Chapter 5A. Summary of the Daykundi Tin, Tungsten, and Lithium Area of Interest

Contribution by Stephen G. Peters

Abstract

The Daykundi tin, tungsten, and lithium area of interest (AOI) contains several tin, tungsten, and lithium mineralized zones whose main deposit types are lithium and tantalum pegmatite, vein, stockwork, tin greisen, tin porphyry, copper, tin and tungsten skarn, and tin-tungsten replacement. Known deposits in the Daykundi AOI are spodumene-bearing pegmatite dikes at the Taghawlor lithium deposit that have a speculative lithium oxide resource of 1,464 thousand metric tons (the content is 0.08 to 2.80 volume percent lithium oxide), a tantalum pentoxide resource of 4.2 thousand metric tons (content is from 0.008 to 0.025 volume percent tantalum pentoxide), and a tin resource of 17.6 thousand metric tons (content is 0.14 weight percent tin).

Several pegmatite bodies are present to the southwest and to the southeast of the main Taghawlor pegmatite field. Many of these unnamed (pegmatite) occurrences also contain lithium as the major commodity along with tin, beryllium, zinc, and tungsten and other minor commodities. The large field of spodumene-bearing pegmatites and the wide distribution of pegmatites and granite in the area indicate that this part of the Daykundi tin, tungsten, and lithium AOI is a promising source of rare metals.

The Nili-Chak tungsten greisen prospect is a scheelite- and wolframite-bearing greisen area that covers more than 18 square kilometers. Other tin- and tungsten-bearing deposits in the area are present as small vein deposits and occurrences. Skarns are rare because the plutons intrude primarily Paleozoic and Mesozoic siliciclastic sedimentary rocks. The potential of the Nili-Chak tungsten greisen area is promising due to the large area of altered granite that surrounds the prospect area. Additional prospecting in the form of detailed geologic mapping, geochemical sampling, trenching, and drilling will be necessary to determine what size and tenor of commercial grade mineral deposits are present. The shallow topographic expression of the mineralized zone and the possible bulk-mining potential are additional positive aspects of the prospect.

Numerous tin-tungsten bearing veins, pegmatites, and skarn occurrences also are present in the eastern parts of the Daykundi AOI in the Oruzgan ore district and are not well prospected.

The presence of several tin-bearing lithium pegmatites in the western part of the Daykundi AOI suggests that parts of the Oligocene batholith have been eroded to mesozonal depths, deeper than most porphyry and stockwork systems. The presence of a number of partially explored tin-, tungsten-, and lithium-bearing magmatic-hydrothermal systems and the widespread occurrence of tin-tungsten geochemically anomalous halos suggest the presence of additional undiscovered tin deposits.

5A.1 Introduction

This chapter summarizes and interprets existing data for the Daykundi tin, tungsten, and lithium area of interest (AOI) that have resulted from joint geologic and compilation activities that were conducted between 2009 and 2011 by the U.S. Geological Survey (USGS), the U.S. Department of Defense Task Force for Business and Stability Operations (TFBSO), and the Afghanistan Geological Survey (AGS). Accompanying complementary chapters 5B and 5C address hyperspectral data and geohydrologic assessments, respectively, of the Daykundi tin, tungsten, and lithium AOI. In addition, supporting digital data for this chapter are available from the Data Center in Kabul.

This chapter provides an overview of the geology and mineral-resource potential for tin, tungsten, and lithium deposits within the Daykundi AOI. Three mining districts (Nili-Chak, Taghawlor (Taghawlor), and Oruzgan) are discussed in greater detail and are considered to be areas that are ideal for further mineral exploration.

The Daykundi AOI is in central Afghanistan and has an area of 6,838.31 square kilometers (km^2). It lies in the Daykundi and Bamyan Provinces and contains parts of the Daykundi, Waras, Shahristan, and Gizab Administrative Districts (fig. 5A–1). Deposit types expected in the Daykundi AOI are greisen tin and tungsten, tin and tungsten skarn and vein, porphyry tin, lithium and tantalum pegmatite, and polymetallic vein.

An inventory of individual data types compiled and included for this summary report is included with data and information packages that have been developed for each AOI in the AGS Data Center in Kabul. Most existing mineral-resource information comes 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 previous information, combined with a preliminary nonfuel mineral-resource assessment by the U.S. Geological Survey in 2007 (Peters and others, 2007) and compilation and interpretation of new hyperspectral data, provided much of the factual basis for technical work during 2009 through 2011.

Some prospects and deposits in the Daykundi tin, tungsten, and lithium AOI have the potential to be developed in the near future. This is because some occurrences and deposits in the Daykundi AOI are near-surface bodies with promising metallurgical and mining possibilities. Additional discoveries are likelybased on the prospective geology and lack of through exploration and prospecting.

5A.2 Previous Work

The first recorded geological investigations in the Daykundi tin, tungsten, and lithium AOI are by Dovgal and others (1971), Sborshchikov and others (1973), and Starshinin and others (1975). These regional geologic reports also describe some of the mineralized areas within the AOI. Studies specifically dealing with the Daykundi ore fields are authored by Karapetov and others (1970), Nagaliov and others (1971), Kabakov (1973), Kirichek and others (1974), and Abdullah and Chmyriov (1977). The Nili tin-tungsten greisen was described by Alkhazov and Afzali (1976), and the lithium-bearing pegmatites at Taghawlor are discussed by Rossovsky (1974) and Rossovsky and others (1976, 1977).

The petrochemistry of the intrusive rocks in the region is reported on by Debon and others (1987), and the volcanic and sedimentary rocks and the general geology of the area are described by Vachard and others (1986). Compilations of mineral occurrences in the area were completed by Abdullah and others (1977), Bowersox and Chamberlin (1995), United Nations Economic and Social Commission for Asia and the Pacific (1995), Metal Mining Agency of Japan (1998), Orris and Bliss (2002), Doebrich and others (2006), and Peters and others (2007). The most recent geologic field work is from the Soviet era in the late 1970s. The USGS conducted hyperspectral remote sensing missions over the Daykundi AOI as part of a countrywide coverage, and this work is summarized in chapter 5B of this report. In addition, geohydrologic summaries of the AOI are contained in chapter 5C of this report.

5A.3 Metallogeny

A number of tin and tungsten mineral occurrences and deposits are present throughout much of Afghanistan (Peters and others, 2007), and many of these occur within the Daykundi tin, tungsten, and lithium AOI. The most common occurrences in Afghanistan are tin- and tungsten-bearing skarn deposits spatially associated with Cretaceous to Oligocene magmatism in the west and east parts of the country. Of less importance are the tin- and tungsten-bearing pegmatite bodies. Lithium- and tantalum-bearing pegmatites also are recorded in the more deeply exposed parts of these magmatic systems (Abdullah and others, 1977). Several distinct mineral deposit types apply to granite-related tin-tungsten (Sn-W) occurrences in Afghanistan, such as tungsten skarn, tin skarn, replacement tin, tin veins, and tin greisen (Taylor, 1979; Cox and Bagby, 1986; Reed, 1986a-d; Reed and Cox, 1986; Pollard, 1995).

