



# Minerals in Afghanistan

## The Aynak Copper Deposit

### Introduction

The area around Aynak, 30 km south-south-east of Kabul in south-east Afghanistan, has been the focus of copper working since ancient times. Numerous old excavations and pits, as well as remains of smelting furnaces, have been discovered at Aynak and also nearby at Darband and Jawkhar. In 1974, Russian geologists prospected and mapped the Kabul area and re-discovered the Aynak, Darband and Jawkhar copper prospects. In 1974–1976 and again in 1978–1989, the Soviet Geological Mission conducted detailed exploration of Aynak, but this work ceased in 1989 with the withdrawal of Russian advisors, and the subsequent civil war halted any further work.

### Geology

Afghanistan sits astride the collision zone of the Indo-Pakistan and Asian crustal plates, which has given rise to the Himalayas. It has a very complex geological history, with a number of small blocks or 'terrane' which split off around 250 million years ago from the margin of the Gondwana supercontinent (*Figure 1*). These terranes then successively accreted on to the southern margin of the Asian continent. The Kabul Block is interpreted to be a one of these fragments and is bound by two major faults, on the west by the Pagman Fault and on the east by the Altimur Fault (*Figure 1*).

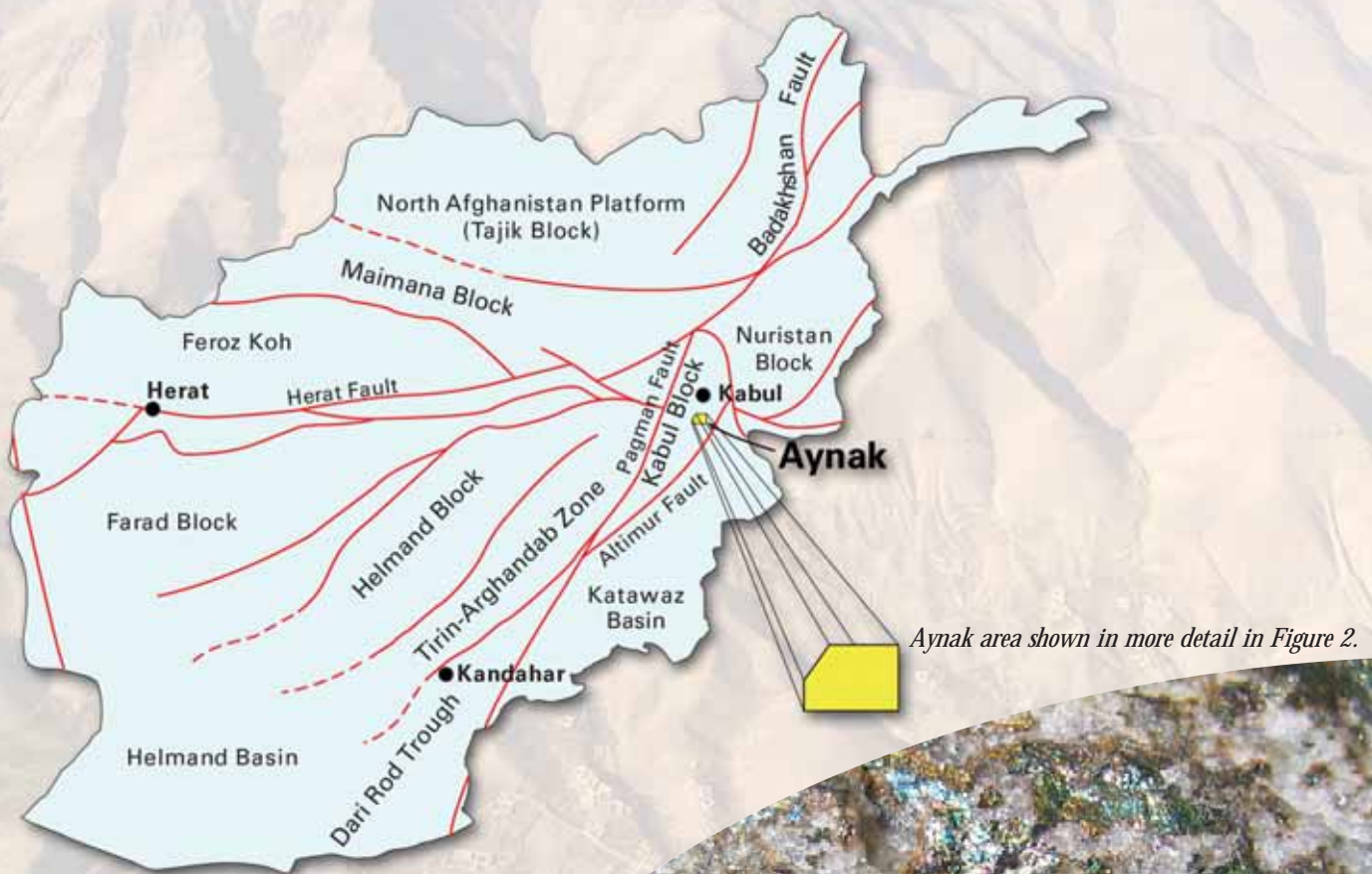
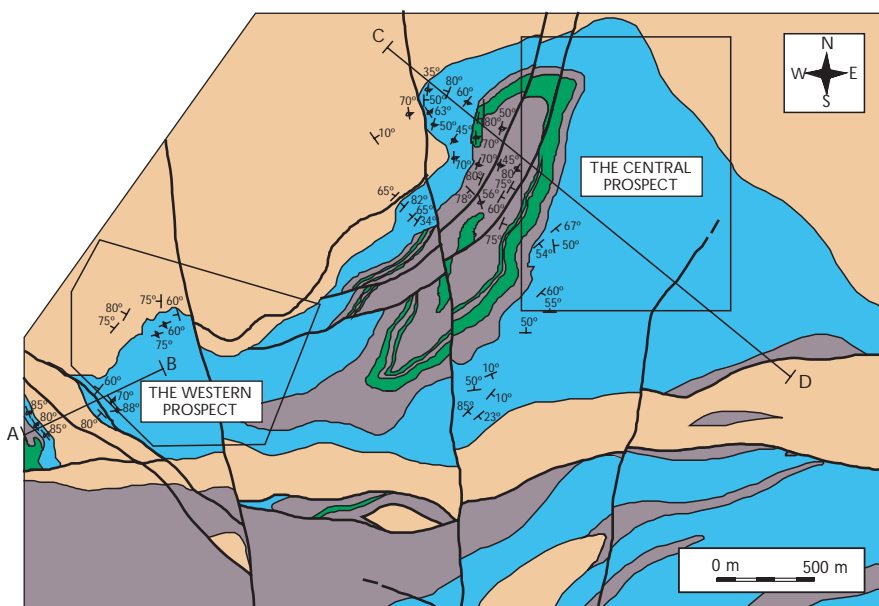


