12.0 Precious and Semi-Precious Stones

Contributions by Lawrence W. Snee, Stephen G. Peters, and Greta J. Orris.

A number of gemstone deposits of different kinds are present mainly in the northeastern parts of the Afghanistan underlain by Proterozoic and Archean rocks. These include emerald deposits of the Panjsher Valley (Snee and others, 2005), ruby, sapphire and spinel occurrences in the Jegdalek area (Orlov and others, 1974) and Balal (Ab-i-Panja) (Bowersox and Chamberlin, 1995), and lapis lazuli occurrences at Sary-Sang on the Kokoschka River in Badakhshan Province (Efinov and Suderkin, 1967). In addition, gemstones are present in many of the numerous pegmatites deposits and include tourmaline, kunzite, garnet and ruby (Orris and Bliss, 2002). Occurrences of peridot are also known along the Afghanistan-Pakistan boarder (Blauwet and others, 1997). Many areas contain sufficient amounts of colored stones and gemstones to commercially support local industries. Much of the material would be exported.

12.1 Emeralds

As part of the mineral resource-assessment task of the USGS effort in Afghanistan, a group of USGS and Afghan geologists visited the Panjsher Valley, Parwan Province, northeastern Afghanistan, in July, 2004 to examine the geology of the valley and the emerald deposits within the valley (Snee and others, 2005). The purpose of these trips was to assess the regional geology of Panjsher Valley, conduct preliminary geologic investigation of the geology of the Panjsher emerald deposits, and collect numerous samples for future detailed geochemical, geochronologic, and petrographic study. A separate report (Snee and others, 2005) outlines the preliminary overview of the geology and structure of the Panjsher Valley and the geologic framework of the Panjsher emerald deposits. Models describing emerald deposits include the emerald veins model, as well as metasomatic or shear zone models.

12.1.1 Description of emerald veins model.

The emerald vein model (model 31, Cox, 1986) is also call emerald in plagioclase-dolomite. These deposits commonly are present as veins in black shale (Sinkankas, 1981). The geological environment includes black shale, claystone, siltstone that is locally calcareous, as well as minor sandstone, limestone, conglomerate, and evaporate deposits. Locally, coarse dolomite breccia is filled by carbonate minerals and oligoclase. Diabasic dikes may be present but are not prominent. Age range is usually Cretaceous to Tertiary. Depositional environment involves thick epicontinental anoxic marine shale. Evaporates may also have provided saline solutions. Tectonic setting of emerald veins includes major faults along with minor intrusions that may have provided heat sources for fluid circulation. Associated deposit types with emerald veins are Pb-Zn deposits on a regional scale.

Mineralogy consists of emerald + greenish beryl + oligoclase + dolomite + calcite + pyrite + fluorite + rutile+ quartz. Apatite, parisite, and REE dolomite are reported in some deposits. Textures consist of crustified banding, vuggy and coarsely crystalline zones. Alteration involves shale that is altered to black hornfels, and fossil shells are replaced by oligoclase. Dolomitization also is locally present. Ore controls are major fault intersections at minor cross faults, which produce sharp-walled veins, and tabular breccia bodies. Veins locally are confined to sedimentary strata that overlie or underlie ferruginous beds. Weathering involves plagioclase that forms pockets of kaolinite. Geochemical signature of the veins is high Be, Na, Mg; low Li, Ba, K, Mo, Pb relative to shale outside of mineralized areas. Some deposits contain REE in veins and copper is anomalously elevated in underlying sedimentary beds.

12.1.2 Emerald Tract Description

Permissive tract (area of interest)—gem01

***Deposit types*—**Emerald

***Age of mineralization*—**Oligocene?

***Examples of deposit type*—**The known emerald deposits of the Panjsher Valley lie along the valley's southeastern side near the village of Khenj (Kazmi and Snee, 1989; Bowersox and others, 1991), although emeralds have also been reported on the northwest side of the valley (Tawach area; Sabot and others, 2001)

The emerald mineralization is localized in linear zones that contain fracturing and brecciation of hydrothermally altered gabbro-diorite dikes, marble, schist and quartz porphyry. The emeralds are present in two zones: in the northwestern zone (locality Buzmal) and in the south-eastern zone (the other occurrences), and occurrences in these zones are associated with the contact between Silurian-Lower Carboniferous carbonate rocks, and Upper-Carboniferous-Permian flysch rocks. Along the contact, a series of closely spaced, steep-dipping faults contain zones of fracturing, brecciation, boudinage, and cataclasis, as well as intensely hydrothermally altered rock (including biotitization, phlogopitization, epidotization, albitization, potasium feldspatization, silicification, tourmalinization, sulfidization, carbonatization, chloritization, and muscovitization). The beryllium mineralization with zones of emeralds is superimposed in a complex system of fractures in hydrothermally altered (carbonate-sulfide) rocks (gabbro-diorites, marbles, schists); especially near hydrothermally altered biotitized (phlogopitized) and chloritized diorite dikes (gabbro-diorites).

Favorable horizons are shear zones intruded by gabbro-diorite or other dikes. The gabbro-diorite dikes are normally strongly altered and sheared. The presence of quartz-porphyry dikes is also favorable. Veinlets of carbonate (with specular hematite in places, quartz, quartz-carbonate, pyrite-carbonate, quartz-tourmaline-carbonate are common). Tourmaline-albite-carbonate-iron oxide alteration is common. Microcline, white mica, and biotite or phlogopite, also form alteration products. Beryl forms in clusters within the alteration and in veinlets. Some beryl crystals are over printed with post-depositional fracturing (Snee and others, 2005).

