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RESEARCH ARTICLE

Mineral Resources of Pakistan-an update

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Abstract:-Pakistan contains Pre-Cambrian to Recent rocks with different tectonometallic and sedimentary basins. The Chagai-Raskoh magmatic arc and Indus Suture areas are the richest metallogenic zones in Pakistan. Pakistan has high potential of minerals like indigenous iron, copper (associated some gold, silver, molybdenum), lead, zinc, barite, chromite, coal, gypsum, ochre, silica sand, granite, limestone (marble), clays, sandstone, etc, and low potential of antimony, asbestos, celestite, fluorite, magnesite, soapstone, sulphur, vermiculite, etc. Some commodities are being utilized and some are being exported but most of the commodities are waiting for their utilization. Cement raw materials are common, so the installation of more cement industries especially in Daman of Sulaiman Range can help a great for the country economy by exporting. Further water resources are two much and water is going into sea after creating flood and loss in the agricultural lands and population, so small and large dams are necessary due to population increasing. To overcome energy crises the small diversion dams are vital. The first and huge gypsum deposits of Pakistan are found in Sulaiman foldbelt of Balochistan but not utilizing for well development of provinces and Pakistan. Most of the coal in Pakistan is lignitic but not being exploited. Only metallic coal is being mined and used. So there is a need to develop technology to mix lignitic and metallic coal. Pakistan is rich in energy and natural resources like coal, solar, wind, biomass, terrestrial and marine water but deficient in development. In short Pakistan should cease the imports of these commodities and to save foreign exchange. The main purposes and goals of the present study are to present handy and brief information based on previous and recent wide spread work and also recent discoveries. Furthermore, the mineral resources are vital for the development of Pakistan due to increasing population.

Keywords: Natural Resources, Balochistan, Khyber Pukhtunkhwa, Punjab, Sindh,

INTRODUCTION

Pakistan contains Pre-Cambrian to Recent rocks with different tectonometallic and sedimentary basins like Khyber-Hazara-Kashmir (northernmost/uppermost Indus), separated by MBT from Kohat and Potwar (north/upper Indus), separated by Sargodha high to Pezu from Sulaiman (middle/central Indus), separated by Sukkur rift to Jacobabad high, and Kirthar (south/lower Indus) basins of Gondwanan, separated from the Balochistan basin and Kohistan magmatic arc of Tethys by western Indus Suture and northern Indus Suture respectively, and Karakoram-Hindu Kush basin of Tethys and Asia (Laurasia). From the beginning of Pakistan, many geoscientists incorporated the new discoveries in the previous records and reported the review of mineral/minerals of Pakistan or part of it. Gee (1949) presented a summary of known minerals of northwestern India (now Pakistan) with suggestions for development and use. Heron (1950) and Heron and Crookshank (1954) reported economic minerals of Pakistan. Ahmad (1969) Ahmad and Siddiqui (1992) and Kazmi and Abbas (2001) presented a comprehensive report on minerals of Pakistan. It is a common routine to report the minerals of Pakistan with fresh discoveries after one or two decades. Arbab and Shah (1997) and Hussain and Karim (1993) prepared a mineral map of Azad Kashmir and NWFP respectively. Malkani (2010b, 2011) presented the mineral potential of Sulaiman

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foldbelt and Balochistan provinces respectively. After Kazmi and Abbas (2001) many discoveries of fluorite, gypsum, celestite, coal, marble, gold-silver, antimony, copper, REE, gemstones, cement resources, etc are made. The main purposes and goals of the present study are to present handy and brief information based on previous and recent wide spread work, recent discoveries and many field observations done by senior author.

MATERIAL AND METHOD

The materials belong to compiled data from previous work and new discoveries and also field data collected by senior author during many field seasons about mineral potential and new discoveries (Fig.1; Table 1, 2, 3, 4, and 5). The methods applied here are many discipline of purely geological description.

RESULTS AND DISCUSSION

Mineral Resources of Pakistan-an updae Industrial Resources (Metallic and non-metallic Minerals)

Antimony: The main antimony mineral stibnite is reported from the Chitral state, Qila Abdullah and Siahan and North Makran ranges. Minor showings of antimony occur in Salt range, Zaimukht hills of Kurram valley and near Khuzdar. The significant stibnite of **Chitral state** is reported from the Krinj, Partsan and Awireth Gol area of Lutkho valley in the north and northwest of Chitral. The **Qila Abdullah** stibnite is reported in the Qila Viala area 40 km east of Qila Abdullah. The stibnite veins are hosted by Eocene–Oligocene Murgha Faqirzai shale and Shaigalu Sandstone. **Makran and Siahan ranges** show many small veins of stibnite (Malkani 2004a,b; 2010b; 2011). Gold, silver and sulphur mineralizations are also enriched in this zone. Stibnite occurs in the form of veins, stringers and lenses in the faults especially oblique strike slip faults, gash fractures and shear zone in the Siahan, Hoshab and Panjgur formations. **The main antimony localities** are Jauder, Hurain, Gokumb and Kuchaki North (35 A/11), Siminj (35A/4), Mir Baig Raidgi, Safed Gilanchi and Machi Koh (35M/15), Palantak Koh (35A/2), Lidi (35A/14), Saghar (35A/4) and Miani. Other small localities of stibnite associated with gold and silver hosted by quartz carbonate veins in toposheet 35A/11 are South Surmagi Patkin, North Surmagi Patkin, Haspi Patkin, Kulo Patkin, Hurain Patkin, Siagari, Kuchaki south, Ahmadab Kaur, Sor Jor Jauder, Mahmoodi Kaur, Kasig Kaur, Musa Kaur, Panir body east, Nagindap Damagi, Hashani Damagi, Hashani and Panir Body west (Malkani 2011).

Arsenic: The orpiment and realgar are reported from Chitral areas. They are associated with marbles and calcareous shales of probable Cretaceous age. The Lundku and Mirgasht orpiment deposits are located few kms to the north of Lundku in the Tirich valley, Malikho district (White, undated). Some of these mines are mined in the past. Arsenopyrite, alongwith chalcopyrite and pyrite occur in Dainyor and Jotiyal nalas in Gilgit agency (Ahmed, 1969).

Bismuth, cadmium and cobalt: These are reported from the Lahor and Pazang areas 3 km N and SE of Besham, Besham nappe.

Bauxite: The commercial bauxite deposits are found in the Indus Formation (bauxite and laterite) in the Katha-Pail area of Salt Range, Chhoi-Akhori area of Kalachitta Range and Muzaffarabad-Kotli region of Azad Kashmir. **Katha-Pail bauxite-laterite-clay** bed (1-7m thick) occurs at the boundary between Wargal/Amb Formation and Hangu Formation. It contains 35.5-72.5% alumina, 8.68 to 50% silica and 10-20% iron (Ashraf et al., 1972). It represents generally low grade bauxite with high silica and moderate to low alumina and iron. The ore contains boehmite and kaolinite with minor amounts of diaspore and gibbsite with more than 100 million tones/mt (Khan and Hussain, 1970; Cruijs 1975). **Chhoi-Akhori deposits** occur between Lumshiwal and Hangu formations and Jurassic Samanasuk limestone and the Triassic Kingriali formation. The upper horizon comprises of upper 3m thick oolitic or pisolitic laterite and lower 4m thick bauxitic material. The alumina clay, laterite, and bauxite occur as lenticular bodies

associated with ironstone, ferruginous and quartzose sandstone and claystone. The bauxite contains 32-76% Al_2O_3, 2.5-43% SiO_2, 0.25-12% Fe_2O_3, and 2.2-4.2% TiO_2 (Cruijs, 1975). The lower lateritic horizon at the base of Datta Formation is more widely distributed and contains alumina clays, and claystones and alumina. The alumina clay samples from Chhoi contain

30-86%) is 11mt, Surge (Alumina 45%) is 13mt, Buta is 17t and Akhori (Alumina 55%) is 3.5mt (Hussain and Naqvi, 1973). **Muzaffarabad- Kotli deposits** occur in Indus formation which is a disconformity between the Cambrian Abbotabad dolomitic limestone an overlying coal and Paleocene coal and shales of Hangu (synonym Patala) formation. The Indus Formation showed in to

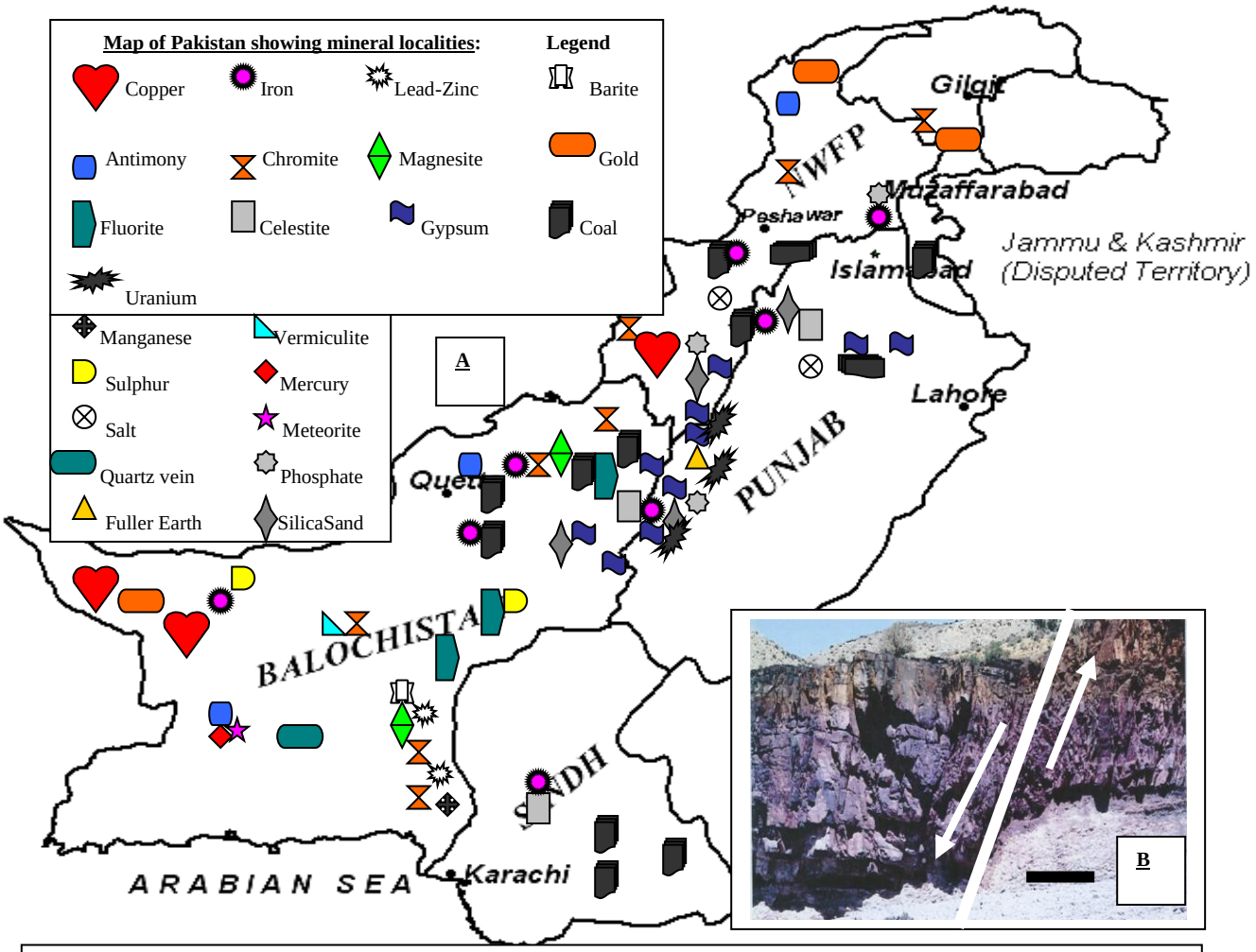

Figure 1. **A**, Map of Pakistan showing mineral localities; **B**, Dilband iron ore (Kakepoto 2011) with right lateral fault, Scale black line=1m.

