Chapter 10C. Geohydrologic Summary of the Kundalan Copper and Gold Area of Interest

By Michael P. Chornack and Thomas J. Mack

10C.1 Introduction

This chapter describes the geohydrology of the Kundalan copper-gold porphyry area of interest (AOI) in southeast Afghanistan identified by Peters and others (2007) (fig. 10C–1*a*,*b*). The AOI is located in southeast Afghanistan in the districts of Shah Wali Kot, Tarnak Wa Jaldak, Mizan, Qalat, Arghandab, and Dayampan in Zabul and Kandahar Provinces (fig. 2C-1*a*,*b*). The Charsu-Ghumbad subarea covers 327 km^2 (square kilometers), the Baghawan-Garangh subarea covers 330 km^2, and the Kunag Skarn subarea covers 738 km^2 of the 2,576-km^2 area of the AOI.

Water is needed not only to process mineral resources in Afghanistan, but also to supply existing communities and the associated community growth that may accompany a developing mining economy. Information on the climate, vegetation, topography, and demographics of the AOI is summarized to provide information on the seasonal availability of, and seasonal demands for, water. The geohydrology of the AOI is described through the use of maps of streams and irrigated areas, generalized geohydrology and topography, and well locations. Where these data are available, the depth to water and height of static water in wells are documented. The results of lineament analyses are presented to identify areas where the rock may be more fractured than in other areas, which may be an indicator of high relative water yield and storage in some bedrock aquifers.

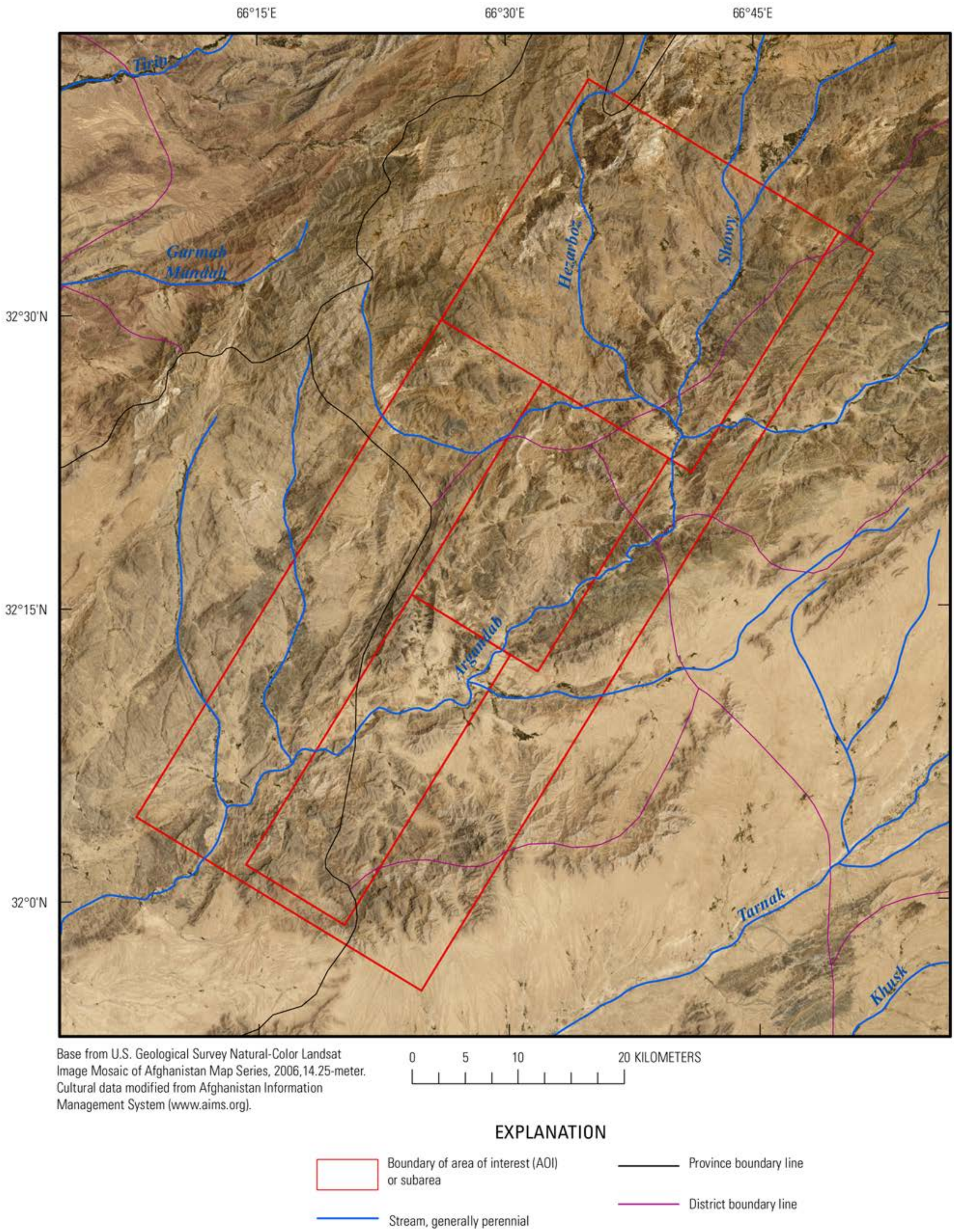
Afghanistan's recent turbulent history has left many of the traditional archival institutions in ruins, and most water-resource and meteorological data-collection activities had stopped by 1980. Recently (2011), nongovernmental organizations (NGOs), foreign government agencies, and the Afghan government have begun water-resource investigations; however, these activities and the amount of data collected are limited. This report summarizes the satellite imagery and climatic, topographic, geologic, surface-water, and groundwater data available. Geohydrologic inferences are made on the basis of an integrated analysis of these data and an understanding of conditions in other areas of Afghanistan.

10C.1.1 Climate and Vegetation

Climate information for the Kundalan copper-gold porphyry AOI is based on data generated for the Afghanistan agricultural-meteorological (Agromet) project. Agromet was initiated by the U.S. Agency for International Development and the United Nations Food and Agriculture Organization in 2003 to establish data-collection stations and develop country-wide agrometeorological services. Scientists with the Agromet project are assisting the Afghan Government to collect and analyze agricultural and meteorological data as they relate to crop production, irrigation, water supply, energy, and aviation. The U.S. Geological Survey (USGS) assumed responsibility for the operation of the project in 2005; by the end of August 2010, 87 Agromet stations were recording precipitation data and other parameters. Additionally, the Agromet project receives data from 18 Afghanistan Meteorological Authority (AMA) weather stations. The Agromet project has developed a database that includes data collected at the Agromet stations over the past 6 years (2005–2011), data collected at the AMA weather stations, and historical data collected at weather stations from 1942 to 1993. Data collected as part of the Agromet project are compiled annually by water year (September through August) and are reported in the Afghanistan Agrometeorological Seasonal Bulletin (Seasonal Bulletin) published by the Ministry of

Agriculture, Irrigation, and Livestock. Unless otherwise specified, the Agromet data cited in this report are from the agricultural season that extends from 1 September, 2009, to 31 August, 2010.

