Chapter 3A. Summary of the Badakshan Gold Area of Interest

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Abstract

This chapter summarizes mineral resource studies of the Badakshan gold area of interest (AOI) and its subareas resulting from joint geologic and compilation activities conducted between 2009 and 2011 by the U.S. Geological Survey, the Task Force for Business and Stability Operations of the Department of Defense, and the Afghanistan Geological Survey. Accompanying complementary chapters 3B and 3C address hyperspectral data and geohydrologic assessments, respectively, of the Badakshan gold AOI. In addition, supporting data for this chapter are available from the Afghanistan Geological Survey Data Center, Kabul, Afghanistan.

The Badakshan gold AOI is best known for its gold deposits and gold prospects, including the Weka Dur gold deposit, one of the largest gold-quartz vein deposits in Afghanistan. Several types of gold deposit types are present in the Badakshan gold AOI, as well as iron skarn and lithium pegmatite prospects. Gold occurrences are present outside the Weka Dur area in the southwestern and southeastern Badakshan gold AOI in the Baharak and Fayzabad subareas, particularly at the Furmorah gold and Nakhchir-Par gold prospects; however, these occurrences are similar to pluton-related gold deposits rather than the regional orogenic-gold deposits represented by the Weka Dur gold deposit. The Badakshan gold AOI also contains some medium- to large-sized iron skarns and a REE-Li pegmatite prospect at Taluzanak. Speculative iron ore reserves in the Furmorah area are as much as 80 million metric tons of ore containing 50 to 68 weight percent iron.

The Badakshan gold AOI, particularly in the Ragh subarea contains deposits that can be exploited with simple metallurgy. A number of the gold-quartz veins may be of sufficient size and tenor to allow support of a local gold mining industry. Extensive modern exploration for gold has not taken place in the area since the 1960s when the gold price was lower than the time of this study (2011). Significant advances have taken place in the exploration and mining industry for gold exploration, mining, extraction, and metallurgy. Additional discoveries of small- to medium-sized deposits are likely in the Badakshan gold AOI. For instance, the geometry of the known gold orebody at Weka Dur is conducive to open pit mining. This would result in a short lead time, and a short payback period for a medium-sized mine with significant future potential. Much of the gold placer and gold lodes at the surface in the Badakshan gold AOI are amenable to artisanal exploitation. The entire AOI area requires additional compilation and analysis.

3A.1 Introduction

The Badakshan gold area of interest (AOI) is in northeast Afghanistan in Badakshan Province. There are three subareas within the main AOI. The entire Badakshan gold AOI is 6,501.42 square kilometers (km^2). The northwestern Badakshan-Ragh subarea is 707 km^2, the southwestern Badakshan-Fayzabad subarea is 1,272 km^2, and the southeastern Badakshan-Baharak subarea is 1,341 km^2 (fig. 3A–1). Deposit types known in the Badakshan gold AOI are metamorphic gold vein (greenstone-hosted gold vein, low-sulfide gold-quartz vein), orogenic vein, gold-copper skarn, iron skarn, and polymetallic vein.

An inventory of individual datasets compiled for the Badakshan gold AOI and its subareas are part of a data information package for each AOI in the data center of the Afghanistan Geological Survey, Kabul. Most existing mineral-resource information has been gathered from reports written between the early 1950s and about 1985 by geologists from the Union of Soviet Socialist Republics and its Eastern European allies who provided Afghanistan with technical assistance. This information, combined with a preliminary assessment report by the U.S. Geological Survey (Peters and others, 2007), and new hyperspectral and data compilations provided much of the factual basis for analysis of work during 2009 through 2011. The Badakshan gold AOI and its subareas could potentially support mineral production in the near term. In addition, some deposits in the Badakshan gold AOI are near-surface bodies with promising metallurgical and mining characteristics (fig. 3A–2).

3A.2 Previous Work

The high mountainous region of Badakshan Province has been known for gold in its streams, and it is likely that alluvial placer gold mining has been taking place there for a long time. Early geologic investigations of the geology of the region are reported by Brueckl (1935), Desio and others (1964, 1965, 1969, 1975), and Bordet and Boutiere (1968, 1969). Most academic geologic work has been done by French and Italian workers, whereas both regional geologic and mineral evaluation work was conducted by Soviet and Afghanistan geologists. Geologic investigations in the 1970s were conducted by Akhipov and others (1970a, b), and Pasquare (1975a–d), and Kafarskiy and Abdullah (1976). Geologic investigations of the nature and timing of igneous events in Badakshan Province were reported by Makstenek and others (1971), Pasquare (1975b), Forcella (1975), and Debon and others (1983). Specific studies of Permian rocks were reported by de Lapparent and others (1972), and Neogene rocks by Achilov (1985). Faryad (1999) has reported on more recent geologic investigations of the general geology of the region.

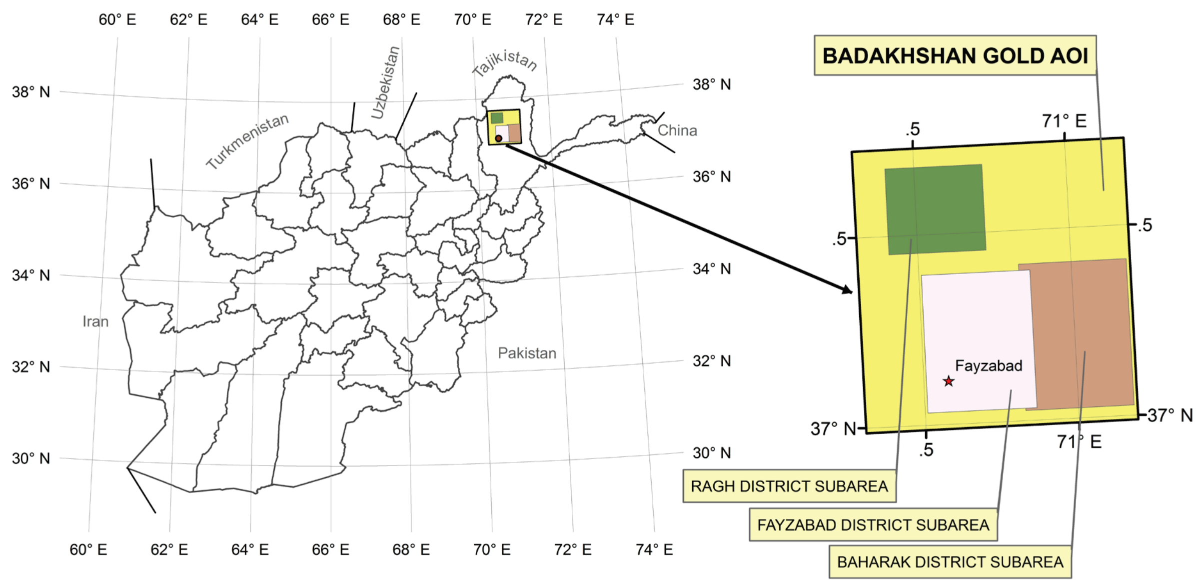

Figure 3A–1. Location of the Badakshan area of interest and the Ragh, Baharak, and Fayzabad subareas.

Geologic reports and studies specifically dealing with the economic geology of the gold resources in the Badakshan Province began with Bothman (1953), followed by Nazarov (1965) and Gugenev and others (1967). Additional investigations of the gold areas continued as part of regional geologic investigations by Semionov and others (1967), Denikaev and others (1971, 1973), Kafarskiy and others (1973), and Sborshchikov and others (1974).

The mineral resources in the Badakshan Province and Badakshan gold AOI were compiled by the United Nations Economic and Social Commission for Asia and the Pacific (1995), Abdullah and others (1977), Metal Mining Agency of Japan (1998), Orris and Bliss (2002), and Doebrich and others (2006). Peters and others (2007) discussed the different types of gold deposits that were likely to be present in the Badakshan gold AOI area as did the U.S. Department of Defense Task Force for Business and Stability Operations (2010).

The Afghanistan Geological Survey conducted reconnaissance mapping as well as site-specific geochemical sampling and trenching at several locations in 2009 and 2010 in the southern areas of the Baharak gold-iron subarea and the Fayzabad gold subarea (figs. 3A–1 and 3A–3). The Ragh gold district subarea, containing the Weka Dur gold deposit and other gold-vein deposits in the north were not visited.

3A.3 Metallogeny

The Central Badakshan Metallogenetic Zone was defined by Soviet workers (Abdullah and others, 1977) and traverses the Badakshan gold AOI. The zone is described as containing various lithostratigraphic and tectono-thermal complexes that crop out in fault blocks, thrust sheets, and nappes. The host rocks to the mineral occurrences and deposits are Proterozoic metamorphic rocks, Paleozoic cratonic rocks, and Mesozoic marine rocks. Intrusive rocks are common in the zone. Oligocene granites are present as multiphase stock-like bodies and also as a large intrazonal batholith. Mineralization in the Central Badakshan Metallogenetic Zone consists of skarn deposits and occurrences of iron and hydrothermal occurrences of gold, copper, and tungsten. The zone includes the Furmorah (iron-gold) district. It is possible that the gold-quartz veins in the Proterozoic rocks are associated with a tectono-thermal event in the Permian that is associated temporally with volcanism and tectonism during that period.

The Badakshan gold AOI is a major gold area in Afghanistan (Abdullah and others, 1977; Peters and others, 2007). Throughout Afghanistan, gold commonly is found within or near Triassic and Oligocene plutons (fig. 3A–3). The Triassic and Oligocene pluton-related and metamorphic-hosted gold veins are most likely to be present in Badakshan gold AOI. In Badakshan Province, gold also is present in areas of Precambrian high-grade metamorphic rocks (fig. 3A–4) and is also spatially associated with Permian volcanic rocks in the western part of Badakshan Province. Additionally, gold may also be present in epithermal deposits in Afghanistan (Peters and others (2007).

In regionally metamorphosed Proterozoic rocks in the western parts of the Badakshan gold AOI, gold is present in low-sulfide gold-quartz veins, or orogenic gold deposits, which form clusters in the northern part of the country in the Ragh subarea (figs. 3A–1, 4 and 5) where discoveries of additional gold vein deposits are likely. A number of these gold-quartz veins may be of sufficient size and tenor to allow support of medium- to large-sized gold mining industry (see also Bothman, 1953; Abdullah and others, 1977). Orogenic gold-quartz veins also contain coarse-grained gold and commonly generate secondary alluvial placer gold deposits.

Permissive tracts for undiscovered gold-quartz vein deposits were delineated by Peters and others (2007) on the basis of the distribution of known deposits and the stratigraphic units that host them (figs. 3A–4 and 3A–5). Most gold-quartz veins in the Proterozoic rocks are present within a northeastern zone of Late Hercynian folding (fig. 3A–5*b*), which is likely based on the genetic aspects of the deposit model (Goldfarb and others 2005; Goldfarb, 2010), that most of these occurrences are due to orogenic processes. Those gold occurrences in the Badakshan gold AOI that are adjacent to or outside the Late Hercynian folding zone most likely are related to plutonic or volcanic processes (fig. 3A–5*b*), such as the deposits in the Fayzabad subarea and the southeastern Badakshan-Baharak subarea, which are contained in areas of Cimmerian (Jurassic) folding (fig. 3A–5*b*).

