Chapter 9A. Summary of the Kharnak-Kanjar Mercury Area of Interest

Contribution by Gregory Fernette

Abstract

This report summarizes and interprets results for the Kharnak-Kanjar area of interest (AOI) and its subareas from joint geologic and compilation activities conducted during 2009 to 2011 between the U.S. Geological Survey, the U.S. Department of Defense Task Force for Business and Stability Operations, and the Afghanistan Geological Survey.

The Kharnak-Kanjar AOI is located on the southeastern margin of the Farah Rod basin and is underlain by Cretaceous and Cenozoic continental sedimentary rocks with lesser amounts of Cenozoic volcanic and intrusive rocks. The area is cut by numerous faults related to the regional scale Kash Rod Fault located to the east of the AOI.

The AOI hosts 19 occurrences of mercury mineralization. With further exploration, a number of the occurrences have the potential to be of economic size and grade as mercury deposits.

Mercury occurrences and associated intrusions and hydrothermal alteration indicate the presence of a very large low-temperature hydrothermal system. Similar systems elsewhere in the world host significant gold resources and are the focus of major exploration investment. As such, epithermal gold is an additional and possibly more attractive exploration target for the area.

9A.1 Introduction

This report summarizes and interprets results of a compilation and review of the geological data for the Kharnak-Kanjar area of interest (AOI) and its subareas from joint geologic and compilation activities conducted from 2009 to 2011 between the U.S. Geological Survey (USGS) of the Department of the Interior, the Task Force for Business and Stability Operations (TFBSO) of the Department of Defense, and the Afghanistan Geological Survey (AGS) of the Ministry of Mines of Afghanistan.

The Kharnak-Kanjar AOI is located in western Afghanistan (fig. 9A–1). It contains a number of mercury prospects which are part of a 380-kilometer (km)-long northeast trending belt of mercury occurrences in western Afghanistan (fig. 9A–2). The mercury occurrences were identified during work by the AGS in the 1960s and 1970s.

This report contains a summary of the geology and mineralization of the AOI based on a review of the available data, and is written to provide information for prospective investors in the Afghan mineral sector.

9A.2 Location and Access

The Kharnak-Kanjar AOI is located in western Afghanistan about 400 km west of the national capital of Kabul. The center of the AOI is about 64°53’ E. longitude and 33°26’ N. latitude. Most of the AOI is within Ghor Province. The northwestern half of the AOI is located mainly in Pasaband District with parts also in the Du Lina and Khadir Districts. The southwestern half of the AOI is located in Taywarah District. The district capitals of Pasaband and Taywarah are both located within the AOI.
No paved roads exist within the AOI, although a major paved road passes just north of the area. Access to the area is via unpaved roads and tracks from the provincial capitals. The area is well populated with numerous small villages, mainly located along valley bottoms, and several medium sized towns, such as Taywarah and Pasaband. Farming is the primary local economic activity.

9A.3 Previous Work and Available Data

9A.3.1 Previous Work

Field work in the Kharnak-Kanjar AOI was conducted between 1967 and 1974. From 1967 through 1971, Soviet contractor Technoexport conducted 1:500,000-scale geological mapping and mineral exploration in southwestern Afghanistan (Dronov and others, 1970, 1973). This work consisted of systematic traverses, stratigraphic studies, heavy mineral concentrate sampling, and prospect examinations in accordance with standardized Technoexport procedures. The program included reconnaissance prospecting over the entire Kharnak-Kanjar AOI in 1969-70 that resulted in the discovery of numerous mercury anomalies in heavy mineral concentrates. These discoveries lead to the recognition of a mercury province in southwestern Afghanistan and recommendations for a long-term mercury exploration program (Kabakov and Litvinenko, 1970, Dronov and others, 1973).

A separate program focusing on mercury exploration was established and started in 1970. The initial focus was on the followup of cinnabar heavy mineral halos in the Farah Rod basin. During this part of the program, reconnaissance exploration consisting of heavy mineral concentrate sampling and
geologic mapping at 1:50,000 scale were carried out (Kotov and Meshcheryakov, 1970; Azhipa and Teleshev, 1971; Orlov and others, 1972). Based on positive results from the initial program, two crews, referred to by the village names of Taywarah and Pasaband, were formed to conduct more detailed exploration in the southwestern and northwestern parts of the AOI (Litvinenko and others, 1971, 1972a,b). Field work continued until 1974 (Orlov and others, 1973; Kornev and Arvanitaki, 1974; Pokidyshev and others, 1974; Kornev and others, 1975). Early in the program, the Pasaband crew recognized the Qalat area as potentially significant, and this area was subjected to more detailed exploration (Mesechko, and others, 1972).

The exploration was conducted using standard Technoexport procedures consisting of spaced geologic traverses, using air photos for geologic mapping, collection and analysis of heavy mineral concentrates from stream sediment, talus, soil and crushed rock samples, trenching, pitting, and channel sampling. In addition, at least one adit was driven and a limited number of shallow drill holes were completed at several prospects. Mineralogical examinations were done in the field camps and chemical analyses were done at the Afghanistan Department of Mines laboratory in Kabul. During the study, tens of thousands of heavy mineral concentrates and thousands of geochemical samples were analyzed and hundreds of pits and trenches were excavated. An important part of the Technoexport work consisted of paleontologic support of geologic mapping with the result that most of the layered rock units have age control based on fossil assemblages.