a



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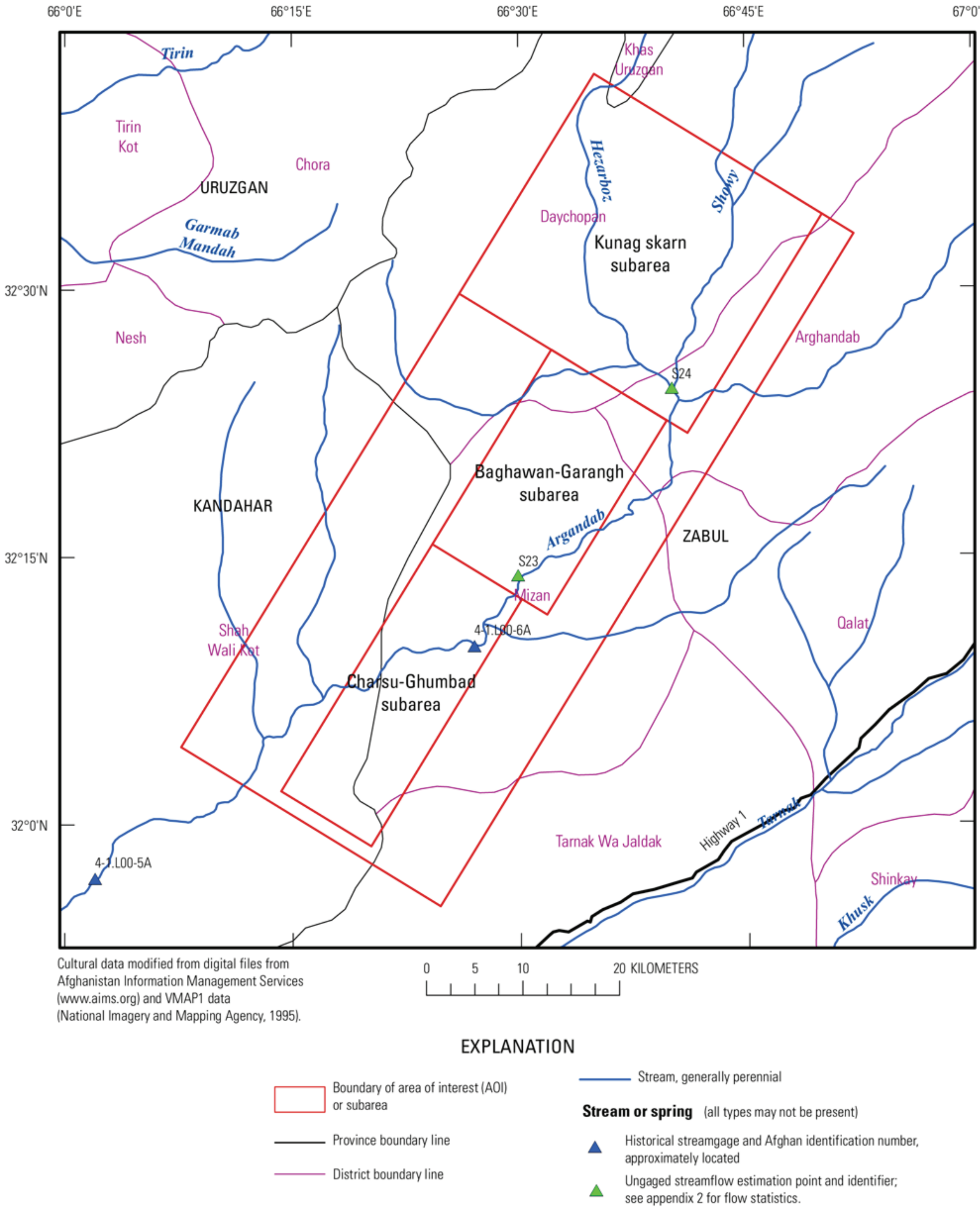


Figure 10C–1. (*a*) Landsat image showing the location of, and (*b*) place names, stream names, and streamgage station numbers in, the Kundalan copper-gold porphyry area of interest in southeast Afghanistan.

The observed total precipitation for the 2009-2010 water year for the AOI, as published in the Seasonal Bulletin (Ministry of Agriculture, Irrigation, and Livestock, 2010, map 2), ranged from 201 to 220 mm (millimeters). The AOI received 41 to 80 mm of precipitation in February 2010, the month with the greatest rainfall, with the amount of precipitation increasing from east to west (Ministry of

Agriculture, Irrigation, and Livestock, 2010, map 3). The AOI received 7 to 18 mm of precipitation, the month with the least rainfall, in October 2009 (Ministry of Agriculture, Irrigation, and Livestock, 2010, map 4).

The Kandahar Agromet station is located in Kandahar Province approximately 110 km (kilometers) southwest of the center of the AOI. This is the closest Agromet station to the AOI for which 2009-2010 water year and long-term average (LTA) precipitation and temperature data are available (table 10C–1).

Table 10C–1. Annual, long-term annual average, and long-term average minimum and maximum precipitation and temperature at the Kandahar Agrometeorological (Agromet) station approximately 110 km southwest of the Kundalan copper-gold porphyry area of interest, Afghanistan.

[AOI, area of interest; km, kilometers; m, meters; mm, millimeters; °C, degrees Celsius]

			Precipitation				Temperature		
					Long-term average[1]		Long-term average[1]		
Agromet Station	Distance from AOI center (km)	Elevation (m)	2009-2010 Annual (mm)	Annual (mm)	Monthly minimum and month (mm)	Monthly maximum and month (mm)	Minimum and month (°C)	Monthly mean (°C)	Maximum and month (°C)
Kandahar	110	1,020	304.3	317.5	1.2 June August	83.2 April	4.8 January	15.9	31.8 July

[1] Long-term averages are based on data from 1942 to 1993 and 2005 to 2010 as reported in the Afghanistan Agrometeorological Seasonal Bulletin (Ministry of Agriculture, Irrigation, and Livestock, 2010).

The Qalat-Zabul Agromet station is located in Zabul Province approximately 40 km southeast of the center of the AOI. This is the closest Agromet station to the AOI for which 2009–2010 water year precipitation and snowfall data are available. A total of 95 mm of precipitation was recorded at this station during the 2009-2010 water year. Total precipitation in the AOI likely is between that at the Kandahar and Qalat-Zabul stations. The Qalat-Zabul Agromet station had a total of 3 reported snow days during the 2009–2010 water year—1 in January and 2 in February. The snowfall reported at this station for the 2009–2010 water year was 8 cm (centimeters). The snow-depth map for 17 January, 2010 (Ministry of Agriculture, Irrigation and Livestock, 2010, map 6), indicates a snow depth of less than 2 cm in the AOI.

The “Potential Natural Vegetation” described in Breckle (2007) is the vegetation cover that would be present if it had not been modified by human activity. Today, as a result of continued exploitation such as grazing, farming, and deforestation, much of the original natural vegetation is found only in a few remote areas of Afghanistan. The destruction of the natural vegetation has resulted in the degradation and erosion of the soil cover in some areas. Many areas exhibit signs of long-lasting desertification caused by human activity.

The vegetation in the AOI is mostly *Pistacia atlantica*-Woodlands in the upper elevations and Dwarf *Amygdalus*-Semidesert in the lower areas as classified by Breckle (2007, p. 161). Much of the upland surface of the AOI is bedrock outcrop with thin alluvial cover and sparse vegetation. Azonal riverine vegetation likely was present in the stream valleys, but the trees have been harvested for fuel and building materials (Breckle, 2007, p. 181). Most land suitable for farming has been plowed and planted, especially in major perennial stream valleys and some of the ephemeral tributary stream valleys. Irrigated fields are present in many of the valleys in the AOI (fig. 10C–2).