Panjsher emeralds have been described by Bowersox (1985), Kazmi and Snee (1989; and articles therein), and Bowersox and others (1991), as well as Samarin and Akkermantsev (1977). The quality of the emerald crystals varies from mine to mine. Crystals are transparent to translucent or opaque and generally range from 4 to 5 carats, although a 190-carat crystal was reported by Bowersox (1985). Crystals are normally euhedral and prismatic, although in some cases crystals were naturally etched by later reactive fluids. Color zoning is common and where present interiors are paler; exteriors are darker green. The green color of all emeralds is the result of the substitution of small amounts of chromium or vanadium for aluminum in the beryl crystal structure (Deer and others, 1986). In Panjsher emeralds, chromium contents of up 19,180 ppm and vanadium up to 690 ppm were measured by instrumental neutron activation analysis (Snee and others, 1989). Hammarstrom (1989) measured chromium contents of up to 13,700 ppm and vanadium up to 3,100 ppm by electron microprobe. Hammarstrom (1989) also showed that the green brightly colored areas of emerald are enriched in chromium. Chemically, Panjsher emeralds fall within the range for natural emeralds (Snee and others, 1989), but appear to be most similar to Colombian emeralds. They can be easily distinguished from Pakistan emeralds (Hammarstrom, 1989; Snee and others, 1989) and other world emerald deposits (Groat and others, 2002) by differences in trace element content.

Exploration history **—**Emerald miners have excavated into the contact zone between carbonate and clastic host rocks; dynamite is commonly used to the detriment of the crystals. Currently, mining is being conducted in the Khenj and Mikeni localities. Miners have followed the yellow hydrothermal alteration zones and veins in search of emeralds. Some tunnels extend only a few meters into the hillside; however, some extend more than 200 m underground (Snee and others, 2005).

Importance of deposits**—**To date, the best emeralds have been found in the Khenj and Mikeni occurrences. Yearly emerald production values are unknown but estimates range up to $50 million for production in year 2000. During geological-exploration and studies of the Khenj locality in 1976 (Samarin and Akkermantsev, 1977), 3,360 g of emerald crystals were recovered. Most of this quantity (3,125.4 g) was recovered from the western zone (carbonate host rocks) of the Khenj deposit; the remainder was recovered from the eastern zone. Samarin and Akkermantsev (1977) report that of this recovered quantity, 591.2 g (2,950.8 carats) were below gem quality, 32.3 g (161.5 carats) were suitable for face cutting, and 557.9 g (2,789 carats) were suitable for convex cutting (cabochon). Samarin and Akkermantsev (1977) estimate that the gemstone-grade quantity of emerald crystals in the western zone within the productive area is 7.5 carats per cubic meter; in the eastern zone it is 0.6 carats per cubic meter. These authors also estimate that as of January 1, 1977 the reserves of emerald resources in the ground at Khenj (both eastern and western zones) was 439.9 kg for all emerald crystals of which 324,625 carats (65.0 kg) were of gemstone-grade quality; of the gemstone-grade quality emeralds, 17,860 carats (3.6 kg) are suitable for face cutting and 306,765 carats (61.4 kg) for convex cutting (cabochon).

Tract boundary criteria—An area of interest was constructed to enclose the emerald-bearing zone that occupies an 8–km-wide and 25–km-long area in Panjsher Valley that extends from southwest near the northwest-flowing tributary Khenj to northeast near the northwest-flowing tributary Riwat, and is confined to the southeastern side of the Panjsher River. The mountain ridge that parallels the Panjsher River rises steeply in elevation from the river near Khenj to the southeast. This ridgeline is dissected by several fast-flowing tributaries, which from south to north are the Khenj, Mikeni, Buzmal, and Riwat streams. The primary emerald-bearing zones are a few km to the east of the Panjsher River.

Needs to improve assessment**—**Geological mapping and sampling both on the prospect scale and along the mineralized zone (1:10,000-scale), and regionally along the northeastern trend of rocks (1:100,000-scale), would improve the assessment.

Optimistic factors**—**Known deposits are producing commercial amount of emeralds and the zone of mineralization extends at least 25 km and is at least 8 km wide.

Pessimistic factors—The area is remote and only small hand-worked areas have been discovered.

Quantitative assessment—Available information is not sufficient to allow a quantitative assessment.