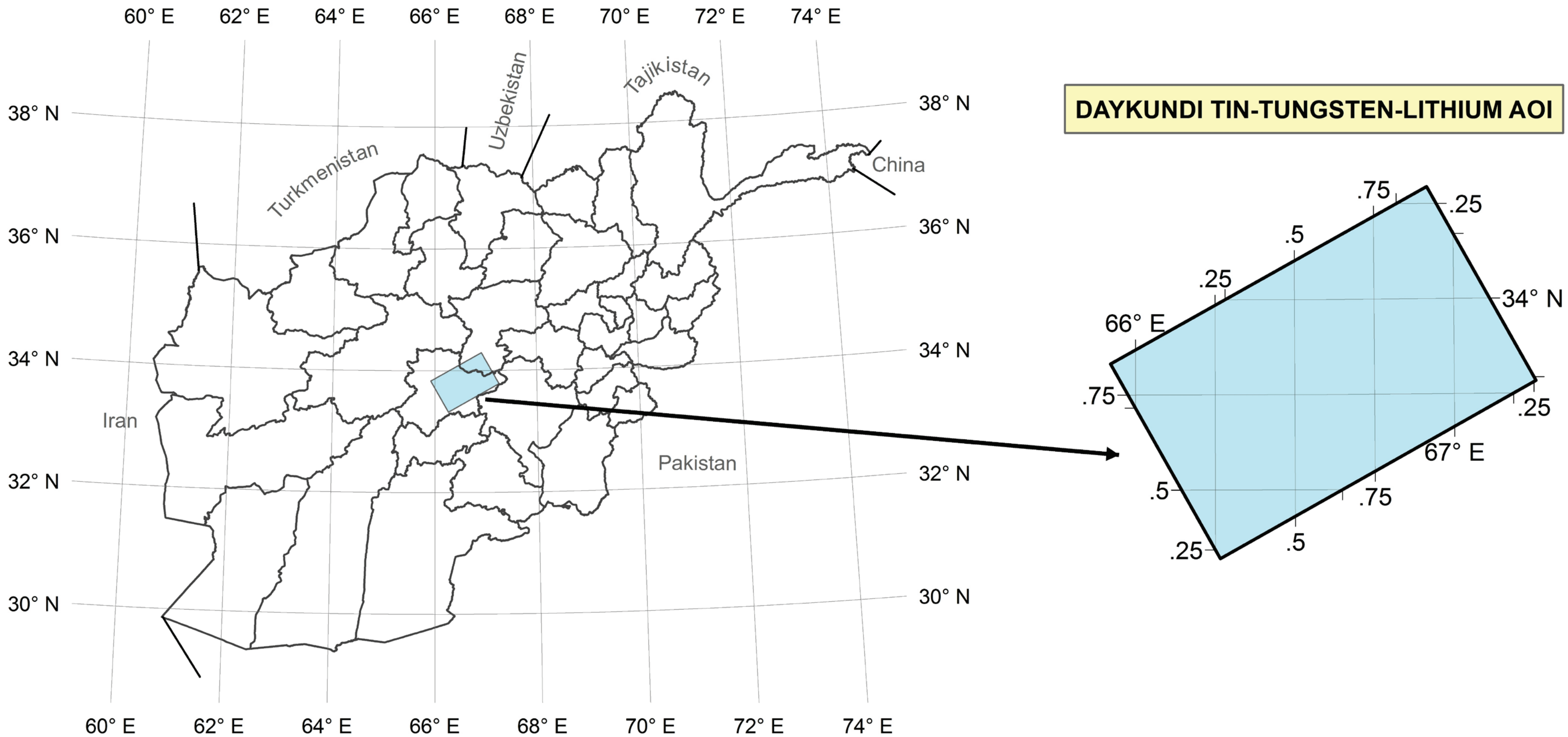

Figure 5A–1. Location of the Daykundi tin, tungsten, and lithium area of interest in central Afghanistan.

The tin and tungsten skarn and replacement tin deposits are associated with epizonal granite emplacement in carbonate terranes. These deposits typically are formed at the contacts and within roof pendants of the batholiths and within the thermal aureoles surrounding apical stocks that intrude carbonate rocks. The geology of the Afghanistan tin- and tungsten-bearing mineral occurrences and prospects is permissive for most model types, although there has been little modern production of tin or tungsten, with the possible exception of tin placer production and unrecorded production from ancient workings.

Six tracts permissive for the occurrence of undiscovered mineral deposits of tin and tungsten in Afghanistan were delineated by Peters and others (2007) (figs. 5A–2, 5A–3*a*,*b*). The main tin and tungsten occurrences are in Farah, Herat, Uruzgan (Daykundi), north Kandahar, Zabul, and Ghazni Provinces. Nearby to the Daykundi AOI, permissive geology and indications of tin- and tungsten-bearing mineralization are present in the Arghandab and Spin Boldak permissive tracts (figs. 5A–3*a*,*b*). Each permissive tract contains known mineral occurrences and is partially defined by tin- and tungsten-rich geochemically anomalous halos, as well as geology compatible with the descriptive models of tin and tungsten deposits (Nagaliov and others, 1971; Yefimenko and others, 1973; Kabakov, 1973; Kirichek and others, 1974; Abdullah and others, 1977; United Nations Economic and Social Commission for Asia and the Pacific, 1995).

Geochemically anomalous halos were generated by Soviet and Afghanistan geologists and are described in Abdullah and others (1977). They are reproduced in digital form in Peters and others (2007). The Daykundi AOI straddles the central part of the Helmand permissive tract (figs. 5A–3*a* and *b*). A number of unnamed tin, tungsten, and polymetallic deposits are present in the Daykundi AOI as well as several named prospects (Abdullah and others, 1977). The AOI contains the Nili-Chak tin-tungsten greisen prospect area, the Taghawlor lithium pegmatite field, and the Oruzgan ore district, which consists of the tin-tungsten Kunak, Charkh, and Sheng-Eskan skarn and vein subareas (fig. 5A–4).

5A.4 Geology

The north and south boundaries of the Daykundi tin, tungsten, and lithium AOI are parallel to a belt of calc-alkaline and subalkaline plutonic rocks that runs through central Afghanistan and was termed the Helmand plutonic belt by Debon and others (1987). This belt forms a small composite Cretaceous to Oligocene granite batholith. The map units associated with tin and tungsten deposits within this belt (fig. 5A–5) are P_3gd (granodiorite) and P_3gdy (granodiorite and granosyenite). These units are described in Doebrich and others (2006).

The dominant rock types within the Daykundi AOI are Early Proterozoic quartz-sericite-carbonate and chlorite-sericite-quartz schist, marble, quartzite, amphibolite, and gneissic granite bodies in the northern parts (units Y_2sc and Ygng). These rocks are in fault contact with Late Proterozoic greenschist, marble, dolomite, and metavolcanic rocks (unit Z_1scp of Doebrich and others, 2006), which is bedrock for the southern two-thirds of the AOI (fig. 5A–5). Late Paleozoic and Early Mesozoic limestone, sandstone, and siltstone lie within faulted inliers in the Late Proterozoic rocks in the southern parts of the AOI, and within smaller exposures of Middle Proterozoic rocks that are in the extreme southeastern part of the AOI. Jurassic and Cretaceous sedimentary rocks also form parts of the northeastern corner of the AOI (not shown in explanation on figure 5A–5).

The Nili-Chak greisen prospect, Taghawlor pegmatite field, and Oruzgan ore district, in the east with multiple areas, are partially explored tin- and tungsten-bearing magmatic-hydrothermal systems that are spatially associated with widespread tin and tungsten geochemically anomalous halos (figs. 5A–4 and 5A–6). These mineralized areas each measure tens of square kilometers in size. The geochemically anomalous halos are discussed in Abdullah and others (1977). Each of the mineralized areas has a direct spatial relation to a granitic body (fig. 5A–5). Uncertainty about which deposit types are present in the area (vein, stockwork, greisen, porphyry, skarn, and replacement) prevented a quantitative estimation of undiscovered deposits by Peters and others (2007). Additional field work and compilation is required to better understand the geology and mineralization in the area.

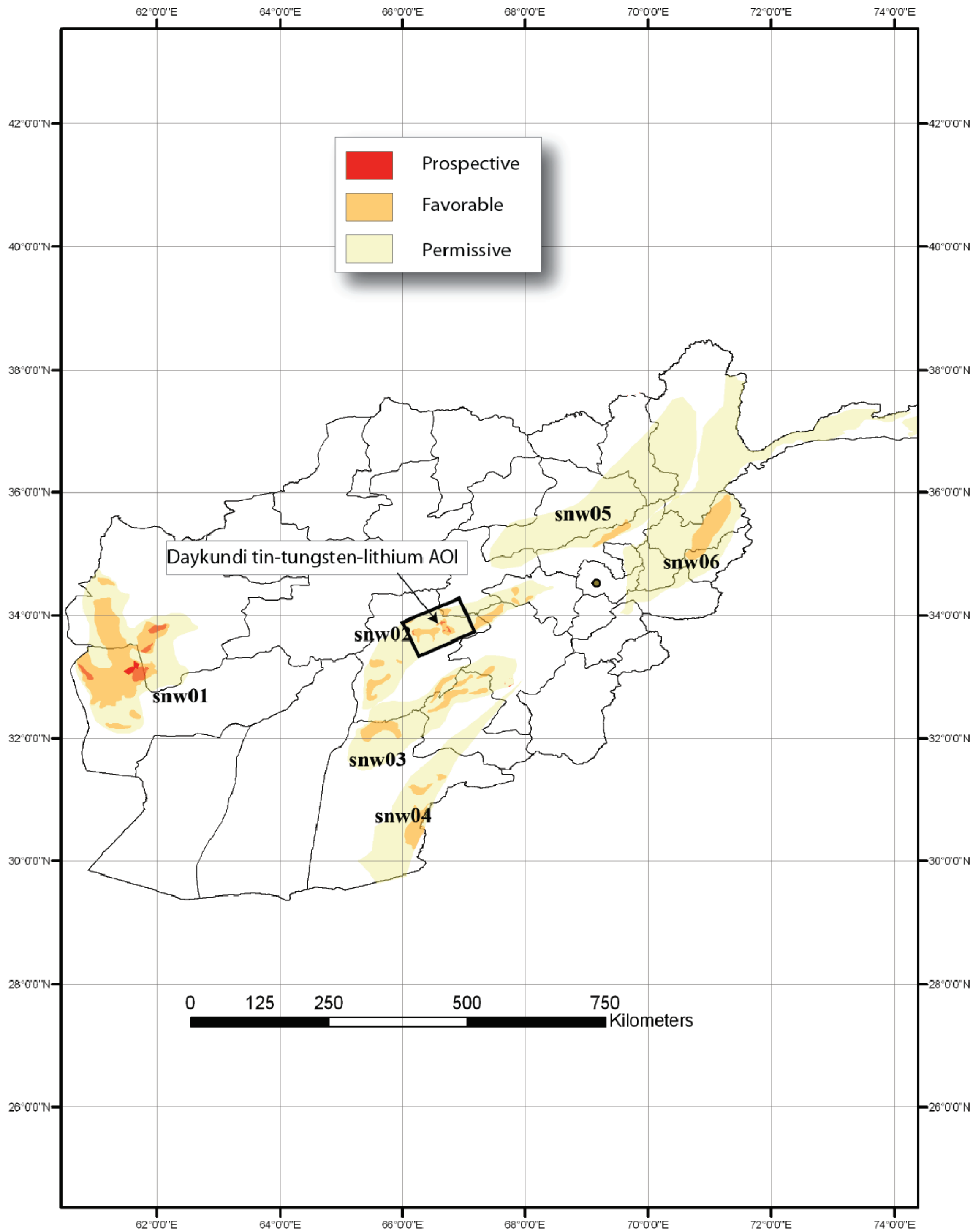

Figure 5A–2. Map showing location of six tracts in Afghanistan permissive for the occurrence of undiscovered tin and tungsten deposits and the location of internal favorable (orange) and prospective (red) tracts, from Peters and others (2007). Location of the Daykundi tin, tungsten, and lithium area of interest is outlined in black.