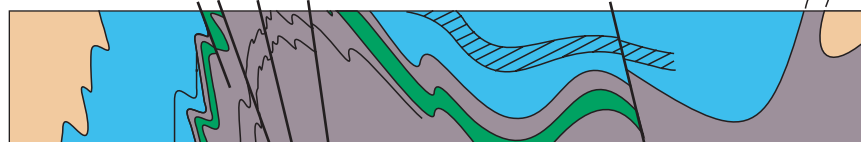
Figure 1. Tectonic map of Afghanistan showing major blocks and faults and location of Aynak.



Cross-section C-D

0 m 500 m

NW

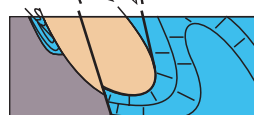


- Gulkhamid Formation; Vendian–Cambrian
- Loy Khwar Formation; Vendian–Cambrian
- Welayati Formation; Late Proterozoic
- Intrusive rocks; Upper Proterozoic–Lower Paleozoic
- Faults
- Orientation of foliations and bedding planes
- Line of cross section
- Main copper ore body (on section)

Cross-section A-B

0 m 500 m

SW NE



## Geology of Aynak

The structure at Aynak is dominated by the Aynak anticline. The anticline is asymmetrical and approximately 4 km in length and up to 2.5 km wide. The south-eastern limb dips gently to the south-east but the north-western limb is steeply dipping and, in places overturned, with dips of 45–70° to the south-east. The periclinal closure of the anticline at its western end is asymmetrical. Here, the southern limb is overturned and the axial plane is inclined towards the north-north-east. Several sets of later faults cut across the folds.