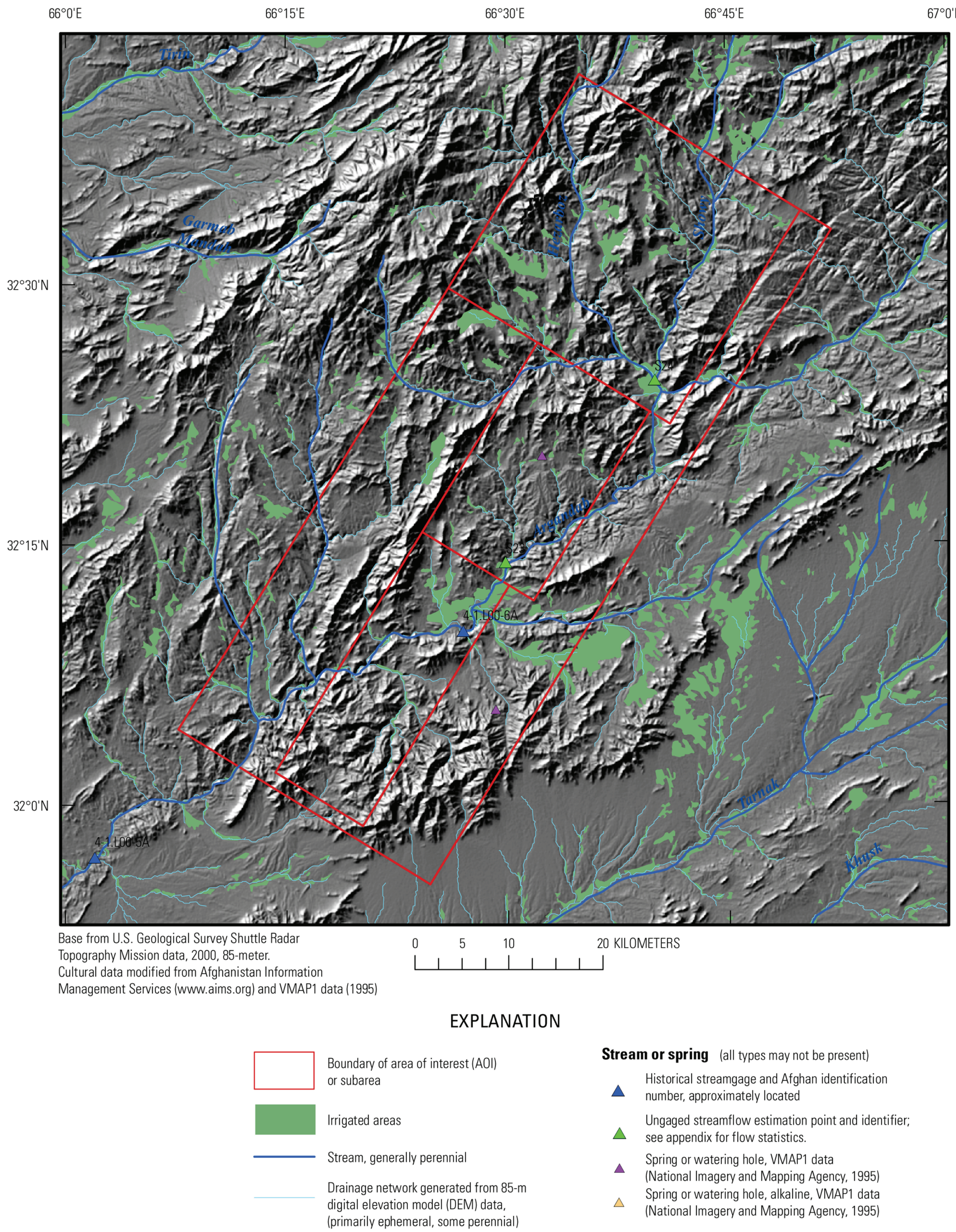


Figure 10C–2. Historical streamgage locations, digitally generated drainage network, and irrigated areas in the Kundalan copper-gold porphyry area of interest in Afghanistan.

10C.1.2 Demographics

The Kundalan copper-gold porphyry AOI is sparsely populated, with much of the mountainous terrain having no inhabitants as indicated by the gray shading in figure 10C–3. Most of the AOI has a population density of 1 to 25/km^2. There are a few populated areas along the Arghandab River and its tributaries, but even in these areas the maximum population density is only in the 51 to 100/km^2 range (fig. 10C–3). The most populated area is the lowland area of the Baghawan-Garangh subarea, where several pixels have a density of 50 to 100/ km^2. The population density shown in figure 10C–3 has a pixel resolution of about 1 km^2 (Oak Ridge National Laboratory, 2010).

10C.1.3 Topography

The topography of the Kundalan copper-gold porphyry AOI is characterized by a central northeast-trending mountain ridge with many peaks higher than 3,500 m (meters) above sea level (asl) (fig. 10C–4). Three mountain peaks in the northeast corner of the Baghawan-Garangh subarea are higher than 4,000 m asl (Bohannon, 2005). The elevations of the valley bottoms range from 2,500 to 3,000 m asl. The drainage patterns formed by the perennial and ephemeral streams are primarily dendritic (Davis, 2006). The major streams generally flow from northeast to southwest in the AOI (fig. 10C–1*b*).

10C.2 Geohydrology

The geohydrology of Afghanistan has been described in general terms by Abdullah and Chmyriov (1977, book 2). As defined in their “Geology and mineral resources of Afghanistan,” the Kundalan copper-gold porphyry AOI is in the “Argandab (Arghandab) Hydrogeological Massif situated in the south-east part of the Helmand-Arghandab Uplift.” The outcrops in the AOI can be grouped according to their physical and hydraulic properties. The generalized geohydrology of the AOI is shown in figure 10C–4 with the underlying topography to allow examination of the geohydrology in the context of relief. Figures 10C–5*a* and *b* show the generalized geohydrology without topography for a clearer depiction of the geohydrologic units. Any wells present in the map area (discussed in the Groundwater section) are shown in figures 10C–5*a* and *b*. Generalized geohydrologic groups were created from a country-wide geologic coverage (Doebrich and Wahl, 2006) by combining sediments and rocks into major sediment- or rock-type groups of similar hydrologic characteristics. The geohydrologic groups in the AOI, ranked from high to low relative hydraulic conductivity (Freeze and Cherry, 1979, table 2.3), are “sands, undifferentiated; conglomerate sediments and rocks; limestones and dolostones; sedimentary rocks; metamorphic rocks; and intrusive rocks and lavas” (figs. 10C–4, 10C–5*a*). Doebrich and Wahl (2006) used geologic maps at a scale of 1:250,000, modified from Russian and Afghan Geological Survey (AGS) mapping, to generate the country-wide geologic coverage. The 1:250,000-scale geologic map that covers this AOI is provided by Sawyer and Stoeser (2005).

10C.2.1 Surface Water

A network of major, mostly perennial streams, in the Kundalan copper-gold porphyry AOI, modified from AIMS (Afghanistan Information Management Services, 1997) and VMAP1 (National Imagery and Mapping Agency, 1995), is shown in figure 10C–2. A network representing likely ephemeral streams, generated with a digital elevation model (DEM), also is shown in figure 10C–2. Two mapped springs, identified in the Vector Map (VMAP1) database (National Imagery and Mapping Agency, 1995), are shown in the AOI; however, others likely are present as well. Names of major streams and identification numbers for any streamgages and ungaged streamflow estimation sites in the AOI are shown in figure 10C–1*b*. The Arghandab River and two named tributaries, the Showy and Hezarboz Rivers, are located within the AOI.

