14A Summary of the Tourmaline Tin Area of Interest

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Abstract

This chapter summarizes and interprets the results from the study of the Tourmaline tin area of interest (AOI) and its subareas from joint geologic and compilation activities conducted during 2009 through 2011 between the U.S. Geological Survey, the U.S. Task Force for Business and Stability Operations of the U.S. Department of Defense, and the Afghanistan Geological Survey of the Ministry of Mines of Afghanistan. The accompanying, complementary chapters 14B and 14C address hyperspectral data and geohydrologic assessments respectively of the Tourmaline tin AOI. Additionally, supporting data and other information for this chapter are available from the Ministry of Mines in Kabul.

In the Tourmaline tin AOI, tin-bearing vein and stockwork prospects surround a moderate-sized (about 60 square-kilometer) tin-bearing granite stock that has intruded a sequence of presumably coeval volcanic rocks. Some of the altered and mineralized areas and prospects are on the order of 0.5 to 3 kilometers in diameter. Several of the tin prospects yielded samples that contained from several tenths to as much as 2 weight percent tin. Tin placer deposits were also reported in the area. Alteration assemblages are reported to be primarily silicification and tourmalinization. A Landsat image of the area suggests that the tin-granite stock was pervasively altered to an advanced argillic assemblage. The widespread occurrence of the mineralized and altered rocks and the tin contents of samples indicate that this area could contain at least one large tin vein, tin-stockwork, or tin-porphyry deposit.

Discovery and exploitation of economic deposits in the Tourmaline tin AOI would be aided by mapping as well as sampling by trenching and drilling in the areas of known occurrences with close attention to the characteristics outlined in the descriptive models of tin deposits.

The 3.5-kilometer-long Tourmaline tin vein is the largest known occurrence in the Tourmaline tin AOI and consists of two silicified zones that lie within the granite along the north- trending granite contact. An approximately 1.6-meter-wide contact zone at the Tourmaline tin prospect contains apatite, bismuthinite, cassiterite, chalcopyrite, galena, hematite, pyrite, sphalerite, zircon; secondary minerals of lead and copper as well as albite, fluorite, and muscovite; and 0.01 to 1.35 weight percent or more tin.

14A.1 Introduction

The Tourmaline tin area of interest (AOI) is in western Afghanistan (fig. 14A–1) and covers an area of 1,365 square kilometers (km^2) in Farah Province in the western Anar Dara District and in parts of Herat Province in the eastern Shin Band District. Mineral types in the AOI are tin- and tungsten-vein, stockwork, and greisen or porphyry tin deposits.

14A.2 Previous Work

There are reports of ancient alluvial tin lode and placer workings and diggings in the area. Aerial photography also shows evidence of previous habitation in and around the granitic intrusive near these workings. The earliest expeditions to the area by Soviet geologists were recorded by Meshcheryakov and Borozenets (1970) and Nagaliov and others (1971). These expeditions led to discoveries of mineralized areas and prospects, resulting in more intensive geologic field work, particularly at the Tourmaline tin prospect on the western contact of the granite stock, which in turn led to trenching and geologic mapping (Kabakov, 1973; Yefimenko and others, 1973). Yefimenko and others (1973) reported on the tin placer potential there and Rulkovsky is credited with the mapping of the Tourmaline tin prospect. These investigations were summarized by Kirichek and others (1974), who also did field work in the area. Domenico and others (1979) compiled basic data for tin in sands in the region. Data for the Tourmaline tin area again were summarized (Afghanistan Department of Geology and Mines, 1976) and reported on by Abdullah and others (1977) and the United Nations Economic and Social Commission for Asia and the Pacific (1995). The USGS compiled mineral deposit data and geology in Afghanistan (Orris and Bliss, 2002; Doebrich and Wahl, 2006); geophysical information on the Tourmaline tin AOI was compiled by Sweeney and others (2006a,b). The Tourmaline tin AOI was highlighted also by Peters and others (2007) as a promising area for tin vein and other tin-tungsten deposits.

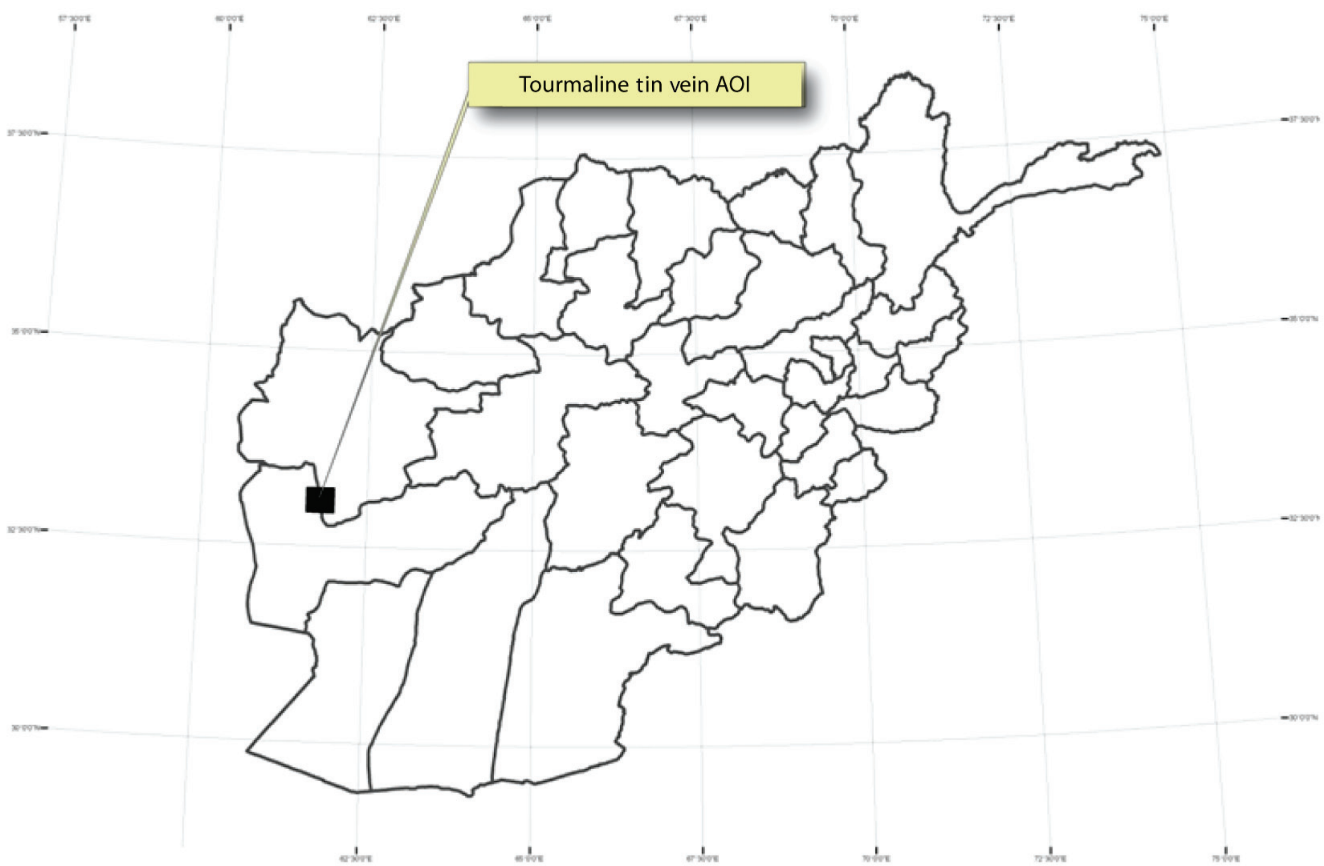

Figure 14A–1. Location of the Tourmaline tin area of interest in Farah and Herat Provinces in western Afghanistan.