74.24-86.84% Al_2O_3, 0.64-0.74% Fe_2O_3, 6-7% SiO_2, and 3.65-4.28% TiO_2. Some of this material is being used for fireclay. Estimated reserves down to 33 m depth of Bagh Nilab (Alumina 40-50%) is 2mt, Chhoi (Alumina

bauxitic and lateritic deposits in Seri Dara, Dhaman Jhal-Niazpur, Khila, Maira Tanolian, etc, areas of Muzaffarabad, and Salhun, Nikial, Khander-Karela,Shiester, Giain, Dandili, Kamroti and Sangar Marg

areas of Kotli District. The bauxite is pisolitic, embedded in a clayey matter, 0-12% boehmite, 0-14% of gibbsite, 1.5-10%quartz, 0-35% chalcedony, 2-89% iron oxides (Ahmad and Siddiqi 1992). These deposits have been sporadically mined. The reserves of Dhanwan (alumina 41-60%, silica 18-40%, iron 1-8%) is 4.9mt, Kamroti (alumina 50-70%, silica 9-28%, iron 1-2.5) is 1.36mt, Sawar (alumina 52-56%, silica 25%, iron 5%) is 0.93mt, Dandili (alumina 34-46%, silica 36-44%) is 1.18mt, Nikial (alumina 41-46%, silica 13-35%, iron 2-27%) is 0.424mt, Goi (alumina 47%, silica 35%) is 1.103mt, Shisetar is 0.656mt, Bermoach (alumina 51%, silica 23%) is 0.2mt, Balmi (alumina 46%, silica 31%) is 0.209mt, Khandar Karela is 0.209mt and Palan is 0.283mt with total 11.454mt. **Aluminous rocks** can be associated in Vitakri formation and Vihowa group red beds (Malkani 2010b; 2011a). Further recently Malkani collected samples of fuller earth from Domanda and Drazinda shales of western (Zin area) and eastern limb (Mahoi area) of Zinda Pair anticline, Tehsil Taunsa, Dera Ghazi Khan District and their chemical results show SiO_2 50.86 to 64.01%, Al_2O_3 9.79 to 17.18%, Fe_2O_3 3.10 to 6.89%, CaO 6.41 to 12.20%, MgO 2.01 to 5.64%, P_2O_5 nil and loss on ignition/volatiles 8.87 to 12.60%.

Iron, late

Iron, laterite and ochre: Iron have been reported from Indus Platform (at Kirana hills near Chiniot 110mt of hematitic iron ore), Indus fold and thrust belt subdivided in to Khyber-Hazara-Kashmir (uppermost Indus) foldbelt (Langrial-30mt, Galdanian-Hazira-Churi Gali 100mt, Nathiagali), Kohat and Potwar (upper Indus) foldbelt (Mazar Tangi, Marai Bala, Samana Range, Nizam Pur 100mt, Kalabagh-Chichali-Makerwal 300mt, Pezu 66mt), Sulaiman/middle Indus foldbelt (Rakhi Munh-Zin-Taunsa), and Kirthar/lower Indus foldbelt (Dilband 200mt), Balochistan Basin include Chagai magmatic arc iron deposits of about 85mt (Saindak, Mashki Chah, Durban Chah, Amir Chah, Chilghazi, Gorband, Kasanen Chapar, Kundi Baluchap, Pachin Koh, Chigendik, Bandegan and Nok Chah), Makran basin, Kaker Khurasan basin; NW Himalayas (Abbottabad, Galdanian, Langrial and Besham), Indus Suture (Shekran and Mona Talar), Besham, Sherkot Kolai and Jijal); Kohistan magmatic arc (Shah Dheri, Mamarai-Saidu, Ghazanosar, Manarsi, Munda, Dammer Nissar-6.5mt and along MKT). Major iron deposits are Dammer Nissar iron deposits, Langrial iron deposits, Kalabagh iron deposits, Pezu iron deposits, Nizampur iron deposits, Dilband iron deposits (200mt; Fig.1b), Pachin Koh-Chigendik iron deposits and Chilghazi iron deposits. **Fort Munro low grade iron deposits** (Fe_2O_3 14-21%) are hosted by Paleocene Rakhi Gaj Formation (Malkani 2010b). The hematite and possibly hydrous iron silicates (chamosite and glauconite) are major iron mineralization of Rakhi Gaj formation. It is widely exposed on the both limbs of Fort Munro anticlinorium, Kingri, Pekal, Aram and Badhi-Dhaola anticlines. This ironstone deposits are very large but low grade. It's testing for steel, cement and other industries should be make, and it may prove worthy. The extensive iron beds thickness varies from 2 to 50m. The highly anomalous thickness is found in Khar, Top Girdu, Fort Munro and Rakhi Gaj and its vicinity areas. Its reserves seem to be 400mt from surface exposure to easily mineable depth 200m. Its mining is easy due to exposure above the ground surface, and at places low dips. The Fort Munro iron deposits seems to be feasible due to availability of huge but low garde raw materials, peacefull and favourable locations on metalled road and near to D.G.Khan railway station. It is located in the centre of Pakistan and ideal location for all provinces. They are mainly located along unconformities in the Foreland basin. The deposits of Ziarat found in the KT boundary disconformity named as Vitakri formation which is contacted by the Dungan and Parh limestones in Ziarat and its vicinity areas. **Gossan/red iron oxide** coloration are found in Shyok Suture. Laterite has also been reported from Moza Mungiwali, Gakkar, Pind Trer, Daud Khel, Kathwai, and several localities in Kalachitta range; in Kohat district at Mazari Tang and Marai Bala; in Samana range16km from Hangu; near

Langrial 32km south of Abbottabad and near Kalabagh. The disconformity in the Eocene Sohnari Formation has limonite and ochre at Lakhra, Meting and Makli hills. Dilband iron ore (Fig.1b) found in Dilband Formation at J/K boundary in the Vicinity of Dilband and Johan area of Mastung, Kalat, and Bolan and Quetta districts. K/T boundary in Sulaiman Range is represented by Vitakri Formation), is also very significant for ochre and lateritic materials. The possible low grade but large deposits of Ochre/Iron from Chitarwata, Rakhi Gaj, Vitakri, Drazinda formations and Vihowa group of Sulaiman Foldbelt have been expected (Malkani 2011). Micaceous hematite is also reported from Muzaffarabad area of Azad Kashmir (Malkani and Mahmood in process; Mahmood and Malkani in process).

Chromite: Chromite occurs mostly in the Indus Suture (Western and Northern Indus Suture). Main localities of Chromite are Chilas, Besham Jijal, Kohistan, Harichand-Sakhakot-Qila west of Dargai, Kot-Pranghar (Mohmand), Bucha (Mohmand), Boya (Waziristan), Muslimbagh, Zhob, Bunap and Rayo Ras Koh, Wad, Sonaro and Ornach. The ophiolite contains lenticular or disseminated bodies of chromite.

Copper: The Saindak, Dasht Kain, Talaruk and Shinkai (Boya) deposits studied in detail so far. Copper deposits at Dir and Drosh in Khyber Pukhtunkhwa are also significant. **Shinkai (Boya),** Mami Rogha and Spin Kama of Waziristan **copper deposits** is located in the west of Razmak. According to Badshah (1994), ninety two test holes revealed average copper content 0.386% with inferred reserves of 120 million tons (mt; 1ton=1000kg) upto depth of 159m. **Dir copper deposits** represent a number of copper showings. The SDA has explored one of the more promising ones in Bekarari-Rokhan area, a few Km NW of Dir. The result indicates total reserves of about 45mt with 0.4-0.6% of copper and 2-30 ppm silver (Khan and Ahmad, undated). Some localies are Mirkhani, Pana Kot, Usheri region and Bekarai-Rokhan of Dir; **Drosh copper deposits** contain several showings of copper within 8-10km of Drosh town. The mineralization is in the Karakoram Suture/Shyok Suture. SDA estimated reserves of 24mt of the ore averaging 0.5% copper with silver ranging from 3 to 130 gms/ton. **Chagai** is the most promising arc which contains many copper occurrences like Talaruk, Saindak, Koh Dalil, Mashki Chah, Darban Chah, Amuri, Yakmach, Kangord, Galtori, Omi, Ziarat Pir Sultan, Kabul Koh, Dasht Kain, Chagai, Koh Marani, Pakus Nala, Nok Chah, Dalbandin, Amir Chah, Ziarat Malik Karkam, Bazgawanan, Kundi Balochap, Bandegan and Robat. **Dasht Kain copper deposit** is a porphyry type copper prospect associated with two tonalite porphyry stocks. Average copper values in quartz sericite zone vary from 0.1-0.17% and in the potassium silicate zone from 0.25 to 0.54 %. The breccia pipe zone in the eastern stock contains surface values upto 4.5% copper but not drilled. **Talaruk copper deposit** is a massive Kuroko type deposit and mineralization is of submarine exhalative origin. **Saindak copper deposit**s are developed in siltstone, sandstone, and tuff of Amalaf Formation. The mineralization is related to small patterns cantered on three porphyry stocks of Mid-Miocene age and consequently there are three main ore bodies, the North, South, East ore bodies. The total reserves at Saindak comprised 412mt of ore containing average 0.38% copper and 0.3228gm/to of gold. At Saindak an open cast mine with infrastructure, crushing plant, concentrators and smelter has been developed and trial production of blister copper has been done. It is planned to produce annually 15,800 tons of copper, 1.47 tons of gold and 2.76 tons of silver (Bizenjo, 1994). **Other porphyry copper deposits in Chagai district are** explored and evaluated by BHP recently. Their results suggest that the western part of the district has great potential for development of porphyry copper deposits. Based on the results of 80 test holes, it is estimated that this region has reserves of **550mt** (Razique 2001) of averaging **0.4 to 0.6% copper** and **0.2 to 0.5gm/ton of gold**. The world class copper-gold deposts are reported in the **Rekodiq area.** According to