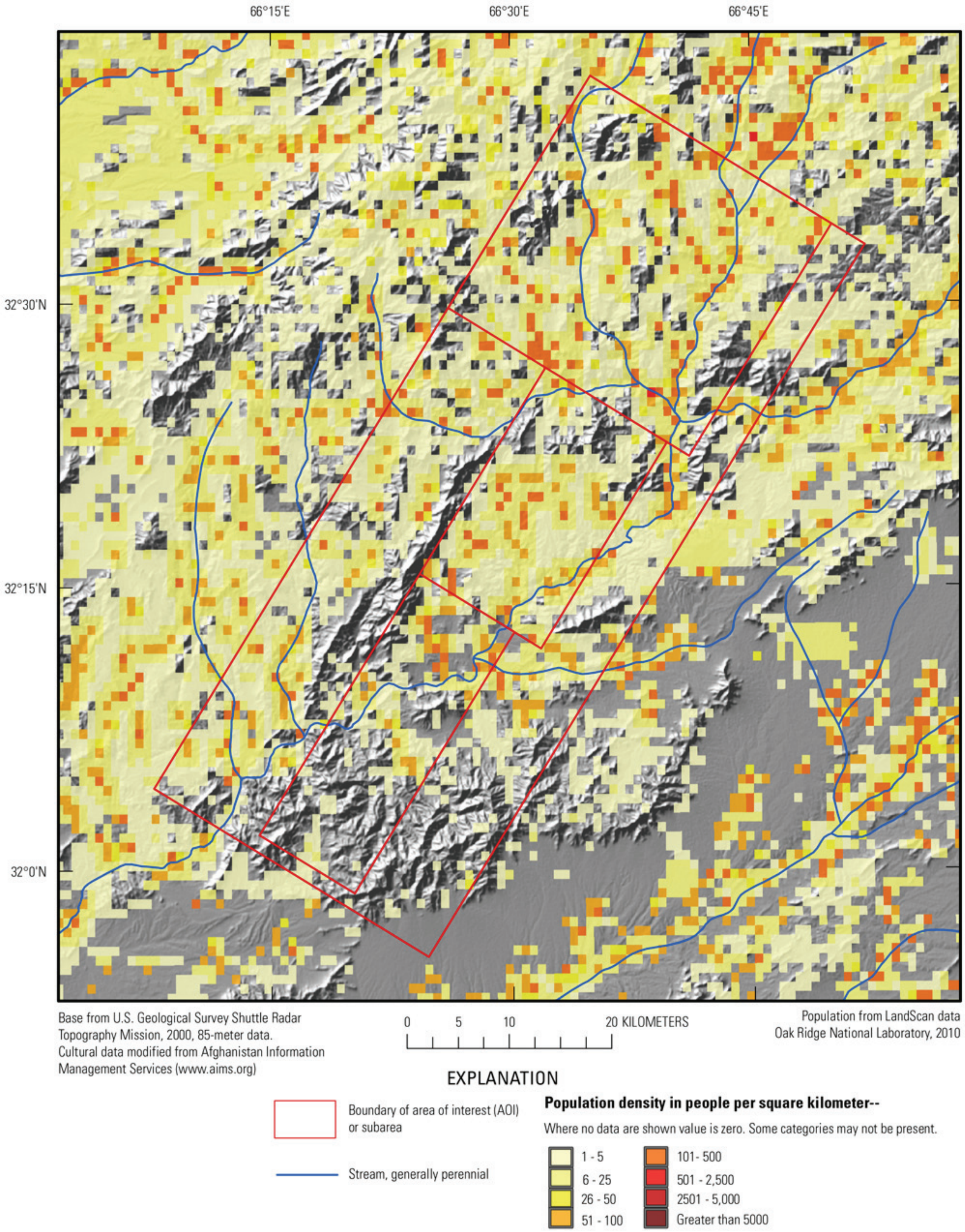


Figure 10C–3. Population density of the Kundalan copper-gold porphyry area of interest in Afghanistan.

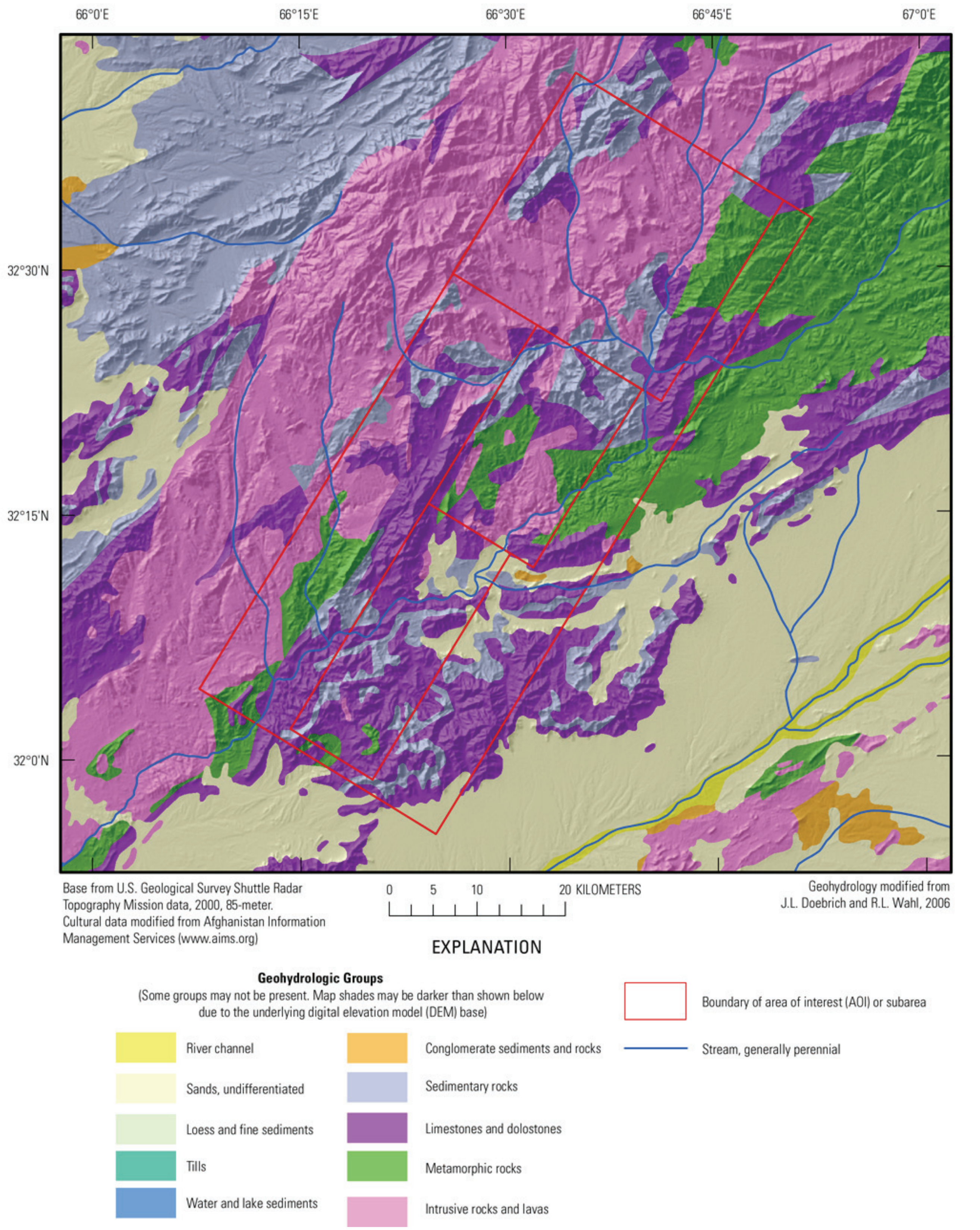
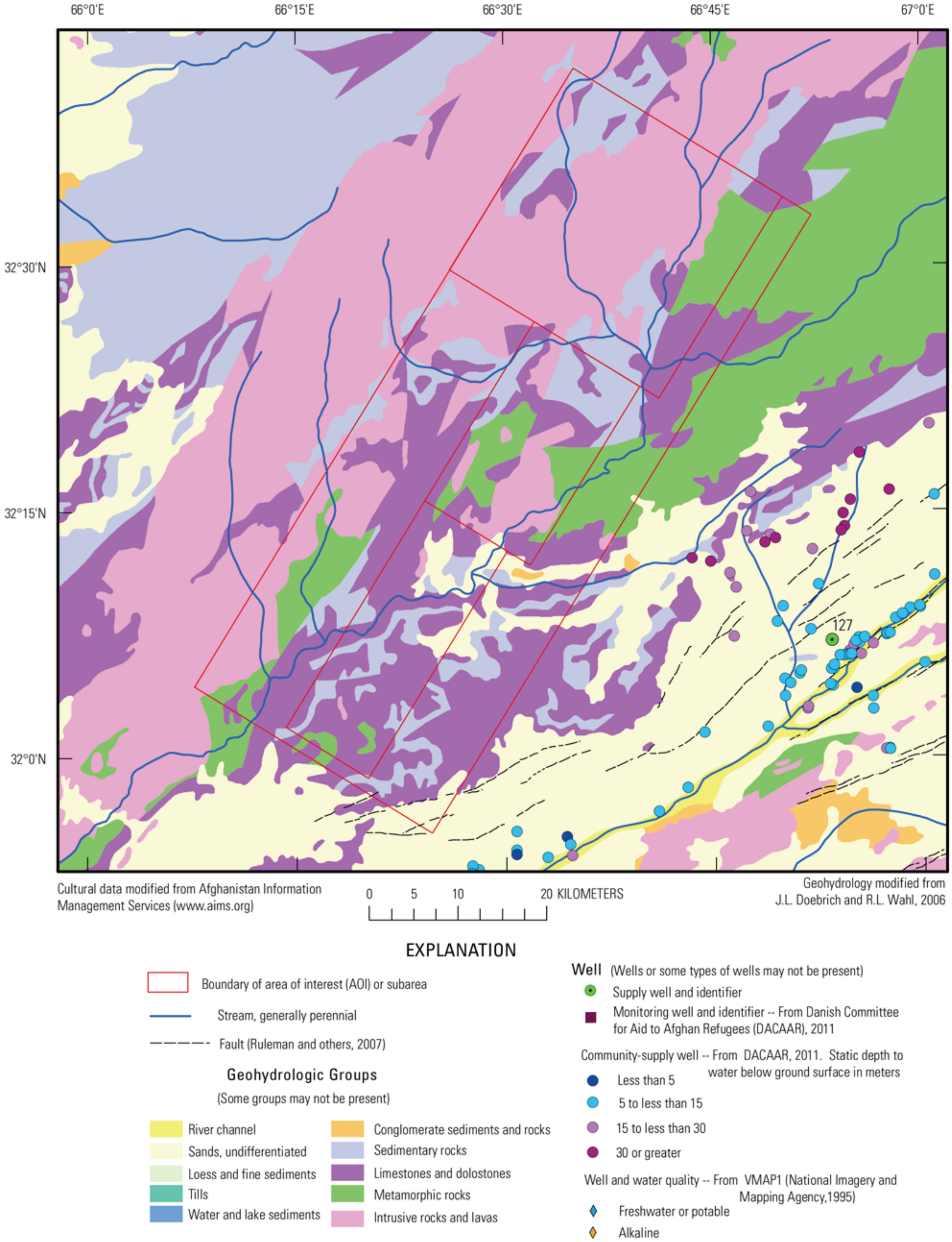