14A.3 Geology

In the Tourmaline tin AOI, tin-bearing vein and stockwork prospects surround a moderate-sized (about 60-km^2) granitic stock that has intruded a sequence of (presumably) coeval volcanic rocks (fig. 14A–2). Alteration assemblages are reported to be primarily silicification and tourmalinization. Landsat and Advanced Spaceborne Thermal Emission and Reflection (ASTER) radiometer imagery of the area suggests that the stock has been pervasively altered to an advanced argillic assemblage (figs. 14A–2 and 14A–3). Some altered and mineralized areas of these prospects are large (dimensions of hundreds of meters to more than 1 to 2 kilometers) as interpreted from remotely sensed data (fig.14A–2). Several of the prospects yielded samples from Soviet-era exploration that contained from several tenths to up to 2.0 weight percent tin (Yefimenko and others, 1973).

The stock is well expressed by geophysical data, such as aeromagnetics and gravity and airborne radiometrics (figs. 14A–3, 14A–4, and 14A–5). The granite stock and a smaller stock to the southwest occupy a magnetic low (figs. 14A–3*a* and 14A–4*a*). Most of the known tin occurrences are proximal to an anomalous gravity low, representing the granitic system below them (fig. 14A–4*b*). The granitic stock is generally marked by rocks anomalously low in radioactivity, whereas the surrounding volcanic rocks and the contact zones are more radioactive (fig. 14A–5).

The widespread occurrence of the mineralized and altered rocks and the tin contents of samples indicate that this area could contain one or more large tin vein, stockwork, or porphyry deposits. Structurally, the Tourmaline tin AOI is marked by northeast-trending alteration zones that parallel the contacts of the main granite stock, which also is elongated into a northeasterly trend. Dikes within the stock trend both north-northwest and northeast. Tin mineralization commonly is aligned or contained within the northeast-trending faults or alteration zones on the southeastern side of the main granitic stock (fig. 14A–2).

14A.4 Metallogeny

In addition to the Tourmaline tin AOI, a number of tin and tungsten mineral occurrences and deposits are present through much of Afghanistan. The most important occurrences are spatially associated with Cretaceous to Oligocene intrusive bodies. Several types of distinct mineral deposits are common to granite-related tin and tungsten occurrences in Afghanistan as defined by their mineralogy. These deposit types are tungsten skarn, tin skarn, replacement tin, tin vein, and tin greisen deposits (Taylor, 1979, p. 57, 247, 252; Cox, 1986; Reed, 1986a,b; Reed and Cox, 1986). Tin- and tungsten-bearing pegmatite bodies are abundant in the eastern parts of the country. Most tin and tungsten deposits throughout the country are spatially associated with epizonal granite emplacement. Although the geology of the Afghanistan tin- and tungsten-bearing mineral occurrences and prospects is permissive for most of these model types, there has been little production of tin or tungsten in the country, with the possible exception of tin placers and unrecorded production from ancient workings, specifically in the Tourmaline tin AOI.

Tin and tungsten skarn and replacement tin deposits typically formed at the contacts, in roof pendants of batholiths, and in the thermal aureoles of apical zones of stocks that have intruded carbonate rocks. Tin and tungsten vein deposits are in quartz-cassiterite and quartz-wolframite veins, in close spatial relation with late-orogenic to post-orogenic multiphase granitic intrusives in continental crust. Tin greisen deposits consist of disseminated cassiterite and also occur as cassiterite-bearing veinlets, stockworks, lenses, pipes, and breccia in greisenized granite. Economic concentrations of tin and tungsten tend to occur within or above the apices of granitic cusps and ridges; localized controls include variations in vein structure, lithologic and structural changes, vein intersections, dikes, and cross-faults. Geochemical signatures include As, B, Be, Bi, F, Mo, Sn, and W, which are good pathfinder elements. Weathering of the lode deposits can produce placer tin deposits.

Permissive tracts for the occurrence of undiscovered and known mineral occurrences of tin and tungsten in Afghanistan were constructed by Peters and others (2007) as tracts snw01 through 05 (figs. 14A–6 and 14A–7). The main tin and tungsten occurrences are in Farah, Ghazni, Herat, northern Kandahar, Uruzgan, and Zabul Provinces. Additional permissive geology and indications of tin- and tungsten-bearing deposits are present in Badakshan, Baghlan, Kunar, Laghman, Nuristan, Parwan, Takhar, and Wardak Provinces (fig. 14A–6). Each permissive tract contains existing mineral occurrences and tin- and tungsten-rich geochemical halo anomalies as well as geology that is compatible with the descriptive models of tin and tungsten deposits (Nagaliov and others, 1971; Kabakov, 1973; Yefimenko and others, 1973; Kirichek and others, 1974; Abdullah and others, 1977; United Nations Economic and Social Commission for Asia and the Pacific, 1995; Peters and others, 2007).

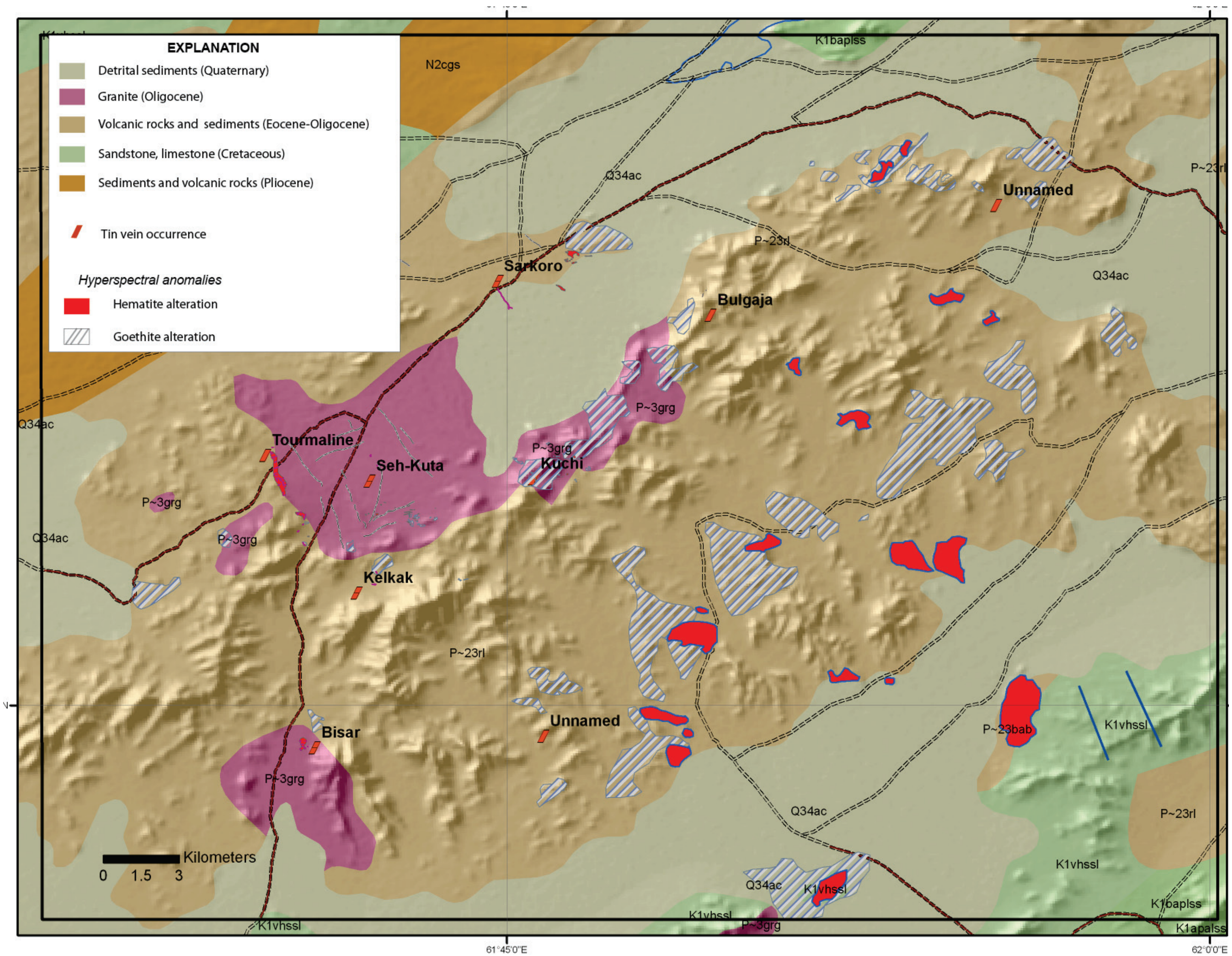

Figure 14A–2. Geology, mineral occurrences, and hyperspectral anomalies of the Tourmaline tin area of interest. Geology from Doebrich and Wahl (2006); mineral occurrences from Peters and others (2007) and Orris and Bliss (2002). Dotted grey and red lines are roads. Blue lines in K1baplss and K1vhsll are faults.

