Chapter 16B. Cement in Afghanistan

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Abstract

This chapter summarizes and interprets the results from the study of the indigenous cement industry in Afghanistan during 2010 and 2011 by the U.S. Geological Survey, the U.S. Department of Defense Task Force for Business and Stability Operations, and the Afghanistan Geological Survey. Supporting data and other information for this chapter are available from the Ministry of Mines in Kabul.

Cement is the most basic of all modern building materials; hence, the availability of reasonably priced cement to the construction industry in Afghanistan is a high priority for reconstruction of the country's infrastructure. The demand for cement in Afghanistan is projected to exceed 5 million metric tons per year by 2012; the demand is currently being met by imports from neighboring countries at prices set by foreign suppliers. There are currently two potential sites for cement production in Afghanistan; one is located south of the Hindu Kush at Jabal-e Saraj in Parwan Province and the other is located north of the mountains at Pul-e Khumri, Baghlan Province. The plant at Pul-e Khumri has the potential to produce up to 1,800 metric tons per day of cement, but it has insufficient electrical power and coal. The facility at Jabal-e Saraj has not produced cement for some years. Restoration of the existing facility would require a substantial investment, and even if the Jabal-e Saraj plant was made operational, the plant would be at least 40 years out of date and would not be economically competitive in a market dominated by products from efficient modern plants. Afghanistan cement production probably cannot compete with imported products without modernizing and completing facilities at Pul-e Khumri, upgrading facilities at Jabal-e Saraj to a modern dry-blending 100-metric-ton-per-day facility, upgrading power lines for all sites, and setting up a sustainable training program for cement engineers, chemists, plant managers, and technicians.

16B.1 Introduction

This report focuses on mineral resources in Afghanistan that could be used in domestic cement production and on production issues at specific cement operations in Parwan and Baghlan Provinces. The work in Parwan and Baglan provides a context for considering the issues that face the Afghan cement business sector at the regional, national, and international levels. The report finishes with an inventory of deficiencies and strengths at existing operations and with ideas for consideration that could facilitate the restoration of Afghan cement production facilities.

Portland hydraulic cement, commonly referred to as ordinary portland cement (OPC), is the type of cement in greatest demand across the world, with global production now exceeding about 1.25 billion metric tons per year (Gregg and others, 2008). Hydraulic cement, which is produced as an anhydrous powder, converts into a mass of interlocking hydrated mineralized needles when exposed to water (Blezard, 1998). Hydraulic cement will take the shape of the confining volume, even under water or when exposed to wet weather. In contrast, nonhydraulic cements, such as lime and gypsum plaster, must be kept dry in order to retain their strength.

Cement is never used in isolation but rather is the most important component in mortars and concrete. The various types of cement, when combined with aggregate and water to produce concrete, have different properties. Five commonly used types of OPC and a dozen or more specialized OPC cement types are produced in response to the demand for concrete with different properties (American Standards and Testing Materials, 2003, 2011). These properties include setting rate, early and long-term compressive and tensile strength, brittleness, hardness, heat of hydration, sulfate resistance, color, and workability of the concrete. Early strength is often required when setting by the end of the working day is important, as in cold climates. The 28-day strength remains the most important specification of most concrete applications. Workability is also an important specification—for example, when concrete must be pumped into place at a job site, the workability is an especially critical consideration. Finally, durability of concrete is always important where the environment (for example, the effects of groundwater, sea water, or sulfates) can attack and destroy the concrete. Special properties, such as low heat of hydration, can also be of primary importance, as is often the case in the construction of massive structures. Whereas the most common use of OPC is in the production of concrete, OPC is also a basic ingredient of mortar and most nonspecialty grouts (Hewlett, 2006).

Concrete is a composite material typically formulated from a standard menu of at least 225 recipes. Aggregates are chemically inert, solid materials that range in shape and size from fine particles of sand to large coarse gravel. Water is a key ingredient in the preparation of the concrete mix. Water enables cement to set by activating hydration of the binding compounds in the cement. The water-to-cement ratio is critical because too much water reduces concrete strength whereas too little water makes the concrete unworkable. The American Standards and Testing Materials (ASTM) standard C150 (2003) describes the various mixes used to create the desired characteristics, such as high strength, sulfate resistance, alkali-silica reactivity resistance, heat of hydration, and other characteristics.

16B.2 Cement Production

This section of the report reviews the essential elements of cement production; the level of technical preparation required by engineering, scientific, and management personnel; and the local and regional infrastructure needed for large-scale production in a highly competitive business sector.

16B.2.1 Chemistry of Cement Production

The production of OPC from raw materials requires a delicate balance of complex chemistry and large-scale engineering. OPC, at the most basic level, is a fine blend of anhydrous calcium silicate minerals. The first step in its production is dehydration of a blend of raw carbonate and silicate materials. The next step is oxidation, followed by calcination of calcium carbonate ($CaCO_3$), and then firing of the oxides at high temperature in a kiln. After milling the output of the kiln and blending in gypsum, the cement powder is ready to be used to create concrete (Hewlett, 2006).

It is well known that the ancient Assyrians, Babylonians, Egyptians, Greeks, and Romans fired mixtures of clay and calcareous stone to make cement (Blezard, 1998). Such natural cement, which is produced by burning naturally occurring mixtures of lime and clay, is still used for structures in traditional societies throughout the world. Because the ingredients of natural cement are mixed by nature, however, its properties vary as widely as the natural resources from which it is made. Such was probably the case with most of the cements created by early civilizations. It was not until 1824 that Joseph Aspdin, a stone mason in Leeds, England, was awarded a patent on a recipe for hydraulic cement. Aspdin called his product portland cement, apparently because the color of his product resembled the stone quarried on the Isle of Portland off the British coast where he worked. Aspdin's main contribution was the introduction of a method to standardize the proportions of raw material and the milling, blending, and firing steps required to create a cementitious product with reproducible properties. His product was a hydraulic lime used primarily for fast-setting stuccos and not the product recognized today as OPC. OPC contains substantial amounts of tricalcium silicate, but Joseph Aspdin's cement contained none of this. William Aspdin, Joseph's son, noted that by increasing the lime content of the mixture and burning it at an elevated temperature, a slow-setting but high-strength product was produced. This is OPC as we know it. The OPC produced today is a rigorously standardized combination of calcium, silicon, iron, aluminum, gypsum and other additives (Francis, 1977).

Once the minerals required for OPC production have been identified, extracted, and transported, minerals containing calcium carbonate ($CaCO_3$), silica (SiO_2), alumina (Al_2O_3), and ferric oxide (Fe_2O_3)

must be brought together and sintered at high temperature (1,450°C) in a kiln to form an entirely new range of silicate minerals in a proto-cement called clinker. In the cement production process, free lime (CaO), silica (SiO_2), and mineral phases of solid solution dicalciumsilicate $(CaO)_2SiO_2$ react to form the early strength-producing material, tricalcium silicate $(CaO)_3SiO_2$. In order to facilitate cement chemistry dialog, cement chemists worldwide have adopted a standard notation for the common oxides found in cement (Locher, 2006). This cement chemistry notation makes use of the fact that most of the elements are present in their highest oxidation state and that cement analyses report mineral components as mass percent of mineral oxides. These notations include calcium oxide or free lime (C), dicalcium silicate or belite (C_2S), tricalcium aluminate or celite (C_3A), tricalcium silicate or alite (C_3S), and tetracalcium aluminoferrite (C_4AF).

Because most of the kiln reactants and clinker minerals remain in the solid state as the high temperature reactions proceed, the components of the kiln feed must be homogeneous and in intimate contact for control of the kinetics and completeness of solid state reactions (sintering). Thus, management of particle size by milling, grinding, and blending are critical steps in the production of high-quality cement. The raw materials for OPC are blended as a dry powder in modern plants or in the form of slurry in older plants; the wet blending method ultimately requires more energy for OPC production than the dry method. Typically, the content of individual components in the blend is controlled within 0.1 percent or better. In modern plants, instrumental analytical chemical monitoring is used to make continuous adjustments to the proportion of materials in the kiln feed (Hewlett, 2006).

Bauxite or laterite is often used to adjust the proportion of Al_2O_3 or Fe_2O_3 in the kiln feed. Clay minerals start to decompose at about 500°C, producing highly reactive finely divided SiO_2 and Al_2O_3. These compounds react with $CaCO_3$ to produce calcium silicates, aluminates, and ferrites at well below the dissociation temperature of $CaCO_3$. Aluminum and iron facilitate the rate and completeness of silicate-forming reactions at the lowest possible temperature by producing a flux that wets the surfaces of the solid particles. All the raw minerals in the cement kiln feed will dissociate below 1,000°C, with $CaCO_3$ calcination consuming most energy in the decomposition of the raw minerals. The surface of the $CaCO_3$ particles may begin dissociation at 850°C where the partial pressure of CO_2 is relatively low. If the $CaCO_3$ particles are too large, CO_2 partial pressure in the outer layers of the particle increases, inhibiting calcination of the particle center (Hewlett, 2006).