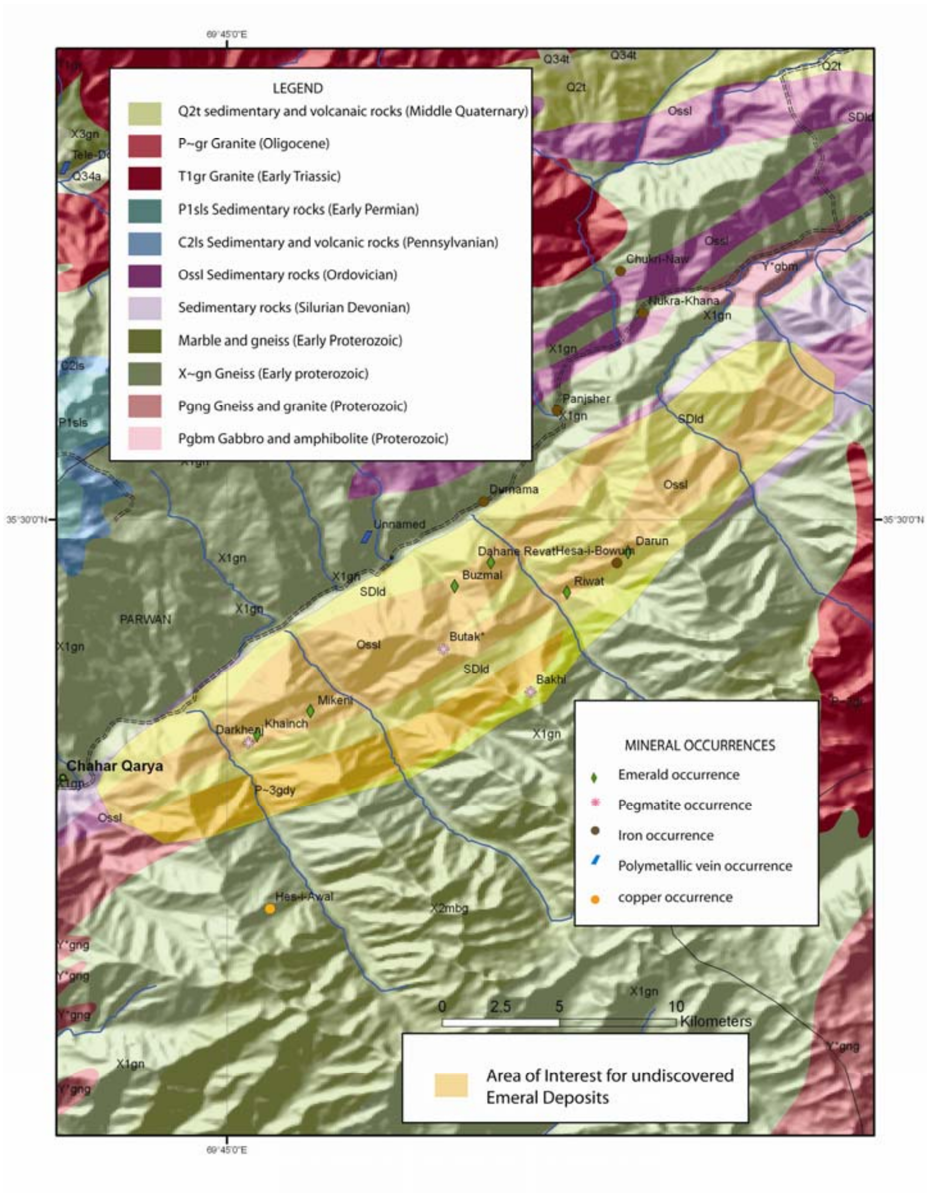

Figure 12.1-1. Location of area of interest for undiscovered emerald deposits in the Panjsher Valley area, showing location of known emerald deposits and main geologic units from Doebrich and Wahl, (2006). See maps and figures in Snee and others (2005) for geographic features.

12.2 Ruby, sapphire, and spinel

The Jegdalek ruby occurrence in Qarghayai District southwest Laghman Province is hosted in Proterozoic marble that is intruded by a small Oligocene granite plug. The wedged-shaped contact zone is 500 m thick on the west and 1,700 to 2,000 m thick on the east and consists of a ruby-bearing calcite and dolomite marble bed. The ruby crystals are in calciphyre and lie next to interbedded aluminum-silicate rocks that are migmatite and pegmatite (Bowersox, and Chamberlin, 1995). A ruby concentrate from the mineralized beds yielded 122 to 157 g/m^3 according to Orlov and others (1974) and Abdullah and others (1977). The Jegdalek occurrence lies within the Surkh-Rod pegmatite field, which is a 50–km-long, up to 20–km-wide east-trending zone intruded by Oligocene and Cretaceous granites that also contains the Surkh-rod and Tatang pegmatites (fig. 12.2-1).