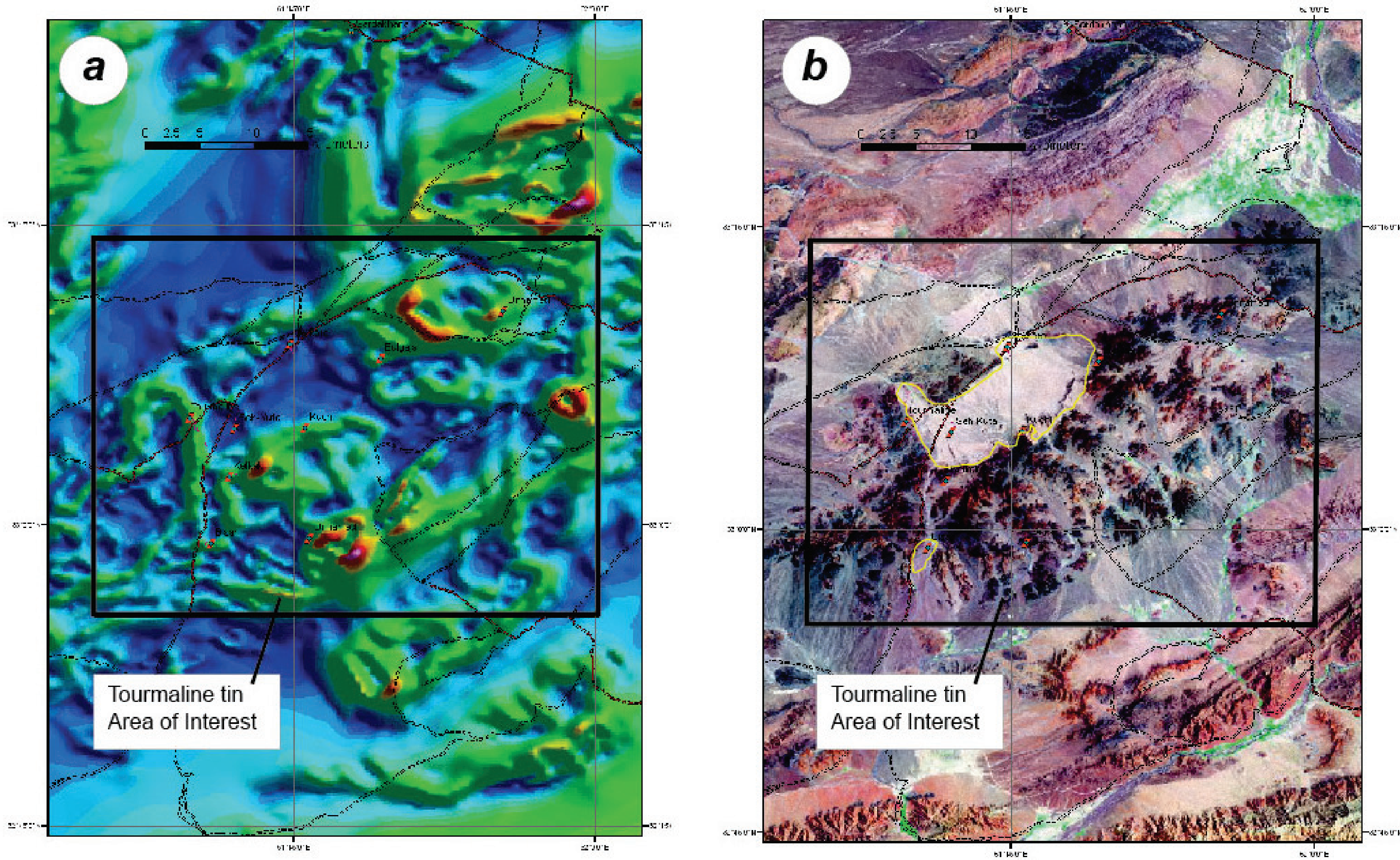

Figure 14A–3. Images of the Tourmaline tin area of interest. (*a*) First derivative aeromagnetic anomaly map generated from Sweeny and others (2006a,b). (*b*) False color Landsat image; lighter areas outlined in yellow are intrusive rocks.

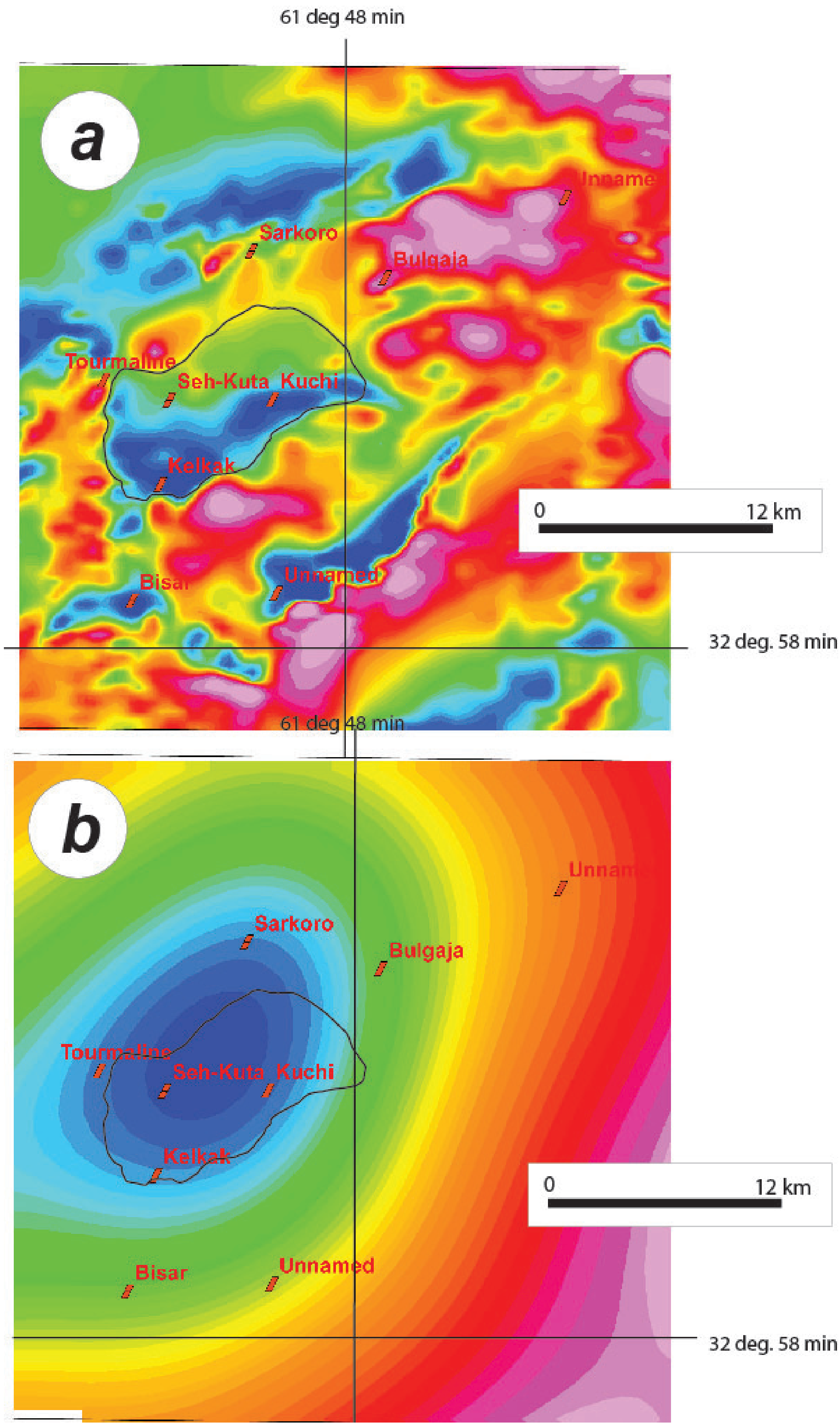

Figure 14A–4. Images of contoured geophysical data in the Tourmaline tin area of interest show relations to tin occurrences. (*a*) Aeromagnetic anomalies. (*b*) Gravity anomalies. Data are from Sweeney and others (2006) and Peters and others (2007). Magnetic expression of stock is outlined in black. The stock and the tin occurrences lie above a gravity low.

