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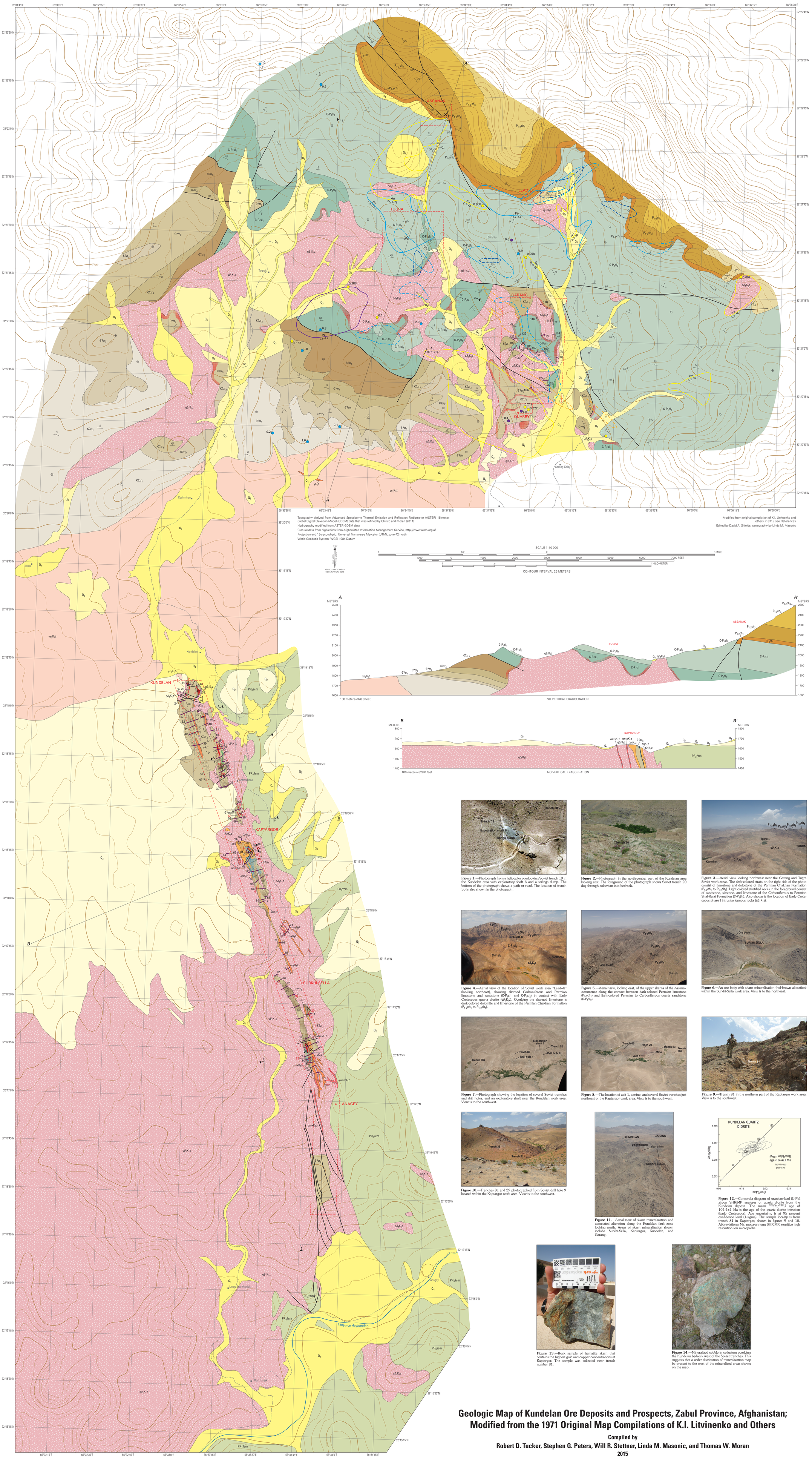
OPEN-FILE REPORT 2015–1198
USGS Afghanistan Project Product No. 335



Topography derived from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) 15-meter Global Digital Elevation Model (GDEM) data that was refined by Chirico and Moran (2011)
Hydrography modified from ASTER GDEM data
Cultural data from digital files from Afghanistan Information Management Service, http://www.aims.org.af
Projection and 15-second grid: Universal Transverse Mercator (UTM), zone 42 north
World Geodetic System (WGS) 1984 Datum

