



Minerals in Afghanistan



Lead and Zinc in Afghanistan

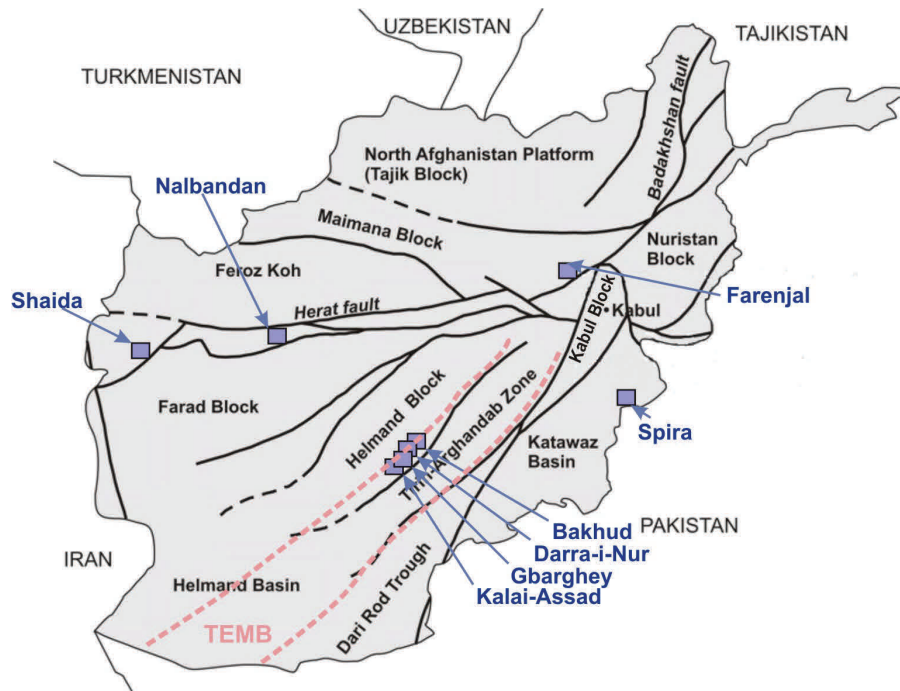


Figure 1. Tectonic sketch map of Afghanistan showing the distribution of Pb-Zn Deposits.

Introduction

Afghanistan is situated on the junction between the Indian and Eurasian crustal plates and is composed of a series of terranes (Figure 1) that broke away from the main Gondwana supercontinent before colliding with and being accreted on to the Eurasian plate. The accretionary events started in the Cretaceous and have continued until recent times. The Herat or Hari Rod fault, which runs E–W across central Afghanistan, marks the boundary between Eurasia to the north and the first of these accretionary terranes, the Farad block, to the south, the intervening Paleo-Tethys ocean having been subducted under the Eurasian continent. The later collision of the Indo-Pakistan continent caused subduction of the Neo-Tethys ocean and formed the Himalayan orogeny, which led to uplift of the Hindu Kush mountain range in Afghanistan.

In Afghanistan eight lead and zinc deposits or advanced prospects have been identified (Figure 1) and more than 90 occurrences and mineral showings located mainly south of the Hindu Kush mountain range. The deposits are situated in Kandahar, Ghor, Paktia and Parwan Provinces.

Metallogenic Framework

The Tethyan orogenic zone, which stretches from Western Europe through Turkey and the Himalayas to Vietnam, marks the former site of the Tethyan Ocean and shows extensive subduction-related igneous activity in the Mesozoic and Cenozoic. The Tethyan orogenic zone is widely mineralised with both copper and gold mineralisation in the centre of the zone and areas of lead-zinc-barium and tin mineralisation on the flanks, typical of subduction-related mineralisation (Coats, 2009). This Tethyan Eurasian Metallogenic Belt (TEMB) extends along the length of the orogen from Europe into South East Asia. Within Afghanistan the TEMB can be recognised from Helmand province in the south extending north-eastwards through Kandahar to near Kabul (Figure 1). An older metallogenic zone (Hari Rod – Panjsher HRPZ) can be recognised in central Afghanistan marking the former site of the Paleo-Tethys Ocean, which closed during the Cimmerian orogeny (Triassic to early Cretaceous). This zone extends from Herat and runs eastwards along the Hari Rod river to the Panjsher valley. In the Soviet literature these two metallic zones were known as the Arghandab-Tirin (part of the TEMB) and the Hari Rod-Panjsher Zones (HRPZ).

