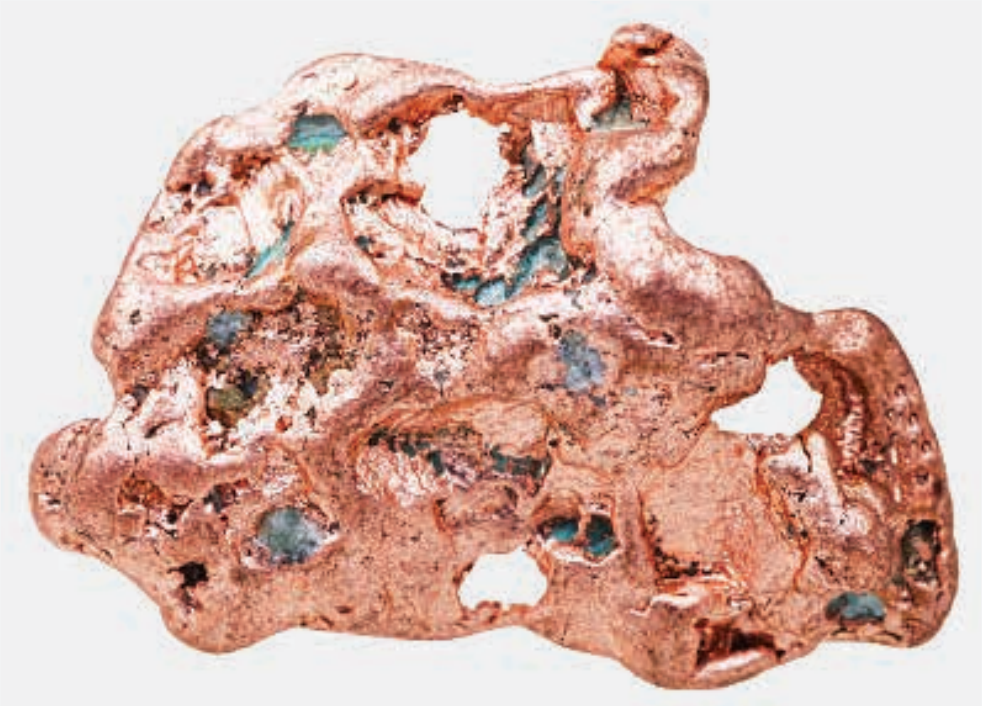
ISLAMIC REPUBLIC OF AFGHANISTAN

Ministry of
Mines and Petroleum



COPPER

MINERAL RESOURCES IN AFGHANISTAN

2021

MOMP.GOV.AF

Standard Disclaimer
This is a technical document drawing on multiple data sources, all of which are open source. While any analysis is based on this data, both sins of commission or omission are the responsibility of the MoMP Public Relations Directorate. Should there be either typographic or data errors in the report, kindly communicate these in writing to pr@momp.gov.af and a revised version will be posted online.

Compiled by
Hussaindad Shafai
Abdullah Asifi
Qasim Akbar

Designed by
Rohola Rezaei

COPPER

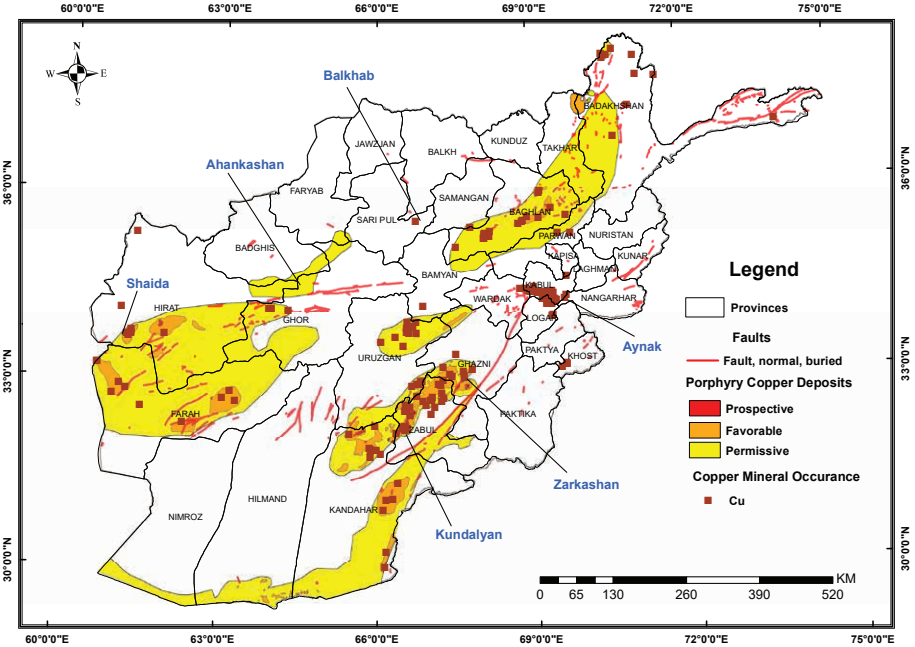
Introduction

Copper is an essential commodity in today's digital and electronic age and in recent years has seen a dramatic increase in its value. Increased demand from the rapidly growing developing economies of Asia has led to a rise in mineral exploration and the opening of new mines in adjacent regions. Afghanistan is well placed to meet this demand and the Aynak copper deposit, one of the largest in Asia, is currently being developed by a Chinese company. The country has a wealth of other copper prospects, most notably a number of porphyry copper deposits along part of the Tethyan Metallogenic Belt (*TMB*) and a recently discovered volcanogenic massive sulphide deposit (*VMS*) at Balkhab.