BHP besides **Rekodiq**, Buzzi Mashi and western Ware Chah, other localities such as Parrah Koh, Borghar Koh, Koh Dalil, Koh Sultan and Ting Daragaun look promising and merit detailed exploration. Tethyan Copper Company has recently drilled 30 holes at Rackodiq (Koh Dalil) and has encountered a chalcocite blanket and hypogene zone. In this zone reserves of **70mt of ore with 0.85% copper** are indicated (Kazmi and Abbas 2001). **Copper, gold** and other minerals are found from epigenetic, polymetallic and metamorphic deposits in Chitral like Kaldam Gol, Shishi, Madashil, Shoghot, Pir Burhanuddin, Kogazi, Baig and Awireth-Shogor-Sewakht-Krinj. Some other copper localities are Babusar, Phalkot and Galdanian; Gujarghuna Parachinar (Kurram Agency), Gawuch Gol, Kaldam Gol, Gorin Gol and Langer; Yarkhun valley (near Kunhar); Chapali, Chapchirag, Pakhturi and Rain of Mastuj. The vein type copper-silver deposits are found from Imirdin, Madashi, Shoghot, Prince Burhanuddin, Koghozi, Mogh and Kokil Gahirat of Chitral. Copper from volcanogenic magnetite deposits of Ashnamal, Lal Qila, Barwa Kambat and Dommel Nissar are reported. In Raskoh arc and ophiolitic rocks include significant pockets of copper minerals which may be categorized as small deposits. From Kirana hills some copper mineralizations are also reported by Hassan et al. 1987. Haq et al. (2013) reported significant copper in Dir area of Kohistan magmatic arc. So this arc is the second arc in Pakistan after the Chagai arc. Like Chagai, the Kohistanh magmatic arc may contain significant world class copper and gold deposits.

Lead and Zinc: The major lead-zinc and barite deposits occurred in Las Bela-Khuzdar region. This region also hosted the Bela ophiolitic thrust belt. The mineralization is found in the upper part of Lower Jurassic Shirinab Formation. Main deposits are Shekran, Ranj Laki, Malkhor (NW of Khuzdar), Gunga, Surmai (SW of Khuzdar, and Duddar (SE of Bela). Minor deposits and showings of **lead-zinc** are found from Parabeck, Imirdin, Muzhigram, Tashker and Pakhturi of Tirich Mir zone, and Baig, Madashil, Awireth of Chitral; Faqir Mohd (Hazara), Hal, Kokal, Mihal, Paswal, Lahor, Pazang and Ushu. The estimated lead zinc reserves of Pakistan are about 16mt, only small, sporadic mining of the smaller deposits in Chitral and Chagai districts have been carried out. The Makki Chah is a zinc deposit. Some Pb-Zn showings are also found near Nikial (on Kotli-Nikial road) and also Surgan and Gamut areas in Neelam valley Azad Kashmir (Malkani and Zafar in process).

Manganese ore: ophiolite related mineralization in Kassai area of Lower Mohmand Agency, Sakhakot-Qila, Prang Ghar, Qila, Behram Dheri, Narai Obe, Bucha, Newe Kili and Hero Shah and Shangla area of Swat; Thal, Shinkai Waziristan; **Lahor-Pazang** area, near Besham; from Galdanian, Churi Gali; In the Himalayan region, the discontinuous lenses occur in red-bed hematitic sequence in the Cambrian Hazara Formation. The manganese in the Bela ophiolitic thrust belt, lenticular manganese ore bodies occur in ferruginous and siliceous horizons overlying basaltic pillow lavas. The more important localities are Kharari Nai, Siro Dhoro, Sanjro Dhoro, Bhampani Dhoro, Gadani ridge and Dadi Dhoro. The estimated total reserves of manganese in Pakistan is 0.5 million tons with manganese range from 15-48% (Nasim 1996).

Nickle: It occurs in Malam Jabba; Souch (Kaghan) and Swat and Shangla-Alpurai areas.

Tungston: Tungston occurs in Oghi Hazara, Susagali granite, Amalaf Chagai and Miniki Gol area of Chitral. The placer sheelite occurs in the Siran River sand (Mansehra district) and in the Indus River of northern areas where it is estimated 96 tons of detritial tungsten minerals in about 40 million tons of placers.

Fluorite: It is reported from Mirgasht Gol and Yarkhun valley (NE part of Chitral); Chakdara (Dir) comprise fluorite quartz veins cutting two mica granite gneiss; Bicheha Kurd (Sherwan); Khyber-Hazara metasedimentary fold and thrust belt as disseminations; After the first largest deposits of fluorite from Dilband and its vicinity areas

of Kirthar foldbelt, the Malkani (2002; 2004d) discovered the second largest deposits (6750 tons) of fluorite from Mula-Zahri Range of Kirthar foldbelt, Malkani (2010b) discovered the third largest deposits of fluorite from Sulaiman Foldbelt. Malkani

Table 1. Reserves size of Mineral Resources of Pakistan.

Industrial Mineral Resources											
Antimony	Small	Arsenic (orpiment)	Small	Bauxite	Small	Laterite	Large	Ochre	Large	Celestite	Medium
Chromite	Large	Quartz veins	Medium	REEs	Small	Copper	Large	Iron ore	Large	Vermiculite	Small
Zinc	Medium	Manganese	Medium	Magnesite	Medium	Asbestos	Small	Fluorite	Medium	Barite	Large
Kyanite	Small	Soapstone&Talc	Small	Pyrite	Small	Mica	Small	Witherite	small	Abrasives	Medium
Pumice	large	Millstone	large	Lead	medium	Rare metal	Small	Quartzite	large	Calcite vein	Medium
Rock Salt	Large	Lake Salt	Medium	Trona	Small						
Ceramic Mineral and Clay Resources											
Clays	Large	Fuller's earth	Large	China clay	Medium	Bentonite	Medium	Fire clay	Large	Feldspar	Small
Silica sand	Large	Nepheline syenite	Medium								
Fertilizer Resources											
Gypsum	Very large		Rock phosphate		Medium		Nitrogen		Large	Brine/Potash salt	Small
Cement Raw Material Resources											
Limestone	Very Large		Clays/shale		Very large		Gypsum deposits		Very large		
Construction, Dimension and Decorative Stone Resources											
Agglomerate	Very Large	Marble	Very Large	Onyx marble	Very Large	Basalt	Very Large	Granite	Very Large		
Gabbro	Very Large	Serpentine	Very Large	Slate stone	Very Large	Dolomite	Very Large	Limestone	Very Large		
Sandstone	Very Large	Gravel	Very Large	Bajri	Very Large	Sand	Very Large	Clays/shale	Very Large		
Conglomerate	Very Large	Chalk	Very Large								
Jewelry and Gemstone Resources											
Gold-Silver-Platinum	Medium		Gemstone Resources		Medium to Large						
Non-Renewable Energy Resources											
Coal	Large		Uranium	Small	Oil	Medium		Natural Gas	Medium		
Renewable Energy Resources											
Solar	Very Large	Air/Wind	Large	Terrestrial water	Very Large	Marine water/ocean	Very Large	Biomass	Large		
Tides	Very Large	Waves	Very Large	Current	Large	Land	Very Large				

(2010b) reported first time **fluorite** from Gadebar and Daman Ghar ranges of Loralai area occurring as veins in faults and fractures which are hosted by the Jurassic Loralai limestone. The fluorite represents many colour like pink, blue, light grey, green, light yellow, etc. Mining is in progress in the Mekhtar (Balao, Inde, Sande and Zhizhghi), Tor Thana and Zarah areas. The estimated reserves are about 50000 tons (Malkani 2011; 2012a). Further exploration in Jurassic Chiltan, Loralai and Samanasuk limestones is promising for **fluorite and trackways of reptiles (dinosaurs, pterosaurs, crocodiles, etc) and birds.**

Celestite deposits: It is reported from Thano Bula Khan (Sindh), Daud Khel (Punjab) and Barkhan (Balochistan). Malkani (2004a, 2010b, 2011) reported celestite from Sulaiman Basin (Balochistan). Malkani (2011) found the celestite nodules in the Late

Eocene Kirthar limestone and shale of Karkh area of Khuzdar district. Both discoveries are compelling for further exploration in Sulaiman and Kirthar basins. (Malkani 2010b, 2012b) reported some new deposits of celestite in the Sulaiman Basin (Balochistan Province) of Pakistan. These are the third deposits in Pakistan and have great significance as the previous proved reserves of celestite in Pakistan are going to be exhausted, shortly. The recently discovered localities are under the administrative control of Barkhan, Kohlu, Dera Bugti, Musa Khel and Loralai districts. These deposits are **Vein type** and **disseminated crystals** in limestone**.** Malkani (2010b,2012b) estimated the reserves of Lal Khan village is 2000 tons, Gadumra area is 2000 tons, Lakha Kach areas is 5,000 tons, Sham area of about 2000 tons, Toi Nala area of about 1000 tons, Chamalang and Bahlol area of about 1000 tons and Pirkoh area of about 100 tons. Further exploration in Kohat sub-basin is promising for **celestite** due to adjacent occurrences in Eocene limestone of Daudkhel in Potwar basin and also in Sulaiman basin.

Asbestos: Asbestos is found in serpentines of the ophiolitic complex near Wad (Khuzdar), Muslimbagh and Naweoba (Zhob), Boya, Kaniguran (Waziristan), and Sakhakot-Qila area (Mohmand/ Malaknd). The asbestos from Sakhakot-Qila area is largely chrysotile with local occurrence of antigorite and tremolite.

Barite: The deposits of Gunga (near Khuzdar) and Duddar in Las Bela district have over 12 million tons of barite (Ahsan and Qureshi, 1997). The Gunga deposit is being mined by joint venture of Balochistan Government and Pakistan Petroleum Ltd. Barite deposits are estimated about 30 mt. It also occurs in Kag, Aluli, Darwaza, Kacchi, Faqir Mohd, and Tipra (near Haripur). Malkani and Tariq (2000; 2004) reported first time **small barite deposits** (20,000ton) in Cretaceous Sembar formation from Mekhtar and Murgha Kibzai areas of Loralai and Zhob districts. It occurred as large nodules arranged as parallel to bedding in Early Cretaceous Sembar shales. These deposits are indicator of hydrothermal activity in this area.

