Chapter 20B. Geohydrologic Summary of the Ghunday-Achin Magnesite and Talc Area of Interest

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20B.1 Introduction

This chapter describes the geohydrology of the Ghunday-Achin magnesite and talc area of interest (AOI) in Afghanistan identified by Peters and others (2007) (fig. 20B–1*a,b*). The AOI is located in 15 districts in east-central Afghanistan: the Hisarak, Sherzud, Khogyani, Pachir Wa Agam, Chaparhar, Rodat, Dih Bala, Achin, Bati Kot Shinwar, Nazyan, Dur Baba, Mumand Dara, and Lai Pur Districts in Nangarhar Province, and the Azra and Jaji Districts in Paktya Province. The southern part of the AOI is located in Pakistan (fig. 20B–1*a,b*). The Ghunday-Mamahel subarea occupies 252 km^2 (square kilometers) and the Achin magnesite subarea occupies 564 km^2 of the 5,844-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 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.

20B.1.1 Climate and Vegetation

Climate information for the Ghunday-Achin magnesite and talc 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.

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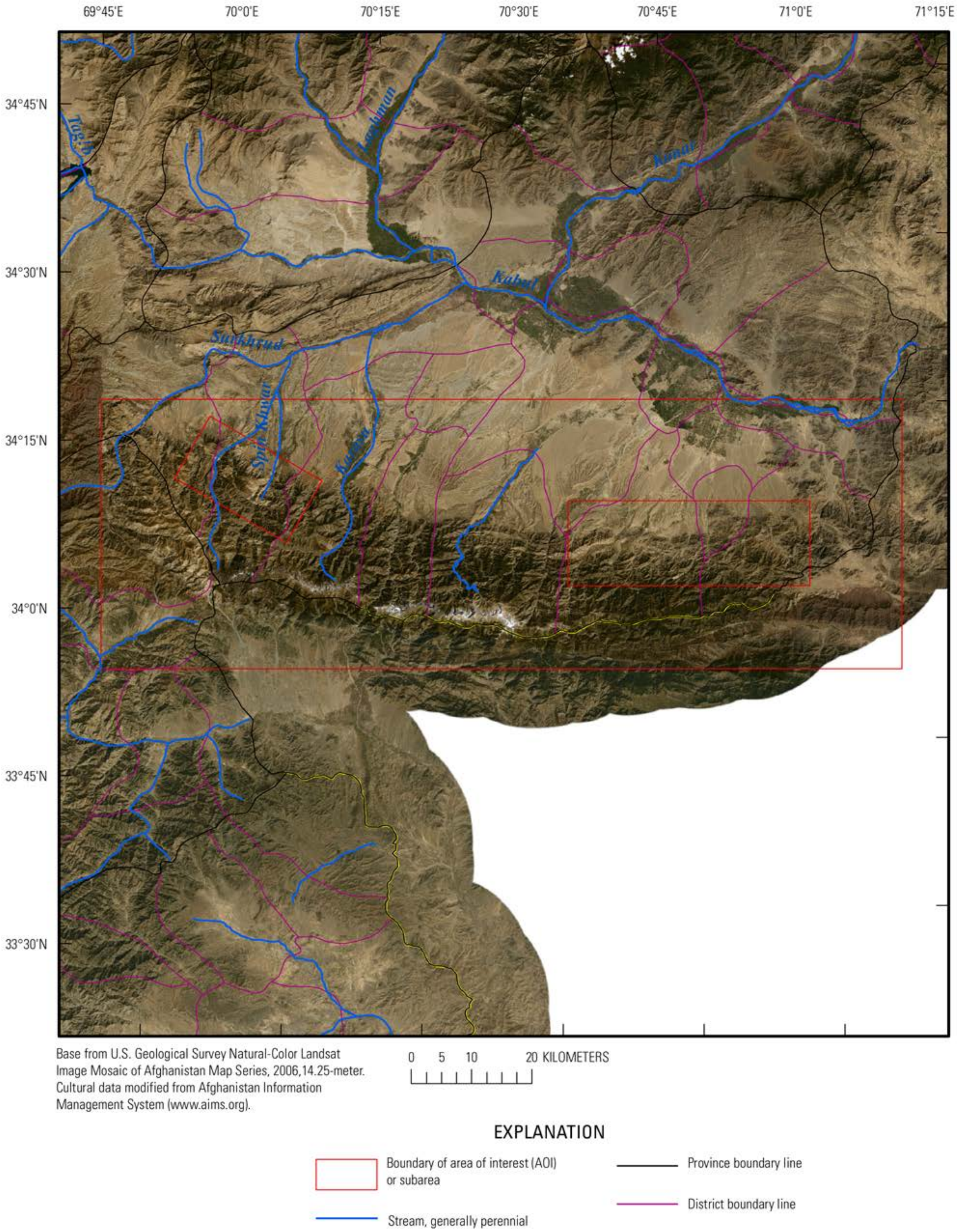

