Chapter 26A. Summary for the Takhar Area of Interest

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Abstract

The currently recognized commodities within the Takhar area of interest (AOI) are evaporite-related commodities such as salt, gypsum, and celestite. There are also known clay, coal, and dimension stone occurrences and the possibility for occurrences of mercury, sand and gravel, limestone, sulfur, and other commodities. The commodities in the Takhar AOI support a local artisanal mining industry, but there is clear opportunity to support much larger efforts if industries and markets can be developed.

26A.1 Introduction

This chapter summarizes and interprets results for the Takhar evaporite area of interest (AOI) (fig. 26A–1) from geologic and compilation activities conducted during 2009 to 2011 by the U.S. Geological Survey (USGS), the U.S. Department of Defense Task Force for Business and Stability Operations (TFBSO), and the Afghanistan Geological Survey (AGS). Chapters 26B and 26C in this volume address hyperspectral data and geohydrologic assessments of the Takhar AOI. Additionally, supporting data for this chapter are available from the Ministry of Mines, Kabul.

Most of the known mineral occurrences and deposits for this area are for evaporite-related commodities such as rock salt and gypsum, and possibly, sulfur and celestite. Currently, these commodities are exploited by hand. There is potential for finding a wide variety of other deposit types and commodities within this tract, such as dimension stone, porphyry copper, and epithermal gold or mercury, but basic data are scarce. Sand and gravel and limestone are present in large quantities and have probably been mined for local use, although no records of occurrences or deposits were found.

26A.2 Previous Work

Limited exploration for evaporite deposits appears to have occurred in the Takhar AOI. In 1963, Mennessier reported visiting the Namakab salt diapir near “Tartcha-Khana,” where the salt was deeply incised in the Dara-e-Namakab Valley. He also reported salt production near Kalafgan, which is north of the Takhar AOI.

26A.3 Regional Geologic Setting

The Takhar AOI lies along the southern boundary of the Afghan-Tajik Basin (fig. 26A–2); the southeastern part of the AOI transitions out of basin fill into basement rocks of pre-Mesozoic age. Most of the recognized commodities in this AOI lie in the basin sediments (fig. 26A–3). The Afghan-Tajik Basin extends from the southern part of western Tajikistan and southeastern Uzbekistan into northern Afghanistan. In its deepest portions in Tajikistan, it contains more than 10 kilometers (km) of sediment. Marginal structural steps surround the depression, including the North Afghan High, and are uplifted as much as 3 to 8 km relative to the deepest parts of the basin (Klett and others, 2006).

26A.3.1 History

Much of the development of the Afghan-Tajik Basin and northern Afghanistan platform has been related to the movement of the Eurasia, Africa, and Indian continental plates and accretion of various terranes (Ulmishek, 2004). Major events include (1) compression due to the closing of the Paleotethys Ocean in the Late Carboniferous to Early Permian; (2) extensional rifting due to continental breakup in the Late Permian to Triassic; (3) collision and associated deformation of the Cimmerian block with
Eurasia; (4) extension from Early to Middle Jurassic; (5) formation of island arcs, passive margins, and postrift sags through the Early Cretaceous; (6) movement of microcontinents in the Neotethys Ocean through the Early Paleogene; and finally, (7) renewed compression due to the closing of the Neotethys Ocean (Klett and others, 2006). A more complete description can be found in Klett and others (2006).

**Figure 26A–1.** Index map showing the location of the Takhar area of interest in northern Afghanistan.

The Afghan-Tajik Basin comprises the eastern part of the original Jurassic Central Asia Salt Basin, which separates the original evaporite basin into two separate modern basins: (1) the Amu Darya Basin in southern and eastern Turkmenistan and southwestern Uzbekistan and the (2) Afghan-Tajik Basin in northern Afghanistan and western Tajikistan. The Gissar Range in southwest Uzbekistan and southeast Turkmenistan has separated these two basins since uplift during the Miocene and in the process uplifted and concentrated significant potash resources on its flanks at or close to the surface within and adjacent to the uplifted area.