The oldest rocks exposed in the area belong to the metavolcanic Welayati Formation, composed of gneiss and amphibolites, and are exposed in the core of the anticline (*Figure 2*). This formation is overlain by the thick metasedimentary sequence of the Loy Khwar Formation, which is a cyclical sequence of dolomite marble, carbonaceous quartz schist and quartz-biotite-dolomite schist and hosts the copper mineralisation (*Figure 2*). Seven members were originally defined during the first phase of exploratory drilling at Central Aynak and are summarised in *Figure 4*. The Loy Khwar Formation is post-dated by basaltic to dacitic metavolcanic rocks of the Gulkhamid Formation, which are also of Vendian–Cambrian age.

As a result of folding, the copper deposit is divided into two prospects, with Central Aynak located on the shallow-dipping eastern limb of the anticline and Western Aynak occurring in the area of the periclinal closure at the western end of the structure (*Figure 2*).

## Mineralisation

The copper mineralisation at Aynak is stratabound and characterised by bornite and chalcopyrite disseminated in dolomite marble and quartz-biotite-dolomite schists of the Loy Khwar Formation (*Figure 3 A and B*). The mineralisation is mainly concentrated in members 3-5 of the Formation (*Figure 4*).

The main zone of mineralisation at Central Aynak is dominated by bornite. Chalcopyrite occurs in only minor amounts in the middle and lower parts of the body, but increases in the upper parts. Cobalt concentrations are very

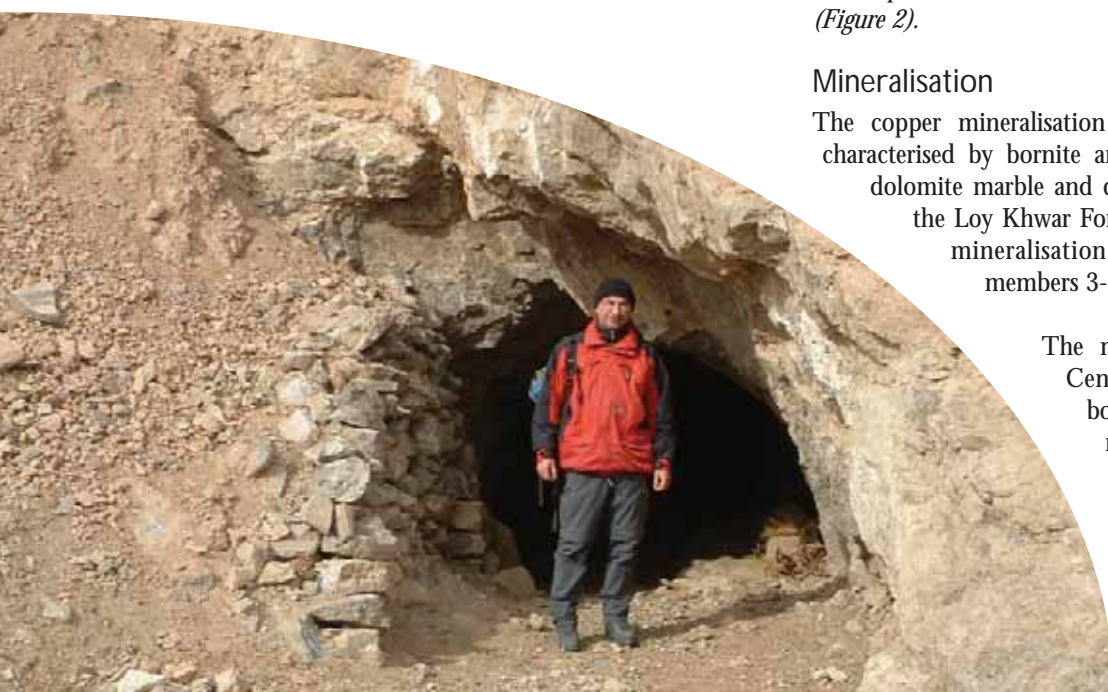


Figure 2. Simplified geological map and cross sections of the Aynak area.

