Summary
Preliminary Non-Fuel Mineral Resource Assessment of Afghanistan, 2007

Introduction

The U.S. Geological Survey (USGS) cooperated with the Afghanistan Geological Survey (AGS) of the Afghanistan Ministry of Mines to assess the undiscovered non-fuel mineral resources of Afghanistan between 2006 and 2007. This report presents the results of this work and contains chapters describing and assessing the mineral resources of Afghanistan. An accompanying Geographical Information System (GIS) is an accompanying disk that includes supporting data. Funding for this effort was provided by the United States Agency for International Development (USAID).

Mineral resources are materials that are in such form that economic extraction of a commodity is currently or potentially feasible. The assessment estimates or evaluates the likelihood for the presence of undiscovered mineral resources within specific volumes of rock. Previously discovered deposits also are noted. This assessment of non-fuel mineral resources is quantified, where possible, in that the results are expressed in numbers. Because of the uncertainty inherent in assessment of the unknown, the results are presented probabilistically. This summary presents mean expected values (table 1, fig. 1).

Mineral resource assessments provide government decision makers and potential private investors and explorationists with information on where undiscovered mineral resources may be located, what kinds of resources are likely to occur, and how much metal may exist in them. This information makes possible wise management of natural resources.

Afghanistan has abundant mineral resources, but they were not successfully developed during the 20th century. Nor have they been systematically studied using modern mineral-resource assessment methodologies. Most of the existing mineral-resource information and estimation of known resources was produced between the early 1950s and about 1985, when the Union of Soviet Socialist Republics (USSR) and its Eastern European allies provided Afghanistan with technical assistance. These data and information form much of the factual basis for this preliminary non-fuel mineral resource assessment. A wide variety of non-fuel mineral resources are known, including important deposits of copper, iron, chromium, silver, barite, sulfur, talc, magnesium, salt, mica, marble, ruby, emerald, and lapis lazuli. By 1985, Soviet surveys had also delineated potentially exploitable deposits of asbestos, nickel, mercury, gold, lead, zinc, fluorspar, bauxite, beryllium, and lithium.

The assessments for mineral deposits in this report are for deposits of non-fuel minerals classified and presented according to the 3-part USGS quantitative mineral assessment method that utilizes mineral deposit models. Estimates of undiscovered resources are made to a depth of 1 km beneath the surface of the Earth. If an area of permissive rock is covered by more than 1 km of rock known to be barren or younger than the mineralizing event under consideration, it is excluded from the tract (table 1).

Resource Summary

This preliminary assessment of non-fuel mineral resources addresses both the known and estimated metallic and non-metallic (industrial mineral) resources of Afghanistan on the basis of available data. The resources are summarized on table 1 and described below. Known resources are portrayed on figure 1. This preliminary assessment resulted in the identification of 20 promising mineralized areas where future development of mineral resources is likely to occur (figs. 1 and 2).

Metals

Copper (Cu) is present in a number of areas both in sedimentary and associated with porphyritic igneous rocks. The known sediment-hosted copper deposits are the Aynak, Darband, Jawkhar and Taghar deposits that contain resources of 12.3 million metric tons Cu. We predict the likely occurrence of several more undiscovered sediment-hosted copper deposits similar to the Aynak deposit in the Kabul and Logar Basin areas containing about 16.9 million metric tons Cu, 7,670 metric tons silver (Ag), and 601,500 metric tons cobalt (Co). The total amount of 29.4 million metric tons Cu from sedimentary rocks would make copper the most substantial non-ferrous metal resource in Afghanistan. Igneous rocks typical of geologic provinces containing porphyry copper deposits also are common in Afghanistan. Relatively little is known about the specific characteristics of the porphyry copper-like prospects in Afghanistan and there are no known deposits. Estimated resources in several prospects in the Herat, Kandahar, and Zabul Provinces are about 68,500 metric tons Cu with auxiliary amounts of gold (Au), lead (Pb), and zinc (Zn). We therefore assessed this deposit type using the general porphyry copper deposit model in 12 separate areas, which resulted in at least 8 estimated undiscovered porphyry copper deposits containing a mean of 28.5 million metric tons copper, 724,010 metric tons molybdenum (Mo), 682 metric tons Au, and 9,067 metric tons Ag. In some cases, these areas also are permissive for gold-bearing copper skarn and vein deposits, but no estimates of numbers of undiscovered deposits were made, because further study is needed (table 1-1).