Magnesite: There are several occurrences in the Indus Suture ophiolitic thrust belt showing small deposits or trivial showings. The main deposits occur at Wad (Khuzdar) and Muslimbagh in Balochistan, Sakhakot Malakand and Sherwan Hazara in KPK. It is found along fractures, joints and faults in ultramafic rocks. The Sherwan (Kumbar) magnesite deposit of Hazara has been estimated 11.2mt of total reserves with good quality. Bashir (2008) reported 1.23 million tons from Khuzdar area.

Mica: In Karakoram block limited and sporadic mining has been done near Baltit, Dassu, Mogh (32km NE of Chitral), and Kasu northeast of Drosh. In the Kohistan magmatic arc, mica has been worked at Khadong Banda (near Dir). In the Himalayan crystalline zone, mica deposits have been reported from Astor, Bagarian, Hawa Gali, and in the Neelam valley of Azad Kashmir. Among these the better deposits are the ones in the Neelam valley and near Astor. **Mica/muscovite** occurs in Mogh village Latkho valley, Simik Gol, Gabar-o-Boch, Imirdin, Kesu-Shera Shing north of Drosh and Kahdujal of Chitral, Khandong Banda/Khadan village north of Chakdara in Dir, Bagarian west of Belega near Hawa Gali, Gidarpur in Indus Kohistan. Significant deposits are found in Rajdhwari pegmatites (significant, 0.2-3%) and Tangali hill of Hazara district.

Lithium: Lepidolite occurs in Shengus of Nanga Parbat Massif; Bagarian, Hawa Gali, Giddarpur and Koga areas.

Niobium and platinum: It occurs in Chilas, Jijal, Sakhakot Qila (west of Dargai) and Loe Shilman of Khyber Agency.

Rare earth: It occurs in Koga (Swat), Sillai Patti (Dargai), Loe Shilman (Khyber Agency) and Sakhakot-Qila (Malakand) areas.

Sulphur: Sanni Sulphur occurs as veins or as replacement of sandstone matrix in the Nari Formation. The reserves are estimated at about 58,000 tons. Koh Sultan deposit is located in the Koh Sultan volcano with 738,000 tons reserve. Minor showings

occur in Muzhigram of Chitral) and Panoba, Jatta and Dandi areas of Kohat.

Alum:; Alum has been manufactured in the past from pyritiferous shales of Gajbeds from Maki Nai, shales of Ranikot group and Nari/Gaj group and at Shah Hassan near Trimi. Bituminous alum shale has occurs possible Carboniferous age near Shahidmena in Khyber Agency, in Jatta and in a gorge near Dozha Banda in Kohat area (Heron and Crookshank 1954). Nearly pure alunogen occurs in veins in sulphur at Sanni. Alum occurs in Koh Sultan (Nok Kundi area).Alum shales occur in two horizons in the Salt Range near Kalabagh. One in Eocene rocks (10feet alum shale), and other in Jurassic age (alum shales 25-40feet thick).The shale from which alum is manufactured contains on average 9.5% sulphur. Many salts deposits and lakes are located in the vicinity of Makran coast and Hamun Mashkel area. Alum may also be associated with these salts

Soapstone and Talc: Soapstone deposits occur in Kharwala Nala (Gujarghuna; Sufaid Koh-Parachinar; Kurram Agency), Jamrud (Peshawar), Khyber Agency; Derai (Swat), Sherwan (Abbottabad) and Golen Gol (Chitral) areas. The Sherwan deposit is the major producer of soapstone in the country. Soapstone deposits of Kurram agency have been estimated to contain 1.6 million tones of reserves (Badshah, 1994). The Golen Gol (Chitral) soapstone deposits are recently reported in Shyok Suture (Ashraf and Khan 2013). The ophiolitic and volcaniclastic rocks in the Wazhdad area and its vicinity show soapstone mineralizations (Malkani 2011). Some showings of soapstones are also observed in the Butrasi area of Mansehra (Malkani and Mahmood in process).

Calcite veins: Calcite is used for paint and transparent pure crystals are also used in microscopes. Pure **calcite** is also found in many calcite veins in limestone of different age.

Mercury: Cinnabar is reported in the sands of rivers in Chitral State (Heron 1954). Malkani (2011) reported mercury and silver mineralization in the western and eastern Thal Waro area of Panjgur district, Balochistan (35 M/16). Chemical results show highly anomalous mercury (more than 115ppb) mineralization in Panjgur formation. Thickness of stringes and lenses vary from 0.5cm to 15cm. Some calcite veins are also stained by yellowish brown to maroon iron colorations (Malkani 2011).

Graphite: It occurs in Chalt, Chhelish, Bola Das and Mohriwal Baikh of Gilgit area, Stak-Pondu Shigar Nala Baltistan, Chota Kazi Nag mountain northern slope of Jhelum River (Salkhala series of Precambrian age). It is found in Shah Salin, Momi village, Mohzigram Gol and Barzin valley of Chitral state; Norang and Babusar pass, Sherwan, Haripur and Garhi Habib Ullah of Hazara district, Sper Tor (Landi Kotal). Shahidmena and Lowaramena of Khyber Agency, Majk to Kundi and Dheri village in Mardan district, Loe Agra in Malakand. It has also been reported from Sheikh Wasil of Mashelakh Range.

Kyanite: Kyanite quartz veins in mica schist occur in the near south of Jabba of Hazara district. Kyanite schists occur in south of Kuza Banda rest house at Oghi-Batgram road. It is also found in Landakai at frontier boarder of Malakand-Saidu Sharif road and near Tindodog police post in Swat state (Ahmad 1969).

Pyrite: Pyrite is disseminated in carbonaceous shale and coal between Nikial and Khandar in Kotli, Mirpur district. It is also reported from north of normal near Hottar peak, near Normal (25% pyrite in slates), in Dainyor Nala and Jutial Gol (pyrite in quartz veins) near the Gilgit town, Gilgit Agency. Pyrite is disseminated in quartz veins in SE of Ghazhazi village at Shingarh north of fort Sandeman and in the Bandagan nala in Chagai district. These mineralization are observed in the Durgi Kaur, Surap Kaur, and Wazhdad Kaur, etc from Makran and Siahan ranges (Malkani 2011). **Pyrite** nodules are common in the shale of different ages.

Vermiculite: Vermiculite deposits are reported from Doki River on the northern edge of the western Raskoh. It occurs in cliff 160m long, 140m wide and 40m high with

reserves of 11 mt. The vermiculite contents vary from 5-20%. Exfoliation tests at 775^0 C resulted in tenfold increase in the particle size.

Witherite A witherite deposit has been discovered a few kilometers west of Degari in Balochistan and it occurs in veins and lenses in the Jurassic Chiltan limestone and mineralization extends for about 1 km (Sispal Kella, verbal communication with Kazmi and Abbass, 2001).

Abrasives: Abrasive type red ochres occur in Eocene Sohnar beds nodular flints between Rohri and Kot Diji; red and yellow ochre in Uchali of Salt range, red ochre in Kutki village of Isa Khel, west of Jhol Dhaund, around Harmon Mohatta coal mine west of Sohnari Dhand (west of Jhimpir), west of Ongar Jhol Dhand (north of Thatta) and Sohnari 15km east of Jhimpir. Grity Pab sandstone of Fort Munro areas can be used for abrasive purposes.

Millstone: It is found in the hard and compact quartzite/ sandstone of Pab Formation of Rakhi Gaj, Girdu and Khar fort Minro, Rakhni, Rarkhan, Mughalkot and Ragha SAR areas of eastern Sulaiman Range.

Fertilizer Resources

Rock phosphate: The phosphate deposits of Kakul-Mirpur, Kalue-de-Bandi and Lagarban, Dalola, Minind and its vicinity areas of Hazara district are most significant. It has been reported in the Cretaceous sequence near Kohat (Chichali Formation), near Chhoi in Kalachitta Range (Kawagarh Formation), in Paleocene and Eocene rocks in the Salt Range (Patala Formation), in the Eocene Chamalang/Ghazij group, and Paleocene Sangiali Group (Sangiali and Rakhi Gaj formations) of Sulaiman Range, and in the Oligocene sequence in the Southern Kirthar Range (Nari Formation) (Ahmad, 1969). The Rakhi Gaj formation (Gorge beds) has possibly phosphate deposits in the Fort Munro, Rakhi Gaj and Bawata areas of Dera Ghazi Khan District. The phosphate from green and black shale and greenish grey sandstone of Mughalkot formation and green to greenish grey shale and greenish grey to red spotted and red wavy laminated sandstone of Rakhi Gaj Formation (in both Girdu and Bawata members) are significant in eastern Sulaiman foldbelt for further study. **Phosphate** is reported from Rakhi Gorge (Sangiali and Rakhi Gaj formations) and Mari-Bugti hills, and in black and green shale and sandstone of Mughalkot formation of Gharwandi (Alu Khan Kach) areas (Malkani 2010b).

Rock salt: Large deposits of rock salt are found in the Slat Range Formation of Precambrian age in Punjab and Eocene Bahadur Khel Salt Formation in Karak and Kohat areas of KPK.

Potash salt: Potassium salts are preent in the rock salt and salt marl of Billianwala salt member of the Salt Range Formation and occur as layers and lenses upto 4m thick and 240-400m wide. These lenticular bodies contain 7.83-9.4% K and the reserves at Khewra are estimated at about 124, 350 ton.

Gypsum: Gypsum is a good for soil conditioning. Its resources are huge (Malkani 2010b, 2011) and are being described here under subtitle Cement resources.

Nitrogen: It is a gas and found in the air. It is being used for Urea production. The urea industries should be increased because Pakistan is an agricultural country.

Ceramic Mineral Resources

Various types of **Clay deposits** are found from Ghazij, Kahan and Vihowa groups.

Ball clay: It is mostly used for ceramics. It is found in the alluvium, alluvial flood plain strata like Potwar/Vihowa/Manchar group, and also Kahan and Chamalang/Ghazij groups.

China clay: It is found in Shah Dheri (Swat) and in Nagar Parker. Drilling for evaluation of Thar coal has revealed large deposits of China clay in Islamkot area. Smaller deposits found from Dir, Hazara and Gilgit also. The Shah Dheri deposits contain 2.8mt of raw china clay.