In addition to the Technoexport program, the area was covered by a regional aeromagnetic survey in 1966 (PRAKLA, 1967; Bosum, and others, 1968). The AGS summarized the geology and
mineralization of the area in the early 1970s as part of a compilation of the geology and development of a minerals database for the country (Abdullah and others, 1977). In the early 1990s, the United Nations prepared a summary of the geology and mineral resources of Afghanistan (United Nations Economic and Social Commission for Asia and the Pacific, 1995) which was based largely on Abdullah and others (1977).

The USGS reviewed and compiled the data on the geology, mineralization, and mineral potential of the area as a part of an assessment of the mineral resources of Afghanistan (Orris and Bliss, 2002; Doebrich and Wahl, 2006; Sweeney and others, 2006; Peters and others, 2007). In the course of the USGS project, new 1:250,000-scale geological maps of the area were compiled (McKinney and others, 2005) and true color Landsat image mosaics were prepared (Davis and Hare, 2007).

The most recent field work in the region was conducted in 2008 by a team from the Department of Geology and Mineralogy of Vilnius University, Lithuania (Motuza and Šliaupa, 2008). They carried out regional geologic work to the north of the AOI and summarized the data from previous work within the AOI.

9A.3.2 Available Data

This report is a compilation of data from previous work. The AGS has an extensive archive of reports, maps, and data which was inventoried by the British Geological Survey (British Geological Survey, 2008). The majority of the reports relating to mineral resources are in Russian and Dari, although some have English translations and English map legends. Will Stetner and Karine Renaud of the USGS electronically scanned 12 reports and the accompanying maps which pertain to the Kharnak-Kanjar AOI. All of these reports and maps were available for review. Four of the reports are available in English or were translated, and most of the maps in the Russian language reports have legends in both English and Russian. Two reports that are available in English (Pokidyshev and others, 1974; Kornev and others, 1975) contain detailed summaries of previous work, and these were heavily relied upon for this review.

9A.4 Regional Geology

The Kharnak-Kanjar AOI is located in west-central Afghanistan in a region with predominantly strike-slip faults and compressional tectonics related to the collision between India and the Eurasian Plate (Tapponier and others, 1981) (fig. 9A–3). The AOI covers part of the northeastern edge of the Farah Rod tectonic block or trough (Abdullah, 1977; Treloar and Izzat, 1993; Leven, 1997). The Farah Rod block or trough is a west-opening wedge-shaped basin composed mainly of Mesozoic sedimentary rocks which is bounded on three sides by major faults (Montenat, 2009). The north boundary of the Farah Rod is the Qarganaw-Band-e-Bayan strike-slip fault zone which separates the Mesozoic basin sediments of the Farah Rod from the Band-e-Bayan fold-thrust zone. The southern margin of the Farah Rod is the northeast trending right lateral Kash Rod Fault zone. This fault forms the northern edge of the Kash Rod Zone or Panjaro Suture which separates the Farah Rod from the Helmand Block to the south (Tapponier and others, 1981). The Helmand Block is the remains of the ancestral Afghan continental block (Treloar and Izzat, 1993). To the west near the Iranian border, the Farah Rod is bounded by the north trending right-lateral strike-slip Hari Rod Fault (Montenat, 2009) which marks the eastern edge of the Sistan Suture Zone (Tirrul and others, 1983).

The central part of the Farah Rod consists of a very thick greater than 15,000-meter (m) section of Late Triassic to Early Cretaceous flysch sediments (Dronov and others, 1973; Montenat, 2009). The basement of the trough is not exposed. The lower part of the Triassic consists of a sequence of siltstone, shale, and polymict sandstone overlying a basal limestone unit. The Triassic rocks are overlain with angular unconformity by a lower to middle Jurassic conglomerate of sandstone and siltstone that is capped by a thin section of limestone. The upper contact of the Jurassic sediments is also an angular
unconformity. The Cretaceous terrigenous red sandstones and conglomerate are capped by carbonate rocks which form the uppermost basinal unit. The Mesozoic basinal sequence is overlain by locally thick units of Paleocene continental volcaniclastic rocks (Montenat, 2009).

The Farah Rod trough and all of western Afghanistan are intruded by scattered Cretaceous to Eocene-Oligocene intermediate to granitic intrusives, which are related to extensional phenomena associated with the later stages of the westward extrusion of Central Afghanistan along the Herat and Helmand Fault zones (Debon and others, 1987).

9A.5 Geology

The Kharnak-Kanjar AOI is underlain by Cretaceous and lower Cenozoic sedimentary rocks which are intruded by small intermediate igneous plugs and dikes (fig. 9A–4). The layered rocks are made up of two structural stratigraphic packages—one comprising lower Cretaceous sedimentary rocks and the second consisting of Eocene to Pliocene sedimentary and volcanic rocks. The entire area is cut by numerous northeast trending faults which are related to the Kash Rod Fault and suture located to the southeast.

The Cretaceous sedimentary rocks in the Kharnak-Kanjar AOI consist of terrigenous clastic and carbonate rocks which were deposited during the waning stages of the Farah Rod basin and during the transition from flysch to molasse-type sedimentation (Montenat, 2009). Unless otherwise noted, the following summary of the geology of the Kharnak-Kanjar AOI is derived from Pokidyshev and others (1974) and Kornev and others (1975).