The Tourmaline tin AOI within the Anar Dara permissive tract of Peters and others (2007) was delineated around a number of tin and tungsten geochemical halo anomalies and encompasses known tin- and tungsten-bearing mineral occurrences that are associated with Oligocene igneous intrusive bodies (map unit P3grg of Doebrich and Wahl, 2006). These causative intrusive bodies comprise granite, granite porphyry, granodiorite, quartz syenite, and granosyenite (figs. 14A–7 and 14A–8). A large central favorable tract was delineated within the permissive Anar Dara tract by Peters and others (2007) to enclose and better approximate the distribution of geochemical halo anomalies in tin and tungsten and to include the major clusters of known mineral occurrences. The location of the Tourmaline tin AOI approximates this favorable tract.

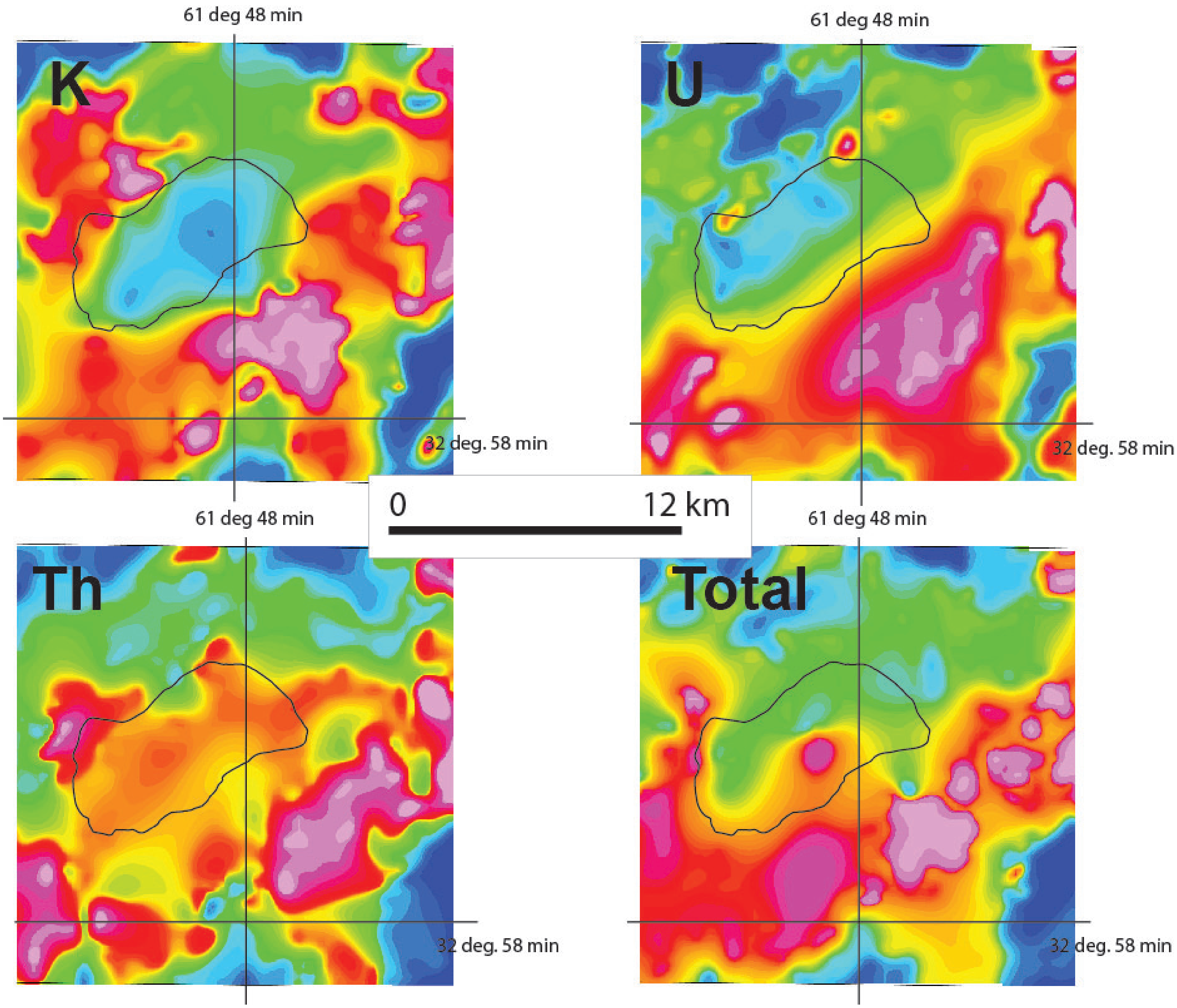

Figure 14A–5. Images of contoured airborne radiometric data from the Tourmaline tin area of interest. The images outline the main tourmaline granite stock in different ways (approximated with black outline). See also figure 14A–2*a* for location of the stock. From Sweeney and others (2007). K, potassium; U, uranium, Th, thorium.