Fuller's earth/Bentonite: It is nonplastic clay usually contain appreciable magnesia and valued for its decolorizing and purifying properties. Thick immense reserves of fuller's earth/bentonite are found in Domanda and Baska formations in eastern Sulaiman foldbelt. The D.G.Khan and

Khairpur are significant producers. In Punjab the main producer is the D.G.Khan while the Thano Bulla Khan (Dadu district) and Shadi Shahid (Khairpur) are from Sindh. It is also found in the Bhimbar area, Mirpur District, Azad Kashmir. It is formed in the flood plains of Tertiary river channels which also deposited coal in Pakistan. With activation this clay may be used in vegetable oil and ghee industries. It is also being used in insecticide, foundries and steel industries. The bentonite is found in Kohala (Hazara slates) and in Karakm areas. Malkani and Mahmood (2016) also found bentonite (10,000 million tons/mt) in Quaternary alluvium of Dheri Chohan, Dheri Laghal and Shenbagh village and surrounding areas located on the southern vicinity of Attock town area (Kala-Chita Range) where now mining is stopped. Further recently Malkani collected samples of fuller earth from Domanda and Drazinda shales of western (Zin area) and eastern limb (Mahoi area) of Zinda Pair anticline, Tehsil Taunsa, Dera Ghazi Khan District and their chemical results show SiO_2 50.86 to 64.01%, Al_2O_3 9.79 to 17.18%, Fe_2O_3 3.10 to 6.89%, CaO 6.41 to 12.20%, MgO 2.01 to 5.64%, P_2O_5 nil and loss on ignition/volatiles 8.87 to 12.60%. Present author estimated reserves of 10mt upto 200 meter easily mineable depth in Zinda Pir anticline areas. Huge reserves of fuller's earth are observed in Domanda, Drazinda and Baska formations in eastern Sulaiman Range. The present research shows its existence from Dera Bugti-Rajan Pur-D.G.Khan-Musakhel-D.I.Khan and Barkhan-Kohlu districts. The deposits upto easily mineable depths 200 meter are estimated about **1billion ton** of eastern Sulaiman foldbelt.

Fire Clay: It is resistant to shrinkage, abrasion and corrosion under high temperatures and low in iron and high in silica. Its main producers are Mianwali, Sargodha and Attock districts. It is also found from Dadu, D.G.Khan, D.I.Khan (Paniala) and Kotli (Tatta Pani to Nikial many localities) districts. These are residual sedimentary deposits generally found at the base of Paleocene Hangu/Patala and Eocene Sohnari beds. The fire clay, ochre, limonite and iron may be expected in Chitarwata, Rakhi Gaj, Vitakri, Drazinda formations and Vihowa group of northern Sulaiman foldbelt. The fire clay beds are associated with many coal horizons in the Sulaiman foldbelt and Azad Kashmir. The possible Fire clay from Chitarwata, Rakhi Gaj, Vitakri, Drazinda formations and Vihowa group, etc of eastern Sulaiman Foldbelt seems to be significant.

Feldspar: Large deposits of potash and sodic feldspar occur near Mingora and Bunair in Swat district (Badshah, 1994). It is widespread in pegmatites in Chitral, Gilgit and Skardu. It is also found in Rajdhwari pegmatite, Khaki, Doga, Trangri and Gidarpur areas of Hazara. Deposits of orthoclase feldspar also occur in Nagar Parkar.

Nepheline syenite: It is rock consisting of albite and microcline feldspar and nepheline. Its deposits occur in Swat and Mardan districts. It occurs as intrusive bodies at several localities like Agari, Landi Patao, Miane Kadao, Shoal, and Kharkai. Jadoon and Baig (1991) reported Tor Ghar nephlene syenite. Malkani and Haq (1998) have reported it as a Tor Ghundi pegmatite (micropegmatite; very coarse grained intrusive) with deposit of feldspar and minor mica crystal (3-5cm) in the southwest of Kasa and south of Killi Shabozai. It is a circular pipe or plug type (1km in diameter) surrounded by Parh limestone and Sember Shale. There are one another showing about 2km in the east in Sembar formation.

Silica sand: It is found in Abbottabad district, Paniala and Shirani areas (D.I.Khan), Nowshera, Dera Bugti and D.G.Khan. Large deposits of silica sand occur also in Nowshera, D.I.Khan and Abbottabad districts of KPK and Dadu district of Sindh. Datta Formation of Jurassic and its equivalent formations contain thick beds of silica sand Khisor and Marawat ranges, between Paniala and Pezu. In Salt range and Surghar range glass sand occur in Datta Formation (Jurassic) and Patala formation (Late Paleocene). Near Malakhel, glass sand beds with over 99% SiO2 occur in Cretaceous Lumshiwal Formation. In Hazara

high grade silica sand occurs as thick layers within a 150 metres thick sequence of metamorphosed calcareous sandstone at Mand Kachcha. Large deposits of silica sands are found in the Eocene and Oligocene strata near Thano Bula Khan in Dadu district. Large lenticular bodies of silica sand occur in Meta sediments in Mohmand agency with reserves of 537mt. Silica Sands is also found mostly in the sandstone of Toi and Kingri formations and Vihowa group in Sulaiman foldbelt. In the Toi and Kingri formations it is found from Duki, Chamalang, Alu Khan Kach (Gharwandi), Kingri and Shirani area, while from the Vihowa Group it is found in the Zinda Pir, Taunsa and Dera Bugti area.

Cement Raw Materials Resources

Cement Industry raw materials like limestone, shale/clays and gypsum are huge in Pakistan and especially in Sulaiman basin. More than a dozen cement industries can be installed in the Dera Bugti, Harand, Barkhan, Kohlu, Loralai, Musa Khel, Rajan Pur, D.G.Khan and D.I.Khan districts due to close existence of its raw material like limestone, gypsum and shale. Further its suitability will be strengthens by the close occurrence of raw materials which will be provided to industry by belts and not by trucks. It is a strong need to fulfill the cement requirement of country and earn foreign exchange through cement export for the development of Pakistan.

Limestone: It is used 75% in cement preparation. The inexhaustible reserves of limestone are found in Pakistan. Huge deposits of easily mineable (200m depth to exposed surface) limestone, sandstone and shale of Sulaiman, Kirthar and Balochistan basins are presently estimated. The limestone deposits of 1205bt with breakup as Jurassic 490bt, Cretaceous 75bt, Paleocene 18bt, and Eocene 622bt. The small fraction of resources is being used by cement industries in Pakistan. Pakistan has the lowest per capita consumption of cement. Further Pakistan is paying several hundred million rupees every year for calcium chemicals. It is highly desirable to take step for extending cement, lime and calcium chemicals industries, so that the country will be self-sufficient and able to export these materials to earn exchange.

Clays/shale: It is used 25% in Cement preparation. Vast and huge deposits of easily mineable (200m depth to exposed surface) limestone, sandstone and shale of Sulaiman, Kirthar and Balochistan basins are presently estimated (Malkani, in process). The shale deposits of Sulaiman, Kirthar and Balochistan basins are estimated about 5799bt with breakup as Jurassic 33bt, Cretaceous 418bt, Paleocene 27bt, Eocene 4131bt and Oligocene-Pliocene 1190 bt (Malkani in process).

Gypsum and anhydrite deposits: Gypsum is reported Kohat and Potwar, Sulaiman and Kirthar ranges. It is also reported from Khyber-Hazara (uppermost Indus) basin like Dowatta (Hazara) and Macol (Abbottabad). Large deposits from Daudkhel, Khewra, D.G.Khan and Rajan Pur areas of Punjab, Karak-Kohat and D.I.Khan areas of KPK, Barkhan, Dera Bugti, Kohlu, Musa Khel and Sibi districts of Balochistan, and small deposits in Dadu district and coastal areas of Sindh, and Las Bela and Chagai districts and coastal areas of Balochistan, and Reshian, Muzaffarabad, etc of Azad Kashmir. Gypsum and anhydrite separate deposits are unknown. **Salt Range** contains at least 137 mt of gypsum. Heron (1950) reported **Saiduwali Khisor gypsum** deposits (3km NW of Saiduwali, D.I.Khan district) as alternating beds of dolomite and gypsum with 150m thickness. These Cambrian Khisor Formation gypsum beds dipping NW are found on the base of Khisor thrust fault near the general ground surface and seems feasible for cement industry. This present investigation shows 5.5mt upto 50m easily mineable depth, and 220 mt reserves upto 2km depth but deposits will more than this estimate and the gypsum strata on other side of fault is also expected subsurface. Very large reserves of **Jatta gypsum** (4.7 bt) have been reported from Karak-Kohat regions. Gypsum beds are 15-60m thick and extend in a 55km long belt. Main deposits occur at Braghdi, Shiwakki, Jatta, Nashpa-Chanda, Mami Khel, Manda Daud Shah, Lachi, Bahadur Khel, Karak, Banda Spina-Dhand,

Idal Khel and Malgin. Alizai et al. (2000) reported three beds ranging in thickness from 0.33 to 0.93m occur in shales near Johi and K.N.Shah in Dadu district in the Miocene Gaj Formation. The estimated reserves are 10.4mt and gypsum beds seem to be extensive. Malkani (2010b) reported 675mt upto **50 m easily minable depths** of 21 localities of **Sulaiman** Foldbelt. The quality of gypsum is good as impurities are less than 2% based on chemical results of 125 samples (Malkani 2010b). There are 4 to 15 beds of gypsum in Baska Formation with cumulative thickness of 5m to 25m in Sulaiman foldbelt while one bed (0.3m-6m) of gypsum in Domanda formation in only southern Sulaiman foldbelt. Malkani (2011) reported 26 billion tons (1bt=1000mt) estimated reserves (measured, indicated, inferred and hypothetical) of Sulaiman foldbelt. The present investigations show **28.5 billion tons** of estimated reserves (measured, indicated, inferred and hypothetical) of Sulaiman foldbelt, which are the **first largest deposit in Pakistan.** The breakup of total gypsum reserves includes 14.5bt in Balochistan Province (Barkhan 4.25bt, Kohlu 5.5bt, Sibi 1bt, Dera Bugti 1.75bt, Musa Khel 2bt); 11bt in Punjab (Rajan Pur 2bt and D.G.Khan 9bt); and 3.1bt in KPK (D.I.Khan and South Waziristan). The Balochistan Province with detail as Barkhan District includes Lakha Kach or Rakhni 1bt, Kodi More-Nodo-Ishani-Gadumra 2bt, Khurcha 0.25bt, Anokai-Bahlol 0.5bt and Bala Dhaka-Karher Buzdar 0.5bt; Kohlu District includes Nisau-Safed 3bt, Kahan-Khatan 1bt, Mawand 1bt, Lunda-Bahney Wali 0.25bt and Janthali 0.25bt; Dera Bugti includes Sham-Kulchas, Phailawagh-Jiandari, and Pirkoh 1.75bt, Sibi district includes Spintangi 1bt; and Musa Khel district includes Drug-Toi Nala-Zamaray 2bt, Kingri 1mt and Chamoz Khan Mohd Kot 1mt; Punjab province with detail as Rajan Pur district 2bt and D.G.Khan district 9bt; KPK province with detail as D.I.Khan district (Mughalkot, Ragha Sar and Khowara Khel; Domanda, Drazinda, Drabin etc) 3bt, and South Waziristan 0.1bt (Malkani 2013b).