The Cretaceous section is divided into three “suites” based on age. The lowermost suite is the Panjshah Suite and hosts all of the mercury mineralization in the AOI. The Panjshah Suite consists of 1,000 to 2,000 m of brown calcareous siltstone with numerous interbeds of calcareous sandstone and limestone. It unconformably overlies folded upper Jurassic sedimentary rocks. Its age is estimated as Berriassian-Valmiginian (Early Cretaceous) based on stratigraphic position (Kornev and others, 1975).

The second suite of rocks is the Kholmiran Suite which conformably overlies the Panjshah Suite. The Kholmiran consists of 2,000 m of gray calcareous siltstone, calcareous sandstone, oolitic limestone, and arenaceous limestone. Its age is Valanginian-Hautvernian (Early Cretaceous) based on its fossil assemblage (Kornev and others, 1975).

The Kholmiran Suite is in-turn conformably overlain by the Kajan Suite. The Kajan is of Baremian-Aptian age based on its fossil assemblage. The suite consists of 800 to 1,000 m of medium- to fine-grained bedded terrigenous limestone, marl and calcareous siltstone capped by thick bedded limestone. The Cretaceous and older rocks in the AOI were folded in what Pokidyshev and others (1974) consider a second deformation event in the late Cretaceous. The possibility that the different deformations may be due to thrusting is not mentioned.

The lower Cretaceous rocks are disconformably overlain by several thousand meters of Cenozoic sedimentary rocks and lesser amounts of volcanic rocks. These consist of Eocene to Pliocene red-colored coarse- and fine-grained clastic continental sedimentary rocks. The predominant lithologies are conglomerate, gritstone, and polymict sandstone with lesser amounts of variegated altered acid to basic volcanic rocks. The Cenozoic rocks are deformed into broad folds, monoclines, and fault blocks.

The major structures in the AOI are the North and South Pasaband Faults which parallel the Kash Rod Fault located to the southeast. At least four other major faults cross the AOI and trend subparallel to the Pasaband Faults. There are also many lesser faults which trend obliquely to the major faults.
Figure 9A–3. Regional geologic setting of the Kharnak-Kanjar area of interest. Pink areas are intrusive rocks. Compiled from Abdullah and others (1977), Tapponier and others (1981), Debon and others (1987), Stocklin (1989), Treloar and Izzat (1993), Montenat (2009).
Figure 9A–4. Geologic and mineral occurrence map of the Kharnak-Kanjar area of interest. Compiled from Pokidyshev and others (1974), Abdullah and others (1977), Orris and Bliss (2002), and Doebrich and Wahl (2006).
Igneous rocks in the AOI consist of Eocene-Oligocene andesite and basalt, and undifferentiated Miocene volcanics. Intrusive rocks in the AOI are dikes and small stocks or plugs of diabase-gabbro, gabbro-diorite, granite porphyry, and granodiorite. The dikes range in width from centimeters to tens of meters and have strike lengths ranging from tens to hundreds of meters. Most of the dikes are steeply dipping. The stocks and plugs are typically ovoid in shape and cover tens of square meters to several hundred square meters; none are large. Most of the intrusive rocks are intensely altered to carbonate and/or dickite and thus the original lithology is often difficult to determine (Pokidyshev and others, 1974). The age of the intrusive rocks is not well understood. Karapetov and others (1969) assigned all intrusive rocks in the Farah Rod to the Paleogene Gariba Complex based on field relations observed during regional geologic mapping. Debon and others (1987) place the intrusives in the Farah Rod into the Northwestern Farah Rod Intrusive and Volcanic Complex, and they report nine K-Ar dates, ranging from 103 Ma (late Cretaceous) to 42 Ma (middle Eocene).

**9A.6 Mineral Deposits**

The mercury prospects in Kharnak-Kanjar AOI are part of a northeast trending belt of mercury prospects which extends for 380 km across central and southwestern Afghanistan (Peters and others, 2007) (fig. 9A–2). Pokidyshev and others (1974) identified a total of 19 mercury prospects in the Kharnak-Kanjar AOI. Abdullah and others (1977) and Orris and Bliss (2002) summarized the data on the area, but no new prospects were added. The locations of the mercury occurrences given by Orris and Bliss (2002) were used in this report but were amended to conform to map locations and/or coordinates provided in the original reports.

All of the mercury prospects in the AOI are proximal to major faults (fig. 9A–3). They are also associated with dikes and small intrusive bodies but not with the possible larger intrusives which can be interpreted from magnetic highs on the aeromagnetic map (fig. 9A–5). Pokidyshev and others (1974) describe the general geologic characteristics of the mercury prospects as follows: (1) all mercury prospects contain mercury as cinnabar with no other significant mercury minerals; (2) commodities, such as arsenic, antimony, or base metals, are present in only trace amounts; and (3) all occurrences have similar carbonate-dickite alteration.

More detailed descriptions of the mercury prospects are given below. Unless otherwise noted, the following summaries are derived from Pokidyshev and others (1974) and Kornev and others (1975). The descriptions proceed from northeast to southwest in the AOI regardless of the significance or amount of exploration work.

**9A.6.1 Khanjar Mercury Prospect**

The Khanjar Hg prospect is located on the North Pasaband Fault zone in the northeastern part of the AOI. The prospect consists of a zone of brecciated and altered rock 2- to 4-m wide and 1-km long. The wall rocks are lower Cretaceous terrigenous sedimentary rocks of the Panjshah Suite. Cinnabar occurs in fractures in calcareous sandstone. Within the fault zone are three mineralized zones measuring 10- to 30-m long and 1.0- to 4.2-m wide. The average grade of the mineralization is 0.35 to 0.96 percent mercury.