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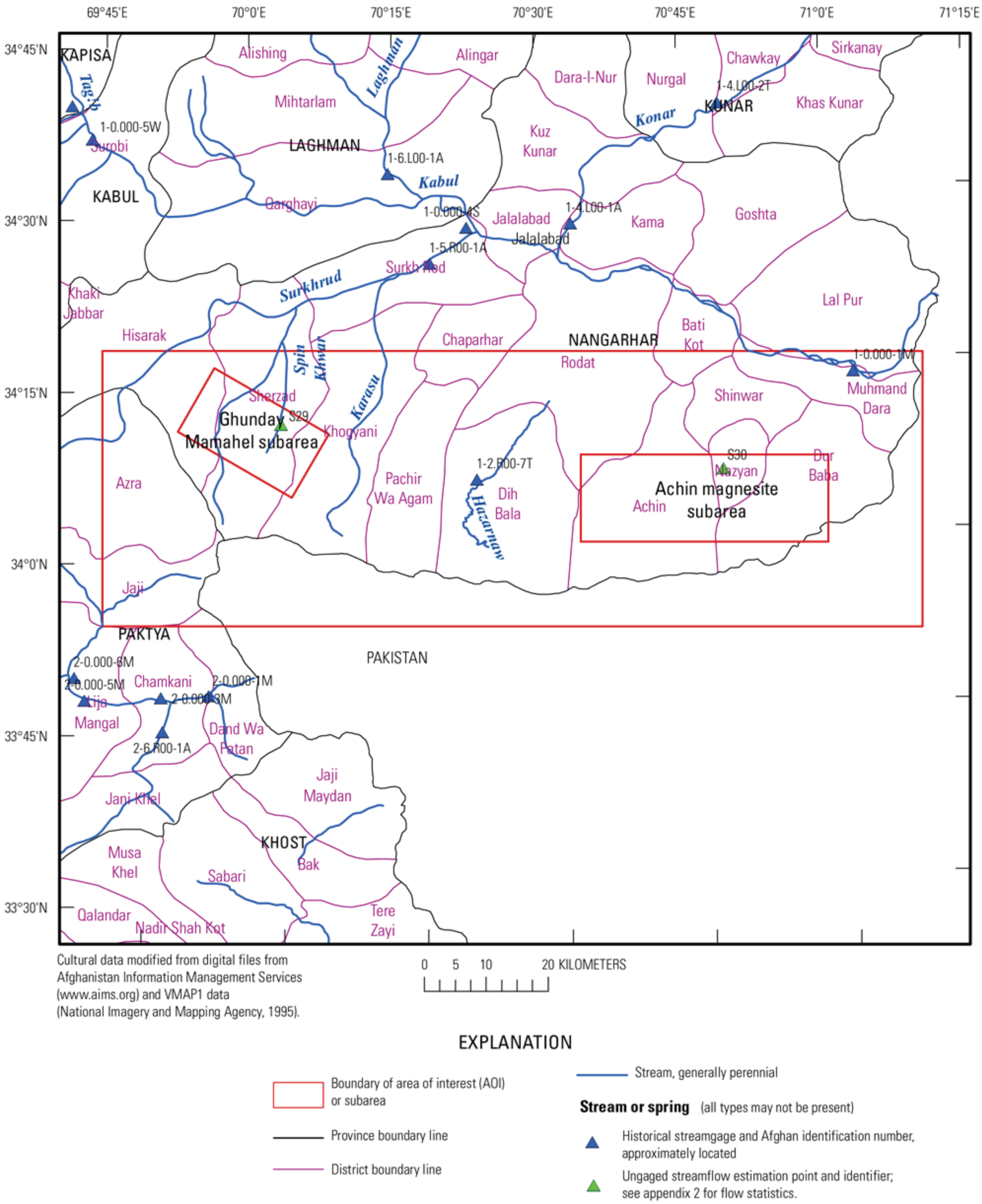


Figure 20B–1. Landsat image showing the location of, and (*b*) place names, stream names, and streamgage station numbers in, the Ghunday-Achin magnesite and talc area of interest in Afghanistan.

The Jalalabad Agromet station is located in Nangarhar Province, approximately 38 km (kilometers) north of the center of the AOI. This station is the Agromet station that is closest to the AOI for which 2009–2010 water year and long-term average (LTA) precipitation and temperature data are available. Precipitation and temperature data for the Jalalabad Agromet station (Ministry of Agriculture, Irrigation, and Livestock, 2010) are shown in table 20B–1.

Table 20B–1. Annual, long-term annual average, and long-term average minimum and maximum precipitation and temperature at the Jalalabad Agrometeorological (Agromet) station 38 kilometers north of the Ghunday-Achin magnesite and talc area of interest, Afghanistan.

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

Agromet Station	Distance from AOI center (km)	Elevation (m)	Precipitation				Temperature		
			2009-2010 annual (mm)	Long-term average[1]			Long-term average[1]		
				Annual (mm)	Monthly minimum and month (mm)	Monthly maximum and month (mm)	Minimum and month (°C)	Monthly mean (°C)	Maximum and month (°C)
Jalalabad	38	560	199	196.5	0.9 June	38.9 April[2]	8.3 January	18.7	33.1 June[3]

[1]Long-term averages (LTAs) 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).

[2]The LTA precipitation for March is 36.2 mm.

[3]The LTA temperature for July is 33°C.

The snow-depth map for January 2010 (Ministry of Agriculture, Irrigation, and Livestock, 2010, map 6) indicates that snow depth in the AOI ranged from less than 2 to 10 cm (centimeters), with the amount of snow increasing from east to west. The snow-depth map for September 2010 (Ministry of Agriculture, Irrigation, and Livestock, 2010, map 7) shows less than 2 cm of snow 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 as classified by Breckle (2007, p. 161) is mostly Sclerophyllous oak forests. The lower elevations in the northern part of the AOI are classified as subtropical dry scrub and savannah and the southwest corner of the AOI is *Rhododendron*-Krummholz (Breckle, 2007). The high mountain areas along the southern border of the AOI reach elevations in excess of 4,000 m (meters) above sea level (asl) (Bohannon, 2005). These areas are classified as thorny cushions, subalpine and alpine semi deserts and meadows. There are perennial snowfields at the higher elevations. Much of the upland surface of the AOI is bedrock outcrop with thin alluvial cover. Azonal riverine vegetation likely was present in the stream valleys, but the trees have been harvested for fuel and building materials. Most land suitable for farming has been plowed and planted, especially along major stream valleys and some of the ephemeral tributary stream valleys. Irrigated fields are present in many of the valleys in the AOI (fig. 20B–2).