Gemstone and Jewelry Resources

The gemstones and jewelry resources are commonly found in the northern Indus Suture and Shyok Suture. The Gilgit-Baltistan has mostly sheared zones and also holds the double sutures like the Shyok Suture (convexing north arced) in the north, and n-type belt of Indus Suture in the south. The limbs of n-type belt are found on the east and west of Nanga Parbat-Haramosh Massif and cap of n-type lobe is formed by northern bend/apex of Nanga Parbat-Haramosh Massif. This is the reason the Gilgit-Baltistan area are enriched in gemstone and gold resources and seems to be rich in copper also. Major and also minor gemstone resources are shown in Table 2.

Gold-Silver-Platinum: Small amount of gold is also recovered by panning in the upper Indus and its tributaries. The production of copper along with gold will be started soon from Saindak porphyry copper deposits. Pakistan has several regions which hold these deposits. **Chagai district** has a number of porphyry copper deposits with gold and silver mineralisations. Telethermal vein type and skarn deposits are also reported. Broken Hill Propriety (BHP) of Australia in collaboration with BDA has discovered world class gold deposits. Lake Resources (Australia) also explored copper and associated gold deposits and their alteration zones (Kazmi and Abbas 2001). In **Northern areas** 24 sites show high anomalous gold (Clavarino et al., 1995). **Sargodha District** shows traces of gold from volcanogenic hematite iron ore near Chiniot. **Chitral district** was studied by SDA for gold and silver prospects in the Sewakht formation in the Awireth-Shogor-Sewakht areas of Chitral, 6-8km west, northwest and north of Krinj. The estimated reserves of gold and silver bearing ferruginous carbonates are about 50 mt (Khan and Ahmad, undated). **Dir district** was studied for gold, silver and copper anomalies in the Dir volcanic group near Zaluka village, 250km north of Peshawar. The host rock show subporphyritic to porphyritic sequence. **Gold-silver-copper** is found in gossans along Shyok Suture (Malkani 2013a). **Besham area** shows PGE associated with gold in the Jijal layered

ultramafic complex. G**old upto** 1.7 ppm occurs in Hall area. **Muslimbagh area** show platinum group elements (PGE) associated with chromitites in the Muslimbagh ophiolites of Saplai Tor Ghar. Preliminary

Table 2. *Gemstone Resources of Pakistan*

Beryl	**Aquamarine**	**Emerald**	**Fluorite**	**Moonstone**	**Ruby**	**Garnet (almandine)**
Peridot	Topaz/Pink Topaz	Fluorapatite	Tourmaline	Vesuvianite/ ifocrase	Pargasite(Hornblende)	Garnet(grossular)
Chert	Jasper	Agate	Flintstone	Quartz/ fool diamond	Sapphire	Garnet (Spessartine)
Spinel	Malachite	Azurite	Kyanite	Pyrite	Rutile	Garnet(Hessonite)
Actinolite	Epidote	Serpentine	Rodingite	Amazonite/microcline	Jadeite/ nephrite	Kunzite (spodumene pyroxene)
Margarite (hydrated silicate of Ca and Mg, with pearly luster from AJK				Turquoise (phosphate minerals)		Sapphire (blue tourmaline)
Lapis Lazuli (lazurite, feldspathoid group)				Tripoli (weathered chert/siliceous limestone)		

study shows the uneconomic deposits and however there are chances of economic placer deposits. Antimony and Siagari Shand quartz vein of Makran and Siahan ranges have anomalous gold (Malkani 2011).

Aquamarine: It is blue sparkling and occurs in the pegmatites of Hindukush-Karakoram and NW Himalayas. The better known deposits are Iskere, Shingus, Dusso and Tisgtung. Deeper colour varieties occur at Gabor-o-Bakh in Chitral.

Emerald: Mingora, Gujarkilli and Shamozai areas of Swat District are well known producers of quality emerald. Mangora emerald deposits occur in Mingora ophiolitic mélange, which appears in the form of highly tectonised fault blocks. Gujarkili emerald deposits are located near Gujarkili 24 kilometers ENE of Mingora, 12km SSW of Alpurai in Swat district. Other emerald deposits occur at Dandao Kandao, Nawe Dand, Gandao Kot and Mora Dara in Mohmand Agency, Arang Barang in Bajaur Agency, Makhad and Charbagh in Swat District and near Khaltaro in Gilgit area.

Garnet: Gem quality almandine (red garnet) is found in Chitral district, red spessartine is associated with pegmatites of Dusso and Shingus in northern areas. Tsavolite or green grossularite is associated with graphitic schist in Jambil are of Swat, near Kot in Malakand and near Targhao in Bajaur agency. Beautiful honey yellow euhedral crystals of hessonite are found in quartz mica schist near Targhao in Bajaur agency. A high quality orange red spessartine garnet has been recently discovered in pegmatites in Neelam valley of Azad Kashmir. This deposit has yielded large transparent crystals.

Moonstone: It is a rock forming feldspar. It has been mined from pegmatites of Shingus and Bulechi in Gilgit Agency. The deposits are large with good quality.

Peridot: It is found near the Kohistan-Kaghan watershed to the NE of Naran. It occurs along shear zones and in pockets in dunitic host rocks and are associated with clinochlore, magnetite and local magnesite (Jan and Khan 1996).

Ruby/corundum: Its deposits occur in the dolomitic marble extending for over 100 km from Hunza valley to Ishkoman, close to Shyok Suture. Ruby deposits of Azad Jammu and Kashmir are located in Nangimali-Khora-Katha, Chitta Ratta and Naril Nala areas close to northern Indus Suture. They are associated with Meta limestone and occur in calcite veins along bedding planes. Ruby also occurs in a 30km long belt of amphibolites extending from Timurgarha to Kohat in Khyber Pakhtunkhwa.

Pargasite: Its deep pistachio green crystals occur along with ruby and spinel in metamorphosed crystalline marbles in the Hunza valley.

Spinel: Spinal with its ruby red colour is closely associated with Hunza ruby deposits. The Hunza **spinels** are larger than

those customarily found in Burma and are far more attractive.

Topaz: Topaz bearing pegmatites are found at Bulechi, Shingus and Gone near Dessu in the Skardu area. **Pink Topaz** is deep red, orange rose is unique to Katlang topaz. In fact this is the only known naturally deep red or deep pink coloured topaz in the world. The colour of these Katlang stones ranges from colourless to very pale beige to light brown and from very pale to deep pink to bright red. Even violet coloured crystals have been found (Gubelin et al., 1986). The Katlang deposit is located in the Gundao hillock 4km north of the town of Katlang, about 20km north of the city of Mardan, 60km NE of Peshawar.

Tourmaline: Deposits of gem quality tourmaline (pink, blue and green varieties) are found in the pegmatites of the Haramosh range near Gilgit. The best known deposits are located in Stak Nala (Between Gilgit and Skardu). Gem grade tourmaline also occurs as Bulechi and Shingus (Gilgit Division). Indicolite (blue tourmaline) is found in the pegmatites of Garm Chashma (Chitral). Green tourmaline has been found in pegmatites of Donga Nar in Azad Kashmir. The study area also contains **precious gem** minerals like **Indicolite (blue tourmaline**) from pegmatite of Garam Chashma.

Fluorite: Attractive fluorite crystals occur in the Koh-Dilband, Mula-Zahri range and Loralai areas of Sulaiman foldbelt (Malkani 2010b, 2011).

Quartz and flint; Clear and well formed crystals of quartz occur in gem pegmatite in Skardu, Gilgit and Chitral areas, and in Azad Kashmir. Smoky quartz occurs in these areas. Rose quartz is abundant is Dusso pegmatites near Skardu. Agate and chalcedony are found in near Nagar Parker Sindh, while jasper occurs in Las Bela area (Balochistan) and **Mari diamond** (quartz) from Indus Mari (Punjab). **Quartz** veins having white transparent to translucent quartz crystals with gem qualities (**Kingri diamond**) are also found in the sandstone of Cretaceous Mughalkot Formation in the Khagoon Range (39 F/10) of Gharwandi (Alu Khan Kach) area, Musa Khel district, Balochistan. **Flint** from Tor Thana area (39F/3) show banded and wavy white and light blue colours which creates beauty for ornamental purposes. Many quartz carbonate veins are observed in the iron oxidized zone of Makran and Siahan ranges. **Siagari Shand quartz vein** (35A/11) is located on the southern slope of the range. Quartz vein thickness is 2 meters with discontinuous length of more than 500 meters. Quartz is crystalline to cryptocrystalline. Elongated hexagonal quartz crystal upto 1cm are observed. The host rock is Siahan shale. Gold upto 0.458 ppm is recorded. **Eastern Waro locality** (35M/16) consists of network of quartz vein and stringers and also have major ferruginous quartz carbonate vein trending northwest to southeast. The best quartz crystals of different localities can be used as Mari diamond (quartz) in jewelry as diamond (Malkani 2011). The study area also contains clear and well developed **crystals of quartz** and **smoky quartz.**

Calcite: Many transparent **c**alcite crystals are commonly found in many calcite veins in limestone of different agea in Sulaiman and Kirthar foldbelts, which can be used for jewelry.

Pegmatite gems: The pegmatite fields of Northern areas have yielded excellent mineral specimens including light pink crystals of fluorapatite, green fluorite, soessartine, hambergite, green microcline, aquamarine, topaz, and many varieties of tourmaline and garnet.