**9A.6.2 Ali Bali Mercury Prospects**

Ali Bali consists of three mercury prospects located between the North and South Pasaband Faults. The most significant are Ali Bali I and Ali Bali II.

Mercury mineralization at the Ali Bali I prospect is hosted by calcareous siltstones of the Panjshah Suite. The prospect occurs on the northern limb of a premineralization anticline, and numerous faults displace the mineralized zones. Diorite porphyry dikes intrude along the fault zones. The dikes are 1.5- to 6-m wide and have lengths of up to 600 m. The prospect consists of two mineralized zones
The first zone strikes northeast, dips 60° to 70° to the northwest, and is 530 m long and 1.7 to 12 m wide. The mineralization is localized along altered dikes and has an average grade of 0.015 percent mercury. The second zone trends northeast, dips 50° to 70° to the northwest, and is 250-m long and 3- to 8-m wide. The mineralization, which is also associated with an altered dike, has an average grade of 0.05 percent mercury.

Cinnabar occurs in veinlets in fractured and altered dike and wall rock. Both dikes and wall rocks are hydrothermally altered and fractured. The alteration sequence is (1) fine-grained quartz; (2) carbonate, often dolomite; (3) dickite (kaolinite); and (4) quartz-carbonate veinlets.

The Ali Bali II prospect is also hosted by rocks of the Panjshah Suite consisting of northwest-dipping calcareous siltstone, sandstone, and silty sandstone. There are numerous northeast trending faults and fracture zones. The larger faults have 2- to 3-m-wide fracture zones that are altered to calcite-siderite and dickite. Diorite dikes have intruded along the fracture zones in the eastern part of the prospect. The dikes are highly fractured and altered to calcite-dickite. The dike contacts locally show silicified zones 0.5- to 1-m wide.

Mercury mineralization at Ali Bali occurs only in sedimentary rocks, primarily sandstone. Cinnabar is present as fine crystals in veinlets of milky white calcite 1 to 2 millimeters (mm) thick. The grade of the mineralization is reported to be 0.0003 to 0.1 percent mercury with the highest grades found in the northeastern part of the prospect.

Pokidyshev and others (1974) note that the heavy mineral halo at Ali Bali II has a strike length of more than 500 m and larger than the size of the mineralized zones in outcrop. They suggest that there may be a source of mineralization other than that exposed in the exploration trenches.

9A.6.3 Gulgadam Mercury Prospect

The Gulgadam prospect is hosted in rocks of the Panjshah Suite near the South Pasaband Fault. The host rocks are gray to brown, calcareous siltstone alternating with lesser black, silty limestone. Numerous northeast trending steeply dipping fault and fracture zones of varying scales are present, the largest being the South Pasaband Fault zone. The prospect consists of two subparallel northeast trending mineralized zones where cinnabar is disseminated in brecciated calcareous siltstone within the fault zones (fig. 9A–7). The two zones are 150- and 170-m long. In addition to cinnabar, minor amounts of pyrite, galena, limonite, hematite, and stibnite are present; however, the textures and relationships between the minerals are not described. The alteration assemblage is carbonate and dickite.

9A.6.4 Sahebdad Mercury Prospect

The Sahebdad prospect is located adjacent to the South Pasaband Fault. The host rocks are folded calcareous and argillaceous siltstone and sandstone of the Panjshah Suite intruded by several northeast trending diorite porphyry dikes. The dikes range from 3.5- to 15-m wide and are brecciated and intensely altered to quartz-carbonate-dickite-limonite rock.

Mercury mineralization has a grade of 0.001 to 0.005 percent mercury, and consists of cinnabar veinlets and patches in altered siltstones which are interbedded with sandstone. One trench cut a 19-m interval which assayed 0.058 percent mercury. Another cut a 1-m interval which assayed 0.78 percent mercury.
Figure 9A–5. Aeromagnetic and mineral occurrence map of the Kharnak-Kanjar area of interest. Compiled from Pokidyshev and others (1974), Orris and Bliss (2002), Sweeney and others (2006).
Figure 9A–7. Geologic map of the Gulgadam mercury prospect. Modified from Pokidyshev and others (1974). Tan indicates Quaternary alluvium; light green indicates Panjshah Suite; dark green indicates mafic to intermediate dikes; pink indicates mercury mineralization; and red lines indicate faults.
Figure 9A–8. Geology of the Qalat mercury prospect. a) Geologic map of the Qalat Prospect; b) Detailed geologic map of Qalat III; c) Geologic cross section of Qalat III. Modified from Mesechko and others (1972). Tan indicates Quaternary alluvium; light green indicates Panjshah Suite; dark green indicates mafic to intermediate dikes; pink indicates mercury mineralization; and red lines indicate faults.
9A.6.5 Qalat Mercury Prospect

The Qalat prospect consists of three separate mercury showings, all of which occur within Panjshah Suite sedimentary rocks adjacent to the South Pasaband Fault. The host lithologies are terrigenous calcareous sediments folded into northeast trending folds and cut by numerous northeast trending fault and fracture zones. The prospect has three mineralized zones (fig. 9A–8). Cinnabar has been found disseminated in alluvium as well as in bedrock.

