8A. Summary of the Katawas Gold Area of Interest

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Abstract

The Katawas gold area of interest (AOI) lies along the northwestern margin of the Katawas 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 Katawas AOI encompasses 1 of more than 19 geochemical halo zones in the Katawas 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 Katawas 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 Katawas Basin to the south of the Katawas 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 Katawas Basin. The presence of geochemical anomalies of mercury and hydrothermal zones in the Katawas 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 Katawas 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.

8A.1 Introduction

This chapter summarizes and interprets results for the Katawas gold Area of interest (AOI) from geologic and compilation activities that were conducted during 2009 to 2011 by the U.S. Geological Survey (USGS), in conjunction with the U.S. Departmenr of Defense Task Force for Business and Stability Operations (TFBSO) and the Afghanistan Geological Survey (AGS). Accompanying complementary chapters 8B and 8C address hyperspectral data and geohydrologic assessments, respectively, of the Katawas gold AOI. An inventory of individual datasets compiled for the Katawas gold AOI is included with the data information package for each AOI as well as an inventory specifying what data have been compiled and are available from the Ministry of Mines, Kabul.

Most existing mineral-resource information in the data package has been gathered from reports written between the early 1950s and about 1985 by geologists from the Union of Soviet Socialist Republics (USSR) and its Eastern European allies, who provided Afghanistan with technical assistance. This information, combined with a preliminary assessment by the U.S. Geological Survey in 2007 (Peters and others, 2007), provided much of the basis for this chapter. The Katawas gold AOI and its subarea are speculative because no known mineral prospects are present, but the area was thought likely to be host to small- to medium-sized gold deposits that might have near-term mineral production. In addition, hypothetical gold deposits in the Katawas gold AOI may be near-surface bodies that contain promising metallurgical and mining characteristics.

The Katawas gold Area of interest (AOI) is in southeast Afghanistan in the Katawas Basin. The AOI has an area of 478.22 square kilometers (km^2) and lies within Ghazni and Paktika Provinces and in the Giro, Andar, Diti Yak, and Sharan administrative districts. Deposit types likely to be present in the Katawas gold AOI are hot-spring (and epithermal) gold and silver, mercury, and base-metal deposits (fig. 8A–1).

In addition, a number of geochemically anomalous halos in mercury, tungsten, gold and (or) lead are present within the Katawas Basin. Studies of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) imagery have identified phyllic and argillic alteration zones in areas to the south of the Katawas gold AOI, which were designated separately as a permissive tract for porphyry copper deposits by Mars and Rowan (2007), Ludington and others (2007), and Peters and others (2007). Other hydrothermal base-metal districts also are documented on the east side of the Katawas Basin (Abdullah and others 1977; Peters and others, 2007). The presence of geochemically anomalous halos and evidence of hydrothermal activity in the Katawas Basin suggest that mineralizing hydrothermal systems may have been active either during or after the development of the basin.

8A.2 Previous Work

No ancient workings or mining activity has been reported in the Katawas gold AOI. The first geologic work recorded in the Katawas Basin was by Auden (1962), who provided an early geologic map of the region (fig. 8A–2). Early work by Soviet and Afghanistan geologists was conducted in the Katawas Basin by Ganss (1964a, b, 1970), the German Geological Mission in Afghanistan (1969), Denikaev and others (1970), Koshelev and others (1972), and Sborshchikov and others (1974, 1975), and other authors listed in the text below. In addition, the Chaman Fault on the west side of the Katawas Basin, near the Katawas gold AOI, was identified as an active earthquake fault by Beun and others (1979), Quittmeyer and Jacob (1979), Yeats and others (1979), Beun (1982), and Lawrence and others (1992). The fault was recently described as a major hazard zone in Afghanistan by Wheeler and Rukstales (2007) and Boyd and others (2007). Mineralization in the area was discussed by Nikitin and others (1975) on the east side of the Katawas Basin at the Spira Lead Mine and in the southwest part of the Katawas Basin by Mars and Rowan (2007) and by Ludington and others (2007). Compilations of and discussion about the Katawas Basin area were done by Abdullah and others (1977), Doebrich and Wahl (2006), and Peters and others (2007). Airborne geophysics at the Katawas Basin were compiled and reprocessed by Sweeney and others (2006).

8A.3 Geology

The Katawas gold AOI lies along the western margin of the Katawas Basin (fig. 8A–2), which is bounded by the Chaman Fault and its splays (figs. 8A–3 and 8A–4*a*,*b*). The Katawas gold AOI lies along one of these fault splays (figs. 8A–4*a*, *b*).

The Chaman Fault system is more than 1,000 kilometers (km) long and extends from the Hindu Kush region in northeastern Afghanistan south-southwestward through eastern Afghanistan into western Pakistan (figs. 8A–3 and 8A–4*a*,*b*). Several large (Mw = 6 to 7) historical earthquakes produced surface ruptures along the fault in Afghanistan in 1505, 1892, and 1975 (Quittmeyer and Jacob, 1979; Lawrence and others, 1992; Yeats and others, 1979). Study of aerial photographs and interpretation of Quaternary geomorphology by Wellman (1965) suggest that slip rates on the Chaman Fault system were between 2 and 20 millimeters per year (mm/yr).

The Katawas Basin is the largest mid-alpine structure of southeast Afghanistan (German Geological Mission in Afghanistan, 1969; Ganss, 1964a, b, 1970; Denikaev and others, 1970; Koshelev, 1972; Sborshchikov and others, 1974, 1975). This synclinorium plunges to the southwest (fig. 8A–3). The northeastern parts are composed of weakly metamorphosed and folded 6,000–meter (m)-thick Permian-Triassic and Jurassic carbonate terrigenous rocks. Rocks constituting the basement complex are Paleogene, mostly Eocene in age. They have been crumpled to form northeast-trending folds that locally have been intruded by small bodies of Miocene diorite and syenite porphyries.

The Katawas Basin was named by the geologists of the German Geological Mission to describe a larger area including the Afghan part of the Kabul and the Khost areas (fig. 8A–5) (Dronov and others, 1973; Sborshchikov and others, 1974, 1975). The basin was studied and described by Mennessier (1968, 1970a, b, c), Kaever (1964, 1967a, b), Ganss (1964a, b, 1970), Bruggay (1973), Denikayev and others (1971), and Koshelev and others (1972). The Katawas Basin extends for 650 km (from south to north), and is as much as 160 km wide (fig. 8A–4). The boundary between the basin and the Khost Ophiolite is obscure, but probably tectonic. The main geosynclinal complex is composed of 4,490- to 7,550-m-thick, flysch-like, and irregularly interbedded, deformed and faulted Oligocene sandstone, shale, and siltstone as well as local limestone and conglomerate. Mafic volcanic rocks are common at the base of the sequence (fig. 8A–5).

The Katawas gold AOI lies along the faulted boundary between the Daste Nawar Trough and the Base Estada Sub-Basin within the greater Katawas Basin (figs. 8A–4 and 6*a*). Most faults in the Katawas Basin strike parallel to the general strike of folds and therefore is likely to be coeval with much of the folding. The structural pattern is dominated by independently different zones of folding (fig. 8A–6*b*). The Katawas gold AOI and its sub-zone lie above or proximal to aeromagnetic anomalies that may signify small intrusive bodies (figs. 8A–7*a, b*).

8A.4 Metallogeny

Mineral deposit types that are likely to be present in the Katawas gold AOI are base- and precious-metal epithermal deposits. Elsewhere in Afghanistan, epithermal occurrences and deposits of mercury, and, locally, associated base metals and possibly precious metals are hosted in Early Cretaceous continental calcareous sedimentary rocks intruded by Eocene to Oligocene porphyritic diorite dikes. These mineralized systems are present in Farah, Ghor, Oruzgan, and Bamyan Provinces (Peters and others, 2007). Porphyry copper deposits were also speculated to occur along the southwestern margin of the Katawas Basin (Ludington and others, 2007).

