Minerals in Afghanistan

The potential for gold

Introduction

Gold has been worked in Afghanistan for centuries from many areas including Takhar province in the north and from Ghazni, Zabul, and Kandahar provinces in the south-west of the country. Currently, gold is produced almost solely by artisanal miners working the Samti Placer Deposit in Takhar Province. Gold deposits and prospects are known in rocks of Proterozoic to Neogene age. Many styles of gold mineralisation occur, in particular skarn, vein-hosted, porphyry and alluvial. Afghanistan is relatively under-explored and has not yet been evaluated in the light of modern mineral deposit models and using up-to-date sophisticated analytical methods and exploration techniques.

There is significant potential for further discoveries of gold mineralisation throughout the country in a variety of styles especially porphyry Cu-Au and skarn Cu-Au.

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, comprising a number of small blocks or 'terranes', which split off around 250 million years ago from the margin of the Gondwana supercontinent. These terranes then successively accreted onto the southern margin of the Asian continent.

Figure 1. *Gold occurrences classified by deposit type (based on ESCAP, 1995).*

Previous work

Gold deposits, occurrences and showings discovered to date are the result of work conducted in the 1960s and 1970s, principally by Russian geologists who identified two main prospective regions: the northeast provinces of Badakhshan and Takhar, and the southern provinces of Ghanzi, Zabul and Kandahar (Chmyriov et al. 1973; Dronov et al. 1972). Further detailed work has not been carried out following the Soviet withdrawal from Afghanistan in 1989 and the subsequent civil war.

In 1980, the *Geology and Mineral Resources of Afghanistan*, a comprehensive two-part volume, was compiled by Abdullah et al. and published by the Afghanistan Geological Survey (AGS) describing all the deposits, occurrences and dispersion haloes of minerals discovered up until January 1977. It is primarily based on the results of geological surveying and prospecting carried out by Soviet and Afghan geologists between 1958 and 1977 although details of work undertaken in the late nineteenth century and early twentieth century are also included.

In 1995, the United Nations Economic and Social Commission for Asia and the Pacific published a report entitled *Geology and Mineral Resources of Afghanistan* (ISBN: 92 1 119681 7). This document includes a summary table and text descriptions for over 1400 mineral deposits, occurrences and showings, including 110 containing gold.

In 2002, the United States Geological Survey (USGS) compiled a digital inventory of more than 1,079 mines and mineral occurrences in Afghanistan of which 112 are gold-related. This digital inventory is available at http://geo-nsdi.er.usgs.gov/cgi-bin/publication?open-file/02-110/.

The AGS holds over 67 reports pertaining to gold, dating between 1960 and 1986. In total, no fewer than 100 reports relating to gold exploration and potential are currently held dating back to 1899. For further information on the archive, visit www.bgs.ac.uk/afghanminerals

Gold deposits and occurrences

The 112 gold occurrences recorded by the USGS are classified by deposit style or genetic class. The potential for finding precious metal deposits in other areas is high using new geological models as well as modern exploration techniques. A summary of the deposit styles present and the number of occurrences of each style is given below.

Skarn gold

There are 34 gold-bearing skarns in Afghanistan mainly hosted by sedimentary carbonate and calcareous clastic rock associated with intrusions. The occurrences are associated with three phases of intrusions: Cretaceous–Palaeocene diorites, Oligocene granitic batholiths and, to a lesser extent, Miocene diorite porphyry and syenite porphyry intrusions and dykes. The main commodities include gold, copper, tin, lead, zinc, molybdenum and silver. Ore minerals present include chalcopyrite, magnetite, bornite, chalcocite, pyrite, covellite, cassiterite, hematite and native gold in varying proportions.

The most prospective areas for gold-bearing skarns are:

- The south central provinces of Zabul, Ghazni and Kandahar which contain over 50 gold-bearing sites including the largest gold resource currently known in Afghanistan, the Zarkashan deposit. These occurrences are associated with Cretaceous subduction-related volcanic arcs within the Helmand Block.

Deposit Profile 1

Deposit name: Zarkashan, Ghazni Province

Deposit style: Skarn

Host geology: Late Triassic dolomites in the exocontact 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 sheet-like deposits. Several ore-bearing zones occur 400–600 m long and 11–75 m wide. The richest gold is found in phlogopite skarns

Gold content: 22 775 t @ 0.1–10.16 g/t Au (7.7 t Au C1 and C2 category of reserves)

Information source: Abdullah et al. 1980

- The Zarkashan deposit, (Deposit Profile 1), assessed between 1967 and 1971, comprises several lenticular mineralised zones between 1 and 25 m wide and 400–600 m long, traceable for 80 m down dip. Grades of up to 10–15 g/t were recorded. Soviet geologists recorded 'indicated', or 'estimated' gold reserves as 7777 kg and 'inferred reserves' are 12 000 to 15 000 kg of metal.