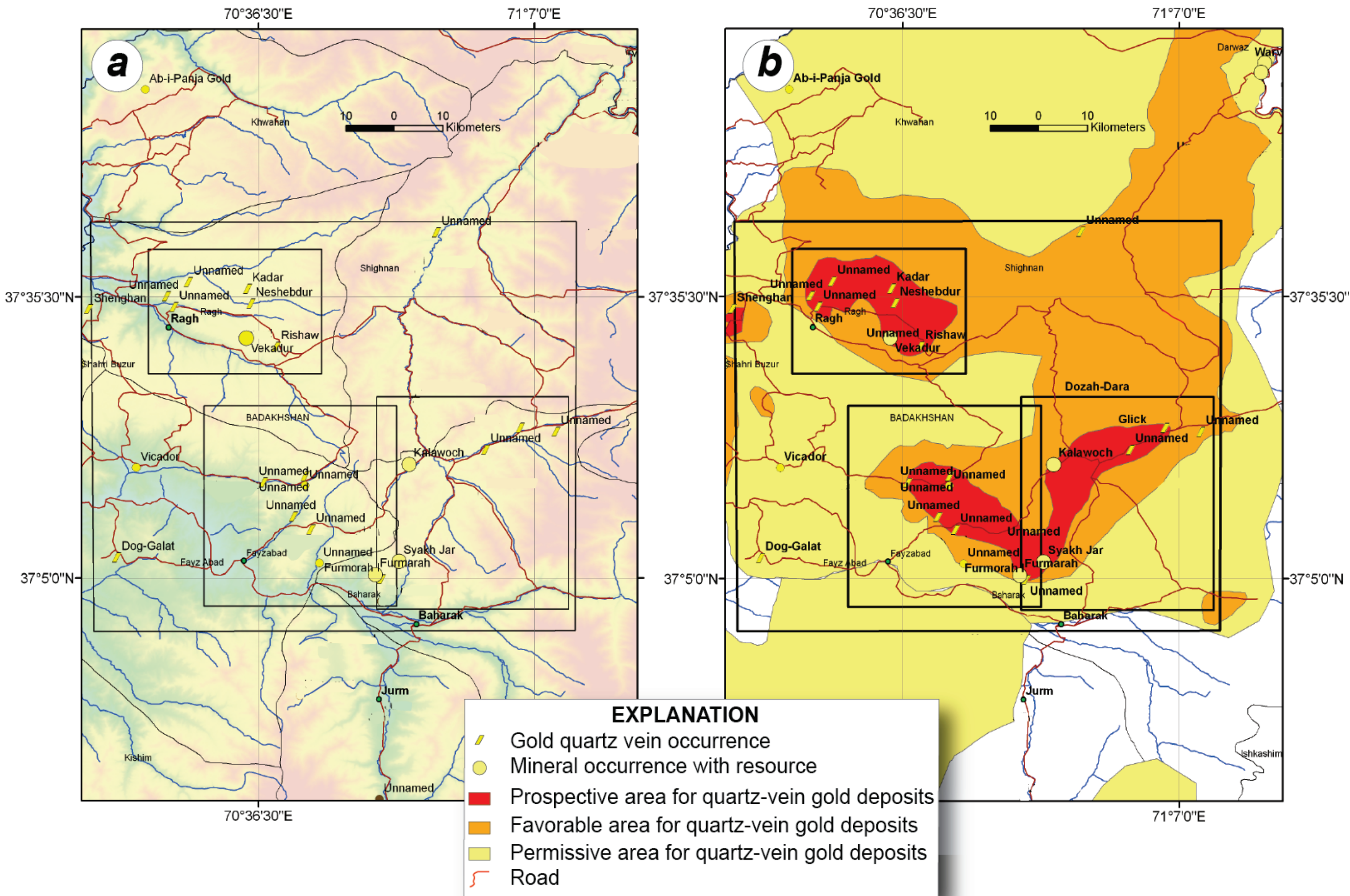

Figure 3A–2. Maps showing location of Badakshan gold area of interest and subareas with mineral occurrences and deposits. (*a*) Shaded color Digital Elevation Model (DEM). (*b*) Tract map of permissive, favorable, and prospective areas for undiscovered gold quartz vein deposits as portrayed and defined in Peters and others (2007).

3A.4 Geology

The geology of the Badakshan gold AOI consists of metamorphic rocks composed of Early and Late Proterozoic schist, and amphibolite metamorphic grade gneiss (map units Xgn, X_1gn, and X_3gn of Doebrich and others, 2006) in the western parts of the AOI, particularly underlying the Ragh and Fayabad subareas (fig. 3A–6). Metamorphic rocks mapped as Archean (units Wgn and Vgn of Doebrich and others, 2006) are present in the southeastern parts of the Badakshan gold AOI (fig. 3A–6). These rocks are overlain by folded and faulted Paleozoic sedimentary and volcanic rocks and, in turn, by Mesozoic sedimentary rocks, including limestone and dolostone. Much of the Ragh subarea is covered by Late Pliocene stratified conglomerate and sandstone (unit N_2ucgs of Doebrich and others, 2006) (fig. 3A–6).

The Badakshan gold AOI contains a number of gold geochemical halo anomalies from stream sediment sampling (data from Peters and others, 2007). The main gold anomalous zones are present in the Ragh and Baharak subareas (fig. 3A–7*a*). These gold anomalous zones outline many of the areas of known gold. In addition, several of the Bi, Hg, Au, and Au-W anomalous zones lie within the Furmorah-Kolowach Lineament (figs 3A–6 and 7*a*).

Igneous intrusive rocks are represented in the Badakshan gold AOI by plutons of Carboniferous gabbro and diorite in the Ragh subarea and by a number of Triassic granite plutons that intrude mainly Proterozoic rocks in the southwestern and western parts of the AOI. A number of Oligocene granodiorite and granite plutons also intrude the eastern parts of the Badakshan gold AOI, particularly in the zone of Cimmerian folding (figs. 3A–6, 3A–7*b*).

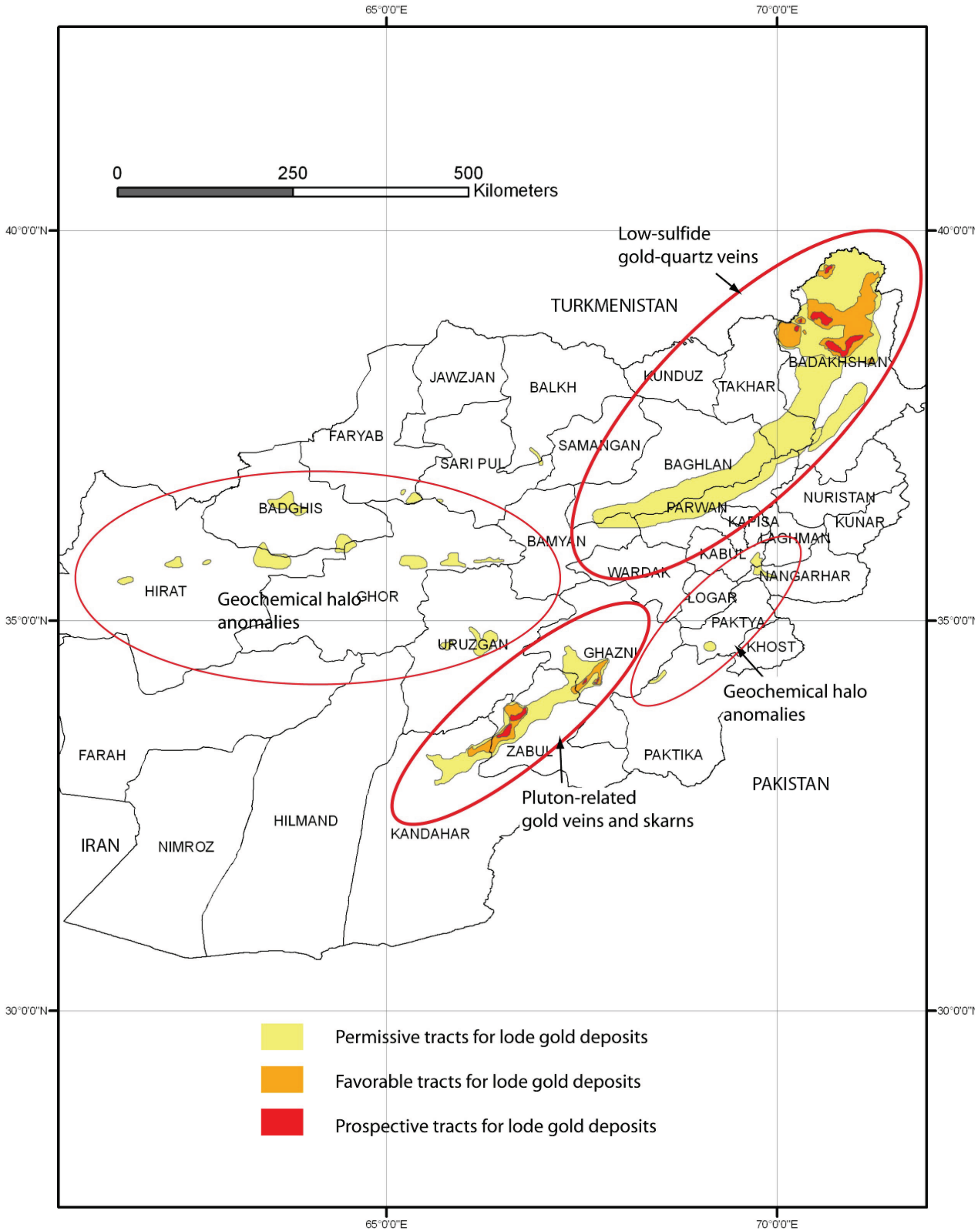

Figure 3A–4. Map showing location of areas with potential for lode gold deposits in Afghanistan. From Peters and others (2007). Heavy red lines in ellipses are known gold areas; thinner red lines are probable gold provinces.