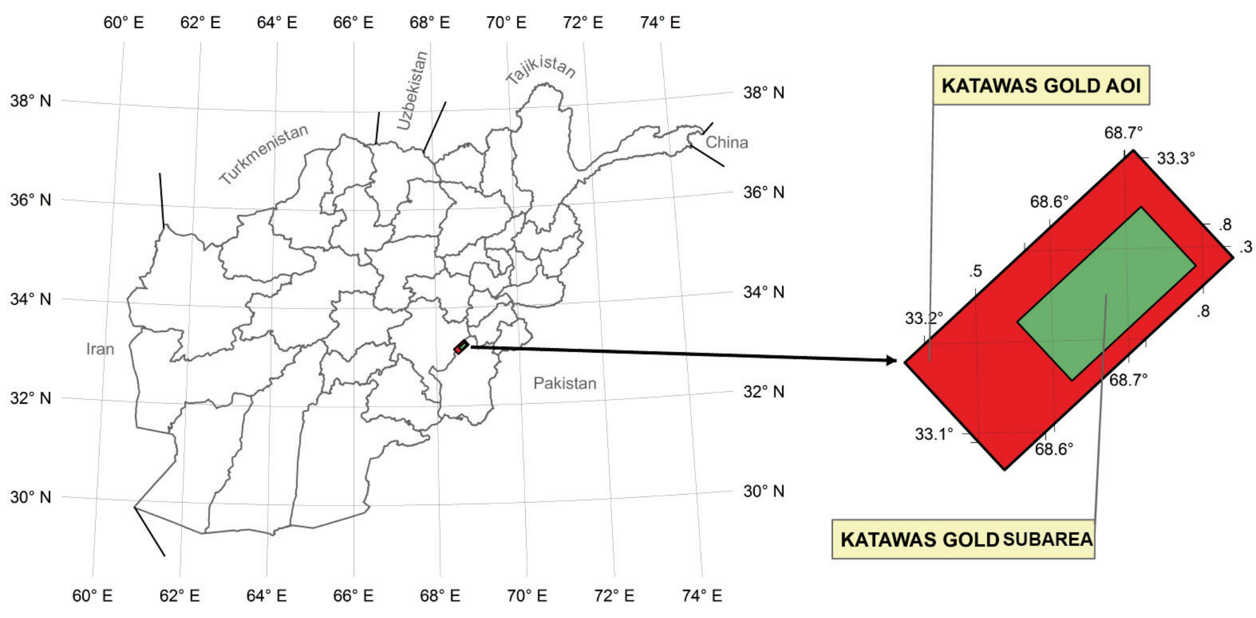

Figure 8A–1. Location of the Katawas gold area of interest in southeastern Afghanistan (and subareas) in Afghanistan. Katawas gold is one of the smaller areas of interest.

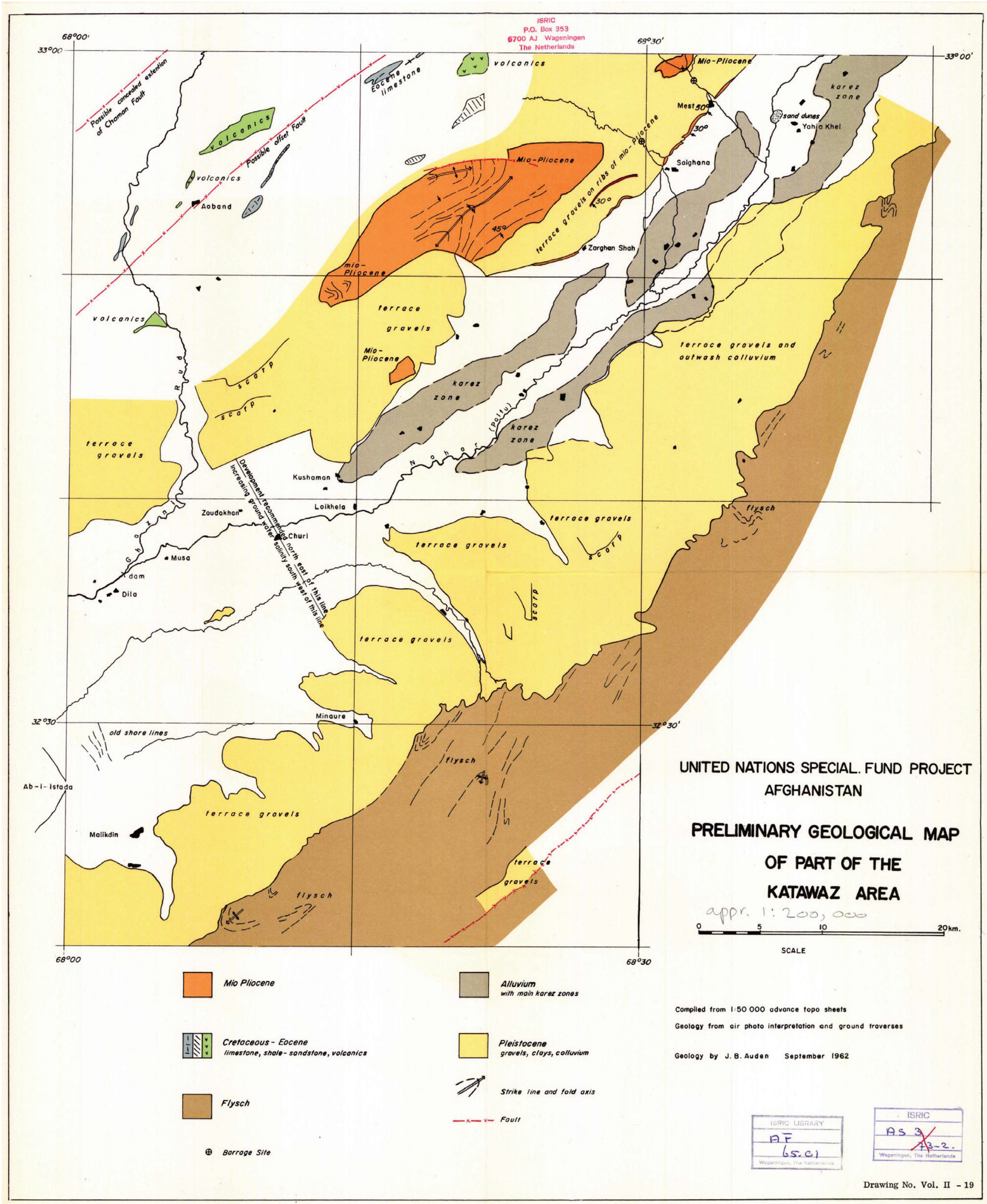

Figure 8A–2. Scanned version of a map from Auden (1962) presented as an example of previous work in the Katawas Basin area. Katawas gold area of interest lies to the north of this figure.

Mercury occurrences elsewhere in Afghanistan occur in shattered fault zones and contain carbonate, dickite, and silica alteration. Mineralization types include disseminations and veinlets of cinnabar, which locally are accompanied by pyrite, chalcopyrite, and arsenic sulfide minerals. The

Katawas Basin had a similar although younger geologic environment (Peters and others, 2007) and also contains numerous mercury geochemical halo dispersion anomalies that are hosted in Mesozoic and Cenozoic sedimentary and volcanic rocks in northeast Kandahar, east Zabul, and Paktika Provinces (figs. 8A–8 and 9). The three principal classes of mercury deposit types that could be present, as suggested in Peters and others (2007), are hot-spring mercury (Rytuba, 1986a), Alamaden mercury (Rytuba, 1986b), and silica-carbonate mercury deposits (Rytuba, 1986c). All three deposit models have some similar characteristics but differ in size and locally in age and host rock type. Characteristics of all three model types are present in Afghanistan in the Katawas Basin (Abdullah and others, 1977); however, the general hot-spring mercury model may be the most understood and the most applicable, because of the widespread mercury geochemically anomalous halos there. Epithermal mercury deposits in Afghanistan contain features that are highly compatible with those found in precious- and base-metal deposits elsewhere in the world. By further speculation, hypothetical precious-metal deposits in the Katawas Basin, such as those targeted in the Katawas gold AOI, should contain compatible features.