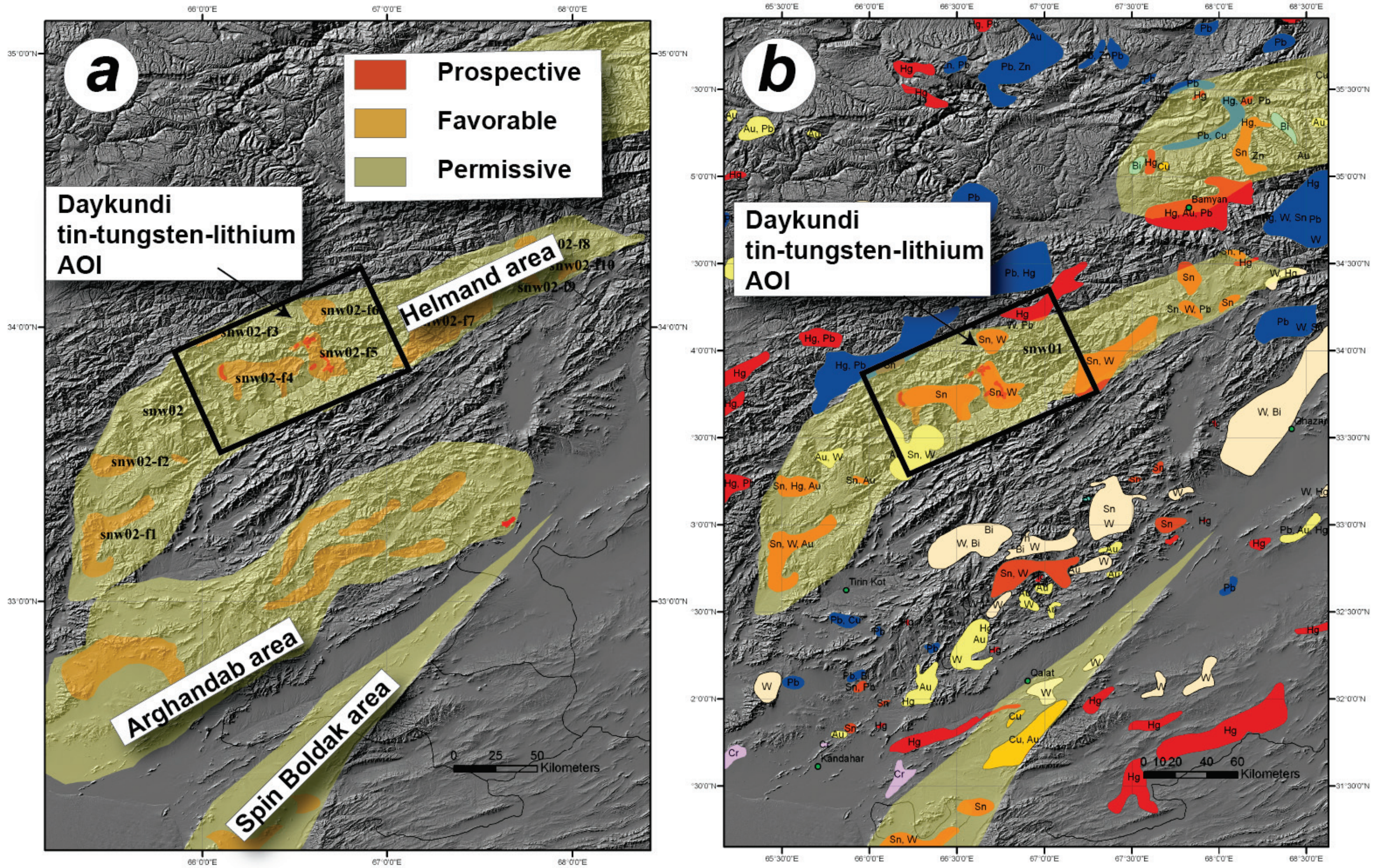

Figure 5A–3. Maps showing location of some permissive tracts for undiscovered tin and tungsten deposits in central Afghanistan (from Peters and others, 2007). See figure 5A–2 for locations. (*a*) Location of main permissive tract (mustard-yellow) and internal favorable tracts and five prospective tracts within favorable tracts in the central part of the permissive tract that contains the Daykundi tin, tungsten, and lithium area of interest. (*b*) Geochemical halo anomalies for tin and tungsten within the permissive tracts.

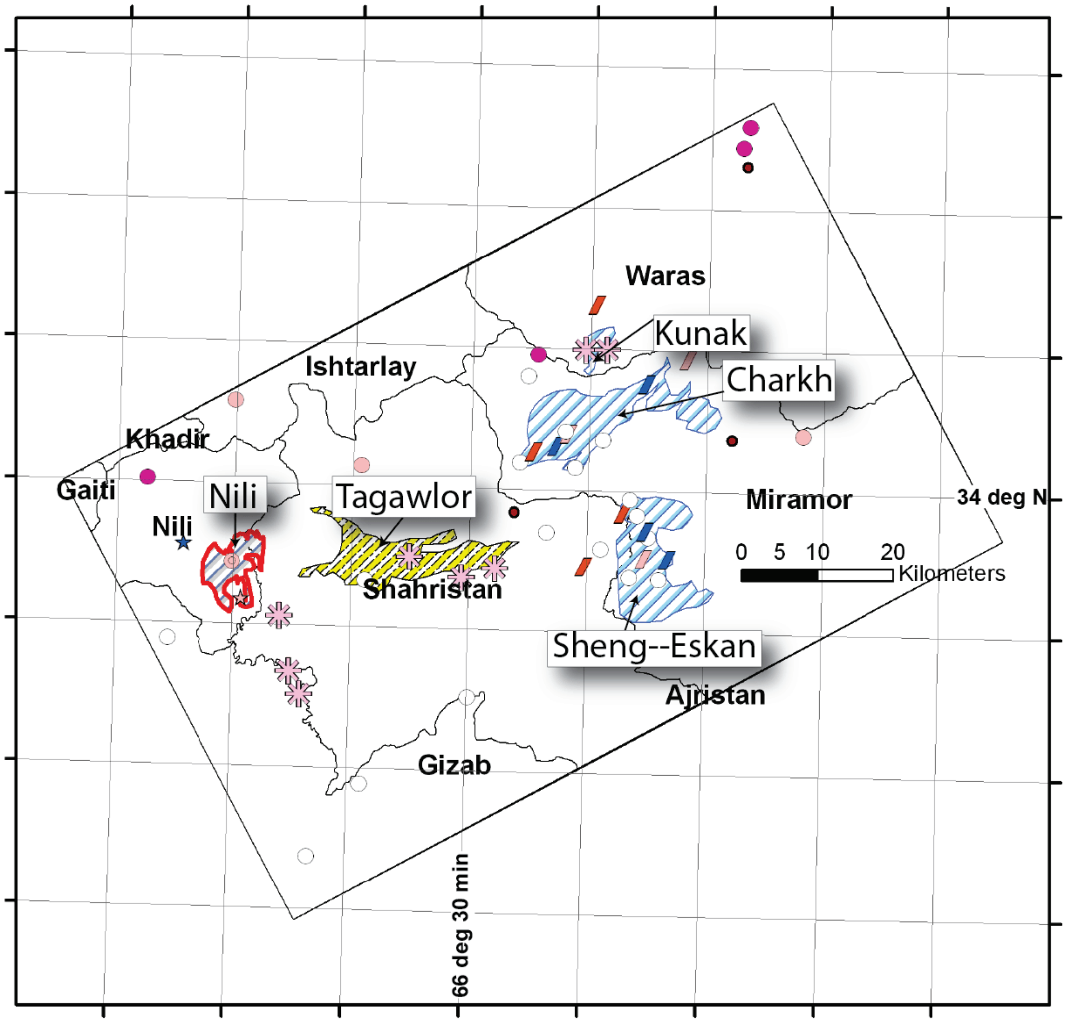

Figure 5A–4. Map showing the main areas within the Daykundi tin, tungsten, and lithium area of interest discussed in the text. The Oruzgan ore district is represented by the eastern blue areas. Patterns are digitized anomalous zones from hyperspectral images. Modified from Doebrich and others (2006). Symbols are derived and explained in Doebrich and others (2006).

5A.5 Discussion of Mineralized Zones

The principal mineralized areas in the Daykundi tin, tungsten, and lithium AOI are the Taghawlor lithium pegmatite field, the Nili-Chak tin-tungsten greisen area, and the Oruzgan ore district (composed of the Kunak, Charkh, and Sheng-Eskan areas) (fig. 5A–4). Each mineralized area has a spatial and genetic association with a specific Oligocene intrusive suite (fig. 5A–5). It is likely that each intrusive body may have specific geochemical and metallogenic influence on the mineralization in the area.