Recent geological fieldwork by the Afghanistan Geological Survey aided by international advisors has improved the knowledge of these deposits and made the information available to the global mining industry.

Geology of Afghanistan

Afghanistan has a complex geology due to junction position between the Indo-Australasian and Eurasian plates. Its geology is composed of a series of small terranes that broke away from the main Gondwana supercontinent before colliding, with each other or, with the Eurasian plate. Ultimately, all terranes accreted onto the southern margin of the Eurasian plate. The final closure of the Neo-Tethys ocean between the Indo-Australasian and Eurasian plates produced the Himalayan orogeny. During this oblique collision, NW directed subduction occurred beneath the Tirin-Argandab zone and calc-alkaline granite bodies were intruded, accompanied by porphyry copper mineralization. The exotic terrane of the Kabul Block brought with it sedimentary copper deposits like Aynak.



Copper Deposits

There are around 300 documented copper deposits, occurrences and showings in Afghanistan (*Abdullah and Chmyriov, 2008*). A variety of styles of copper mineralization occur in rocks ranging in age from Proterozoic to Neogene. These include sediment-hosted, skarn, porphyry, and vein-hosted. The largest and best-known copper discovery in Afghanistan is the world-class Aynak stratabound deposit hosted within Vendian-Cambrian quartz-biotite-dolomite metasedimentary rocks 30km southeast of Kabul. Soviet surveys in the 1970s and 1980s outlined an indicated resource of 240Mt grading 2.3% Cu. However, Afghanistan has yet to be evaluated in the light of modern mineral deposit models and improved analytical methods. From a global perspective, Afghanistan is relatively under explored and the potential for further discoveries of copper and other minerals is high. A ranking of significant known deposits and prospects is given below.

Ranking of Known Cu Deposits
1. Aynak
2. Zarkashan
3. Kundalyan
4. Balkhab
5. Shaida
6. North Aynak
7. Ahankashan
8. Darrah-i-Alansang
9. Gologha

DEPOSIT PROFILE 1	
Deposit Name	Aynak
Status	Tendered
Location	Logar Province
Deposit Style	Stratiform Cu, metasediment-hosted
Host geology	Vendian–Cambrian metamorphosed limestones and volcanics
Ore minerals	Bornite, chalcopyrite, chalcocite, native Cu, malachite, covellite, tenorite
Deposit geology	Deposit divided into Central and Western areas. Mineralisation traced for 2km, up to 1km wide and 60-210m thick to max depth of 1000m
Metal content	Drill-indicated reserves >240Mt @ 2.3% Cu

Sediment-Hosted Stratiform Copper Deposits

AYNAK

Sediment-hosted stratiform copper (*SHSC*) deposits are a large and diverse group that includes some of the richest and largest copper deposits in the world. The largest and best-known copper deposit in Afghanistan is the SHSC type Aynak deposit located in the Kabul Block 30 km southeast of Kabul (*Deposit Profile 1*). The deposit is of Vendian-Lower Cambrian age and is divided into two areas, Central Aynak and Western Aynak. Mineralization is characterized by stratabound disseminated bornite and chalcopyrite in dolomite marble and quartz-biotite dolomite schists of the Loy Khwar Formation. The deposit is thought to have formed by circulating hypersaline solutions leaching metals from underlying volcanic rocks (*BGS, 2005*).

The Aynak Copper Deposit is a well-explored resource, defined by extensive geological data and preliminary feasibility study work prepared by the Russian authorities and later on by MCC. The deposit has known to be truly "world class," being regarded as the second-largest known, unmined deposit in the world and of exceptionally high grade.