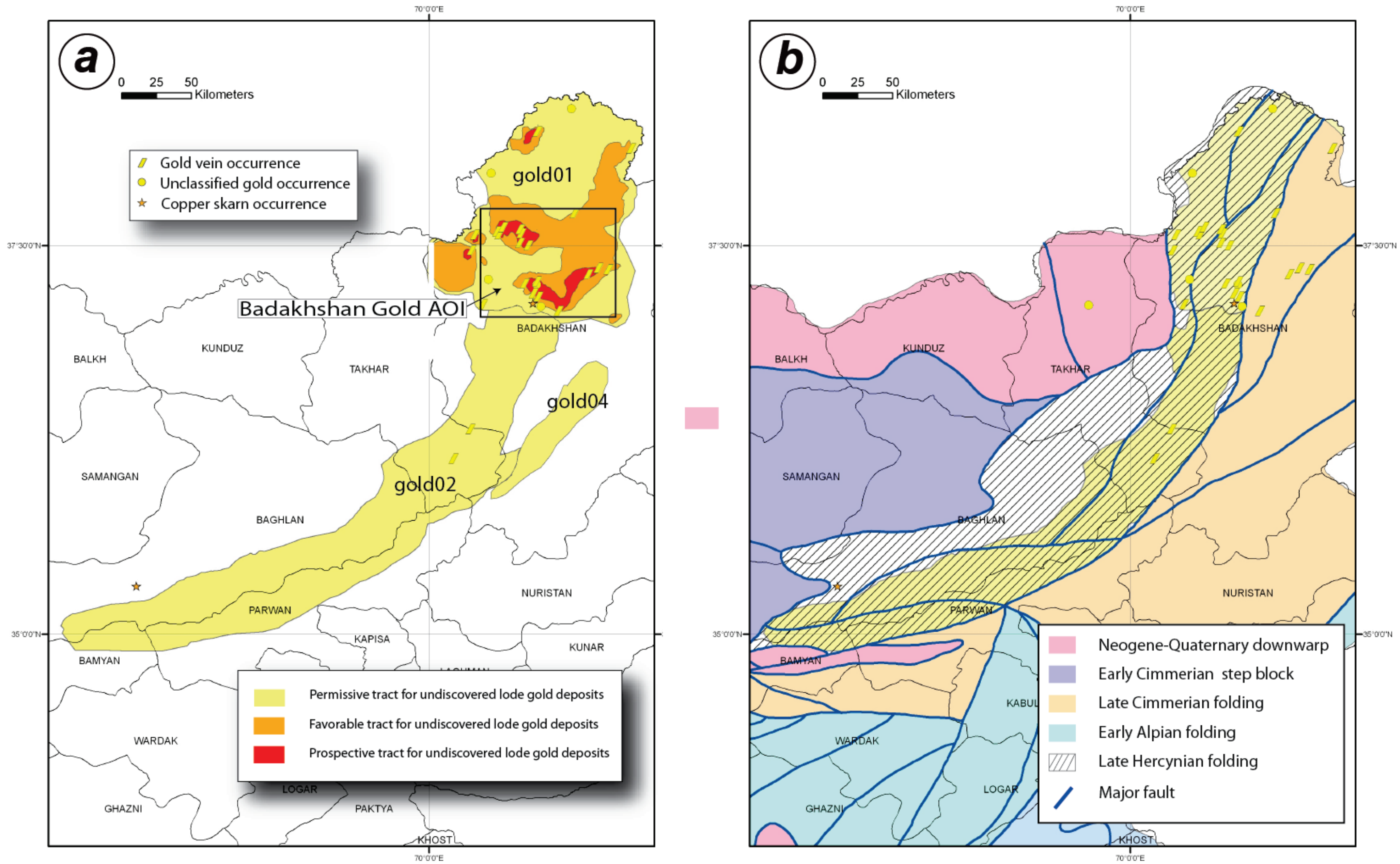

Figure 3A–5. Map showing location of Badakshan gold area of interest in northern Afghanistan. (*a*) Permissive, favorable and prospective tracts for gold veins hosted within areas underlain by Precambrian rocks. Location of Permissive tracts gold01, gold02, and gold 04 (from Peters and others, 2007). (*b*) Permissive tracts superimposed over major tectonic and fault zones in northern Afghanistan. Most of the gold veins are present within a northeastern zone of Late Hercynian folding or Late Cimmerian folding.

The Badakshan gold AOI contains several north to northeast-trending lineaments, shear zones, and faults, especially along the boundary between the zones of Hercynian and Cimmerian folding (figs. 3A–6 and 3A–7*b*). A number of sedimentary and plutonic units also have stratigrapahic contacts elongated along this zone. This zone is the northeast-trending 15- to 20-km-wide Furmorah-Kalawoch Lineament and it is a composite tectonic zone made up of several strands.

3A.5 Known Deposits

The Weka Dur gold deposit in the Ragh consists of a series of splaying northwest-striking, west-dipping quartz veins and brecciated zones (fig. 3A–8), hosted by Proterozoic quartz-mica schist, quartz-chlorite-sericite schist, and biotite-muscovite schist. These rocks are intruded by diabase and quartz keratophyre dikes. The main tabular west-dipping orebody is 350 meters (m) long and 2 m wide and can be traced downdip for 110 m (Abdullah and others, 1977). The southen part of the mineralized zone lies on the western side of a west-facing hill and the northern part traverses a ridge (fig. 3A–8). Pan concentrate sampling has documented a zone anomalous in gold that trails down the drainage to the west of the Weka Dur gold deposit for about 1 kilometer (km). Toward the east and 1 km north of the Weka Dur deposit, pan concentrate gold anomalies are also present in three other locations (the Rishab, Pas Pul, Jegshud, and Kwilar anomalies) (fig. 3A–8).

The Weka Dur gold deposit has been explored by five adits, eight pits, and 10 or more trenches (Gugenev and others, 1967). The adits are excavated from the hanging wall west of the outcrop of the vein and tunnel eastward into the mountain. Examples of two of the adits are contained in figures 3A–9 and 10. Variations in the widths of the quartz veins and mineralized rock in each of the adits are shown on table 3A–1. Examples of mapping and sampling in two of the adits is contained in figures 3A–9 and 3A–10.

Mineralization consists of ochreous, brecciated quartz-mica schist containing high gold concentrations along gently and steeply dipping fissures. The limonitic ochreous zones are probably fault gouge. The brecciated rocks grade 46.7 grams per metric ton (g/t) Ag and contain arsenopyrite, galena, chalcopyrite, and scheelite. Calculated resources ($C_1 + C_2$ categories approximately equal to possible ore) are 958.3 kilograms (kg) Au averaging 4.1 g/t Au (Nazarov, 1965; Gugenev and others, 1967). The geometry of the deposit is amenable to open pit mining, because there is very little overburden in the hanging wall side of the vein.

Table 3A–1. Interpretation of adit maps 1 through 5.

[From Gugenev and others (1967); m, meters; g/t, grams per ton]

Adit number	Orebody width, in m	Width of mapped mineralization, in m	Composite gold grade of mineralization, in g/t	Comments
1	1	4	1.78	Faulting
2	1.5	13	2.2	Faulting, crushing
3	12 to 20	22	2.7	Limonite and gouge (?)
4	1	8	1.6	Minor faults
5	3	4	1.4	Wide mineral zone

3A.6 Ragh District Subarea

The Ragh subarea contains the Weka Dur gold deposit. The subarea is in the northwestern part of the Badakshan gold AOI and contains a number of additional unnamed gold occurrences in the west and central parts (figs. 3A–11 and 3A–12). The geologic setting of most gold occurrences in this subarea is similar to that at the Weka Dur gold deposit. A prospective tract was delineated in the western part of a favorable tract by Peters and others (2007) to enclose the known low-sulfide gold-quartz vein occurrences in the Badakshan area (fig. 3A–11). The prospective tract was delineated along the southern outcrops of Proterozoic rocks (units X_1gn and X_3gn) that are intruded by Triassic granitites (mainly units Tgdg and T_1gr) and locally overlain by Siluro-Devonian and Permo-Carboniferous sedimentary and volcanic rocks (mainly rock units SDld, P_1sls and C_2ls of Doebrich and others, 2006).

These named gold occurrences include the Kadar, Neshebdur, and Rishaw gold prospects and the Weka Dur gold deposit. The Ragh subarea also contains outcrops of Cenozoic conglomerate and sandstone (unit N_2uncgs of Doebrich and others, 2006) that may have potential for gold placer deposits, resulting from weathering and secondary distribution of the lode gold deposits (fig. 3A–12).

The Kadar (Kalar) gold occurrence is hosted in Lower Triassic granodiorite in a 400-m-long, 20- to 70-m-wide shear zone that contains numerous quartz veinlets with disseminated pyrite and chalcopyrite. The mineralized rock in the shear zone contains concentrations of 0.1 to 1.6 g/t Au (Semionov and others, 1967). The Neshebdur gold occurrence is hosted in weathered Proterozoic gneiss and is composed of three 120- to 360-m-long, 1.5- to 4.0-m-wide quartz veins that contain disseminated galena, sphalerite, arsenopyrite, pyrite, and chalcopyrite. The mineralized zone contains gold concentrations of 0.2 to 1.1 g/t Au (Semionov and others, 1967). The Rishaw gold occurrence is hosted in Lower Carboniferous marbled limestone and consists of a 400-m-long, 0.6- to 2.3-m-wide quartz vein that grades as much as 5 g/t Au (Semionov and others, 1967).

Gold occurrences in the western part of the Ragh subarea typically are shattered zones in mineralized rock, including quartz veinlets and limonite. The thicknesses range from 1.2 m to about 10 to 15 m and are from 70 to 100 m long. Host rocks are Proterozoic gneiss or Mississippian granodiorite (fig. 3A–12).

Gold quartz veins in Proterozoic metamorphic rocks in the Ragh subarea are similar to gold-bearing zones in metamorphic rocks in other parts of the world (Berger, 1986; Drew, 2003) and are characterized by gold-bearing quartz veins with low-sulfide mineral content, which are distributed in the ore districts as several hundred gold deposits or prospects of ±1 metric ton (t) of gold each and one or more giant gold districts (Peters, 1993a,b; Goldfarb, 2010). Characteristics and descriptions of primary gold deposits in Badakshan Province, Afghanistan, are similar to deposits in other productive cratons. Common features include quartz with low-sulfide mineral content that is present in stockworks and massive veins, which are structurally controlled and are hosted by many of the lithologic units of the tectonic fold belts in which they occur.

3A.7 Baharak Subarea

The Baharak subarea in the southeastern part of the Badakshan gold AOI (figs. 3A–1, 3A–13a,b, and 3A–14) contains several gold and polymetallic mineral occurrences hosted in Triassic and Jurassic shale and limestone rocks along the contacts above Oligocene granodioritic plutons (fig. 3A–13b). In addition, several iron skarn occurrences at Kolowach and Syakha Jar also are present in the western part of the subarea (figs. 3A–13a,b).