Exploration history

Ancient lead mines are known from Farenjal (Ghorband valley) where lead was mined together with small amounts of silver. Other ancient small mining sites are known from other places in southern Afghanistan, mainly Kandahar and Herat Provinces. In nearly all cases lead was mined as galena, which was easy to melt with the available primitive methods.

The first geological description of the **Farenjal** deposit dates from 1838 and primitive mining continued until 1919. In the 1920s some exploration and mining work was done by the Czechs, followed by more detailed investigations carried out by Lemmon (1950a) and Soviet geologists drilled five boreholes between 1961 and 1965 (Khasanov, 1967).

Several lead-zinc deposits can be found about 70-90 km northeast of Kandahar (see Figure 1). These deposits comprise **Kalai-Assad** with the main deposit **Bibi Gauhar**, **Darra-i-Nur** with Yakata Khum and Dike 41, **Gbarghey** copper-lead and **Bakhud** fluorite-lead deposits. Old pits are known at all these places, but shafts and galleries up to 100 m have been mined only at Darra-i-Nur and Dyke 41. The first modern exploration was carried out by Lemmon at Bibi Gauhar, which involved trenching and drilling (Lemmon, 1950b). Some further exploration work was done in 1965-1966 by Soviet geologists and the sites have been visited by German geologists.

Another area with several old lead workings is north of Tulak, Ghor Province, where hundreds of old pits were worked until the 1950s and Nalbandan until 1966. The most important areas are **Nalbandan** and Sia Sang, which were visited several times by the German Geological Mission to Afghanistan in the 1960's and a large exploration programme, involving trenching, drilling, exploration adits and metallurgical testing, was carried out between 1967 and 1969 (Scheer, 1969). At Nalbandan additional sampling and mapping were conducted by the Soviets in 1956-1966. Old mines are also known from Regjoi, Nawad and Gawkush.

In the area of **Spira** several old mines and exploration shafts to 20 m depth were found. In 1972 stream sediment, rock sampling and geophysical work was carried out by Soviet geologists, followed by more detailed exploration in 1973.

All other areas with lead-zinc or polymetallic lead-zinc mineralisation (**Shaida**, Talah, Udmanay etc.) were explored by geochemical stream sediment sampling and mapping by the Afghan-Soviet team in the period between 1963 and 1979. Nearly all lead mineralisation shows traces of ancient mining.

Pb-Zn Mineral Deposit Styles

The following styles of lead-zinc deposits can be recognised in Afghanistan.

1. Carbonate Replacement Deposits (CRD) and Skarns
2. Mississippi Valley Type (MVT)
3. Sedimentary Exhalative deposits (SEDEX)
4. Volcanogenic Massive Sulphide deposits (VMS)
5. Vein-style deposits

The five deposits or major prospects have been identified in Afghanistan: Darra-i-Nur, Kalai Assad, Nalbandan, Spira, Farenjal are described using the above classification. Two further major prospects - Shaida and Bakhud have lead and zinc associated with primary copper and fluorite mineralisation respectively.