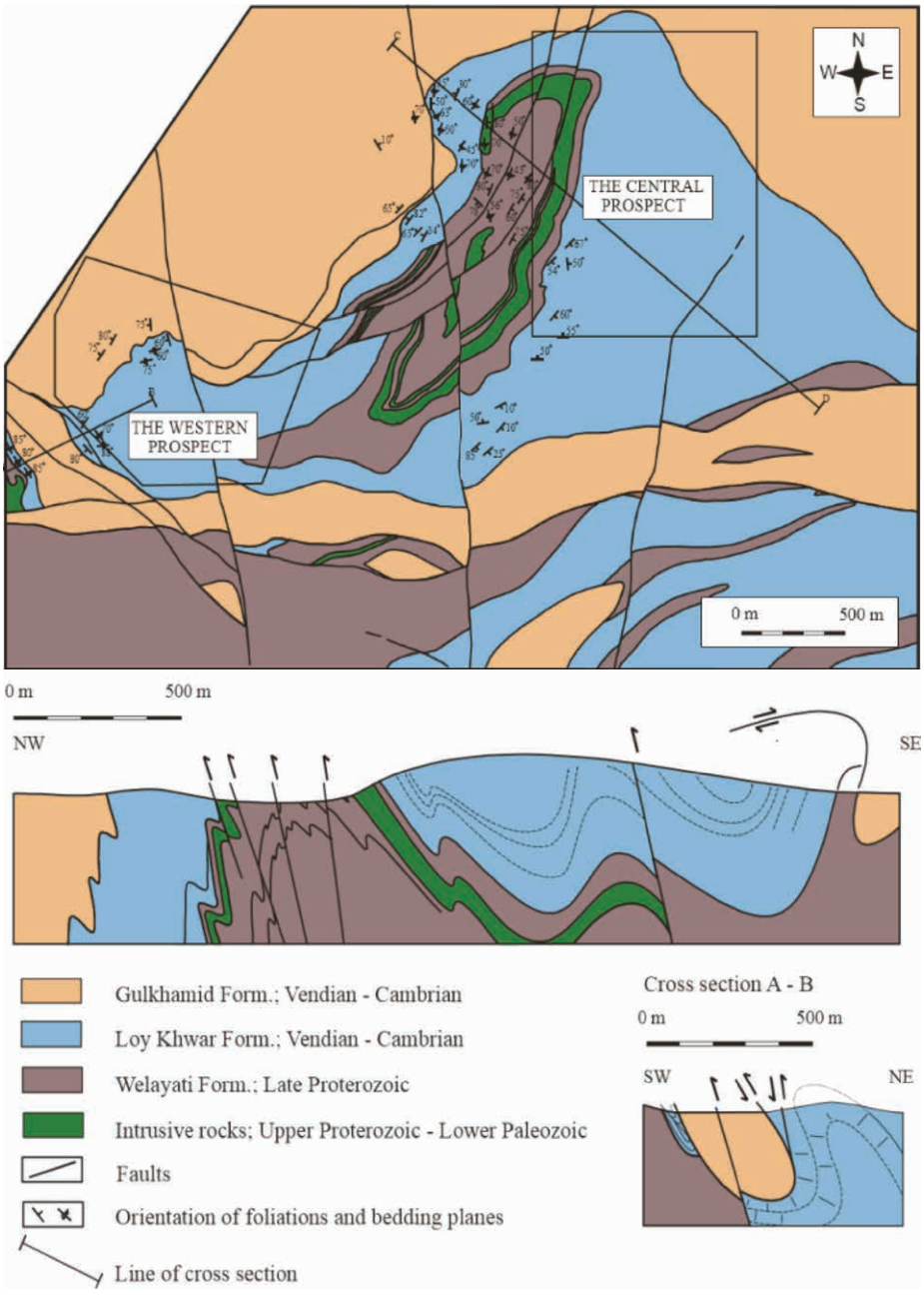
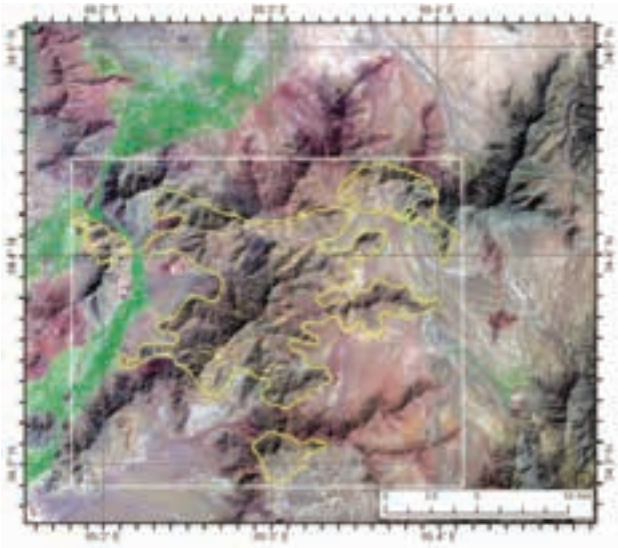


Figure 2. Geological sketch map and sections of the Aynak copper deposit. The deposit is hosted by the Loy Khwar formation shown in blue (BGS 2005).

Figure 3. North Aynak Landsat TM enhanced color image. TM bands 1-4-7 are shown in blue-green-red. Yellow outline is the Loy Khwar Formation that hosts copper deposits. Spectral analyses of ASTER and HyMap images, shows that the distinctive tan-colored outcrops within the Loy Khwar Formation are dolomite members, which host the Aynak copper deposit further south.



The resource was measured at 240Mt @ 2.3% Cu. Recently the contractor MJAM exploration has doubled the stated resource from 5.5Mt to 11.1Mt-contained Cu.

The Aynak Copper project was awarded in May 2008 to two Chinese state-owned companies, the China Metallurgical Group Corporation (*MCC*) and the Jiangxi Copper Company Limited. The consortium later called itself MCC-JCL Aynak Minerals (*MJAM*) to formally operate the project.
As per the Aynak 2014 Feasibility report, mineral resource statement, resulting in the value of the deposit being doubled:

- MJAM 662Mt @ 1.67% Cu containing 11.1Mt Cu
- RUSSIAN STUDIES 240Mt @ 2.3% Cu containing 5.5Mt Cu

NORTH AYNAK

Recent geological mapping of the North Aynak area (*Bohannon, 2010*) and interpretation of high quality remote sensed data (*Peters et al., 2011 and Department of Defense, 2011*) have improved the potential of this area and the latter estimate that more than half of the copper deposit could lie outside of the MCC area. One example of a known occurrence in North Aynak is described below. The Katasang occurrence is an 800m long, 3.6 to 13.8m thick (*average 7.2m*) mineralized zone within steeply dipping, albitized marble containing disseminated bornite, chalcopyrite, chalcocite and minor malachite. Limited exploration conducted at this site included 1:2,000-scale geological mapping, trenching, and geochemical sampling, and resulted in the calculation of a potential resource containing 42,100 tonnes of copper at an average grade of 1.04% Cu (*Kutkin and Gusev, 1977*).