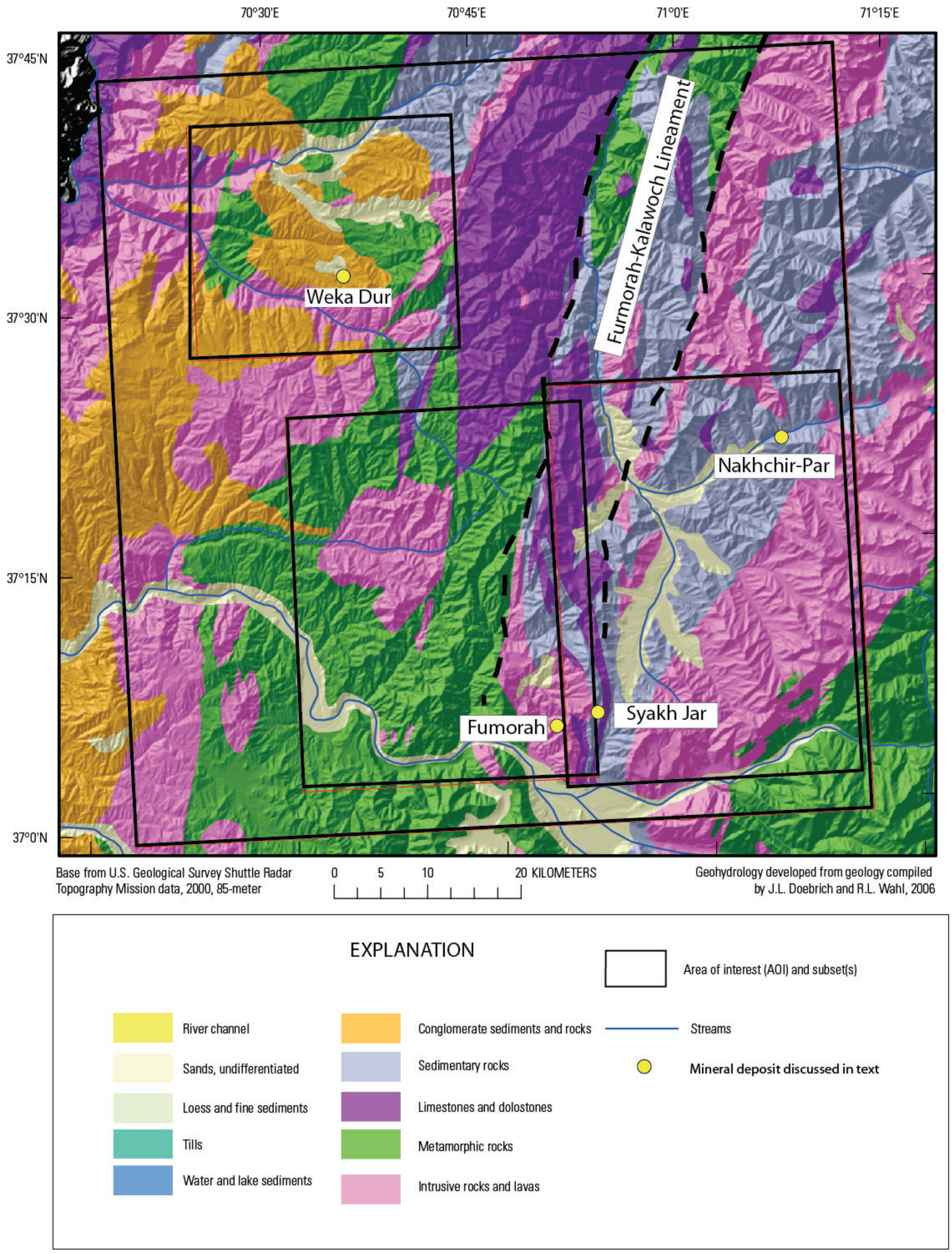

Figure 3A–6. Geologic map of the Badakshan gold area of interest showing outline of the area of interest and its internal subareas. The Furmorah-Kolowach Lineament traverses the central parts of the area. Geology and units from Doebrich and others (2006) and Peters and others (2007).

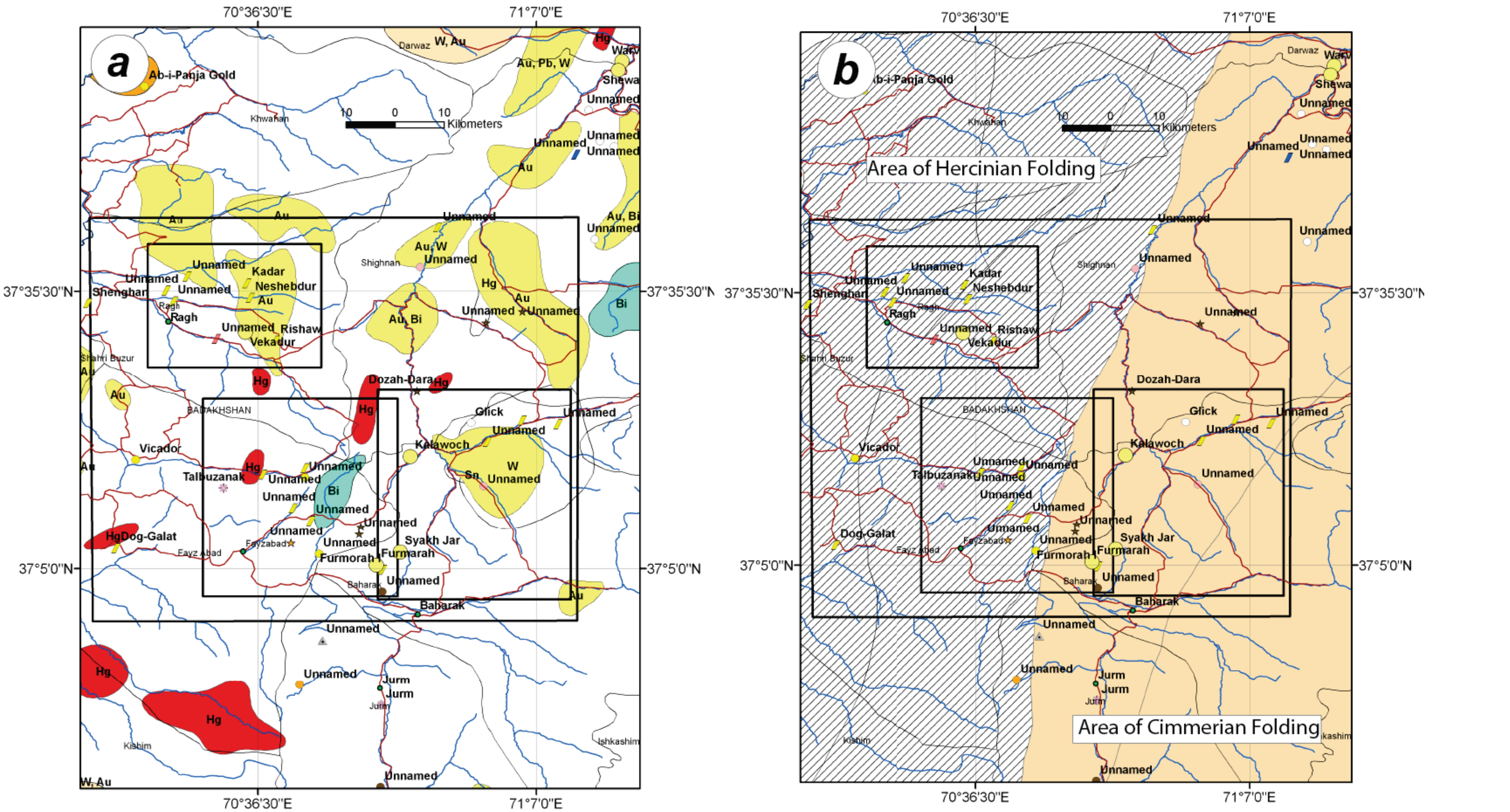

Figure 3A–7. Maps showing features of the Badakshan gold area of interest. (*a*) Map showing location of geochemical dispersion halos. Areas are color coded by element, which are labeled in the areas. (*b*) Map showing the areas of Hercynian and Cimmerian folding in the region. The boundary between the two tectonic areas is marked by the Furmorah-Kolowach Lineament. Data from Peters and others (2007).

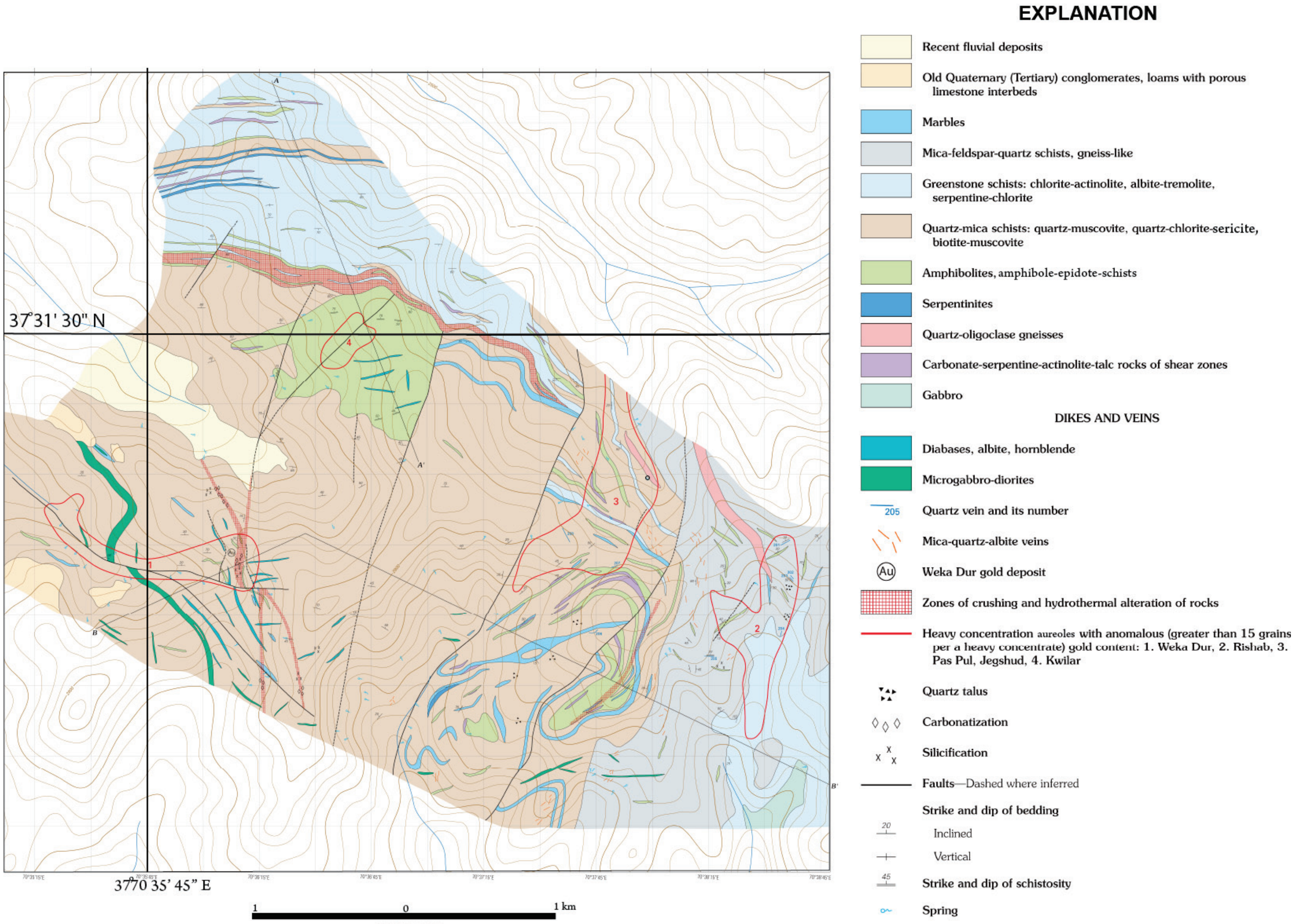

Figure 3A–8. Geologic map of the Weka Dur Gold deposit area, Ragh subarea, Badakshan gold area of interest. Adapted from Gugenev and others (1967).

