ISLAMIC REPUBLIC OF AFGHANISTAN

Ministry of Mines and Petroleum

GOLD

MINERAL RESOURCES IN AFGHANISTAN

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GOLD

Background
Gold has been worked in Afghanistan from ancient times and small-scale artisanal mining is still being carried out on placer gold deposits in Takhar Province. There are a number of other prospects, which have been evaluated by Soviet and Afghan teams in the 1970's and there is a high probability that some of these could be developed into working mines. Improved exploration methods and modern metallogenetic models, coupled with knowledge that Afghanistan lies on a continuation of the Tethyan Metallogenic Belt, have greatly improved the potential of the country. Several areas of the country have potential for new deposit types, such as fine-grained epithermal gold, not sought by the Soviet-Afghan teams, and have been largely unexplored.
The reports of the earlier Soviet exploration are now available in Kabul. BGS and USGS have published summaries of the geology and re-interpreted the earlier data in the light of remote sensed information (*Peters et al., 2007* and *2011*).

Afghanistan has a complex geology due to its position on the junction between the Indo-Pakistan and Eurasian crustal 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 the terranes became accreted onto the southern margin of the Eurasian plate. The final closure of the Neo-Tethys Ocean between the Indo-Pakistan and Eurasian plates produced the Himalayan orogeny. During this oblique collision NW-directed subduction occurred beneath the Tirin-Argandab zone and a number of calc-alkaline granite bodies were intruded, accompanied by porphyry copper-gold mineralisation of the Tethyan Metallogenic Belt (*TMB*). Further north in Badakhshan there are a number of prospects and occurrences of metamorphic lode gold in areas of Hercynian and later Cimmerian folding. This zone may extend southward into Parwan as shown in Figure 1 and even further to the west associated with folding related to the closure of Palaeo-Tethys along the Herat terrane boundary.

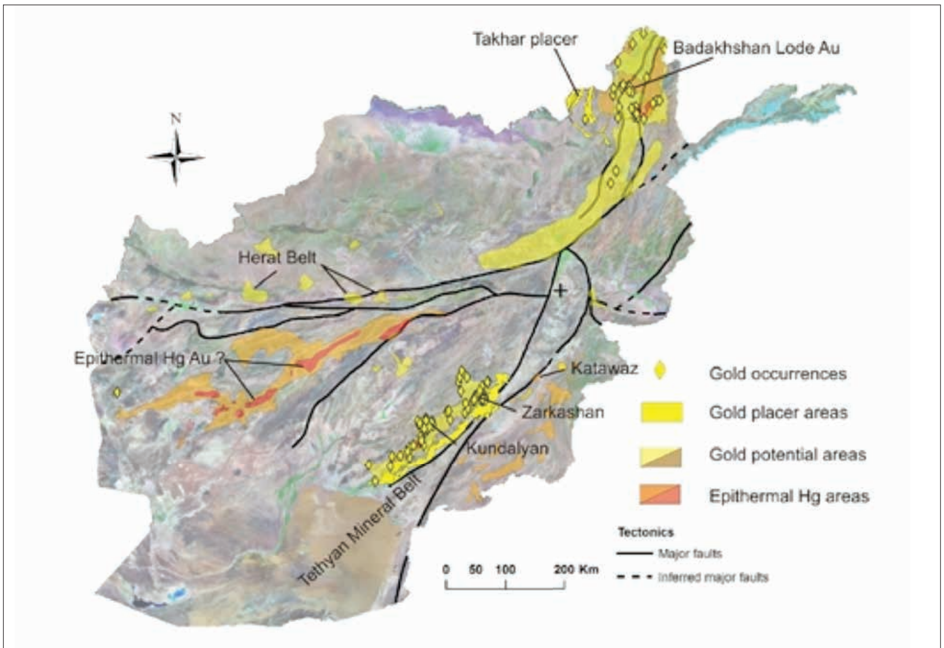


Figure 1. Gold occurrences in Afghanistan on a low-resolution Landsat image, with areas of enhanced gold and mercury potential (after Peters et al., 2007).

Orogenic Gold Deposits

Potential for shear-zone vein-gold mineralisation exists along the major trans-crustal 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 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 (*Figure 2* and *Deposit Profile 1*). The Vekadur gold deposit has been explored by five adits, eight pits, and 10 or more trenches (*Gugenev et al., 1967*). The adits are excavated from the hanging wall west of the outcrop of the vein and tunnel eastward into the mountain. There is little overburden in the hanging wall side of the vein and the deposit could be worked as an open pit.