Iron (Fe) deposits and occurrences are present associated with both sedimentary and igneous rocks. Sedimentary iron deposits present in central parts of Afghanistan are abundant, and the Haji Gak iron deposit (approx. 2 billion metric tons at 63 to 69 weight (wt.) percent Fe) is of world-class size and is sufficient to support a major mining operation. Known iron resources are present in a number of additional sedimentary deposits totaling 2.26 million metric tons of iron ore with greater than 62 wt. percent Fe. Additional discoveries are likely. A number of skarn or igneous-related deposits are present in Badakhshan, Farah, and Kandahar Provinces, the biggest of which is the Furmorah deposit that contains speculative resources of 35 million metric tons of ore having 47 to 68 wt. percent Fe with potential byproduct sulfur (S), phosphorous (P), nickel (Ni), and manganese (Mn). All igneous-related deposits are known to contain 178 million metric tons of ore at between 47 and 68 wt. percent Fe; additional discoveries are likely.

Gold (Au) is present both in hard rock lode deposits and in alluvial or placer deposits. A number of gold-bearing quartz vein and skarn occurrences are present in Badakshan and adjacent Provinces. Additional gold-bearing veins and skarns in West Zabul and Western Ghazni Provinces are possibly related to Cretaceous porphyry copper deposits, which together have a measured resource of 1,780 kg of gold. Placer gold deposits are present in northern Takhar Province and in Ghazni Province and together have a measured resource of 918 kg. Additional discoveries are probable, and these gold-bearing occurrences could provide a source of local industry and employment from small- to medium-scale mining.

Lead (Pb) and zinc (Zn) deposits are present in sedimentary and igneous rocks. There are a number of carbonate sedimentary rock-hosted, vein-style deposits in central Afghanistan, such as Nalbandon in Ghor Province and Spira in Paktia Province that both lay along a major structural zone in the central part of the country. These deposits have previously been estimated to contain 153,900 metric tons of combined lead and zinc, but understanding their size and genesis requires further study. These Pb-Zn-Ba-(± Cu, Ag) deposits are of interest due to their potential to support local mining activity. Igneous-related lead-zinc skarns are common throughout areas identified to be permissive for porphyry copper deposits. The largest are the Darra-i-Nur and Kalai-Assad occurences in Kandahar Province that together contain about 90,000 metric tons of combined Pb and Zn.

Tin (Sn) and tungsten (W) occurrences are abundant in Afghanistan and the Tourmaline area in western Afghanistan was identified in this study as having potentially important tin deposits. The size and style of these deposits need further study.

Mercury (Hg) deposits are present along a 400–km-long by 30–km-wide permissive area in southwestern Afghanistan; this zone contains a number of hot-spring mercury occurrences with similar geologic characteristics. Known occurrences in this area may contain a mean expected value of 32,000 metric tons of undiscovered Hg, large enough to support a local mercury industry. There are likely numerous undiscovered deposits. Two other areas in west central and eastern Afghanistan also contain anomalous mercury zones. All the areas containing mercury might also contain silver and gold deposits.

Bauxite aluminum (Al). Bauxite, the main source of aluminum, occurs in karst and laterite deposits at Obato-Shela, Zabul Province and Nalag (Tala), Baghlan Province and together contain 4.5 million metric tons bauxite ore grading 50.5 wt. percent alumina and about 12 wt. percent silica. Although the laterite deposits in Baghlan Province are the largest, their overall small size relative to deposits elsewhere, high silica content, and the need for large amounts of electricity to produce aluminum make bauxite mining unlikely in the near term.

Industrial Minerals

Asbestos is present in the Loghar and Khost Provinces in the same rocks that contain chromite; estimations for undiscovered deposits made by the USGS-AGS Assessment Team in these two locations give a mean of 13.4 million metric tons of undiscovered asbestos, which may be sufficient quantity to support a local industry.