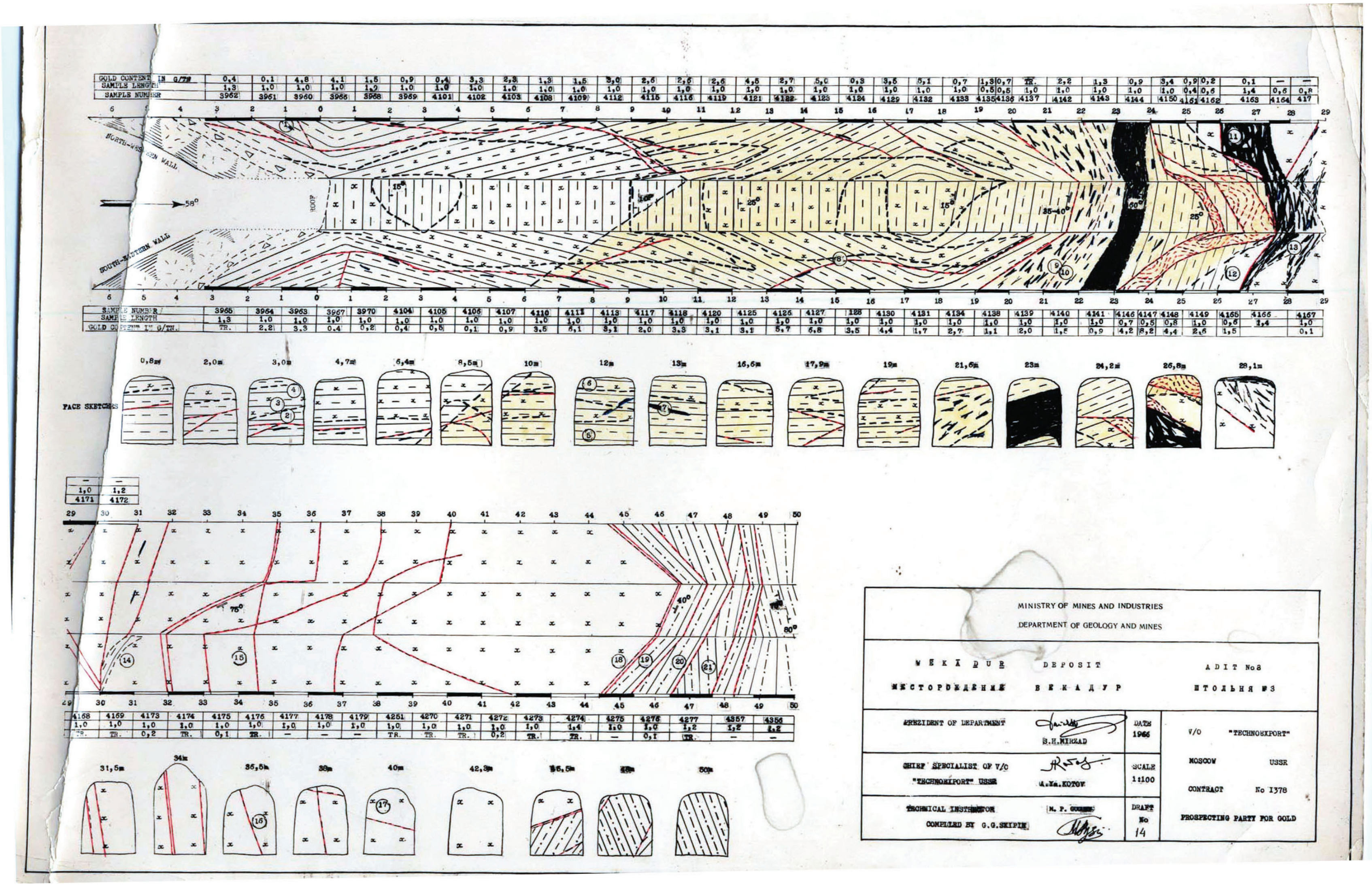

Figure 3A–9. Scan of Trench sampling map for Trench No. 2. From Gugenev and others (1967). This scan is included as an example of the type and detail of work that has been done on the Weka Dur deposit.

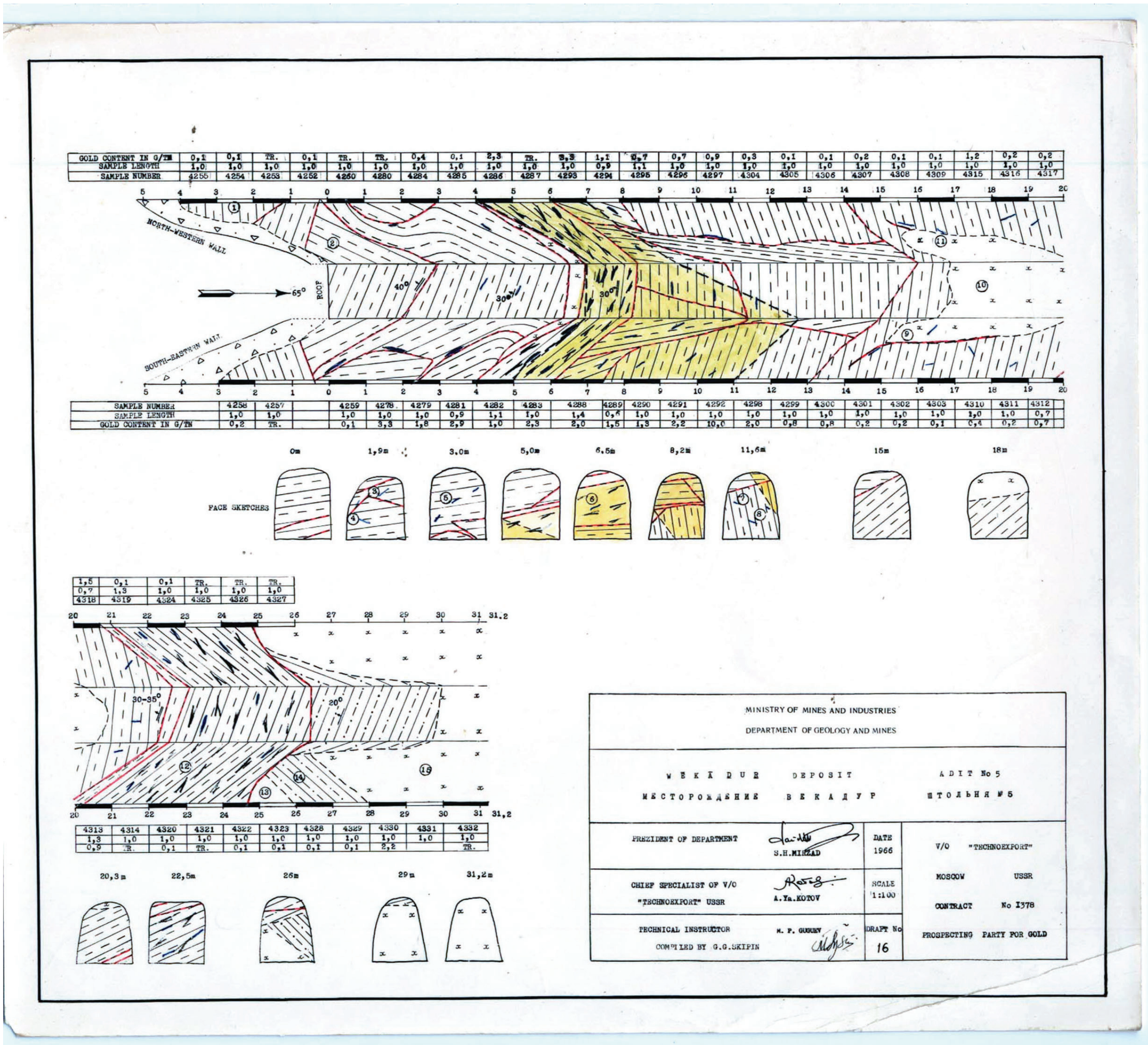

Figure 3A–10. Scan of Trench sampling map for Trench no. 5, Weka Dur gold deposit. From Gugenev and others (1967). This scan is included as an example of the type and detail of work that has been done on the Weka Dur deposit.

The most well known gold occurrence in the Baharak subarea is the Nakhchir-Par gold occurrence, which is hosted in Upper Triassic to Middle Jurassic sandstone (fig. 3A–13b) in a hornfelsed, silicified zone that is 300 m long and contains abundant pyrite, pyrrhotite, chalcopyrite, and 80-cm-long lenses of magnetite. The strongest mineralization is in a 25-m-long zone that contains concentrations of 0.4 g/t Au, 0.04 wt. % Cu, and as much as 0.06 wt. % WO_3 (Sborshchikov and others, 1974). This gold occurrence may be amenable to exploitation by small to medium-size open pit mining and leaching of the oxide ores and also may be the source of possible undiscovered gold placer deposits to the west.

East and west of the Nakhchir-Par gold occurrence, additional mineralized zones are present that also contain quartz, pyrite, pyrrhotite, and magnetite and are anomalous in gold, copper, arsenic, silver, and tin. The unnamed occurrence to the east is 27 m thick and extends for 60 m (Orris and Bliss, 2002) (fig. 3A–13b). The Glick mineral occurrence to the west (fig. 3A–13b) is as much as 10 m thick and 4 to 5 km long and is anomalous in copper, lead, zinc, and tungsten (Orris and Bliss, 2002).

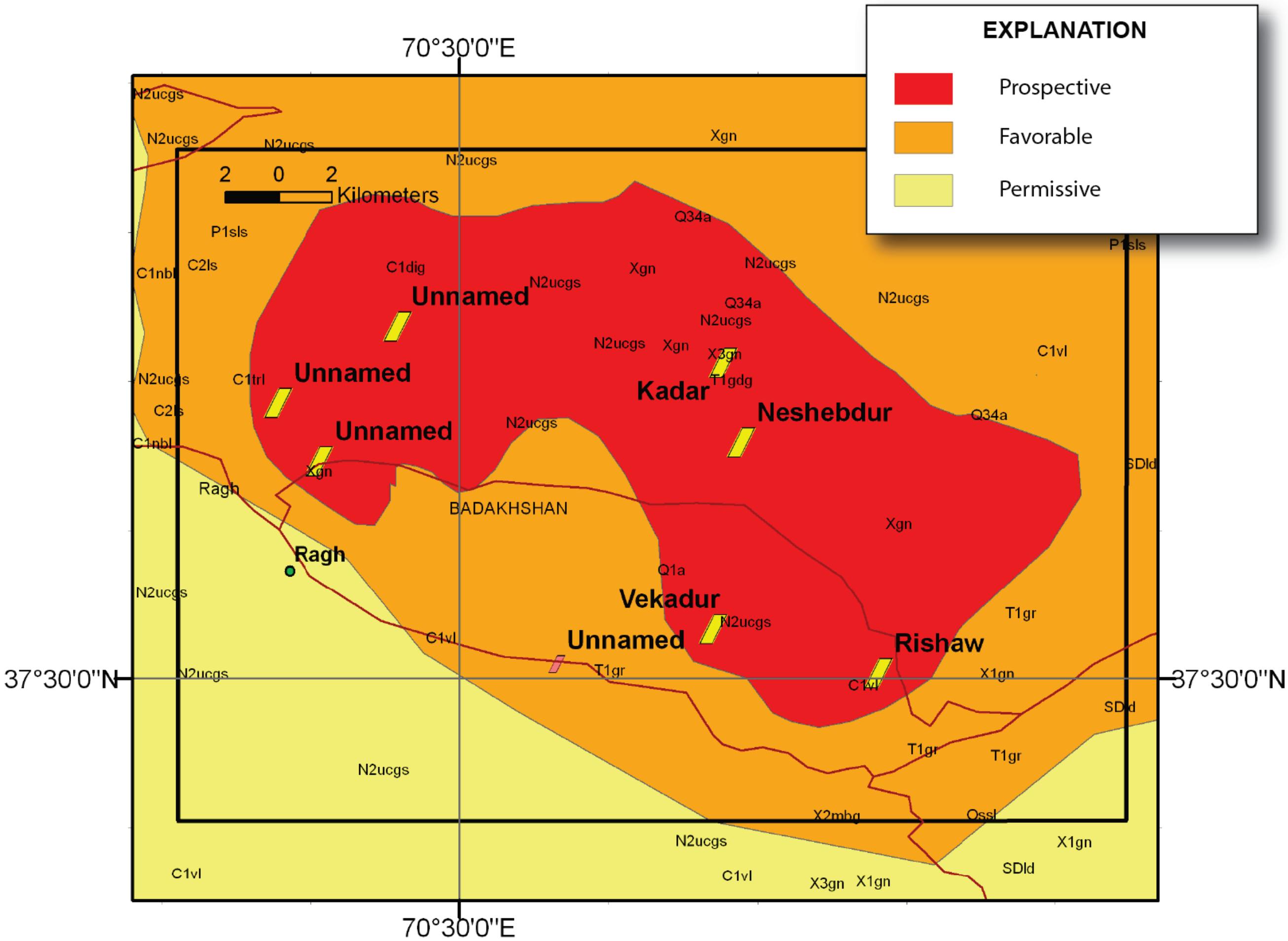

Figure 3A–11. Map showing areas of prospective, favorable and permissive ranks for undiscovered gold quartz vein deposits in the Ragh subarea, Badakshan gold area of interest. Data from Peters and others (2007). Unit labels from the geology of Doebrich and others (2006). Red lines are roads. Yellow parallelograms are gold vein occurrences.