A number of other occurrences are known in the Ragh District and, like Vekadur, are found in shatter zones containing gold-bearing quartz veins with a low-sulphide mineral content. These features are common to a number of productive cratons where several hundred small deposits of about one tonne of gold are present as structurally controlled stockworks and massive veins.

DEPOSIT PROFILE 1	
Deposit Name	Vekadur
Location	Badakhshan Province
Deposit Style	Orogenic / Metamorphic lode gold
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 2m thick and 300m extent. Traced for 100m down dip
Estimated Resources	960 kg contained gold at grade of 4.1g/t Au, 46.7g/t Ag

Information: Abdullah et al. 2008; Peters et al. 2011

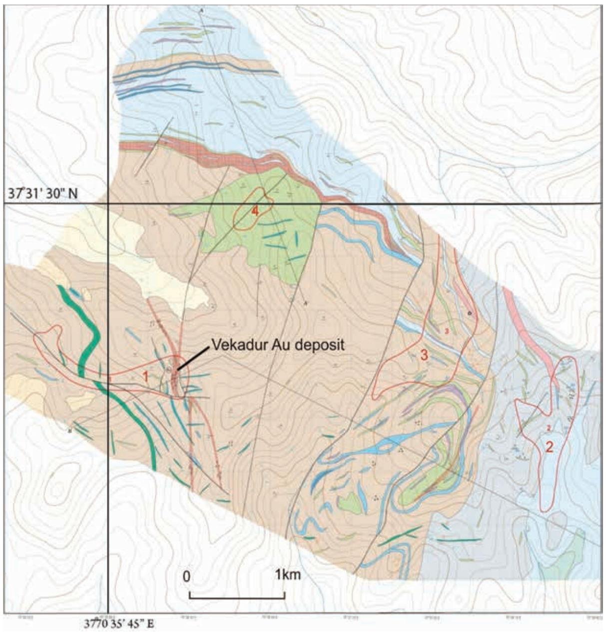


Figure 2. Geological map of the Vekadur gold deposit. Red hatched areas are zones of crushing and hydrothermal alteration in Proterozoic quartz-mica (*light brown and grey*) and chlorite schists (*pale blue*) Red outline shows gold heavy mineral anomalies (*after Peters et al., 2011*).

Figure 3. Afghanistan Geological Survey field work conducted in 2010 at Furmorah gold prospect, Fayzabad district, including prospect evaluation and trench digging. Photographs by the Afghanistan Geological Survey (*Figure 3c Peters et al., 2011*).

No modern exploration has been carried out in the Badakhshan region since the 1960's.

Other prospective districts such as Baharak and Fayzabad as well as having lode gold deposits, also contain iron skarns some of which contain gold. The Furmorah pluton is surrounded by several iron skarns, one of which grades as much as 3.3g/t Au.

Placer Gold
Small-scale placer gold mining appears to have been conducted in the streams and rivers of the Hindu Kush for many centuries and continues locally today in both placers and paleoplacers in Takhar Province. Reports persist of local people putting sheepskins in mountain streams in Badakhshan Province to serve as fleece sluices capable of catching fine gold, reminiscent of tales of the 'Golden Fleece'.

Soviet and Afghan geologists undertook the first industrial-scale exploration for placer gold and made some major discoveries (*Galchenko et al., 1972*), notably Samti, Nuruba, Chah-i-Ab and Jar Bolshi and a large number of smaller occurrences (Figure 4).

It is clear the grades and extent of the placer gold has been underestimated by the Soviet geologists due to limitations in the Soviet exploration methods:

Firstly, it is apparent the Soviet-driven exploration effort was limited to areas with good water supplies in order to facilitate wet washing of the placer ores by wash-plants such as PgSh sluices that require water cannons. Accordingly, less than 10% of Afghanistan was explored for placer gold. Indeed, no evidence has been found of drywashers having been used for prospecting for placer gold in Afghanistan. This is being remedied in 2014 with the introduction of USA drywashers by the USAID MIDAS project, and making by the Ministry of small recirculating sluices based on a USA design that requires minimal water.