Marine conditions existed through most of the Paleogene in the combined Amu Darya and Afghan-Tajik Basin (Klett and others, 2006). During the late Paleogene, the collision of the Arabian, Iranian, and Hindustan continental plates into the Eurasian plate closed the Neotethys Ocean, resulting in uplift, marine regression, and, finally, deposition of continental sediments by the end of the Paleogene.

Structural movements of the Afghan-Tajik Basin during the basinal stage of development (Jurassic through Paleogene) are characteristic of block-type platform tectonics (Klett and others, 2006). Structural highs, such as the North Afghan High and smaller uplifts, experienced slower subsidence and occasional positive movements that resulted in local disconformities and the absence of parts of the sedimentary sequence (Ulmishek, 2004).
The Neotethys Ocean reached maximum size at the end of Late Jurassic time. At its northern edge (in present-day Afghanistan and Iran) a northward dipping subduction zone with associated island arcs was developed (Boulin, 1988); this is suggested by the presence of calc-alkalic extrusive rocks, which are considered to be indicative of this development (Klett and others, 2006; Doebrich and others, 2006). These island arcs collided with the continental plates resulting in rift inversion, undeveloped passive margins and uplift of the eastern regions of Central Asia.

Most of the Lower Cretaceous in eastern central Asia was deposited under arid continental conditions with some intervening shallow marine and lacustrine deposition (Ulmishek, 2004). In places in the foothills of the Hindu Kush, most of the Jurassic is missing, and Lower Cretaceous sandstones and conglomerate lie directly on Triassic or older rocks (Klett and others, 2006). Overall, the thickness of Lower Cretaceous rocks in eastern Afghanistan is about 300 m.

Upper Cretaceous rocks of the Afghan-Tajik Basin part of northern Afghanistan were deposited in more marine conditions and consist of marine, lagoonal, and continental deposits. These depositional conditions remained through the early Cenozoic (Klett and others, 2006). The maximum marine transgression during this period occurred in Maestrichtian to Paleocene time.

Paleogene sediments are most complete in northern Afghanistan; these are classified as part of the Bukhara series and the slightly younger Suzak Formation (Klett and others, 2006; Afzali, 1981). These sediments were deposited in marine to lagoonal environments and are as much as 650 m thick in the southeastern-most part of the Afghan-Tajik Basin.
Deposits and occurrences are shown on a natural color Landsat 7 mosaiced image (Davis and others, 2007).

26A.4 Evaporites

Thick accumulations of chloride evaporite deposits occur in basins where evaporation exceeds the inflow of water. Most salt deposits are believed to form from evaporitic concentration of vast volumes of seawater in hydrographically isolated (restricted) basins under arid conditions (Warren, 2006; 2010). In hydrographically isolated basins, the inflow of large amounts of seawater in conjunction with evaporation leads to development of brines and, with ever increasing concentration, to precipitation of evaporites which may total many hundreds of meters in thickness (Gornitz, 2009; Warren, 2010). Under the most hypersaline conditions, bitterns, including potash and magnesium salts, are deposited. In some basins, hydrologic input from precipitation, geothermal brines, or continental runoff may impact the chemistry of the basin brines and the rate of evaporation.

Salt has a low density and will flow in a plastic manner (halokinesis) when subjected to enough compressive stress, which can result from the weight of overlying sediments or from a variety of tectonic and structural factors (Raup, 1991b; Harben and Kuzvart, 1996). When this happens, salt will flow into the area of decreased pressure, commonly vertically through the overlying sediments; this process forms salt domes and related features. Salt domes most commonly originate from thick-bedded salt deposits.

The complex mix of tectonics, depositional conditions, climate, chemistry, mineralogy, and syn- and post-depositional alteration creates deposits that are vulnerable to destruction by surface conditions.
26A.5 Geology of the Takhar Evaporite Area of Interest

The exposed geology of the Takhar AOI consists largely of Cretaceous to Recent sediments. The lithologies of the Mesozoic and Early Cenozoic units consist of a mix of marine to lagoonal to continental sediments with contained evaporites such as gypsum and anhydrite.