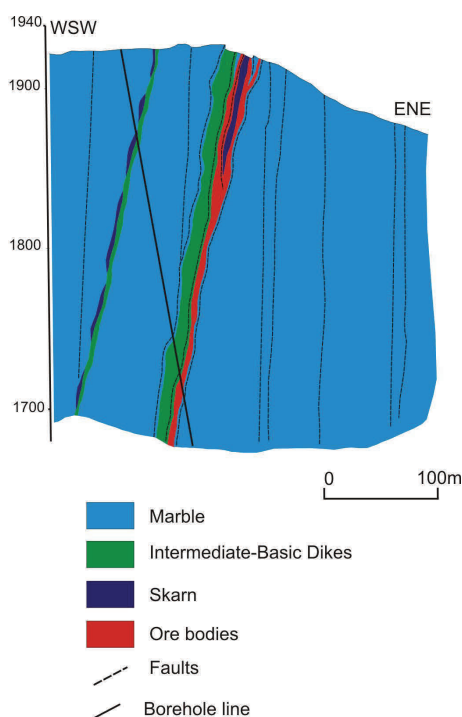


Figure 2. Geological Cross Section of Dyke 41, after Khasanov, (1967).

Carbonate Replacement Deposits (CRD) and Skarns

Darra-i-Nur and Kalai-Assad

The Darra-i-Nur and Kalai-Assad lead-zinc deposits are located in Kandahar Province, Karkhez District and can be classified as skarn or replacement deposits related to contact zones of the Oligocene granitic Arghandab pluton. The Kalai-Assad deposit also known as Bibi Gauhar deposit can be divided in five ore areas (Bibi Gauhar, Central, Southern, Western and Eastern area), the Darra-i-Nur deposit is located about 20 km to the northeast and comprises the deposits/occurrences of Darra-i-Nur, Yakata Khum, Dyke 41 and Dailanar.

The mineralised area is represented by carbonate rocks of Late Triassic and Jurassic ages, strongly metasomatised to skarns (Kalai Assad, Dailanar) or invaded by basic dykes of Oligocene age (Figure 2). The ore bodies in the skarn zone are lens shaped, up to 10 m thick and explored to 100 m depth at Bibi Gauhar (Figure 3). The largest of all dykes (Dyke 41) ranges in thickness from 5.5 to 13 m and is 950 m long. The ore varies from massive ore consisting of sphalerite and galena (Bibi Gauhar) to disseminated sulphides with magnetite and/or copper carbonates. The upper few metres of the ore zones are mainly oxidized and consist of cerussite, smithsonite and hydrozincite. High metal contents were found in Bibi Gauhar: 30.4% Zn, 7.8% Pb (sulphide ore) and 22.2% Zn, 9.5% Pb (oxidized ore) with silver content up to 178 ppm. The highest zinc content 36.49% Zn is reported from Yakata Khum. The metal content of the other areas varies between less than 1 to 5% lead, 0.5 to 21% zinc and up to 1.45% copper.

According to Table 1 the speculative metal reserves for the Kalai Assad – Darra-i-Nur lead-zinc area amount to about 125,000t zinc and 32,000t lead with probable reserves of 13 t silver. Based on a preliminary economic assessment (GTZ-IS/Projekt Consult, 2010)

based on available information the Kalai Assad – Darra-i-Nur lead-zinc area has a Net Present Value (NPV) of about 35 million US\$, using a discount factor of 10% and actual metal prices (July 2010).

Resources/Reserves	Tons	Grade	
		Zn %	Pb %
JORC/CIM			
Bibi Gauhar			
Proven Ore Reserves	26,600	30.4	7.8
Probable Ore Reserves	42,800	30.4	7.8
Indicated Ore Resources	16,800	6.0	Trace
Total	86,200		
Kalai Assad Area			
Speculative Metal Resources (Zn+Pb)	100,000		
Dyke 41			
Speculative Metal Resources (Zn and Pb)	40,000 Zn 10,000 Pb	9.6	2.4
Darra-i-Nur			
Inferred Ore Resources	70,000	7.0	3.0

Table 1. Details of the mineral resources and grades of the Kalai Assad – Darra-i-Nur Pb-Zn mineralisation.