Deposits commonly genetically and spatially associated with epithermal mercury deposits are epithermal gold and silver deposits, and a few gold anomalies are present in the Katawas Basin (fig. 8A–8). Epithermal gold deposits are divided into a number of different types by Cox and Singer (1986). The quartz-adularia types have been described by Berger (1986) and quartz-alunite by Mosier and others (1986a, b). Associated deposit types are porphyry copper, polymetallic replacement, and volcanic-hosted Cu–As–Sb. Alteration products such as pyrophyllite, hydrothermal clay, and alunite also are commonly associated with these deposits. Summaries of the characteristics of precious- and base-metal epithermal deposits are contained in Cox and Singer (1986) and Simmons and others (2005). The presence of 19 geochemically anomalous halos of mercury, tungsten, gold, and (or) lead within the Katawas Basin (figs. 8A–8 and 9) suggests the likelihood that several mineralizing hydrothermal systems may have been active in the basin either during or after the development of the basin. A number of areas within the Katawas Basin have evidence of hydrothermal activity and base- or precious-metal activity.

The first area that shows evidence of hydrothermal activity in the Katawas Basin is area 1 on figure 8A–9. Mapping of ASTER imagery has identified phyllic and argillic alteration zones that are spatially associated with Miocene plutons and stocks (map unit N^1dig, Doebrich and Wahl, 2006) (fig. 8A–10*a*). This altered area was designated as a permissive tract for porphyry copper deposits (Mars and Rowan, 2007; Ludington and others, 2007; Peters and other, 2007). The area is locally anomalous in mercury and tungsten with trace amounts of lead and zinc along a northeast-striking linear zone. The western boundary of the altered zone is the Chaman Fault (fig. 8A–10*a*). The alteration patterns are linear and spatially correspond with the distribution of the Miocene alkaline intrusive outcrops and faulting (fig.8A–10*a*). The intrusive rocks have no apparent magnetic signature and therefore could be ilmenite-series rocks and are described as diorite, granodiorite, monzonite, syenite, and nepheline syenite porphyry (Doebrich and Wahl, 2006).

The second area that shows evidence of hydrothermal activity in the Katawas Basin is area 2 on figure 8A–9. The area contains a number of hydrothermal quartz veins discovered recently by a local prospector (fig. 8A–11). These veins have comb textures that are indicative of mesothermal to epithermal depths of formation. Additional information is not available (A. Chaihorsky, Reno, NV, oral commun., 2010).

The third area that shows evidence of hydrothermal activity in the Katawas Basin is area 3 on figure 8A–9, the Spira–Zanda Gharay lead-zinc (copper) area that contains the Spira lead-zinc prospect and the Zanda Gharay lead-zinc vein, both in Khost Province along the eastern, faulted boundary of the Katawas Basin (fig. 8A–10*b*). The Spira lead-zinc prospect lies along the contact between Triassic sandstone, slate, and limestone and Paleocene conglomerate and sandstone in a 40– to 60–m-wide brecciated, hydrothermally altered zone. Mineralization is 380 m long, 7 to 15 m wide, and 40 to 77 m deep and contains disseminated veinlets of massive sphalerite, galena, and pyrite grading 1.12 weight percent zinc, with traces of antimony, arsenic, nickel, and silver. Estimated reserves are 11,900 tonnes combined Pb and Zn (3,100 tonnes Pb, 8,800 tonnes Zn) (Nikitin and others, 1973). The Zanda Gharay vein lies along the north- northeast-trending brecciated and hydrothermally altered fault zone between Lower Carboniferous slate and Eocene conglomerate (fig. 8A–10*b*). Individual zones are anomalous in copper. These two occurrences indicate that there has been post-Eocene hydrothermal activity on the eastern margin of the Katawas Basin. The features in each occurrence are compatible with the hydrothermal processes.

8A.5 Known Deposits

There are no known mineral deposits within the Katawas gold AOI. This is a speculative AOI and requires ground visits, field mapping, and sampling to authenticate remote-sensed indications of mineralization.

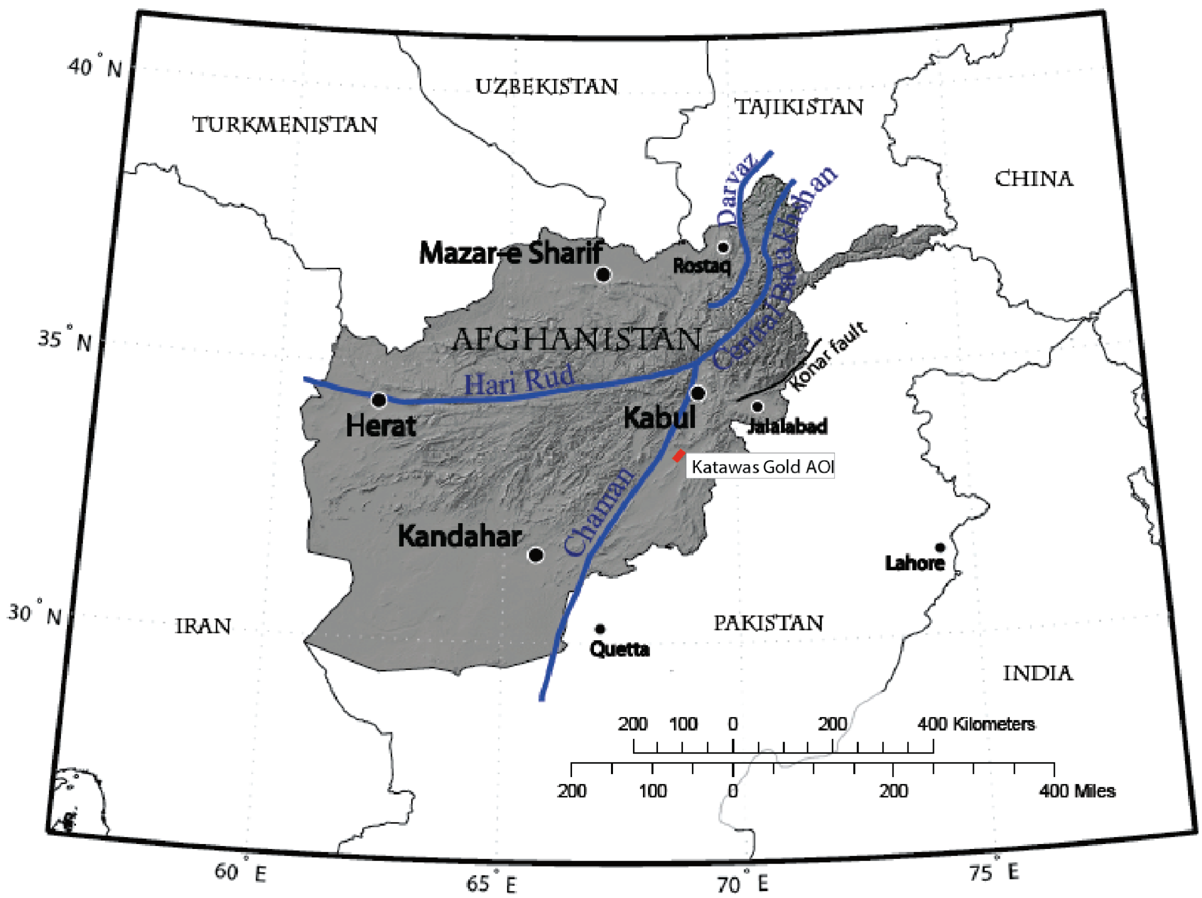

Figure 8A–3. Shaded relief map of Afghanistan showing major earthquake faults from Boyd and others (2007) and proximity of the Katawas gold area of interest to the Chaman Fault.