The evaporite deposits within the Takhar AOI are part of the Afghan-Tajik Basin fill, which in part is composed of the eastern portions of the Central Asia Jurassic Salt Basin. The geologic age of these deposits appears to be in question, based on the literature. Most workers consider the thick halite deposits like those in Afghanistan to be Jurassic (Afzali, 1981; Smith, 1975, Abdullah and others, 1977; Abdullah and Chmyriov, 2008). Other workers consider the salt to be Cretaceous in age based on the age of some of the limestone into which the diapirs and domes intrude. However, diapirs commonly intrude younger sediments, so while the salt may be Cretaceous, it is more likely older. Additionally, evaporites known to be Cretaceous that are found farther north and northwest in the basin have relatively thin halite and are dominated by gypsum. The thickness of the known salt resources and other evaporites needed for halokinesis supports a Jurassic age for the diapiric salt.

Jurassic salt is present within the Takhar AOI as salt domes or diapirs; the gypsum is commonly described as “bedded” but is closely associated with the salt structures (fig. 26A–4). Remote sensing data of the area indicate it is dominated by carbonates (fig. 26A–5), and there is little indication of the local pervasiveness of the gypsum (halite is not detectable by hyperspectral methods). Assessment of salt in Afghanistan was previously discussed in Orris and Bolm (2007a).

There have been no reports of potash or magnesium salts in the Jurassic evaporites in Afghanistan. However, potash is widely distributed within the Jurassic evaporites to the northwest in the more western parts of the Central Asia Salt Basin. Much of the Jurassic evaporite section within most of the Afghan-Tajik part of the Salt Basin is too deep (several kilometers) for evaluation or economic extraction; it is largely known only in diapirs, and the process of halokinesis can destroy these highly soluble deposits.

There is also some potential for evaporite deposits related to younger Paleogene to Neogene sediments. Paleogene sediments are most complete in the northern part of Afghanistan; these are classified as part of the Bukhara series and the slightly younger Suzak Formation (Klett and others, 2006; Afzali, 1981). These sediments were deposited in marine to lagoonal environments and are as much as 650 m thick in the southeastern-most part of the Afghan-Tajik Basin. Two of the three members of the Bukhara series are gypsum-bearing.

26A.6 Known Deposits and Occurrences

Halite, or rock salt, deposits and occurrences occur at several locations within the Takhar AOI (table 26A–1). It is found in salt domes, including Taqca Khana (Namakab), which is the largest rock salt deposit in northern Afghanistan. It occurs in a Late Jurassic diapir that is overlain by Paleogene to Neogene sedimentary rocks (Abdullah and others, 1977; Abdullah and Chmyriov, 2008).
Figure 26A–4. Geology of the Takhar area of interest showing distribution of evaporite deposits and occurrences (Doebrich and others, 2006).
In 1963, Mennessier reported that the dome here was several kilometers in diameter and that the salt core was surrounded by gypsum and marl, which in turn was surrounded by a limestone 12 or more meters thick. On the north side of the salt core, the surrounding rocks are overturned by 45°, but then straighten to a steep dip. The rock salt is reported to be finely crystalline, light gray to red-brown, and to
have a highly variable texture. Impurities include clay, anhydrite, and dolomite. The salt has a low bromine content that may indicate that it has been recrystallized. The Namakab River cuts through the salt structure on its western edge (Kulke, 1972).

Miklov and others (1967) report that rock salt at the Chal-I occurrence can be traced along a creek for at least 1 km; talus prevents estimates of the extent of the salt at Chal-II. Local workings at both sites extend to depths of about 20 m and remain in rock salt.