20B.1.2 Demographics

The lower elevations of the Ghunday-Achin magnesite and talc AOI, occupied by the city of Jalalabad, are densely populated, with many areas having 501 to 2,500 inhabitants per square kilometer as mapped by LandScan (Oak Ridge National Laboratory, 2010) (fig. 20B–3). The city of Jalalabad is estimated to have more than 190,000 people (Central Statistics Organization, 2010). Higher elevation areas, essentially the bedrock uplands (fig. 20B–1*a*), have few to no inhabitants as indicated by the gray shading in figure 20B–3. The population density shown in figure 20B–3 has a pixel resolution of about 1 km^2 (Oak Ridge National Laboratory, 2010).

20B.1.3 Topography and Geomorphology

The topography of the Ghunday-Achin magnesite and talc AOI consists of a northerly sloping high plain in the northern part of the AOI that gradually transitions to high, rugged mountain in the southern part (figs. 20B–1*a*, 20B–4) (Bohannon, 2005; Davis, 2006). The elevations along the northern border of the AOI range from about 450 m asl in the east to 2,000 m asl in the extreme northwest corner. The break in slope between the high plain and the mountain foothills is at about 1,400 m asl (Bohannon, 2005). The highest peaks form the international border between Afghanistan and Pakistan. The highest peak is mapped as being 4,520 m asl, and several other peaks are higher than 4,000 m asl. The relief between the high plain and the mountains is as much as 2,600 m in much of the AOI. The geomorphology of the high mountain areas is dominated by alpine glacial features. The international boundary follows an arête and there are several cirques. The high plain appears to have been formed by sediments discharged from the mountain streams, forming coalescing alluvial fans. The alluvial fans have been dissected by perennial and ephemeral streams flowing from the mountains onto the high plain (fig. 20B–1*b* and 20B–2).

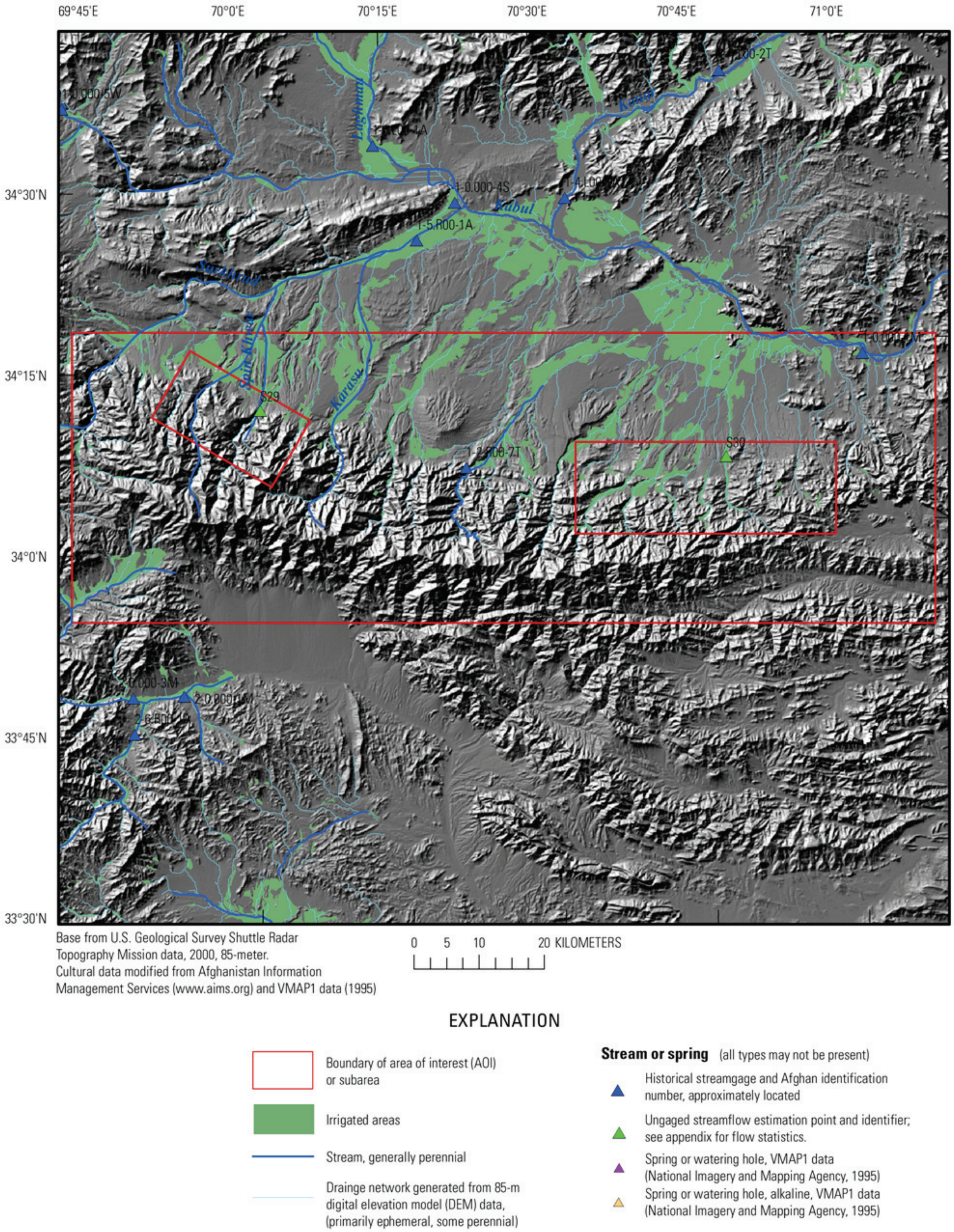


Figure 20B–2. Historical streamgage locations, digitally generated drainage network, and irrigated areas in the Ghunday-Achin magnesite and talc area of interest in Afghanistan.