Barite ($BaSO_4$) is present in a number of layered deposits in central Afghanistan, many of which are spatially related to lead and zinc deposits. The largest known occurrence is the Farenjal Barite deposit in Parvan Province that contains 150 million metric tons of barite. Barite is also present proximal to some iron deposits. The quantity of barite is probably sufficient to be used in local industry and in the exploitation of oil and gas.

Borate ($HRBO_3$, where R= Mg, Mn, or Zn) may be present in some young evaporate deposits, and additional study of these environments in Afghanistan is recommended.

Celestite ($SrSO_4$) deposits, similar to those in Pakistan and Iran occur in Afghanistan in Baghlan and Kunduz Provinces. Together they have a speculative resource of 1 million metric tons ore at about 75 vol. percent celestite. Targeted exploration would probably reveal additional deposits.

Chromite ($FeCr_2O_4$) is present in Logar and Khost Provinces, and calculated resources, mainly in the Logar Valley, are approximately 200,000 metric tons at about 43 wt. percent chromium oxide. Like other ophiolite complexes worldwide, these areas are typified by many small podiform chromite deposits. Estimation of undiscovered resources in two areas resulted in a mean expected value of an additional 980,000 metric tons of chromium oxide. The total resources of these deposits might be sufficient to support small-scale industries.

Clays are present in Afghanistan in abundant deposits adequate for local construction. Known resources of kaolin occur in residual and sedimentary deposits mainly in Baghlan Province and these two types total about 535,000 metric tons of clay. Many clay deposits are also associated with coal, but little information is available about the composition of the clays. About 2.2 million m^3 of brick clay is present at the Deh Kepak deposit in Kabul Province. Further investigation into the type and composition of the clays is necessary to determine specialized uses.

Fluorite (CaF_2) is present as sedimentary rock-hosted occurrences at Bakhud, Uruzgan Province. Resources are 8.8 million metric tons of ore averaging 47 vol. percent fluorite. Additional occurrences in the same region suggest the potential for economic deposits sufficient for local consumption.

Gemstones. Before the 1979 Soviet intervention, precious and semiprecious stones were a major industry in Afghanistan, which has been one of the world's premier sources of lapis lazuli; emeralds and rubies were also major products. During the civil war, production of these stones declined. Most of the gemstones come from northeast Afghanistan (Badakshan, Konar, and Nuristan Provinces). These include emerald deposits of the Panjsher Valley, ruby, sapphire and spinel occurrences in the Jegdalek area and Balal (Ab-i-Panja), and lapis lazuli occurrences at Sary-Sang on the Kokoschka River in Badakhshan Province. In addition, gemstones are present in many of the numerous pegmatite deposits and include garnet, kunzite, ruby, and tourmaline. Occurrences of peridot are also known along the Afghanistan-Pakistan border. Many areas contain sufficient amounts of colored stones and gemstones to commercially support local industries. Much of the material would be exported.

Graphite is present in a number of occurrences in Archean metamorphic rocks in Badakhshan Province and south of Kabul as disseminated flake graphite. While the known resources are small (5,000 metric tons graphite), additional deposits may be located in those areas, and an expected mean value of 1 million metric tons of undiscovered flake graphite is estimated. Disseminated flake graphite could be used locally in handling molten metals and as lubricants.

Gypsum ($CaSO_4.2H_20$) is present in abundance and is widely dispersed. There are sufficient quantities for local industries that might develop around it, such as uses for cement, wallboard, and soil enhancement.

Halite (NaCl) is present in a number of locations in Afghanistan, and there is enough salt to support a local industry and the country's current internal needs.

Pegmatites in Afghanistan have a measured resource of about 3.8 million metric tons of lithium oxide. Abundant pegmatite fields, principally in northeast Afghanistan, contain a variety of mineral commodities, including lithium, beryllium, quartz, feldspars, micas, gemstones, tantalum, niobium, and cesium. These could be used for local glass, chemical, or artisanal industries.