Secondly, the Soviet drillers used numerous placer drilling rigs of a single type—Soviet churn drills—that while being the respected industry standard for terraces and dryish floodplains are known to systematically lose most of the gold when used in waterlogged ground such as wet floodplains. This fact has been known for many decades in the Russian placer gold industry.

Samti Gold Dredge Resource
An outstanding success was the systematic proving of a resource of 30 tonnes of placer gold by churn drilling on the active floodplain of the Amu Darya near the village of Samti in Takhar Province. The United States Geological Survey confirms the manual Soviet estimated resource of 30 tonnes, which is large by current world standards. Nevertheless it is believed to be a substantial underestimate of the true magnitude of the Samti gold resource.

The heavy gold losses of Soviet churn drills was familiar to Soviet placer geologists, and indeed the remains of an unused Soviet bucket drill has been identified at the AGS Khair Khana Engineering Warehouse. A Soviet-Canadian data set of more than 1,000 boreholes in Mongolia proved the gold recovery of Soviet bucket drills to be close to 100%, while Soviet churn drills usually lost more than 65% of the gold in the same wet ground (*Grayson 2014*). Applying the correction factor to the Samti churn drilling indicates that the actual gold resource is likely to be in the region of 100 tonnes, with an in-the-ground value of about 4 billion USD, which would rank Samti among the largest gold dredge projects in the world. A limited programme of repeat drilling by a Russian bucket drill would suffice to confirm the appropriate correction factor to be applied to the gold grade, so enabling the resource envelope to be identified and the dredge envelope to be calculated. The appropriate method of mining would be a civil engineering cutter-suction dredge pumping the overburden away to raise flat land several kilometres away so creating a large dredge pond to hold a large mineral dredge such as a Russian, Dutch or USA bucket-line dredge with on-board wash-plant to recover the gold. Accordingly a modified German Ruhr grab dredge may be an attractive alternative, having a reach of more than twice the depth of the placer gold. Finally a large civil cutter suction dredge might be considered, having the merit of wide availability and lower cost, albeit at some peril of losing some gold.

Discovery of Other Deposits of Placer Gold
There is large potential for further discoveries of large placer gold deposits on the Afghan side of the Amu Darya river, as well as discovery of large extensions of the Samti placer itself. Drilling on wet floodplains must only be done with Russian bucket drills to ensure gold grades are reliable and gold losses avoided.

Copper-Gold Porphyry Deposits
The Soviet-Afghan teams identified a number of Cu-Au prospects and occurrences in the Tirin-Argandab zone which forms part of the Tethyan Metallogenic Belt (*Figure 1*) 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 the Triassic and Cretaceous sediments and is associated with garnet-vesuvianite-diopside and with irregular zones of diopside skarns. The mineralisation consists of chalcopyrite, pyrite, sphalerite, chalcocite, bornite, and native gold in the hydrothermally altered skarns. Preliminary exploration, including rock sampling, trenching and underground adits, has indicated the presence of several ore-bearing zones of 400-600m long and 1-15m thick, with lenticular and nest-shaped bodies of 1.5-50m long and 0.5-3.8m thick. Gold mineralisation is traceable for 80m down dip, assaying from 0.10 to 16g/t Au. Category C1+C2 resources are 7,775kg and speculative resources are 12,000 to 15,000kg of contained gold. Copper grades vary from 0.01 to 15%. Recent sampling by USGS (*Peters et al., 2011*) has shown that disseminated mineralisation is extensive within a large contact aureole zone and holds potential for large, medium to low grade ore bodies that are amenable to bulk mining and ore processing methods, during this period of prevailing high copper and gold price.
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.