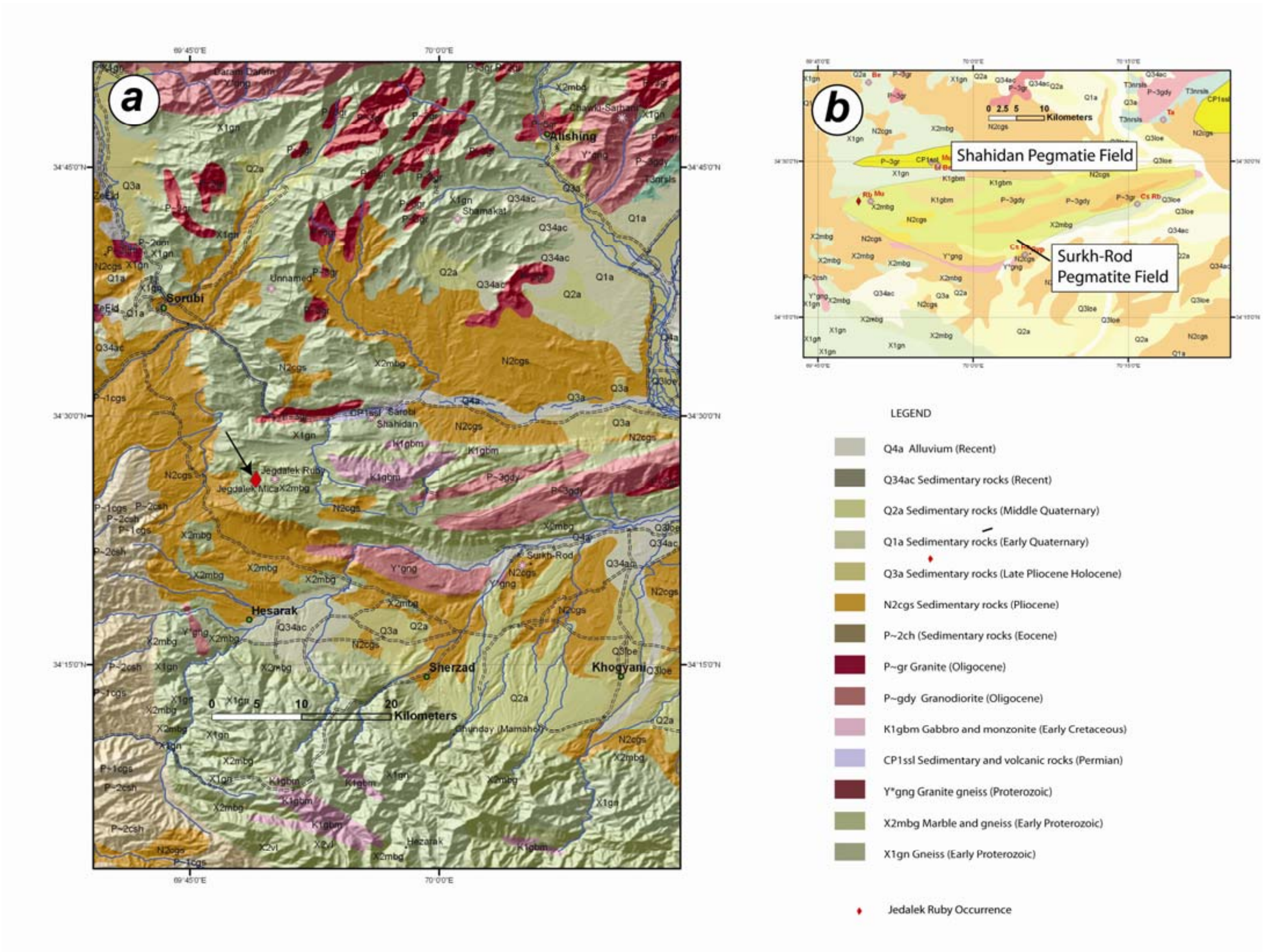

Figure 12.2-1. Map showing location of the Jegdalek ruby occurrence in Qarghayai District southwest Laghman Province. (*a*) General geology of the Jegdalek area Jegdalek with arrow and red diamond. (*b*) Location of the Jegdalek ruby occurrence within the Surkh-rod Pegmatite field. Geologic units and mineral symbols from Doebrich and Wahl (2006).

The Ab-i-Panja Gem (Balal) area in northeastern Badakhshan Province includes the Kuh-i-Lal spinel occurrence in the northern parts of the Ishkashim District. The area is the site of ancient mining of ruby and spinel, some of which took place in adjacent Tadjikistan (Bowersox, and Chamberlin, 1995). The occurrences are hosted in Middle Archean biotite-garnet, amphibole and biotite-amphibole gneiss, magnesian marble, and calc-silicate gneiss (Doebrich and Wahl, 2006) (fig. 12.2-2)

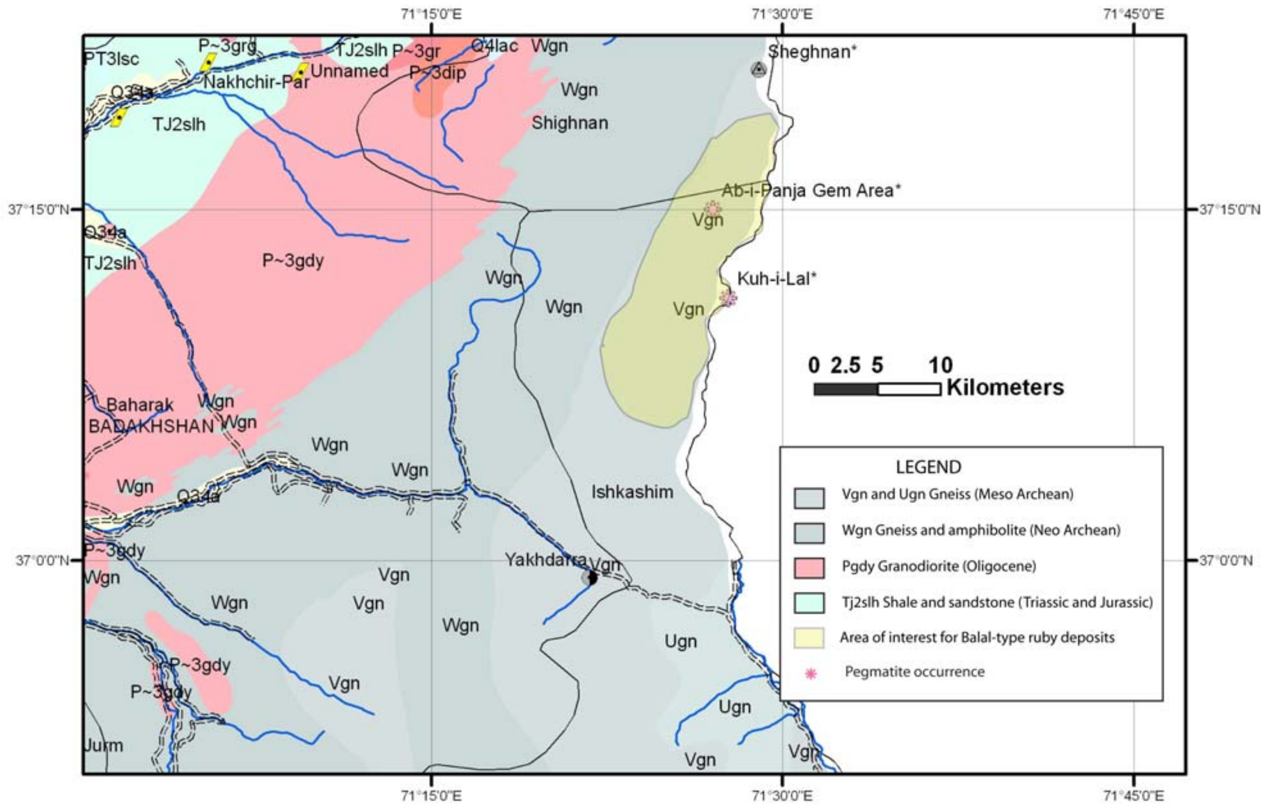

Figure 12.2-2. Location of the Ab-i-Panja (Balal) gem area in northern Badakhshan Province, Ishkashim District.