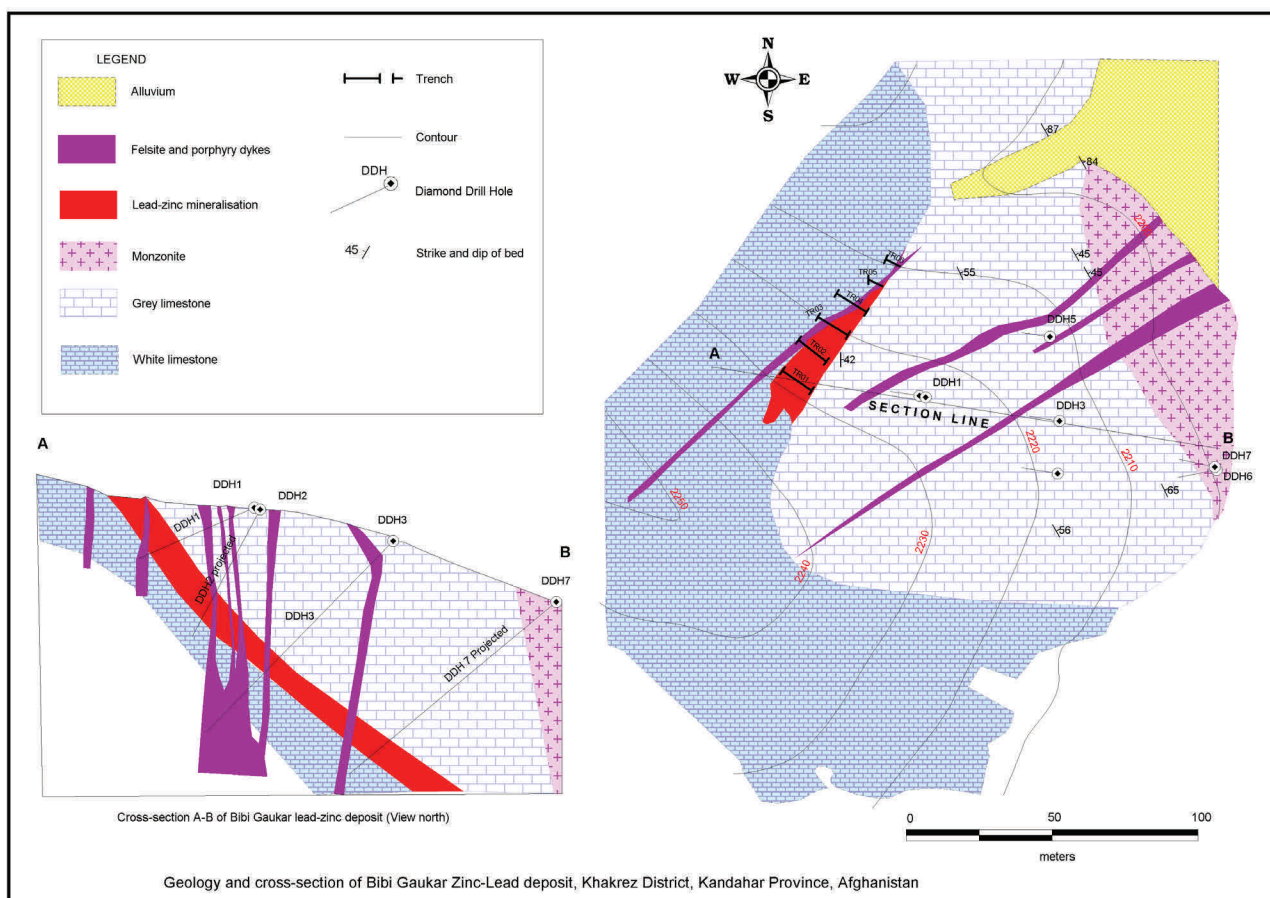


Figure 3. Geological Map and Cross Section of the Bibi Gauhar Pb-Zn Deposit, after Lemmon (1950b)

Mississippi Valley Type (MVT)

Nalbandan and Sia Sang

The Nalbandan stratiform deposit is hosted by Triassic calcareous and clayey siliceous sedimentary rocks. It consists of a 850 m long by 3 to 9 m thick stratiform mineralised zone containing sphalerite, galena, and minor boulangerite with pyrite, chalcopyrite, and pyrrhotite. The Sia Sang lead-zinc mineralisation is connected to sandstone lenses within Lower to Middle Jurassic limestone within a 1,700 m long and up to 7.5 m thick shear zone containing galena and sphalerite, accompanied by chalcopyrite and pyrrhotite (Peters, 2007; Scheer, 1969; Wirtz, 1963).