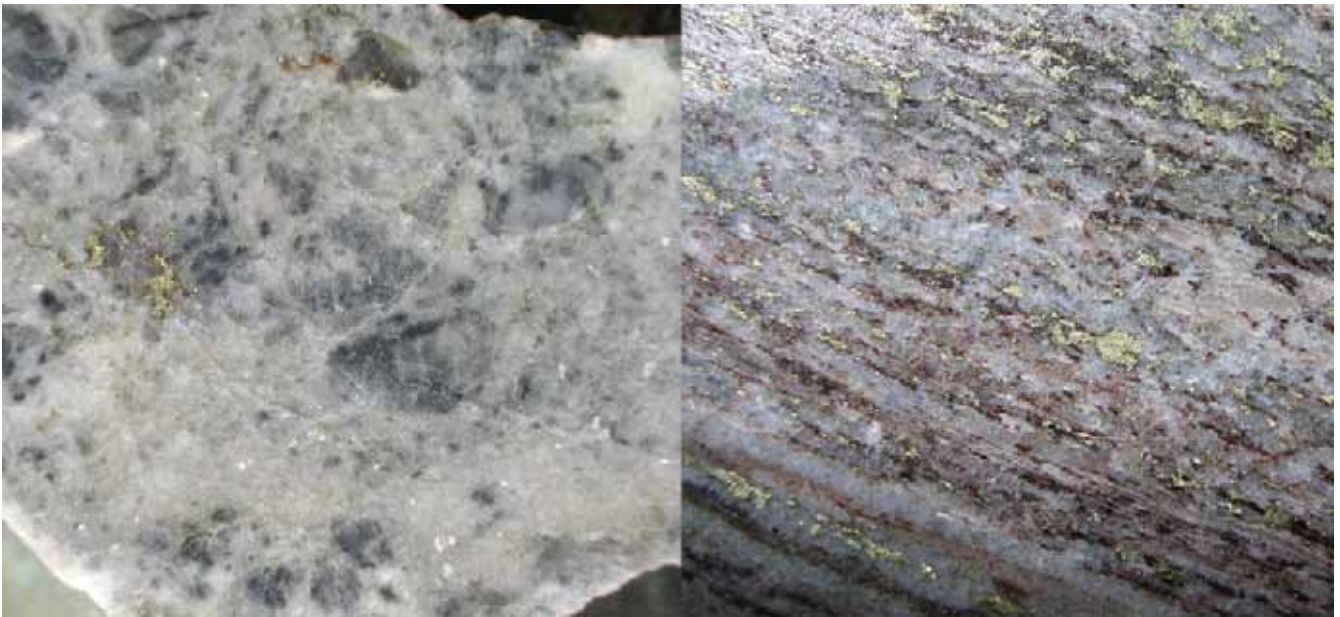


Figure 3 A. (left) *Porphyroblastic dolomite marble with chalcopyrite.*

Figure 3 B. (right) *Finely laminated biotite-feldspar-quartz schist with disseminations and stringers of chalcopyrite.*

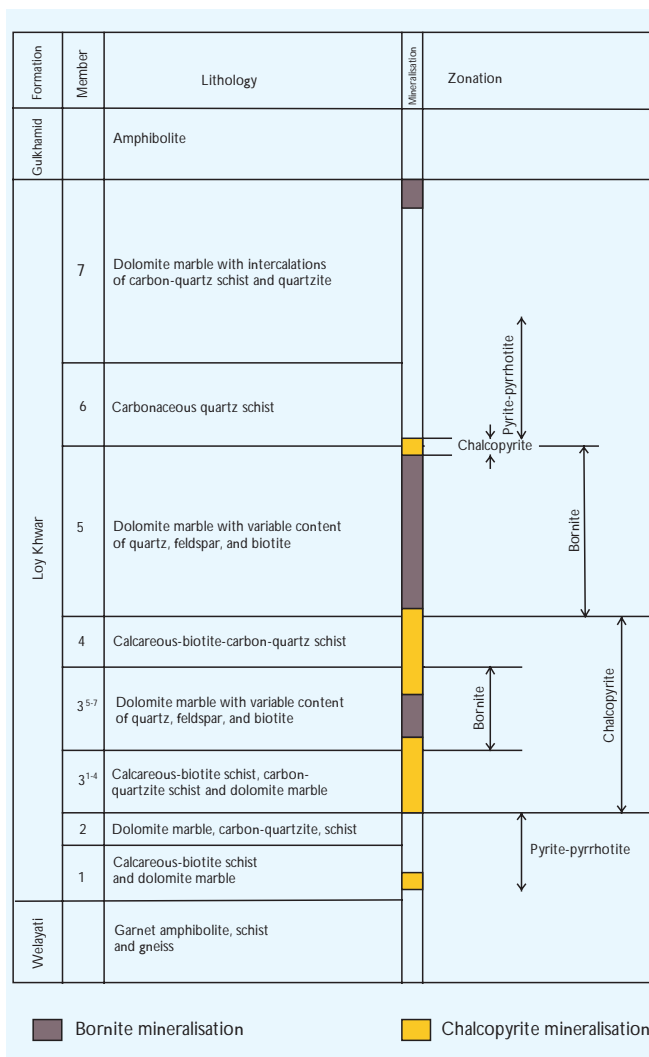


Figure 4. *Simplified stratigraphic column shown the major rock types and mineral zonation.*