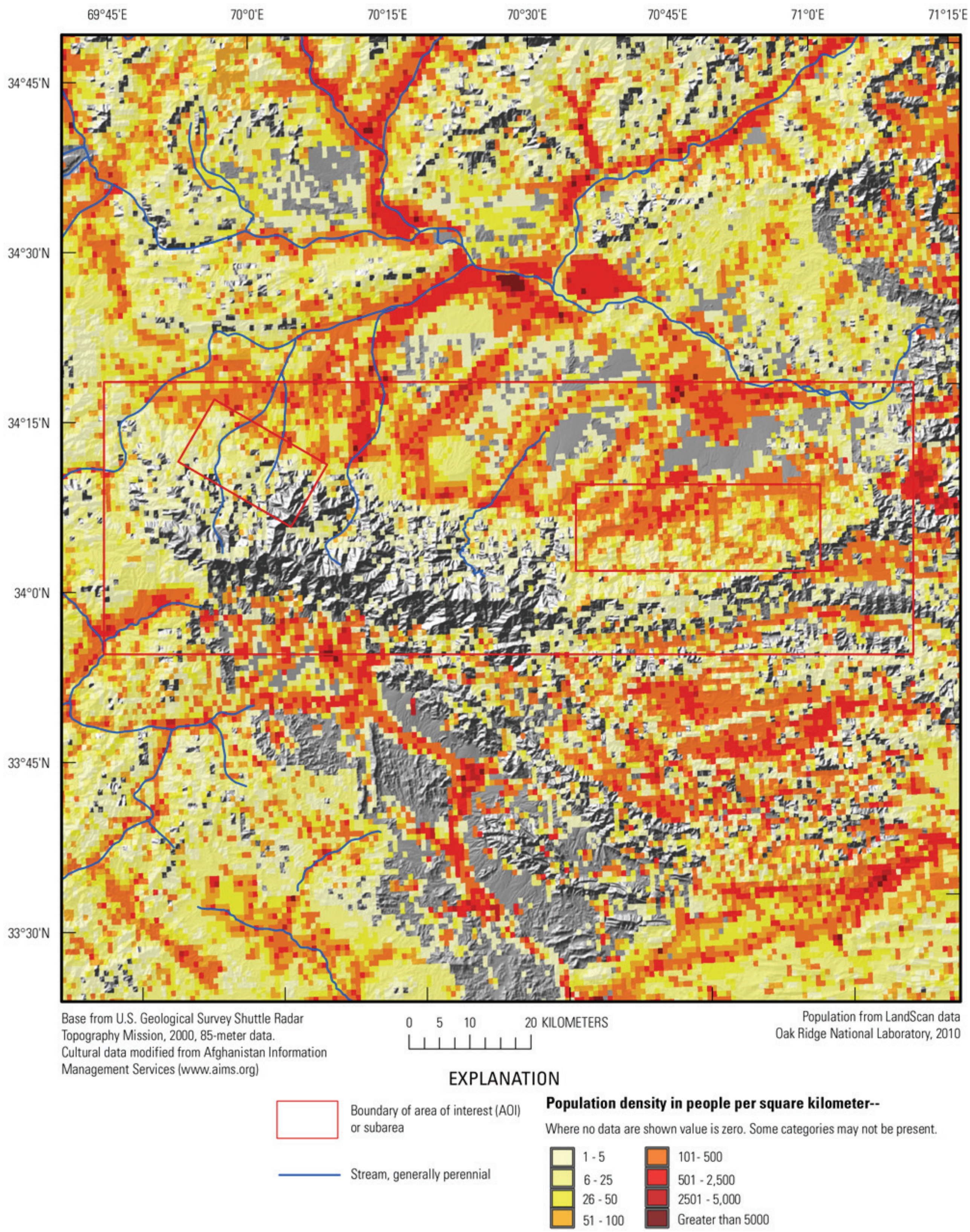


Figure 20B–3. Population density of the Ghunday-Achin magnesite and talc area of interest in Afghanistan.