A tungsten anomaly, based on pan concentrate samples and taken during Soviet times, is present in the north-central parts of the Baharak subarea in the drainage basins (fig. 3A–7). The halo is 500 km^2 and is present in Upper Triassic-Middle Jurassic sandstone and shale that is intruded by Oligocene granite. Scheelite is present in all samples,from single grains in a sample to 0.8 grams per cubic meter (g/m^3), and single grains of wolframite were also present in some samples (Sborshchikov and others, 1974).

The Kalawach iron skarn occurrence is in the northwestern part of the Baharak subarea and consists of a 9-m-thick, 300-m-long iron magnetite skarn that is developed along the contact between a Paleogene gabbro-diorite stock and Cambrian limestone (fig. 3A–13b). The Syakha Jar iron skarn is described below with the Furmorah District (figs. 3A–13a,b).

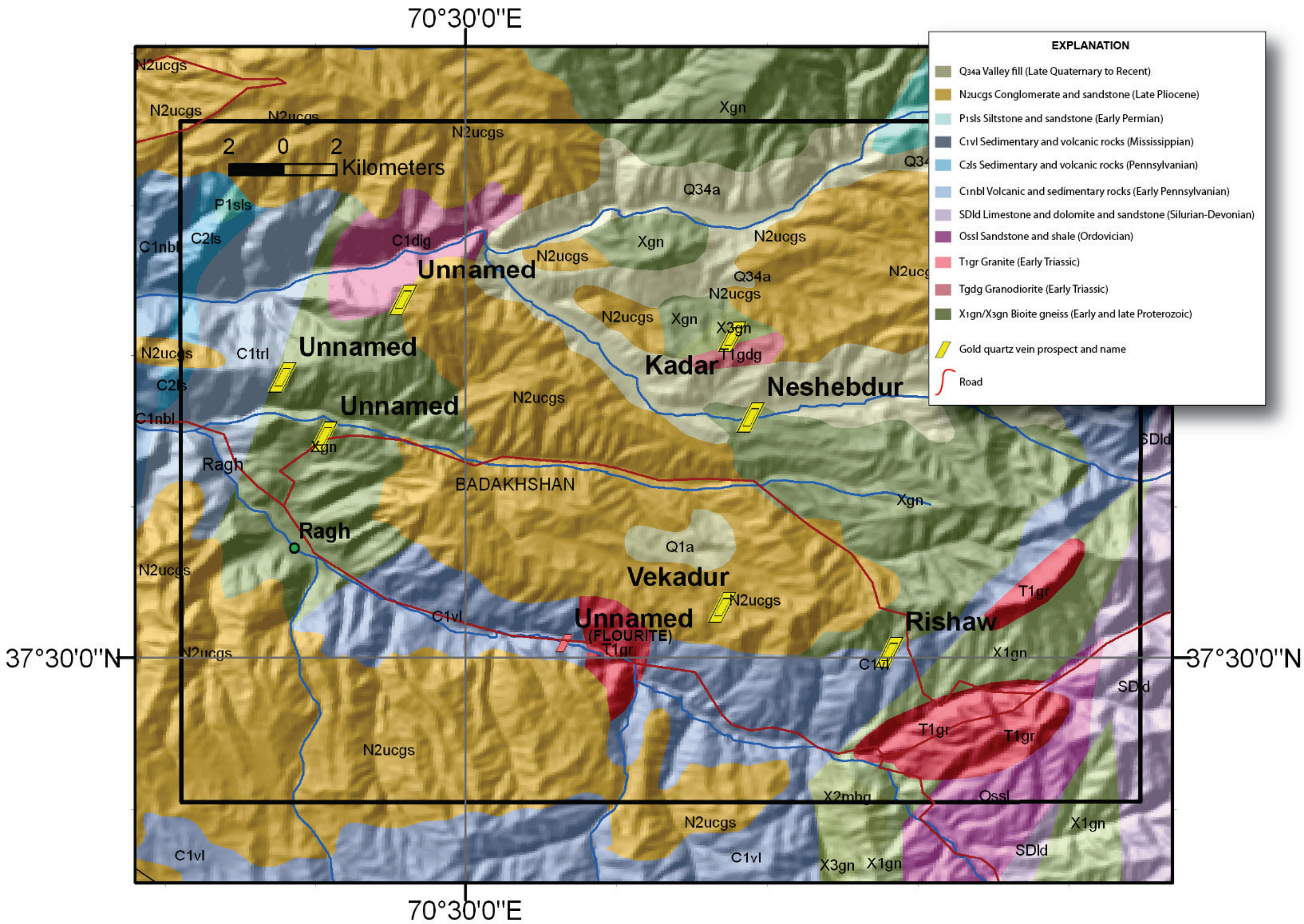

Figure 3A–12. Geologic map of the Ragh subarea of the Badakshan gold area of interest. Geology from Doebrich and others (2006). Note the extensive areas of Pliocene conglomerate and sandstone.

3A.8 Fayzabad Subarea

The Furmorah iron-gold ore district is in the southern part of the Central Badakshan Metallogenetic Zone in the eastern part of the Fayzabad subarea in the Badakshan gold AOI (fig. 3A–13a). The district also contains Triassic and Jurassic carbonate-terrigenous rocks and Eocene-Oligocene felsic volcanic rocks that are intruded by an Oligocene granite pluton and are offset by thrust sheets and small fault blocks. Most iron occurrences and deposits surrounding the Furmorah pluton are magnetite skarns that formed within the margins of the pluton. Gold occurrences, composed of quartz-gold-sulfides, are present in a northwest trending sheared zone in silicified carbonate and terrigenous rocks along the southwestern margin of the pluton. High concentrations of gold have also been recorded in garnet and garnet-magnetite skarns at Furmorah (Abdullah and others, 1977).

The Furmorah pluton is surrounded by several iron skarn deposit occurrences, including the Syakh Jar and Furmorah iron skarns. The mineralized zone around the pluton consists of an 80-km^2 mineralized area along the outer contact between the Furmorah pluton and the Upper Permian to Upper Triassic sandstone and limestone country rock (figs. 3A–14 and 3A–15). Gold-mineralized zones of the Furmorah gold occurrence consist of garnetiferous and garnet-magnetite skarn that grades as much as 3.3 g/t Au. Away from the skarn areas, mineralization consists of quartz-sulfide veins containing 0.1 to 2.8 g/t Au and as much as 1.0 wt. % Cu, 1 to 3 wt. % As, 0.1 wt. % WO_3, and as much as 0.5 wt. % Mo (Semionov and others, 1967).

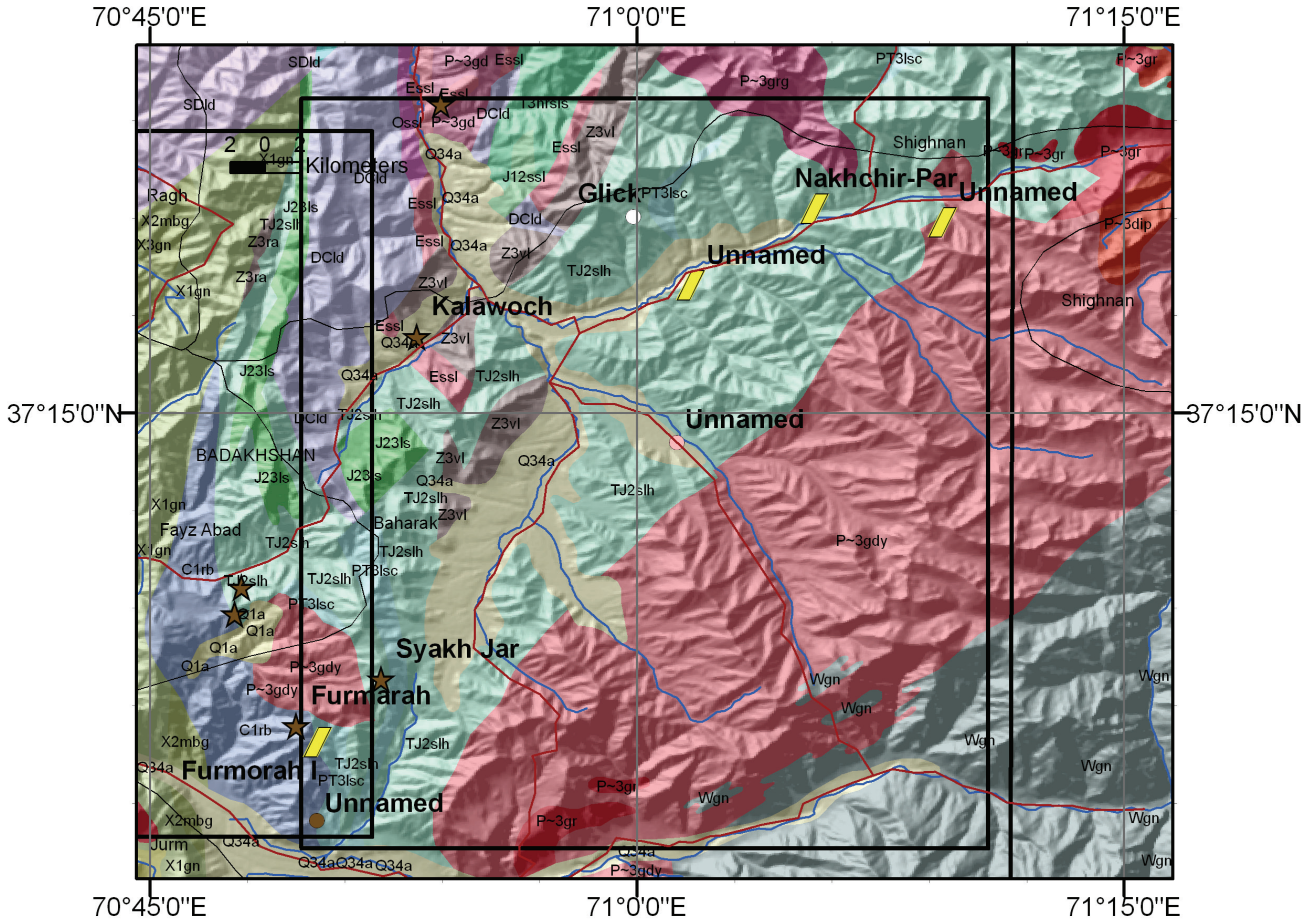

Figure 3A–13a. Geologic map of the Baharak subarea in the Badakshan gold area of interest. Geology and units from Doebrich and others (2006).