The final clinker formation reaction takes place by the solid reactants dissolving in the Al_2O_3 or Fe_2O_3 flux and the solid product crystallizing out of this flux. In actuality, reaction equilibria are subject to controls imposed by stoichiometric relationships, reactant concentrations, reaction-free energies, reaction kinetics, and residence time in the kiln. The reaction-free energies and reaction kinetics depend on the temperature at which the reactions take place. It is well understood that the free energy of most compounds is reduced when the crystal structure is disrupted, either thermally or by incorporation of minor substitutions in the lattice. The temperature profile along the length of the kiln is designed to follow a nonlinear pattern with a steep gradient between the decomposition zone on the uphill end of the kiln and the burning zone about one-half-way downhill toward the burner. The steep temperature gradient between the decomposition zone and the burning zone, along with kiln rotation, accelerates the transition from the low temperature proto-cementitious materials in the kiln to clinker, while maximizing crystalline disorder in the most hydraulically active phases (Hewlett, 2006).

16B.2.2 Mineral Inputs for Cement Production

At the core of the OPC business sector is the beneficiation of a collection of minerals that are perhaps the most common on Earth's surface; these include the primary constituents of carbonate rocks, clay, and sand. Bauxite and iron ore are also needed to adjust the proportions of Al_20_3 and Fe_20_3 in the raw material blend to comply with standard formulas. A certain amount of gypsum is also needed, depending on the ultimate application of the OPC. Approximately 1.5 metric tons (t) of dry raw material is required to produce 1 t of clinker (International Energy Agency Greenhouse Gas R&D Programme, 1999). By substituting pozzolanic materials, such as fly ash or blast furnace slag, for the gypsum, the cement industry has been able to reduce CO_2 emissions in the production process. In cement production, raw materials make up less than 25 percent of the total cost of production.

Production begins with the discovery and quantitative assessment of primary mineral deposits needed for the enterprise. Soviet and Afghanistan geologists identified a number of limestone deposits during geologic surveys in the 1970s, but very little exploration specifically for limestone deposits was conducted. Figure 16B–1 shows the areas in Afghanistan that are geologically permissive for the limestone, gypsum, and bauxite used to produce OPC; clay, which is also required, is not shown on the map because it is ubiquitous across Afghanistan. The map shows that calcareous materials are permissive over vast areas north and south of the Hindu Kush and within the area encircled by the ring road and beyond. The tract, which has been delineated using the digital geologic map of Afghanistan (Doebrich and Wahl, 2006; Ludington and others, 2007), consists of map units having limestone or marble identified as a major or dominant component. Although limestone of different ages may have different qualities and uses, lithological age was not used to delimit the permissive tract because of the lack of information about the quality or consistency of the various limestone deposits.

Limestone is the most important component of cement and it also has many additional uses in agriculture and industry. Many of the currently active limestone quarries in Afghanistan are mined on a small scale and provide building stone for local markets. Especially promising larger limestone deposits that could support open-pit mining methods include the following:

- Badakshan Province:
  - Jamarchi-Balo, Darwazi Bala District (38°15′15″ N, 71°21′10″ E)
  - Sabz limestone—Early Carboniferous with speculative reserves of between 500 and 1,300 million metric tons (Mt) (United Nations Economic and Social Commission for Asia and the Pacific, 1995)
- Baghlan Province, Pul-e Khumri (35°58′50.54″ N, 68°41′14.834″ E)
- Parwan Province, Jabal-e Saraj (35°07′40.49″ N, 68°14′21.04″ E)
- Herat Province:
  - Darra-i-Chartagh (34°26′20″ N, 62°46′00″ E)—Early Triassic deposit that is more than 5 km long and greater than 200 meters (m) thick
  - Rod-i-Sanjur (34°26′ N, 62°44′ E)—Middle Triassic deposit that is up to 400 m thick (United Nations Economic and Social Commission for Asia and the Pacific, 1995)
  - Given that the value-to-weight ratio is relatively low for input materials and for finished cement, transportation of the input materials or the finished product can significantly affect the return-to-investment bottom line. Hence, it is not surprising that limestone, which is the primary material needed for OPC, is usually mined on site. Ideally, sites with plentiful deposits of limestone containing approximately the correct proportion of minerals for grinding and directly firing into clinker can be identified for cement plants. In less ideal locations, cement plants have to use mixtures of limestone or marble, clay, sand, bauxite, or iron ore to fine-tune the chemical composition of the feed to the kiln. Although the U.S. Geological Survey (USGS)-Afghan Geological Survey (AGS) assessment team has identified three categories of clays (brick, adobe, and fire clay) in the country, the particular type of clay is less important to the quality of the cement production than is precise knowledge of the clay chemistry for a particular batch in relation to the particular chemistry of the limestone for the batch. This underscores the requirement for facilities to adjust the composition of raw materials in the blending stage of cement production and for real-time online chemical analysis. Based on the prevalence of clay used for clay structures everywhere in the country, Afghanistan appears to have abundant clayey materials for cement production. The distributions of clay and gypsum resources are cross-referenced to areas of interest in chapter 16A, table 16A–1.

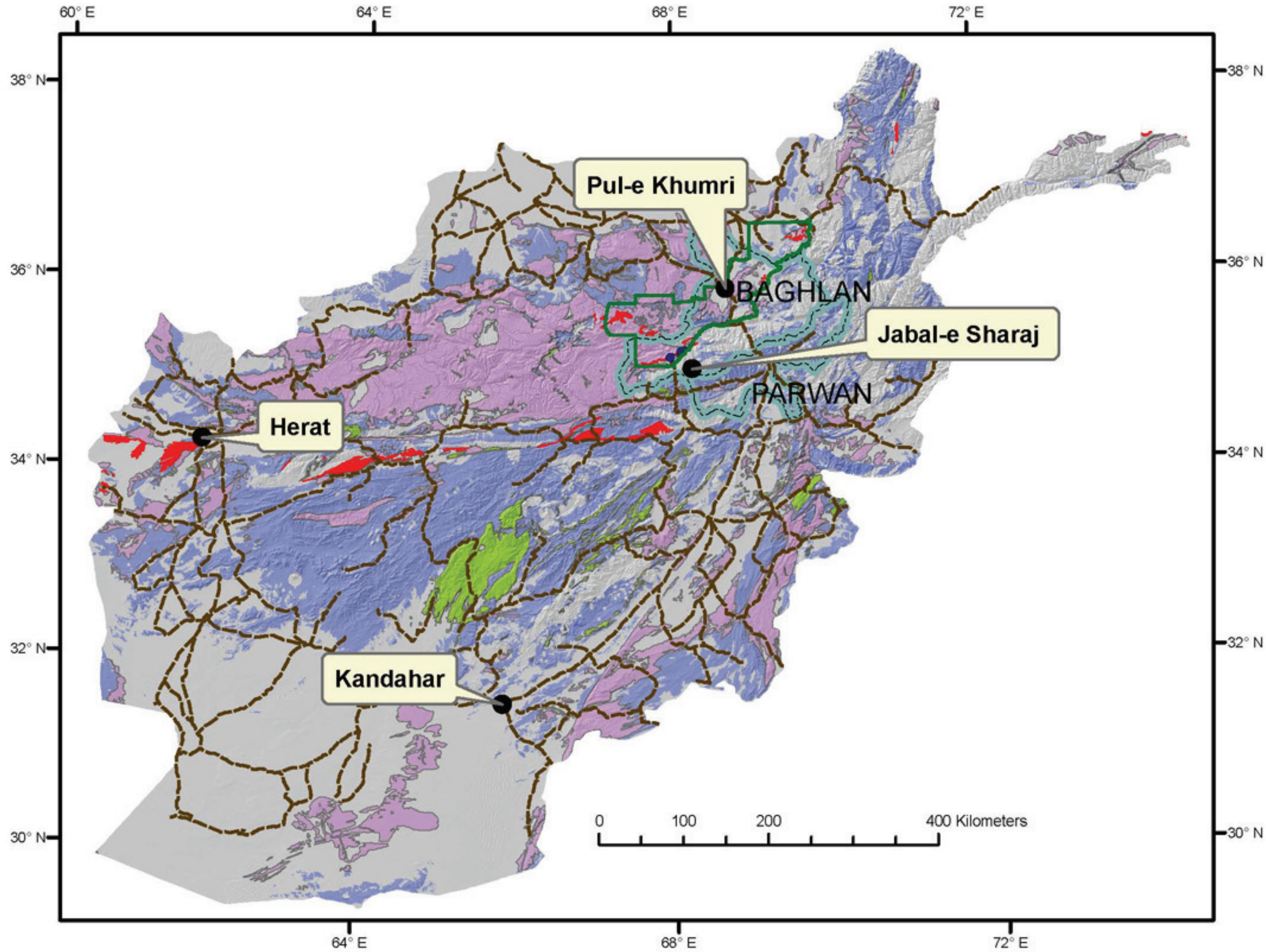

Figure 16B–1. Map showing permissive areas for minerals required for cement production; clay is not shown on the map because it is ubiquitious across Afghanistan. (Base map from Doebrich and Wahl (2006).

Because cement production is capital intensive, the long-term success of a cement production facility can hinge on the quantitative accuracy of the mineral resource estimates. It is critically important to resolve and remove as much uncertainty as possible before developing or expanding a production facility. This can be accomplished by close-grid three-dimensional geologic mapping of potential quarry sites using combinations of geophysics, surface trenching, and deep core drilling. We suggest that proven reserves of raw materials be secured for production inputs for (the normal) 60- to 80-year production lifecycle at a given site.