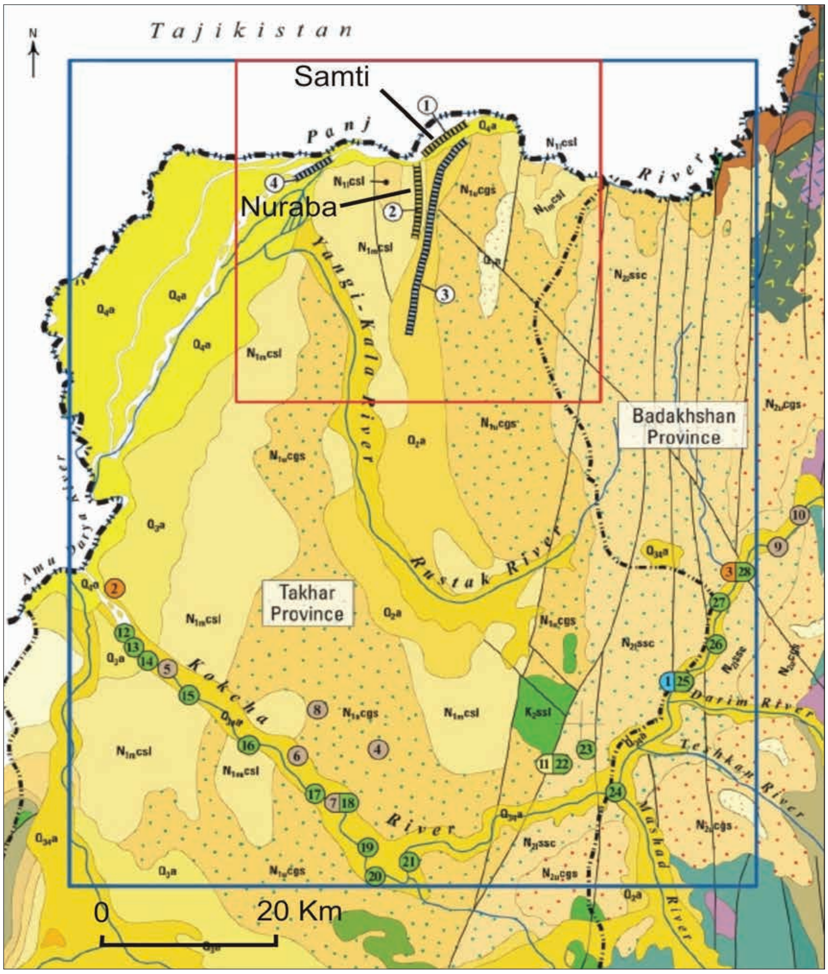


Figure 4. Geological map of northern Takhar showing the distribution of Neogene and Quaternary strata and major gold placers (hatched lines). Colored circles are placer gold occurrences from earlier authors. (*Peters et al., 2011*).

DEPOSIT PROFILE 2	
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
Estimated Resources	7.7t Gold contained in C1 and C2 categories

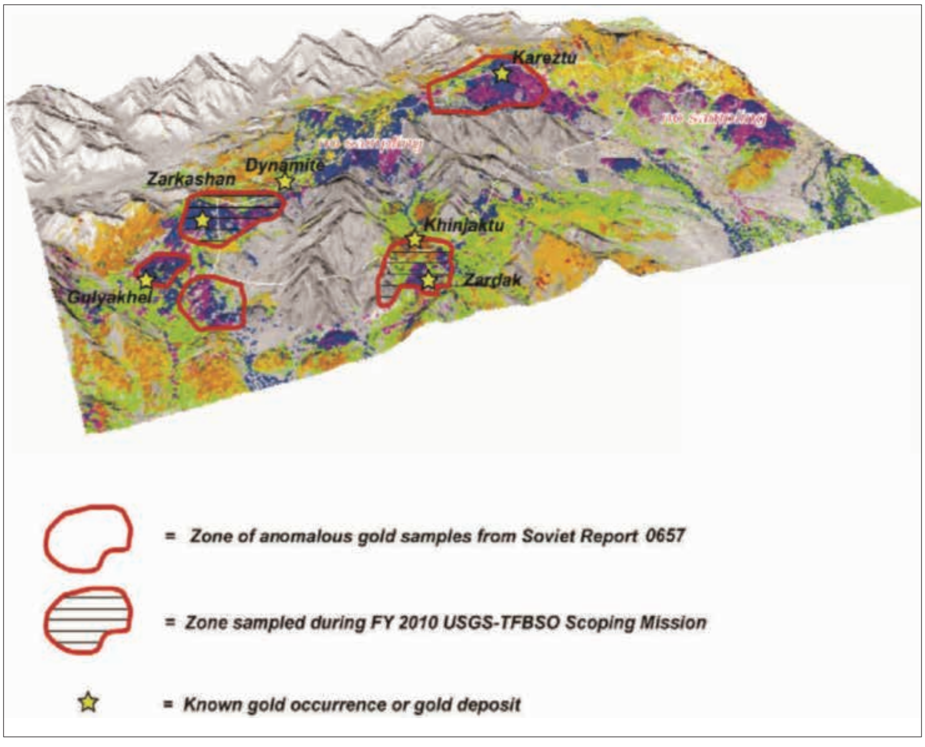
Figure 5. Placer gold deposit consisting of alluvial sand and conglomerate of the Panj River.

