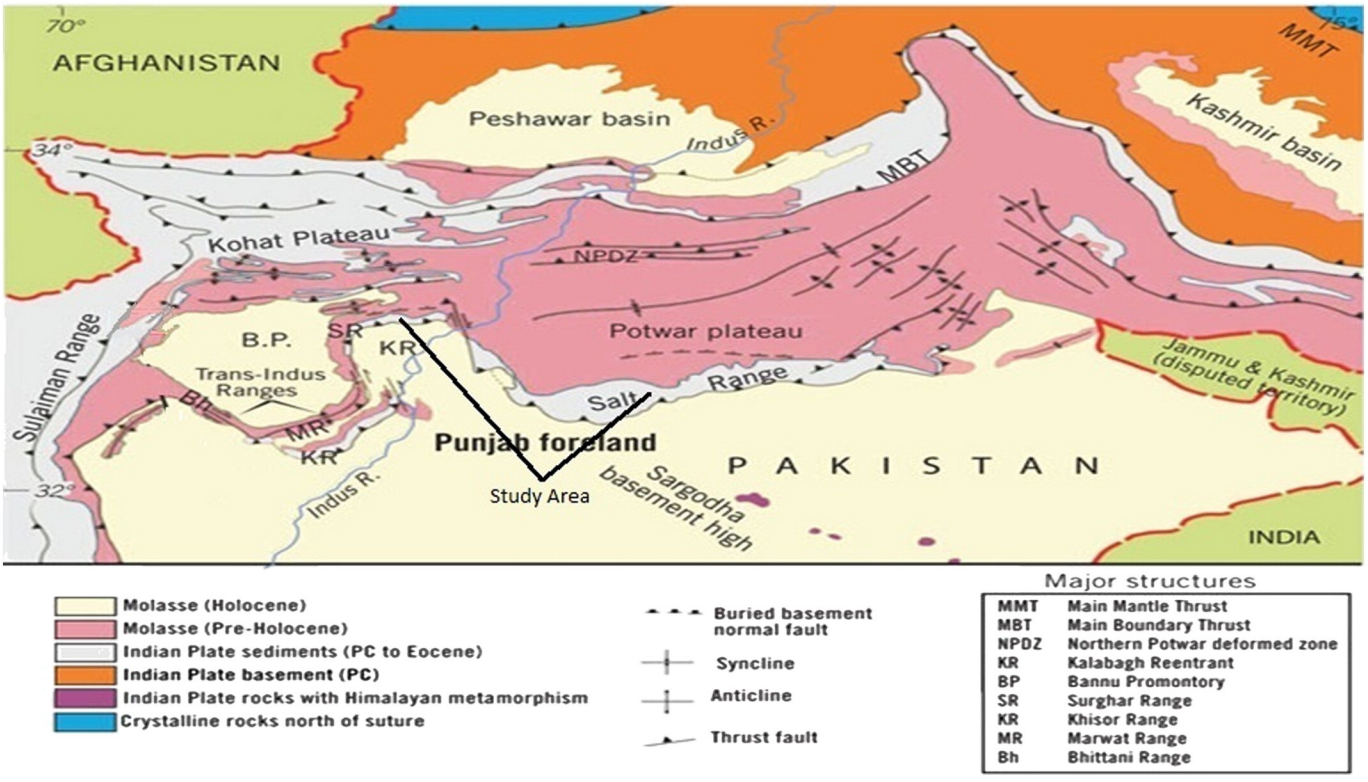

Fig. 1. Salt Range and Trans Indus (Surghar) Range in the geological background.
Source: Modified after Kazmi and Rana (1982).

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