Copper of Afghanistan

Figure 1. Map of Afghanistan, showing major deposits and prospects, and permissive tracts for porphyry copper deposits (ppycu01-12) (after Peters et al., 2007).

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 TethyanMetallogenic 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 its position on the junction between the Indo-Australasian and Eurasian plates. Its geology is composed of a series of 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 - similar in age and style to those of the Zambian Copper Belt.
Copper deposits in Afghanistan

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 stratiform deposit hosted within Vendian-Cambrian quartz-biotite dolomite metasedimentary rocks 30 km southeast of Kabul. Soviet surveys in the 1970s and 1980s outlined an indicated resource of 240 Mt 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 with Darband and Jawkhar
2. Zarkashan
3. Kundalyan
4. Balkhab
5. Shaída
6. North Aynak
7. Akhankoshan
8. Darrah-i-Alansang
9. Gologha

### 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. Among the best examples of this type are those of the Zambian Copper Belt which have to date produced in excess of one billion tonnes of copper at an average grade of about 2.7% Cu, as well as significant quantities of cobalt and silver. Aynak closely resembles the SHSC of the Zambian Copper belt in age, mineralogy and presence of both of stromatolites and shungite. 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 deposit is currently being developed by the Metallurgical Corporation of China (MCC) and they are planning a large open pit mine to exploit the shallow dipping ore in the Central section. Adjacent deposits hosted by the Loy Khwar formation at Darband and Jawkar lie within the Exploration Licence granted to MCC.

North Aynak is outside the area awarded to MCC and extends along the strike of the formation to the north.
North Aynak

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.

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 Katsang 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). The occurrence was classified as “noncommercial,” but more detailed exploration by drilling was recommended.

Volcanogenic Massive Sulphide Deposits

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 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. Old surface and underground workings are in the high-grade areas. In 2008 to 2009 the AGS confirmed the highly mineralized copper zones.

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

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
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 deposit is hosted by Triassic and Cretaceous sediments and is associated with garnet-vesuvianite-diopside and irregular zones of diopside skarns. 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 400-600 m long and 1-15 m thick, with lenticular and nest-shaped bodies of 1.5-50 m long and 0.5-3.8 m thick. Gold mineralization is traceable for 80 m down dip, assaying from 0.10 g/tonne to 16 g/tonne gold. Category C1 + C2 resources contain 7,775 kg 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.

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 400–600 m long and 11–75 m wide. The richest gold is found in phlogopite skarns
Metal content: 7.7 t Gold contained in C1 and C2 categories

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).

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 copper-gold 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.

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).
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 12.3 m thick and from 36 to 175 m 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 copper grading 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 5 km 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 calcisilicate 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).

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 155 m long and 2.59–3.89 m 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

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).
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 300 m 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 500 m 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 to 10 m thick (average ~4 m) and up to 2400 m 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 0.20-0.3 g/t Au. Potential ore resources are estimated at 4.8 Mt assaying 1.1% Cu and 1.2% Zn.

Sources of Information


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).

Further Information:

For further information on technical and investment matters, please contact the following offices within the Ministry of Mines and Petroleum:

Mineral Sector Development Directorate
Ministry of Mines and Petroleum
Kabul, Afghanistan
Telephone: +93 (0) 752 076 483
E-Mail: miningenquiries@mom.gov.af
Website: http://www.mom.gov.af

Afghanistan Geological Survey
Kabul, Afghanistan
Tel: +93 (0) 75 200 1714
E-mail: ags@mom.gov.af
©Afghanistan Geological Survey

updated January 16, 2014 by MoMP with assistance of USAID MIDAS project