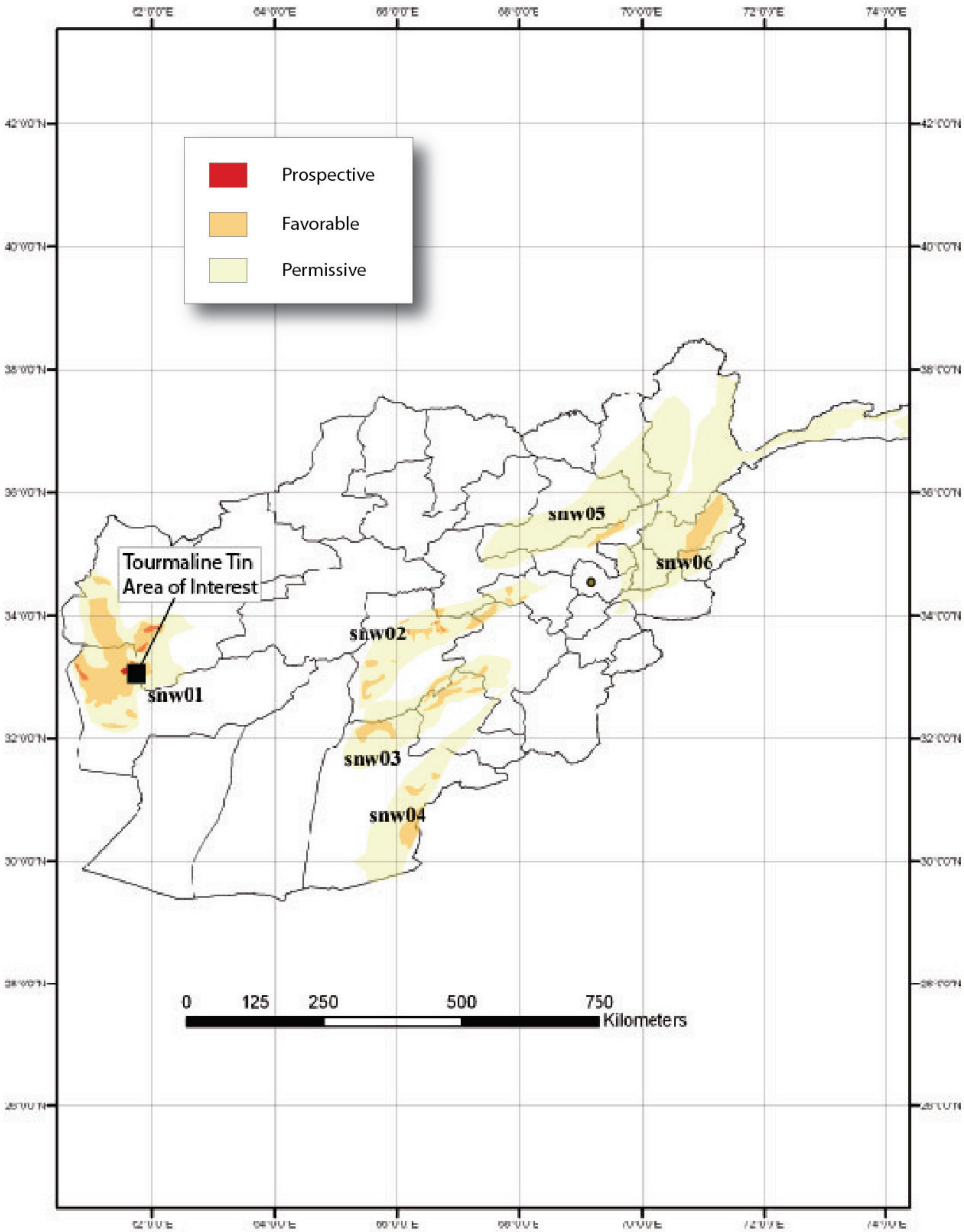

Figure 14A–6. Location of tracts permissive for the occurrences of tin and tungsten deposits and the location of internal favorable (orange) and prospective tracts. Source: Peters and others (2007).

14A.5 Known Deposits

There are no known lode deposits that contain measured or calculated resources within the Tourmaline tin AOI and no recorded production of tin or other commodities, other than early tin placer mining that has taken place there. However, a number of tin prospects and occurrences and a greater number of remote-sensed alteration anomalies of goethite, sericite, and silica show promise (fig. 14A–2). Several of the identified alteration anomalies contain known tin prospects and have received exploration in the form of trenching, drilling, geologic mapping, and sampling by the Soviet and Afghanistan geologists during the 1970s. Many of the prospects and anomalies deserve additional exploration and evaluation.

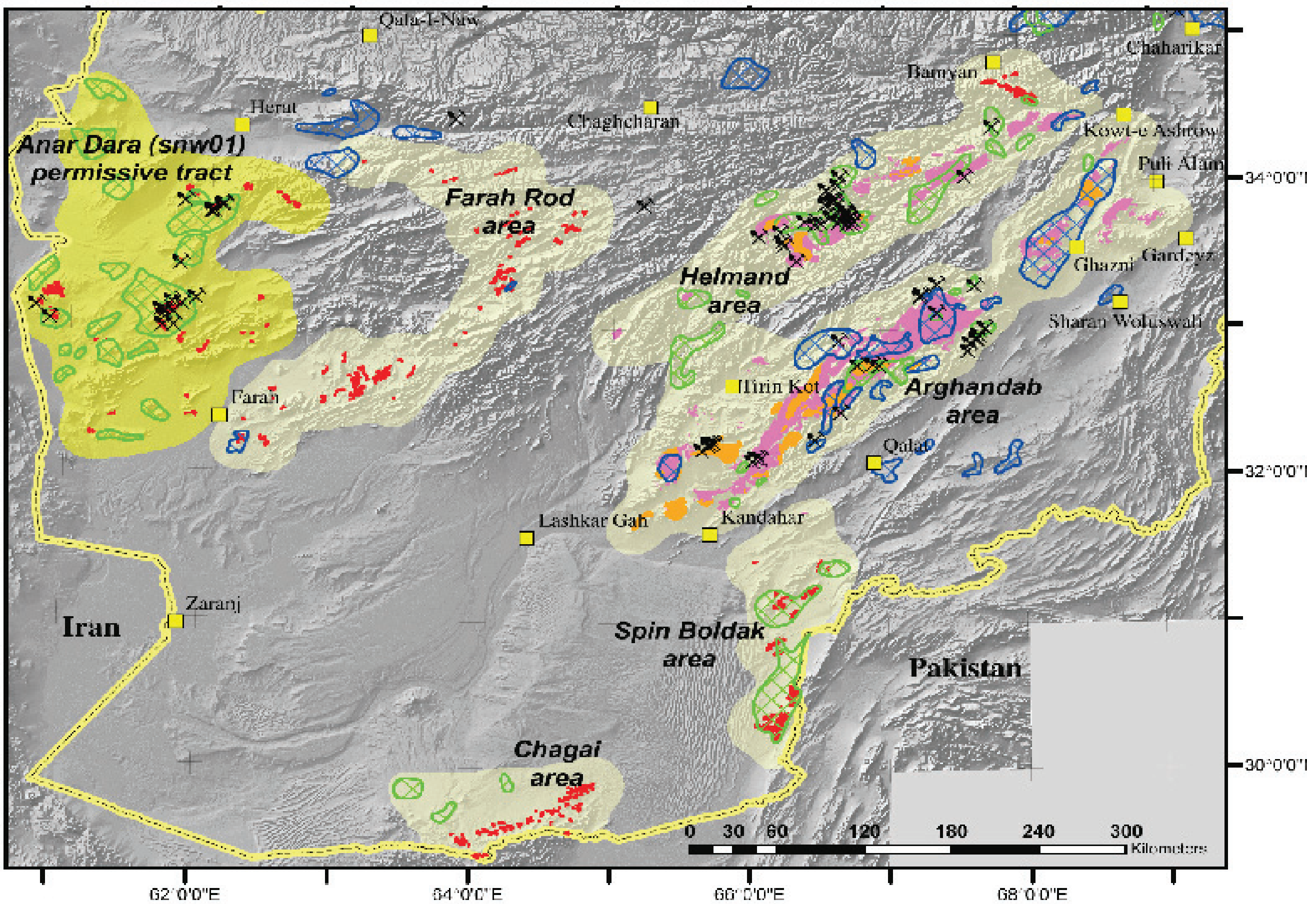

Figure 14A–7. Map showing location of areas in Afghanistan that may contain deposits of tin and (or) tungsten. Permissive tract snw01 (Anar Dara) that contains the Tourmaline tin area of interest is delineated specifically for its vein, stockwork, and porphyry deposits. Solid color polygons (red, map unit P_3grg; pink-purple, map unit P_3gdy; orange, map unit P_3gd) indicate intrusive rocks associated with tin and tungsten deposits. Green crosshatch indicates tin geochemical halos; blue crosshatch indicates tungsten geochemical halos. The Farah Rod favorable tract contains abundant outcrops of the same intrusive rocks that occur in the Anar Dara tract. The Arghandab, Boldak, Chagai, Helmand, and Spin areas of interest contain some tin and tungsten deposits, but were delineated for porphyry copper deposits by Peters and others (2007) rather than for tin and tungsten deposits. Symbols and map units from Doebrich and Wahl (2006). Map locations and data are from Peters and others (2007).

14A.6 Prospects and Anomalies

Several tin- and tungsten-bearing vein and stockwork occurrences are present in the Tourmaline tin AOI, and most of these are centered around or lie south of an Oligocene granitic stock that has intruded Eocene to Oligocene volcanic (porphyritic dacite and rhyolite) and sedimentary rocks (figs. 14A–2 and 14A–9). The largest known prospect, and the one that has been most sampled and mapped, is the Tourmaline tin prospect on the western margin of the granitic stock. The AOI also includes the Bisar, Bulgaja, Kelkak, Kuchi, Sarkoro, and She-Kuta tin-vein occurrences as well as several unnamed occurrences and alteration anomalies (fig. 14A–2). Streams to the west of the prospective tract contain alluvial tin placers (Kabakov, 1973; Abdullah and others, 1977).