12.3 Lazurite (Lapis Lazuli)

The Sary-Sang Lapis Lazuli occurrence lies east of the Kokoschka River in northern Kuran Wa Mun district in Badakhshan Province (fig. 12.3-1) and is hosted in Archean gneiss, marble, calciphyre, and crystalline schist that is intruded by alaskite granite and mafic dikes forming a north-striking skarn zone that contain lapis lazuli lenses, which are spatially associated with diopside, forsterite, scapolite, sodalite, elbaite, chondrodite, and monticellite (Efinov and Suderkin, 1967; Bariand, 1972: Bowersox, and Chamberlin, 1995) (fig. 12.3-2). There are nine (9) lazurite zones within an area that is 20 to 300 m long and 1 to 8 m thick. The largest zone has been explored for 450 m along strike and 125 m down dip. Five lazurite grades have been defined. Due to the very irregular mineral distribution the complex structure, this deposit is considered to be erratic in shape. Total resources are estimated to be about 1,500 metric tons of lazurite (Mayorov and others, 1965; Bariand, 1972; Orlov and others, 1974; Abdullah and others, 1977).

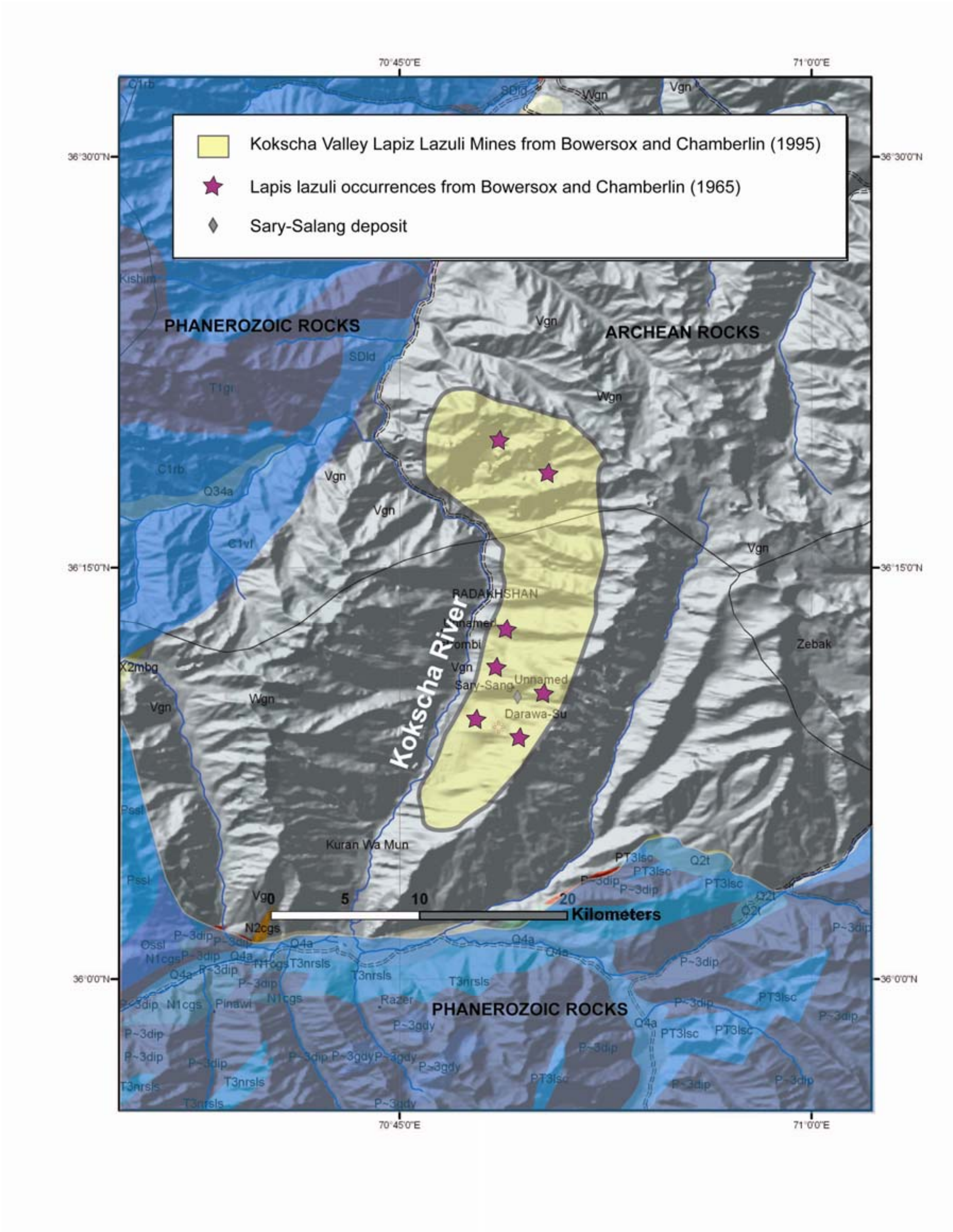

Figure 12.3-1. Map showing location of the Sary-Sang Lapis Lazuli Mine and associated prospects in the Kokoschka River Valley. Modified from Doebrich and Wahl (2006) and Bowersox, and Chamberlin (1995).

Figure 12.3-2. Example of Lapis lazuli specimens and other minerals from the Sary-Sang Lapis Lazuli Mine and associated prospects in the Kokoschka River Valley. (a through e) Lapis lazuli. (f) sodalite, (g) elbaite, (h) winchite, (i) chondrodite. Photographs from ***mindat.org***.