The Qalat I prospect is a 10- to 12-m-wide mineralized zone consisting of fracture zones intruded by altered dikes which have been traced for 145 m in trenches. The fracture zone trends northeast and dips 50° to 70° to the southeast. The mercury mineralization consists of disseminated grains and veinlets of cinnabar which are confined to the hanging wall of the fracture zone where alteration is most intense. The average grade of the mineralization is 0.16 percent mercury.

The Qalat II prospect is a 210-m-long mineralized zone which occurs within a brecciated and altered diorite porphyry dike. The dike trends 70° to 80° and dips 60° to 75° to the south.

The Qalat III prospect is a wide zone of fractured calcareous siltstone intruded by a 0.2- to 5.0-m-thick diorite porphyry dike. The mineralization consists of cinnabar with lesser pyrite, galena, and chalcopyrite. The gangue minerals are dickite, calcite, quartz, as well as rare barite, siderite, and ankerite. However, there is no description of the relations between the various minerals.

9A.6.6 Pasaband Mercury Prospect

The Pasaband mercury prospect is located 26 km to the southwest from the Qalat prospect and is situated between the South Pasaband Fault and an unnamed northeast trending fault zone. The host rocks are calcareous clastic sediments of the Panjshah Suite which have been intruded by diorite porphyry dikes (fig. 9A–9). Mercury mineralization is present in hornfelsed, dickite-carbonate altered breccia. In addition to cinnabar, realgar and native copper are reported. The mineralized zone is 400-m long and 3- to 8-m wide. The average grade of the mineralization is less than 0.01 percent mercury.

9A.6.7 Sebak Mercury Prospect

The Sebak prospect is the northernmost of a cluster of six mercury prospects which are located on or near the Katif Fault. The prospect area is underlain by poorly exposed sandstone, siltstone, argillite, and minor limestone of the Panjshah Suite (fig. 9A–10). The host sedimentary rocks strike northwest and dip gently to the southwest.

Mercury mineralization is present within a 30- to 40-m-wide northwest trending sheared and altered zone. Within the fracture zone, the rocks are sheared and brecciated and permeated by veinlets of white calcite and local dickite. The mineralized zone is 140 m long and 3 to 13 m wide. The mercury mineralization consists of fine disseminated grains of cinnabar in or near calcite veinlets and locally near dickite veinlets. Cinnabar in altered igneous rock is reported in one trench. The average grade of the mineralization is 0.001 to 0.002 percent mercury. Arsenic is also present at concentrations of 0.003 to 0.06 percent.

Kornev and others (1975) noted that a large number of ancient mines discovered at the Sebak prospect and surmised that this could account for the low grade of the mercury mineralization. They concluded that the samples taken from the trenches only contained low grade mineralization which had been left behind by the ancient miners. The description of the Sebak prospect in Kornev and others (1975) differs significantly from the map of Kornev and Arvanitaki (1974), so the description above is based on the map by Kornev and Arvanitaki (1974).
9A.6.8 Surkhnow Mercury Prospect

The Surkhnow prospect is located 2.5 km south of the Sebak prospect. The area is underlain by northwestern-dipping siltstone, argillite, and sandstone of the Panjshah Suite. The sediments are cut by a 1,500-m-long and 300- to 400-m-wide northeast trending zone of brecciation, fracturing, and shearing. Abundant calcite veinlets are present as well as lesser amounts of dickite and limonite.

![Geologic and sampling map of the Pasaband mercury prospect. Modified from Orlov and others (1972). K1sd2 indicates Panjshah Suite; Q indicates Quaternary sediments; red lines indicate fracture zones; and red lines with triangles indicate breccia zones.](image)

9A.6.9 Duwalak Mercury Prospect

The Duwalak prospect is located 4.5 km southwest of the Sebak prospect on a splay of the Katif Fault. The prospect is underlain by Panjshah Suite siltstone with interbeds of limestone. The sedimentary rocks strike 040° to 060° and dip 45° to 70°. Mercury mineralization occurs in two shear/fracture zones (fig. 9A–11). The east zone trends 40° to 60° and the west zone trends 10° to 20°.
Three mineralized zones are present within the shear zone. The first zone is 18-m long and 1- to 3-m wide, and trends 20°. The average grade is 0.006 to 0.08 percent mercury and 0.01 to 0.06 percent arsenic. The second mineralized zone is a fractured and brecciated area measuring 50 by 40 m which contains disseminated cinnabar in calcite veinlets. The grade is 0.0006 to 0.25 percent mercury and 0.003 to 0.06 percent arsenic. The third zone consists of several 1- to 2-m-thick carbonate altered lenses containing disseminated cinnabar and veinlets of clay, but for which no mercury grade is reported.

Figure 9A–10. Geologic and sampling map of the Sebak Hg prospect. Modified from Kornev and Arvanitaki (1974). Q indicates Quaternary sediments; green indicates Panjshah Suite; cross hatch indicates zone of brecciation, silicification, and carbonate; red dash indicates hydrothermal alteration; and black bars in trenches indicates mercury mineralization.

The eastern zone has been traced in trenches for over 800 m and has four mineralized bodies separated by covered areas. East Zone number 1 consists of two parts. The first part is 200-m long, 13- to 27-m wide, and has an average grade of 0.01 to 0.07 percent mercury. The second part of East Zone number 1 is 140-m long, 2- to 13-m wide, and has an average grade of 0.11 to 0.29 percent mercury. East Zone number 2 is 42-m long, 2- to 8-m wide, and has a grade of 0.31 to 0.43 percent mercury. East Zone number 3 has not been fully explored and its full extent is not known. Mineralization in the trenches is 2- to 4-m wide and has a grade of 0.01 to 0.07 percent mercury. East Zone number 4 is an isolated exposure cut by one trench and its full length is not known. The trench exposes 6 m of mineralization is 6 m with a grade of 0.72 percent mercury.