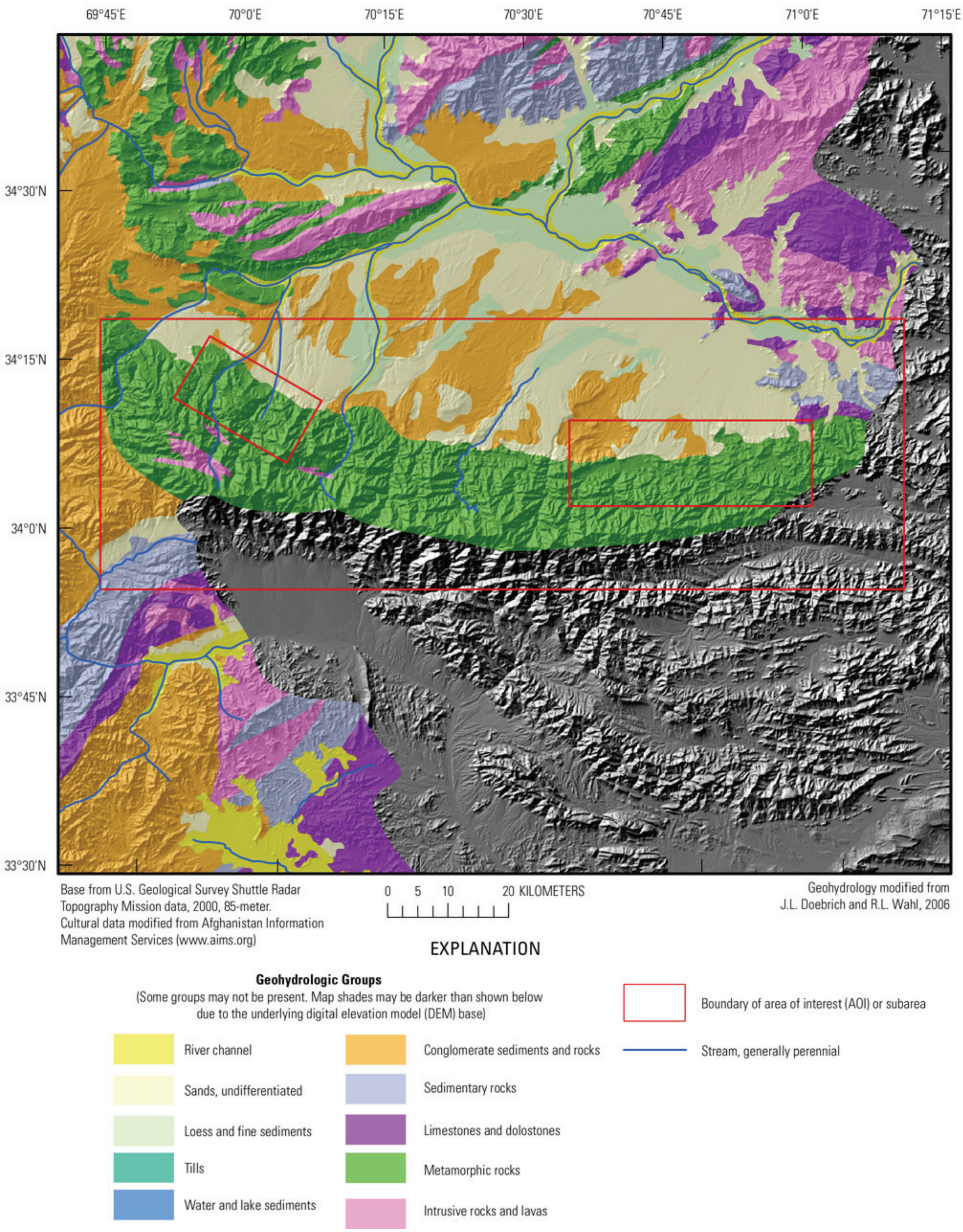


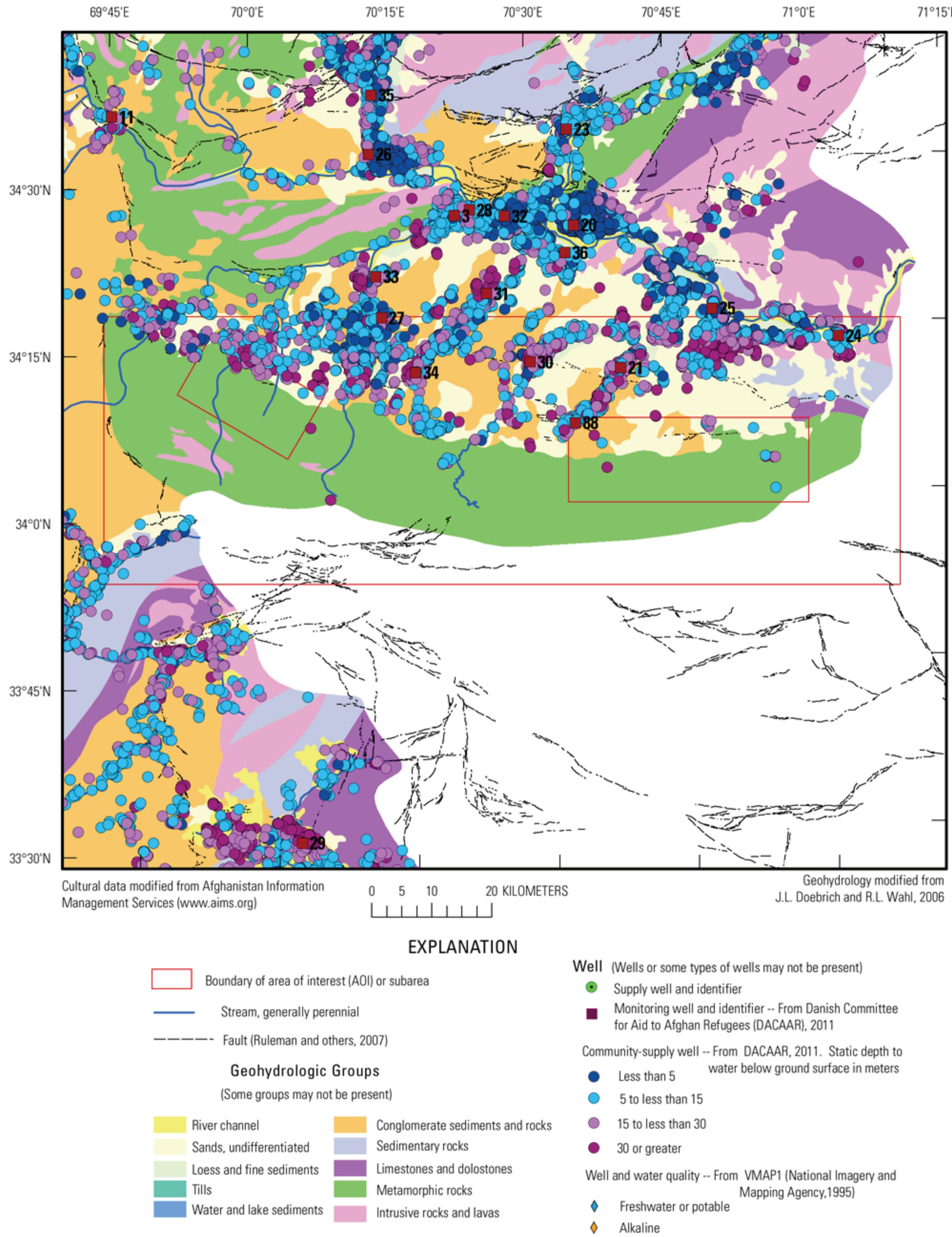
Figure 20B–4. Topography and generalized geohydrology of the Ghunday-Achin magnesite and talc area of interest in Afghanistan.