Potash (KCl), an important fertilizer mineral, may be present in the evaporate deposits spatially associated with petroleum resources in northern Afghanistan. The USGS-AGS Assessment Team estimated a mean expected value of undiscovered potash of 27.5 million metric tons.

Rare-earth elements (REE) and uranium (U) are present in a poorly explored carbonatite volcano at Khanneshin in southern Afghanistan. Magmatic systems with similar characteristics in other parts of the world can contain important quantities of barite, fluorite, nepheline, rare-earth elements, niobium, tantalum, and/or uranium. Other volcanic centers like Khanneshin may exist and quantitative estimation for undiscovered resources, conducted on a partial list of elements, produced a mean expected value of 1.4 million metric tons REE and 3.5 million metric tons Nb with additional P, U and Th (table 1-1).

Sulfur (S) is present in a number of different types of deposits. Previous resource calculations for two deposits in Bakhud and Badakhshan Provinces gave 450,000 metric tons sulfur. Probabilistic estimates of significant bedded sulfur deposits in rocks of the Afghan-Tajik Basin give a mean of 6 million metric tons of undiscovered sulfur. These deposits formed from microbial breakdown of organic fuel deposits.

Talc and magnesite deposits in Afghanistan are of two types. The smaller ultramafic talc-magnesite deposits are present in the Logar Valley and in Khost Provinces; the larger talc and magnesite deposits associated with metamorphic rocks are the major source of talc in the world. Metamorphic talc is present at the Achin deposit south of Jalalabad, which is the largest deposit of this type in Afghanistan. It has a measured resource of 1.25 million metric tons of talc and 31,200 metric tons magnesite. It is likely that additional deposits might be located in the same type of rocks nearby.

Building Materials

Building and dimension stone. The mountains of Afghanistan contain abundant rocks suitable for use as building and decorative stone. Like most industrial mineral commodities, quality and location are critically important in determining suitability for large-scale development. Granite, marble, limestone, travertine (aragonite), and sandstone occur in abundance. The possibilities of a major dimension stone industry for some or all of these commodities exist if economic and expertise factors can be overcome. Limestone deposits suitable for cement production are widespread in Afghanistan, and deposits suitable for exploitation are identified Badakshan, Baghlan, and Herat Provinces.

Sand and gravel. Afghanistan has abundant sand and gravel resources and equally abundant sources of rock for crushed stone and aggregate. However, the quality of these resources is unknown. Many deposits may not be accessible due to isolation, presence of cities, and/or lack of infrastructure. Impurities and other characteristics affecting quality may exclude or limit many applications. Sand and gravel and aggregate material adequate for local industry are present adjacent to most existing population centers.

Table 1. Summary of known resources and estimated undiscovered resources for selected commodities in Afghanistan identified by the U.S. Geological Survey-Afghanistan Geological Survey Joint Mineral Resource Assessment Team.