16B.2.3 Fuel and Electrical Power Requirements for Cement Production

Energy efficiency is an important concern for the cement industry. On a global basis, the cement industry's energy demand is estimated to be about 2 percent of global primary energy consumption and almost 5 percent of total industrial energy consumption (International Energy Agency Greenhouse Gas R&D Programme, 1999). On a plant-by-plant level, energy inputs account for 50 percent to 60 percent of the total cost of production. The demand for energy is distributed between electrical energy for grinding and milling and thermal energy for firing the kiln. Efficient modern cement kilns, which are optimized with kiln preheaters for productivity and energy consumption, require about 3,000 kilojoules per kilogram (kJ/kg) of clinker produced. Basic thermodynamic calculations show that nominally 1,735 kJ/kg of clinker is consumed by the chemical reactions involved in the conversion of the kiln feed into clinker. The remainder of the thermal energy input to the kiln is lost from the system as latent heat in the clinker, dust, and exhaust gases, and as radiation and convection from the kiln shell. For every 1 t of cement produced, 0.82 t of CO_2 is generated, of which 0.43 t is owing to the decomposition of raw materials and 0.39 t is from fuel combustion.

Table 16B–1. Plant operational factors for dry blending cement production.

[kJ/kg, kilojoules per kilogram; kWh/t, kilowatthours per metric ton; mg/m^3, milligrams per cubic meter; MPa, megapascals]

Operational factor	Average plant in China	Advanced international plant
Heat consumption (kJ/kg clinker)	3,344	2,900
Total consumption (kWh/t)	110	85
Kiln dust emission (mg/ m3)	100	15
Kiln NOx emission (mg/ m3)	1,200	200
Kiln SO2 emission (mg/ m3)	400	50
Clinker compressional strength (MPa)	70	58

Table 16B–1 contrasts the energy demands at advanced technology plants with the average plant in China (Jänicke and others, 1985). The table shows the power requirements for cement production and suggests benchmarks to meet for Afghanistan cement producers to be competitive. About two-thirds of the electrical energy required for cement production is consumed in grinding and milling raw materials and for milling clinker into the final cement product. Based on data in Table 16B–1, about 16 megawatts (MW) of power (a mix of electrical and thermal power) is needed to produce 1 million metric tons of cement over a 330-day period of continuous plant operation. Plants using the wet method require significantly more energy.

16B.2.4 Physical Infrastructure for Cement Production

The sequential steps in the production of cement are listed below; each of these steps represents an area of engineering specialization and requires sophisticated infrastructure. To be competitive, the capacity of a plant would need to be designed to deliver bagged or bulk cement in the range of 1,500 to 2,000 metric tons per day (t/d) to a market within a 300-kilometer (km) radius, assuming that the infrastructure (roads, traffic control, and so forth) of the service area is in reasonable condition. In steps 1, 2, 5, 7, 11, and 14, chemical analysis and (or) other physical testing is required to determine particle size distribution or strength. The steps are as follows:

1. Raw materials are quarried and sized down to nominally minus 30 centimeters (cm), then transported by wheel loader to a dump hopper for transport by belt conveyor up to .5 km to the crushing station.
2. Raw materials are crushed in closed-loop crusher-separators.
3. Raw materials are reclaimed.
4. Raw materials are proportioned and blended, using either the wet or the dry method.
5. Materials are transported and blended (optimized for cement type with silica and iron).
6. Materials are transported and milled (in roller and ball mills) to a fine powder (quartz is milled to less than 150 µm and calcite is milled to less than 50 µm).
7. Materials are transported and dried in preheaters and then further blended.
8. Materials are calcined before entering the kiln (modern plants only).
9. Materials are fired in a rotary kiln at approximately 1,450°C to produce clinker.
10. Clinker is cooled and transported for storage.
11. Clinker is crushed and blended with 3.5 percent to 5 percent gypsum to control setting time, and possibly with other additives (blast furnace slag or fly ash).
12. Clinker is milled (using roller and ball mills) to finely powdered cement.

13. Cement is transported for storage.
14. Cement is loaded in bulk into tankers, or into bags by automatic filling and palletizing systems.

16B.2.5 Quality Control

The broad variations in the chemical makeup of the natural raw materials that go into cement production, and the sensitivity of the final product to relatively small differences in chemistry, make quality control mandatory at all stages of production. One of the challenges is that computation of mineralogy based on total oxide composition provides only the potential mineralogy of the product; that is, the possible mix of cementitious minerals in the final product under the assumption that the sintering reactions and cooling take place as designed. Analysis of raw materials and blends for chemistry and homogeneity are best used when conducted real-time in closed-loop systems. Typical methods applied in modern cement plants include automated particle size distribution measurements; cross-belt chemical analysis with prompt gamma neutron activation analysis that provides one analysis per minute for silicon, aluminum, iron, calcium, magnesium, sodium, potassium, sulfur, chlorine, nickel, phosphorus, manganese and titanium; wavelength dispersive x-ray fluorescence for raw materials; and x-ray diffraction for free lime estimation. It is necessary to actively control the chemistry, particle distribution, and blend homogeneity of the kiln feed, and it is equally essential to conduct systematic physical testing on the final product to ensure that the production stages are executed as designed and that the properties of the cement conform to the requirements of the industrial standards. These tests are typically relatively low-technology tensile and compressional strength measurements. Finally, statistical process control is exercised across the production line to ensure that product that is noncompliant with standards is never produced. Foreign cement producers have adopted the quality control system outlined here without exception (Hewlett, 2006).

16B.3 Framework for Field Investigations

In the spring and summer of 2010, a USGS-U.S. Department of Defense Task Force for Business and Stability Operations (TFBSO) field team visited cement plants at Jabal-e Saraj in Parwan Province and at Pul-e Khumri in Baglan Province. The team also conducted a number of meetings at the AGS with geologists and cement plant personnel. The central questions driving the team's inquiry at the cement plants were as follows:

- How prepared are particular indigenous industry sectors and specific operations to capitalize on Afghanistan's mineral resources?
- What is needed at the sector level and at the local plant level?
- What suggestions can the field team offer to the TFBSO?
- What are the expected effects of the suggested actions?
- What are the likely effects of not taking action?

16B.4 Assessment of Specific Sites for Cement Production

The following sites are regularly mentioned in unpublished reports and on the Internet as hosting cement plants that are either in production or are scheduled to be brought online in the near future:

- Herat (Herat Province) (34°19′19.72″ N, 61°57′12.61″ E)
- Kandahar (Kandahar Province) (31°34′22″ N, 65°49′25″ E)
- Jabal-e Saraj (Parwan Province) (35°07′40.49″ N, 68°14′21.04″ E)
- Pul-e Khumri (Baghlan Province) (35°58′50.54″ N, 68°41′14.834″ E)

Interest in cement production at these sites developed because of their vicinity to population centers in the north and south of the Hindu Kush and in the east and west of the country. Although the sites in Herat and Kandahar have never produced cement, they are favorably mentioned in various reports as being licensed sites for greenfield plants (this report provides only a brief overview of the conditions at the Herat and Kandahar sites). The sites at Jabal-e Saraj (Parwan Province) and at Pul-e Khumri (Baghlan Province) have a long history of cement production.

16B.4.1 Cement Production Site at Herat, Herat Province

For thousands of years, the City of Herat has been an important center of commerce in the region; in that respect, nothing in recent years has changed. The most important industry is trade in imported used vehicles from Iran (Box, 2006a). After vehicles, the second most imported product is reported to be cement. The customs office in Islam Qala reported that 27,750 t of cement was imported from Iran during the Ramadan month of October 2005, and that 750 t was imported from Turkmenistan (Box, 2006a).

16B.4.1.1 Existing Facilities

The plant, or more accurately, what is left of the plant, located in western Afghanistan in Herat Province is 25 km west of Herat City at an elevation of 896 m (fig. 16B–2). The Harirud River that flows from east to west is approximately 1 km north of the plant site. The site, which covers approximately 140 hectares, is surrounded by sparse residential settlements to the north and west and by the Kaftarkhana Mountains (the potential limestone source) to the south. Several members of the field team visited the site of the Herat cement facility on April 12, 2010. Because of a security threat and because there were few facilities of interest to examine, the field team stayed at the site for only 15 minutes.

The original circumstances under which the Herat plant was planned have changed demonstrably since its conception in the mid-1970s. Construction of the Herat facility was scheduled to be completed by the end of 1978. The plant was originally designed to produce 700 t/d, or 210,000 metric tons per year (t/yr), using the wet blending process. After 2½ years into a 4-year construction schedule, all work was halted because of the onset of artillery attacks on the job site. The Czech contractor[1] pulled their engineers and immediately abandoned the project. At the time, no more than 25 percent of the mechanical process equipment had been installed. The equipment that had been delivered was either removed to unknown destinations or left exposed to the elements where it rusted or was salvaged for use elsewhere in the country. Of the electrical equipment delivered to the Herat facility, it appears that several diesel generators and large electrical motors were shipped to the cement plant at Jabal-e Saraj and possibly to Pul-e Khumri.