Modified from original compilation of K.I. Litvinenko and others, (1971); see References
Edited by David A. Shields; cartography by Linda M. Masonic

SCALE 1:10 000
CONTOUR INTERVAL 25 METERS
APPROXIMATE MEAN DECLINATION, 2015

INTRODUCTION

This map and cross sections are redrafted modified versions of the *Geological map of the Kundelan ore deposit area*, scale 1:10,000 (graphical supplement no. 18) and the *Geological map of the Kundelan deposits*, scale 1:2,000 (graphical supplement no. 3) both contained in an unpublished Soviet report by Litvinenko and others (1971) (report no. 0540). The unpublished Soviet report was prepared in cooperation with the Ministry of Mines and Industries of the Royal Government of Afghanistan in Kabul during 1971. This redrafted map and cross sections illustrate the geology of the main Kundelan copper-gold skarn deposit, located within the Kundelan copper and gold area of interest (AOI), Zabul Province, Afghanistan. Areas of interest (AOIs) of non-fuel mineral resources within Afghanistan were first described and defined by Peters and others (2007) and later by the work of Peters and others (2011a). The location of the main Kundelan copper-gold skarn deposit (area of this map) and the Kundelan copper and gold AOI is shown on the index map provided on this map sheet.

The estimated resources of the Kundelan copper-gold skarn deposit are 21,400 metric tons (t) of copper, 1.6 t of gold, and 133.4 t of molybdenum at an average grade of 1.21 weight percent (wt. %) copper (ranging from 0.66 to 4.03 wt. % copper); 0.9 grams per metric ton (g/t) gold (ranging from 0.3 to 3.1 g/t gold); 0.14 wt. % molybdenum; and as much as 10 g/t silver and 0.03 wt. % bismuth (Peters and others, 2011b).

Small past production of gold and base metals is also reported by Douvgal and others (1971) from many prospects within the Kundelan copper and gold AOI. Outside the skarn areas, argillic hydrothermal alteration is present (Abdullah and others, 1977). Most copper and gold prospects in the Kundelan copper and gold AOI are reported to contain commercial-grade ores of copper and (or) gold, and many prospect areas have potential for these commodities to be discovered in commercial volumes. Future initial mine exploration and later development in many of the prospects, and specifically in the Kundelan copper-gold skarn deposit, could result in near-term small- to medium-sized gold mining operations (Peters and others, 2011b).

The redrafted map and cross sections reproduce the topology of rock units, contacts, faults, and so forth, of the original Soviet map and cross sections, and they include modifications based on our examination of these documents and our observations made during a brief field visit in August of 2010. We have attempted to translate the original Russian terminology and rock classifications into modern English geologic usage as literally as possible without changing any genetic or process-oriented implications in the original descriptions. We also use the age designations from the original Soviet maps, except for the phase I and II intrusive igneous rocks. Phase I and II igneous rocks are reassigned an Early Cretaceous age (from lower Paleogene) based on a uranium-lead (U-Pb) zircon SHRIMP analysis from quartz diorite, which yielded an age of 104±1 Ma (mega-annum). The information provided in the description of map units is from both the source report by Litvinenko and others (1971) and the original 1:10,000 scale map (graphical supplement no. 18), also from Litvinenko and others (1971). Because of the poor quality of the original map, some map features could not be identified and some features may be misinterpreted. The rock unit colors used on the redrafted maps and cross sections differ from the colors shown on the original Soviet version. Colors were selected according to the color and pattern scheme of the Commission for the Geological Map of the World (CGMW) at http://www.ccgm.org.

Elevations on the cross sections are derived from the original Soviet topography and may not match the Global Digital Elevation Model (GDEM) topography used on the redrafted map of this report. Most hydrography derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) has not been included on our redrafted version of the map because of a poor fit with alluvial deposits from the unmodified original Soviet map (graphical supplement no. 18; Litvinenko and others, 1971).

DESCRIPTION OF MAP UNITS

STRATIFIED ROCKS

[Map unit descriptions for stratified rocks are from pages 11 to 13 and graphical supplement no. 18 (English translation) of Litvinenko and others (1971). Some chronostratigraphic units transcribed from Litvinenko and others (1971) are not formally recognized divisions of geologic time. For example, upper and middle Quaternary, and middle and lower Permian.]