Commodity	Province(s)	Deposit Type	Known Resource Estimates from Abdullah and others (1977)	USGS-AGS assessment of undiscovered deposits (mean expected values) (metric tonnes)
METALS				
Aluminum	Zabul, Baghlan	bauxite	4,535,000 metric tons at 50.5 wt. % alumina and 12 wt. % (silica)	Further study recommended
Copper	Kabul, Logar	sediment-hosted copper	12.340,600 metric tons	16,880,000 metric tons
	Kandahar, Zabul, Herat	igneous-related copper	68,500 metric tons (copper)	28,469,200 metric tons, 724,010 metric tons (molybdenum), 682 metric tons (gold), 9,067 metric tons (silver)
Iron	Bamyan, Baghlan	sediment-hosted iron	2,261,200,000 metric tons > 62 wt. %	Further study recommended
	Badakhshan, Kandahar	igneous-related iron	178,000,000 t at between 47 and 68 wt. %	Further study recommended
Lead and Zinc	Kandahar, Herat, Paktia	igneous-related lead and zinc	90,000 metric tons (combined)	Further study recommended
	Ghor	sediment-hosted lead and zinc	153,900 metric tons (combined) lead and zinc	Further study recommended
Tin and Tungsten	Herat, Farah, Uruzgan	Sn veins, Sn and W skarns and greisen	No previous estimates	Further study recommended
Mercury	Farah, Ghor	hot-spring mercury	May contain gold and silver	32,234 metric tons
Gold	Takhar, Ghazni	Placer gold	918 kg	Further study recommended
	Badakhshan, Ghazni, Zabul	lode gold	Approx. 1,780 kg	Further study recommended
INDUSTRIAL MINERALS				
Barite	Parvan, Herat	bedded and vein barite	151,500,000 metric tons	Further study recommended
Brick clay	Kabul	clay	2,200,000 m^3	Further study recommended
Kaolin	Baghlan	residual kaolin	100,000 to 150,000 metric tons	Further study recommended
	Baghlan	sedimentary kaolin	385,000 metric tons	Further study recommended
Celestite	Baghlan, Kunduz	celestite	>1,000,000 metric tons at 75 wt. %	Further study recommended
Chromite	Logar, Paktia	chromium oxide	aprox 200,000 metric tons at about 43 wt. %	979,484 metric tons
Halite	North Afghanistan	evaporite	No previous estimate	Further study recommended
Potash	Balkh, Samangan, Kunduz	evaporite	No previous estimate	27,513,690 metric tons
Fluorite	Uruzgan	fluorspar	8,791,000 metric tons ore averaging 46.69 wt. %	Further study recommended
Rare earth elements	Helmand	carbonatite	No previous estimates	1,405,179 metric tons REE, 3,480,159 metric tons (niobium, phosphorous, uranium, and thorium)
Sulfur	Balkh, Badakhshan	Bedded and fumarolic	450,000 metric tons S	6,000,000 metric tons r
Graphite	Badakhshan	Disseminated flake graphite	5,000 metric tons	1,050,223 metric tons (flake graphite)

Lazurite	Badakhshan	skarn lazurite	1,300 metric tons	Further study recommended
Talc, asbestos, and magnesite	Nangarhar	metasomatic/metamorphic replacement magnesite	1,250,000 metric tons (talc) with 31,200 metric tons (magnesite)	Further study recommended
	Nangarhar	ultramafic-hosted talc-magnesite	50,000 metric tons (mined previously)	13,365,563 metric tons asbestos

BUILDING MATERIAL

Marble	various	building stone	1.3 billion metric tons (coarsely crystalline marble)	Further study recommended
Sand and Gravel	Badakhshan	aggregate	136,000,000 m^3	Further study recommended
Sandstone	Bamyan	building stone	650,000 metric tons (siliceous sandstone)	Further study recommended
Limestone	Bamyan	building stone	3,500,000 metric tons	Further study recommended
	Badakshan, Herat, and Baghlan	cement and flux	>500,000,000 metric tons	Further study recommended
Dolomite	Bamyan	building stone	1,040,000 metric tons	Further study recommended
Aragonite	Helmand	dimension stone	770,000 metric tons	Further study recommended
Glass Sand	Balkh	sand	110,000 metric tons siliceous sand and 10,900,000 metric tons sandstone	Further study recommended

Further information

Supporting geologic studies of mineralized systems and assessment areas, and reports on the methodology used in this study are in progress. Assessment results are available at the USGS Afghanistan website (http://afghanistan.cr.usgs.gov/) and at the Afghanistan Geological Survey website (http://www.bgs.ac.uk/afghanminerals/).

U.S. Geological Survey-Afghanistan Geological Survey Joint Mineral Resource Assessment Team