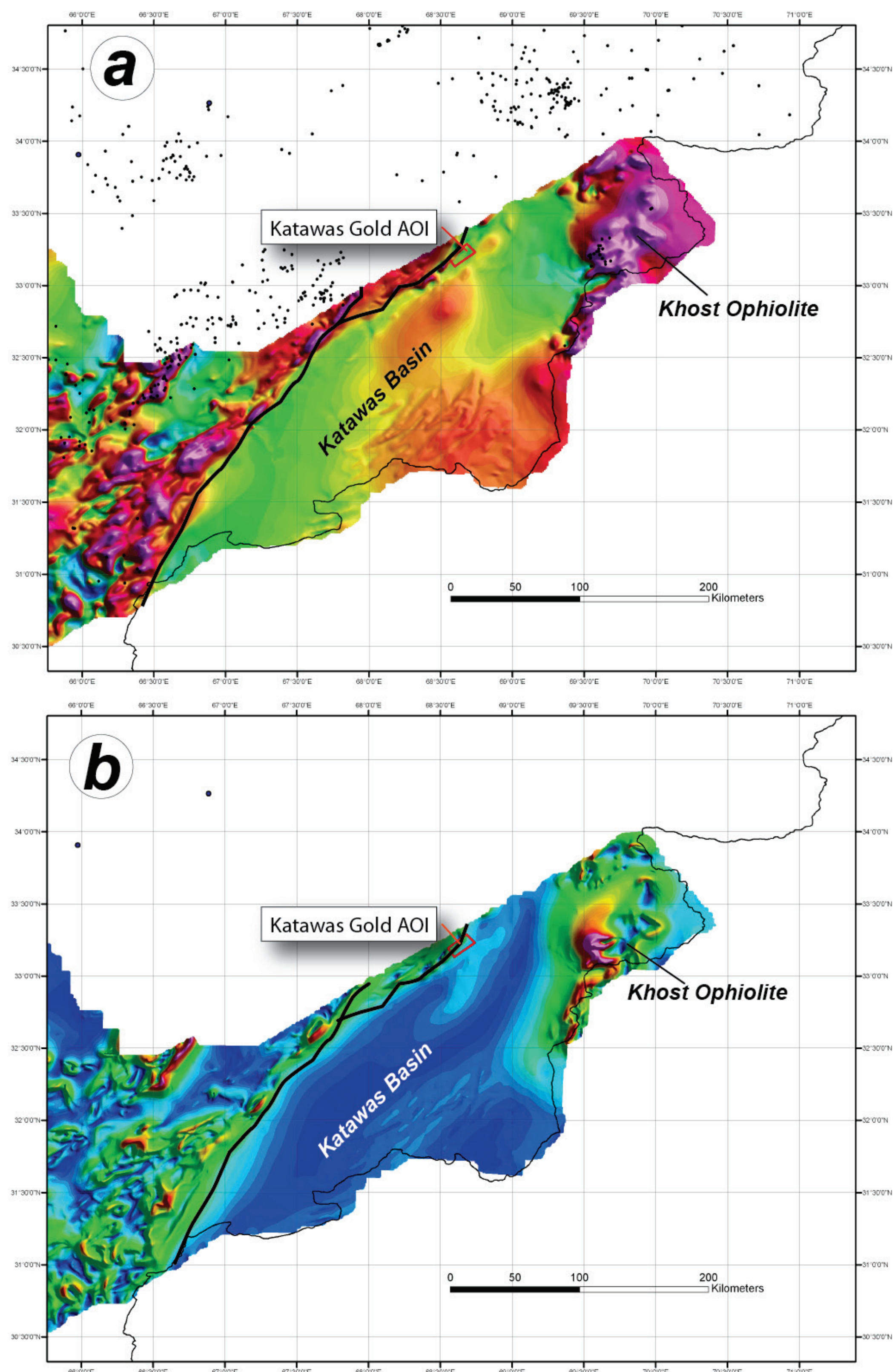

Figure 8A–4. Geophysical maps of the Katawas Basin area, eastern Afghanistan showing location of the Chaman Fault (thick black line), Katawas gold area of interest, Katawas Basin, and Khost Ophiolite. Data from Sweeney and others (2006). (*a*) Aeromagnetic anomaly map reduced to pole. Small dots are villages. (*b*) First-derivative aeromagnetic map.