- Skarn-type mineralisation occurs in association with Miocene granite porphyries in Badghis Province at Ahonkashan, (see Deposit Profile No. 2), and also within the North Afghanistan Platform (Tadjik Block). Polymetallic mineralisation at Ahonkashan, grades up to 3.6 % Cu and 5 g/t Au occurring in pods, veinlets as well as shear zones.

- In Badakhshan, porphyry-style mineralisation in neighbouring Iran and Pakistan highlights potential for skarn style mineralisation.

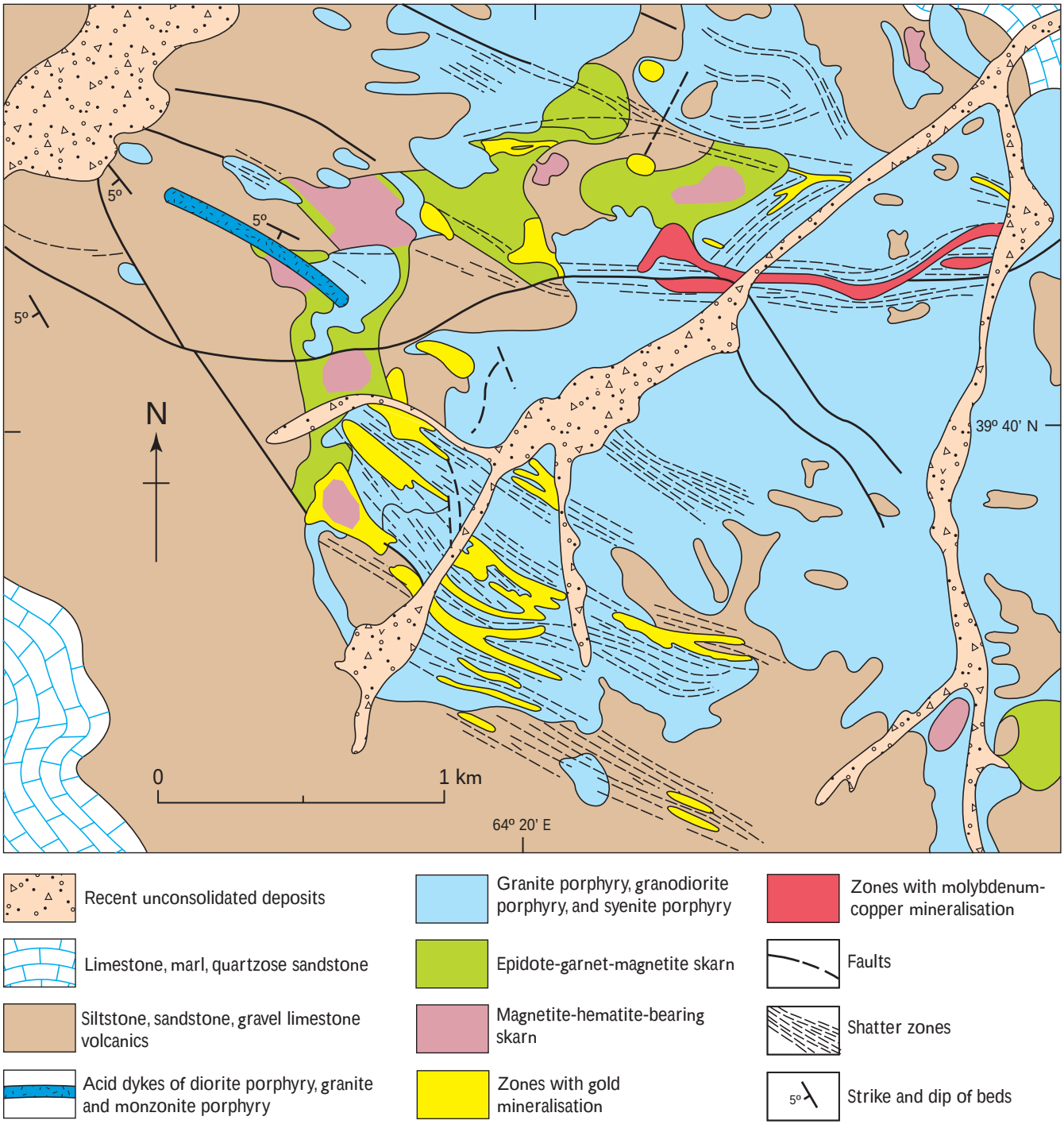


Figure 2. *Simplified geological map of the Zarkashan deposit.*

Deposit Profile 2

Deposit name: Ahonkashan, Badghis Province

Deposit style: Skarn

Host geology: Miocene granite porphyry intruded into Triassic and Cretaceous sedimentary rocks

Ore minerals: Magnetite, hematite, chalcopyrite, covellite, gold, molybdenum, azurite and chalcocite

Deposit geology: Occurs in pods and veinlets as well as shear zones. Associated with magnetite-hematite skarns. Six mineralised zones 700–2500 m long and 11–75 m wide

Gold content: Grades of 1.0-9.0 g/t Au, 0.2-0.5% Cu, 0.5% Pb, up to 0.4% Zn, up to 0.07% Mo

Information source: ESCAP, USGS 2002

Vein gold (in shear zones, fractures and breccias)

Gold-bearing quartz veins ranging from Archaean to Upper Palaeogene age occur in association with shear zones and intrusive masses. Vein occurrences in gneisses and schists, Upper Palaeozoic and Mesozoic carbonate rocks and Oligocene granites and granodiorites are located in two areas.

- Badakhshan and Takhar Provinces e.g. the Chilkonshar deposit (Deposit Profile 3) and at Vekadur (Deposit Profile 4).