The Furmorah iron orebody is in a fault along the contact between cherty sandstone and limestone of Early Carboniferous age, near the Furmorah Oligocene pluton (fig. 3A–15). The mineralized rock is massive, stratabound magnetite that is 2 to 35 m thick and as long as 1,000 m and has been traced to a depth of 350 m. The iron orebody contains (a) 47.2 to 67.8 wt. % Fe, (b) 0.02 to 0.03, and more rarely, to 0.3 wt. % S, and (c) 0.04 to 0.1 wt. % P. Speculative iron ore reserves are 35 million metric tons (Mt) of ore (Semionov and others, 1967).

The Syakh Jar iron deposit is a 2- to 3.5-m-thick bed-shaped body of magnetite and hematite that is 150 m long and is present in Upper Triassic to Middle Jurassic hornfels from slate at the eastern margin of the Oligocene Furmorah pluton (figs. 3A–14 and 15). Speculative iron ore reserves are 40 to 45 Mt (Semionov and others, 1967). Other iron occurrences on the northwestern contact of the Furmorah pluton (fig. 3A–15) consist of approximately 5-m-thick magnetite and garnet-magnetite skarn in Upper Triassic to Middle Triassic limestone (Semionov and others, 1967).

In the center of the Fayzabad subarea, several gold veins are present within and adjacent to a 15-km diameter Lower Triassic granite pluton (fig. 3A–14). The gold occurrences on the eastern side of the pluton are contained in shattered zones in Proterozoic shale, gneiss, and amphibolite, and typically are 70 to 100 m wide and 100 m long and contain quartz and feldspar alteration with galena, arsenopyrite, chalcopyrite, pyrite, and native gold (Semionov and others, 1967).

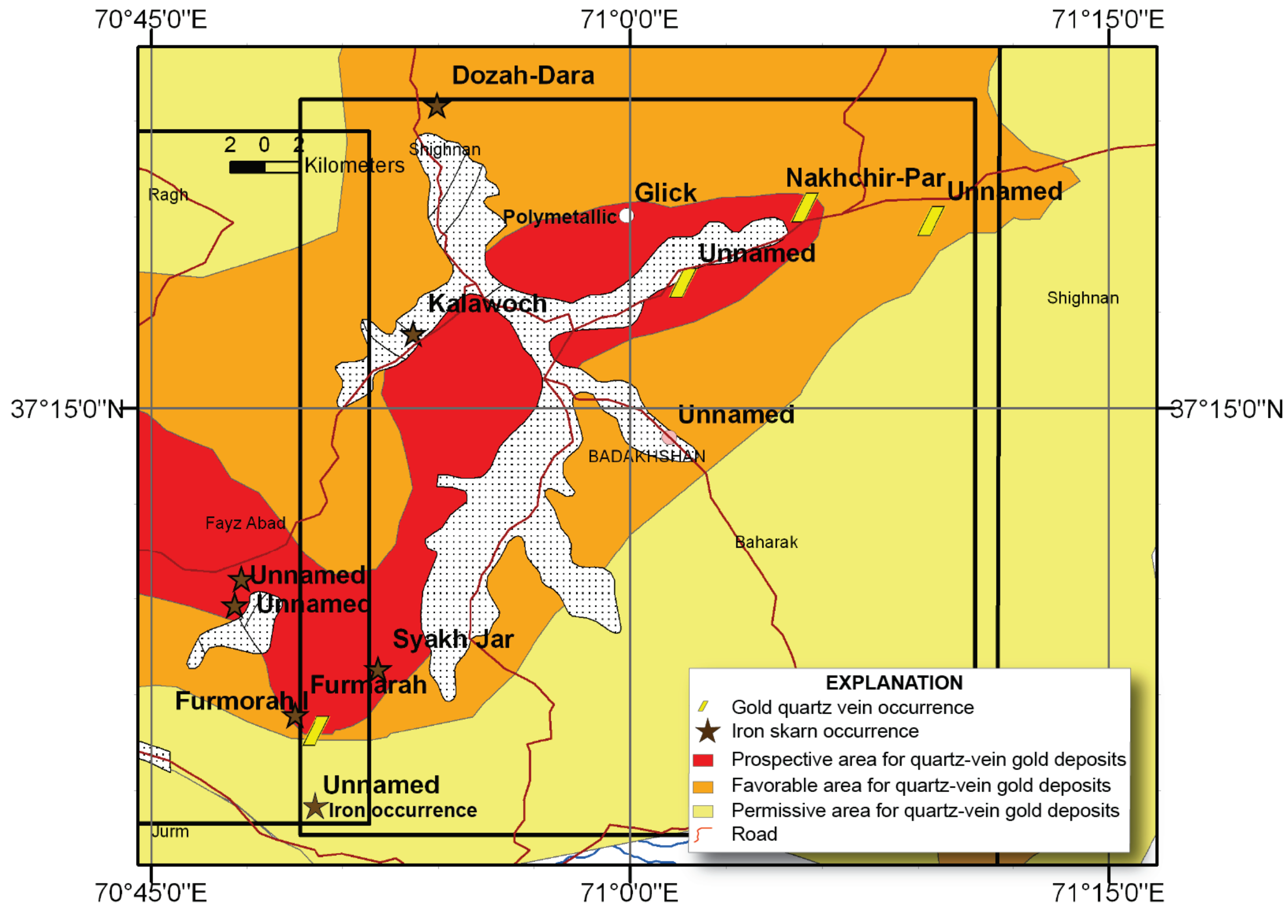

Figure 3A–13b. Map showing prospective, favorable and permissive areas for gold-quartz vein deposits from Peters and others (2007) in the Baharak subarea, Badakshan gold area of interest. Patterned area denotes Pliocene or younger sediments that are permissive for gold placer deposits.

The Fayzabad subarea contains an Early Triassic Li-Be-Ta-Nb biotite-microcline-quartz pegmatite at Taluzanak (fig. 3A–14) that is hosted in Proterozoic amphibolite and contains spodumene, cleavalandite, beryl, columbite, tantalite, and pollucite. The pegmatite dikes crop out on the southwestern side of the Lower Triassic granite pluton in an area covering 50 km^2 (fig. 3A–14). The dikes vary from 0.3 to 5 m in thickness and from 40 to 70 m in length. One of the dikes contains 40 by 50 centimeter (cm) vugs with beryl crystals and muscovite (Rossovsky and others, 1975; Chmyriov and others, 1977).

3A.9 Placer Gold

Gold placer deposits have been known in the Badakshan gold AOI since ancient times, although no production has been recorded except by artisans. Identification of a major placer deposit is also lacking. Besides gold placer deposits in the active streams and rivers, there is potential for placer gold deposits in perched Neogene deposits (Nazarov, 1965; Gugenev and others, 1967). Peters and others (2007) evaluated the potential for young and recent gold placer deposits in the Badakshan gold AOI area, and these areas are shown on figure 3A–16. The northwest Ragh subarea contains outcrops of Neogene conglomerate and sandstone that also may have potential for gold placer deposits (fig. 3A–12).

3A.10 Summary of Potential

The Badakshan gold AOI has potential for production from a number of gold deposit types, including metamorphic gold vein (greenstone-hosted gold vein, orogenic vein, low-sulfide gold-quartz vein, polymetallic vein, and gold placer). In addition, deposits of iron skarn, gold-copper skarn, and REE and Li pegmatites are likely to be present.

Exploration for gold-quartz veins can be difficult and complex, because the gold in the mineralized zones is not always distributed evenly. As a result, large amounts of sample need to be collected and assayed to determine an accurate grade for each intercept and the whole of the deposit. Drilling of quartz veins presents a specific problem, because small diameter drilling techniques produce samples that may not statistically represent the mineralized zone intersected. Recovery of drill samples in the mineralized zone is commonly poor, because the mineralized zones are broken and fragmented. Large diameter drills, using reverse circulation techniques work best in the first 100 m where the orebodies are typically weathered and broken. Additional analytical tools can augment and supplement standard sampling techniques. The best technique for exploration of gold quartz veins is the application of contour longitudinal sections of the width of quartz or the mineralized zone or contours of other features of the mineralized zone, such as deviation from a standard plane as proposed by Conolly (1936) and detailed by Campbell (1990).

An example of how the application of contouring exploration techniques can be applied to the Weka Dur gold deposit is as follows. Of the five adits that were driven into the mineralized zone at Weka Dur, one of them has a 12 to 20 m mineralized zone with quartz (table 3A–1), whereas the other adits only penetrated the same mineralized zone in thickness of from 1 to 3 m. Gold quartz vein deposits commonly contain oreshoots that represent the thickest and richest parts of the mineralized zone, and these are where the most economic parts of the structures are located (Peters, 1993a,b). If a significant oreshoot crops out in the pits and trenches of the Weka Dur mineralized zone at the surface, this should correspond to a thickness of quartz in one of the adits. Connecting the two thicker and richer parts of the mineralized zone may provide the rake of an oreshoot. Such analysis may lead to more productive drill targets across the plane of the Weka Dur mineralized zone.

Several gold-quartz veins are present in the Badakshan gold AOI, and no extensive modern exploration for gold has taken place in the area since the 1960s when the gold price was near $32 per ounce. Significant advances have taken place in the exploration and mining industry for gold exploration, mining, extraction, and metallurgy. The Badakshan gold AOI, particularly the Ragh District subarea, contains deposits that are amenable to modern exploration techniques and can also be exploited with simple metallurgy. The known orebody as Weka Dur has good geometry for open pit mining, and this will result in a short lead time and short payback period for a medium-sized mine with significant future potential. The area requires additional compilation and analysis. Many of the gold placer and gold lodes at the surface in the Badakshan gold AOI are amenable to artisanal exploitation (see figs 3A–14 and 3A–16).