5A.5.1 Taghawlor Lithium Pegmatite Field

The Taghawlor pegmatite field is described as an elongated, nearly east-west-trending zone of steep-dipping tabular spodumene-bearing pegmatite veins (Rossovsky and others, 1977). Hyperspectral mapping has defined a zone of chlorite and calcite that closely fits this description (figs. 5A–5 and5A–7). The Taghawlor lithium pegmatite field is about 20 km long and ranges in width from 1.0 to 1.5 km. The alteration zone in the hornfels contact rocks of the composite granites is as much as 5 to 7 km wide (fig. 5A–7). The Taghawlor pegmatite field was designated as favorable for deposits of tin and tungsten and related metals (figs. 5A–8*a* and *b*) by Peters and others (2007), and the field lies within a geochemical mineral dispersion halo of tin-tungsten-gold (fig. 5A–8*b*).

The pegmatite dikes in the field are in the hornfels contact zone between Oligocene granite to the south and Late Proterozoic metasedimentary and volcanic rocks in the north (fig. 5A–7). There are three principal types of pegmatites (Rossovsky, 1974; Rossovsky and others, 1976, 1977): (1) spodumene-microcline-albite, the main type, an ore-bearing pegmatite that contains 10 to 25 volume percent, 5- to 10-centimeter (cm) - long, rarely as much as 30- to 60-cm-long, spodumene crystals; (2) microcline-muscovite, and beryl; and (3) cymatolite-albite. These are normal types of pegmatites as outlined by London (2008).

The Taghawlor lithium pegmatite field contains as many as 300 pegmatite dikes that vary in thickness from 0.5 to 35 m and are from 50 to 2,000 m long. The pegmatites contain 1-millimeter (mm) by 3- to 5-mm tantalite-columbite lamellae and up to 5-mm-long cassiterite grains. The pegmatite dikes have a speculated lithium oxide resource of 1,464 thousand metric tons with a grade of from 0.08 to 2.80 volume percent LiO_2, a TaO_5 resource of 4.2 thousand metric tons (content is from 0.008 to 0.025 volume percent TaO_5), and a tin resource of 17.6 thousand metric tons (content is 0.14 weight percent Sn).

The content of TaO_5 in the spodumene veins of the Taghawlor pegmatite field averages 0.013 volume percent TaO_5; the tantalum-niobium ratio is 2.5:1. Analysis of the distribution of tantalum-niobium mineralization in the pegmatite fields of Afghanistan shows that the flat-lying pegmatite bodies are most promising for tantalum (Rossovsky, 1974; Rossovsky and others, 1976, 1977).

Several pegmatite bodies present to the southwest and to the southeast of the main Taghawlor pegmatite field (figs. 5A–5 and 5A–7) and many of the unnamed occurrences also contain lithium as the major commodity in addition to Sn, Be, Zn, W, and other minor commodities (Abdullah and others, 1977; Orris and Bliss, 2002). The large field of spodumene pegmatites and the wide distribution of pegmatites and granites indicate that this part of the Daykundi AOI is a promising source of rare metals.

Previous geologic field work has indicated that the spodumene-bearing pegmatites of the Taghawlor field were formed within an elongated deep fracture zone in hornfels and schist. The tabular shape, considerable extension, and limited thickness of the pegmatite bodies suggest a high penetrating ability and mobile character of the pegmatite-forming melts. A number of geologic characteristics indicate that crystallization of the melt solutions occurred within tensional fissures under lithostatic pressures that are typical of shallow depth in zones of high strain, seen (expressed) as (1) orientation of long prismatic spodumene crystals, as well as quartz in the pegmatite bodies, and (2) spodumene pseudomorphs after petalite that are perpendicular to the pegmatite body (Rossovsky, 1974).

Spodumene pegmatite veins are in a 1.0- to 1.5-km-wide band of quartz-feldspar-biotite hornfels that is the exocontact of the Oligocene granite (fig. 5A–5). The spodumene pegmatite veins are not present in schist outside the hornfels zone. Consequently, the thermodynamic conditions in the narrow zone of contact metamorphism were the most favorable for the formation of spodumene pegmatite veins; this allows a rough estimation of the initial crystallization of pressure and temperature (P-T) conditions of pegmatite deposition. The mineral species in the hornfels generally correspond to an amphibole-hornfels facies of contact metamorphism (Rossovsky and others, 1976), which is characterized by pressures of several hundred to 3,000 atmospheres and temperatures of between 500 and 600 °C.

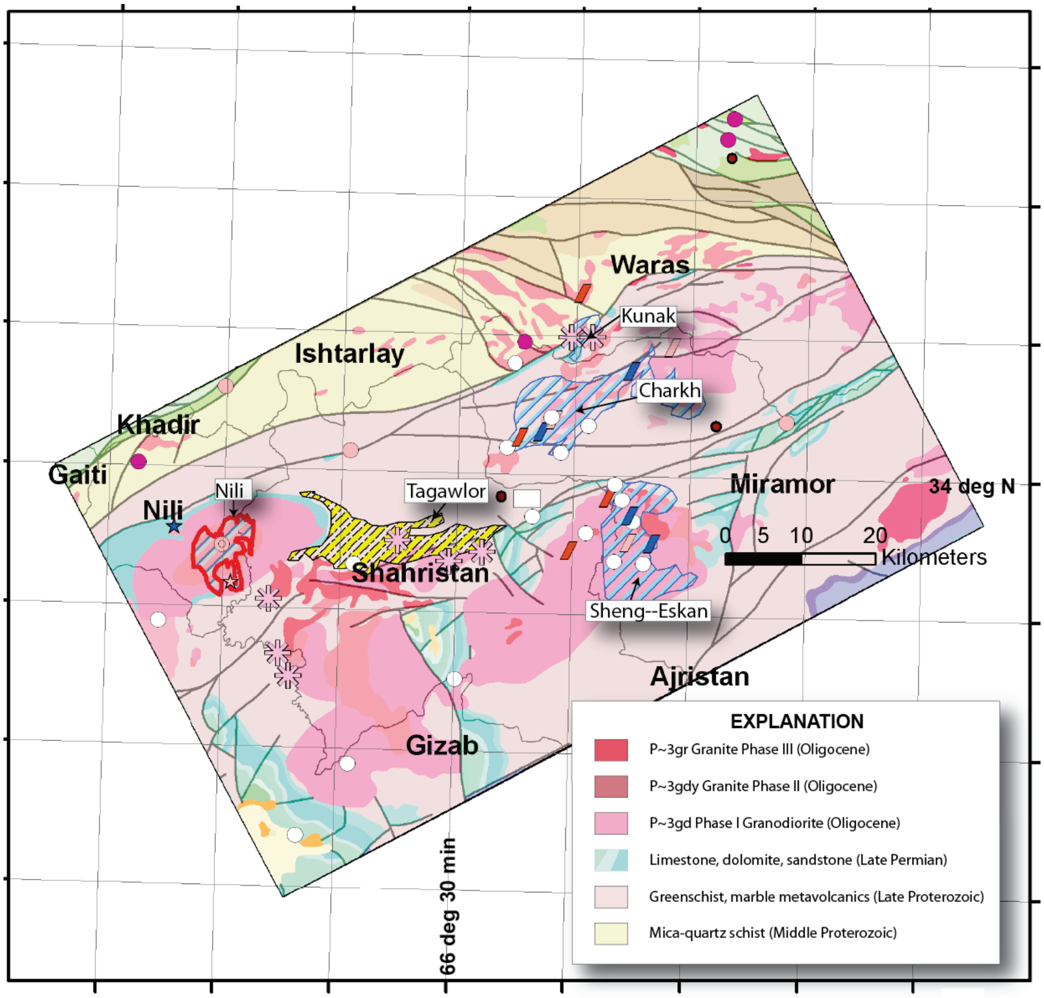

Figure 5A–5. Geologic map and location of major mineralized areas in the Daykundi tin, tungsten, and lithium area of interest. The Nili, Taghawlor), and Oruzgan ore district (Kunak, Charkh and Sheng-Eskan) areas are the main mineralized zones. Symbols represent different types of tin-tungsten occurrences and are explained in Doebrich and others (2006). Pink stars represent pegmatite occurrences and (or) deposits. Bold labels represent names of administrative districts.

The Taghawlor spodumene pegmatites are noted for their alternation of banded spodumene and petalitic aggregates inside the pegmatite bodies. This can be explained by a variation of SiO_2 concentration under similar P-T crystallization conditions. Subsequently, petalite becomes an unstable phase and changes normally into spodumene and quartz as the temperature drops. The initial petalite-spodumene composition of the Taghawlor pegmatites and subsequent transformation of petalite into spodumene and quartz suggest that the lithium pegmatites were formed at a relatively shallow depth (3.0-3.5 km) (Rossovsky and Matrosov, 1975).

5A.5.2 Nili-Chak Tungsten Area

An arcuate-shaped prospective tract was delineated by Peters and others (2007) to encompass the Nili tungsten greisen and the Chak tungsten skarn occurrences within or adjacent to an oval-shaped Phase II Oligocene granite pluton of the Helmand complex (unit P~3gdy of Doebrich and others, 2006) that has intruded a larger Phase I Oligocene granodiorite and quartz porphyry of the Mirali complex (unit P~3gd of Doebrich and others, 2006) (fig. 5A–9*a*). Both occurrences lie within a larger greisen zone defined by hyperspectral mapping of muscovite-illite and portrayed in figure 5A–9*b*. The main parts of the greisen zone coincide with the oval-shaped, 10 km by 6 km central parts of the Phase II granite (unit P~3gdy of Doebrich and others, 2006) that intrudes a Phase I granodiorite (figs. 5A–10*a* and *b*).