Volcanogenic Massive Sulphide

BALKHAB

This poorly described occurrence has been reinvestigated by AGS and mapped using remote sensing data (*Peters et al., 2011*). The Balkhab copper volcanogenic massive sulfide (*VMS*) prospect lies within the Balkhab copper

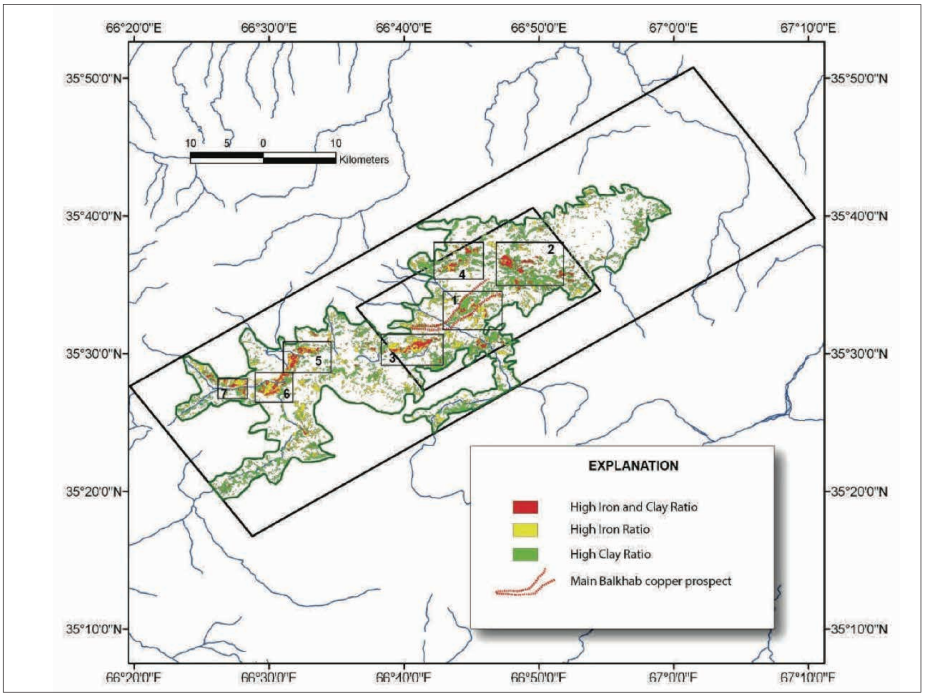


Figure 4. Anomalous zones (1-7) determined from Landsat TM alteration patterns in the Balkhab copper area (Peters et al., 2011).

Figure 5. Malachite- and azurite-coated phyllite from Balkhab copper prospect (Peters et al., 2011).

DEPOSIT PROFILE 2	
Deposit Name	Balkhab
Location	Sari-i-Pul Province
Deposit Style	Volcanogenic Massive Sulphide
Host geology	Ordovician schist and phyllite with bimodal felsic volcanics
Ore minerals	Pyrrhotite, chalcopyrite, bornite, galena, malachite, azurite
Deposit geology	Copper mineralisation consists of a silicified limonite-bearing zone 4 to 5m long by 300 to 400m wide
Metal content	Zone grades 0.25 to 1.34% Cu but no estimate of tonnage

area of interest and is part of an eroded inlier of deformed pre-Triassic, mainly Ordovician rocks, in Sar-i-Pul Province. It lies in a canyon unconformably below horizontal Mesozoic sedimentary rocks (*Peters et al., 2011*). Copper mineralization consists of a silicified limonite-bearing zone 4,000 to 5,000m long by 300 to 400m wide of deformed and faulted rock that contains at least four areas of extensive malachite, azurite, pyrite, and disseminated chalcopyrite, bornite, and galena grading from 0.25 to 1.34% Cu.

Remote sensing studies suggest that the mineralization may extend for over 40km (*Figure 4*).

Copper Porphyry Deposits

Soviet-Afghan teams identified a number of Cu-Au prospects and occurrences in the Tirin-Argandab zone and Peters et al., (*2007*) defined this as their prospective tracts ppycu05-07 (*Figure 1*). The zone forms part of the Tethyan Metallogenic Belt of world-class porphyry copper-gold deposits, which stretches from Europe, through Turkey, Iran, Pakistan, Afghanistan, Tibet and into SE Asia. The prospective tracts have been identified by a distinctive group of Cretaceous-Paleocene intrusive rocks that are spatially related to the known Cu skarn deposits and prospects, alteration zones from ASTER and aeromagnetic anomalies. Within them two deposits, Zarkashan in the north and Kundalyan in the south, have been investigated by detailed sampling, trenching and drilling.