12.4 Gems in Pegmatites

Gemstones are present in many pegmatites in Afghanistan, such as tourmaline, garnet, and ruby and these occurrences are part of the south Asian pegmatite belt of the Hindu Kush, (Denikaev and others 1972, 1973; Rossovskiy and Chmyre, 1976; 1977; Rossovskiy and Konovalenko, 1976: 1979, 1980; Rossovskiy, 1980). Many of the pegmatite-hosted gem occurrences are due to internal zoning within the pegmatite bodies (Rossovskiy and Shmakin, 1978; Rossovskiy and others, 1976c and d). The tourmaline may be associated with beryl or with kunzite. In addition, rare earth elements—lithium, beryllium tantalum, and cesium—are present (Rossovskiy, 1977; 1981a, b; 1986; 1990; Rossovskiy and others, 1976a and b, Rossovskiy and others, 1976; 1979; 1987). Descriptions of elements and commodities contained in pegmatites are addressed in section 4.3

Pegmatite occurrences in Afghanistan have been divided into a number of pegmatite fields, mostly contained within an area of Late Cimmerian folding in the northeastern part of the country along the Pakistan border (figs. 12.4a and b).

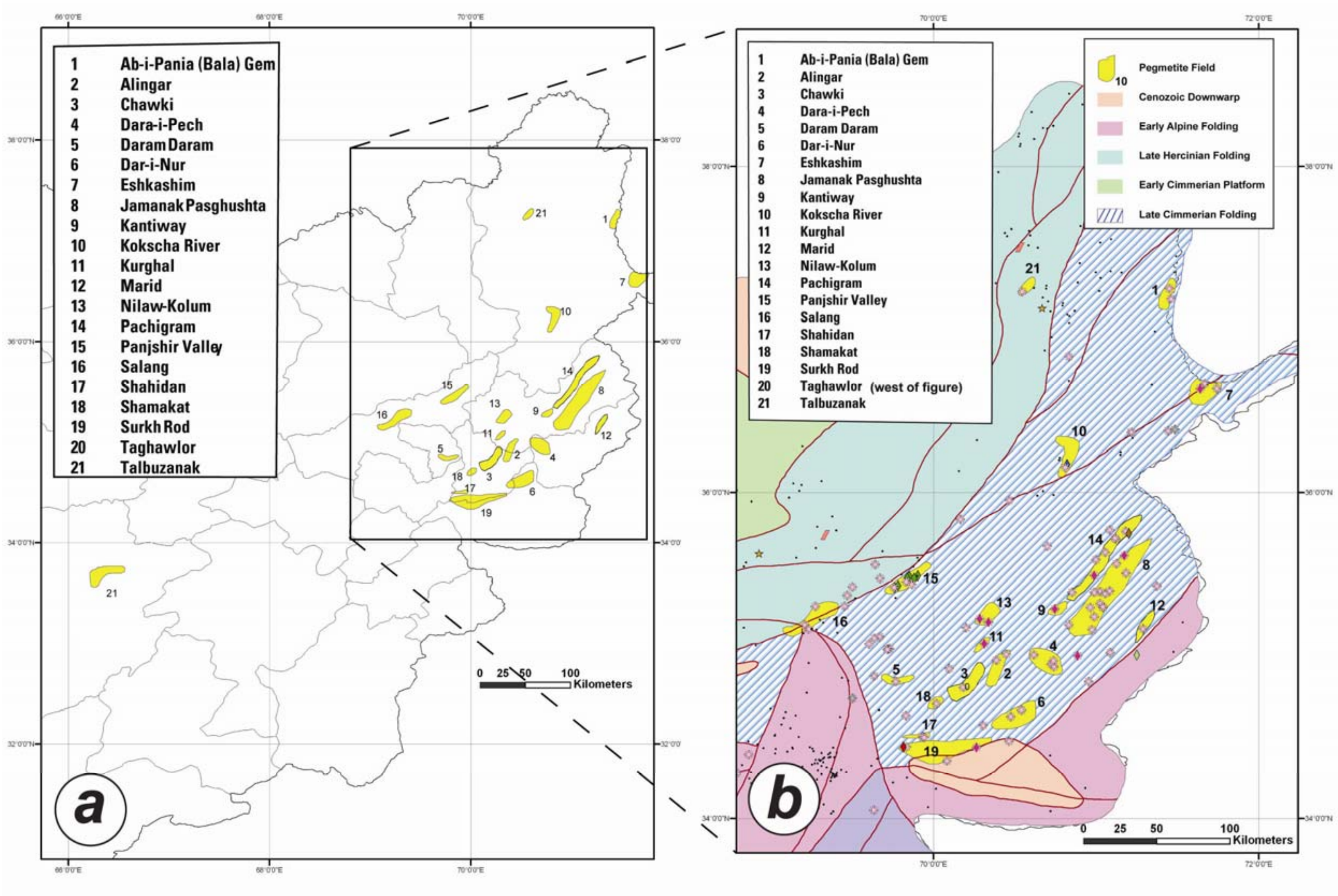

Figure 12.4-1. Maps showing location of pegmatite fields in Afghanistan modified from those described by Abdullah and others (1977). (*a*) Location of main fields. (*b*) Most of the pegmatite fields lie within an area of Late Cimmerian folding in northeast Afghanistan.

12.4.1 Tourmaline

Tourmaline is common in a number of pegmatites in northeastern Afghanistan. Tourmaline belongs to a group of boro-silicate minerals, but is of lesser importance for boron compared to borax, colemanite, ulexite, and others (section 7.9).