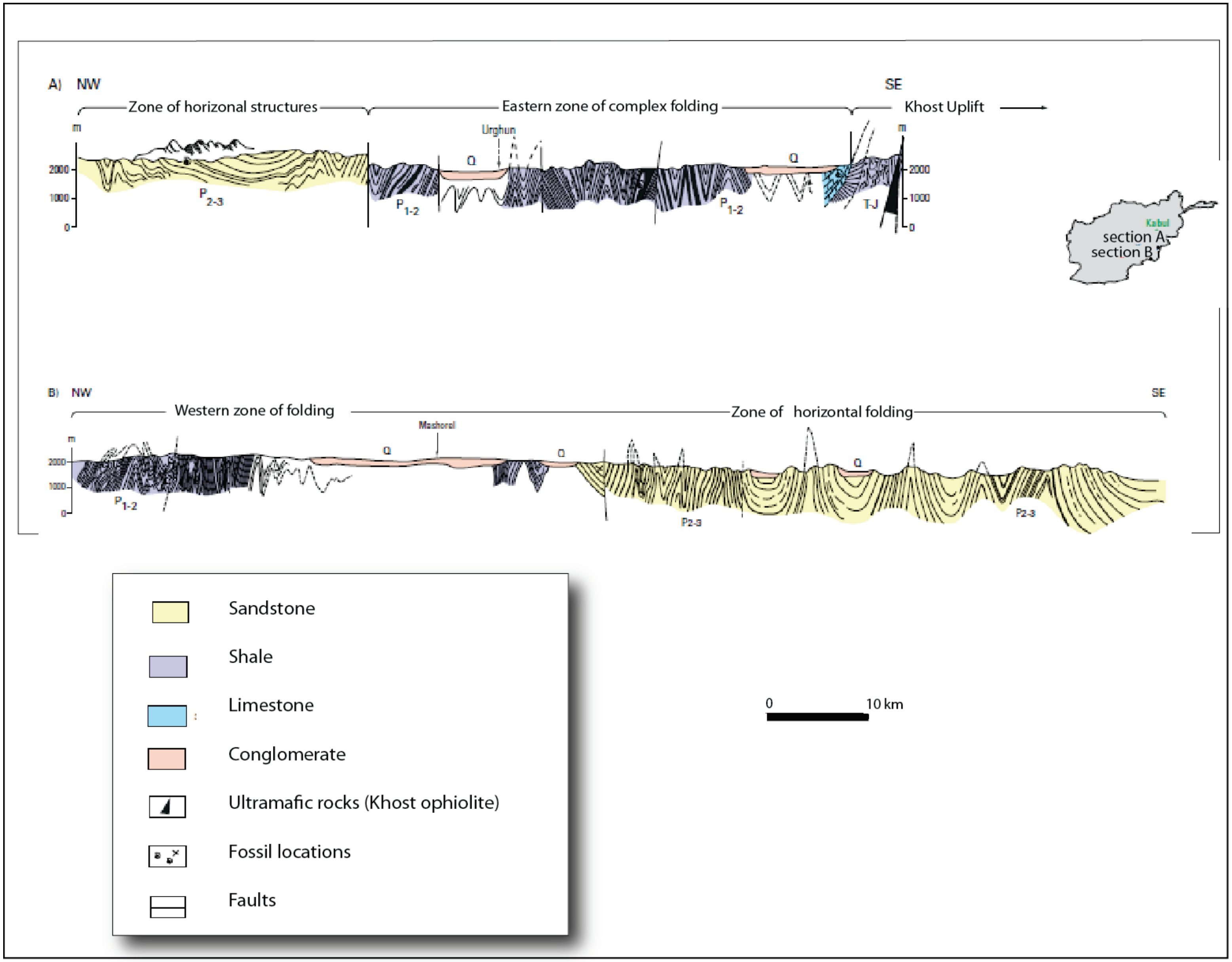

Figure 8A–5. Geologic cross section through the Katawas Basin, from Sborshchikov and others (1975), as reproduced in Abdullah and others (1977). (A) Along the Urgun-Shkin line. (B) Along the Mashorei line.

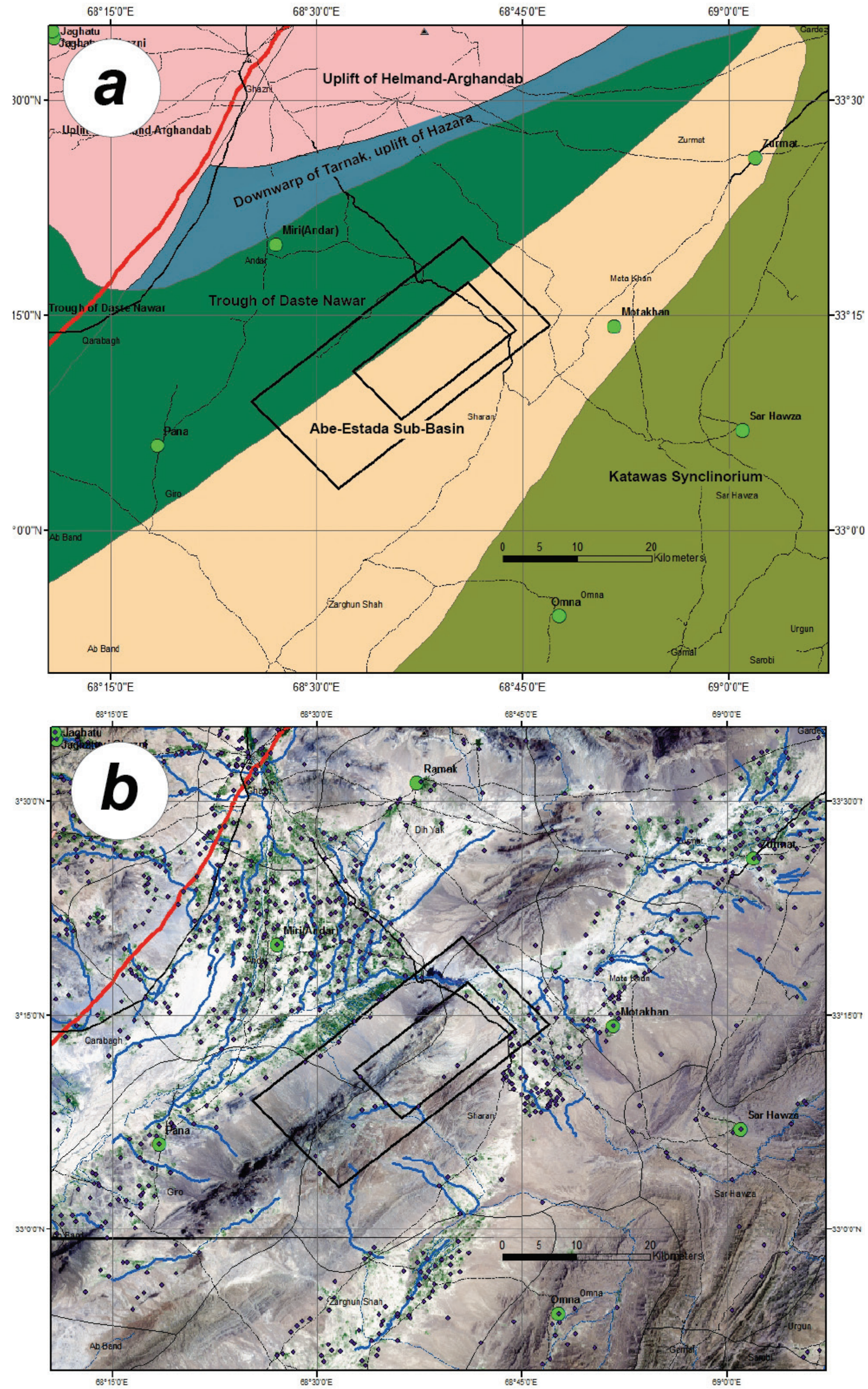

Figure 8A–6. Maps showing features in and around the Katawas gold area of interest (AOI). (*a*) Tectonic divisions of the area (data from Peters and others, 2007). The Katawas gold AOI lies along the boundary between the Daste-Nawar Trough and the Abe-Estada Sub-Basin. (*b*) Landsat image showing outline of the AOI, major villages (green circles), smaller villages (small black dots), and rivers. A northeast-trending lineament is evident in the outcrops.