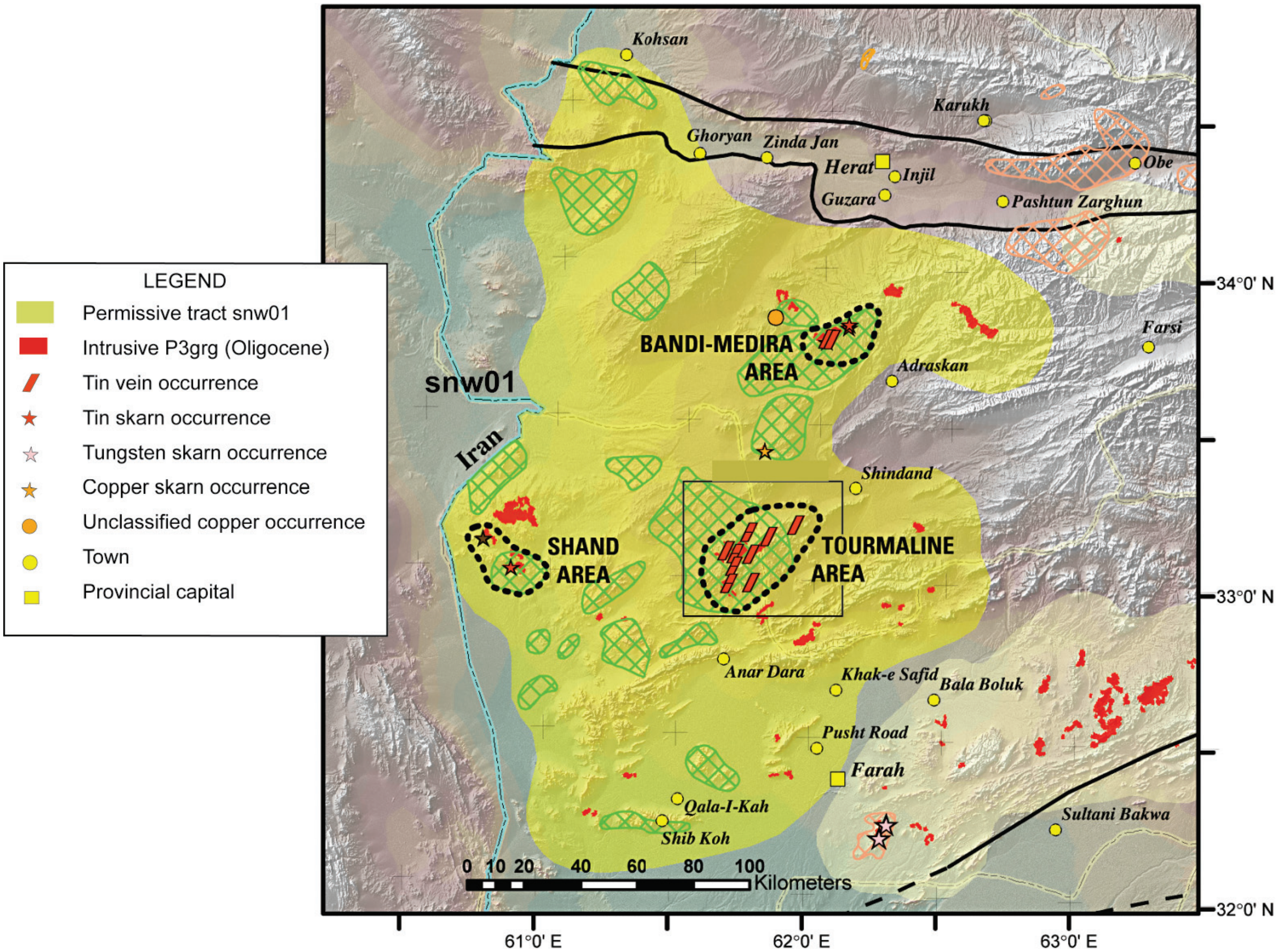

Figure 14A–8. Map showing Anar Dara (snw01) permissive tract in western Afghanistan, showing mineral prospects and occurrences, geochemical halos, and outcrops of granitic rock and location of Tourmaline tin area of interest. The area shaded in yellow is permissive for tin- and tungsten-bearing veins, stockworks, and porphyry deposits. Bright red polygons are outcrops of granite (map unit P_3grg). Green crosshatch indicates tin geochemical halos; salmon crosshatch indicates tungsten geochemical halos. Areas outlined in dotted line are discussed in detail in this and other chapters of this report. Source: Peters and others (2007).

The 3.5-km-long Tourmaline tin occurrence is the largest known in the AOI and comprises two silicified zones that lie within the granite along the north-trending contact (figs. 14A–9 and 14A–10). An approximately 1.6-m-thick contact zone at the Tourmaline tin prospect contains apatite, bismuthinite, cassiterite, chalcopyrite, galena, hematite, pyrite, sphalerite, zircon, and secondary minerals of lead and copper as well asalbite, fluorite, and muscovite (fig. 14A–10). Deposits in the zone grade 0.01 to 1.35 weight percent tin or more (Kabakov, 1973; Yefimenko and others, 1973). The alteration along the zone is well expressed in the thermal bands of the ASTER imagery (fig. 14A–10*b*).