Gypsum is known to occur in Jurassic and Cretaceous sedimentary formations within the Takhar AOI; this includes map units J3cgs and K2ssl on the Doebrich and others map (2006). These formations are permissive for the occurrence of the bedded gypsum deposit type (Raup, 1991). There is also gypsum associated with the salt domes in the area, believed to be Jurassic. Gypsum is also a significant component of several Paleogene and Neogene units in northern Afghanistan.

<table>
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<tr>
<th>Name</th>
<th>Commodity(s)</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Age</th>
</tr>
</thead>
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<td>69.544</td>
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</tr>
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<td>69.532</td>
<td>Late Jurassic</td>
</tr>
<tr>
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<td>36.537</td>
<td>69.519</td>
<td>Late Jurassic</td>
</tr>
<tr>
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<td>69.643</td>
<td>Late Jurassic</td>
</tr>
<tr>
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<td>Late Jurassic</td>
</tr>
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<td>69.625</td>
<td>Late Jurassic</td>
</tr>
</tbody>
</table>

26A.7 Celestite

Sedimentary celestite deposits are the main source of celestite in the world. The known deposits in Afghanistan and other parts of the Afghan-Tajik Basin are believed to be a variant of the sedimentary celestite deposit type that can form in a variety of ways, including primary precipitation and diagenetic and various alteration processes. The strontium needed to form these deposits is believed to be sourced from marine-derived brines, from fluids resulting from the conversion of aragonite to calcite or gypsum to anhydrite, from waters formed by dolomitization of limestone, from dissolution of subsurface gypsum, and from basinal waters that have leached strontium from associated rocks (Evans, 1999; Hanor, 2000). Celestite is commonly associated with evaporite deposits, as well as with limestone and dolomite. Mineralization is in the form of concretions, seams, or impregnations (Harben and Kuzvart, 1996). There is a school of thought that all of these deposits are telethermal and precipitate from hydrothermal fluids or fluids enriched in strontium supplied by hydrothermal fluids (Abdullah and others, 1977; United Nations Economic and Social Commission for Asia and the Pacific, 1995; Ehrlich, 2002).

Khasanov (1983) reports that celestite in the Afghan-Tajik region formed as result of diverse sedimentary processes in coastal sea and lagoonal conditions where there was significant salinity. Epigenetic celestite has formed in associated with gypsum, fluorite, strontianite, barite, calcite, dolomite, anhydrite, and gypsum and may be found in karsts, and as streaks, veins, lenses and disseminations. Khasanov (1983), Kotkin and others, (1979) and other researchers believe that the celestite in the Afghan-Tajik basin area is a secondary product of leaching and recrystallization at low temperatures. Features of the Afghan celestite deposits that support a sedimentary-diagenetic origin for the mineralization include (1) the occurrence of the mineralization within the same horizon(s), (2) the persistence of celestite mineralization over long distances, and (3) the association of these celestite deposits with coal, which all in turn suggests a lagoonal or near-shore depositional environment.

There are two known celestite deposits in Afghanistan, Kunduz and Tangi-Murch (Orris and Bliss, 2002). Neither deposit is located within the Takhar AOI in Baghlan Province. However, similar Paleocene rocks are believed to occur within the Takhar AOI. Kazak and others (1965) report celestite lenses associated with bituminous limestone. Four celestite bodies at this location are reported to contain speculative resources of 0.085 megatonne (Mt) of ore containing 53.96 volume percent celestite (Abdullah and others, 1977; Abdullah and Chmyriov, 2008). Similar to the Kunduz deposit described
below, the Tangi-Murch mineralization is present in the Paleocene bituminous limestone of the Bukhara series but is also reported to be present in Suzak units. At the Kunduz (Kartaw, Kortau) deposit, celestite is found in folded sediments of the Paleogene Bukhara series sediments, specifically in a horizon of gypsum and light-gray bituminous limestone (Lim and Hyupperen, 1976). None of the mineralization shown is present in the younger Paleocene Suzak Formation, as reported in some literature (Afzali, 1981; United Nations Economic and Social Commission for Asia and the Pacific, 1995). The celestite forms massive and disseminated ore that extends over 1,000 m along strike and up to 14 m down-dip and ranges from approximately 1 to 8 m thick. The Kunduz deposit has speculative resources of 1 Mt of celestite (Abdullah and others, 1977; Abdullah and Chmyriov, 2008).