Dimension, Construction and Decorative stone Resources: Pakistan has very large deposits of dimension and construction stones like attractive granite, marble, recrystallised limestone, quartzite, schist and slatestones**.** The most commonly used are marble, various types of limestones and igneous rocks, mainly granite. Large reserves of recrystallised limestone and **marble** occur widely in the Gilgit and Skardu region, in Chitral, Khyber Agency, Swat and Mardan districts of KPK, Bajaur and Khyber agencies of FATA, in Azad and Kashmir (Asrarullah and Hussain, 1985). Vast reserves of onyx marble of high quality are found in Chagai district of Balochistan

province (Ahmad, 1969). Large reserves (56million tons) of good quality and high reflectance white marble is found in Nauseri-Jhugian area, Neelam valley, Muzaffarabad, Azad Kashmir (Malkani and Mahmood in process; Mahmood and Malkani in process). **Igneous** along with some metamorphic rocks are found in the Indo-Pakistan shield (Nagar Parker, Kirana and Khyber-Hazara crystalline zone), Western and Northern Indus Suture, Balochistan magmatic arc, Kohistan magmatic arc and Karakoram block. Attractive and good quality granitic rocks occur in Gilgit, Chital, Swat, Hazara, Raskoh, Las Nela, and Nagar Parker areas. Large reserves of good quality gabrro are found in Muslimbagh- Nisai area. Dolerite dykes from several localities provide jet black slabs for tiles and wall facings. Milk white granite has been mined from a locality 18km north of Gilgit. The major **dolomitic** deposits are Kachi Haripur (Abbottabad Fm. Large), Sherwan (Abbottabad Fm. Large), Wagh (Precambrian, Large), Nilawahan (Salt Range Fm.Large), Saidu Wali Khisor Range (Salt Range Fm. Large), Ghundai Tarako Mardan (Paleozoic), Khyber Agency (Khyber Fm., Shagai limestone, Large), Kuch Kalabagh (Kingriali Fm. 0.5mt), Makarwal (Datta, Doya-Lunda, Narmia-Punnu) (Kingriali Fm. 900 mt), Burikhel Mianwali (Kingriali Fm. Large), Kalachitta (Very Large), Kohat, NW of Pail (Large), and Chiltan Range-Ziarat Nala (250mt). Several kinds of multicolored **brecciated rocks** are mined from the Bela and Kanar mélanges in Bela-Khuzdar area. Several varieties of fossiliferous **limestone** with beautifully oriented designs of foraminifers, mollusk shells and quartz and calcite veins, ranging in shade from cream to fawn, light brown to shades of grey occur extensively in the Paleocene to Eocene sequences in Las Bela area and various parts of Sindh and in the Salt range. The huge deposits (more than one billion ton) of Dungan limestone (white) in the Kasa, Karu and Anambar areas of Loralai district is being well used as marble for the preparation of many types of tiles. It is also found in Barkhan, Musa Khel, Kohlu and Dera Bugti districts. Building stones like Limestone from Chiltan, Loralai, Parh, Mughal Kot, Fort Munro, Sangiali, Dungan, Drug, Habib Rahi and Pirkoh formations, sandstone from Sembar, Pab, Vitakri, Sangiali, Toi and Kingri formations and Vihowa group have been reported. Gravel and sand from Chaudhwan and Dada formations, Subrecent and recent surficial deposits are significant (Malkani 2010b, 2011; Gondal 2007). The northern Sulaiman basin represents Jurassic Chiltan and Paleocene Dungan **limestones** as **marble** from Mughal Kot and Ragha Sar areas of Shirani. Vast and huge deposits of easily mineable (200m depth to exposed surface) limestone, sandstone and shale of Sulaiman, Kirthar and Balochistan basins are presently estimated (Table 3). The limestone deposits of Sulaiman, Kirthar and Balochistan basins are round about 1205bt with breakup as Jurassic 490bt, Cretaceous 75bt, Paleocene 18bt, and Eocene 622bt (Table 3). The **shale** deposits of Sulaiman, Kirthar and Balochistan basins are about 5799bt with breakup as Jurassic 33bt, Cretaceous 418bt, Paleocene 27bt, Eocene 4131bt and Oligocene-Pliocene 1190bt (Table 3). Further some **clay** deposits are also found in Subrecent and Recent alluvium in plain areas. The **sandstone** deposits of Sulaiman, Kirthar and Balochistan basins are about 5730bt with breakup as Cretaceous 1129bt, Paleocene 15bt, Eocene 953bt and Oligocene-Pliocene 3640bt (Table 3). Further vast deposits of **gravels** (Gondal et al. 2007; Malkani 2010, 2011; Somro et al. in process; Alyani and Malkani in process; Khosa in process; Malkani and Mahmood in process; Shehzad et al. in process) are found as terrace and fans. Large deposits of **sands** are found in Thar, Cholistan and Balochistan desert, in many different parts of country.

Karakoram may be correct for gold. It is found in Chitral area but enriched in Gilgit-Baltistan. It is also found in Kohistan magmatic arc like Karakar (Swat) and also Khyber-Hazara areas like Ahl and Rajdhwari (Mansehra granite), Loe Shilman (30km w of Warsak), Silai Patti (35km W of Dargai in Malakand granite), Bunji and Thakot near Besham. It is also found in Parachinar (Kurram Agency) and Qabul Khel (Bannu

Basin). The main deposits are in the Dera Ghazi Khan and Taunsa areas. The fluviatile cross bedded sandstones of the Vihowa group host the uraniferrous placers. It is traced along 190 kms NS oriented outcrop along the Foot Mountains of Sulaiman fold and thrust belt, in the territory of Dera Ghazi Khan,

Table 3. Limestone, Shale and Sandstone Resources (in billion tons from exposure to 200m depth from ground surface) of Sulaiman and Kirthar basins, Western Indus Suture and Balochistan Basin. (J-Jurassic, K-Cretaceous, P-Paleocene, E-Eocene, Ol-Pl- Oligocene-Pliocene)

Area	**Limestone**				**Shale**					**Sandstone**			
	J	**K**	**P**	**E**	**J**	**K**	**P**	**E**	**OL-PL**	**K**	**P**	**E**	**Ol-PL**
Loralai	50	0.3	0.3	-	5	100	1	1	-	5	-	-	-
Ziarat	50	0.4	0.4	-	-	50	-	100	-	-	-	Min	50
Quetta	50	0.1	0.1	-	-	1	-	50	-	-	-	3	100
Mastung	50	0.1	0.1	1	1	-	-	50	-	-	-	Min	min
Kalat	50	0.1	0.1	10	1	1	-	200	-	-	-	5	5
Khuzdar	50	10	2	50	1	5	2	200	-	-	-	5	5
Lasbela	min	min	1	min	min	min	min	20	-	10	-	-	20
MusaKh	50	50	2	200	-	200	2	500	-	400	3	500	-
Barkhan	-	1	1	200	-	5	5	300	-	50	2	200	5
D.G.Khan	-	-	1	50	-	5	10	500	-	500	7	-	550
Panjgur	-	-	-	min	-	-	-	500	-	-	-	10	550
Gawader-Pasni-Ormara	-	-	-	-	-	-	-	350	-	-	-	-	500
Bolan	50	10	1	5	-	-	-	50	10	-	-	5	50
Sibi	-	-	-	1	-	-	-	-	150	-	-	-	150
Pishin	-	-	-	-	-	-	-	-	50	-	-	-	20
Qila Abdullah	-	-	-	-	-	-	-	-	100	-	-	-	30
Dear Bugti	-	-	20	-	-	-	-	10	150	-	-	-	200
Zhob	20	1	1	-	5	5	-	-	50	2	-	-	50
Qila Saif	20	1	min	-	20	30	-	-	20	-	-	-	10
Kohlu	-	-	1	50	-	5	1	300	10	10	1	30	200
Rajan Pur	-	-	5	30	-	1	5	400	50	2	-	-	400
D.I.Khan	50	1	2	5	-	10	1	400	100	100	2	200	400
Turbat	-	-	-	min	-	-	-	-	500	-	-	-	300
Total	490	75	18	622	33	418	27	4131	1190	1129	15	953	3640
Grand Total	1205				5799				5737				

Rajan Pur and Dera Ismail Khan. It may extend further south to Dera Bugti, Kohlu and Sibbi districts. Radioactive primary and secondary uranium mineralization are commonly existed in the Vihowa group and in other sandstone formations like Mughal Kot, Pab, Vitakri, Sangiali, and Rakhi Gaj formations. The Sandstone of Toi and Kingri formations have source from northwest and can not be ignored.

Radioactive Mineral Resources: Uranium concentration is increasing toward east in **Iridium** anomalies can be found in the KT boundary laterite, muds and coal especially in the Gharwandi, Aram, and Kingri, Vitakri, Fort Munro and other areas of Vitakri Formation. **Uranium and metatuyamunite** in the Vihowa group, coal and sandstone formations like Mughal Kot, Pab, Vitakri, Sangiali, Rakhi Gaj, Toi and Kingri formations in Shirani areas are promising. **Uranium and iridium** anomalies can be found in the Cretaceous-Tertiary/K-T boundary laterite, muds and coal especially in the eastern Sulaiman foldbelt in Vitakri Formation.

Coal Resources: Due to present field work by senior author, the revised and updated total coal reserves of Pakistan are increased from 186,282.41 million tones/mt (Malkani 2012e) to 186,288.03mt (Table 4) with break up as Sind 185457 mt,

Balochistan 458.7mt, Punjab 235mt, Khyber Pakhtunkhwa 126.74mt and Azad Kashmir 10.59 mt. Kali Mati (Harnoi, Bagnotar)-Kala Pani new coalfields of Abbottabad, Hazara found in Latest Cretaceous-Early Paleocene Hangu Formation (synonym Patala) include 3.75mt deposits with break up as 0.25mt

Table 4. Coal Reserves of Pakistan (million tones).Mea-Measured reserves, Ind-Indicated reserves, Inf-Infered reserves, Hyp-Hypothetical reserves.Vol. Mattaer-Volatile Matter, T Sulphur-Total Sulphur, BTU/lb-Brististh Thermal Unit/Pound.