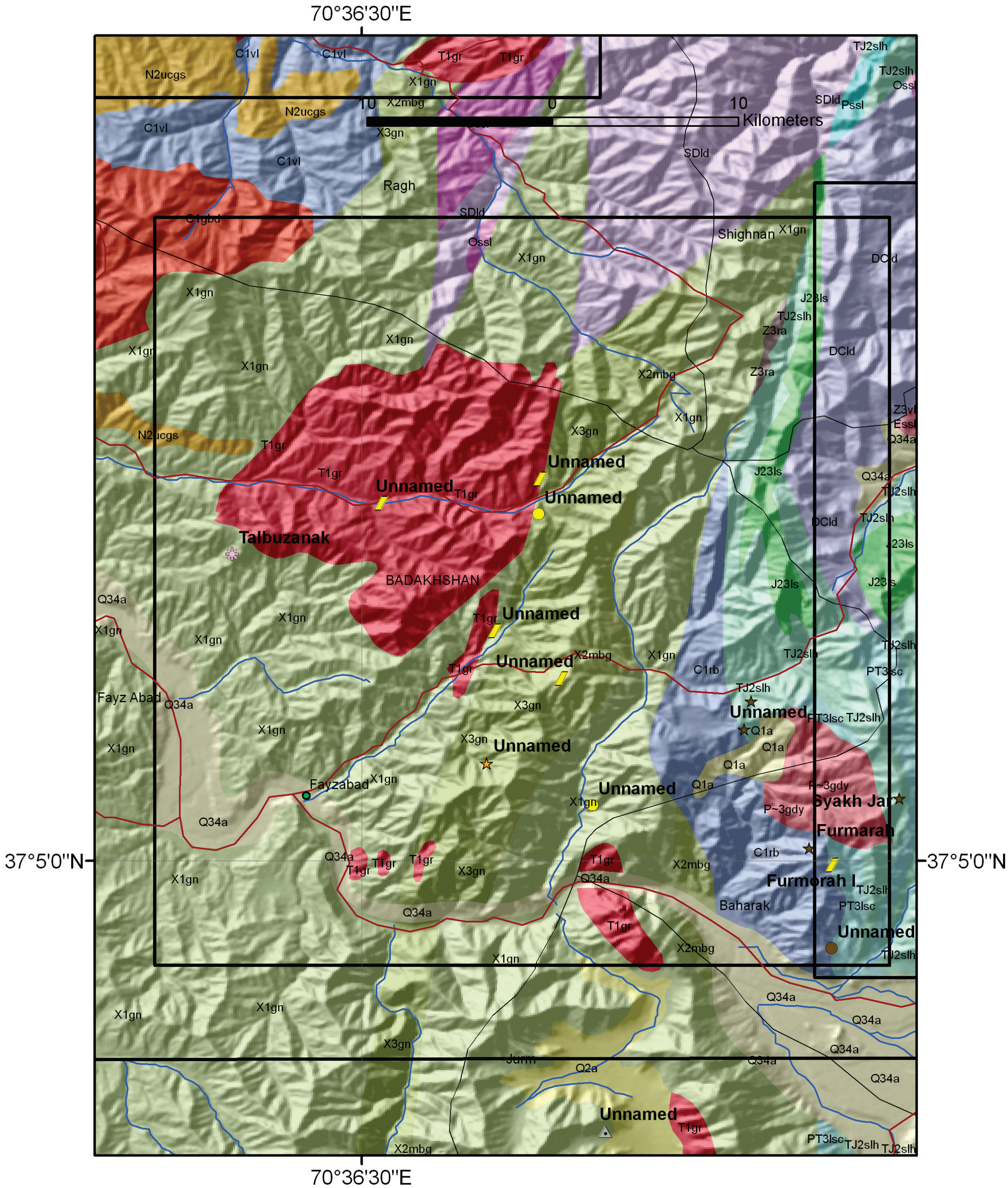

Figure 3A–14. Geologic map of the Fayzabad subarea in the Badakshan gold area of interest. Geology and units. from Doebrich and others (2006). The Furmorah area lies in the southeastern part of the subarea.

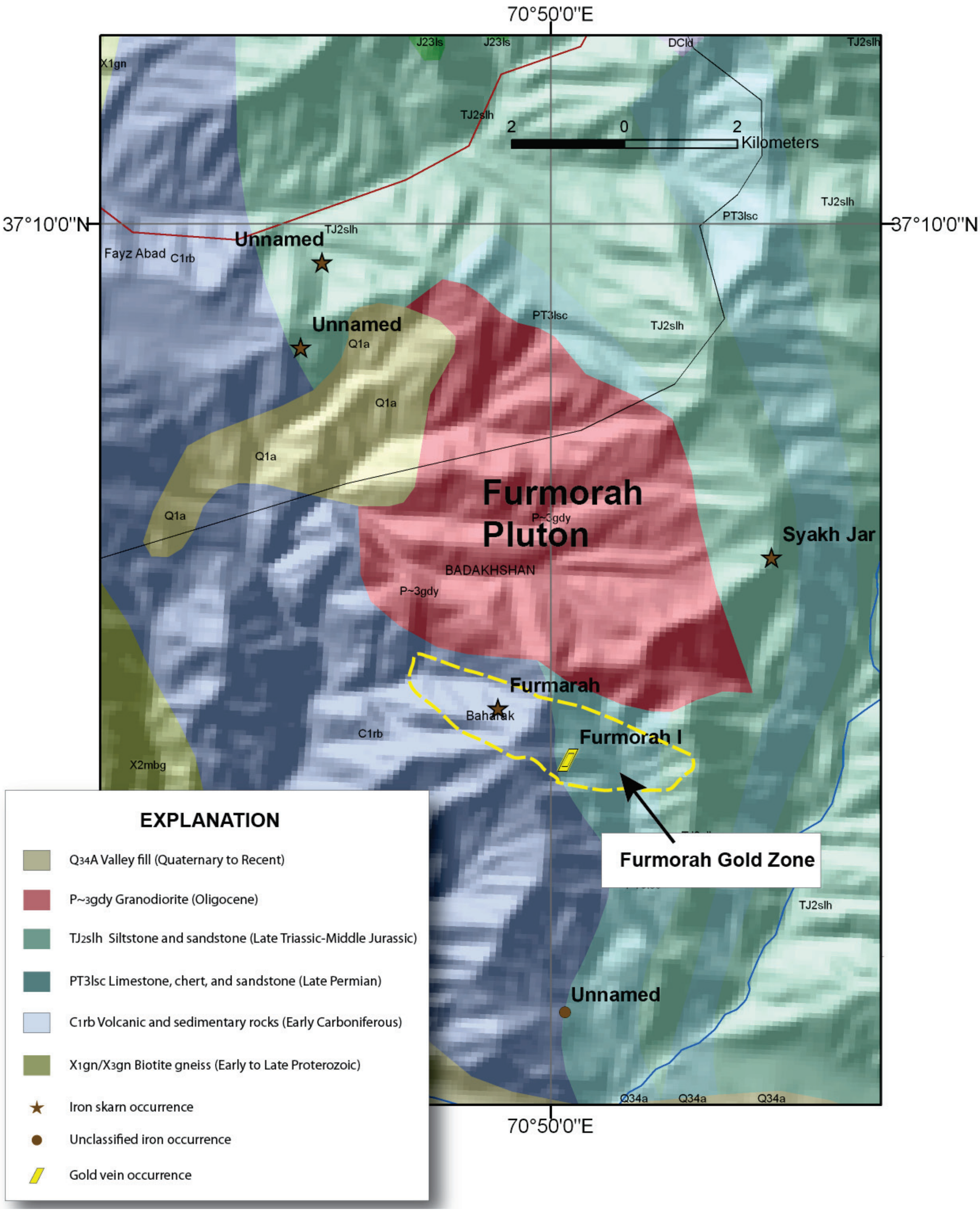

Figure 3A–15. Geologic map of the Furmorah iron-gold area in the Fayzabad District subarea, Badakshan gold area of interest.

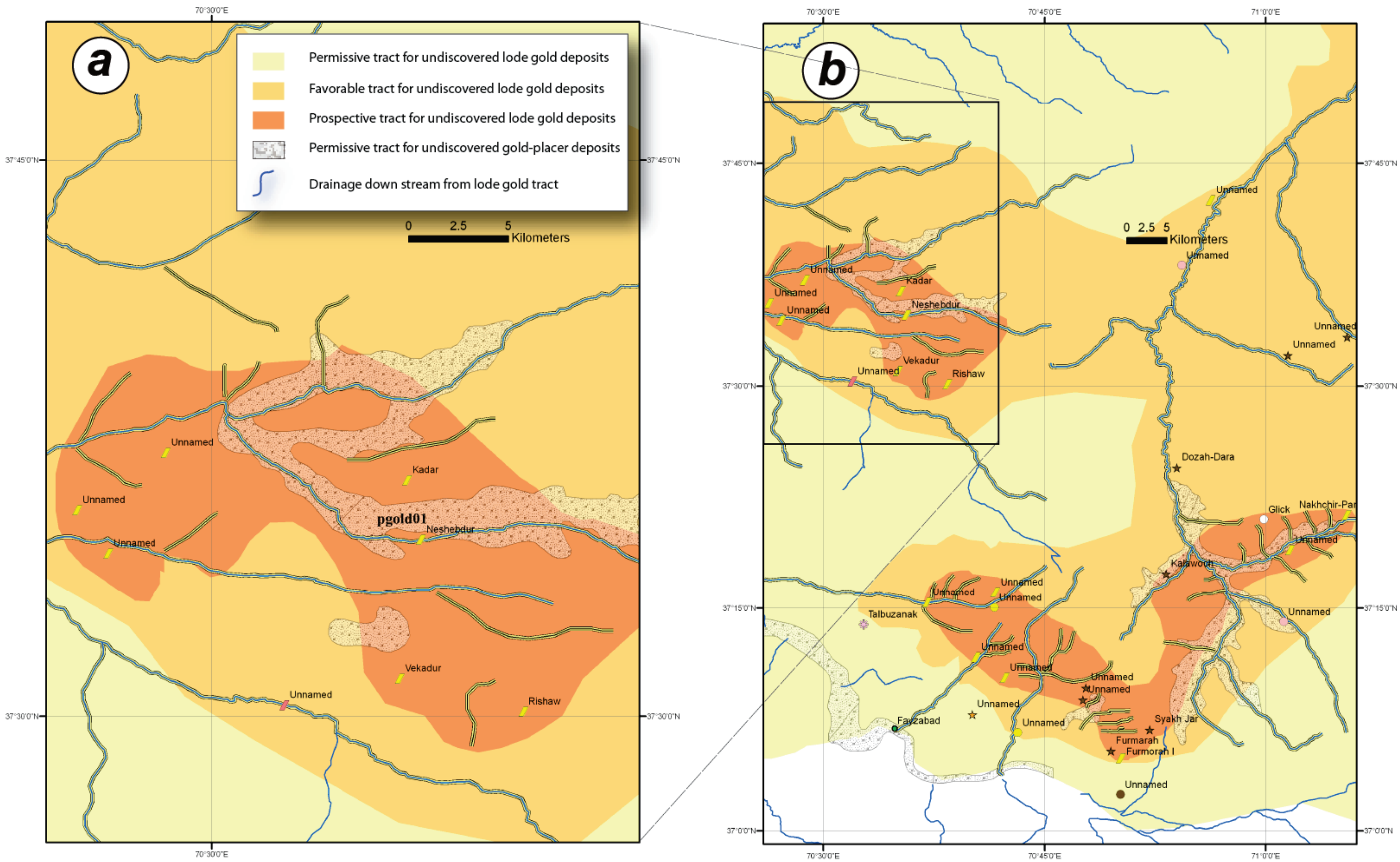

Figure 3A–16. Maps showing location of parts of permissive tract for undiscovered gold placer deposits in the perched basins and main stream in the Badakshan gold area of interest. (*a*) Map showing location of perched drainages and Pliocene sediments around the Kadar and Neshebdur prospects in the Ragh District subarea. (*b*) Map showing areas permissive areas or lode gold deposits and undiscovered gold placer deposits in the perched upper reaches of drainages in the entire area of interest.

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