low but, like zinc, increase peripherally in some parts of the deposit. The depth of the oxidised zone is variable with the deepest oxidation occurring 250 m below the surface in the northern part of Central Aynak, beneath thick Neogene deposits. The oxidised zone, with chalcocite and native copper, passes downwards into a mixed zone of oxidised and primary sulphides. No evidence for a supergene-enriched zone occurs.

### Exploration

The work of the Soviet-Afghan geologists' on Aynak and its neighbouring deposits is documented in a large number of reports in the Afghanistan Geological Survey archive. A database lists all the reports and contents, and important diagrams and text have been scanned. In total, the exploratory work included over 150 boreholes, 70 trenches, nine adits and surface geological and geophysical surveying. Assays of the drillcore are recorded on the borehole logs and this information, combined with the detailed lithology from boreholes, cross-sections and geological plans, made it possible to produce a 3D model showing the distribution of copper in the orebodies (*Figures 6 and 7*).

Original resource estimations carried out by Soviet geologists, at varying cut-off grades, delineated several large ore bodies and a number of smaller lenses. At a 0.4 % Cu cut-off grade, the main orebody at Central Aynak extends 1850 m along strike and 1200 m down dip and has a maximum thickness of 210 m. At Western Aynak the main body extends 2230 m along strike and 1640 m down dip, and has a maximum thickness of 214 m, based on a similar cut-off.

### Metallogenic Model

The Aynak copper deposit is stratabound and is disseminated through dolomite marble and schist and, as such, it may be classified as a sediment-hosted stratiform copper deposit. It is believed to have formed by the action of evaporitic brines and