RESOURCES/RESERVES	Tons	Grade	
		Zn %	Pb %
JORC/CIM			
Nalbandan			
Probable Ore Reserves	105,000	4.4	0.5
Indicated Ore Resources	315,000	4.4	0.5
Inferred Ore Resources	1,300,000	1.3	0.25
Total	1,720,000		
Sia Sang			
Speculative Ore Resources	1,500,000	(3% Pb+ 17%Zn)	

Table 2. Mineral resources and grades of the Nalbandan and Sia Sang Lead-Zinc mineralisation

Based on Table 2 the speculative metal reserves for the Nalbandan - Sia Sang area amount to about 300,000 t Zn and 50,000 t Pb. An economic assessment (GTZ-IS/Projekt Consult, 2010) shows that due to the low ore grade at Nalbandan the profit per ton is very low resulting in a negative NPV. However, the average silver content (210–575 ppm Ag) of the Pb-Zn concentrates could provide additional value.

Bakhud

The Bakhud carbonate-hosted fluorite deposit consists of a number of tabular zones dipping 5° to 20° located at the base of an angular unconformity between Upper Triassic dolomitic limestone and Lower Jurassic clay-marls. There are four discontinuous mineralised zones with 0.66–0.99 % Zn and 0.17–0.34 % Pb and galena contains 100 g/t silver (Abdullah, 1980). Taking into account the calcareous fluorite occurrences which constitute 60 to 70 volume % of the ore and the total fluorite reserves (B+C1+C2 categories) of about 8.8Mt the following inferred metal resources can be calculated: zinc 55,000 t, lead 20,000 t, and silver 2 t.

Sedimentary Exhalative (SEDEX)

Farenjal

The main Farenjal baryte deposit lies in Ordovician brecciated limestone and contains baryte-bearing bodies with lead and zinc disseminated mineralisation over an area that contains 16 fine-grained barite lenses that are 10 to 70 m long and 1 to 9 m wide and grade 84% baryte. The proximal Pb and Zn mineralisation associated with the baryte is 500m x 100m x 10–20m. The occurrence of bedded baryte and proximal Pb-Zn deposits indicates that, at least in part, this is a SEDEX deposit.

RESOURCES/RESERVES	Tons	Grade	
		Zn %	Pb %
JORC/CIM			
Farenjal			
Speculative Metal Reserves	25,000—30,000	10% (Pb + Zn)	

Table 3. Mineral resources and grades of the Farenjal Lead-Zinc mineralisation.