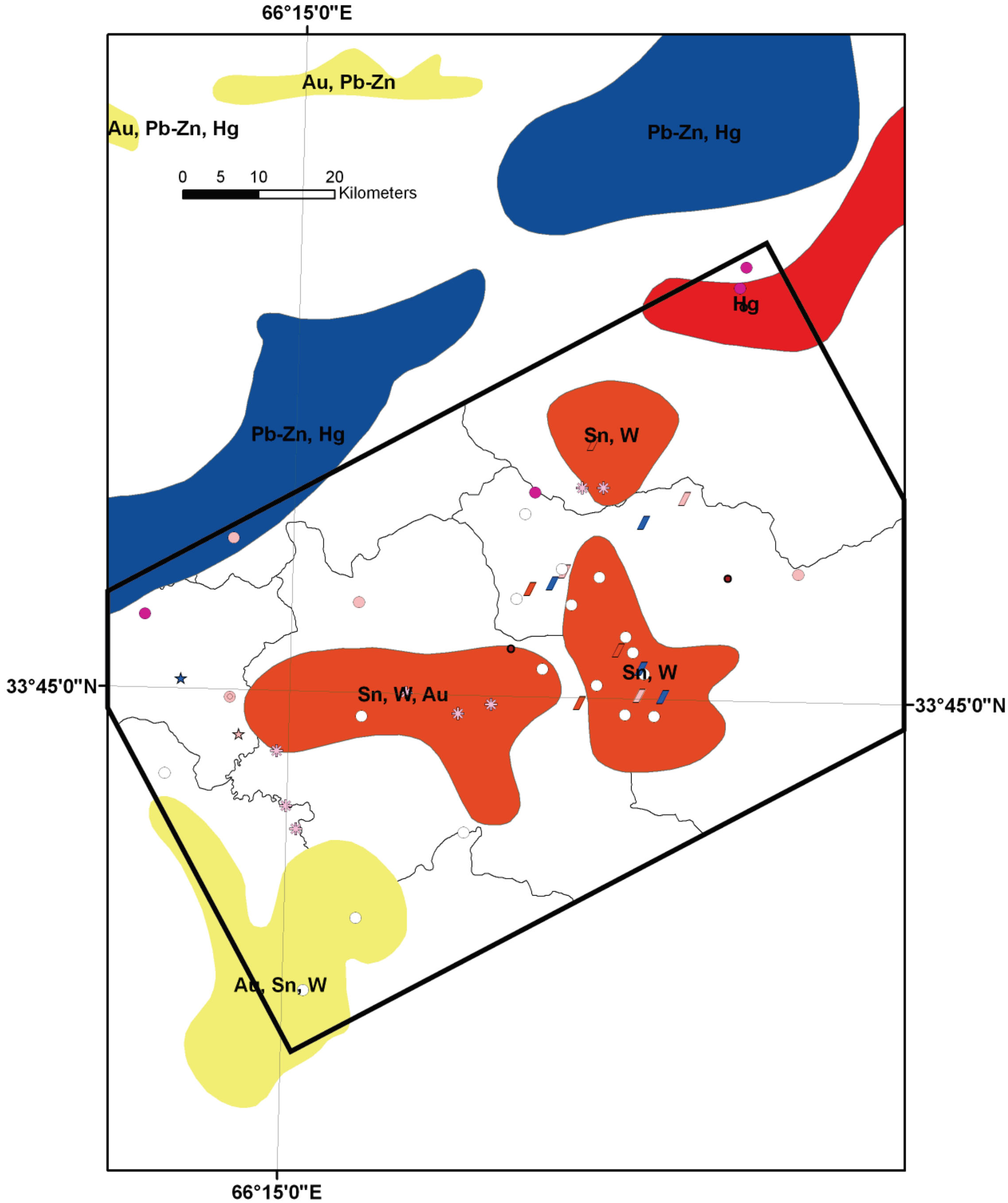

Figure 5A–6. Map showing the geochemically anomalous halos (data from Peters and others, 2007) within the Daykundi tin, tungsten, and lithium area of interest. The description of these geochemically anomalous halos is in Abdullah and others (2007), and the digital polygons are in the GIS file from Peters and others (2007). Symbols are mineral occurrences explained in Doebrich and others (2006).

The Nili tungsten prospect is in the center of the Phase II Oligocene granite (figs. 5A–10*a* and *b*) and is one of many scheelite-bearing greisen zones in an 18-km^2 area. The greisens consist of altered granite with secondary silica and muscovite that contain disseminated scheelite, wolframite, and copper sulfide minerals. One of the intense greisen zones is 0.84 km^2 in area and contains subparallel quartz stringers and a 3.74-m-thick interval containing 0.13 weight percent WO_3. The greisen zone also contains quartz veins with large crystals of wolframite and scheelite. The quartz veins vary in thickness from 0.1 to 0.3 m, extend for tens of meters, and contain 0.03 to 0.5 weight percent WO_3 (Starshinin and others, 1975).

The Chak tungsten prospect is to the south of the Nili-Chak tungsten prospect area (figs. 5A–10*a*,*b*) within "fingers" of the larger greisen zone defined by hyperspectral mapping of muscovite-illite, but the prospect is hosted in older Phase I granodiorite (unit P~3gd of Doebrich and others, 2006). The Chak tungsten prospect consists of two skarn lenses. The first is from 0.1 to 10 m thick and 150 m long; the other is 45 by 65 m in size. Both skarns are present along the contact zone between the Phase I Oligocene granite and roof pendants of Permian marble (not shown on figs. 5A–10*a* and *b*). The WO_3 content of the skarns ranges from 0.78 to 0.84 weight percent WO_3, and in one sample the grade was 3.75 weight percent WO_3 (Starshinin and others, 1975). An unnamed lead-bearing skarn also is present to the northwest of the Nili tungsten prospect (figs. 5A–10*a* and *b*).

The potential of the Nili-Chak tungsten-bearing greisen area is promising due to the large area of muscovite alteration and mineralization in the oval Phase II granite. Additional prospecting in the form of detailed geologic mapping, geochemical sampling, trenching, and drilling will be necessary to determine if commercial-grade mineral deposits are present there. Ground radiometric prospecting [using the potassium (K)-channel] may also be helpful in mapping the greisen alteration zones. The lesser topographic relief of the mineralized zone (fig. 5A–9*b*) and the possible bulk-mining target are additional positive aspects of the prospect.

5A.5.3 Oruzgan Ore District

The Oruzgan ore district, as described by Abdullah and others (1977), lies to the east of the Taghawlor lithium pegmatite field (fig. 5A–5). This report interprets the Oruzgan ore district to contain the Kunak, Charkh, and Sheng-Eskan mineralized areas (figs. 5A–4 and 5). The principal metals likely to be exploited in the Oruzgan ore district are (1) tungsten and tin in skarn-scheelite, quartz-wolframite and quartz-scheelite zones, (2) polymetallic veins with base metals and tin and tungsten, and (3) Proterozoic pegmatites containing mica and tin. The base-metal occurrences in the Oruzgan ore district contain copper, lead, and zinc in quartz-sulfide, skarn pyrite-chalcopyrite, and shattered and silicified zones of magnetite and chalcopyrite. The mineralized skarns were formed at the contacts between Oligocene granites and roof pendants of Devonian limestone.

The Sheng-Eskan area, 15 by 8 km, lies within the lobe of an Oligocene Phase I granite, which also contains stocks and plutons of Phase II and Phase III granite and approximately nine polymetallic mineral occurrences, including the Dariw-Sheng and Eskan vein occurrences (fig. 5A–11). The Sheng-Eskan area also is within a tin and tungsten geochemically anomalous halo (fig. 5A–12*a*) and is also within the prospective, favorable, and permissive tracts for undiscovered tin and tungsten deposits delineated by Peters and others (2007) (fig. 5A–12*b*).