The West Zone trends 10° to 20° and has been traced for 750 m along a strike within a 75- to 160-m-wide zone of fracturing and shearing. The host lithologies are steeply dipping siltstone, limestone, and minor argillite. Several mineralized zones are present within the larger shear zone and these range from 3 to 4 m up to 49-m wide. Most of the mineralized zones contain 0.01 to 0.06 percent mercury, although thin intervals contain 0.14 percent mercury. The mineralized rock is altered with dickite and calcite veinlets and limonite stain.
Figure 9A–11. Geologic map of the Duwalak mercury prospect. Modified from Kornev and others (1975). Tan with no pattern indicates Quaternary sediments; tan with pattern indicates Panjshah Suite; and red indicates mercury mineralization.
In summary, the Duwalak prospect has two zones of mercury mineralization of which the eastern zone is better explored. The eastern zone has a total strike length of 550 m with individual mineralized zones that are 30- to 140-m long, 4- to 6-m wide, and has a grade of 0.02 to 0.72 percent mercury.

Kornev and others (1975) noted that a number of outcrops of mineral spring deposits are present at the Duwalak prospect. These formations consist of talus and alluvium cemented by clay and calcite with segregations of brown iron and manganese oxides. The formations occur in small bodies of a few tens of square meters. No comment was made on their possible relationship with the mercury mineralization.

9A.6.10 Katif Mercury Prospect

The Katif prospect is located near the Duwalak prospect adjacent to a splay of the Katif Fault zone. The area is underlain by Panjshah Suite siltstone, marl, calcareous sandstone, and limestone which are cut by east to west and northeast trending faults. At the Katif prospect, the faults are accompanied by fracture zones with calcite-dickite veining which are 100- to 150-m long and 10- to 20-m wide (fig. 9A–12).

Mineralization at Katif consists of cinnabar either in calcite veins or as disseminated grains in calcareous sandstone with dickite alteration. Realgar is present locally as an accessory mineral. The mineralization is confined to a fracture zone along a fault. The fracture zone strikes 60°, dips 70° to the southeast, and is 110 m long and 0.5 to 6 m wide. The highest grade reported is 0.06 percent mercury over a width of 0.5 m.

9A.6.11 Qasem Mercury Prospect

The Qasem prospect is an area with numerous ancient mine workings. The mercury mineralization consists of disseminated and fracture coating cinnabar in calcareous siltstone. The mineralized zone trends 10° to 20°, is 6 to 13 m wide, and has a length of 650 to 700 m. The grade is 0.001 to 0.005 percent mercury. Individual grab samples from ancient workings contain 0.03 to 0.07 percent mercury.

Kornev and others (1995) feel that the prospect warrants further work, as it has not been well explored, has a large, heavy mineral concentrate anomaly, numerous ancient mine workings, and mercury mineralization that is similar to that at the Duwalak prospect.

9A.6.12 Koh-i-Katif Mercury Prospect

Kornev and others (1975) consider the Koh-i-Katif prospect to be the southwest extension of one of the mineralized zones at the Duwalak prospect. Mercury mineralization occurs near a fault zone which is a branch of the Katif Fault zone and trends 60° to 70°. The country rocks are siltstone, limestone, and argillite of the Panjshah Suite.

Within the fault zone is a 20- to 30-m-wide zone of fracturing and brecciation with strongly “ocherous” rocks and calcite veinlets where cinnabar occurs within calcite veinlets and on fracture surfaces. Dickite alteration is locally intense. No average grade is given in Kornev and others (1975), but they do report that a sample of fractured rock contained 0.08 percent mercury and that a grab sample of dickite-altered rock contained 0.01 percent mercury. The mineralization also contains 0.01 to 0.03 percent arsenic.
Figure 9A–12. Geologic and sampling map of the Katif Hg prospect. Modified from Orlov (1973). Yellow indicates Quaternary sediments; green indicates Panjshah Suite; and cross hatch indicates mineralized and altered zone.
9A.6.13 Pushwara Mercury Prospect

The Pushwara prospect is located 15 km to the southwest and is also on the Katif Fault. Bedrock in the prospect area mainly consists of limestone of the Kajan Suite overlying poorly exposed Panjshah Suite argillite, siltstone, and sandstone. The sedimentary rocks are intruded by andesite dikes which trend 20° and dip to the northeast. The dikes are 5 to 10 m wide and extend for up to 200 m.

Mercury mineralization is restricted to the fault zone where the Panjshah Suite rocks and dikes are fractured, brecciated, and contain calcite and minor dickite veins. The mineralization is reported to extend for 1 km, and no mercury grade is reported. The mineralization also contains 0.0003 to 0.008 percent arsenic and 0.01 to 0.03 percent barium.

9A.6.14 Kharnak Mercury Prospect

The Kharnak prospect is located along the Kharnak Fault in the southwestern end of the AOI. The prospect area is underlain by Panjshah Suite argillite, siltstone, and fine-grained sandstone which have been intruded by dikes of syenite porphyry, quartz, diorite, and lamprophyre. In addition, two small stocks are present in the area. The eastern stock is composed of gabbro-diorite and has abundant veins and fractures (fig. 9A–13).