26A.8 Dimension Stone

Dimension stone commercially sold as limestone is sedimentary rock that is primarily composed of calcium carbonate with or without magnesium. This includes limestone, dolomite, dolomitic limestone, and travertine. Limestone is quarried in Afghanistan for dimension stone (McReady, 2006), but there are no occurrences or mines in the Takhar AOI.

Some of the sandstone found within the AOI, such as that at the Frahkar siliceous sandstone occurrence (fig. 26A–3), may be suitable for use as dimension stone, as well as a source of silica. Because there is no new information on these deposits, readers are referred to Sutphin and Orris (2007) for a more complete discussion of dimension stone potential in Afghanistan.

26A.9 Epithermal Gold and Mercury

No gold or mercury occurrences are documented within the Takhar AOI. However, epithermal gold and (or) mercury deposits may be present. A mercury anomaly in the stream sediment sampling in part corresponds to goethite anomalies spotted in the 1-µm wavelength HyMap hyperspectral imagery (fig. 26A–6). This area was not discussed by Rytuba and others (2007). The lack of documented occurrences, with the exception of a single lead-zinc vein occurrence in the southwest part of the AOI, may suggest a low probability for one of these deposits being found within this AOI.

26A.10 Limestone and Carbonates

The Takhar AOI has the potential for limestone and related deposit types. Several of the Cretaceous to Neogene geologic units on the Doebrich and others geologic map (2006) within the AOI list limestone as a major (unit P1lssb, SDld, C2ls) or minor component (units J3cgs, J12ssl, N1lcs1, N1mcsl, K2ssl, Ossl), but there are no deposits or occurrences documented within this area. Because there is no new information on carbonate resources within the Takhar AOI, readers are referred to the chapters on limestone (Orris and Bolm, 2007b) and dimension stone (Sutphin and Orris, 2007) in Peters and others (2007a), the USGS assessment of mineral resources in Afghanistan.
26A.11 Porphyry Copper

A small section of the West Hindu Kush porphyry copper tract of Ludington and Peters (2007) occupies the southeastern half of the Takhar AOI. Possible indications of porphyry copper mineralization within the AOI include (1) a small lead-zinc vein occurrence in the southwest of the AOI; (2) a lead-zinc stream-sediment anomaly in the south-central part of the area; and (3) an area of stream
sediment mercury anomalies in the eastern portion of the lead-zinc anomaly (fig. 26A–7). There is no guarantee that these anomalies are linked to porphyry copper mineralization, but the possibility exists. The lack of copper prospects and anomalies in this area is not encouraging for the presence of an undiscovered porphyry copper deposit in the AOI. For a more complete discussion of the possibilities, the reader is referred to Ludington and Peters (2007).

26A.12 Sand and Gravel

There are no reported sources of sand and gravel in the Takhar AOI, which occupies part of Basin 13 as identified in Bliss and Bolm (2007). However, parts of several major roads are recognized in the northern and western sections of this AOI, and the presence of those roads suggests that some sand and gravel was likely extracted in the vicinity of the AOI for their construction and ongoing maintenance. However, neither the intensity nor the extent of sand and gravel exploration is known. Exploitation of deposits near major and other roads is likely, given that both the U.S. Army Corps of Engineers and the Former Soviet Union have historically been involved in developing roads in Afghanistan. Sand and gravel is most commonly produced near the points of consumption; this implies that locations in regions that are distant from existing roads and towns are not likely to have been exploited at any scale.