20B.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 Ghunday-Achin magnesite and talc AOI is in the “Central Afghanistan Hydrogeological Folded Region that occupies the central part of the country with a predominantly mountain climate.” The outcrops and near-surface rocks in the AOI can be grouped according to their physical and hydraulic properties. The generalized geohydrology of the AOI is shown in figure 20B–4 with the underlying topography to allow examination of the geohydrology in the context of relief. Figures 20B–5*a* and 20B–5*b* show the generalized geohydrology without topography for a clearer depiction of the geohydrologic units. Wells present in the map area (discussed in the Groundwater section) are shown in figures 20B–5*a* and 20B–5*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 “river channel; sands, undifferentiated; conglomerate sediments and rocks; loess and fine sediments; limestones and dolostones; sedimentary rocks; metamorphic rocks; and intrusive rocks and lavas” (figs. 20B–4, 20B–5*a* and 20B–5*b*). 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 Bohannon and Turner (2005).

The sands, undifferentiated and the conglomerate sediments and rocks geohydrologic groups make up most of the high plain area. These areas, including areas north of the AOI, are extensive, but no information is available about the combined thickness of these units. Many wells are constructed in these units in this area. These two geohydrologic groups appear to be the major source of groundwater that is currently being used by the local inhabitants. Many perennial and ephemeral streams that begin in the high mountains in the southern part of the AOI flow through or discharge onto the rocks and sediments that make up these geohydrologic groups (figs. 20B–2, 20B–4). The potential for recharge is good and the proximity of these groups to sources of recharge could indicate that there may be untapped sources of groundwater here. The metamorphic rocks geohydrologic group is the largest geohydrologic group in the AOI. Most of the high mountain areas are mapped as outcrops of this unit (fig. 20B–4). If the metamorphic rocks are fractured, the potential for recharge and storage of groundwater is good. Some water-supply wells are located in this unit (fig. 20B–5*a*,*b*), but these wells are probably constructed in alluvial material in the valley bottoms. There are two named streams that originate in this unit, the Spin Khwar and the Karasu, which probably are fed by a combination of snow melt and spring streamflow (fig. 20B–1*b*). The presence of springs indicates that considerable recharge is occurring in this geohydrologic group. Field studies would be needed to confirm and characterize groundwater resources in this geohydrologic group and to investigate the presence of deeper aquifers in the sands, undifferentiated and conglomerate sediments and rocks geohydrologic groups.

a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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