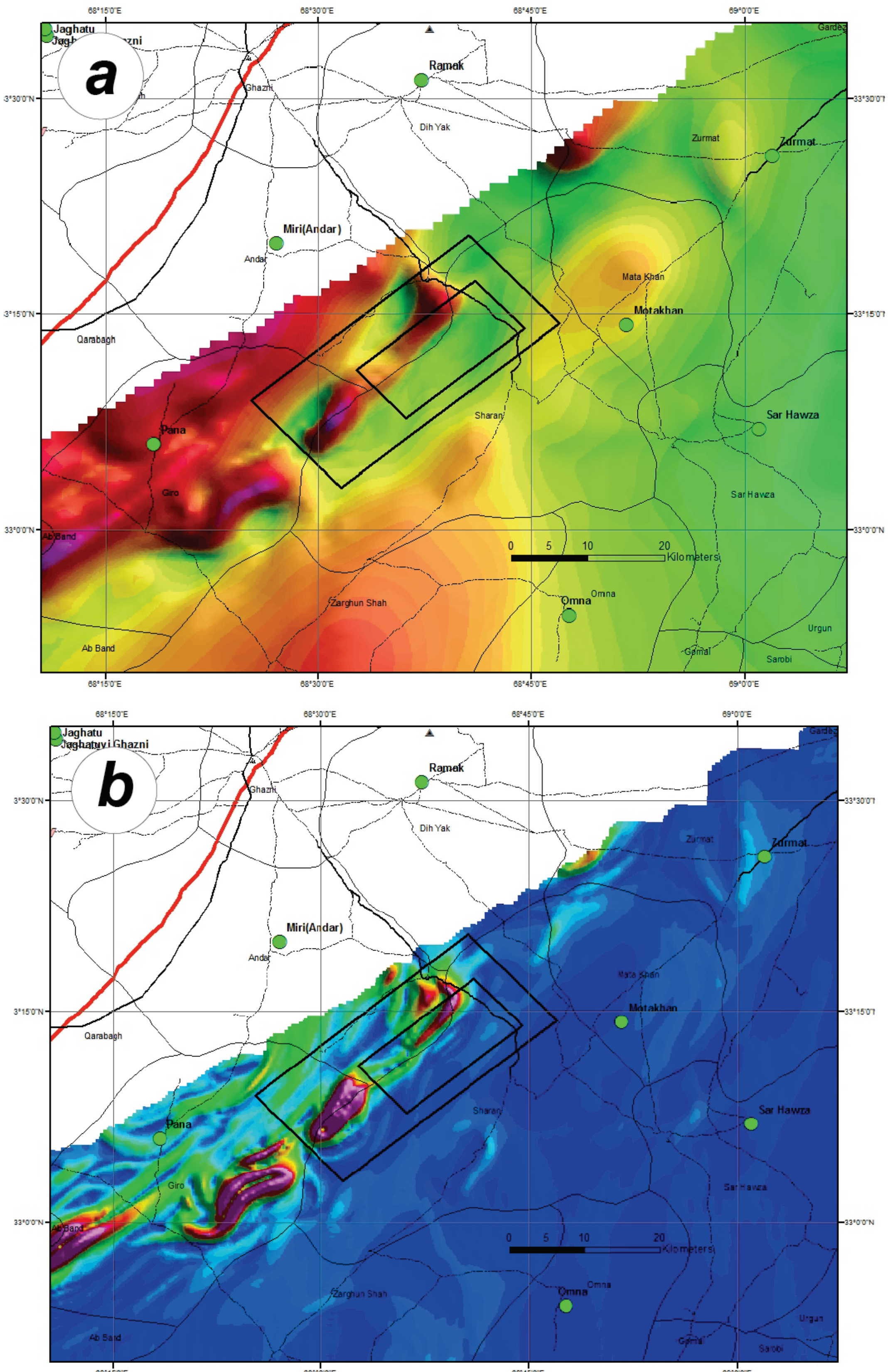

Figure 8A–7. Maps of airborne geophysical data of area proximal to the Katawas gold area of interest (AOI) (derived from Sweeney and others, 2006). (*a*) Magnetic anomalies. (*b*) First- derivative magnetic anomalies. Warmer colors indicate higher magnetic zones. Probable igneous intrusives are indicated within and proximal to the AOI by red-colored anomalies.

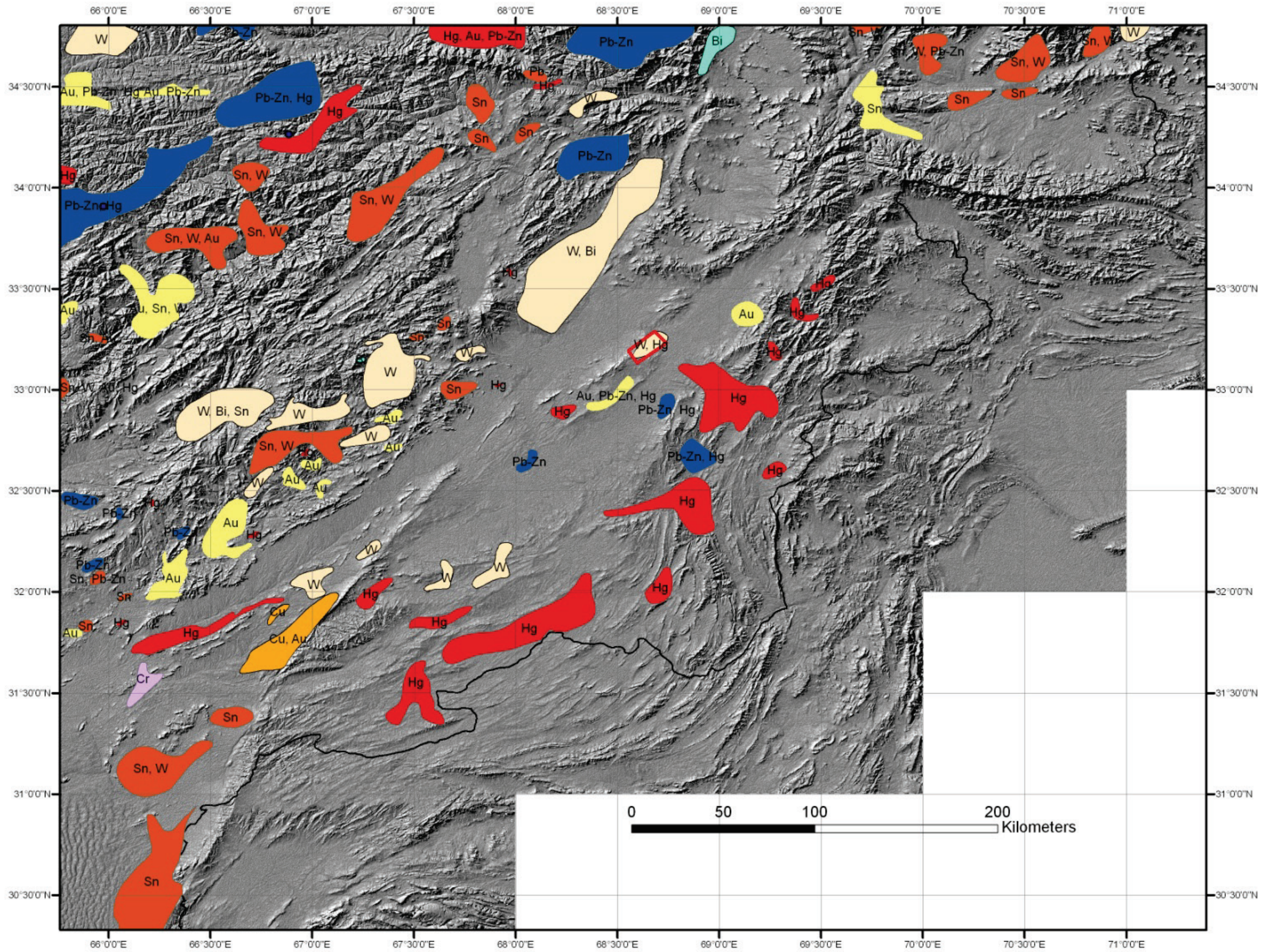

Figure 8A–8. Shaded relief map showing location of geochemical dispersion halo stream-sediment sample anomalies in proximity to the Katawas gold AOI (red rectangular outline). Anomalies are labeled as to the major anomalous element(s) present. Note that the Katawas gold AOI lies within a tungsten-mercury anomaly and is proximal to gold anomalous halos. Data from Peters and others (2007).

8A.6 Katawas Gold AOI Area Anomaly

Stream-sediment geochemistry used together with targeted identification of hydrothermal alteration and (or) aeromagnetic anomalies has been successful in locating volcanic-hosted epithermal Au–Ag–Zn–Pb–Cu deposits on the North Island of New Zealand (Sheppard and others, 2009), as well as sedimentary rock-hosted epithermal (Carlin-type) Au deposits in China (Zhang and others, 2010). Hedenquist and others (2000) review the deposit textural types, host-rock environments, fluid hydrothermal alteration regimes, resulting mineralogy, weathering, and supergene processes related to the formation and exhumation of epithermal gold deposits. In particular, they distinguish different types of epithermal deposits such as (1) high-temperature argillic alteration—dominated by illite ±quartz, (2) moderate-temperature argillic alteration—dominated by interstratified illite-smectite clay minerals, and (3) low temperature argillic alteration—dominated by smectite. In addition they describe high temperature propylitic alteration (with epidote present) type deposits and low temperature propylitic alteration types (with chlorite and (or) calcite present).