ZARKASHAN

The Zarkashan Area of Interest surrounds the Late Cretaceous-Paleocene Zarkashan diorite, granodiorite to adamellite intrusion and consists of a number of gold and copper occurrences (*Figures 6* and *7*). The mineralization consists of chalcopyrite, pyrite, sphalerite, chalcocite, bornite, and native gold in the hydrothermally altered skarns. Preliminary exploration, including rock sampling, trenching and underground adits, indicates the presence of several ore-bearing zones 400-600m long and 1-15m thick, with lenticular

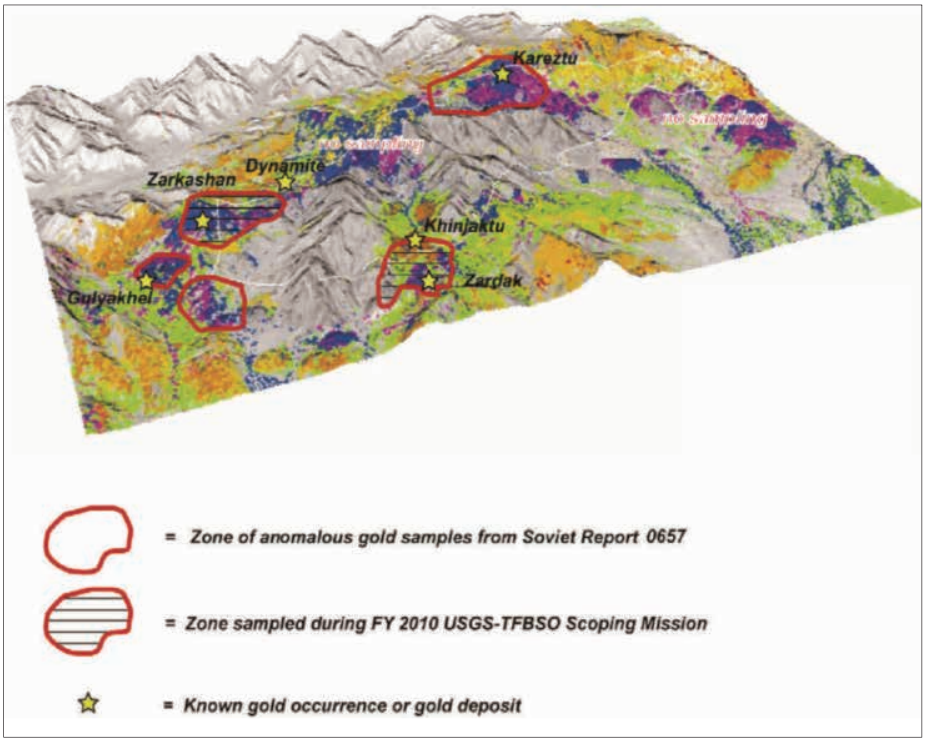


Figure 6. Three-dimensional view of the Zarkashan copper and gold area of interest showing hyperspectral anomalies surrounding the Zarkashan intrusive (white outline). Blue and purple zones represent alteration zones with goethite and jarosite. These alteration zones are coincident with anomalous gold areas from earlier Soviet sampling (Peters et al., 2011).

DEPOSIT PROFILE 3	
Deposit Name	Zarkashan
Location	Ghazni Province
Deposit Style	Porphyry Cu-Au and related Skarn
Host geology	Late Triassic dolomites in the contact zones of the Zarkashan gabbro, monzonite and syenite intrusion
Ore minerals	chalcopyrite, pyrite, sphalerite, chalcocite, bornite and gold
Deposit geology	Skarns occur in pockets or as sheetlike deposits. Several ore-bearing zones occur 400– 600m long and 11–75m wide. The richest gold is found in phlogopite skarns
Metal content	7.7t Gold contained in C1 and C2 categories