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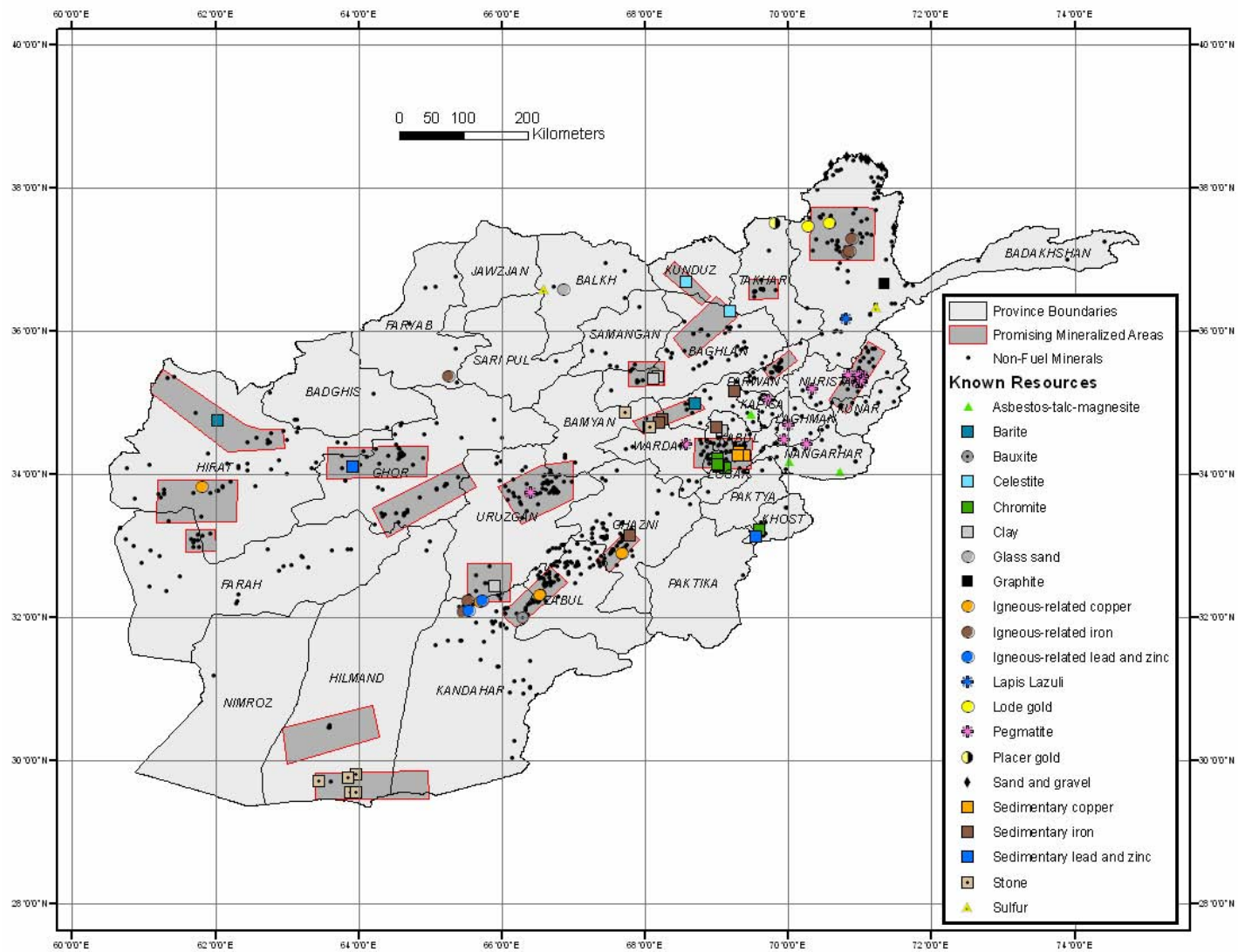

Figure 1. Map of Afghanistan showing location of known mineral occurrence (small dots) and 20 prioritized areas identified by the U.S. Geological-Afghanistan Geological Survey Joint Mineral Resource Assessment Team as having promise for economic occurrences of different mineral types (large symbols) See figure 1-2. Main commodities are copper, iron, lead and zinc, mercury, rare-earth elements, uranium, chromite, and gold. Industrial minerals are numerous and include asbestos, barite, celestite, clay, pegmatites minerals and elements, potash, sulfur, talc and magnesite, as well as building materials, such as dimension and decorative stone, glass sands, limestone for cement, and sand and gravel.