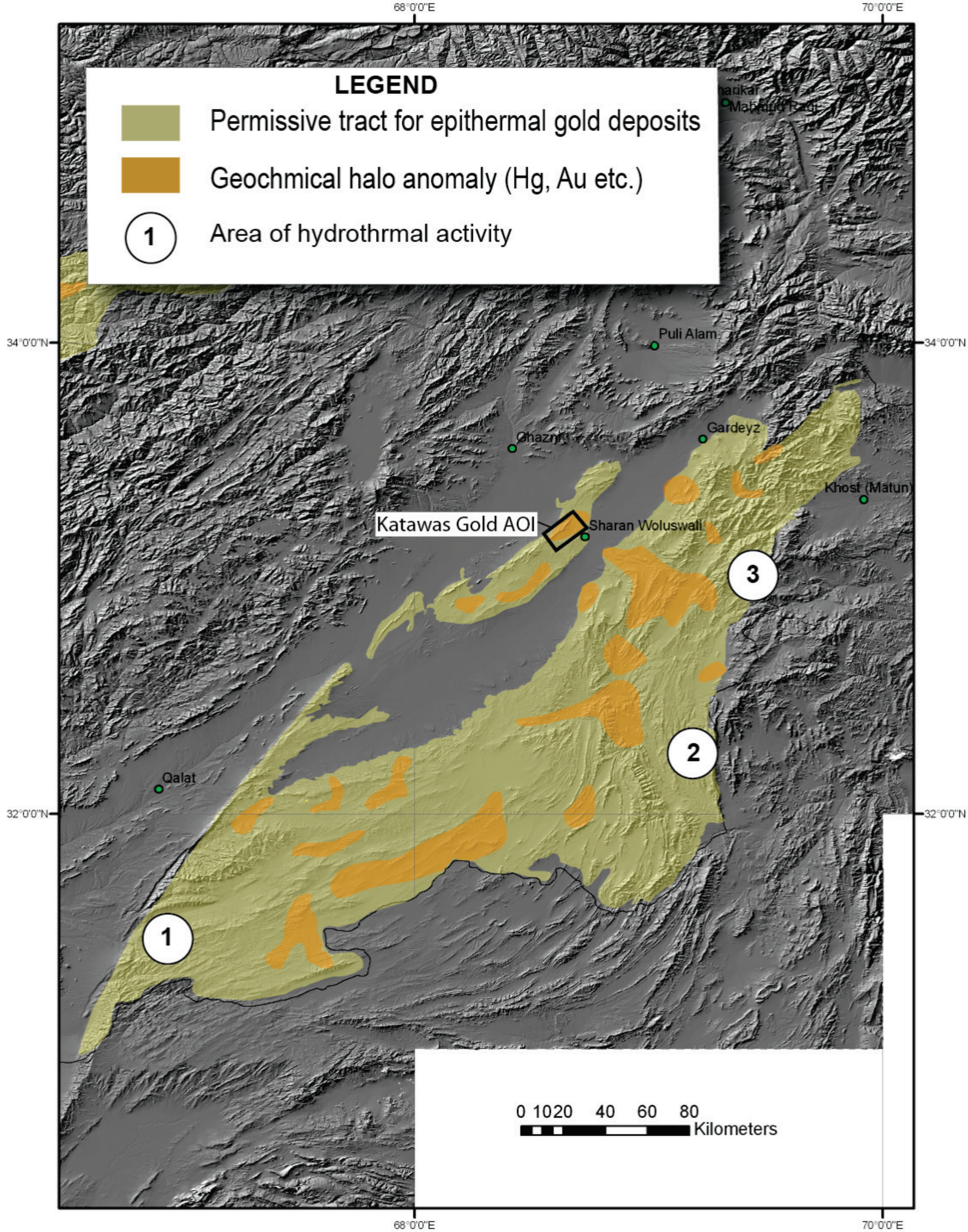

Figure 8A–9. Map showing location of Katawas gold area of interest (AOI) in the Katawas Basin and permissive area for epithermal gold and mercury deposits (Peters and others, 2007). Areas where additional hydrothermal activity has been described in the Katawas Basin outside the AOI are (1) southwestern Katawas, from Mars and Rowan (2007), (2) East Paktika, and (3) West Khost Spira lead-zinc prospect area.

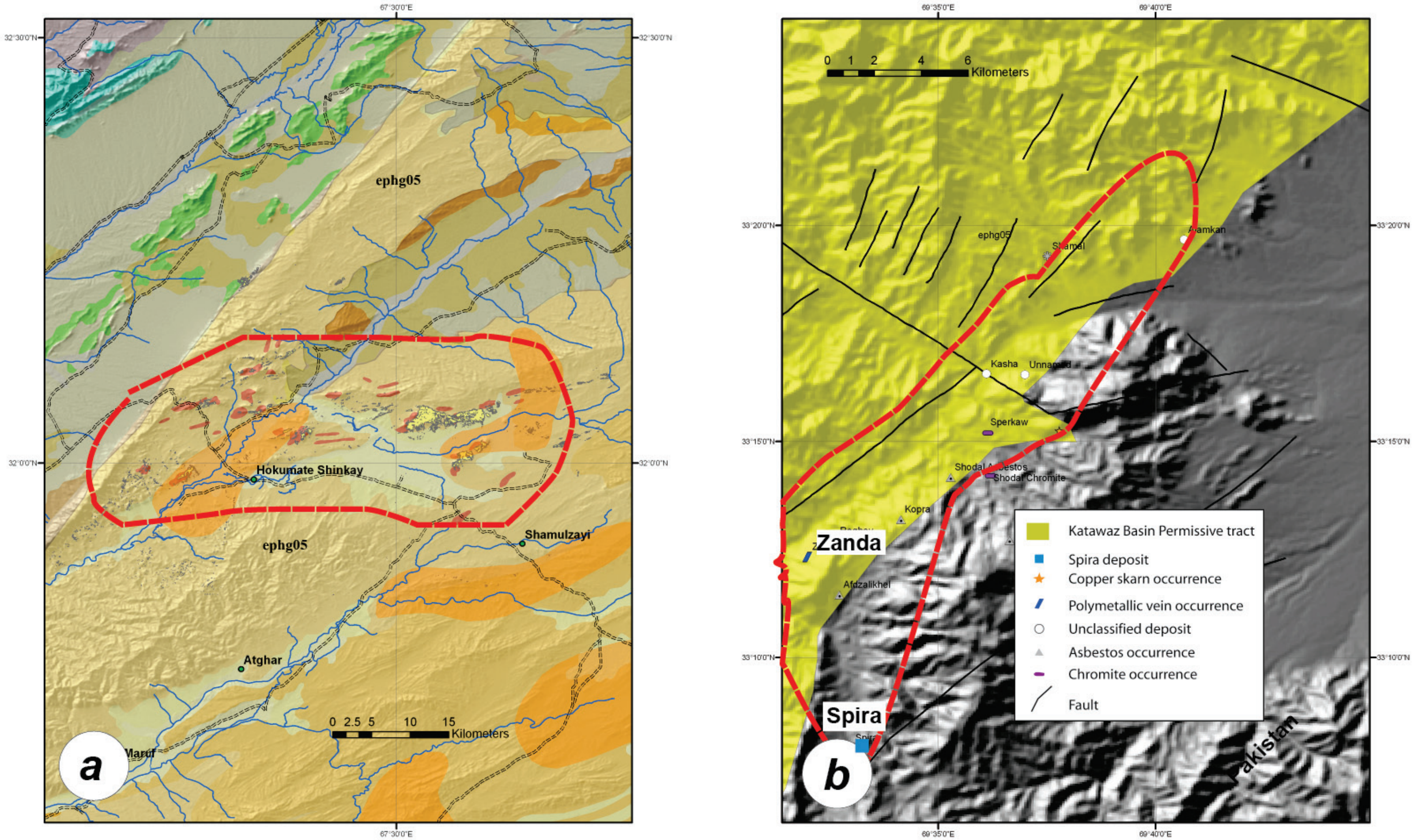

Figure 8A–10. Maps of two areas suspected of hydrothermal activity in the Katawas Basin (Peters and others, 2007). (*a*) Southwestern Katawas ASTER anomaly area (outlined dashed red line) of Mars and Rowan (2007). This is area 1 in figure 8A–9. Miocene intrusives contain both argillic and propylitic alteration assemblages within and proximal to them. Alteration areas are gray and yellow polygons. (*b*) Map of Spira–Zanda Gharay lead-zinc (copper) area (outlined with dashed red line) in eastern Paktia Province on the faulted eastern margin of permissive tract for mercury. This is area 3 on figure 8A–9.