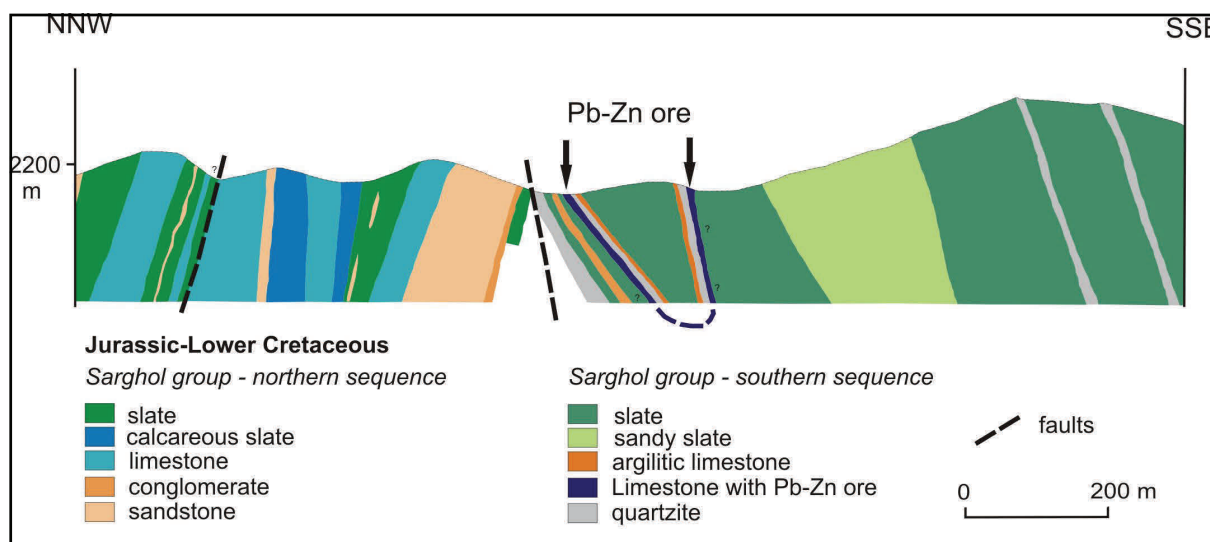


Figure 4. Section through the stratiform Nalbandan lead-zinc deposit, after Scheer (1969).

Vein-type Deposits

Spira

The Spira lead-zinc occurrence is located in the faulted contact between Triassic sandstone, slate, and limestone and Paleocene conglomerate and sandstone; the occurrence is in a 40 to 60 m-wide, brecciated, hydrothermally altered zone (Nikitin, 1973).

RESOURCES/RESERVES	Tons	Grade	
		Zn %	Pb %
JORC/CIM			
Spira			
Speculative Metal Reserves	8,800	3.28	
	3,100		1.12

Table 4. Mineral resources and grades of the Spira Lead-Zinc mineralisation.

VMS deposits

Shaïda

The Shaïda copper deposit has been interpreted to be a simple vein deposits or volcanogenic massive sulfide deposit (VMS). The deposit and nearby occurrences include a number of polymetallic veins and skarn copper deposits. It is unclear whether the mineralisation is associated with a Late Jurassic to Lower Cretaceous quartz porphyry and Jurassic quartz keratophyre volcanic rocks that are intruded by Oligocene granite porphyry forming silicified lenses that contain chalcopyrite and oxide minerals or related to Cretaceous volcanic activity. Based on a resource of 4,800,000 t of ore (probable resources) grading 1.1 % Cu, 1.3 % Zn, 0.08 % Pb, and 0.3 ppm Au (Abdullah, 1980) the metal content is calculated as follows: 50,000 t Cu, 60,000 t Zn, Pb and 14 t Au.

There are other potential areas for VMS deposits and one at Balkhab with Cu and Zn recorded in massive sulphide bodies hosted by Ordovician metamorphic rocks.

Future Potential

A reassessment of non-fuel mineral resources was carried out by Peters (2007) using modern mineral deposit models to estimate undiscovered resources to a depth of 1 km beneath the surface of the Earth.

The largest lead-zinc prospects in Afghanistan are sedimentary, rock-hosted and related both to the southern suture of the TEMB and the northern equivalent, the Hari Rod – Panjsher metallogenic zone (HRPZ).

The TEMB has high potential for CRD and skarn deposits and the exploration model used in Mexico and Peru (Figure 5) should be used to drive modern exploration for further discoveries.

Most of the currently known deposits in Afghanistan are in the skarn zone but in other areas of the world the chimney and manto zones are the most productive, particularly when the high silver content increases their value. Recent economic modelling by GTZ/ Project Consult also indicates that existing known deposits at Kalai Assad – Darra-i-Nur have a current NPV of \$35 million. The prospective tracts have been indicated by Peters (2007) and within these areas detailed geological mapping to discover the extent of favourable carbonate lithologies and alteration haloes. This zone should also be investigated for near surface, supergene-enriched zinc carbonate and oxide deposits, which are known in comparable areas in Iran (Angouran) and China.