Mineralization at the Kharnak prospect is hosted by the eastern intrusive body. Three separate mineralized zones present in the area were referred to by Kornev and others (1995) as “ore runs.”

Ore Run #1 is located on the western contact of the intrusive body. Mercury mineralization occurs within a fault zone which trends 330° and dips 35° to the northeast. The ore run is 160-m long and 6.5- to 24-m wide. The host rocks consist of brecciated and altered gabbro and, less commonly, altered siltstone wall rock. Cinnabar occurs in vugs, as encrustations and in veinlets. Radial clusters of stibnite crystals are an accessory mineral. The gangue consists of dickite, dolomite, siderite, and calcite, and the mineralized rocks are strongly limonite stained. The grade of ore run #1 is 0.01 to 0.51 percent mercury, and the best trench showed 6.5 m at 0.17 percent mercury.

Ore Run #2 crosses the central part of the intrusion. The zone dips 60° to 80° to the northeast and consists of two parallel mineralized zones which are 7- to 15-m apart. The western part of the ore run is 160-m long, 2-m wide, and has an average grade of 0.2 percent mercury. The eastern part of the ore run is 70-m long, 1.5-m wide, and has an average grade of 0.55 percent mercury.

Ore Run #3 is located along the eastern contact of the intrusive body. The mineralization occurs in a mylonitized zone which dips 50° to 55° to the southwest. The mineralized zone is 180-m long and 1.5- to 9.0-m wide. The mineralization consists of cinnabar veinlets which crosscut earlier dickite and calcite veinlets.

9A.6.15 Mullayan Mercury Prospect

The Mullayan prospect is located along the Kharnak Fault in the southwestern end of the AOI. The prospect consists of two areas of quartz-dickite alteration within fault zones which cut Panjshah Suite siltstone and limestone. The sedimentary rocks are intruded by small stocks and dikes of diorite porphyry. One altered and mineralized area measures 3.5 by 2.0 m and has a grade of 0.01 to 0.1 percent mercury. The second area measures 9 by 200 m and has samples which assay up to 0.09 percent mercury.

9A.6.16 Panjshah Mercury Prospect

The Panjshah prospect is located 2.3 km northwest of the Mullayan prospect. Weakly disseminated mercury mineralization occurs in dickite-carbonate altered terrigenous sedimentary rocks of the Panjshah Suite which has been intruded by diorite porphyry dikes (Litvenko and Parfenov, 1971).
Cinnabar occurs in the most heavily altered rocks, and the grade of mineralization is less than 0.05 percent mercury.

**Figure 9A–13.** Geologic map and cross section of the Kharnak mercury prospect. Modified from Kornev and others (1995). Yellow indicates Quaternary sediments; green indicates Panjshah Suite; pink and orange indicate altered gabbro-diorite; and red indicates mercury mineralization.

### 9A.7 Discussion of Exploration Potential

The available data indicate that the previous exploration work in the Kharnak-Kanjar AOI was conducted in a systematic and technically sound manner using techniques and technology appropriate to the time. The exploration has been thorough; however, with the exception of a few shallow drill holes, none of the prospects have been tested at depth.

Based on the current review, mercury mineralization in the Kharnak-Kanjar AOI has the following characteristics:

- **Simple mineralogy:** More than half of the prospects have only cinnabar, and when arsenic, antimony, copper, or lead minerals are present, they are in trace amounts.
- **Simple alteration:** More than half of the prospects have dickite-calcite alteration; the remainder have dickite-calcite ±quartz, siderite, and ankerite.
- **Structural control:** All prospects are on faults and near major fault zones.
- **Intrusive rocks:** All prospects are associated with intrusive rocks; some are hosted by intrusive rocks, but it is not clear whether the mineralization is related genetically to the intrusions.
- **Host rock:** Mineralization always occurs in Panjshah Suite rocks.
The spatial distribution of mineralogy and alteration of the mercury prospects in the Kharnak-Kanjar AOI is shown in figures 9A–14 and 9A–15. Prospects with arsenic-antimony and other minerals occur in two groups. The first is a northeast trending group of four prospects (Gulgadam, Sahebdad, Qalat, and Pasaband) in the central part of the AOI. The second is an east-west trending group of four prospects (Katif, Kharnak, Mullayan, and Panjshan) in the southern part of the AOI. Only one prospect, Qalat, has quartz as a prominent part of the alteration assemblage and it is hosted by a diorite intrusion. Of these two groups, six prospects have siderite and (or) ankerite in their alteration assemblage, and two of these, Sahebdad and Pasaband, also have arsenic-antimony in addition to mercury minerals. The remaining four prospects which have siderite ± ankerite as part of their alteration assemblage; Katif to Panjshah, are located in the southern part of the AOI. Several of these prospects also have arsenic-antimony and other minerals in addition to cinnabar. There is a general spatial correlation between accessory minerals and alteration assemblage but no obvious correlation of these variations with major geologic features such as faults or large intrusive bodies.

Pokidyshev and others (1974) and Kornev and others (1975) citing Fedorchuck (1969) classified the mercury mineralization in the Kharnak-Kanjar AOI as “dickite-carbonate type,” a classification that is not used in western geologic literature. Peters and others (2007) considered the mineralization to be of the “Hot Springs” type according to the deposit models of Cox and Singer (1986). A summary of this model quoted from Peters and others (2007) is given below.