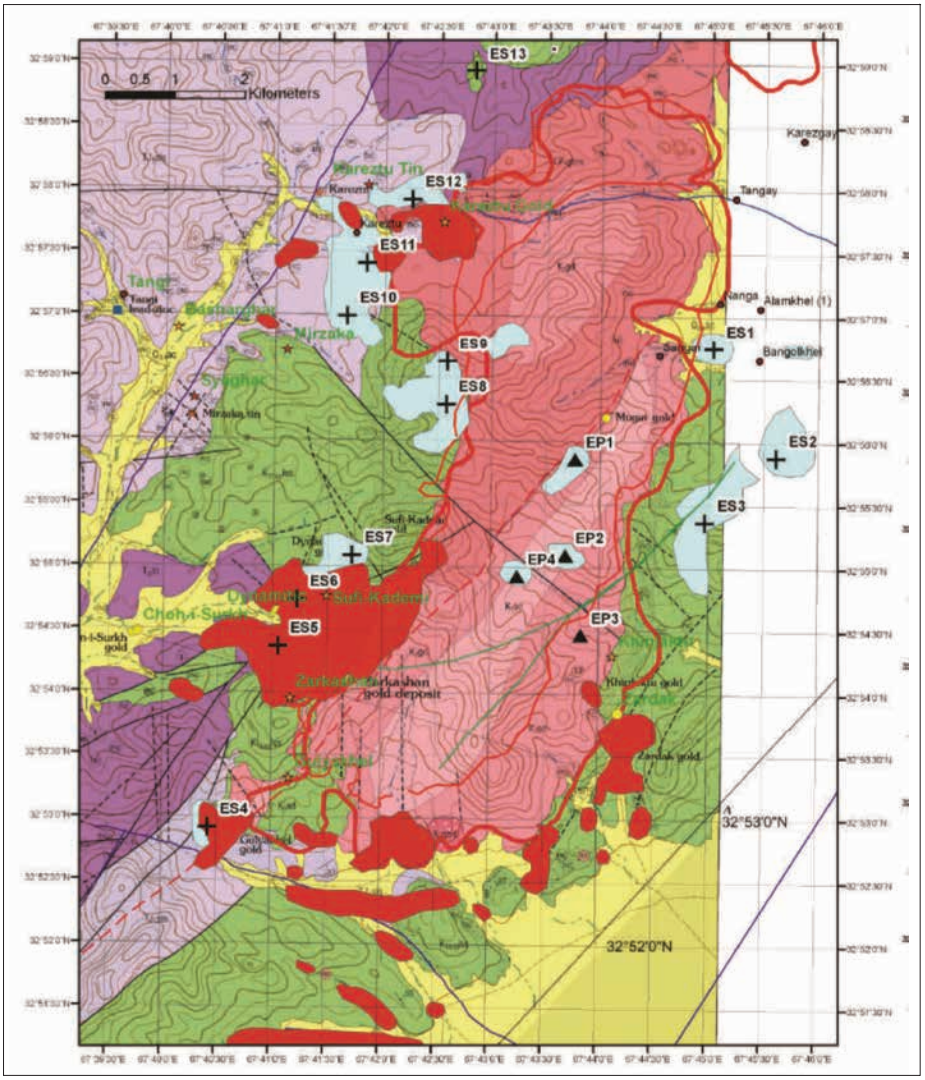


Figure 7. Geological map of the Zarkashan area showing the mineralized areas (bedrock gold anomalies in red) surrounding the Zarkashan pluton (lighter shades of red). (Peters et al., 2011).

and nest-shaped bodies of 1.5-50m long and 0.5-3.8m thick. Gold mineralization is traceable for 80m down dip, assaying from 0.10 g/tonne to 16 g/tonne gold. Category C1+C2 resources contain 7,775kg Au and speculative resources are 12 to 15 tonnes of gold. Copper grades vary from 0.01 to 15%. Recent sampling by USGS (*Peters et al., 2011*) has shown that extensive, disseminated mineralization is present in the large contact (*hornfels*) zones indicating large medium- to low-grade ore bodies that are amenable to modern excavation methods at current gold and copper prices.

A number of other prospects, such as Zardak, Dynamite, Choh-i-Surkh and Sufi Kademi, around the Zarkashan intrusive are also highly prospective for porphyry coppergold deposits and worthy of further investigation. Peters et al., (*2007*) predicted that in the Zarkashan-Kundalyan tract there is a high probability (*50%)* of one porphyry copper-gold deposit and a 10% probability of two deposits.

DEPOSIT PROFILE 4	
Deposit Name	Kundalyan
Location	Zabul Province
Deposit Style	Cu-Mo-Au-Ag skarn
Host geology	Proterozoic and Vendian–Cambrian metamorphosed limestones and cherts
Ore minerals	Chalcopyrite, magnetite, pyrite,sphalerite, molybdenite, chalcocite, bornite, covellite, native Cu, malachite
Deposit geology	Three deposits up to 155m long and 2.59–3.89m thick. Mineralization restricted to hematite-kaolin-quartz and meta-carbonates
Metal content	C1+C2 resources 13600t Cu @ 1.07% Cu; 1.1t Au, @ 0.9 g/t Au; 127.3t Mo @ 0.13% Mo

KUNDALYAN

The Kundalyan copper-gold skarn deposit is localized along a 400 meter long, 1.5km wide inlier that consists of altered limestone, chert, and skarn (*Peters et al., 2011 after Soviet authors*). The chief minerals in the skarn are pyroxene, garnet, amphibole, phlogopite, and magnetite. Mineralization is present both in skarn and chert. There are 13 orebodies along the Kundalyan Fault Zone (*Figure 8A*) that are between 2.65 to 12.3m thick and from 36 to 175m long, containing 0.62-1.2% Cu and 0.5-2.0 g/t Au. The mineralization is predominately chalcopyrite and pyrite and more seldom sphalerite, gray copper ore, and enargite. The Category C1+C2 reserves in the Soviet classification system, were reported as 13,600 tonnes of coppergrading 1.07% Cu and 1.1 tonnes of gold grading 0.9 g/t Au.

The Kundalyan copper-gold skarn deposit area was explored by a series of trenches, adits, and drill holes. Data was presented on cross sections (*Figure 8B*) for about 5km of strike length along a NNW-trending zone that is exposed in a valley. The Kundalan copper-gold deposit has been explored where a northweststriking stream has eroded through colluvial cover and exposed a granodioritic intrusive intruding Precambrian, Cambrian, and Carboniferous limestone. The skarn zone contains brecciated, stromatolitic (?) limestone and contains large areas of layered calcsilicate rock related to skarn formation and metasomatic kaolin-carbonate rock. Malachite-stained siliceous skarn and porphyroblastic marble also are common in the mineralized zone. Despite the extensive trenching and the boreholes in the main zone there seems to have been little exploration of the colluvium covered areas to the west and east.

Several copper and copper-gold and gold prospects and occurrences are present peripheral to or away from the main Kundalyan copper-gold skarn deposit. Prospects generally cluster near and around the Kundalan group of deposits in the Kaptarghor, Shela-i-Surkh, Baghawan-Garangh, Kunar and Chasu-Ghumbad areas. Further details can be found in Peters et al., (*2011*).