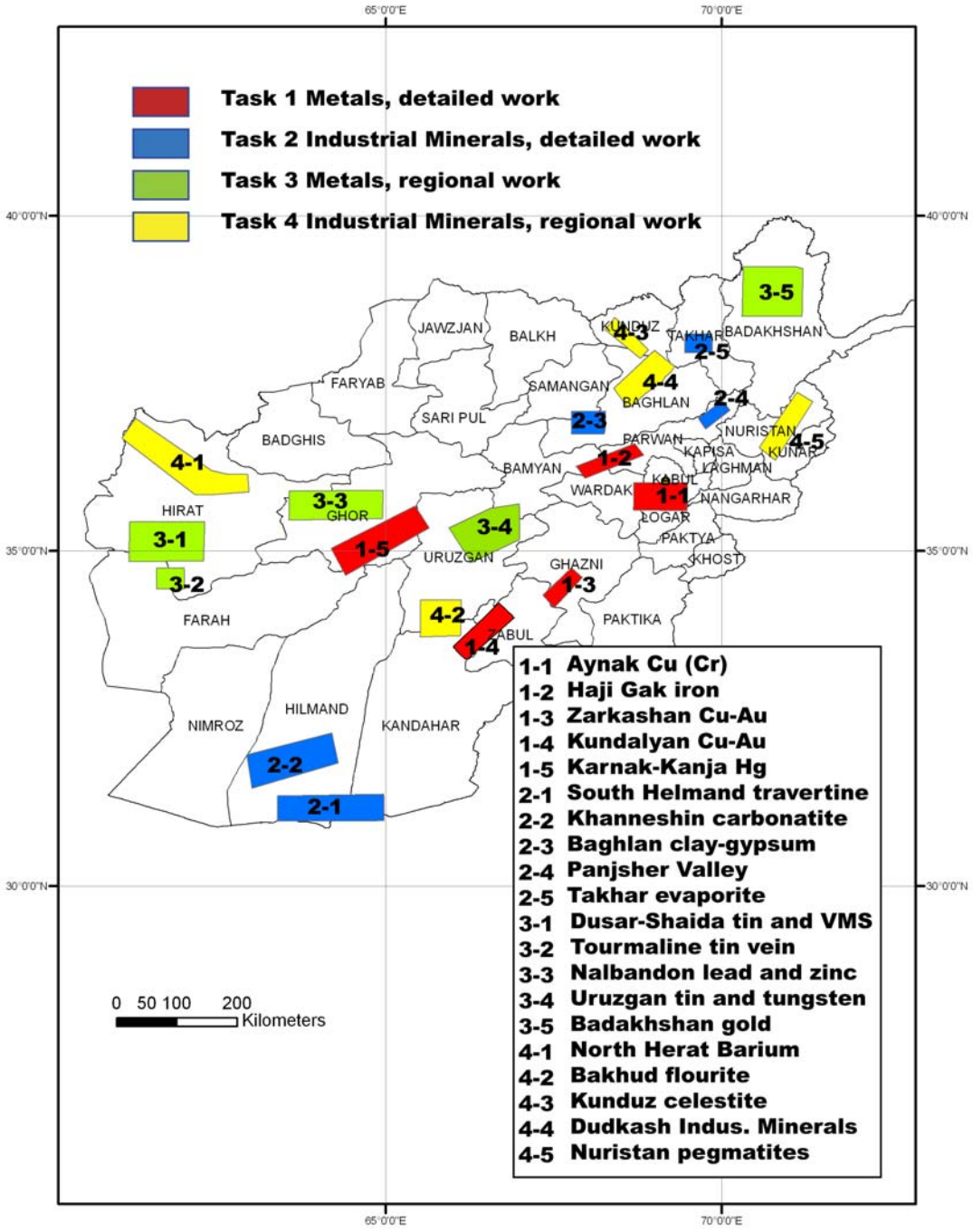

Figure 2. Map showing location and names of promising mineralized areas resulting for analysis of the preliminary assessment of non-fuel mineral resources in Afghanistan. These areas have been prioritized by task and recommended for detailed examination in Phase II. This detailed work would be designed to bring these areas to advanced development that could lead to exploitation.