“Hot-spring mercury deposits (model 27a; Rytuba, 1986) typically contain cinnabar and pyrite, which are disseminated in siliceous sinter superjacent to greywacke, shale, andesite, basalt flows and diabase dikes. Their age is usually Tertiary. The depositional environment is near the paleo ground-water table in areas of fossil hot-spring systems. The tectonic setting is continental margin rifting with associated small-volume mafic to intermediate volcanism. Associated deposit types include hot-spring gold. Mineralogy includes cinnabar + native mercury + minor marcasite, as well as pyrite, zeolites, potassium feldspar, chlorite, and quartz. These are present as disseminations and coatings on fractures in hot-spring sinter. Opal is deposited near the ground-water table. Alteration is found above the paleo ground-water table and includes kaolinite-alunite-iron oxide minerals and native sulfur. Ore controls are the paleo ground-water table within hot-spring systems that formed along high-angle faults. A characteristic geochemical signature is mercury + arsenic + antimony + gold.”

The mercury prospects in the Kharnak-Kanjar AOI have some features in common with the hot springs model but lack the presence of hot springs deposits, such as siliceous sinter, except for the possible “spring” deposits at the Duwalik prospect. A more significant difference, however, is the presence of dickite as part of the alteration assemblage. Peters and others (2007) note that dickite-calcite is not a common alteration assemblage because the two mineral assemblages form under different pH conditions. Dickite forms under acid conditions at 200°C to 250°C, conditions that occur in “high sulfidation” epithermal systems (White and Hedenquist, 1995). Their presence together would require a multistage hydrothermal system.

Dickite is also known to occur in medium to high grade diagenetic conditions where it forms by transformation of kaolinite (Ehrenberg and others, 1993). Such conditions occur at depths of 2,500 to 5,000 m and temperatures of 110 to 165 °C (Fialips and others, 2003), but under certain conditions, dickite can form at even lower temperatures. Parnell and others (2000) describe the widespread occurrence of kaolinite and dickite in the Highland Boundary Fault Zone in Scotland and Ireland and conclude that kaolinite formed at less than 50 °C by alteration of volcanic rocks and as a result of local heating that accompanied the intrusion of dikes.
Figure 9A–14. Mineral association map of the Kharnak-Kanjar area of interest. Compiled from Pokiyshev and others (1974), Abdullah and others (1977), and Oris and Bliss (2002).
Figure 9A–15. Hydrothermal alteration map of the Kharnak-Kanjar area of interest. Compiled from Pokiyshev and others (1974), Abdullah and others (1977), and Orris and Bliss (2002).
The dickite in the Kharnak-Kanjar area could have formed from kaolinite during diagenesis of the Panjshah Suite and/or the intrusion of dikes and plugs along the Pasaband and associated faults. The presence of eroded Eocene sedimentary rocks indicates that the Panjshah Suite could have reached the requisite depth of burial. The dickite could, therefore, be unrelated to the hydrothermal activity that formed the mercury mineralization. Carbonate alteration would have formed later as part of the mineralization process, giving a mercury-carbonate association. This would explain the coexistence of dickite and calcite plus permit the application of the hot springs or low sulfidation epithermal model to the Kharnak-Kanjar AOI.

Epithermal hydrothermal systems such as Southwestern Afghanistan may also host gold mineralization as well as mercury (Rytuba, 1986). This association is common in the Central Asian mercury belt (Obolensky and Naumov, 2003, Borisenko and others, 2005).

A significant problem with consideration of the Kharnak-Kanjar AOI as a potential gold exploration area is the lack of reported gold mineralization. Despite the extensive and systematic use of heavy mineral concentrates in the exploration of the area, very few concentrates showed grains of gold, the best indicator of gold mineralization in the bedrock. Both Pokidyshev and others (1974) and Kornev and others (1995) mention the local occurrence of trace amounts of gold when referring to prospects. However, it is not clear whether the gold was visible and found by mineralogical examination or found through chemical analysis. A large number of rock samples were chemically analyzed during the exploration of the Kharnak-Kanjar AOI. The results are summarized in Kornev and others (1995), but no gold values are mentioned so it is not clear whether all samples were analyzed for gold. The samples collected during the Technoexport program were analyzed by spectroscopic methods which in the 1970s would have had a very high detection limit for gold. This, in addition to the propensity for some styles of epithermal gold mineralization to have very fine-grained gold, indicates that the lack of gold mineralization in the reports from previous workers may be more apparent than real.

Nonetheless, the large extent of the epithermal hydrothermal system, the presence of gold mineralization in association with mercury in other areas and the nature and vintage of the prior exploration support the conclusion that the Kharnak-Kanjar AOI has the potential for epithermal gold mineralization.

9A.8 Conclusions

The previous work in the Kharnak-Kanjar regions has identified a belt of mercury prospects more than 380 kilometers long. Peters and others (2007) made an estimate of the undiscovered hot-spring type mercury deposits in an area which included the Kharnak-Kanjar AOI and concluded that the Kharank-Kanjar AOI has the potential for the discovery of economic mercury deposits. They also note that epithermal gold mineralization may be associated with mercury deposits. The Kharnak-Kanjar AOI covers a large and underexplored epithermal hydrothermal system which is potentially an attractive target for epithermal gold mineralization.

9A.9 References Cited


PRAKLA, 1967, Report on aeromagnetic surveys in the Kingdom of Afghanistan: Contract executed for Bundesanstalt Für Bodenforschung, Hanover, Germany.