QUATERNARY

Q_4 **Recent deposits (Quaternary)**—Alluvial to proluvial deposits of cobble roundstones, shingles, sands, and clays; alluvial deposits of "recent bed" and floodplain facies of the Arghandab River and its tributaries are poorly sorted and are as much as 0.5–1.0 to 3–5 meters (m) thick. Deluvial to proluvial debris cone deposits are no more than 5–10 m thick and composed of material of local origin

Q_3 **Proluvial deposits (upper Quaternary)**—Unsorted, fragmental, local rock material that is well-cemented by carbonate and marl; thickness of the cemented alluvium is as much as 30–80 m. Forms debris cone deposits exposed at the foot of slopes

Q_2 **Alluvial river terrace deposits (middle Quaternary)**—Cobble roundstones and "shingled" conglomerates with dense carbonate-sandy cement; fragments are well rounded and vary in composition; thickness of the conglomerates that occur on the Kundelan intrusion varies from 1–2 m to 60–80 m. Deposits are 300–500 m above sea level

CARBONIFEROUS PERMIAN

P(?) **Limestone (Permian)**—Fragmental

CHAKHAN FORMATION

$P_{1-2}ch_4$ **Bed 4 (middle Permian)**—Light-gray and white, banded, limestone and dolomite; 170 m thick

$P_{1-2}ch_3$ **Bed 3 (middle Permian)**—Dark-gray, stratified, limestone and dolomite with concretions and lenses of black silica; 170 m thick

$P_{1-2}ch_2$ **Bed 2 (lower Permian)**—Dark- and light-gray, massive limestone and dolomite; 120 m thick

$P_{1-2}ch_1$ **Bed 1 (lower Permian)**—Black, massive, bituminous dolomite with rugosa and crinoid fossils; 40 m thick

SHAL-KALAI FORMATION

$C\text{-}P_1sl_2$ **Bed 2 (lower Permian to Carboniferous)**—Quartz sandstone with "aleurolite" (siltstone) interbeds; 280–300 m thick on the northeast side of the map. Contains fossil remnants of flora and fauna of lower Permian age

$C\text{-}P_1sl_1$ **Bed 1 (lower Permian to Carboniferous)**—Light-gray, massive limestone; occurs as a horizontal layer from 30 to 150 m thick. Contains brachiopod and crinoid fossils of lower Permian to Carboniferous age

ZARGARAN FORMATION

CAMBRIAN

ϵ_2zr_5 **Bed 5, Chert (Cambrian)**—Platy with limestone interbeds; 140 m thick

ϵ_2zr_4 **Bed 4, Schist and slate (Cambrian)**—Siliceous, light-colored; 60 m thick

ϵ_2zr_3 **Bed 3, Limestone (Cambrian)**—Platy with dark-gray siliceous layers; 50 m thick

ϵ_2zr_2 **Bed 2, Schist and slate (Cambrian)**—Multi-colored, "phyllite-like;" 30 m thick

ϵ_2zr_1 **Bed 1, Sandstone (Cambrian)**—Polymictic with conglomerate interbeds of crimson-brown color; 120 m thick

CHAMAN FORMATION

[The description for unit $PR_3?cm$ is from the Soviet report Litvinenko and others (1971), page 11 of the English translation. The description in the report and the description on the Soviet map, also from Litvinenko and others (1971) graphical supplement no. 18, are considerably different. Graphical supplement no. 18 describes unit $PR_3?cm$ as: aleurolite, argillite, and limestone.]

PROTEROZOIC

$PR_3?cm$ **Schist and meta-sandstone (upper Proterozoic)**—The lower part contains "phyllite-like" schist with interbeds of lilac-colored schist and quartz-feldspar sandstone; thickness is 1250 m or more. The upper part contains alternating layers of "rosy-gray" and greenish-gray meta-sandstone with rare interbeds of lilac-colored schist and "aleurolite" (siltstone); approximately 800 m thick

INTRUSIVE ROCKS

[Map unit descriptions for intrusive rocks are from pages 13 to 15 and graphical supplement no. 18 (English translation) of Litvinenko and others (1971).]