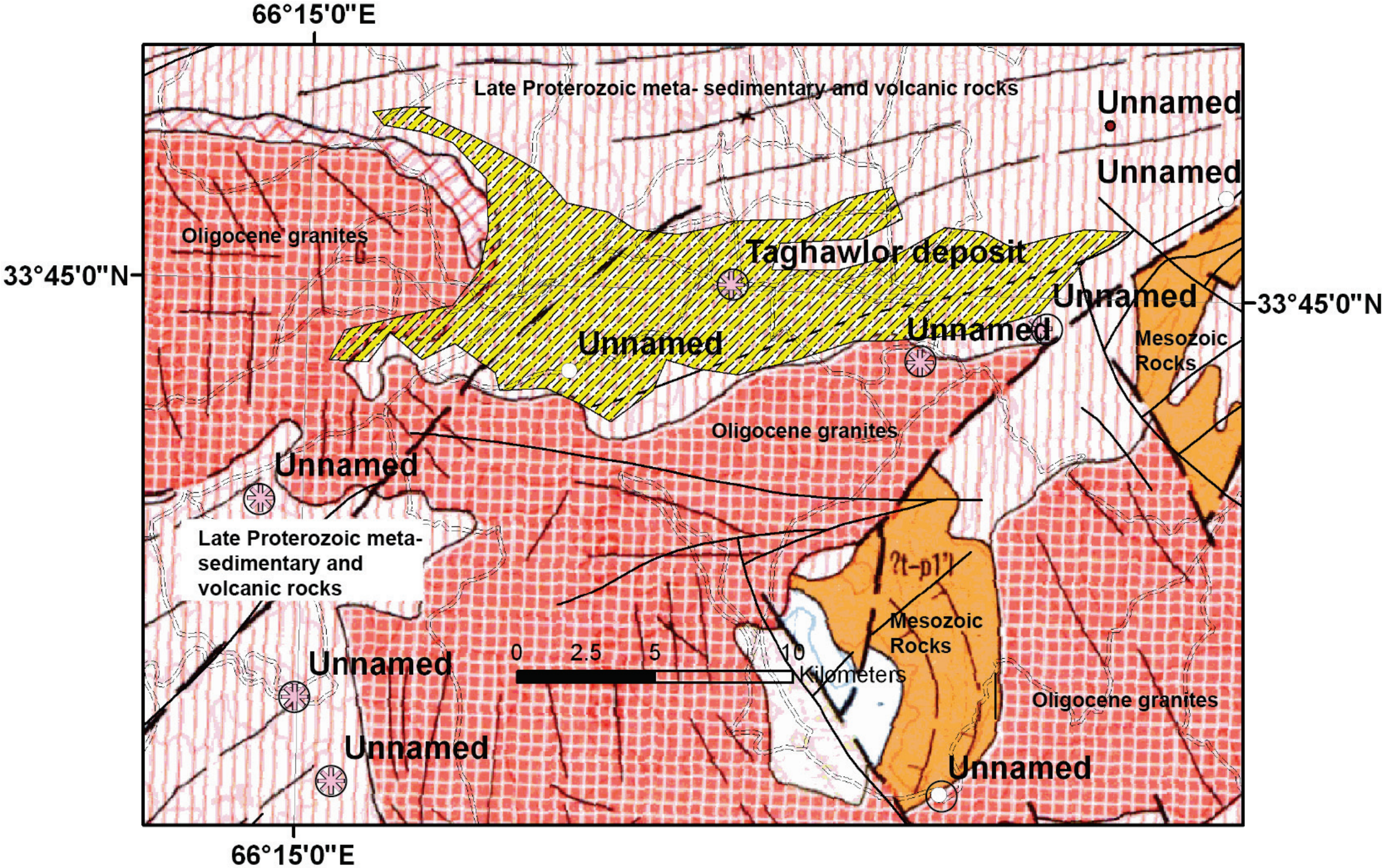

Figure 5A–7. Geologic map of the Taghawlor lithium pegmatite field showing outline of hyperspectral alteration zones for chlorite and carbonate (yellow hatched area). Geologic units and patterns are labeled on the figure. Geology from Doebrich and others (2007).

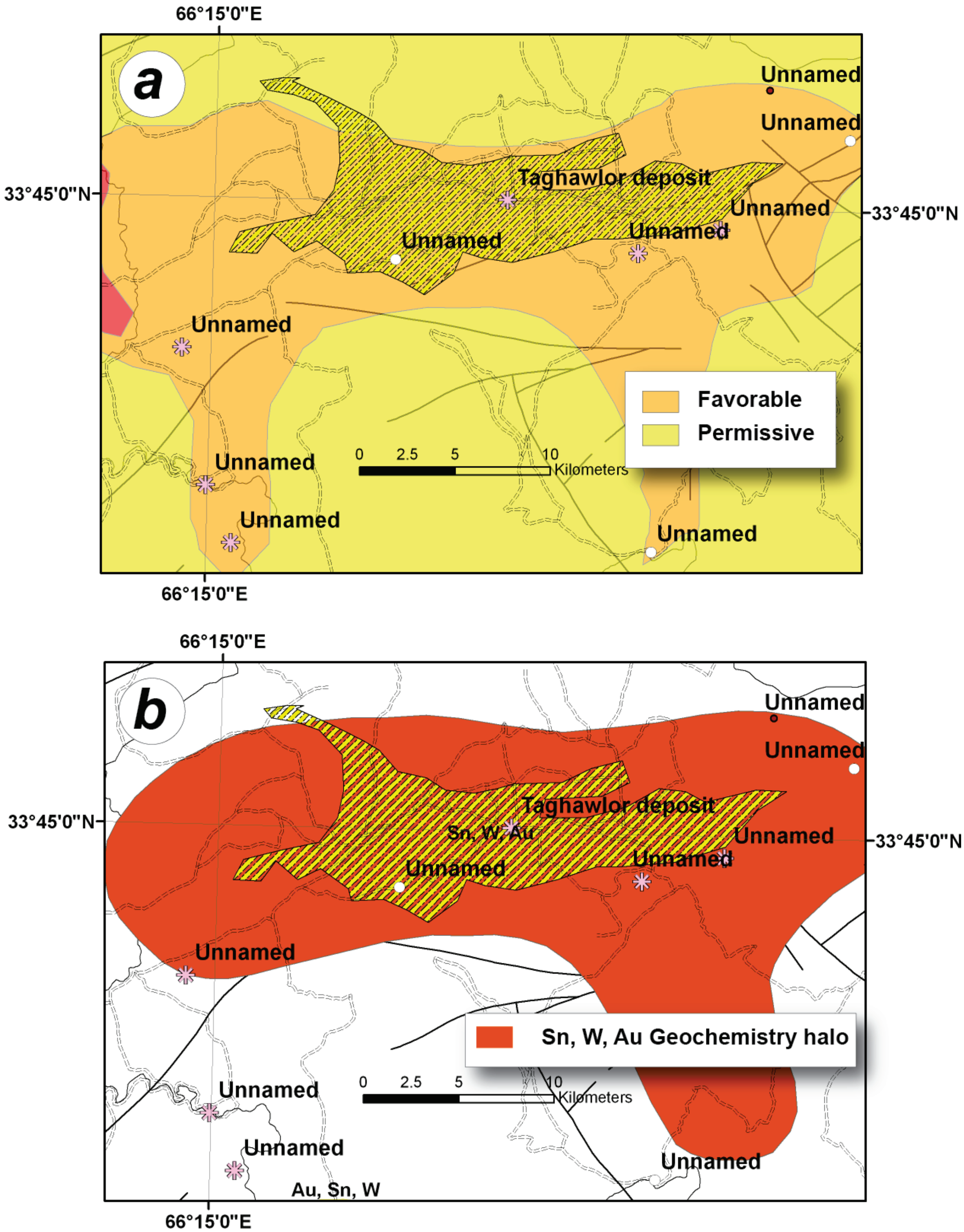

Figure 5A–8. Maps of the Taghawlor lithium pegmatite field. (*a*) Favorable and permissive tracts from Peters and others (2007) for tin-tungsten deposits. Pink on west side is prospective area shown in fig. 5A-9. (*b*) Geochemically anomalous halo for tin, tungsten, and gold with superimposed hyperspectral zone of chlorite and carbonate alteration (yellow hatched area in both (*a*) and (*b*) containing the Taghawlor lithium pegmatite field). Pink stars represent known pegmatite occurrences.

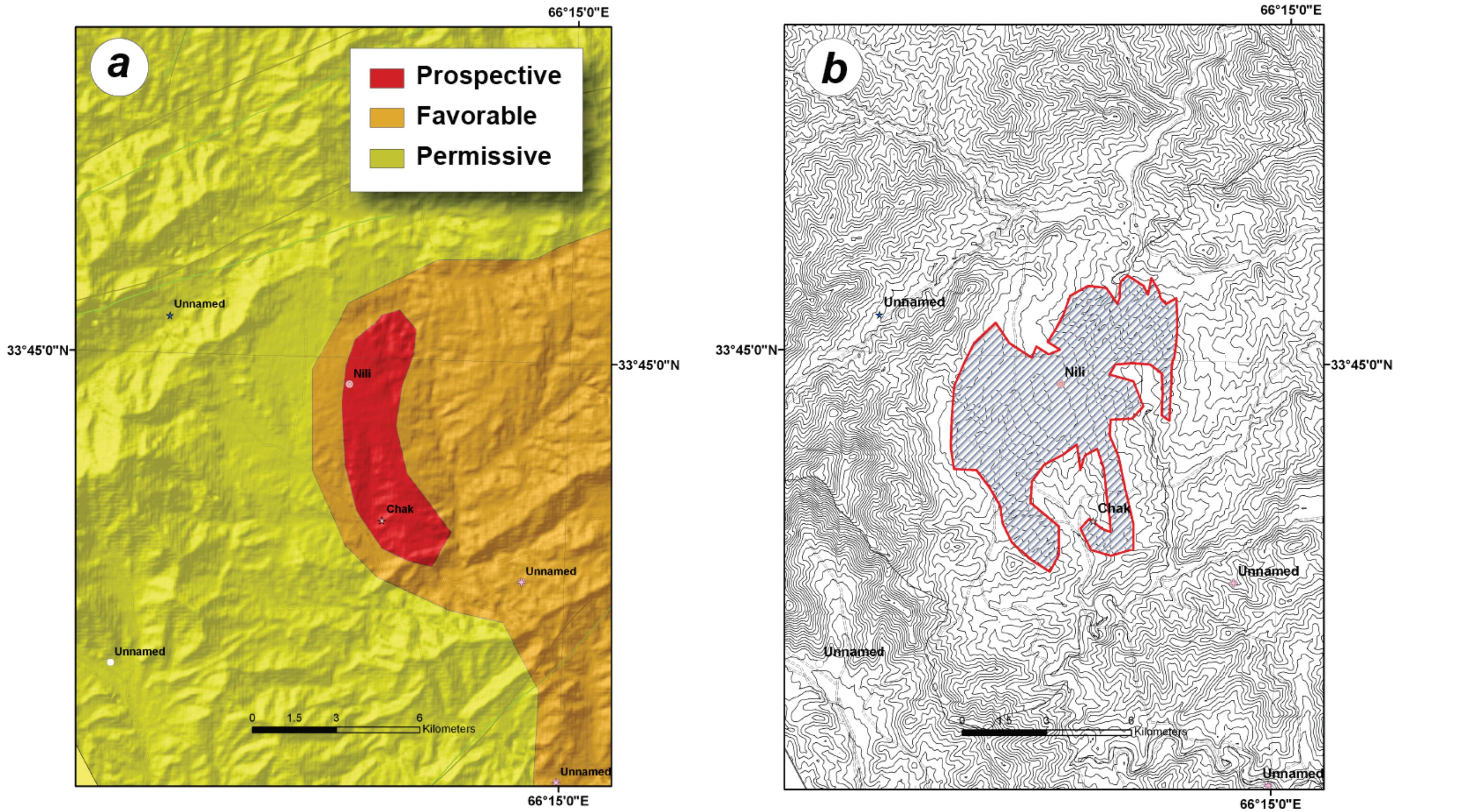

Figure 5A–9. Maps of the Nili-Chak tungsten greisen area, Daykundi tin, tungsten, and lithium area of interest. (*a*) Assessment tract produced for qualitative assessment in Peters and others (2007). (*b*) Greisen zone digitized from hyperspectral imagery superimposed on topographic contour map. Greisen zone lies within a plateau area.