b

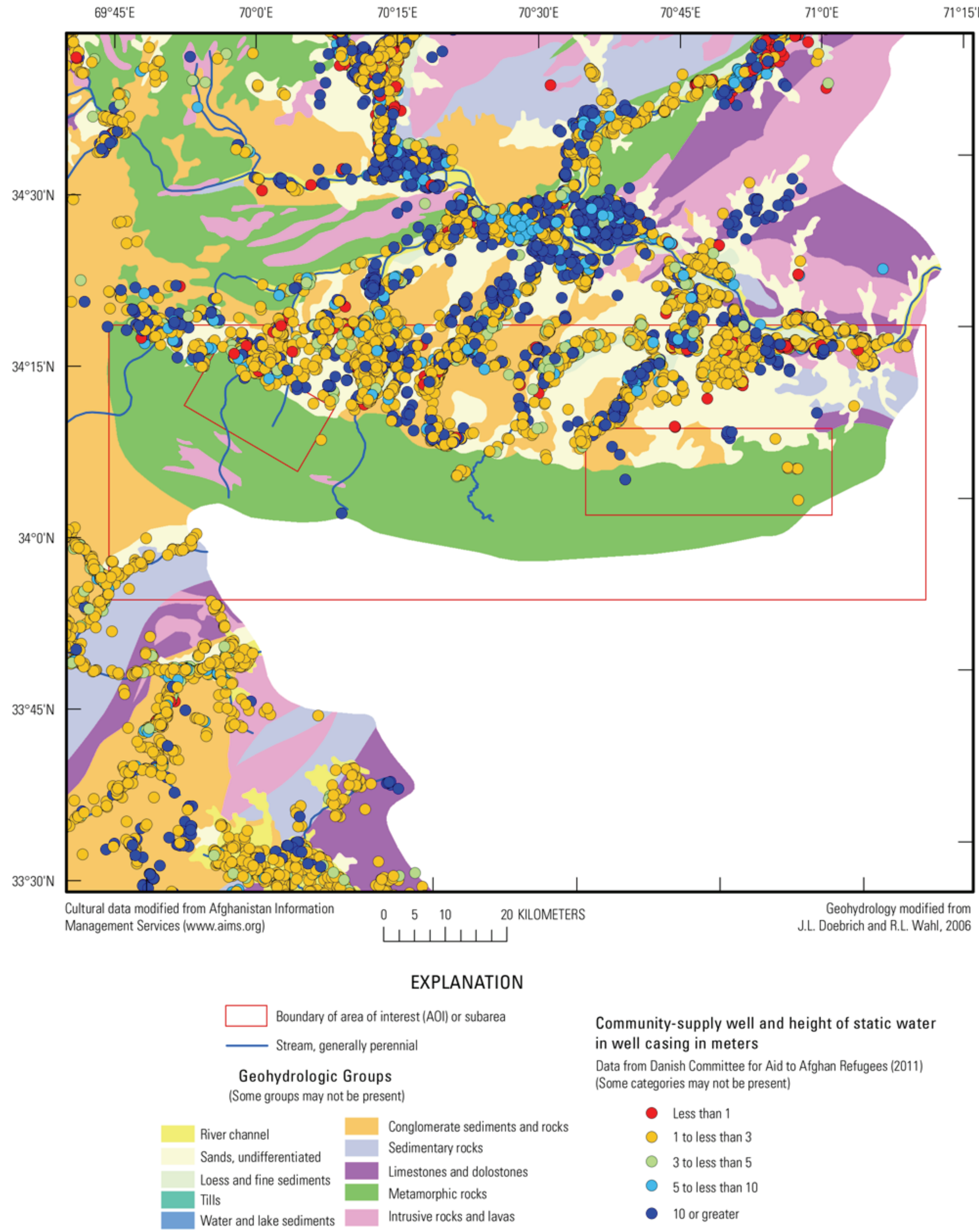


Figure 20B–5. (*a*) Generalized geohydrology, mapped faults, well locations, and depth to water, and (*b*) geohydrology and height of static water in well casings in community-supply wells in the Ghunday-Achin magnesite and talc area of interest in Afghanistan.

20B.2.1 Surface Water

A network of major, mostly perennial streams, modified from AIMS (Afghanistan Information Management Services, 1997) and VMAP1 (National Imagery and Mapping Agency, 1995), is shown in figure 20B–2. A network representing likely ephemeral streams, generated with a digital elevation model (DEM), also is shown in figure 20B–2. Names of major streams and identification numbers for any streamgages and ungaged streamflow estimation sites in the Ghunday-Achin magnesite and talc AOI are shown in figure 20B–1*b*.

There is one streamgage within the AOI. The Kabul River at Dakah streamgage station (Afghanistan identification number1-0.000-1M) is located in the northeast corner of the AOI (figs. 20B–1*b*, 20B–2). This station is at an elevation of 420 m asl and has a drainage area of 67,370 km^2 and a period of record that extends from 21 February, 1968, to 22 July, 1980 (Olson and Williams-Sether, 2010). The annual mean streamflow per unit area for this station is 0.0091 $m^3/s/km^2$ (cubic meters per second per square kilometer). The seasonal timing of maximum and minimum monthly streamflow is high flows in the late spring through summer and low flows in winter. A statistical summary of monthly and annual mean streamflows for this station is presented in table 20B–2. Statistical summaries of streamflow data for all available historical gages in Afghanistan can be accessed at *http://afghanistan.cr.usgs.gov/water.php.*

Table 20B–2. Statistical summary of monthly and annual mean streamflows for the Kabul River at Dakah streamgage station (Olson and Williams-Sether, 2010).

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

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	310	1974	209	1975	269	35.3	0.13	3.56
November	268	1970	132	1975	217	37.2	0.17	2.88
December	248	1970	105	1975	187	37.1	0.2	2.47
January	252	1970	89.1	1975	164	43.8	0.27	2.17
February	267	1980	81.2	1975	165	50.5	0.31	2.19
March	377	1968	104	1975	234	89.3	0.38	3.10
April	1,290	1973	369	1971	651	245	0.38	8.61
May	1,880	1973	593	1977	1,020	327	0.32	13.4
June	2,230	1972	1,150	1970	1,570	404	0.26	20.8
July	2,080	1973	999	1971	1,480	355	0.24	19.6
August	1,430	1973	817	1974	1,080	188	0.17	14.3
September	763	1973	380	1974	529	118	0.22	7.00
Annual	924	1973	477	1977	614	130	0.21	100

The Surkhrud River near Sultanpur streamgage station (Afghanistan identification number 1-5.R00-1A) is 18 km north of the AOI and approximately 9 km upstream from the confluence with the Kabul River (figs. 20B–1*b*, 20B–2). This station is at an elevation of 700 m asl and has a drainage area of 2,590 km^2 and a period of record that extends from 8 March, 1968, to 30 September, 1975, and from 15 January, 1976, to 31 March, 1980 (Olson and Williams-Sether, 2010). The annual mean streamflow per unit area for this station is 0.0010 $m^3/s/km^2$. The seasonal timing of maximum and minimum monthly streamflow is high flows in the spring through early summer and low flows in fall and winter. A statistical summary of monthly and annual mean streamflows for this station is presented in table 20B–3.

Table 20B–3. Statistical summary of monthly and annual mean streamflows for the Surkhrud River near Sultanpur streamgage station (Olson and Williams-Sether, 2010).
[m^3/s, cubic meters per second; ng, not reported]

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	1.33	1969	0.01	1972	0.49	0.39	0.79	1.40
November	2.71	1970	0.07	1972	0.82	0.9	1.09	2.36
December	3.13	1969	0.09	1972	1.09	1.04	0.95	3.12
January	2.01	1973	0.18	1971	0.89	0.65	0.74	2.54
February	2.47	1979	0.15	1974	1.18	0.87	0.74	3.38
March	8.16	1973	0.18	1971	1.92	2.25	1.17	5.51
April	22.6	1973	0.35	1974	7.23	6.62	0.92	20.7
May	27.5	1972	0.14	1971	11.0	11.4	1.04	31.6
June	24.1	1973	0	1971	6.63	8.38	1.27	19.0
July	8.98	1973	0	ng	1.83	2.57	1.41	5.24
August	5.50	1975	0	ng	1.33	1.88	1.41	3.81
September	1.35	1972	0	ng	0.48	0.47	0.98	1.38
Annual	**8.41**	**1973**	**0.15**	**1971**	**2.70**	**2.72**	**1.01**	**100**

The Konar River at Pul-i-Kama streamgage station (Afghanistan identification number1-5.R00-1A) is 25 km north of the AOI and approximately 7 km upstream from the confluence with the Kabul River (figs. 20B–1*b*, 20B–2). This station is at an elevation of 555 m asl and has a drainage area of 26,005 km^2 and a period of record that extends from 28 December, 1966, to 30 September, 1979 (Olson and Williams-Sether, 2010). The annual mean streamflow per unit area for this station is 0.018 $m^3/s/km^2$. The seasonal timing of maximum and minimum monthly streamflow is high flows in the summer and low flows in the winter and early spring. A statistical summary of monthly and annual mean streamflows for this station is presented in table 20B–4.