16B.4.1.2 Outlook

Over the long term, the Herat site offers a number of positive attributes for the location of a cement plant. It is near a large population center and has a significant supply of limestone and clay nearby. Coal is available from the Sabzak coal operation located 140 km north of the plant, and there is a spur electrical power line from the Iranian grid already pulled into the site. In the short term, a significant capital investment is necessary to demolish the remnants of the existing facility and for installation of a greenfield plant. Capital investment is also needed to improve the road and rail transportation infrastructure between Herat and the Sabzak coal region, which currently are less than optimal. The main factor working against the viability of a greenfield plant at Herat is the intense competition from the cement manufacturing facilities in Iran and Turkmenistan.

16B.4.2 Cement Production Site in Kandahar Province

Kandahar is a large province in southern Afghanistan with an estimated population of about 500,000, nearly 88 percent of which reside in or near the provincial capital city of Kandahar (Ministry of Rural Rehabilitation and Development, 2011). The region produces pomegranates and grapes, and the city has a thriving dry fruit and canning industry. Kandahar City is linked by road to Farah to the west,

[1]Prerovske Strojirny of Czechoslovakia

Herat to the northwest, Tarin Kot in Uruzgan Province to the north, Ghazni and Kabul to the northeast, and Quetta in Pakistan to the southeast.

Figure 16B–1. Google Earth satellite imagery showing the setting for the Herat cement plant.

16B.4.2.1 Existing Facilities

In the spring of 2003, Hamid Qaderi (a prominent Afghan businessman) proposed to establish a 1,500-t/d (nominally 500,000-t/yr) cement plant in Kandahar to serve reconstruction activities in the surrounding region (United States Trade and Development Agency, 2003). The proposed project, which was based on a 1977 report (Chase World Information Corp., 1977), was approved by the Afghanistan Government and the local authorities. The Afghan sponsors of the project anticipated contributing about 30 percent of the costs by providing land, raw materials, and services. A tender was prepared for funding or financing the uncovered part of the capital investment. The plan was to build a modern cement plant and industrial park; the tender outlined a turnkey plant to be build by PSP Engineering A.S. of the Czech Republic. As of mid-2011, a cement plant has not been built in Kandahar.

16B.4.2.2 Outlook

Although demand for cement in Kandahar Province is increasing, the development of a competitive cement production operation in Kandahar City presents a number of challenges. At this time, coal provides the source of energy in the region. Coal for a plant at Kandahar would have to be delivered from the Sabzak coal mine, which is located more than 600 km north of the site. Without a cost-efficient means of delivery, such as by rail, the fuel cost would be untenable. The coal problem could possibly be resolved in the long run by the installation of a natural gas pipeline to Kandahar (Afghan Chamber of Commerce, 2011) (fig. 16B–3), but there is still a more difficult problem with no obvious solution: there are only minimally adequate limestone reserves close to Kandahar. For a 500,000-t plant, the three relatively small limestone quarries in the Province may be depleted before a greenfield plant could be fully amortized. Under this scenario, limestone transportation costs from more distant mineral resources would be prohibitive, and a 1-million-metric-ton-per-year (Mt/yr)-capacity plant, which would be more competitive, would not be feasible. Finally, owing to the site's close proximity to Pakistan, the regional market would be difficult to penetrate.

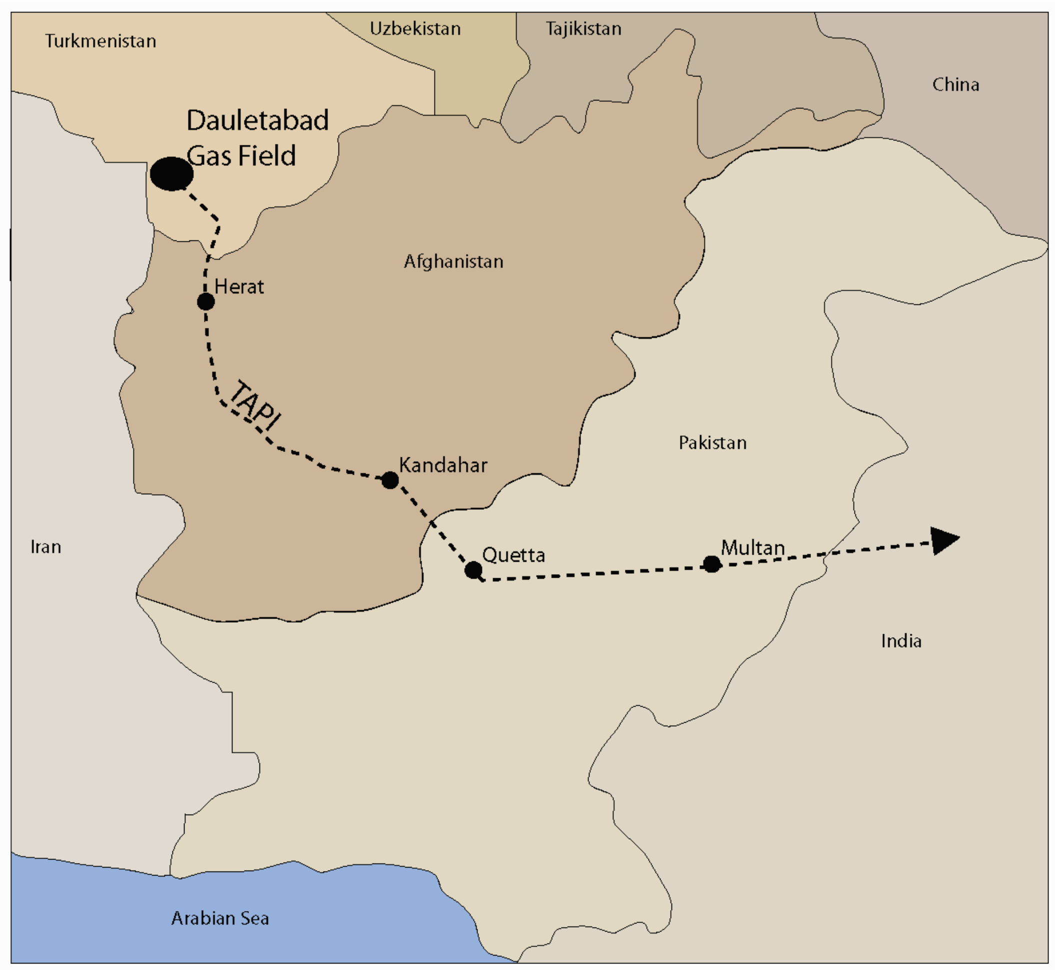

Figure 16B–3. Map showing proposed Turkmenistan-Afghanistan-Pakistan-India (TAPI) natural gas pipeline. Base map from Doebrich and Wahl (2006); pipeline route after Foster (2008).

16B.4.3 Cement Production Site at Jabal-e Saraj, Parwan Province

The cement plant at Jabal-e Saraj is located at the southern base of the Hindu Kush next to the town of Jabal-e Saraj (population about 726,600) at an elevation of 1,670 m. Ownership and control of the plant is the responsibility of the Afghanistan Ministry of Mines. The Jabal-e Saraj plant, which was the first rotary kiln built in Afghanistan, delivered its first bag of cement in 1957. The plant was built for Afghanistan as part of an economic aid package from the Soviet Union. The Czechoslovakian firms Prerovske Strojirny and Prerov Machinery were contracted to provide the equipment and do the construction. Production at the Jabal-e Saraj plant was halted by the Taliban regime in 1996. During the

Taliban period, the plant was bombed 10 times, including a direct hit on the main central kiln ring bearing; the kiln has not operated since that time. No plant upgrades or expansions have been made to the original layout or design of the plant since 1957.

Figure 16B–4. Google Earth satellite imagery showing the Jabal-e Saraj cement plant (foreground) and the plant's main limestone deposit.

16B.4.3.1 Existing Facilities and Plant Development Potential

The Jabal-e Saraj plant was designed as a single kiln, wet process plant with a production capacity of 100 t/d of clinker (33,000 t/yr). On March 27, 2010, a field party of the USGS-TFBSO team traveled to Jabal-e-Saraj in Parwan Province to inspect the cement plant; collect samples of raw materials, clinker, and cement; inspect the equipment; and hold extended discussions with the chief engineer of the plant, Mr. Islamuddin Ahmadi. The team spent about 5 hours at the plant. The equipment appeared to be in virtually the same condition as shown in the photographs made by Box 4 years earlier (Box, 2006b). The following day, the team spent most of the day in discussions on the merits of any number of models for restoration and renovation of the plant. At the end of the meeting, the team had concerns about the viability of the plant, while at the same time agreed that an electrical power spur line from the main grid might serve to attract investors to the plant. It was agreed collectively that before proceeding with any forward movement at the Jabal-e Saraj site, the equipment at the plant would need to be shown to be operational.

16B.4.3.2 Limestone Quality

Figure 16B–4 shows an oblique view of the cement production facility at Jabal-e Saraj with the cement plant in the foreground of the main limestone deposit used for the factory. Inspection of hand samples of limestone collected at the quarry revealed the presence of significant amounts of siderite ($FeCO_3$), which is a mineral that often is associated with significant amounts of magnesium. Some iron and magnesium are tolerable in the limestone, but if these elements are present at concentrations exceeding a few percent, they can cause the concrete made from the limestone to degrade. It would be relatively easy to assess the quality level of the limestone by conducting geochemical mapping at the limestone quarry at Jabal-e Saraj using a hand-held energy dispersive x-ray fluorescence spectrometer. Geologists at the AGS report that another favorable limestone deposit has been identified in relatively close proximity to Jabal-e Saraj, but the grade and tonnage of the deposit has not yet been determined. Verification of this deposit and close-grid geochemical mapping of the main limestone deposit are essential in evaluating the cement production potential of the Jabal-e Saraj site.