Figure 10C–4. Topography and generalized geohydrology of the Kundalan copper-gold porphyry area of interest in Afghanistan.

a


66°0'E
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127
Cultural data modified from Afghanistan Information Management Services (www.aims.org)
0 5 10 20 KILOMETERS
Geohydrology modified from J.L. Doebrich and R.L. Wahl, 2006
EXPLANATION
Boundary of area of interest (AOI) or subarea
Stream, generally perennial
Fault (Ruleman and others, 2007)
Geohydrologic Groups
(Some groups may not be present)
River channel
Sands, undifferentiated
Loess and fine sediments
Tills
Water and lake sediments
Conglomerate sediments and rocks
Sedimentary rocks
Limestones and dolostones
Metamorphic rocks
Intrusive rocks and lavas
Well (Wells or some types of wells may not be present)
Supply well and identifier
Monitoring well and identifier -- From Danish Committee for Aid to Afghan Refugees (DACAAR), 2011
Community-supply well -- From DACAAR, 2011. Static depth to water below ground surface in meters
Less than 5
5 to less than 15
15 to less than 30
30 or greater
Well and water quality -- From VMAP1 (National Imagery and Mapping Agency,1995)
Freshwater or potable
Alkaline

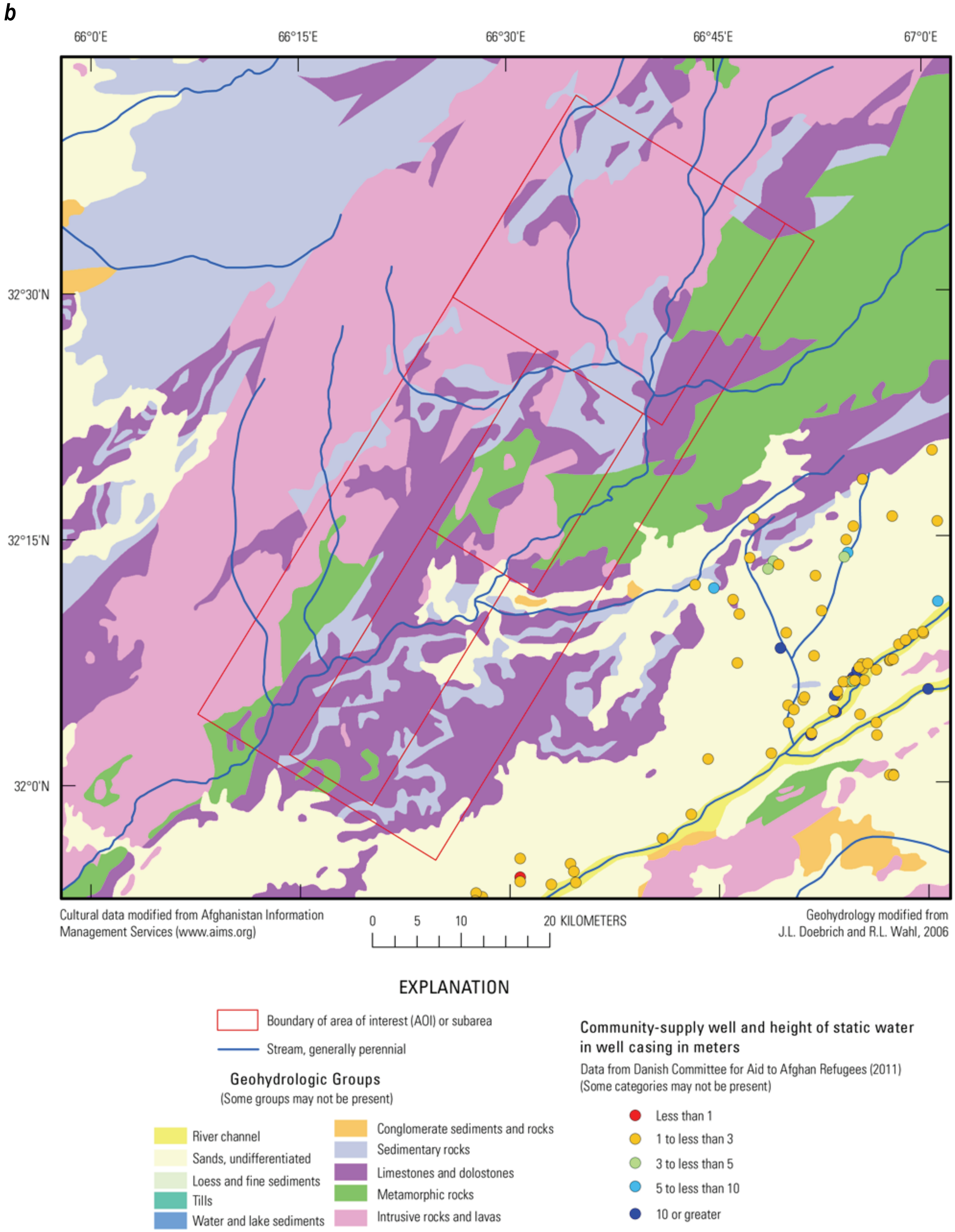


Figure 10C–5. (*a*) Generalized geohydrology, mapped faults, well locations, and depth to water, and (*b*) geohydrology and height of static water in well casings in community supply wells in the Kundalan copper-gold porphyry area of interest in Afghanistan.