- Zabul, Ghazni and Kandahar Provinces where deposits are associated with intrusives occurring from Kandahar to Zarkashan.

Deposit Profile 3

Deposit name: Chilkonshar, Badakhshan Province

Deposit style: Quartz vein-hosted gold

Host geology: Early Carboniferous vein gold hosted in volcanic rocks

Ore minerals: Gold

Deposit geology: Mineralised area is 21 km^2 restricted to a fault zone containing 40 quartz veins with widths of 0.2–6.5 m and lengths up to 285 m

Gold content: 12.3–84.9 g/t–4 veins have commercial value

Information source: Watts, Griffis, McOuat, 1977

Potential for shear-zone vein-gold mineralisation exists along the major transcrustal structural breaks representing remnant terrane collisional boundaries. Gold potential also occurs within Phanerozoic rocks in moderate to gently dipping fault/suture zones related to continental margin collisional tectonism. Suture zones characterised by ophiolitic remnants between diverse assemblages of island arcs, subduction complexes and continental-margin clastic wedges are also prospective. The older Archaean volcano-sedimentary greenschist facies rocks occurring within the South Badakhshan Fault Block are favourable hosts for shear-zone vein gold of the greenstone type developed in Archaean terranes elsewhere such as Canada, Australia and Zimbabwe.

Deposit Profile 4

Deposit name: Vekadur (Weka Dur) Badakhshan Province

Deposit style: Breccia

Host geology: Silicified and ochreous brecciated schist. Diabase and keratophyre dykes in vicinity (Proterozoic)

Ore minerals: Gold, arsenopyrite, galena, chalcopyrite and scheelite

Deposit geology: Podiform orebody average 2 m thick and 300 m extent. Traced for 100 m down dip