16B.4.3.3 Quality Control at Jabal-e Saraj

When the cement plant at Jabal-e Saraj was in operation, limestone and clay materials were analyzed by classical wet chemical methods to determine the relative proportions of the input materials to be blended. Because the analytical procedures required many hours to complete for a batch of samples, the practice was to select samples from input ores randomly at the truck-load scale; the assumption was that the chemical composition of the input materials was reasonably consistent throughout the entire batch, which might be as large as 5 to 10 t. Because this procedure was carried out before the input materials were crushed, blended, and fired in the kiln, the system was open-loop and provided no quality control of the product during processing. Regular quality testing was conducted on the mechanical properties of the finished clinker, however. The mechanical testing was conducted in accordance with industry standards for compression and tensile strength (fig. 16B–5).

During earlier visits to Jabal-e Saraj, USGS scientists were provided cement samples that were represented as being recent Jabal-e Saraj products; what follows is a mineralogical comparison of these samples with those of other producers. The samples were submitted to the USGS laboratories for analysis and were labeled JblShrz-1 and JblShrz-2. USGS scientists later acquired samples from Ghori I, which is a cement plant site in Pul-e Khumri, as well as samples from Pakistan and Iran. These samples were also submitted to USGS laboratories for analysis. Based on the major oxide compositions of the field samples, potential mineral phases were computed using the Bogue algorithm (Bogue, 1955) and compared with compositional patterns computed from data from five separate U.S. producers. Themineral compositions of the JblShrz-1, JblShrz-2, Ghri-I, and Pakistani products are compared in figure 16B–6. Cursory inspection of the patterns in figure 16B–6 reveals that the JblShrz-1 and Ghri-I are mineralogically nearly identical. If JblShrz-1 and JblShrz-2 were made at Jabal-e Saraj, the significant difference in C_2S composition between JblShrz-1 and JblShrz-2 indicates that quenching of the high temperature C_3S phase by the satellite coolers in the Jabal-e Saraj kiln is not adequately reproducible for meeting modern quality control standards. A more likely explanation is that clinker fired at Ghori I was milled at Jabal-e Saraj but not fired at the Jabal-e Saraj plant. Figure 16B–6 also shows that JblShrz-2 submitted as a product of the Jabal-e Saraj plant is mineralogically identical to the Pakistani sample; several alternative interpretations are possible to account for these data.

The compositional patterns graphically represented in figure 16B–7 show that the Pakistani cement is much closer in mineral composition to Iranian cement, and as shown in figure 16B–8, the Iranian cement is similar to that produced in the United States.

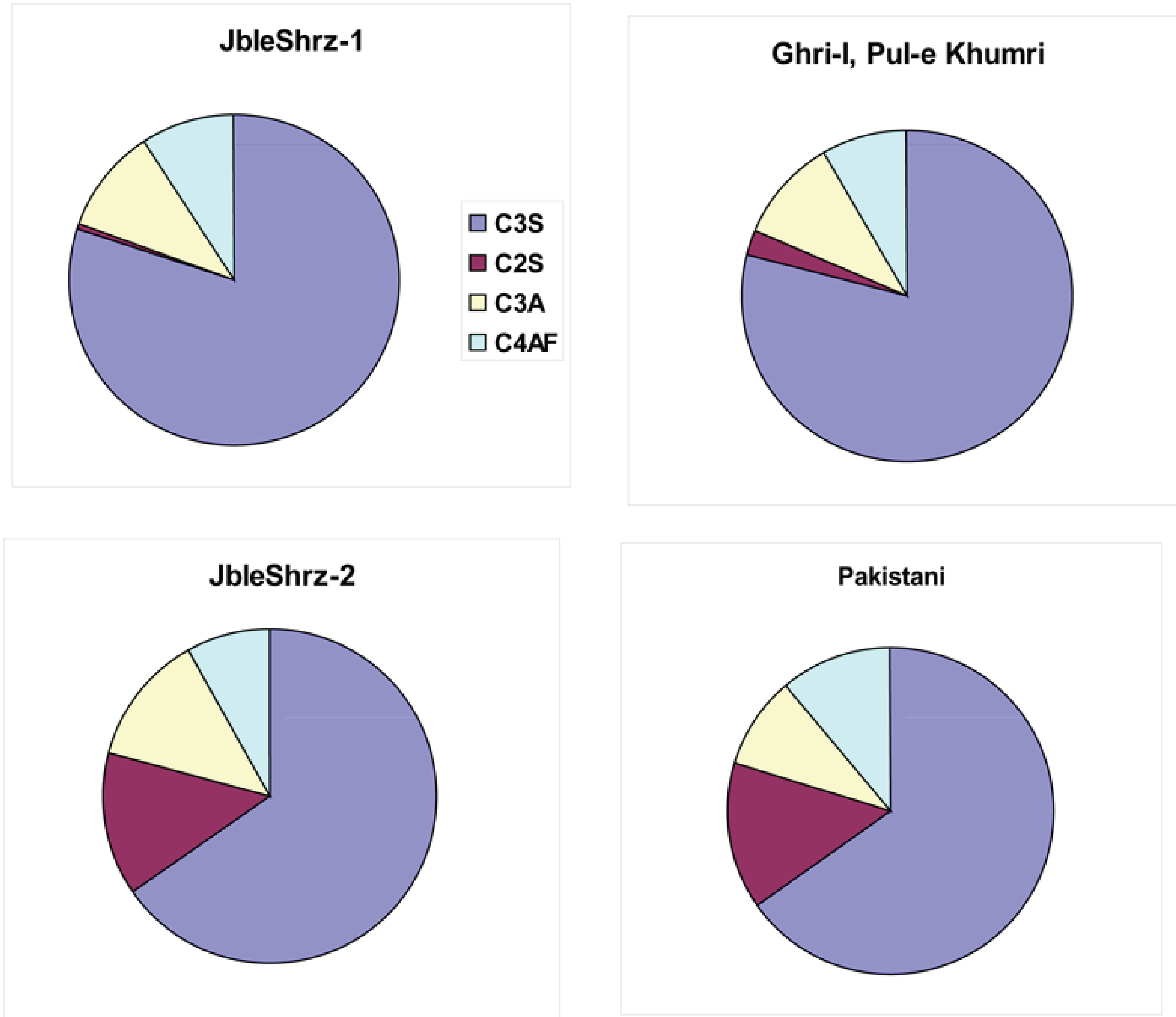

Figure 16B–6. Charts showing mineral composition of JblShrz-1 and JblShrz-2, Ghri-I, and Pakistani cement samples. Charts are from Bogue (1955). C_3A, tricalcium aluminate; C_4AF, tetracalcium aluminoferrite; C_2S, bicalcium silicate; C_3S, tricalcium silicate.

16B.4.3.4 Electrical Power

At the Jabal-e Saraj cement plant, there are two potential sources for long-term supply of electrical power. The first, and that which could provide the greatest amount of power, is a spur line that would connect a substation at Jabal-e Saraj with the main north-south power grid for Kabul. The estimated cost of building the spur line, which would include a transformer farm at Jabal-e Saraj, is expected to be less than US$1 million. The second source of power, a facility that is primarily for the use of the town of Jabal-e Saraj, is a micro-hydroelectric plant that is to be located relatively close to the cement plant. This small powerplant, which will have a capacity of 2.5 to 4.5 MW, is planned for completion in 2011.[2] The fraction of the electrical power from the hydroelectric plant that will be available for cement production was undetermined. It should also be noted that there are considerable uncertainties in the power estimate and timelines for production.

[2] According to a discussion at Jabal-e Saraj with Mr. Ethan Glick, U.S. State Department representative in Parwan, such a facility is in the advanced planning stages, although the precise cost and funding source for the spur line have not yet been determined.

As a backup system, the Jabal-e Saraj plant has a diesel electric generator (salvaged from the Herat plant) that was intended to provide emergency power (fig. 16B–9). This backup generator was designed to have sufficient power to keep the kiln rotating and the essential pumps running (it is important to keep a kiln operating at its functional temperature for many months without interruption). If the generator were restored to its new condition, it could provide enough power to rotate the kiln and to run the basic mechanical support systems for the kiln, but not enough power to run the grinding and milling equipment. This generator has never been in operation, however, and the engine that drives the generator, and virtually all of the support equipment for the engine (starter engine, starter compressor, cooling system, fuel tank, exhaust system, and turbo charger), are not working at present.