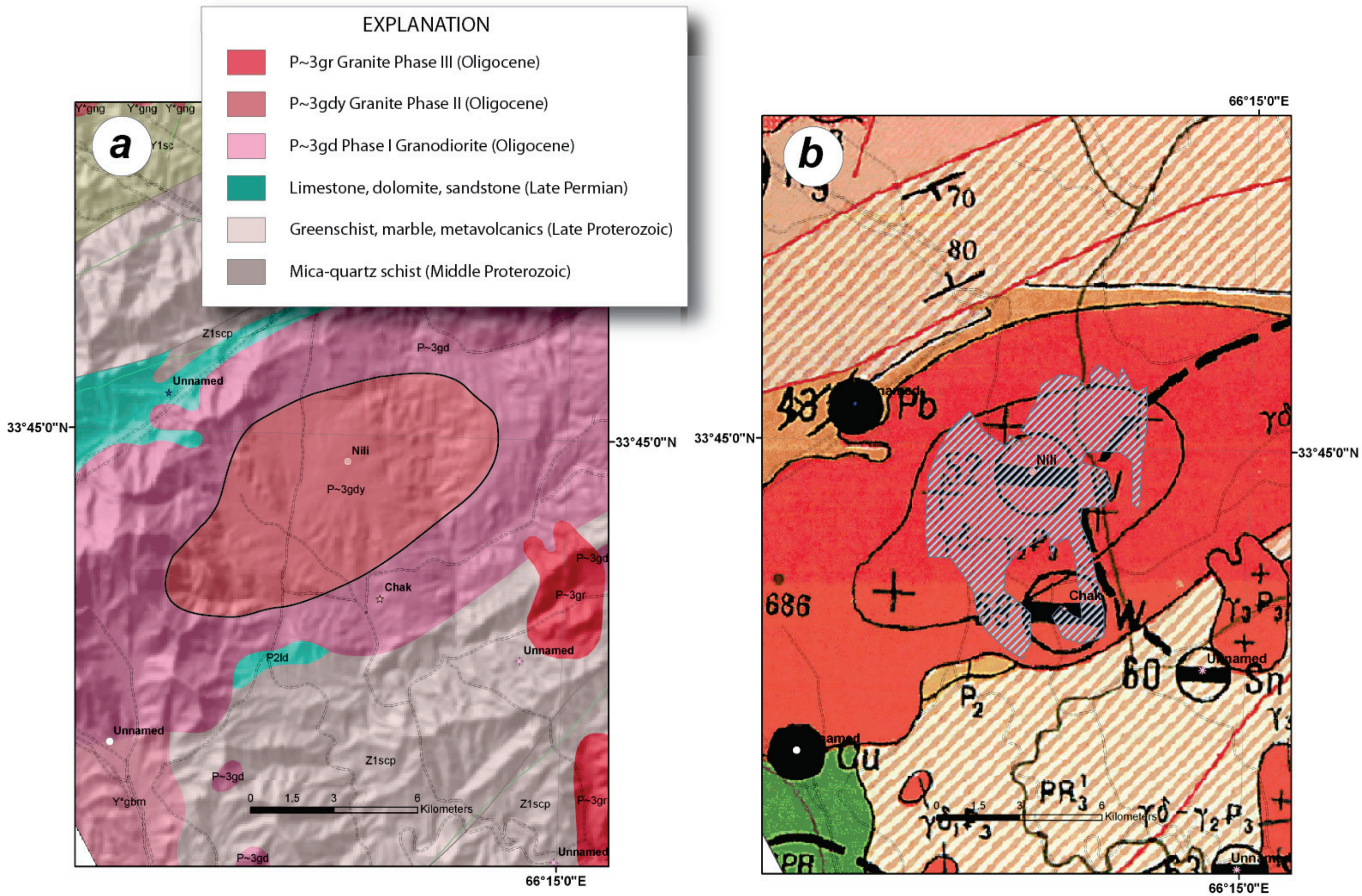

Figure 5A–10. Geologic maps of the Nili-Chak tungsten greisen area, Daykundi tin, tungsten, and lithium area of interest. (*a*) Image of digital geologic map over shaded relief digital elevation map, showing location of Nili tungsten prospect in the center of a circular granite. (*b*) Scanned image of original geologic map with greisen zone digitized from hyperspectral imagery. (Geology from Doebrich and others, 2006, and Peters and others, 2007).

The Sheng tin occurrence is to the west of the main occurrences in the lobe of the granite (fig. 5A–11) and includes about 300 quartz veins and silicified zones in an intrusion of Oligocene granite (Abdullah and others, 1977). The veins vary in thickness between 1 and 15 cm, but are as much as 1 m thick, and are between 10 and 100 m long. The mineralized zones are from 0.3 to 1.5 m wide and from 30 to 100 m long. The mineral composition of the veins in the mineralized zones may contain quartz, pyrite, chalcopyrite, arsenopyrite, galena, limonite, malachite, and azurite, as well as sparsely disseminated cassiterite and scheelite grains. The veins and zones contain 0.01 to 2 weight percent Sn (single samples contain as much as 14 weight percent Sn over a 10- to 15-cm interval), 0.02 to 0.16 weight percent WO_3 (0.3 weight percent WO_3 in one sample), 0.01 to 0.05 weight percent Cu, and up to 1 weight percent As (Kabakov, 1973).

The Dariw-Sheng tungsten vein prospect lies in a 12-km^2 area associated with silicified shear zones that are hundreds of meters long and up to 30 m wide and contain disseminated sulfide minerals, cassiterite, and scheelite. The shear zones contain anomalous concentrations of tungsten, tin, copper, and bismuth (Starshinin and others, 1975). The other unnamed prospects have similar geologic characteristics and also contain anomalous concentrations of copper, tungsten, tin, zinc, arsenic, and bismuth (Abdullah and others, 1977; Orris and Bliss, 2002) (figs. 5A–11, 12*a* and *b*).

The Eskan lead-zinc prospect lies east of the Dariw-Sheng area and is in a 25-m- wide and 300-m-long fault zone (figs. 5A–1 and 12*a* and *b*). The host Oligocene granite is shattered, ochre colored, and impregnated with quartz stringers. The mineralized rocks contain 0.76 to 1.04 weight percent Pb, 0.2 to 0.62 weight percent Zn, 0.17 to 0.6 weight percent Cu, and 0.12 weight percent Sn (Karapetov and others, 1970).

The Charkh area is a northeast-elongated zone 16 km long and between 4 and 9 km wide that spatially surrounds a Phase I (unit P~3gd of Doebrich and others, 2006) pluton (fig. 5A–11). The mineralized occurrences also lie above a number of Proterozoic stocks that are intruded into the Late Proterozoic greenschist, marble, and metavolcanic bedrock (fig. 5A–11). Parts of the area are underlain by a tin-tungsten geochemically anomalous halo (fig. 5A–12*a*) and are within the favorable and prospective tracts delineated by Peters and others (2007) (fig. 5A–12*b*). The area contains as many as six mineral occurrences including the Charkh tungsten and the Charh II prospects (fig. 5A–11).

The Charkh tungsten occurrence is spatially associated with a Phase I Oligocene granodiorite that intruded Proterozoic schist and is in a less than 4,000-m-long and 1- to 2-m-wide shear zone that contains tungsten mineralization with anomalous concentrations of copper, tin, and arsenic. The Charh II tungsten vein occurrence has similar geology and lies in a 400-m-long ferruginous shear zone with grades of 0.1 weight percent WO_3 and copper, tin, and arsenic values (Starshinin and others, 1975).

The Kunak pegmatite area lies in the northern part of the Oruzgan ore district along the faulted contact between Middle Proterozoic mica-quartz schist in the north and greenschist, marble, and metavolcanic rocks in the south (fig. 5A–11) The Proterozoic(?) Kunak pegmatite occurrence is a 1.5 to 20 meters thick and 10- to 100-meters long muscovite garnet, cassiterite, and quartz-oligoclase pegmatite. An unnamed pegmatite to the west is also purported to be Proterozoic in age and contains cassiterite, microcline, muscovite, and tourmaline (Abdullah and others, 1977; Bowersox and Chamberlin, 1995).