Gold content: 960 kg Au; grade of 4.1 g/t Au, 46.7 g/t Ag

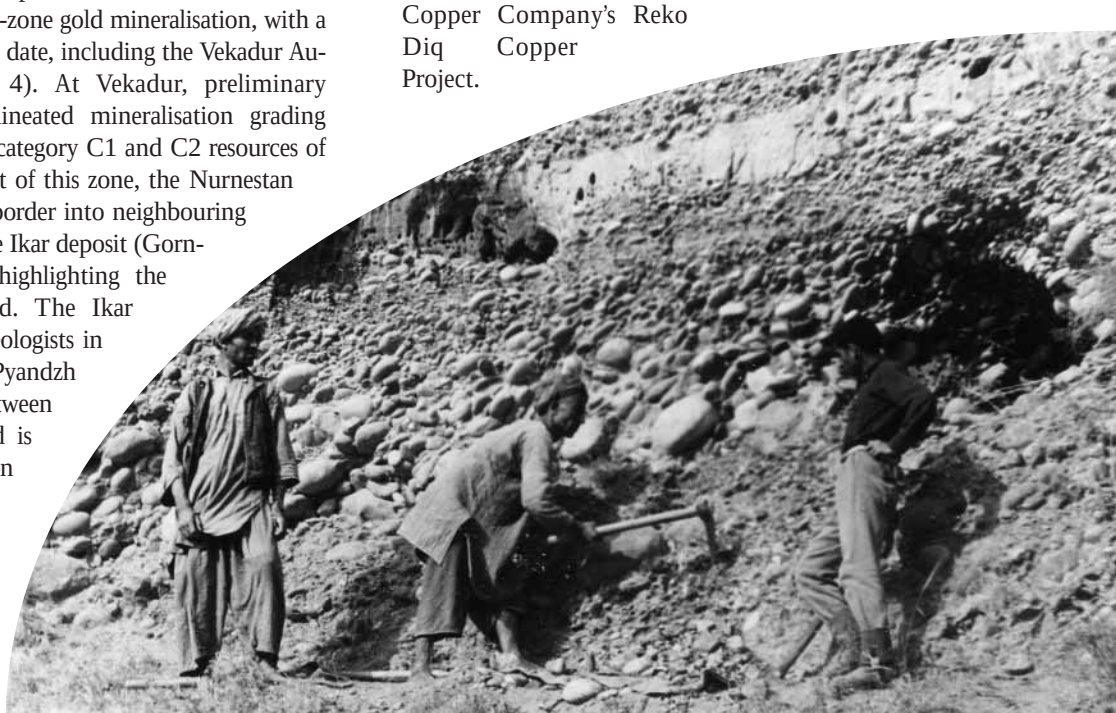
Information source: Abdullah et al. 1980 ESCAP, USGS 2002

The zone of late Hercynian folding on the eastern end of the North Afghan platform, in the provinces of Badakhshan and Takhar, are prospective for shear-zone gold mineralisation, with a number of deposits identified to date, including the Vekadur Au-Ag deposit (Deposit Profile 4). At Vekadur, preliminary exploration in the 1960s delineated mineralisation grading 46.7 g/t Ag and 4.1 g/t Au for category C1 and C2 resources of just over 30 000 oz. To the east of this zone, the Nurnestan Fault Block extends across the border into neighbouring Tajikistan, where it is host to the Ikar deposit (Gorn-Badakhshan district), further highlighting the potential for vein-hosted gold. The Ikar deposit, discovered by Soviet geologists in 1975–1977, lies east of the Pyandzh River that defines the border between Afghanistan and Tajikistan and is estimated to contain 3.1 million tonnes at 5.6 g/t, 4.7 Ag, 0.13 % Cu. It is a polymetallic hydrothermal vein deposit consisting of massive sulphide veins and sulphide stringer zones. The deposit, which is developed within andesitic rocks, contains tungsten, gold, silver, copper, arsenic and cobalt. A skarn deposit is developed adjacent to the mineralisation at the contact of dioritic rocks and porphyritic andesites.

Porphyry copper-gold and epithermal gold

Afghanistan has considerable potential for the discovery of precious metal deposits such as porphyry and epithermal gold associated with younger Tertiary volcanic and high-level plutonic rocks. Gold porphyries are prospective in the following areas:

- South, west and central Afghanistan lies within the Tethyan Magmatic Arc that contains the Tethyan Eurasian metallogenic belt hosting numerous world-class porphyry Cu-Mo-Au deposits including the Sar Chesmeh (>1.2 Bt @ 0.8 % Cu and 0.3g/t Au) and Sungun deposits in Iran, the Gumushane, Guzelyayla and Derekoy deposits in Turkey and the Saindak deposit in Pakistan.
- Copper in small porphyritic intrusions of Tertiary age were documented during the 1970s (Dronov *et al*, 1972, Chmyriov 1972). In Iran, all significant porphyry mineralisation is related to Tertiary subduction-related granitoids; hence they are attractive targets in Afghanistan.
- Cu-Au-Mo porphyry occurrences are located on the southern margin of the Northern Platform in the Faryab Province in a belt of Miocene granodiorite-, granite- and dacite porphyries (Deposit Profile 5, *(see overleaf)*). Mineralisation occurs within fracture zones 20–270 m wide and up to 2.5 km in length containing 0.1–1.5 % Cu, 1–32 g/t Au and 0.01-0.06 % Mo.
- Significant potential for porphyry-style mineralisation occurs in Nimroz, Helmand and Kandahar provinces. Although limited work has been carried out, the area's prospectivity is indicated by the presence of exploration for porphyry copper-gold and epithermal gold mineralisation in the bordering Balochistan Province in Pakistan. In Balochistan, Cretaceous island-arc basement rocks, together with Tertiary sedimentary, volcanic and intrusive rocks of Andean-type affinities host important mineral deposits including the Saindak copper-gold mine and the Tethyan Copper Company's Reko Diq Copper Project.