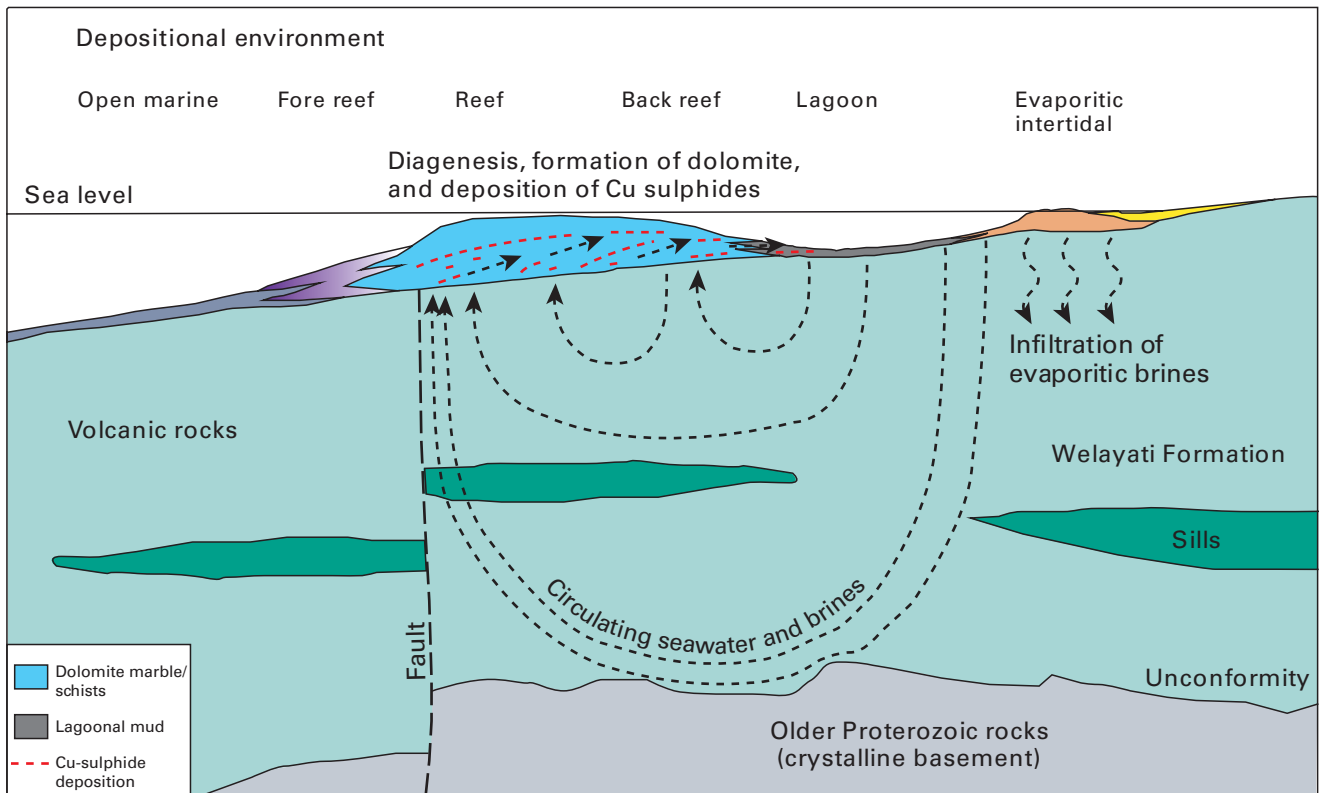


Figure 5. Metallogenic model showing circulation of brines through underlying volcanic rocks.

seawater circulating through the underlying volcanic rocks of the Welayati Formation (Figure 5). The circulating fluids leached copper from the volcanics and gained heat until they began to rise up faults and fractures. Just beneath the surface they reacted with newly deposited limestones and marls, containing abundant organic matter and reduced sulphide ions, precipitating copper sulphides and altering the limestone to dolomite.

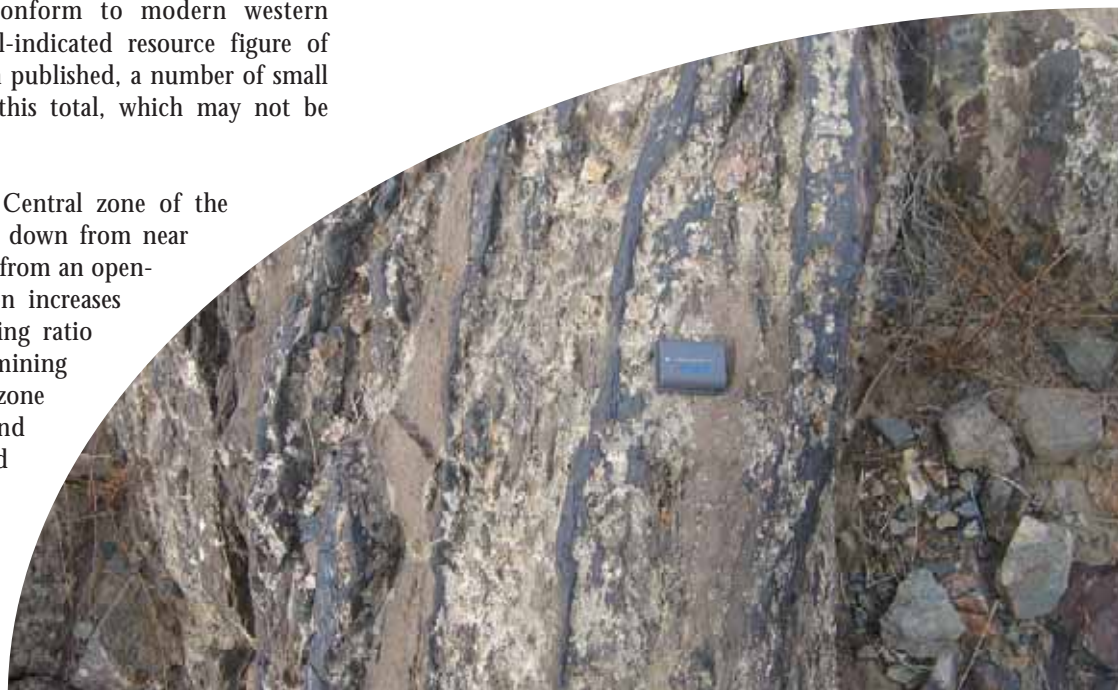
### Future Development

The Soviet-era exploration was very detailed and comprehensive in nature. It outlined a main orebody up to 210 m thick which was consistent down dip and along strike. A number of resource calculations were carried out but these do not easily conform to modern western classifications. Whilst a drill-indicated resource figure of 240 Mt at 2.3% Cu has been published, a number of small 'ore lenses' are included in this total, which may not be mineable in practice.