One streamgage in the AOI is located in the Charsu-Ghumbad subarea of the AOI on the Arghandab River at Mizan (Afghan identification number 4-1.L00-6A) (fig. 10C–1*b*). This station is at an elevation of 1,312 m asl and has a drainage area of 9,310 km^2 and a period of record that extends from 12 February, 1972, to 30 September, 1980 (Williams-Sether, 2008). The annual mean streamflow per unit area for this station is 0.0045 $m^3/s/km^2$ (cubic meters per second per square kilometer). Maximum monthly streamflow occurs in the spring and minimum monthly streamflow occurs in the fall, reflecting the seasonal precipitation pattern discussed above. A statistical summary of monthly and annual mean streamflows for this station is presented in table 10C–2. Statistical summaries of streamflow data for all available historical gages in Afghanistan can be accessed at *http://afghanistan.cr.usgs.gov/water.php.*

Another streamgage station on the Arghandab River is the Arghandab River above Arghandab Reservoir (Afghan identification number 4-7.L00-5A), located about 60 km downstream from the Arghandab River at Mizan station (10C–1*b*, 10C–2). This station is at an elevation of 1,154 m asl, has a drainage area of 11,525 km^2, and has a period of record from 1 October, 1951, to 31 March, 1979 (Williams-Sether, 2008). The annual mean streamflow per unit area for this station is 0.0036 $m^3/s/km^2$. The seasonal timing of the maximum and minimum monthly streamflow is similar to that at the Arghandab River at Mizan, reflecting the seasonal precipitation pattern and, likely, seasonal changes in evapotranspiration. A statistical summary of monthly and annual mean streamflows for the Arghandab River above Arghandab Reservoir streamgage station is presented in table 10C–3.

Streamflow statistics were estimated for selected ungaged streams that may be prominent in the AOI or subareas to provide some probable estimates of flow for these locations. Streamflow statistics, presented in appendix 2, were calculated for points S23 and S24 (figs. 10C–1*b* and 10C–2) using a drainage-area-ratio method (Olson and Mack, 2011) based on historical flows at the Arghandab River at Mizan (Afghan identification number 4-1.L00-6A) (Williams-Sether, 2008). This streamgage station was selected as the most representative historical gage, based on drainage-basin size and location in Afghanistan, for use with this method at this location. The estimated mean annual streamflow for point S23 (app. 2), with a drainage area of 8,700 km^2, is about 38.85 m^3/s (cubic meters per second). The estimated mean annual streamflow for point S24 (app. 2), with a drainage area of 1,833 km^2, is about 7.47 m^3/s. The seasonal timing of maximum and minimum monthly streamflows at the two estimation points, with high flows in the spring and low flows in the fall, probably is similar to that at the Arghandab River at Mizan streamgage station.

Table 10C–2. Statistical summary of monthly and annual mean streamflows for the streamgage station on the Arghandab River at Mizan (Williams-Sether, 2008).

[m^3/s, cubic meters per second]

4- 1.L00-6A ARGHANDAB RIVER AT MIZAN

Month	Maximum		Minimum		Mean			
	Streamflow (m^3/s)	Water year of occurrence	Streamflow (m^3/s)	Water year of occurrence	Streamflow (m^3/s)	Standard deviation (m^3/s)	Coefficient of variation	Percentage of annual streamflow
October	16.3	1980	4.35	1978	10.6	4.39	0.41	2.17
November	24.2	1980	9.86	1978	15.3	5.03	0.33	3.13
December	28.8	1980	12.8	1978	18.3	5.18	0.28	3.73
January	28.9	1980	14.8	1979	21.0	5.17	0.25	4.28
February	57.8	1976	26.2	1978	39.7	11.5	0.29	8.11
March	195	1976	46.0	1977	96.9	48.7	0.50	19.8
April	323	1976	50.0	1977	152	98.9	0.65	31.1
May	182	1976	17.1	1977	70.8	56.4	0.80	14.5
June	47.8	1976	6.18	1978	22.4	16.8	0.75	4.57
July	51.0	1976	4.19	1977	22.7	15.5	0.68	4.63
August	18.4	1976	4.21	1974	12.0	5.91	0.49	2.46
September	14.8	1976	2.67	1977	8.01	4.28	0.53	1.64
Annual	**79.2**	**1976**	**20.9**	**1977**	**41.8**	**21.3**	**0.51**	**100**

Table 10C–3. Statistical summary of monthly and annual mean streamflows for the streamgage station on the Arghandab River above Arghandab Reservoir (Williams-Sether, 2008).

[m^3/s, cubic meters per second]

4- 1.L00-5A ARGHANDAB RIVER ABOVE ARGHANDAB RESERVOIR

Month	Maximum		Minimum		Mean			
	Streamflow (m^3/s)	Water year of occurrence	Streamflow (m^3/s)	Water year of occurrence	Streamflow (m^3/s)	Standard deviation (m^3/s)	Coefficient of variation	Percentage of annual streamflow
October	18.7	1966	1.08	1972	11.1	4.10	0.37	2.24
November	41.8	1958	6.87	1972	17.1	6.61	0.39	3.43
December	59.1	1969	7.85	1972	21.4	10.9	0.51	4.30
January	57.3	1958	13.0	1963	23.4	9.39	0.40	4.71
February	82.8	1954	12.7	1963	39.9	18.1	0.45	8.02
March	216	1972	20.5	1963	95.1	57.9	0.61	19.1
April	333	1976	13.7	1971	138	89.4	0.65	27.8
May	230	1965	3.03	1971	81.8	60.6	0.74	16.4
June	90.2	1965	0.505	1971	29.2	22.4	0.77	5.87
July	104	1956	0.001	1971	21.5	21.3	0.99	4.31
August	28.7	1956	0.123	1971	11.0	6.95	0.63	2.21
September	18.2	1957	0.460	1971	8.01	4.39	0.55	1.61
Annual	**84.8**	**1957**	**8.61**	**1971**	**41.6**	**20.0**	**0.48**	**100**

10C.2.2 Groundwater

There are no reported wells in the Kundalan copper-gold AOI, but shallow water-supply wells probably have been constructed in the valley-bottom sediments in the populated areas. Approximately 110 shallow community groundwater-supply wells have been installed by NGOs within 30 km of the AOI in the Tarnak River valley east of the AOI (fig 10C–5*a*). Information about these wells can be found in a database maintained by DACAAR (Danish Committee for Aid to Afghan Refugees, 2011). Well-depth and static-water-level information is available for most of the wells in this database (figs. 10C–5*a*,*b*). About 90 percent of the supply wells near the AOI are less than 30 m deep and the median well depth is 11 m. The depth to water in the supply wells is generally between 5 and 30 m (fig.10C–5*a*) and the median depth to water is 9 m. The depth to water generally increases with distance from the Tarnak River (fig.10C–5*a*).

Available well-construction information is limited; however, most wells near the AOI are “tube” wells (driven wells with polyvinyl chloride (PVC) casing) or dug wells with concrete-ring casing. Wells are generally installed in unconsolidated sediments, completed a few meters below the depth at which water is first encountered, and equipped with a hand pump. Figure 10C–5b shows the height of static water in the casings of the water-supply wells near the AOI (well depth minus static depth to water). The median height of static water in well casings is 2 m. In the areas near the AOI, less than 3 m of static water is present in most wells (fig.10C–5*b*). Such shallow wells were found to be vulnerable to seasonal water-level fluctuations and becoming dry for extended periods of time, or even permanently in areas of the Kabul Basin, where groundwater withdrawals are increasing (Mack and others, 2010). Any new groundwater withdrawals in this area must be closely monitored to avoid dewatering existing wells.

A supply well located about 30 km southeast of the AOI (well 127, fig. 10C–5*a*) is known to have been drilled to a depth of 457 m (driller’s log, CH2M Hill, written commun., 2010). A lithologic log for this well indicates that the well penetrated silt and clay with intervals of gravel that likely consist of conglomerate sediments. The well was screened between 170 and 380 m below ground surface and had a static depth to water of 12 m. The well yield is about 10 L/s (liters per second) with a drawdown of about 18 m below static level. The water is known to be potable, but no additional water-quality information was available at the time of the study.