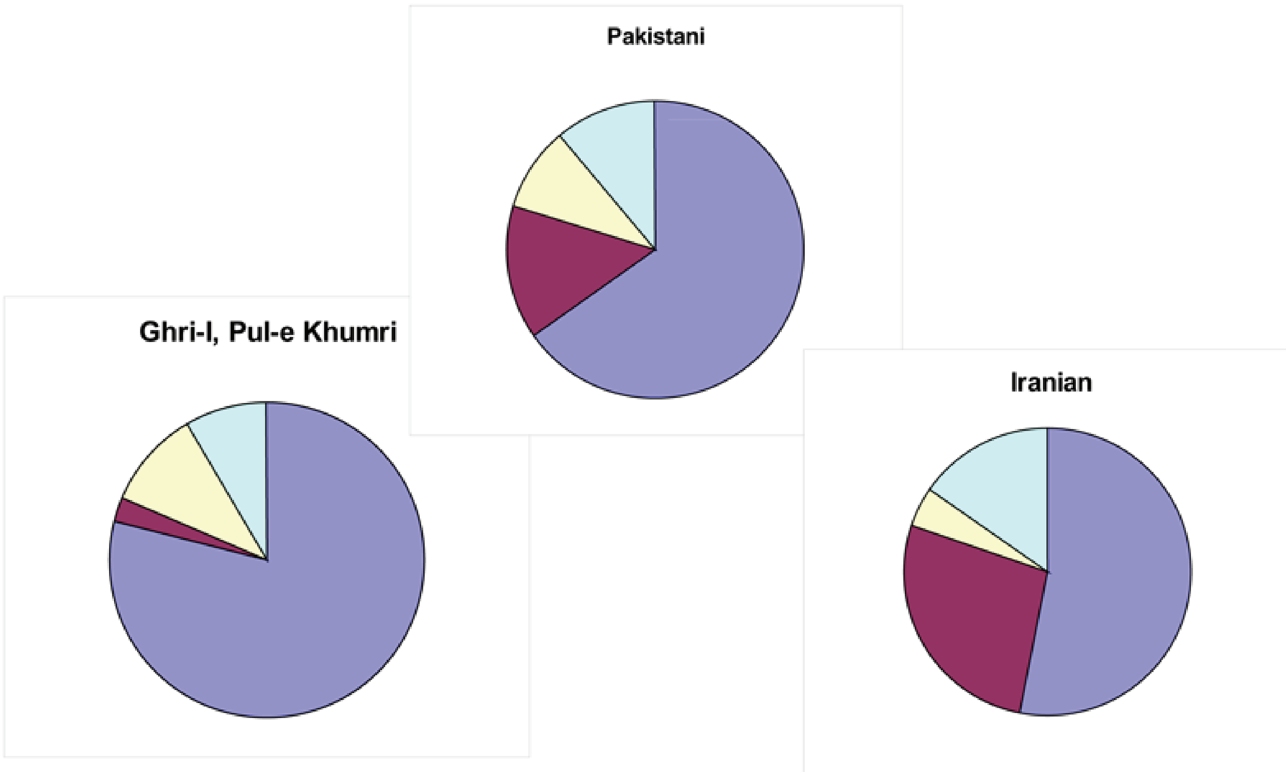

Figure 16B–7. Charts showing mineral composition of cement samples produced at Ghori I, Pakistan, and Iran plants. Charts are from Bogue (1955).

On April 17, 2010, representatives of the TFBSO had a meeting at the AGS in Kabul with the Director of the Jabal-e Saraj cement plant. At that meeting, they decided to go forward with the restoration of the backup diesel electric generator at the plant in order to be able to test some of the machinery used for cement production. Arrangements were made for three engineers from the Czech Republic to work on the generator at the plant for 10 days. On July 27, 2010, members of the USGS-TFBSO team met with the engineers at Bagram when they arrived from the Czech Republic. Work began that afternoon at the Jabal-e Saraj plant.

On first inspection, it was concluded that the generator could not be put into operation without new parts and a great deal of work. For a variety of reasons, it was decided that the engineers would continue in Jabal-e Saraj for two more weeks, using the time to analyze the mechanical and electrical issues with the generator system thoroughly and to prepare a proposal for its repair. The data in Table 16B–2 summarize the cost of implementing a highly detailed plan for restoration of the generator submitted by CKD Elektrotechnika of Prague, Czech Republic.

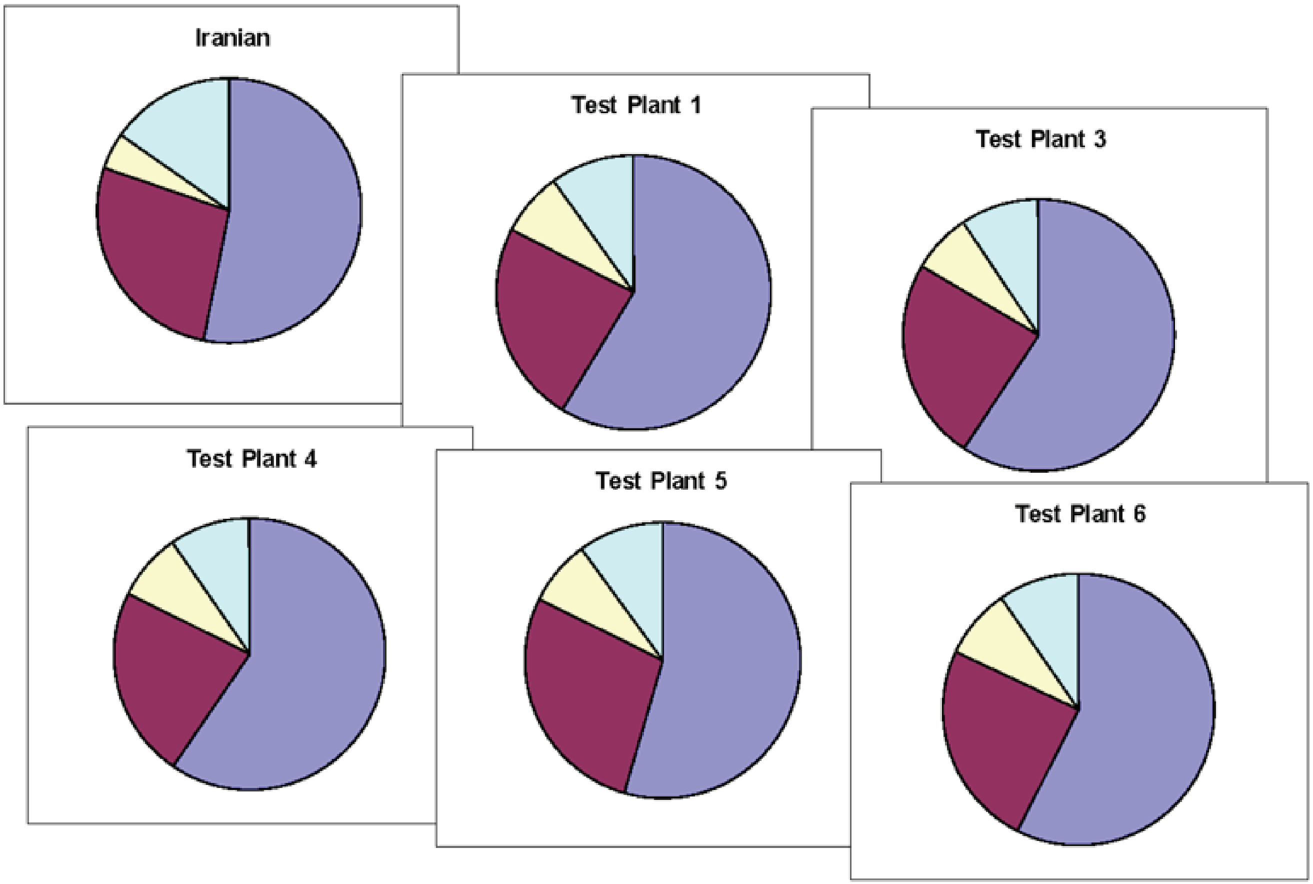

Figure 16B–8. Charts showing mineral composition of cement samples from one Iranian and five U.S. cement plants. Charts are from Bogue (1955).

Because it was clear that the generator would not be available for testing the plant equipment, the USGS representative arranged with the director of the Jabal-e Saraj plant to have all the electrical power that might be available in the area of Jabal-e Saraj redirected to the cement factory. When the power was routed to the plant, it was apparent that the main switch box was adequate to handle the power load. The electrical power was sufficient to test only pumps, compressors, conveyers, bagging equipment, and the rotation of the kiln, however (fig. 16B–10). All the equipment tested was found to operate. It was also apparent that the machinery was in need of maintenance and would require parts to be replaced in order to be able to hold up to continuous operation. The USGS representative closely inspected the interior of the kiln by crawling through its interior to about one–third of its length from the burner. The brick lining and slag deposits on the interior sides in the burning zone were found to be in reasonably good condition (fig. 16B–11). On being apprised of the findings, the TFBSO representative met with the plant director and the Parwan Power commissioner and agreed to explore pulling in a spur line to the plant.

16B.4.3.5 Raw Blending

Kiln roasting of raw blends prepared by the wet method is significantly more energy intensive than roasting dry kiln feed. Because of this, there are questions as to whether the production of products involving calcining and kilning at Jabal-e Saraj can be cost competitive with products delivered to the marketplace by the dry method.

16B.4.3.6 Availability of Trained Workforce

Because cement has not been produced at Jabal-e Saraj for a considerable period of time, the engineering and management staffs would likely need updated training to deal with the complexities of modern cement production and with up-to-date marketing, sales, and delivery methods. Recent graduates or students that are near graduation could be trained at Kabul University or Kabul Polytechnic University where a venue could be arranged to support a training program.