Coalfield	Mea.	Ind.	Inf.	Hyp.	Total	Moisture	Vol. Matter	Fix Carbon	Ash	T Sulphur	BTU/lb	Rank
BALOCHISTAN												
Chamalang	6	12	72	10	100	2.46-4.58	12.66 - 41.71	7.96-50.05	6.25-74.80	3.44-6.93	2193-13569	LigC to hvBb
Kingri (K-T)	3.9	7.8	35	34.3	81	1.64	18.4	25.1	55.2	5.58	2000-10,000?	LigC to SubC?
Kingri-Shikar	1	-	-	-	1	**Interpreted Same as Chamalang Coalfield**						
Narwal-Dab	1	-	-	-	1	**Interpreted Same as Chamalang Coalfield**						
Toi Nala-Ghoze Ghar	1.2	2.4	10.8	1	15.4	1.8-1.9	42.3-42.9	32.1-32.9	22.8-23.1	5.8-6.1	9,790-13000?	SubC to hvBb?
Khost-Sharig-Harnai	20.9	41.8	23.7	-	86.4	1.7-11.2	9.3-45.3	25.5-43.8	9.3-34.0	3.5-9.5	9,637-15,499	SubC to hvCb
SorRange-Deghari	9.84	19.68	25	-	54.52	3.9-18.9	20.7-37.5	41.0-50.8	4.9-17.2	0.6-5.5	11,245-13,900	SubA to hvBb
Duki-Anambar	22.8	45.6	12	-	80.4	3.5-11.5	32.0-50.0	28.0-42.0	5.0-38.0	4.0-6.0	10,131-14,164	SubB to hvAb
Mach-Abegum	9	13.7	-	-	22.7	7.1-12.0	34.2-43.0	32.4-41.5	9.6-20.3	3.2-7.4	11,110-12,937	SubA to hvCb
Pir Ismail Ziarat	3.6	7.2	5	-	15.8	6.3-13.2	34.6-41.0	19.3-42.5	10.3-37.5	3.2-7.4	10131-14164	SubB to hvAb
Johan	0.25	0.25	-	-	0.5	**Interpreted Same as Mach Coalfield**						
Subtotal	**79.49**	**150.43**	**183.5**	**45.3**	**458.72**							
PUNJAB												
Makerwal	7	15	-	-	22	2.8-6.0	31.5-48.1	34.9-44.9	6.4-30.8	2.8-6.3	10688-14029	SubA to hvAb
Salt Range	50	16	2	145	213	3.2-10.8	21.5-38.8	25.7-44.8	12.3-44.2	2.6-10.7	10131-14164	SubC to hvAb
Subtotal	**57**	**31**	**2**	**145**	**235**							
SINDH												
Lakhra	244	629	455	-	1328	9.7-38.1	18.3-38.6	9.8-38.2	4.3-49	1.2-14.8	5503-9158	LigB-SubC
Meting-Jhimpir	10	43	108	-	161	26.6-36.6	25.2-34.0	24.1-32.2	8.2-16.8	2.9-5.1	7734-8612	LigA-SubC
Sonda-Thatta	60	511	2197	932	3700	22.6-48.0	16.1-36.9	8.9-36.1	2.7-52.0	0.2-15.0	8878-13555	SubC-hvBb
Jherruck	106	810	907	-	1823	9.0-39.5	20.0-44.2	15.0-58.8	5.0-39.0	0.4-7.7	8800-12846	SubC-hvCb
Ongar	18	77	217	-	312	9.0-39.5	20.0-44.2	15.0-58.8	5.0-39.0	0.4-7.7	5219-11172	LigB-SubA
Indus East	51	170	1556	-	1777	9.0-39.5	20.0-44.2	15.0-58.8	5.0-39.0	0.4-7.7	7782-8660	LigA-SubC
Badin	150	200	500	-	850	9.0-39.5	20.0-44.2	15.0-58.8	5.0-39.9	0.4-7.7	11415-11521	LigB?-SubA
Thar	2700	9395	50706	112705	175506	29.6-55.5	23.1-36.6	14.2-34.0	2.9-11.5	0.4-2.9	6244-11045	LigB-SubA
Subtotal	**3339**	**11835**	**56646**	**113637**	**185457**							
KHYBER PAKHTUNKHWA												
Hangu/Orakzai	2	4	75	-	81	0.2-2.5	16.2-33.4	21.8-49.8	5.3-43.3	1.5-9.5	10500-14149	SubA-hvAb
Cherat	0.5	1	6.24	-	7.74	0.1-7.1	14.0-31.2	37.0-76.9	6.1-39.0	1.1-3.5	9386-14171	SubC-hvAb
Gulakhel	-	-	25	5	30	2.8-6.0	31.5-48.1	34.9-44.9	6.4-30.8	2.8-6.3	10688-14029	SubA to hvAb
Shirani	0.25	0.25	-	-	0.5	Interpreted same as Toi Nala						coalfields
Dara Adamkhel	0.25	0.50	3	-	3.75	Interpreted same as Cherat						coalfields
Bagnotar-Kala Pani (Hazara)	0.25	0.50	3	-	3.75	Interpreted same as Cherat and Kotli-Tatta Pani						coalfields
Subtotal	**3.25**	**6.25**	**112.24**	**5**	**126.74**							
AZAD KASHMIR												
Kotli-Tatta Pani	1	1	6.72	-	8.72	0.2-6.0	5.1-32.0	26.3-69.5	3.3-50.0	0.3-4.8	7336-12338	LigA-hvCb
Muzaffarabad	0.12	0.25	1.50	-	1.87	interpreted same as Kotli Tatta Pani						coal fields
Subtotal	**1.12**	**1.25**	**8.22**	**-**	**10.59**							
Grand Total	**3479.86**	**12023.93**	**56951.96**	**113832.30**	**186,288.05**							

measured, 0.5mt indicated and 3mt inferred (Malkani in process; Malkani and Mahmood in process). Further from Azad Kashmir the Seri Dara-Khila-Maira Tanolian new coalfields of Muzaffarabad area found in Latest Cretaceous-Early Paleocene Hangu Formation include 1.87mt deposits with break up as 0.12mt measured, 0.25mt indicated and 1.50mt inferred. Further the new showings of caol in the Reshian area-a more than 1 m thick carbonaceous shale with some coal has been found in the Precambrian Hazara Formation in the Reshian area of Hattian District, Jhelum Valley. These coal seams seem to be metamorphosed to graphite in the Neelam valley of Azad Kashmir (Malkani in process; Malkani and Mahmood in process).

Table 5. Significant source, cap and reservoir rocks/formations in the Kohat and Potwar (upper Indus), Sualiman (middle Indus) and Kirthar (lower Indus) basins of Pakistan.

Age	Source and cap rocks			Reservoir rocks		
	Upper Indus	**Middle Indus**	**Lower Indus**	**Upper Indus**	**Middle Indus**	**Lower Indus**
Olig-Pliocene	Potwar gr. clays	Vihowa gr. sh.	Vihowa gr. sh.	Potwar gr. sst	Vihowa gr. sst	Manchar/Vihowa gr. sst
Eocene		Vihowa gr. Shale Drazinda sh. Domanda sh. Bask ash. Drug sh. Kingri shale Toi shale Shaheed Ghat sh.	Vihowa Gr. Sh. Laki/ Kirthar sh. Sohnari sh. Shahed Ghat sh.		Pirkoh marl/lst Habib Rahi lst Drug lst Kingri sst Toi sst	Laki/ Kirthar/Gorag lst Kuldana lst/sst Sakesar lst Shekhan lst
Paleocene	Nammal shale Hangu/Patala shale	Sangiali/Rakhi Gaj shale	Khadro shale	Sakesar/Lockhart lst	Dungan lst Sangiali lst,Rakhi Gaj sst	Lakhra lst Khadro and Bara sst
Cretaceous		Mughalkot shale Goru marl/shale Sembar shale	Mughalkot shale Goru marl/shale Sembar shale	Kawagarh lst	Mughalkot, Pab&Vitakri sst;Fort Munro lst Lumshiwal sst Mekhtar sst	Goru and Parh lst/marl
Jurassic	Shinawari shale	Sulaiman Gr. shale (Spingwar & Loralai shale)	Sulaiman Gr. shale (Shirinab/Anjira shale)	Samanasuk lst	Sulaiman Gr. lst	Sulaiman Gr. lst Datta sst
Triassic		Wulgai shale Gwal shale	Wulgai shale Gwal shale	Musakhel group lst/dolomite/sst		
Permian				Nilawahan-Zaluch groups (sst/lst)		
Cambrian	Khewra group shale			Khewra group sst, dolomite.		

Petroleum Resources: Due to the present energy crises in the world and particularly in Pakistan, the government and power generation sectors have shown keen interest in the coal and petroleum resources. Production of domestic coal and petroleum will reduce the demand for imported fuels and ultimately save foreign exchange resources. Petroleum is known in Pakistan since 1833. Sedimentary basins are the primary host of oil and gas. Pakistan has two large sedimentary basins like Indus and Balochistan which can yield significant oil and gas (Kazmi and Abbas 2001). So far no economic oil and gas reservoirs are known from Balochistan basin (300,000 km^2) comprises about 10,000m thick flysch, deltaic and continental sediments. Super Indus Basin (533,500 km^2) subdivided in to northernmost (uppermost) Indus, northern (upper) Indus, central/middle Indus and southern/lower Indus basins. Oil resources are frequently being developed from upper Indus basin, while gas resources are being developed from middle and lower Indus basins. Attractive structures, extensive source and cap rocks are found in Kohat sub-basin and northern Sulaiman fold and thrust belt. The share of northern areas of Khyber Pakhtunkhwa and FATA (part of Hindukush-

Karakoram block, Kohistan magmatic arc, northern Indus suture and NW Himalaya/Khyber-Hazara basin) are nothing so far due to mostly igneous and metamorphic rocks (which are devoid of petroleum) with minor sedimentary rocks may act as negligible petroleum hosts because of discontinuous nature and metamorphism. The share of southern areas of FATA regions (western Indus Suture) seems to be nothing due to mostly igneous with some sedimentary and metamorphic rocks which may host negligible petroleum. The share of southern areas of Khyber Pakhtunkhwa including the Kohat sub-basin is encouraging and significant, while the northern Sulaiman basin may share successfully in future due to 15-20km thick sedimentary cover with attractive structures, extensive source and cap rocks. Kohat sub-basin and northern Sulaiman foldbelt mostly includes the sedimentary rocks and show promising petroleum exploration targets (Malkani 2013b). The significant source, cap and reservoir formations are shown in Table 5.

Natural Resources: The minerals, coal, oil, natural gas, hot springs, geysers, paleovertebrate fossils etc are non-renewable resources while the solar, air/wind, terrestrial water, marine water/ocean, tides, waves, current, land, forest, biomass, tourism, etc are renewable (recycled) resources of Pakistan which can play significant role for its development. It is our urgent need to convert the non conventional energy resources into conventional energy resources. Our global earth is receiving huge amount of energy from sun. The coastal areas have high potential of wind energy. Gravitational force of moon produces tidal energy in sea which can be converted in energy by the construction of dams which can store water at high tides and release water at low tides. Pakistan has a long sea shore from Nagar Parker to Jiwani. Energy from sea waves can also be benefited by stable and non stable plate's movements. Pakistan also has a large waste biomass. Pakistan has some hot water springs like Mahiwal, Zinda Pir, and Karu etc. which can be used during severe winter. Pakistan is famous for paleontological discoveries like dinosaurs, walking whale, baluchitherium, proboscideans, etc which can earn significant foreign exchange during peaceful conditions.

CONCLUSIONS AND RECOMMENDATIONS

Pakistan has a best potential of minerals. The minerals alongwith other natural resources like petroleum, solar, forest, wind, water, land, agriculture, vertebrate fossils like dinosaurs-the largest land animals, walking whales-the largest sea animal and baluchithere-the largest land mammals, etc, tourism, etc can play significant role for the development of Pakistan because population is increasing rapidly. Pakistan is spending a lot of earnings for importing glass, glass wares, pottery, iron raw materials and product, copper, aluminium, lead, zinc, manganese, gold, nickel, sulphur, tools, clay, coal, etc. Pakistan has these resources but not exploiting. As Griffiths (1987) Pakistan may be prince or pauper with reference to its mineral and natural resources. Try should be made to cease the imports and use own country raw materials and commodities. This capital can be saved and spent on developing minerals, science and technology. In short Pakistan is rich in mineral, energy and natural resources but poor in development.

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