KUNDALYAN

The Kundalyan copper-gold skarn deposit is localized along a 400-metre long, 1.5km wide 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. Mineralisation is present both in skarn and chert. There are 13 ore bodies along the Kundalyan Fault Zone (*Figure 8A*) that are from 2.65 to 12.3m thick and from 36 to 175m long, containing 0.62-1.2% Cu and 0.5-2.0g/t Au. The mineralisation is predominately chalcopyrite and pyrite and more seldom sphalerite, gray copper ore, and enargite. The Category C1+C2 reserves in the Soviet classification system, are 13,600 t of contained copper and 1.1t gold at grades of 1.07% Cu and 0.9g/t Au. The Kundalyan copper-gold skarn deposit area was explored by a series of trenches, adits, and drill holes. Data were 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 Kundalyan copper-gold deposit has been explored where a northwest-striking 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 calc-silicate rock related to skarn formation and metasomatic kaolin-carbonate rock. Malachite-stained siliceous skarn and porphyroblastic marble also are common in the mineralised zone. Despite the extensive trenching and the boreholes in the main zone there seems to have been little exploration of colluvium covered areas to 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 Kundalyan group of deposits in these areas: Kaptarghor, Shela-i-Surkh, Baghawan-Garangh, Kunar and Chasu-Ghumbad. Further details can be found in Peters et al., (*2011*).

Hot-spring epithermal gold deposits have not been positively identified but there are indications that they may be present in the epithermal mercury zone of central Afghanistan and Katawaz basin (*Figure 1*).

Figure 6. Three-dimensional view of the Zarkashan copper and gold area of interest showing hyperspectral anomalies surrounding the Zarkashan intrusive (white outline). The 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*).