16B.4.3.7 Transportation Infrastructure

The chief advantage of Jabal-e Saraj is its location to Kabul. At present, the surface of the road linking Jabal-e Saraj to the Kabul highway is quite broken up; a rail line linking Jabal-e Saraj with Kabul would be ideal.

Figure 16B–9. Power generator at Jabal-e Saraj cement plant (not functional). Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.4.3.8 Outlook and Near-Term Guidance

For the Jabal-e Saraj cement plant to become productive in the near term, the actions outlined below are suggested. Although the factory at Jabal-e Saraj could produce cement in the near term, it would be challenging to produce cement at a competitive price without extensive renovation of the facility. The following are the essential elements of a near-term model for producing cement at Jabal-e Saraj, which is based on utilizing existing production infrastructure with as few upgrades as possible.

Funding: Conduct a detailed feasibility study to determine if the following actions can be achieved and funding obtained.

Staff: Hire well-qualified people who already know how to make cement. The following positions are suggested:

- Chief executive officer and chief financial officer
- Cement factory engineer
- Cement chemist
- Administrative officer
- Information technology/database technician
- Marketing/sales person
- Human resources personnel to handle all issues related to staff
- Mining geologist
- Factory workers to specialize in specific plant operations

Electrical power: AA spur line to power the plant.

Fuel for kiln: Make arrangements with a coal producer that can guarantee a reliable supply of coal. Consider purchasing coal from wherever it is available.

Table 16B–2. Summary of cost for restoration of the 1,450 kilovolt-ampere DG generator at the Jabal-e Saraj cement plant.

[Source: CKD Elektrotechnika]

Restoration cost				
Item	**Name**	**Total price**		**Remarks**
1–16	Accessories	$86,061		Necessary
17–20	Measuring instruments	2,2062		Necessary
21–91	Tools	14,043		Necessary
92–379	Installation material	132,149		Necessary
380–445	Set of spare parts for initial operation	129,123		Necessary
446–465	Compressor spares	5,533		Necessary
466–468	Turbocharger tools and spares	15,904		Necessary
469	Set of spare parts for governor	1,371		Necessary
470–471	Electrical items	45,087		Necessary
	Total necessary	451,333		
472–481	2-stage signaling system	678		Optional
482–489	2-cooling circuits	53,908		Optional
490–499	Cooling tower	146,661		Optional
500	Exhaust silencer	12,984		Optional
501–531	Workshop equipment	9,578		Required
	Total optional	223,810		
	Grand total	675,142		
Estimated cost of technicians				
		Days	**Rate per day**	**Total**
I. stage	Mechanical engineer	23	$1,600	$36,800
	Electrical engineer	12	1,600	19,200
II stage	Mechanical engineer	16	1,600	25,600
III stage	Mechanical engineer	16	1,600	25,600
	Electrical engineer	12	1,600	19,200
	Total	79		126,400
	Total restoration cost			801,542

Physical infrastructure suggested:

- A “Rock Hawg” for excavation, primary crushing, road preparation, and trenching in limestone and clay quarries.
- Gypsum and bauxite.
- At least four trucks: two trucks to haul ore; one truck to haul product; and a truck for hauling maintenance equipment and materials around the plant grounds.
- Grinding and milling: Buy new milling balls, but use existing open-loop equipment without introducing updated particle-size distribution engineering and monitoring methods.

- Renovate conveyer systems.
- Renovate the chemistry laboratory and purchase a wavelength dispersive x-ray fluorescence spectrometer.
- Renovate the machine shop and storage facilities for spare parts.
- Renovate the power station and backup generator, cooling cistern, and pumps. The kiln should run 24×7×12; it should be allowed to cool only for repairs.
- Spare parts for the kiln, pumps, and grinding and milling equipment.
- Renovate the office facilities to accommodate management staff and factory workers.
- Instigate a training program.

Methods suggested:

- Stay with the wet method of blending with existing equipment.
- Use existing bagging equipment.
- Spot monitor particle sizes with sieves.
- Monitor kiln temperature.

Figure 16B–10. Kiln at Jabal-e Saraj cement plant with rotary motor powered on. Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.4.4 Cement Production Site at Pul-e Khumri, Baghlan Province

Ghori I has been operating at this location since the 1950s and is still in operation. Construction of Ghori II was started in 1986 but was halted in 1989 with the Soviet withdrawal from Afghanistan. In 2005, the Afghan Ministry of Mines elected to share ownership of the Ghori cement works with the newly created, and privately held, Afghan Investment Company (AIC). As its first endeavor, the AIC decided to finance rehabilitation of the coal mines, to complete and finish the Ghori II cement plant, and to initiate the design of a new modern cement plant with the capacity of 4,000 t/d (Ghori III). According to the Afghanistan Enterprise Information Center and cement plant officials, the Afghan Ministry of Mines seeks to continue privatizing the facilities and the parcel of land occupied by the facilities.[3]

Figure 16B–11. Interior of kiln at Jabal-e Saraj cement plant. Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.4.4.1 Existing Facilities

The cement plants identified as Ghori I and Ghori II are located side-by-side 200 km north of Kabul along highway A76 and 1 km west of the highway in Baghlan Province near the town of Pul-e Khumri. A plant identified as Ghori III is still on the drawing board as a greenfield plant to be situated next to Ghori I and Ghori II. The photograph in figure 16B–12 provides a perspective of the spatial relationship of the cement plants to the water supply from the Pul-e Khumri River and to the large limestone deposit framing the view. The quality of the buff-colored limestone and of the clean clay is reported to be very high (Box, 2006a). The deposit is located directly west of the plant and forms a north-south trending ridge about 1 km long. The clay deposit, which is light-gray in color with a brownish tint, extends about 1 km south from the limestone quarry. The limestone reserve is reported to be about 11 Mt, and that of clay is about 3 Mt (Box, 2006a). Ample quantities of coal are potentially available at the Karkar and the Dudkash coal mines located within 18 km (by road) from the plant. The limestone deposit is intended to be shared with Ghori II when it comes into production. Gypsum required for the last stage of production is mined from a quarry located adjacent to the Dudkash coal

[3]No deed records could be located that document the transfer of ownership of the property to the Afghan Investment company (Box, 2006a).

mine, about 10 km east of Pul-e Khumri. The gypsum, which is sized to less than 300 millimeters, is received by truck at the plant site.

Ghori I is a two-kiln operation with a design capacity of 400 t/d (120,000 t/yr) of clinker with closed-loop grinding, wet blending, and limited quality-control facilities (fig. 16B–13). At Ghori I, one kiln (kiln #2) was down for repair when the USGS-TFBSO team visited the facility on March 30, 2010. The kiln appeared to have been out of commission for a considerable period of time. Kiln #1 was running but upon inspection of the satellite cooler (fig. 16B–14), the team witnessed only a low rate of clinker delivery at its output. Product testing at the plant was conducted only on the finished product. During open-loop processing as practiced at Ghori I, the chemistry of materials in the production stream and the temperature of the kiln was not monitored. The team inquired about the heaps of discarded clinker outside the perimeter of the factory, which was reportedly placed there for storage.

The team observed the operation of a hammer mill receiving limestone at the foot of the deposit; each load was delivered using a 30-year-old truck. A conveyer transported crushed stone into the plant for slurry blending with clay. Water for the operation is pumped from the Pul-e Khumri River, which flows north-south just adjacent to the Ghori I and Ghori II plants.

Ghori II was said to be 95 percent completed. The plant is new in the sense that it has never been in operation since construction began 25 years ago. Just as with Ghori I, Ghori II is a dual kiln wet blending plant (fig. 16B–15), but its designed capacity of 1,000 to 1,200 t/d (1 to 1.2 Mt/yr) of clinker is three times that of Ghori I. The 400-foot-long kilns are impressive, one of which is visible in figure 16B–16. The workshop is well equipped with clean 20-year-old equipment that has never been turned on. The equipment appeared to be in working order. A deficiency at Ghori I and Ghori II is the lack of modern analytical chemistry instrumentation.

The control and recycling of airborne particulate material and fugitive dust emissions is an important concern in all modern cement factories. Improved dust collection at Ghori I and Ghori II is suggested, including installation of dust collection and recycling on kiln exhaust stacks, cooler vents, crushing and milling operations, packaging houses, silos, material conveyances. Apart from the apparent absence of dust control equipment, the team did not explicitly assess any other environmental issues associated with the use of the Pul-e Khumri River or with coal mining.

16B.4.4.2 Outlook and Near-Term Guidance

The Ghori I and Ghori II production facilities are uniquely positioned to initiate the restoration of the cement sector across Afghanistan. Currently, the northern Afghan OPC market is dominated by Pakistan, although Pakistan is located south of the Hindu Kush and about 1,000 km from the northern Afghanistan market. In contrast, the facilities at Pul-e Khumri are located in the heart of the northern Afghanistan region and relatively close to an abundance of high-quality raw materials, including coal. The current deficiencies in coal production and electrical power are fundamentally solvable problems.

Given that the quality and quantity of the mineral resources near the Ghori cement works is exceptional, the plant has the potential to produce high-quality cement. The crucial tasks that we suggest be addressed in the near-term are (1) complete the remaining 5 percent of construction, (2) modernize coal production at the nearby mines, (3) install a modern instrumental analytical chemistry laboratory and online analysis equipment, and (4) provide training in modern production methods for workers at all levels.