Deposit Profile 5

Deposit name: Okhankoshan, Faryab Province

Deposit style: Porphyry Cu-Au-Mo

Host geology: Miocene granodiorite-, granite- and dacite porphyries

Deposit geology: Mineralisation controlled by zones of fractures forming linearly elongated stockworks. Zones vary in width from 20–30 to 270 m and extend up to 2.5 km

Alteration: Extensive silicification, pyritisation, sericitisation and kaolinisation

Metal content: 0.1–1.5% Cu, 1–32 g/t Au, 0.01–0.06% Mo, 0.3-2.5% Pb and Zn

Information source: Abdullah et al. 1980

- Further potential occurs in Zabul, Ghazni and Kandahar provinces, on the south-east of the Helmand Block. Clustering of copper deposits with peripheral zones of lead and zinc suggests that they may be porphyry-related. The presence of skarn deposits in the area further highlights the potential for porphyry-style mineralisation. In the province of Badakhshan and Takhar in the north-east corner of Afghanistan, the favourable geology and known gold showings, including the discovery of Miocene copper or porphyry copper style mineralisation, makes the zone of late Hercynian folding on the eastern end of the North Afghan platform prospective.

Placer gold

Over 86 placer gold deposits are known, mainly occurring in Takhar and Badakhshan. The deposits formed from eroded veins, and now occur on the western flanks of the mountains in alluvial or alluvial fan deposits in several river valleys, particularly in the Panj, Nooraba, Hasar and Anjir valleys.

Deposit Profile 6

Deposit name: Samti Deposit, Takhar

Deposit style: Placer gold

Host geology: Recent alluvial type confined to floodplain and the first terrace of the Panj River

Deposit geology: Alluvial deposits up to 40 m thick. Placer is 8 km long and from 900–17 000 m wide and commercial gold to depth of 27.9 m. Irregular distribution of gold

Alteration: N/A

Metal content: Gold in layers varies between 100 mg/m^3 and 30-40 g/m^3 and layers vary in thickness between 0.25 and 4 m thick

Information source: Abdullah et al. 1980

Gold occurs in terraces, in abandoned channels at higher elevations, and in the Recent valley alluvium *(figure 3)*.

The largest placer deposits occur in the Panj River valley. The most important is the Samti deposit (Deposit Profile 6), estimated to contain 20–25 t of gold, which is currently worked by artisanal miners. The gold may be derived from several bedrock sources including palaeo-conglomerates (ESCAP, 1995). Other examples of placer gold deposits include those at Takhar Province where many small gold placers occur as beds less than 2.5–3.0 m thick in U-shaped valleys. The gold occurs in sandy, pebbly and conglomeratic beds and is irregularly distributed, varying in abundance from 50–100 mg Au/m^3 to 19 g Au/m^3. Alluvial gold also occurs near the Zarkashan skarn deposit in Ghazni. Soviet geologists working between 1967 and 1970 indicated Category C2 resources as 1597 kg Au, having an average thickness of 1.3 m with an average concentration of 729 mg Au/m^3 (Watts, Griffis and McOuat, 1977). Further work identified other placer deposits with an average thickness of 1.5–2.0 m and an average concentration of 11.4 g Au/t. Category C1 and C2 resources were calculated at 7800 kg Au.

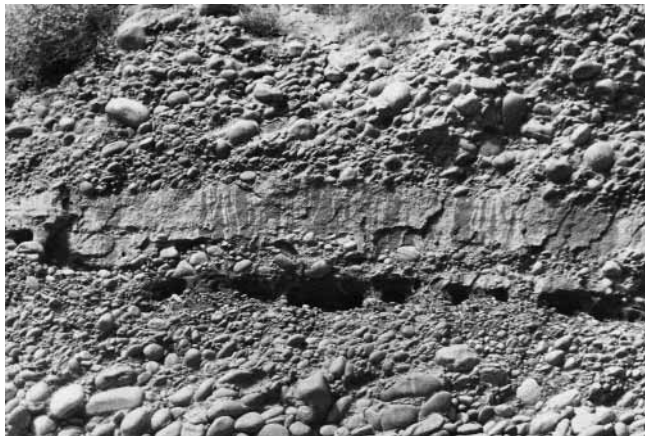


Figure 3 *Placer gold deposit in sands and conglomerate of the Panj River Valley.*

Other deposit types

Iron-oxide copper gold (IOCG) and Banded Iron Formation hosted gold: large resources of Fe oxide like the Hajigak deposit, contain about 5% sulphides, including chalcopyrite. These have never been analysed for gold and they should therefore be re-evaluated with modern-day IO CG models in mind.