Sand and gravel deposits within 25 km of towns and major roads are identified as possible sources of sand and gravel (figs. 26A–3, 26A–8). These permissive areas consist of fluvial sand and gravel deposits as determined by Bliss and Bolm (2007). Areas considered permissive for fluvial sand and gravel deposits are defined by their study to have slopes of less than 10°. Other factors such as the topography of individual basins, degree of association with active rivers and (or) mountain ranges, and source rock geology, all of which impact the availability of sand and gravel with acceptable properties, are delineated, but the implication of these factors is that some significant proportion of the permissive area for sand and gravel will not contain deposits. The reader is referred to Bliss and Bolm (2007) for more detailed information on sand and gravel resources in this area.

26A.13 Sandstone

Sandstone sold commercially is lithified sand that comprises chiefly quartz or quartz and feldspar with a clastic texture. Sandstones are all bedded rocks of sedimentary origin consisting of grains of weathered quartz, feldspar, or other noncarbonate material more or less strongly bound together by some type of interstitial cement (Wybergh, 1932) such as calcite, clay, iron oxides, or silica. Sandstone dimension stone varies widely in color, texture, and composition of the material in the grains and the cement. Two sandstone mining operations are known in Afghanistan. The Frahkar siliceous sandstone deposit in the Takhar AOI, near its eastern border, occurs in a Lower Carboniferous unit composed of siltstone, sandstone, and slate and contains two siliceous sandstone beds that are 1.2 to 8.0 km long and 50 to 120 m thick. Containing 95.0 to 97.3 percent silica, production can be used to make dinas brick or coke and for facing electric furnaces (Kolchanov, 1967).
Figure 26A–7.  Anomalous amounts of lead and mercury in stream sediments relative to the geology of the Takhar area of interest.
26A.14 Sulfur

Native sulfur and gypsum deposits may occur within the Takhar AOI, although no occurrences are known. There is a celestite deposit in the vicinity of the AOI and in similar rocks in other areas of the Afghan-Tajik Basin where native sulfur deposits are spatially associated with celestite (Lein and others, 1978; Petrov, 1971; Mikhalev and others, 1967). The sulfur deposits are hosted by evaporitic sedimentary rocks with a biogenic component; sulfates were reduced to sulfur by bacteria feeding on hydrocarbons trapped in the host rock as part of the deposit’s formational process. These sulfur deposits may be notably younger than their host rocks, and within the Takhar AOI, the late Cretaceous to Neogene evaporite-bearing rocks are permissive for the occurrence of this deposit type. Known occurrences of this deposit type in northern Afghanistan are small, but deposits of this type can be extremely large. For additional information on sulfur deposits in Afghanistan, readers are referred to Peters and others (2007b).

There is also some possibility that native sulfur deposits associated with salt domes could occur within the Takhar AOI. These deposits form in a biogenic process where sulfur replaces anhydrite, gypsum, and (or) limestone (Long, 1992). Because these types of sulfur deposits typically occur in the cap rock, they would be expected to be found early in the exploration of salt dome deposits. However, there is no information to definitively determine if these deposits are present.

26A.15 Summary of Potential

The known and possible resources of rock salt within the Takhar area of interest are extensive; the possibility of associated potash deposits is small but cannot be discounted, given the low level of exploration. Gypsum is widespread in Mesozoic and Cenozoic rocks in this AOI, with a greater

Figure 26A-8. Areas permissible for sand and gravel deposits, Takhar area of interest (Bliss and Bolm, 2007).
likelihood of deposits within the Jurassic sediments. Undiscovered celestite deposits could exist in the Paleocene gypsiferous carbonate sediments similar to the deposits at Tangi-Murch and Kunduz. Limestone and sand and gravel resources are clearly present, although not documented, and are likely of sufficient size to support a local industry. Rock suitable for dimension stone includes granitic and sedimentary units present within the AOI. Development may be hindered in the southeastern parts of the Takhar AOI, where there are few main roads (fig. 26A–3).

Overall, the limited available data suggest that the resource base in the Takhar AOI could support much larger mining efforts for the commodities that are already being exploited by artisanal efforts.

26A.16 References Cited