[Litvinenko and others (1971) assigned a lower Paleogene age for phase I and phase II intrusive igneous rocks. Based on our uranium-lead (U-Pb) zircon age of 104±1 Ma (mega-annum) for phase I quartz diorite, we have reassigned an Early Cretaceous age for both phase I and phase II intrusive rocks (see fig. 12). The geologic age symbols for these units have been changed accordingly to reflect Early Cretaceous age, symbol K]

Phase II

λnK_1z **Albitophyre and dacite dikes (Early Cretaceous)**

$\alpha n\text{-}\nu K_1z$ **Andesite porphyry, lamprophyre, and dacite dikes (Early Cretaceous)**—Cross-cut phase I and phase II intrusive rocks; 0.5 to 8–15 m thick and 300 to 1800 m long

γK_1z **Leucocratic granite (Early Cretaceous)**—Distributed unevenly, majority are found among quartz diorites of the Kundelan intrusion as leucocratic granites from 5.5 to 8 m thick and 60 m long; contacts are subvertical and linear

$\gamma\epsilon_2K_1z$ **Porphyritic granite and granosyenite (undivided) (Early Cretaceous)**—Contains porphyroblasts of microcline from 3 to 5 centimeters (cm) in diameter and quartz 1 cm in diameter. The matrix is hypodiomorphic and composed of plagioclase, quartz, microcline, dark biotite, hornblende, and rare pyroxene. Granosyenite, quartz syenite, and quartz monzonite are present in its middle part

Phase I

$q\delta_1K_1z$ **Quartz diorite (Early Cretaceous)**—Quartz diorite, diorite, and rare gabbro is present as sills, dikes, and small stock-like bodies distributed within the boundary of the deposit (Kundelan intrusion) and within the Garang area of detailed Soviet work. Melanocratic varieties are rich in dark-colored minerals (35–50%) biotite, hornblende, and augite; leucocratic varieties are rich in zoned plagioclase and xenomorphic quartz that may also contain porphyry of pink feldspar. Contact zones with other intrusive bodies are fine grained and medium grained away from contacts. Contact metamorphism is characterized by thin zones of marblization, skarning, and "keratinization" within the surrounding rocks

ALTERATIONS

[Mapped alterations are from Litvinenko and others (1971), graphical supplement no. 3. Not all alterations from graphical supplement no. 3 are shown.]

Hornfels

Skarns

Magnetite

Garnet

Hematite

Serpentine

Carbonaceous

EXPLANATION OF MAP SYMBOLS

[Explanation of map symbols is reproduced from Litvinenko and others (1971), graphical supplement no. 18, except where noted.]

Contact—Dashed where inferred; dotted where concealed

Fault, fracture—Showing dip where known; dashed where inferred; dotted where concealed

Strike and dip of bedding

Horizontal

Inclined

Strike and dip of schistosity

Mineral concentration halos

Au 24, 5–78 — Native gold—First number, number of samples analyzed within halo; second number, number of grains of gold in each individual sample. Ex. 24, 5–78 means 24 samples analyzed within the halo and between 5 to 78 grains of gold present in each sample. See Litvinenko and others (1971), pages 55 to 57 of the English translation, for more information

Pb 1.0–118.0 — Lead minerals—In grams per cubic meter (g/m^3)

W 0.5–2.0 — Scheelite ($CaWO_4$)—In grams per cubic meter (g/m^3)

Heavy mineral concentrates with weight contents—In grams per cubic meter (g/m^3)

.212 Gold

0.1 Lead minerals

0.4 Scheelite

Elemental geochemical halos

Copper with concentration from 0.05 to 0.09 weight percent

Lead with concentration from 0.02 to 0.06 weight percent

Zinc with concentration from 0.05 to 0.09 weight percent

20 **Ore body and number**—Ore body and numbers from Litvinenko and others (1971), graphical supplement nos. 6 to 14

Geochemical assay of gold—Between 0.1 to 0.5 grams per ton

12 **Soviet trench location and number**—From Litvinenko and others (1971), graphical supplement no. 3 and graphical supplement no. 20

Exploration shaft location and number—From Litvinenko and others (1971), graphical supplement no. 3

Drill hole location and number—From Litvinenko and others (1971), graphical supplement no. 3

Adit location and number—From Litvinenko and others (1971), graphical supplement no. 3

Areas of detailed Soviet work: Kundelan–1, Kaptargor–2, Surkhi-Sella-3, Anagey–4, Garang–5, Tugra–6, Assanak–7, Lead–8, Quarry–9

Ancient mine

Site of photograph—Tip of arrow indicates direction of view; number keyed to figures 1 to 11. Photos were taken by Stephen G. Peters of the U.S. Geological Survey; Emily Scott of the Department of Defense in 2010; Robert D. Tucker of the U.S. Geological Survey, and James Gilbertson of SRK Consulting in 2012

Road or trail

Village

Figure 1.—Photograph from a helicopter overlooking Soviet trench 19 in the Kundelan area with exploratory shaft 6 and a tailings dump. The bottom of the photograph shows a path or road. The location of trench 50 is also shown in the photograph.