5A.6 Summary of Potential

The presence of several partially explored tin- and tungsten-bearing magmatic-hydrothermal systems and the widespread occurrence of tin-tungsten geochemically anomalous halos within the Daykundi tin, tungsten, and lithium AOI suggest that a large metallogenic system may be present in the area. The geologic setting further indicates that there is a likelihood of a number of undiscovered tin and tungsten deposits. Because each mineralized system has strong spatial associations with a specific Oligocene granite body, it is likely that additional mineralized zones may be present in association with these granites. Additional field work is necessary to determine the nature of the mineralized zones. Uncertainty about deposit types present in the area (vein, stockwork, greisen, porphyry, skarn, and replacement) prevented a quantitative estimate of undiscovered deposits by Peters and others (2007). Additional compilation, and field geologic mapping and sampling should identify specific targets for additional testing.

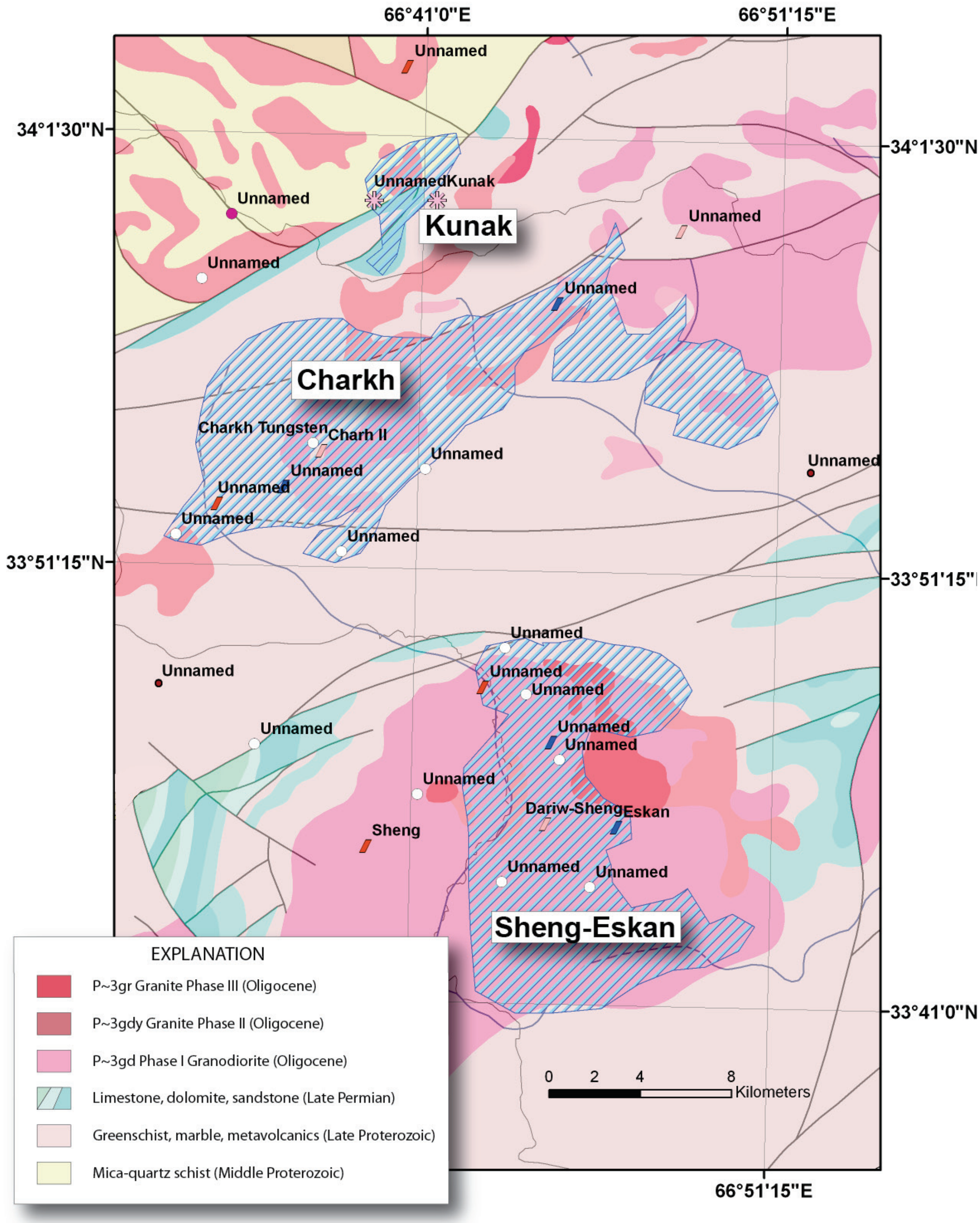

Figure 5A–11. Geologic map of the Oruzgan ore district, east-central Daykundi tin, tungsten, and lithium area of interest. Geology and mineral occurrence symbols from Doebrich and others (2007). The district contains three mineralized areas. Blue-line patterns indicate digitized carbonate and epidote-chlorite alteration areas identified by hyperspectral mapping (chapter 5B of this report).

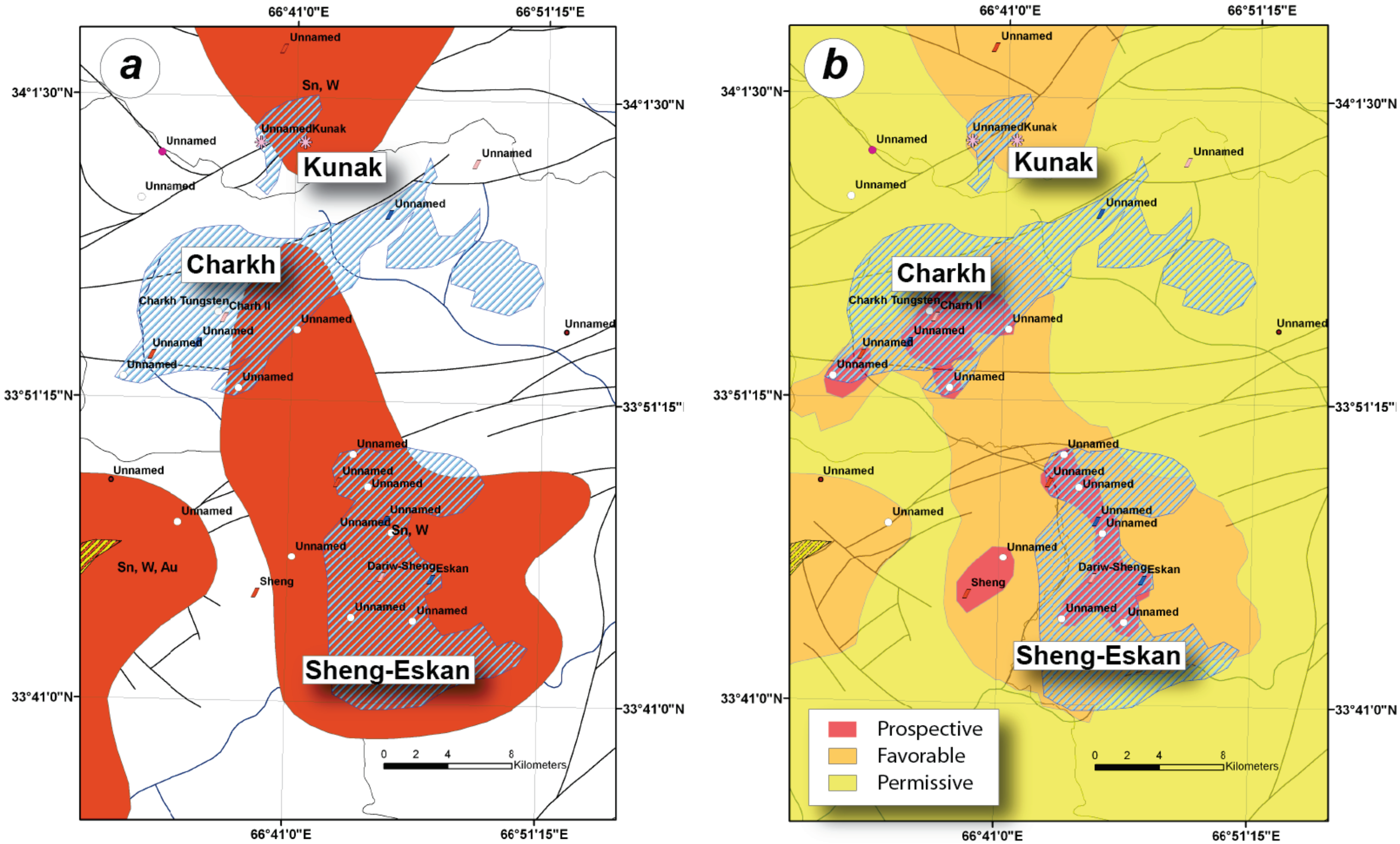

Figure 5A–12. Maps showing the Oruzgan ore district. (*a*) Sheng-Eskan, Charkh, and Kunak pegmatite areas defined by hyperspectral anomalous polygons superimposed on tin-tungsten geochemically anomalous halos reproduced from Peters and others (2007). (*b*) Prospective, favorable, and permissive tracts from Peters and others (2007). The northern areas are associated with a smaller Oligocene granite body intruding Proterozoic metamorphic rocks, whereas the southern areas are shear-zone-hosted occurrences in Oligocene granite plutons intruding larger Oligocene granodiorite.

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