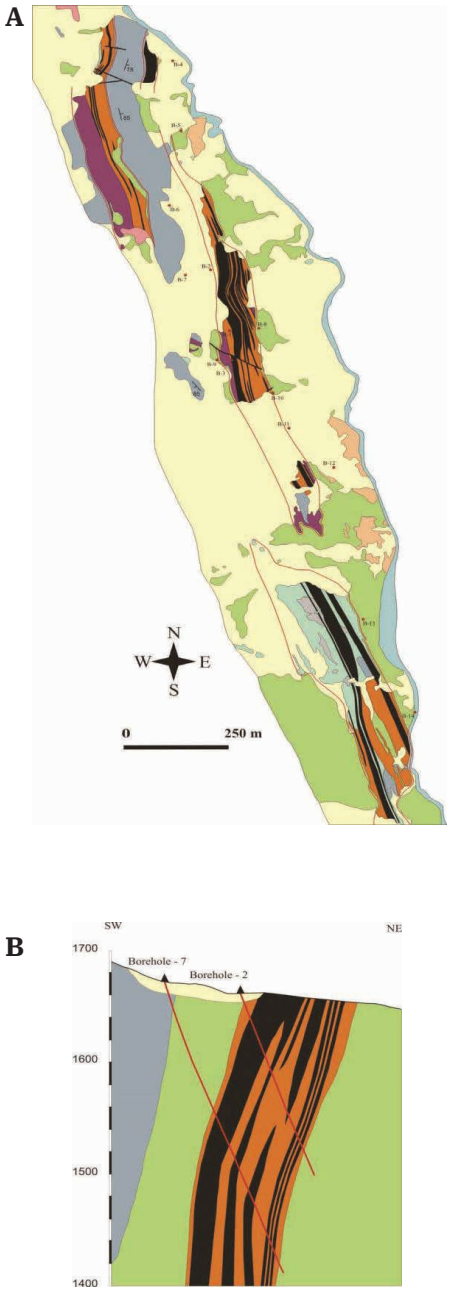


Figure 8. (A) Geological map of the Kundalyan area showing the ore zone (black), skarn (orange), kaolin-carbonate rock (grey), altered granitoids (pale blue), granodiorite (green) and colluvium (pale yellow). (B) Illustrative cross section through boreholes 2 and 7 at Kundalyan (key as above).