Most of these minerals (all of the phyllosilicates) can be detected using visible to infrared reflectance data (0.4- to 2.5-micrometer (µm) wavelength region) from either hyperspectral sensors or an advanced multispectral sensor such as ASTER. The latter has additional multispectral bands in the 8- to 14-µm wavelength region of the thermal infrared (TIR) useful for mapping quartz and other primary rock-forming silicate minerals. The ratio of ASTER visible wavelength bands 2/1 is useful for mapping ferric-iron minerals, while the ratio of ASTER TIR bands 13/12 is useful for mapping quartz (Rowan and others, 2003). Collectively, these two ASTER band ratio results can be thresholded to map gossanized areas (as well as ferricrete, "pseudogossans" and some types of laterites – Raines and Gabell, 1982; Raines and others, 1985; Fraser and others, 1986) containing both mineral types. This same mineral combination is depicted as green in figure 8A–12.

The resulting image spectral analysis and classification (fig. 8A–12) show that the Katawas gold AOI contains an ASTER anomaly with spectral and mineralogical characteristics that is similar to epithermal gold-silver deposits. The alteration assemblage mapped in the ASTER images lies well within a tungsten and mercury mineral stream-sediment dispersion anomaly (figs. 8A–12*a* and *b*). The geochemical anomaly is about 9 km long and 2 km wide and consists of a north-central area. The location of the geochemical and ASTER anomalies is the basis for identification of the AOI. The mapped ASTER imagery contains multispectral bands useful for identifying areas containing ferric-iron, clay, and quartz-rich gossans. These altered zones are mixed with signatures of illite and (or) muscovite and are bordered on the northwest and east by smectite on the lower slopes. Locally, there are also small zones of calcite and residual clays (fig. 8A–12). These alteration assemblages lie along a northeast-striking linear zone which is likely to be above or adjacent to a small igneous body (figs. 8A–6*a* and *b*) or may be hosted in a splay of the Chaman Fault zone (fig. 8A–4) separating two adjacent accreted terranes, along which such epithermal gold (and mercury) mineralization is common (Groves and others, 2003).

Figure 8A–11. Photograph of quartz vein from Paktika Province, area 2 on figure 8A–9. Width of view is 17 centimeters.

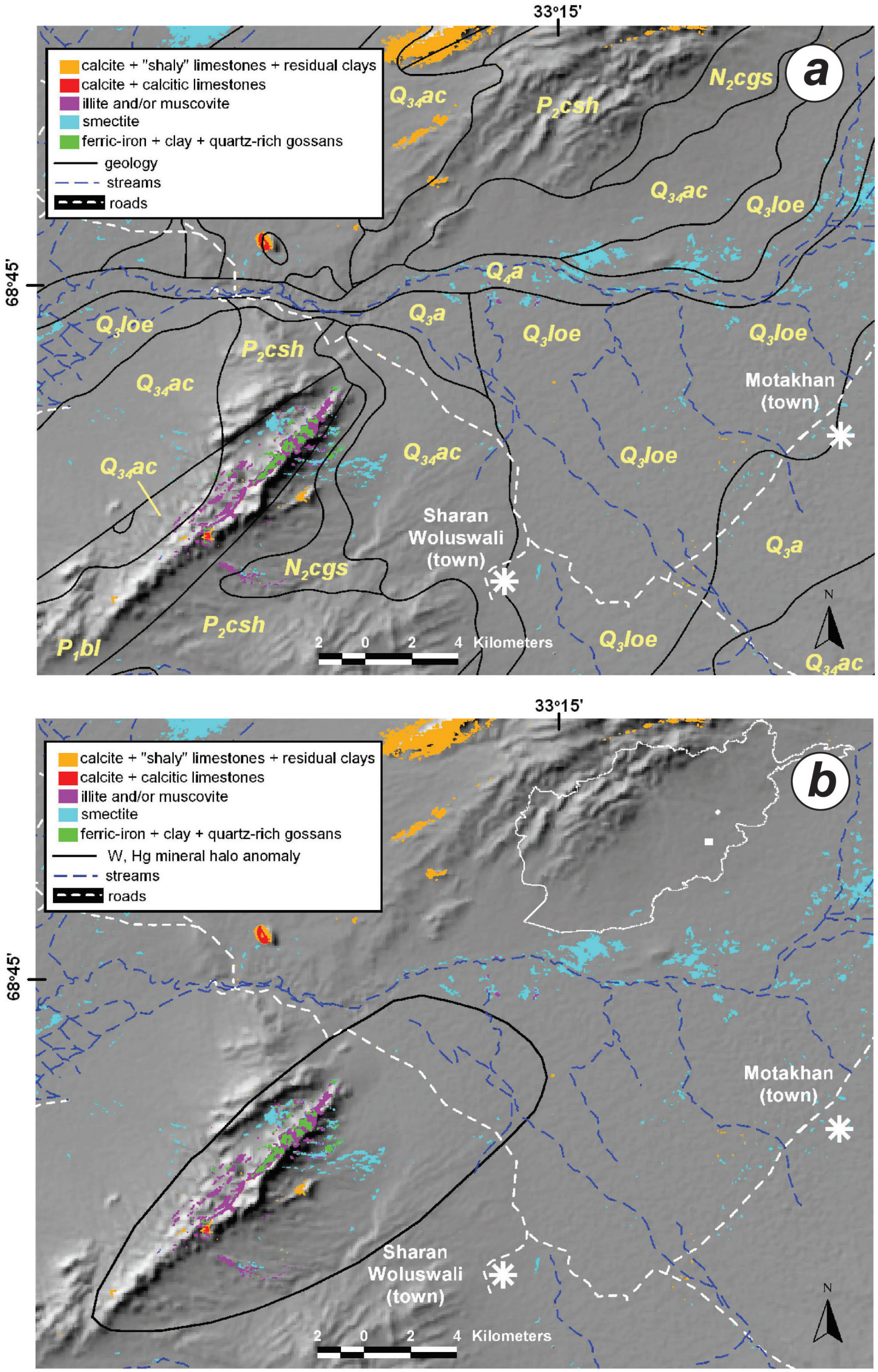

Figure 8A–12. Maps showing ASTER anomalies in and around the Katawas gold area of interest. (*a*) Geologic map areas (lithologic symbology after Doebrich and Wahl, 2006) and ASTER anomalous zones. (*b*) Geochemical anomaly of tungsten and mercury around ridge containing gold subarea.

8A.7 Summary of Potential

The Katawas gold Area of interest (AOI) was delineated because it was thought to contain a specific multi-mineralogical alteration assemblage mapped in ASTER imagery that matches many precious- metal epithermal systems. The AOI also has a linear shape suggesting that it is also structurally controlled. In addition, the alteration zone lies well within a geochemical dispersion halo anomaly that also is compatible with geochemical signatures found in epithermal base- and precious-metal deposits. The presence of quartz and limonite in ASTER mapped "gossanized" areas is a good indication that such a system may be present.

The alteration area in the AOI should be visited, mapped, sampled, and prospected for mineralized rock. If epithermal deposits are present in the altered area, it is likely that other minor zones on the margins or locally within the Katawas Basin may also contain both concealed and other exposed epithermal deposits.

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