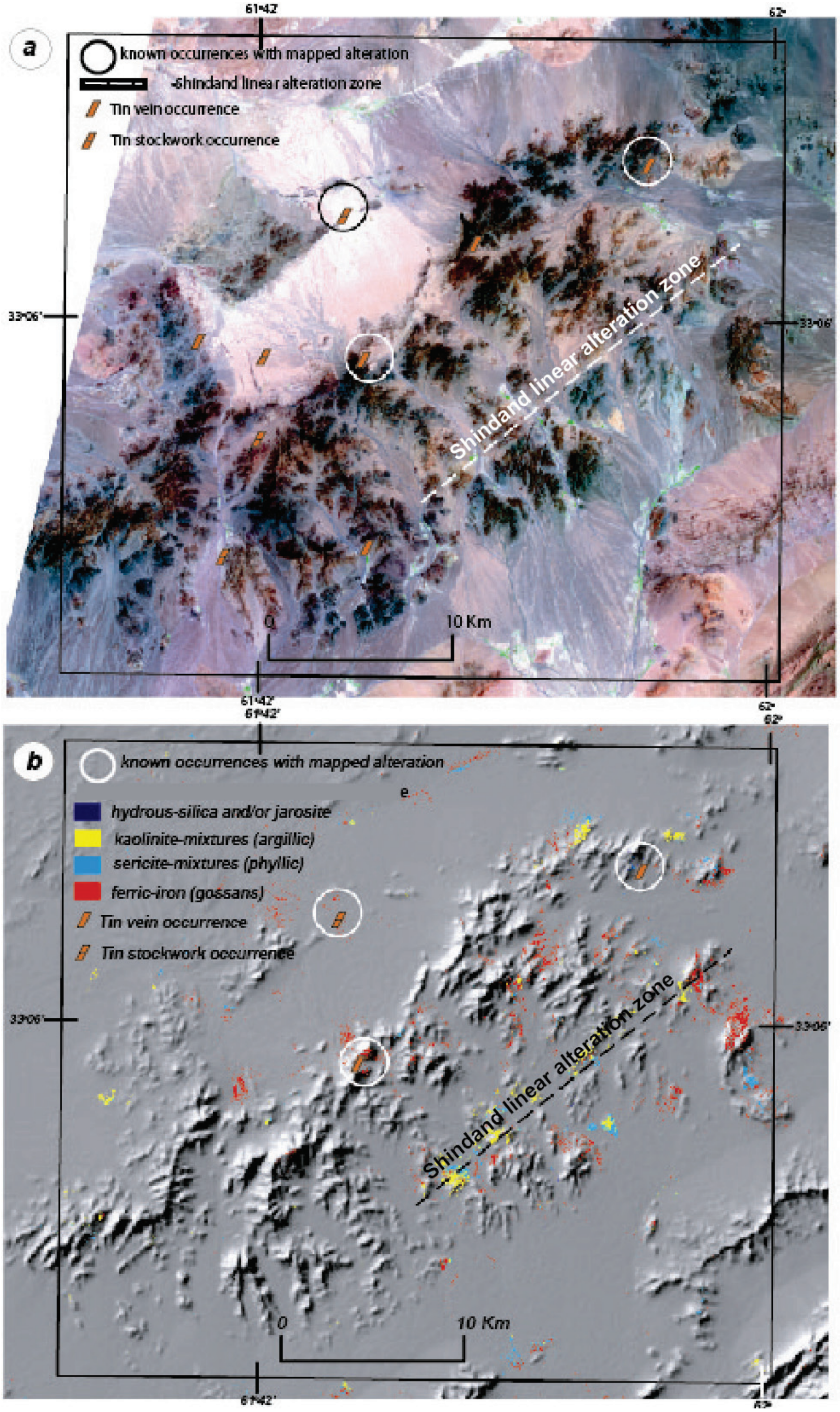

Figure 14A–9. Advanced Spaceborne Thermal Emission and Reflection (ASTER) radiometer bands R–G–B=6–3–1 (*a*) covering most of the Tourmaline tin area of interest and resulting alteration mineral map. (*b*) Although most known occurrences were not mapped using either ASTER or hyperspectral (fig. 14A–8), both datasets depict the linearly trending Shindand mineralized area (dashed line), exposed within the Eocene-Oligocene volcanic/extrusive complex encompassing the Oligocene granites.

A central area along the Tourmaline tin prospect zone contains eight orebodies, some of which are 600 m long and range from 3 to 50 meters (m) wide and grade from 0.01 to 1.19 weight percent tin with average grades of 0.24 weight percent tin at the surface (fig. 14A–11). The grade of the ore at the northern parts of the Tourmaline tin area occurrence is not as high, but locally contains as much as 0.39 weight percent tin. The southern parts of the contact zone in the Tourmaline tin prospect contain numerous 40- to 460-m-long and 3- to 17.4-m-wide quartz-tourmaline-sulfide veins that grade up to 0.68 weight percent tin (fig. 14A–11).

The Bisar tin occurrence is located within but near the contact between a small isolated stock of Oligocene granosyenite and in Eocene-Oligocene volcanic rocks. The prospect is reported to be 2,000 m long and up to 100 m wide and is marked by silicified, hematite-bearing zones with individual 40- to 100-m-long and 0.5- to 2.0-m-wide intervals grading 1.0 weight percent tin and up to 0.07 weight percent tungsten (fig. 14A–2; Abdullah and others, 1977).

The Bulgaja tin occurrence in volcanic rocks lies along the eastern margin of the granite stock in a 500-m-long and 10-m-wide silicified, serpentinized, and brecciated zone that grades 0.1 weight percent tin with trace amounts of lead and zinc (fig. 14A–2) (Kabakov, 1973; Abdullah and others, 1977).

The Kelkak tin occurrence lies within volcanic rocks proximal to a goethite alteration zone. The occurrence is a 244-m long quartz stockwork containing cassiterite, chalcopyrite, and scheelite grading 0.01 to 0.03 weight percent tin with local values of copper, lead, and tungsten (fig. 14A–2; Yefimenko and others, 1973).

South of the Kelkak tin occurrence, the volcanic rocks contain numerous multidirectional quartz veins and veinlets containing scheelite with 0.03 weight percent tungsten with values of molybdenum (fig. 14A–2; Yefimenko and others, 1973). This stockwork zone lies between Kelkak and a smaller granitic stock at Bisar and may represent a shattered roof pendant zone (Abdullah and others, 1977).

The Kuchi tin occurrence also is hosted by the Oligocene granite along a magnetic low between the Bulgaja and She-Kuta occurrences and comprises three 25- to 70-m-long and 3- to 7- and up to 22-m-wide silicified, felspathized zones grading from 0.034 to 0.5 weight percent tin with trace concentrations of copper, lead, and zinc (fig. 14A–2; Yefimenko and others, 1973). The area lies within a goethite alteration zone that parallels the granite contact along the northeast-trending margin of the intrusive (fig. 14A–2).

The Sarkoro tin occurrence, on the northern contact of the granite stock, contains quartz-hematite veinlets in a 100-m-wide and 500-m-long brecciated, slightly silicified shear zone that contains 0.01 to 0.79 weight percent tin with traces of copper (figs. 14A–2; Kabakov, 1973; Abdullah and others, 1977).

The She-Kuta tin-bearing vein is hosted in granite and lies within a magnetic low. It contains numerous quartz veins in a 6.5-km-long and up to 50- to 60-m-wide brecciated zone that contains disseminated cassiterite, galena, limonite, and secondary lead minerals. This vein grades from 0.1 to 0.03 weight percent tin with trace amounts of lead (fig. 14A–2; Yefimenko and others, 1973).

14A.7 Tin Placers

Tin placers are reported from the Tourmaline tin AOI in the streams that drain the main granitic stock and in alluvial fans and talus slopes that shed sediment from the granitic stock and volcanic rocks (fig. 14A–12). The North placer (33°11'N, 61°43'E) contains cassiterite in talus in 5- to 10-m-thick paleoterraces (30 to 175 grams of cassiterite per cubic meter) and in 0.3- to 0.5-m-thick alluvial channels (150 to 1,111 g/m^3 cassiterite). Ravine placers range in length from 50 to 100 m, in width from 0.2 to 1.5 m, and in thickness from 0.1 to 0.2 m and contain 700 grams to 13 kilograms (kg) of cassiterite per cubic meter. The speculative reserves of all these placers are about 11.5 metric tons cassiterite (Yefimenko and others, 1973).

The Cone tin placer (33°03'50"N, 61°30'00"E) comprises alluvial and talus sediments that contain from 0.2 to 0.9 kg of cassiterite per cubic meter (Yefimenko and others, 1973).