The sedimentary rock-hosted, MVT lead-zinc prospects within the KRPZ occur in carbonate rocks of Jurassic – Cretaceous age. Three prospective tracts were delineated by (Peters, 2007) that are permissive for sediment-hosted lead-zinc deposits. The most promising area is within tract along the KRPZ (Herat fault) in the central parts of Ghowr Province (Nalbandan area). Newer models of basin dewatering, the importance of faulting to provide channels for the evolving hydrothermal fluids and the lithological and structural traps controlling the deposition of the base metal sulphides, are important guides to the discovery of new deposits. MVT deposits may be transitional into SEDEX deposits, such as Farenjal, if the fracture channel reaches the surface and the fluids do not react with carbonate rocks at lower levels. An origin for the deposits by escape of basinal fluids from basins of Triassic and Jurassic age south of the suture and their expulsion during collision with the Eurasian continent and closure of Paleo-Tethys ocean.

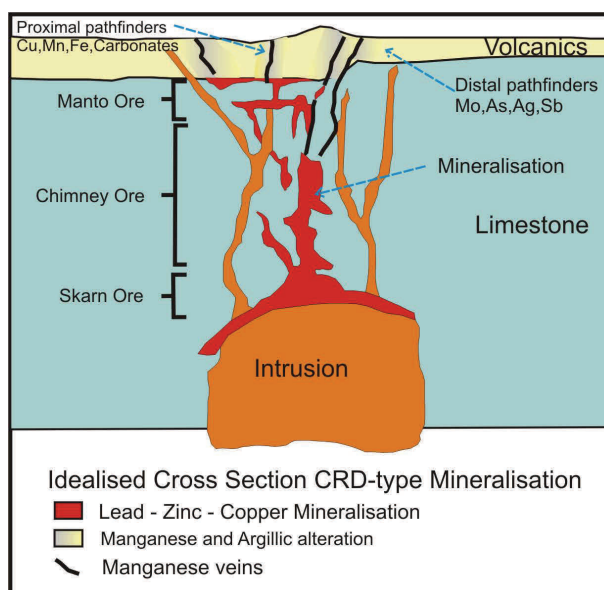


Figure 5. Mineral deposit model for Carbonate- Replacement CRD and Skarn Deposits

Some SEDEX deposits and occurrences are closely associated with large accumulations of bedded barite, such as Farenjal, that may be of additional economic importance. Detailed knowledge of the local geology and the importance of growth faults in the formation of the brine pools, where such deposits are formed, are key to the discovery of new orebodies. Geochemical exploration can also locate these deposits because of their stratabound nature and long strike length.

Economic VMS deposits can be difficult to locate because there is often a large number of small satellite bodies but because of the massive, pyritic nature of the ore they respond well to geophysical methods, such as EM.

The carbonate-hosted lead-zinc and barite occurrences present in several Phanerozoic stratigraphic units have been interpreted as been remobilized from lower levels, and redeposited in upper sequences within veins, shear and stratabound zones (Peters, 2007). It is possible but not described so far that these types of deposits and occurrences may also be present within Proterozoic sedimentary and volcano-sedimentary sequences of Afghanistan. However, the missing link between the TEMB in central / southern / western Afghanistan and the continuation of the TEMB in the north / northeast of Afghanistan and the high metamorphic grade of the wall rocks generally indicate that the erosion levels are deeper than the level at which most magmatic-hydrothermal deposits are formed (Peters, 2007; Coats, 2009).

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Summary of the potential for Lead and Zinc in Afghanistan

- High potential for CRD and skarn deposits in the TEMB area
- Potential for MVT and SEDEX deposits in the Hari Rod-Panjsher zone
- Potential for Zn carbonate and oxide deposits in supergene zones above these prospects