The main ore body in the Central zone of the deposit, with its shallow dip down from near surface, is probably mineable from an open-pit. The depth of overburden increases to the south and the stripping ratio may be too high to extend mining further south. The Western zone is steeply dipping and underground mining would be needed to exploit the main ore body.

### References:

- ESCAP, 1995. Atlas of Mineral Resources of the ESCAP Region: Geology and Mineral Resources of Afghanistan, Vol. 11. 1995 United Nations 85pp.
- Abdullah, S H, Chmyriov, V M, and Dronov, V I. 1980. Geology and mineral resources of Afghanistan: Kabul. 2 volumes.
- Orris, G J, and Bliss, J D. 2002, Mines and Mineral Occurrences of Afghanistan, USGS Open-File Report 02- 110 available at <http://geopubs.wr.usgs.gov/open-file/of02-110/>.



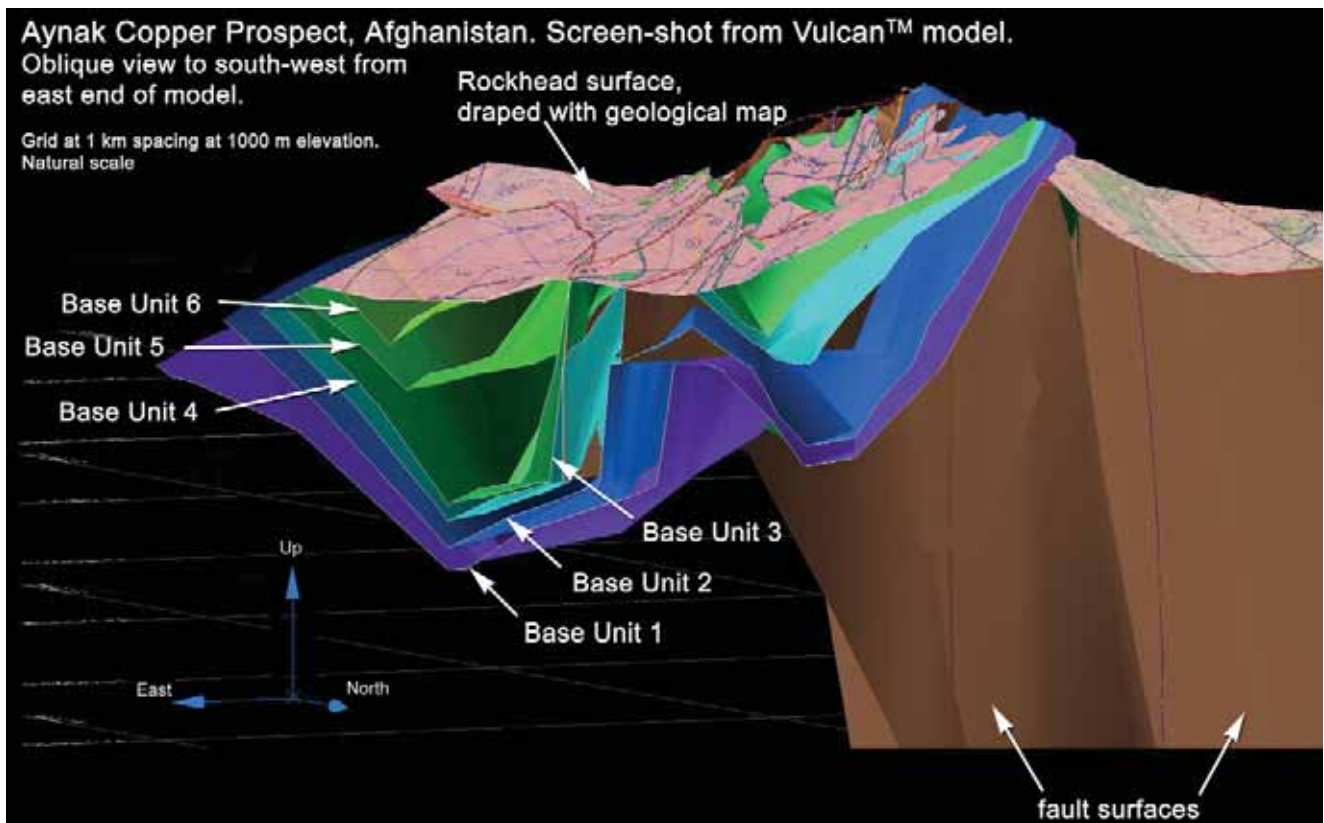


Figure 6. 3D model of the Aynak copper deposit showing shallow dips of the main orebody in Unit 5 in the Central Prospect.