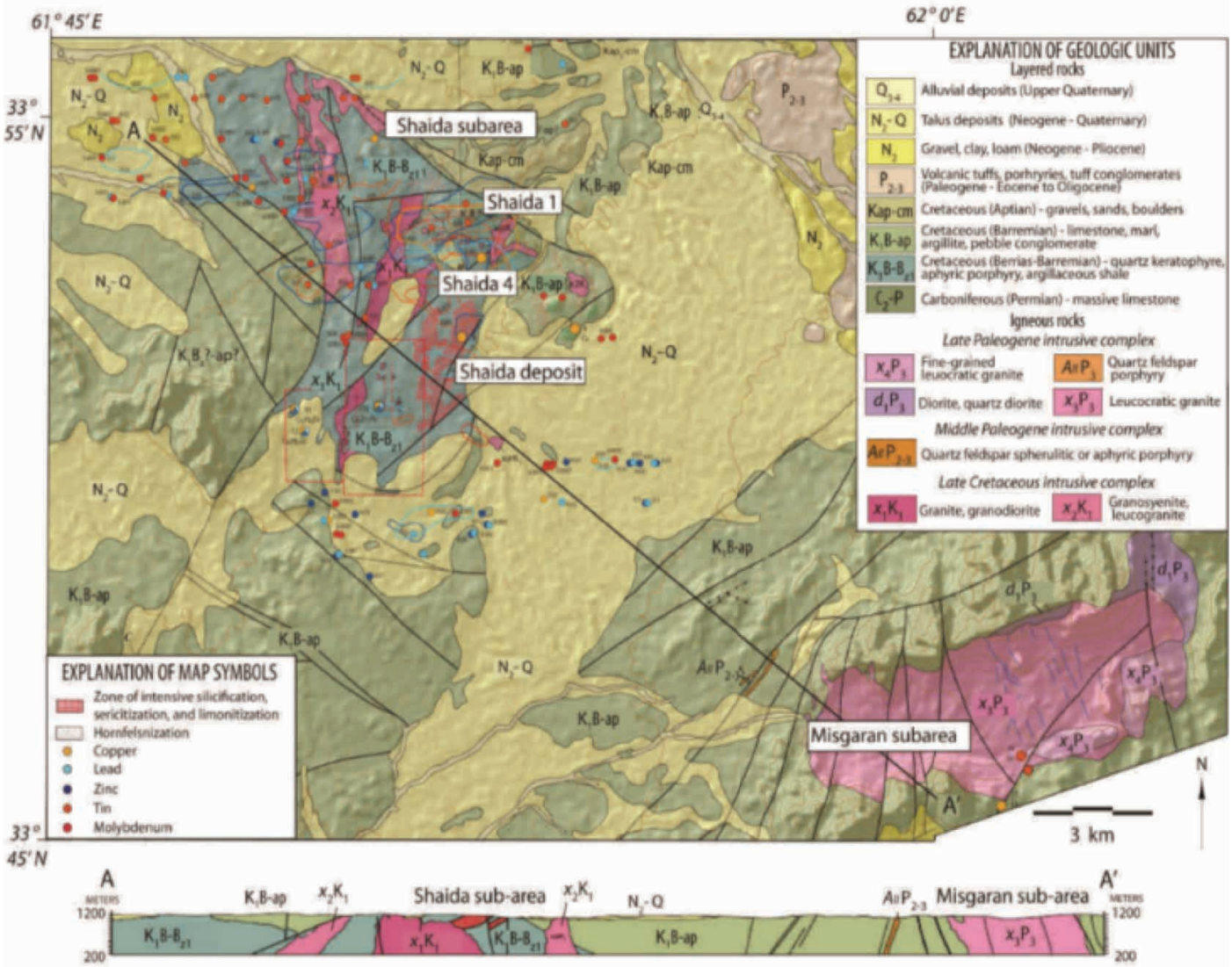


Figure 9. Geologic map and cross section of the Shaida and Misgaran subareas. All of these sites are within heavily mineralized (copper) volcanic rocks of Early Cretaceous age, as indicated by the cross-hatch pattern. (Peters et al., 2011).

SHAIDA

Shaida and its related prospect Dusar lies SW of Herat in permissive tract ppycu09 (Figure 1). The Shaida subarea is classified as a highly prospective copper porphyry deposit. The host rocks are early Cretaceous volcanics. The copper mineralization coincides with a 200 to 300m wide, strongly fractured, limonitized and kaolinitized fault zone, where six steeply dipping mineralized bodies and a Cu- pyrite gossan are present. The main zone of mineralization, 2.6km long and 300 to 500m wide, consists of secondary copper minerals assaying 0.27 to 3.02 % Cu and 0.02 to 0.37 % Zn The grade was confirmed by the USGS in August 2010. Based on diamond drilling the individual occurrences are 1 to10m thick (average ~4m) and up to 2400m long. Minerals are pyrite, pyrrhotite, sphalerite and minor chalcopyrite in massive veinlets and disseminated ores that assay between 0.04-1.6% Cu (average 0.63%), between 0.09-7.0% Zn (average 1.3%), between 0.01-0.5% Pb (average 0.08%), and between 0.20.03 g/t Au. Potential ore resources are estimated at 4.8 Mt assaying 1.1% Cu and 1.2% Zn.

SOURCES OF INFORMATION

Abdullah S.H., et al. (1980): *Geology and Mineral Resources of Afghanistan* (2 volumes), English Version, Republished in 2008 by British Geological Survey Occasional Publication No.15. 292 pages.

Bohannon, R.G. (2010): *Geologic and topographic maps of the Kabul South 30'×60' quadrangle, Afghanistan: USGS Scientific Investigations Map* 3137, 34 pages. pamphlet, 2 map sheets, 1:100,000.
Available at: http://pubs.usgs.gov/sim/3137

BGS (2005): *Aynak information package - Part II, Geological setting of Aynak and summary of exploration*; Afghanistan Geological Survey and British Geological Survey, compilers, Kabul, Ministry of Mines, Department of Mines Affairs.
Available at: www.bgs.ac.uk/afghanminerals/DMA_tender_docs.htm

British Geological Survey, (2008): *Geological archive of Afghanistan: BGS Miscellaneous Report*, 360 pages.

Department of Defense (2011): *Mineral Resource Team 2010 Activities Summary. Task Force for Business and Stability Operations, Washington, DC,* 49 pages.

ESCAP (1995): *Atlas of Mineral Resources of the ESCAP Region: Geology and Mineral Resources of Afghanistan, Vol. 11.* (1995): United Nations 85 pages.

Orris, G.J., and Bliss, J.D. (2002): *Mines and Mineral Occurrences of Afghanistan, USGS Open-File Report 02-110*. http://geopubs.wr.usgs.gov/openfile/of02-110

Peters, S.G., Ludington, S.D., Orris, G.J., Sutphin, D.M., and Bliss, J.D., eds. (2007): *Preliminary Non Fuel Mineral Resource Assessment of Afghanistan. USGS Open-File Report 2007-1214.*

Peters, S.G., King, T.V.V., Mack, T.J., Chornack, M.P., eds., and USGS/AGS Afghanistan *Mineral Assessment Team (2011): Summaries of important areas for mineral investment and production opportunities of nonfuel minerals in Afghanistan: USGS Open-File Report 2011–1204*, 1,810 pages plus appendixes on DVD.
Available at http://pubs.usgs.gov/of/2011/1204/

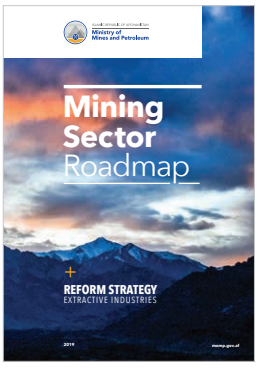
MESSAGE FROM AN INVESTOR

"Afghanistan is really exciting geologically. If you look at the chain of tethyan deposits that stretch across Asia, the density of developments in South East Europe is really impressive. We expect that same density of developments to be found here in Afghanistan. Its virgin territory for exploration, and some of the last, large near-surface porphyry deposits are likely to be found here. We have been very excited by what we have found at our exploration area Shaida so far, and look forward to bringing Afghan copper to market."

Samuel Dean Sidiqi
Chairman and Co-founder
Silk Road Mining and Development

OUR PUBLICATIONS

Available for download at: momp.gov.af



ISLAMIC REPUBLIC OF AFGHANISTAN
Ministry of Mines and Petroleum

For more information:
Email: invest@momp.gov.af
Visit: www.momp.gov.af