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Tectonic zone	Geological setting	Mineral deposit type
North Afghanistan Platform (Tadijk Block, Karakum Basin)	Palaeozoic basement intruded by Triassic granitoids. Southern edge cut by an early Mesozoic Magmatic Arc covered by younger mid-Mesozoic to Neogene sediments	– mesothermal lode Au (greenstones, shear zones) – alluvial style placer gold – porphyry Cu-Mo-Au – sediment-hosted Cu (± Co, Ag, Pb, Zn, PGE, Au, U, V)
Helmand Block (west-central Afghanistan)	Middle Proterozoic high grade metamorphic rocks (2000–5000 m) overlain by greenschist facies Late Proterozoic metasediments (5000–7000 m). Cover rocks are Vendian to Cretaceous formations (1000–8000 m) intruded by Palaeogene acidic to ultrabasic rocks	– mesothermal lode Au (shear zones) – granite-related vein, replacement and skarn mineralisation (Au, Cu etc) – sediment-hosted Cu (± Co, Ag, Pb, Zn, PGE, Au, U, V) – VHMS Cu-Zn-Ag-Mn-Ba-Au deposits in calc-alkaline complexes – skarn-type, porphyry-related and possibly epithermal style gold mineralisation, related to Cretaceous Tertiary subduction systems
Farad Block (West and South-west Afghanistan)	Unstudied basement. Vendian-Cambrian terrigenous, carbonate and volcanic rocks (420 m), overlain by 9,000 m Carboniferous-Jurassic carbonate and volcanic rocks. Infilled by Cretaceous sedimentary rocks. Intruded by Palaeogene granitoids and Miocene diabase swarms, andesite, diorites and porphyry dykes	– mesothermal lode Au (shear zones) – granite-related vein, replacement and skarn mineralisation (Au, Cu etc) – skarn-type, porphyry-related and possibly epithermal style gold mineralisation, related to Cretaceous Tertiary subduction systems – VHMS Cu-Zn-Ag-Mn-Ba-Au deposits in calc-alkaline complexes
Dari-Rod Trough (south Afghanistan)	Middle Proterozoic metamorphosed basement (800 m) overlain by Cretaceous sedimentary-volcanogenic rocks (3300 m). Intruded by Cretaceous and Oligocene (?) ultrabasic and granitoid rocks	– mesothermal lode Au (shear zones) – skarn-type, porphyry-related and possibly epithermal style gold mineralisation, related to Cretaceous Tertiary subduction systems – VHMS Cu-Zn-Ag-Mn-Ba-Au deposits in calc-alkaline complexes
Nurestan Block (north-east Afghanistan)	Mainly highly metamorphosed Early Proterozoic (10 000 m) basement overlain in parts by Carboniferous-Triassic sedimentary rocks. Intruded by Proterozoic and Cretaceous-Paleogene granitoids and gabbro-diorite intrusions	– mesothermal lode Au (shear zones) – Porphyry Cu-Mo-Au
South Badakhshan Block (north-east Afghanistan)	Archaean and Proterozoic basement rocks (9000 m). No intrusions.	– mesothermal lode Au (greenstones, shear zone) – alluvial style placer gold
Kabul Block	Lower Palaeozoic basement overlain by Mesozoic sedimentary rocks.	– mesothermal lode Au (greenstones, shear zone) – sediment-hosted Cu (± Co, Ag, Pb, Zn, PGE, Au, U, V)
Katawaz Basin	A flexural basin on the western margin of the Indian Plate comprising 10 km of Palaeocene sediments, mostly flysch material, resting on a Palaeozoic and Mesozoic basement.	– sediment-hosted Cu (± Co, Ag, Pb, Zn, PGE, Au, U, V)

Table 1. *Summary of tectonic zones within Afghanistan and associated gold potential.*

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