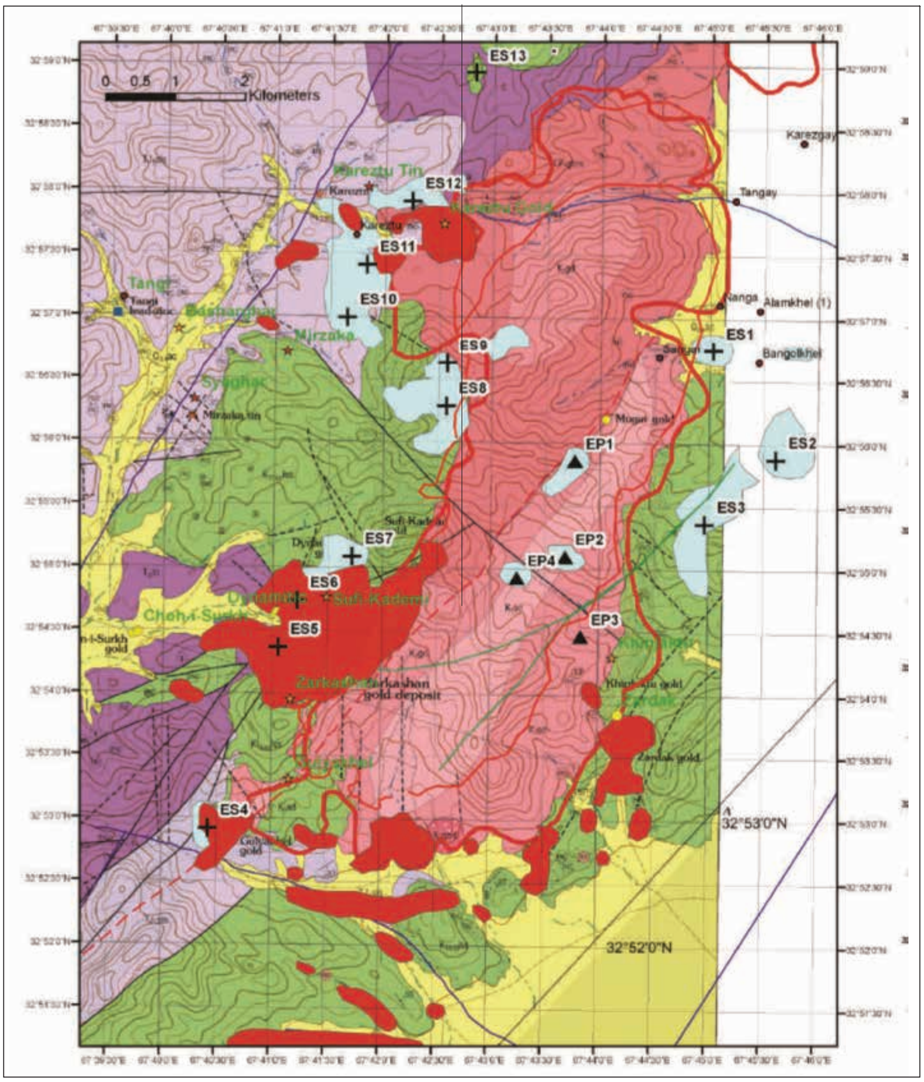


Figure 7. Geological map of the Zarkashan area showing the mineralised areas (bedrock gold anomalies in red) surrounding the Zarkashan pluton (lighter shades of red). (Peters et al., 2011).

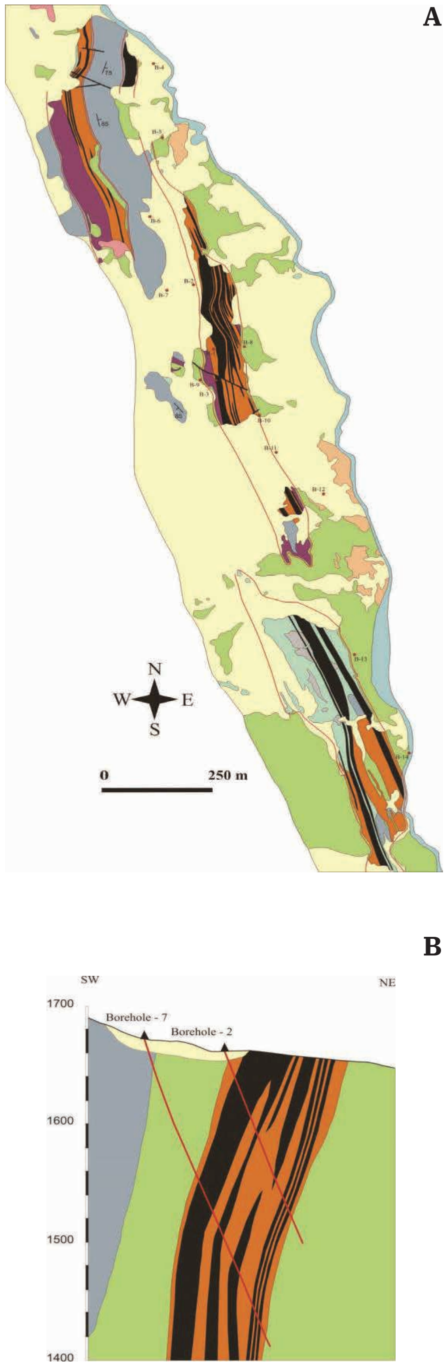


Figure 8. (A) Geological map of the Kundalyan area showing the ore zone (black), skarn (orange), kaolin-carbonate rock (grey), altered granitoids (pale blue), granodiorite (green) and colluvium (pale yellow). (B) Illustrative cross section through boreholes 2 and 7 at Kundalyan (key as above).

Epithermal Gold

In central Afghanistan in the Kharnak-Kanjar area, (*Figure 9*) disseminations and veinlets of cinnabar accompanied by carbonate, dickite and silica alteration and lesser pyrite, chalcopyrite and arsenic minerals are found in early Cretaceous calcareous rocks intruded by Eocene to Oligocene porphyry diorite dykes and volcanics. The features indicate the presence of a very large low-temperature hydrothermal system. Elsewhere in the world, such systems host significant gold resources and are the focus of major exploration investment (*Peters et al., 2007, 2011*). In the Katawaz basin Abdullah et al. (*2008*) observed telethermal (*epithermal*) lead, zinc, mercury and gold mineralisation belonging to the orogenic (*Miocene*) stage of the basin's evolution.