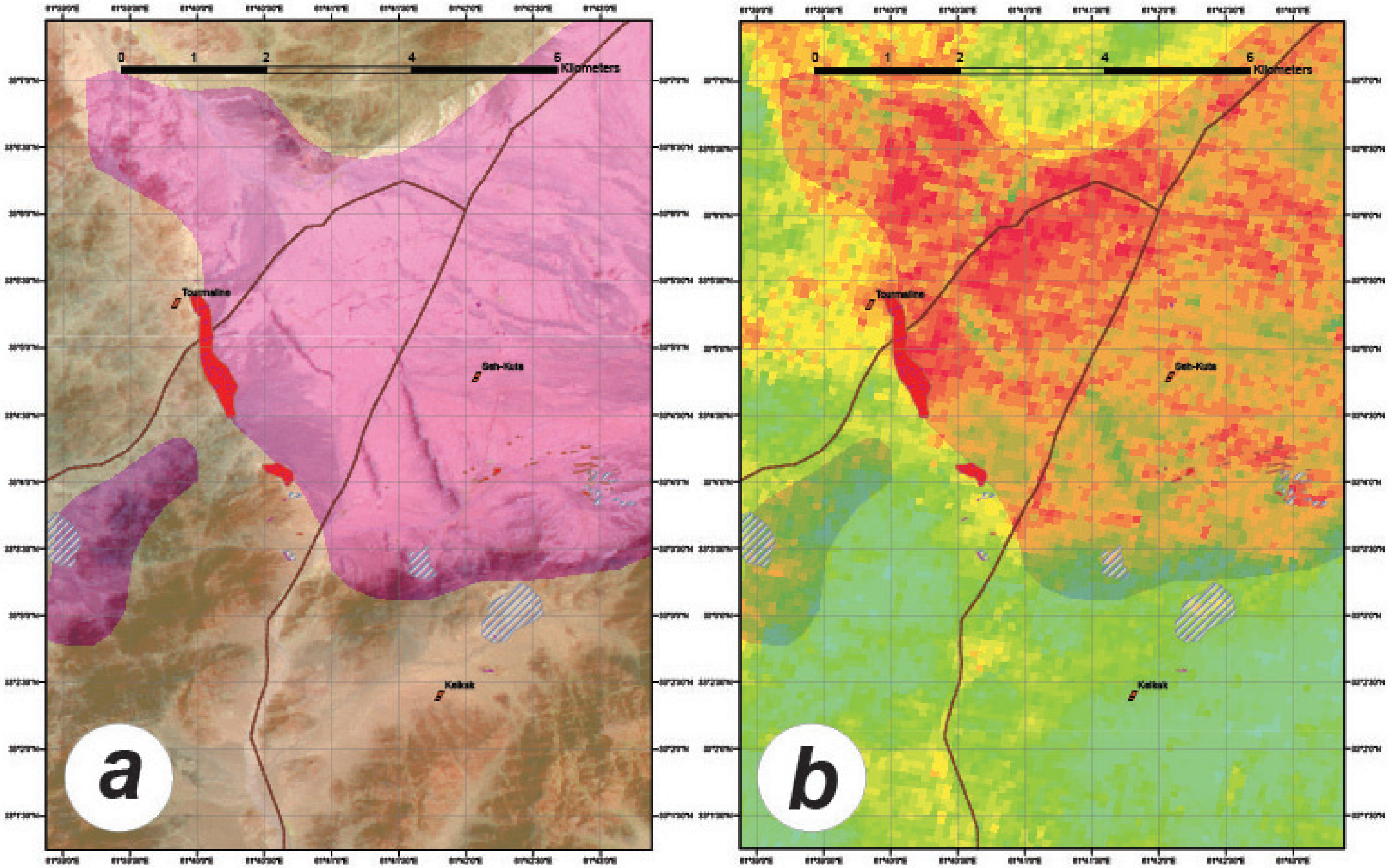

Figure 14A–10. Maps of the Tourmaline tin prospect in the Tourmaline tin area of interest. (*a*) Geologic map (Doebrich and Wahl, 2006) overlain on Landsat image with added exploration areas (red zones) and hyperspectral alteration (goethite) zones (hatched) from fig. 14A–2. (*b*) Geologic map overlain on Advanced Spaceborne Thermal Emission and Reflection radiometer thermal imagery that shows siliceous (red colored areas) and sericitic (yellow colored areas) alteration zones. Green colors indicate relatively unaltered areas.

Figure 14A–11. Geologic map of the Tourmaline tin prospect area in the Tourmaline tin area of interest; based on information from Yefimenko and others (1973). Dacite porphyry is the same as the volcanic rocks described in the text.

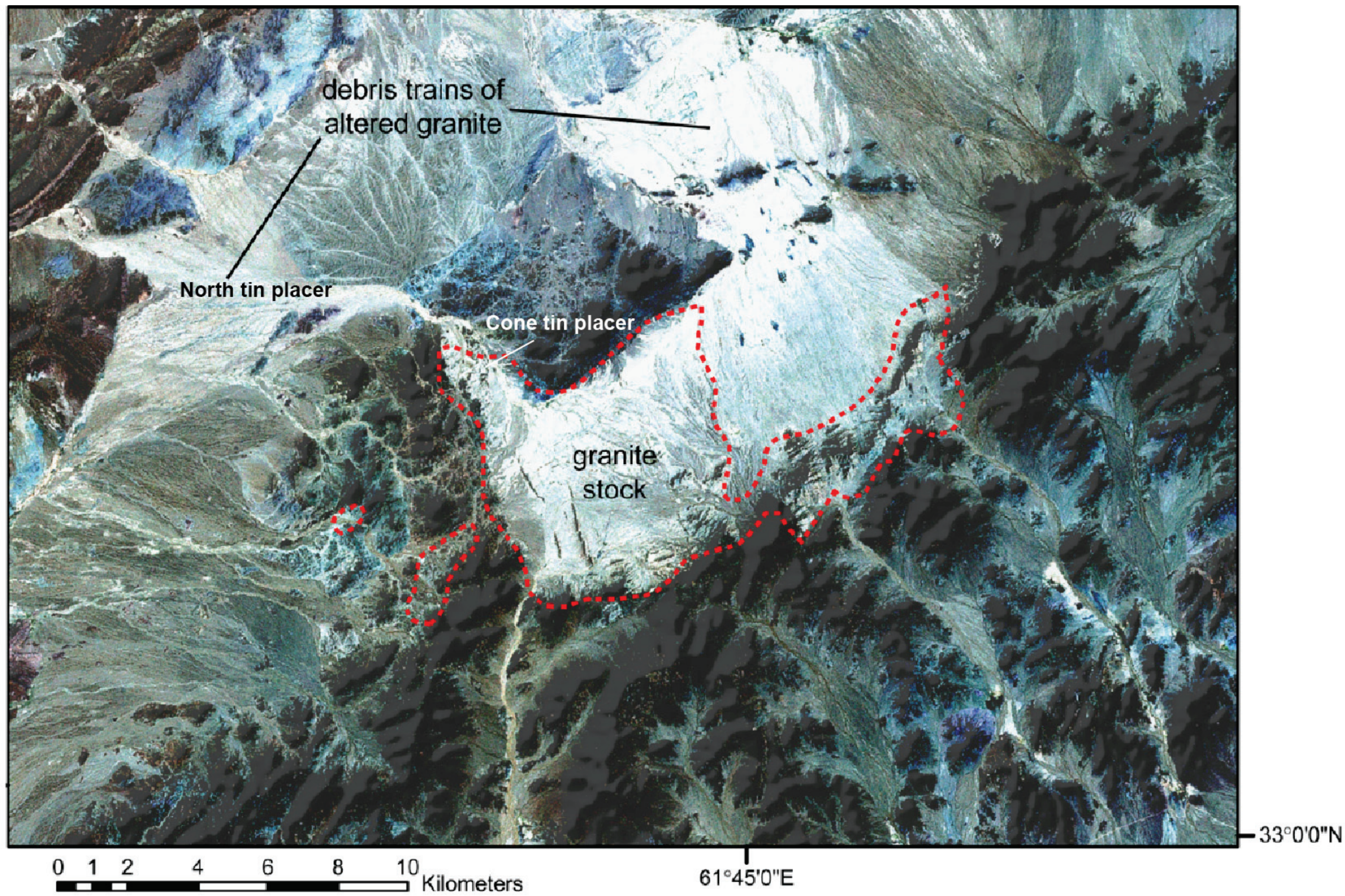

Figure 14A–12. Landsat image of the Tourmaline tin area of interest that shows alluvial channels and fans draining the granite stock to the west and northwest. Reproduced from Peters and others (2007). Ravine channels directly drain the Tourmaline prospect area at the southwestern part of the granitic stock and also drain the hills of dacite porphyry to the southeast.

14A.8 Summary of Potential

Discovery and exploitation of economic lode and placer deposits of tin can be aided by mapping and sampling and by trenching and drilling in the areas of known occurrences with close attention to characteristics outlined in descriptive models (Peters and others, 2007). The mean tonnages and grades from grade-to-tonnage models of common lode tin and tungsten deposit types throughout the world, similar to those that might be found in the Tourmaline tin area of interest, are listed in table 14A–1.

Table 14A–1. Quantitative grade tonnage means for different U.S. Geological Survey tin and tungsten deposit models.

Model	Mean tonnage, in million metric tons	Mean grade, in percent	Reference
Tungsten skarn	1.1	0.67 tungsten oxide	Jones and Menzie, 1986.
Tin skarn	9.4	0.31 tin	Menzie and Reed, 1986b.
Tin veins	0.24	1.3 tin	Menzie and Reed, 1986d; Reed, 1986b.
Replacement tin	5.2	0.8 tin	Menzie and Reed, 1986a.
Tin greisen	7.2	0.28 tin	Menzie and Reed, 1986c; Reed, 1986a.

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