10C.2.3 Lineament Analyses

Lineaments are photolinear features that may result from the presence of underlying zones of high-angle bedrock fractures, fracture zones, faults, or bedding-plane weaknesses. Lineament analyses of the Kundalan copper-gold porphyry AOI (B.E. Hubbard, T.J. Mack, and A.L. Thompson, U.S. Geological Survey August 24, 2011, written commun.) were conducted using DEM and natural-color satellite imagery (fig. 10C–6) and Advanced Spaceborne Thermal Emission and Reflection Radiometry (ASTER) satellite imagery (fig. 10C–7*a*,*b*). Lineament identification and analysis have long been used as a reconnaissance tool for identifying areas in carbonate bedrock environments where groundwater resources are likely to be found (Lattman and Parizek, 1964; Siddiqui and Parizek, 1971). Lineament analyses are increasingly used to identify areas of high relative well yields in other bedrock settings, including crystalline bedrock (Mabee, 1999; Moore and others, 2002). The lineaments shown in figure 10C–6 were delineated visually, whereas those in figure 10C–7 were delineated using an automated process and on the basis of the multispectral characteristics of the land surface (B.E. Hubbard, T.J. Mack, and A.L. Thompson, U.S. Geological Survey August 24, 2011, written commun.). Water wells in bedrock aquifers generally are most productive where boreholes are located in areas of highly fractured bedrock. Areas where lineament density is high (figs. 10C–6, 10C–7*a*, 10C–7*b*) potentially are areas where bedrock fractures are more prevalent than in other areas of the AOI. Lineaments provide an indication of areas that warrant further investigation for optimal bedrock water-well placement. Lineaments may also indicate areas of preferential flow and storage of groundwater, and areas with a high density of lineaments may indicate high secondary porosity. Any lineament analyses, including those presented in this investigation, need to be corroborated by field investigations and additional data to confirm the nature of the lineaments and their relation to water-filled bedrock fracture zones.

10C.3 Summary and Conclusions

Water resources are more likely to be available in the Kundalan copper-gold porphyry area of interest (AOI) than in other areas of Afghanistan because of the availability of surface water and the potential for groundwater storage in and near the AOI. Water resources in the AOI and surrounding area consist mainly of surface water, particularly in the Arghandab River and in two large tributary streams. Shallow alluvial aquifers in the valley bottoms of the AOI are a highly utilized groundwater resource. Most streams are also highly utilized by the local population and represent the primary source of water for irrigation. Any new diversion of water from the rivers would need to be closely monitored, particularly during low-flow periods, if the quantity and quality of the water resource are to be preserved so that surface-water flow remains sufficient to supply water for irrigation and to provide recharge to the aquifers that supply groundwater to the shallow wells for domestic consumption.

There is no reported information about community water-supply wells within the AOI boundary, but more than 100 wells are identified in the Tarnak River valley southeast of the AOI. Shallow dug wells are probably present in the AOI. Wells in the AOI are generally located in shallow alluvial aquifers in the valley bottoms and may have little static water (less than 3 m (meters)). Groundwater resources are available in deep basin-fill sediments, which are likely more than 1,000 m thick, in the Tarnak River valley southeast of the AOI. This resource could potentially supply water for mining-related activities; however, no information is available on the quality or sustainability of this resource. Some areas of the AOI, as indicated by generalized geohydrologic maps and lineament analyses, are likely areas for further exploration for groundwater resources. Close monitoring and careful management of potential new surface-water or groundwater withdrawals would help to protect the quantity and quality of the existing supply for current local water uses. Field investigations including geologic mapping, geophysical surveys, and hydraulic well testing are needed to adequately characterize the extent and availability of groundwater resources in the AOI.

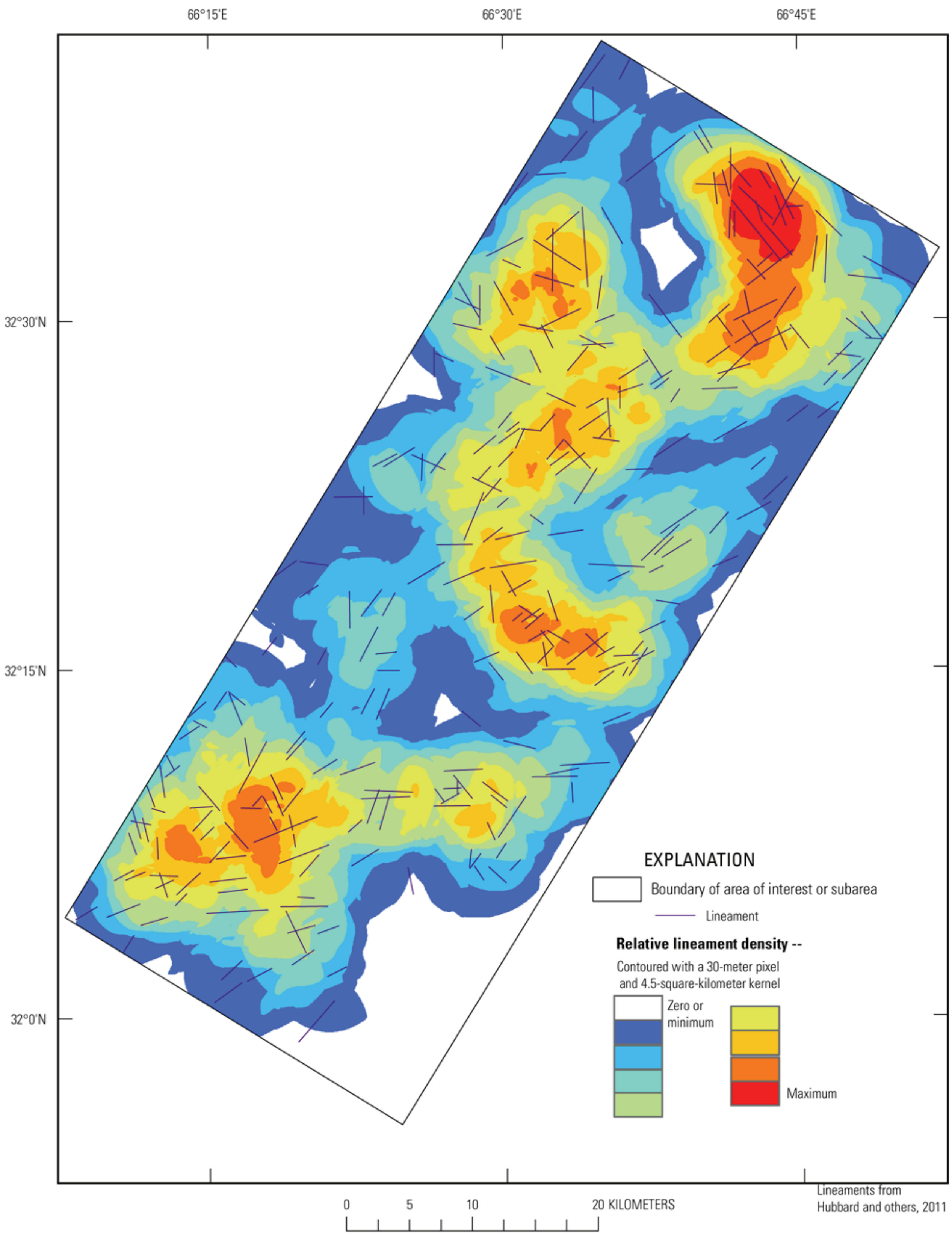
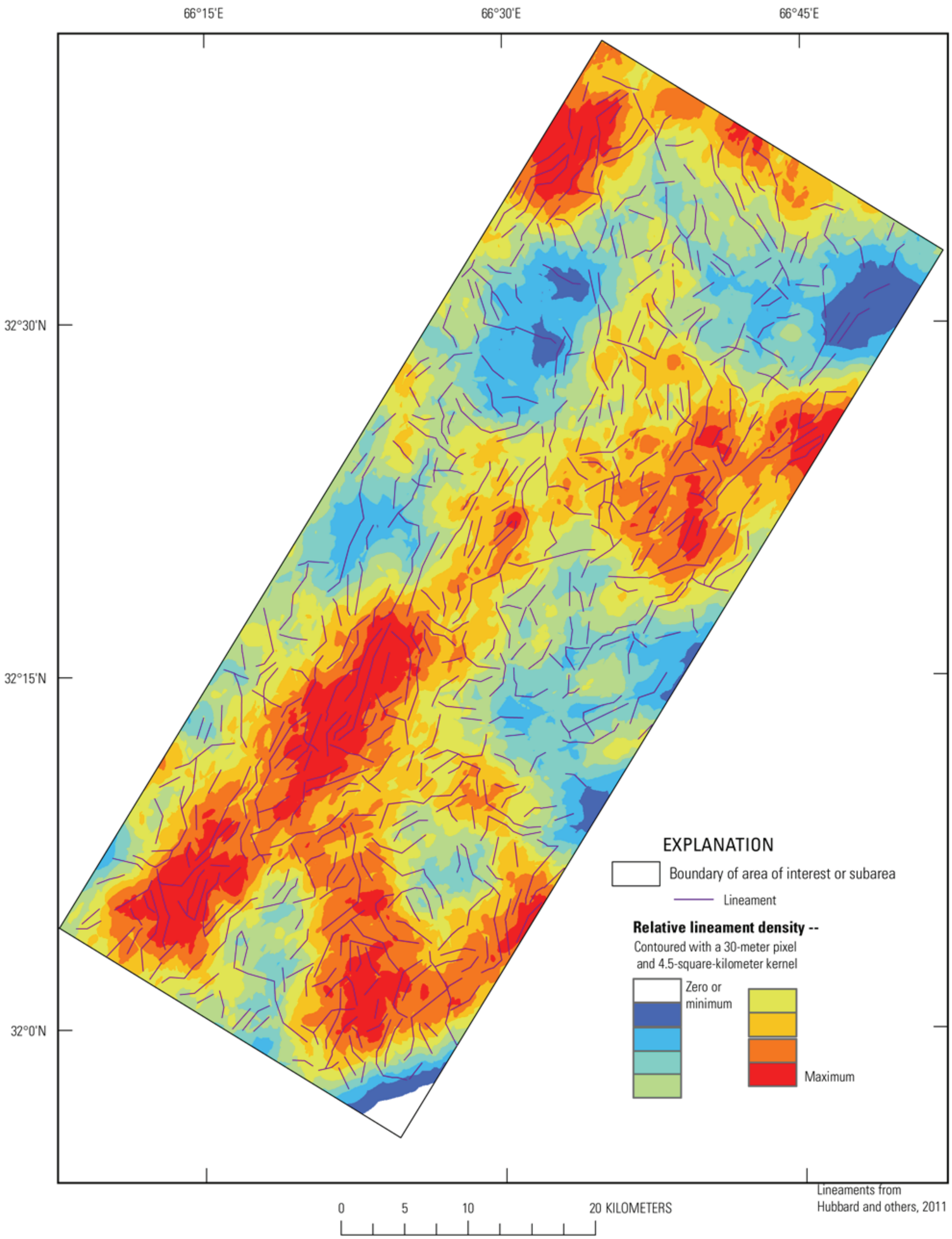