KATAWAZ GOLD

The Katawaz gold area of interest (*AOI*) lies along the northwestern margin of the Katawaz Basin in eastern Afghanistan. Although no known mineral occurrences or deposits are present in the AOI, geologic and remote-sensing data suggest that the environment is conducive to the occurrence of epithermal gold deposits. The Katawaz AOI encompasses 1 of more than 19 geochemical halo zones in the Katawaz Basin area that are anomalous in mercury, tungsten, gold and (or) lead. Studies of Advanced Spaceborne Thermal Emission and Reflection Radiometer (*ASTER*) imagery have identified linear phyllic and argillic alteration zones on Cenozoic sedimentary and volcanic rocks within the AOI. Mapping of the ASTER imagery in the Katawaz gold AOI has specifically identified illite, ferric iron, and clay with local calcite and smectite along a northwest structure that is likely a splay of the Chaman Fault zone. Airborne magnetic data also indicate that small igneous bodies may underlie or be proximal to this altered zone.

Evidence of hydrothermal mineralization occurs along the western margin of the Katawaz Basin to the south of the Katawaz gold AOI where phyllic and argillic alteration zones are spatially associated with Miocene plutons and stocks. In addition, base-metal mineralization is present along the eastern faulted margin of the Katawaz Basin. The presence of geochemical anomalies of mercury and hydrothermal zones in the Katawaz Basin suggests that a mineralizing hydrothermal system may have been active either during or after the development of the basin. Because there are no known mineral deposits within the Katawaz gold AOI and because this is a speculative AOI, the area requires ground visits, field mapping, and sampling to authenticate remotely-sensed indications of mineralization.

DEPOSIT PROFILE 3	
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 2.59–3.89 m thick. Mineralization restricted to hematite-kaolin-quartz and meta-carbonates
Estimated Resources	C1+C2 resources 13600t Cu @ 1.07% Cu; 1.1t Au, @ 0.9 g/t Au; 127.3t Mo @ 0.13% Mo

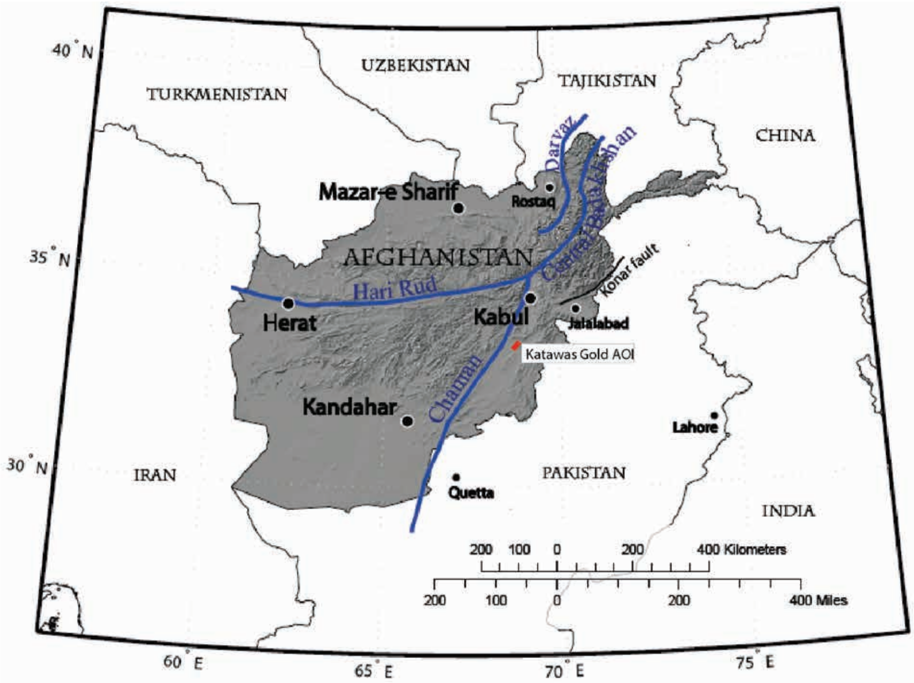


Figure 9. Shaded relief map of Afghanistan showing major earthquake faults from Boyd and others (2007) and proximity of the Katawas gold area of interest to the Chaman Fault.

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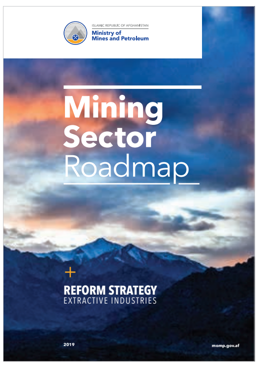

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