Figure 2.—Photograph in the north-central part of the Kundelan area looking east. The foreground of the photograph shows Soviet trench 20 dug through colluvium into bedrock.

Figure 3.—Aerial view looking northwest near the Garang and Tugra Soviet work areas. The dark-colored strata on the right side of the photo consist of limestone and dolostone of the Permian Chakhan Formation ($P_{1-2}ch_1$ to $P_{1-2}ch_4$). Light-colored stratified rocks in the foreground consist of sandstone, siltstone, and limestone of the Carboniferous to Permian Shal-Kalai Formation ($C\text{-}P_1sl_1$). Also shown is the location of Early Cretaceous phase I intrusive igneous rocks ($q\delta_1K_1z$).

Figure 4.—Aerial view of the location of Soviet work area "Lead–8" (looking northeast), showing skarned Carboniferous and Permian limestone and sandstone ($C\text{-}P_1sl_1$ and $C\text{-}P_1sl_2$) in contact with Early Cretaceous quartz diorite ($q\delta_1K_1z$). Overlying the skarned limestone is dark-colored dolomite and limestone of the Permian Chakhan Formation ($P_{1-2}ch_1$ to $P_{1-2}ch_4$).

Figure 5.—Aerial view, looking east, of the upper skarns of the Assanak occurrence along the contact between dark-colored Permian limestone ($P_{1-2}ch_1$) and light-colored Permian to Carboniferous quartz sandstone ($C\text{-}P_1sl_2$).

Figure 6.—An ore body with skarn mineralization (red-brown alteration) within the Surkhi-Sella work area. View is to the northeast.

Figure 7.—Photograph showing the location of several Soviet trenches and drill holes, and an exploratory shaft near the Kundelan work area. View is to the southwest.

Figure 8.—The location of adit 1, a mine, and several Soviet trenches just northeast of the Kaptargor work area. View is to the southwest.

Figure 9.—Trench 81 in the northern part of the Kaptargor work area. View is to the southwest.

Figure 10.—Trenches 81 and 29 photographed from Soviet drill hole 9 located within the Kaptargor work area. View is to the southwest.

Figure 11.—Aerial view of skarn mineralization and associated alteration along the Kundelan fault zone looking north. Areas of skarn mineralization shown include Surkhi-Sella, Kaptargor, Kundelan, and Garang.

Figure 12.—Concordia diagram of uranium-lead (U-Pb) zircon SHRIMP analyses of quartz diorite from the Kundelan deposit. The mean $^{206}Pb/^{238}U$ age of 104.4±1 Ma is the age of the quartz diorite intrusion (Early Cretaceous). Age uncertainty is at 95 percent confidence level (1-sigma). The sample locality is from trench 81 in Kaptargor, shown in figures 9 and 10. Abbreviations: Ma, mega-annum; SHRIMP, sensitive high resolution ion microprobe.

Figure 13.—Rock sample of hematite skarn that contains the highest gold and copper concentrations at Kaptargor. The sample was collected near trench number 81.

Figure 14.—Mineralized cobble in colluvium overlying the Kundelan bedrock west of the Soviet trenches. This suggests that a wider distribution of mineralization may be present to the west of the mineralized areas shown on the map.

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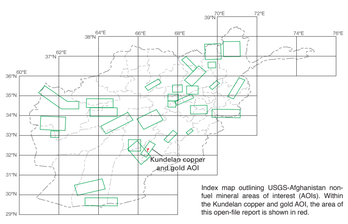

Index map outlining USGS-Afghanistan non-fuel mineral areas of interest (AOIs). Within the Kundelan copper and gold AOI, the area of this open-file report is shown in red.

Geologic Map of Kundelan Ore Deposits and Prospects, Zabul Province, Afghanistan; Modified from the 1971 Original Map Compilations of K.I. Litvinenko and Others

Compiled by
Robert D. Tucker, Stephen G. Peters, Will R. Stettner, Linda M. Masonic, and Thomas W. Moran
2015

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