There are nine identified tourmaline-bearing pegmatite occurrences reported in Afghanistan (Orris and Bliss, 2003). They are present in four provinces in the eastern part of the country, Badakhshan, Laghman, Kunar, and Nangarhar. Abdullah and others (1977) has information on two pegmatite districts with tourmaline mineralization, Kantiwa in Nangarhar Province, and Kurghal in Laghman Province. The occurrences are noted for their gem-quality tourmaline. It is probable there are other non gem-quality tourmaline-bearing pegmatites are present within the pegmatite fields.

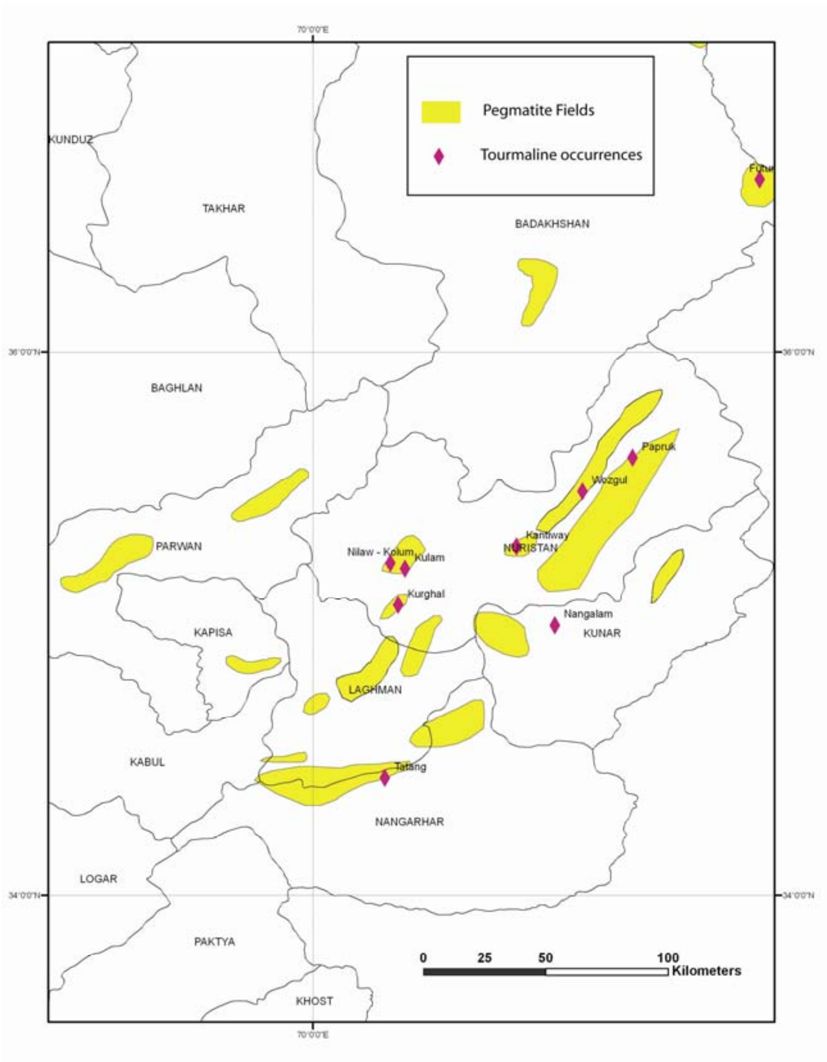

Figure 12.4-2. Map showing location of tourmaline occurrences (pink diamonds) in pegmatite fields (yellow) in northeastern Afghanistan. (Modified from data from Abdullah and others, 1977 and Orris and Bliss, 2003).

The tourmaline and associated occurrences are described below.

The Futur tourmaline occurrence in Badakhshan Province may be of Oligocene age (fig. 12.4-2). It is present as pegmatite veins that cut Lower Triassic quartz-micaceous shale (Orris and Bliss, 2003). Minerals of economic importance present in the occurrences include spodumene, tourmaline, cassiterite, and columbite-tantalite.

A number of tourmaline occurrences are present in Laghman Province (fig. 12.4-2). Nilaw-Kolum is a small deposit of pegmatites in Lower Cretaceous diorites and gabbro-diorites (Orris and Bliss, 2003). Mineralization is in veins and pockets. Kulam is a small deposit in pegmatites in Lower Cretaceous gabbro-diorite massif (Orris and Bliss, 2003). Mineralization occurs as bed-shaped veins, lenticular veins, and pockets. The main vein extends to 3 km and is 0.5 to 20 m thick. Kurghal occurs in Proterozoic garnet-sillimanite-biotite gneiss and crystalline schist as three tourmaline pegmatite dikes being mined by local artisans as a source of green tourmaline (Abdullah and others, 1977). The first pegmatite dike is 150 m long and 10 to 15 m thick and consists of medium-grained leucocratic rocks (50 percent) and smaller, massive, microcline pegmatites, with graphic quartz inter growths in the microcline. It is common in this dike, to have a quartz-muscovite assemblage with 0.1– by 1.0–cm to 1.0– by 4.0–cm-size green tourmaline crystals (Abdullah and others, 1977). The second dike is over 100 m long and 7 to 10 m thick. It consists of a coarse-grained aplitic rock with cleavlandite aggregates, lepidolite, green tourmaline, and cassiterite (Abdullah and others, 1977). The third dike at Kurghal is about 30 to 35 m long and 2 to 7 m thick. It exhibits a heterogeneous, asymmetrical zonal texture. Five zones have been described from hanging wall to footwall. The first zone is the inner contact consisting of a muscovite-quartz 10– to 30–cm-thick rim. The next zone is a massive 4–m-thick microcline pegmatite with green tourmaline. The third zone consists of massive, 0.5– to 2.0–m-size quartz segregations. The next zone contains violet lepidolite aggregates, cleavlandite, dark-grey quartz, and disseminated cassiterite in a massive microcline pegmatite. The final zone consists of leucocratic aplitic zones (Rossovskiy, 1974).