Figure 10C–6. Lineaments and lineament density based on 30-meter digital-elevation-model data and natural-color Landsat imagery in the Kundalan copper-gold porphyry area of interest in Afghanistan.

a


66°15'E
66°30'E
66°45'E
32°30'N
32°15'N
32°0'N
EXPLANATION
Boundary of area of interest or subarea
Lineament
Relative lineament density --
Contoured with a 30-meter pixel and 4.5-square-kilometer kernel
Zero or minimum
Maximum
0 5 10 20 KILOMETERS
Lineaments from Hubbard and others, 2011

b

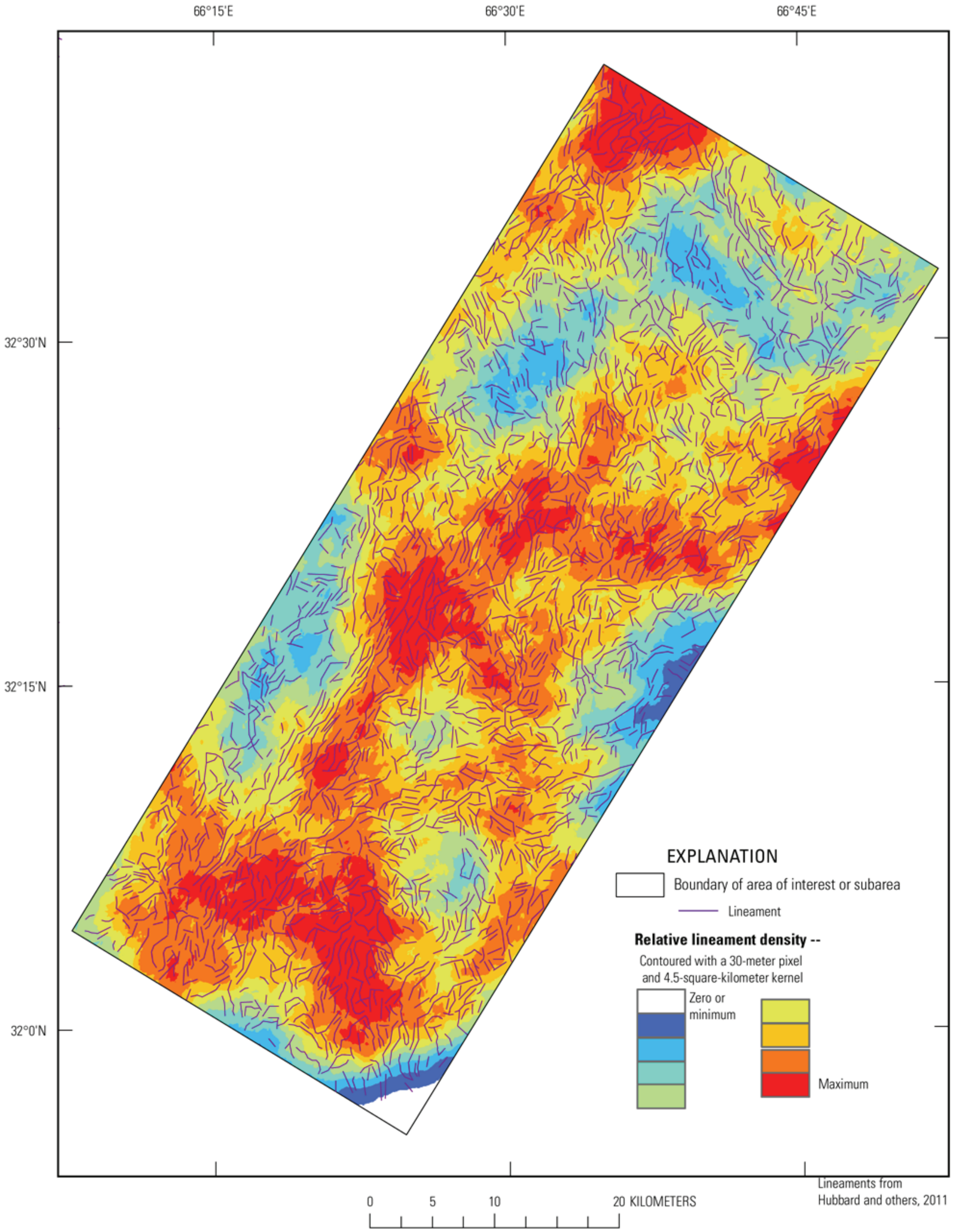


Figure 10C–7. (*a*) Lineaments and lineament density based on 30-meter multispectral Landsat imagery and (*b*) lineaments and lineament density based on 15-meter multispectral Landsat imagery in the Kundalan copper and gold area of interest in Afghanistan.

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