16B.5 Challenges from Afghanistan's Neighbors

The strategies and suggestions for improvement of specific production operations investigated here are ultimately driven by consideration of (1) production factors at specific production sites, (2) the cost-effective availability of indigenous mineral resources for cement production, (3) the dynamics as they exist in the regional and national cement manufacturing sector (supply, demand, distribution systems, local and regional economics), and (4) the challenges related to the dynamics of the international import and export trade in OPC.

Figure 16B–12. View of the Pul-e Khumri Ghori I and Ghori II cement plants. Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.5.1 Perspective on Markets and Competition

As a matter of perspective, in the United States in 2010, 102 cement plants in 36 States produced about 61 Mt of OPC and 1.8 Mt of masonry cement (Kelly and others, 2010). By comparison, China produced about 1.1 billion metric tons of OPC in the same year. About 85 percent of the cement produced in the United States is manufactured using dry process technology. The cement business is typically seasonal. Nearly two-thirds of U.S. cement consumption occurs in the 6 months between May and October. Cement producers typically build up inventories during the winter and ship them during the summer.

16B.5.2 Import Competition

The Afghan national cement market study by Lister and Karaev (2004) reported that, by 2004, Afghan producers in key domestic markets were already displaced by imports of excess capacity from new cement plants in Iran, Pakistan, and Turkmenistan. What follows is a brief sketch of the production capacity of Afghanistan's immediate neighbors and an update on the state of saturation of the Afghanistan OPC market with imported product.

Figure 16B–13. View of the Ghori I cement plant at Pul-e Khumri with kiln #2 dismantled for repair. Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.5.2.1 Cement Production Capacity in Uzbekistan

Uzbekistan has recently reported cement production of 6.8 Mt for a country with a population of 25 million (Ashurmatov, 2007; Kelly and others, 2010). There are currently six cement plants in operation; those with the largest capacity are the plant at Qizilqum (3.15 Mt/yr), the plant owned by Ohangaron Cement JSC (1.74 Mt/yr), and the Quvasoy cement plant (1 Mt/yr). The Uzbek Government announced in 2010 that, to allow Uzbekistan to increase the export potential of its cement industries, three additional plants had been ordered with a total capacity of 4.5 Mt/yr. These include the Jizzakh (3 Mt/yr), Surkhandarya (1 Mt/yr), and Karakalpakstan (0.5 Mt/yr) plants. According to experts, the total recent investment in the development of the Uzbekistan cement industry is about US$250 million (Ashurmatov, 2007).

16B.5.2.2 Cement Production Capacity in Tajikistan

According to recent reports, production at Tajikistan's cement plant in Dushanbe, which is located 130 km north of the border with Afghanistan, is less than 200,000 t/yr (Pšeničný, 2006). Tajikistan, which has a population of 7 million, has one of the lowest gross domestic products in the region, and until recently, Tajik cement did not represent significant potential competition to the Afghanistan cement manufacturing sector. In May 2010, however, the Inekon Group was contracted to build a US$100 million cement plant in the town of Shartous, Tajikistan. The planned cement plant is projected to have an initial capacity of 500,000 t/yr, which could eventually be increased to 2.5 Mt/yr.

Financing for the project is to be provided by the Czech Export Bank. While it was part of the Soviet Union, Tajikistan produced about 1.1 Mt/yr of cement at the Dushanbe cement plant. Rail access from Dushanbe is available to the northern border of Afghanistan by way of the connection near Termez.

Figure 16B–14. Satellite cooler in operation at the Ghori I cement plant. Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.5.2.3 Cement Production Capacity in Turkmenistan

Turkmenistan is a country of approximately 5 million people, in contrast with Afghanistan, which has a population of about 27 million. With the opening of the Turkmenistan Siemens AG OPC plant, which is scheduled for 2011, Turkmenistan will have a cement production capacity of about 1.4 Mt/yr. Siemens Industry Solutions (SIS) is supplying a complete range of high-efficiency equipment for the new plant, including electrical equipment and automation systems. The SIS design is centered on a modern real-time process-control system for supervisory control and data acquisition. Siemens is also responsible for the design and installation of the plant. The requirement for OPC in Turkmenistan is roughly half that of Afghanistan, which leaves an excess production capacity of 0.9 Mt/yr; any excess OPC produced would be available for export.

16B.5.2.4 Cement Production Capacity in Iran

The Iranian cement industry currently produces some 65 Mt/yr to service a population of 68 million. Iran will reportedly export about 550,000 t of cement in 2010, about 65 percent of which will go to Afghanistan; the remainder will go to the Persian Gulf countries. By the end of 2011, eight additional cement production projects in Iran, all with state-of-the-art technology, are projected to be completed; this will boost Iran's cement production capacity to 76 Mt/yr (Tehran Times Economic Desk, 2011). The Iranian cement industry, which has some of the lowest manufactured cement costs in the world, is heavily subsidized by the Iranian Government (Box, 2006a, p. II-13). Iran could control the cement market in western Afghanistan because of (1) state-of-the-art cement manufacturing technologies, (2) low-cost fuel and electrical power, (3) the transportation infrastructure on Iran's eastern border into western Afghanistan is in relatively good condition, (4) an historically strong trading relationship with western Afghanistan, and (5) the port of entry for imports from Iran to Afghanistan is Islam Qala, a border town 115 km northwest of Herat City (Box, 2006b).

Figure 16B–15. View of the Ghori II cement plant's dual 400-foot-long kilns. Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.5.2.5 Cement Production Capacity in Pakistan

Pakistan exports OPC to many countries around the world. In 2004, OPC exports from Pakistan to Afghanistan were estimated to total 1.3 Mt (Box, 2006a). By 2010, OPC production soared to about 33 Mt/yr (All Pakistan Cement Manufacturers Association, 2011). For the most part, Pakistan cement plants are modern and efficient, making them cost competitive. As of 2011, the surplus capacity from Pakistani production was estimated to be about 10 Mt/yr. Cement produced in northern Punjab Province and Khyber Pakhtunkhwa Province (formerly North-West Frontier Province; name changed in 2010) is exported to Afghanistan principally along the Peshawar-Jalalabad highway using Torkham as the port of entry. Torkham is a border town located on the Durand Line on the eastern edge of Afghanistan's Nangarhar Province. Torkham is the busiest port of entry between Afghanistan and Pakistan.

Pakistan cement exports also come into Afghanistan from the southern Provinces of Balochistan and Sindh through Chaman, a town situated in Pakistan just south of the Afghanistan town of Spin

Boldak in the Province of Kandahar. Pakistani OPC dominates the cement markets in Kabul and Kandahar (Box, 2006a, p. II-10). Pakistan cement is even competitive with imports from Afghanistan's neighbors north of the Hindu Kush, which must be trucked through the Salang Tunnel (Box, 2006a, p. II–10).

Figure 16B–16. View of the Ghori II cement plant's 400-foot-long kilns and satellite coolers at Pul-e Khumri. Photograph by Victor G. Mossotti, U.S. Geological Survey.

16B.5.2.6 Cement Production Capacity in Afghanistan

The cement sectors in the countries neighboring Afghanistan are continuing to expand production significantly with a view toward competing in export trade. The most promising markets for Afghan OPC are domestic.

The current dominant source of cement to the OPC market north of the Hindu Kush is from Pakistan. High-quality cement produced in Pul-e Khumri, Baglan Province, could have a location advantage over Pakistani cement, considering that the only practical means to transport cement from Pakistan to the north is by way of the Salang Tunnel. Likewise, a location advantage would also apply for cement produced in Parwan Province near Kabul.

16B.6 Long-Term Suggestions

Suggested near-term improvements for cement plants at Jabal-e Saraj and Pul-e Khumri are outlined in sections 16B.4.3.8 and 16B.4.4.2, respectively. The long-term goal for Ghori I and Ghori II is to establish the cement works at Pul-e Khumri for markets north of the Hindu Kush. Similarly, the long-term goal for the Jabal-e Saraj cement plant is to penetrate the Afghan market south of the Hindu Kush. This first step would need a reliable source of fuel for firing the four kilns at Pul-e Khumri and one kiln at Jabal-e Saraj. Potential fuels include coal or natural gas.

16B.7 Acknowledgments

I wish to thank Dr. Henrik Weissling (Lehigh-Hanson Cement/Permanente Plant) and Dr. Hendrik G. van Oss (U.S. Geological Survey) for their generous support of this project and Thomas D. Box (Box International Consulting) for providing a solid informational foundation of the Afghanistan cement sector. I would also like to express my gratitude for the hospitality and cooperation from cement plant representatives in Afghanistan, including Director Islamuddin Ahmadi (Jabal Saraj Cement), Mr. Karim Farokh (Chief Executive Officer, Afghan Investment Corp.), Engineer Abdul Karem (Director, Ghori I and Ghori II cement plants), and Mr. S.S. Sharma (Chief Financial Officer, Ghori Cement). I would also like to thank Dr. Mohammad Omar (Director, Afghanistan Geological Survey) and his staff of geologist at the AGS for their elucidation of the many issues related to the beneficiation of mineral resources and to the functioning of indigenous industries in Afghanistan. Finally, I want to express my appreciation to Rudi Shenk (TFBSO) for facilitating the field work for this task.

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