Kunar Province also contains a number of occurrences of tourmaline (fig. 12.4-2). The Nangalam occurrence is present in pegmatites among Proterozoic shales and marbles (Orris and Bliss, 2003). Spodumene and tourmaline are economic minerals present. The Wozgul occurrence is present as pegmatites among Proterozoic gneisses (Orris and Bliss, 2003). The occurrence is in an area of greisen alteration. Spodumene, cleavlandite, tantalite, pollucite, tourmaline, and cassiterite also are present. The Kantiwa (or Kantiway) occurrence in Kunar district is of Oligocene age and occurs as pegmatites in Proterozoic gneisses in exocontact with an Oligocene age granite massif (Orris and Bliss, 2003). Quartz crystal, tourmaline, and kunzite are also present as gemstones. At the Papruk occurrence, Kunar district, pegmatite dikes cut Upper Triassic slate. The dikes are 50 to 60 m long and 5 to 8 m thick with gem-quality tourmaline crystals as much as 3 cm by 7 cm in size that are often associated with cleavlandite, smoky topaz, and lepidolite. The occurrence has been worked intensively by local artisans (Rossovskiy, 1974).

In Nangarhar Province, the Tatang occurrence is characterized by pegmatite veins, lenses, and veinlets in Silurian-Devonian shale and limestone (Orris and Bliss, 2003). Pollucite, cleavlandite, tourmaline, lepidolite, and cassiterite are the main economic minerals.

The Kolum (Kalam) tourmaline-kunzite deposit in Nuristan Province, Nuristan District is hosted in Early Cretaceous gabbro and gabbro-norite that contain ten (10) albitized, microcline pegmatite dikes with REE mineralization (fig. 12.4-3). The most important dikes are two (2) tabular, lenticular-shaped dikes containing large bulges and numerous apothesies. The main dike is 3,000 m long and 0.5 to 20 m wide with a number of cavities. Tourmaline crystals are 13 by 5 by 4 mm and 35 by 20 by 20 mm in size and are pink (rubellite), light-blue, indigo-blue, and polychromatic (green to pink and blue to green). Average standard quality tourmaline crystals yield 20 to 22 vol. percent of the rock volume. The main dike also contains macro-crystalline beryl in a 10– by 18– by 1.5–m-size block that grades 2 to 12 vol. percent beryl. Hand sorted resources are 20 metric tons bulk beryl. A second dike, the Kunzite dike is 150 m long and averages 5 m thick and contains numerous m-scale cavities. These cavities contain varieties of spodumene and tourmaline, vorobyevite, pollucite, cassiterite, manganotantalite, microlite, petalite, beryllium phosphates, and tantalum-bearing minerals. A number of cavities contain 90 to 150 kg of spodumene crystals and tourmaline. About 1,056 metric tons of spodumene were mined yielding 615 kg of gem quality spodumene and 4.5 kg gemstone tourmaline. Resources of beryl are estimated to be about 50 metric tons bulk beryl (Rossovskiy and others, 1976; 1977; 1978; Yenikeyeva and Akkermantsev, 1984; Yenikeyeva and others, 1985, 1987).

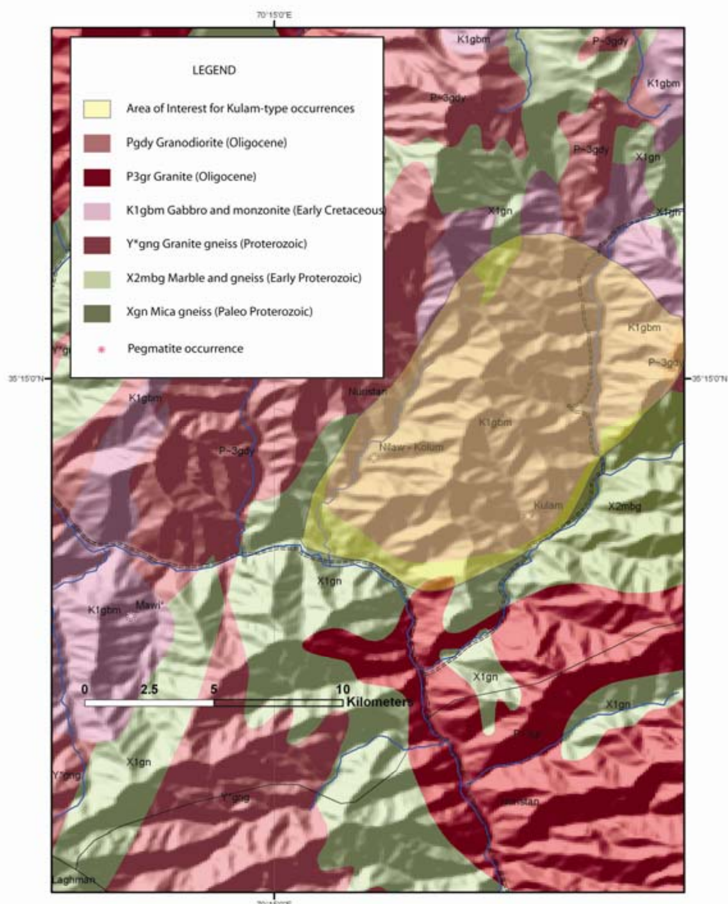

Figure 12.4-3. Map showing location of Nilaw-Kolum and Kulam tourmaline-kunzite occurrences in Nuristan Province, Mandol district, containing large areas of kunzite with associated amounts of tourmaline, beryllium, cesium, tantalum, rubidium and quartz.

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