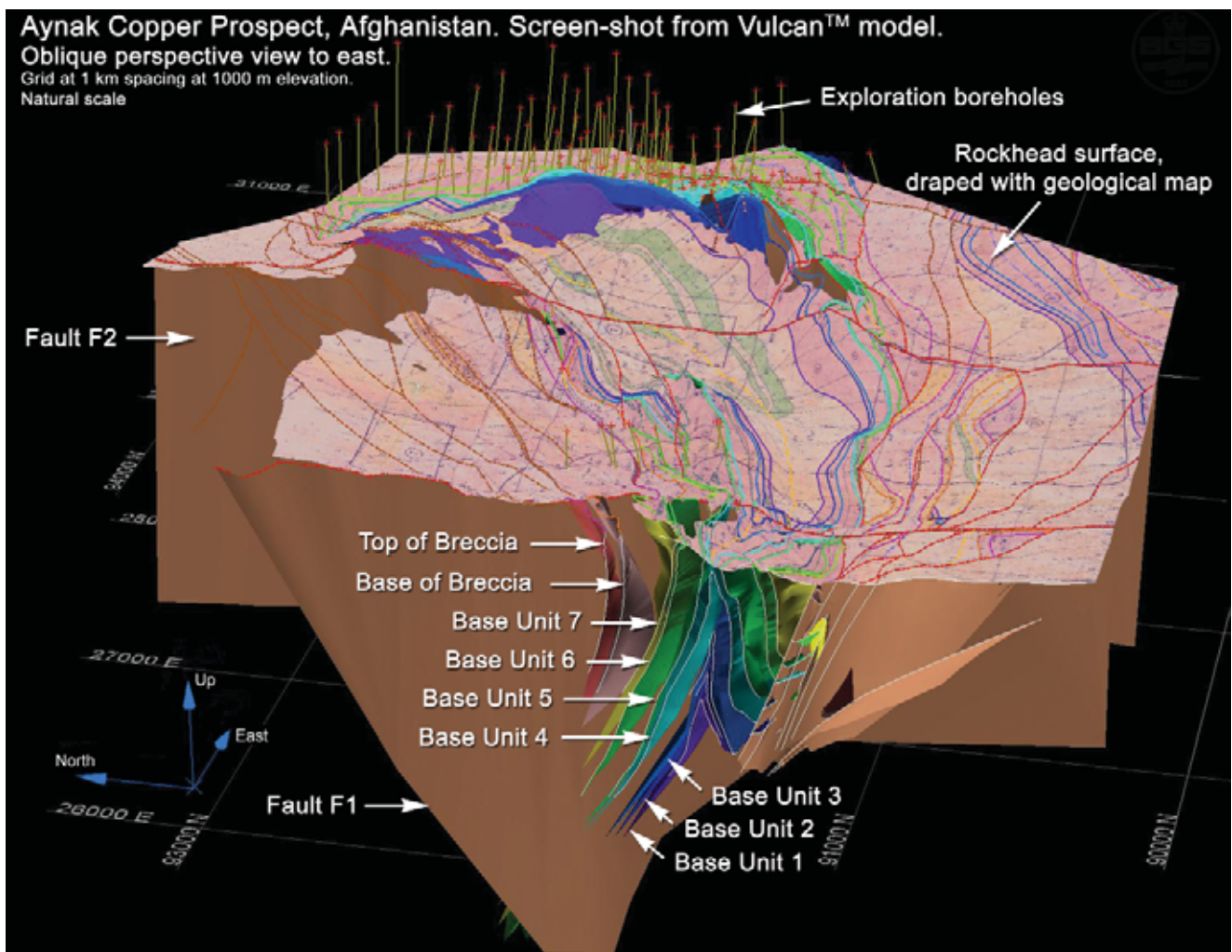


Figure 7. 3D model of the Aynak copper deposit showing a section through the anticline at the Western prospect.

**Aynak** is a world-class copper deposit which, but for the upheavals of the last 25 years in Afghanistan, would surely have become an operating mine. Its main features are:

- world-class stratabound ore deposit (240 Mt at 2.3 % Cu)
- simple sulphide mineralogy
- amenable to open-pitting
- easy access and close to Kabul with its infrastructure
- few environmental problems
- new minerals law (2005)
- government favourable to mining development

The challenge is for an enterprising company to develop this exciting deposit.

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