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 S29 and S30 (figs. 20B–1*b* and 20B–2) on selected streams in the AOI or subareas, using a drainage-area-ratio method (Olson and Mack, 2011) based on historical flows at the Harzarnaw River at Sabay streamgage station (Afghan identification number 1-2.R00-7T) (Olson and Williams-Sether, 2010). The Harzarnaw River at Sabay streamgage station was selected as the most representative historical gage for use with this method, even though it had a short period of record (3 full years), because of its similar drainage-area size and proximity to the estimation points. The estimated mean annual streamflow for point S29 (app. 2), with a drainage area of 132.6 km^2, is about 2.6 m^3/s (cubic meters per second). By applying the same method, the estimated mean annual streamflow at point S30 is 2.17 m^3/s. The seasonal timing of maximum and minimum monthly streamflow, with high flows in the summer and low flows in the winter and early spring (app. 2), probably is similar to that at the Surkhrud River near Sultanpur station.

Table 20B–4. Statistical summary of monthly and annual mean streamflows for the Konar River at Pul-i-Kama streamgage station (Olson and Williams-Sether, 2010).

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

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	249	1979	177	1975	223	22.3	0.10	3.92
November	195	1972	113	1975	164	26.77	0.16	2.88
December	173	1970	88.2	1975	131	22.3	0.17	2.30
January	147	1970	74.8	1975	109	16.4	0.15	1.92
February	131	1970	60.2	1975	103	18.1	0.18	1.81
March	205	1969	65.0	1975	136	38.6	0.28	2.40
April	776	1973	223	1971	378	146	0.39	6.64
May	1,380	1973	408	1977	657	236	0.36	11.6
June	1,360	1968	800	1970	1,055	204	0.19	18.5
July	1,690	1973	883	1970	1,243	246	0.20	21.8
August	1,280	1973	786	1974	1,010	143	0.14	17.7
September	690	1973	335	1977	481	111	0.23	8.46
Annual	681	1973	385	1971	473	84.4	0.18	100

20B.2.2 Groundwater

More than 3,085 shallow community groundwater-supply wells have been installed in the Ghunday-Achin magnesite and talc AOI by NGOs. 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. 20B–5*a*,*b*). About 80 percent of the supply wells are less than 30 m deep and 95 percent are less than 50 m deep. The median well depth is 16.8 m. The depth to water in 60 percent of the supply wells in the AOI is less than 15 m (fig.20B–5*a*). The median depth to water is 12.8 m.

Available well-construction information is limited; however, of the wells with construction information 70 percent are “tube” wells (driven wells with polyvinyl chloride (PVC) casing) and 30 are 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 20B–5*b* shows the height of static water in the casings of the water-supply wells (well depth minus static depth to water). The median height of static water in well casings is 2 m. In the AOI, less than 3 m of static water is present in most wells (71 percent). 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). The eight groundwater-monitoring wells (GWMs 21, 24, 25, 27, 28, 30, 34, and 88) in or near the AOI (fig. 20B–5*a*) are monitored by DACAAR for groundwater levels and specific conductance. Hydrographs of water levels in GWMs in the AOI, provided by DACAAR, are shown in appendix 3. The hydrographs show the date in week number and year, groundwater specific conductance in microsiemens per centimeter at 25° Celsius (µS/cm), and depth to water in meters below ground surface. The GWMs in the AOI are constructed in alluvial material and generally are within a few hundred meters of perennial or ephemeral streams. The typical seasonal range in water level is about 2 to 3 m and the specific conductance ranged from about 350 to 1,100 µS/cm.

20B.2.3 Lineament Analyses

Lineaments are photolinear features that could be the result of underlying zones of high-angle bedrock fractures, fracture zones, faults, or bedding-plane weaknesses. Lineament analyses of the Ghunday-Achin magnesite and talc AOI (B.E. Hubbard, T.J. Mack, and A.L. Thompson, unpub. data, 2011) were conducted using DEM and natural-color satellite imagery (fig. 20B–6) and Advanced Spaceborne Thermal Emission and Reflection Radiometry (ASTER) satellite imagery (fig. 20B–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 analysis is 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 20B–6 were delineated visually, whereas those in figure 20B–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, unpub. data, 2011). Water wells in bedrock aquifers generally are most productive where boreholes are located in areas of highly fractured bedrock. Many lineaments trend to the northeast and follow drainage patterns, particularly in metamorphic rocks of the subareas. Areas where lineament density is high (figs. 20B–6, 20B–7*a*, 20B–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.

20B.3 Summary and Conclusions

Water resources are likely to be more available in the Ghunday-Achin magnesite and talc area of interest (AOI) than in other areas of Afghanistan. Water resources in the AOI and surrounding area consist mainly of surface water, but undiscovered groundwater resources could be available. 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. The diversion of water from the rivers to support mining activities 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 deep groundwater in the AOI or adjacent areas. Some areas of the AOI, as indicated by generalized geohydrologic maps and lineament analyses, are likely areas for further exploration for groundwater resources. The quality and sustainability of water resources in the AOI remain to be determined, however. 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.

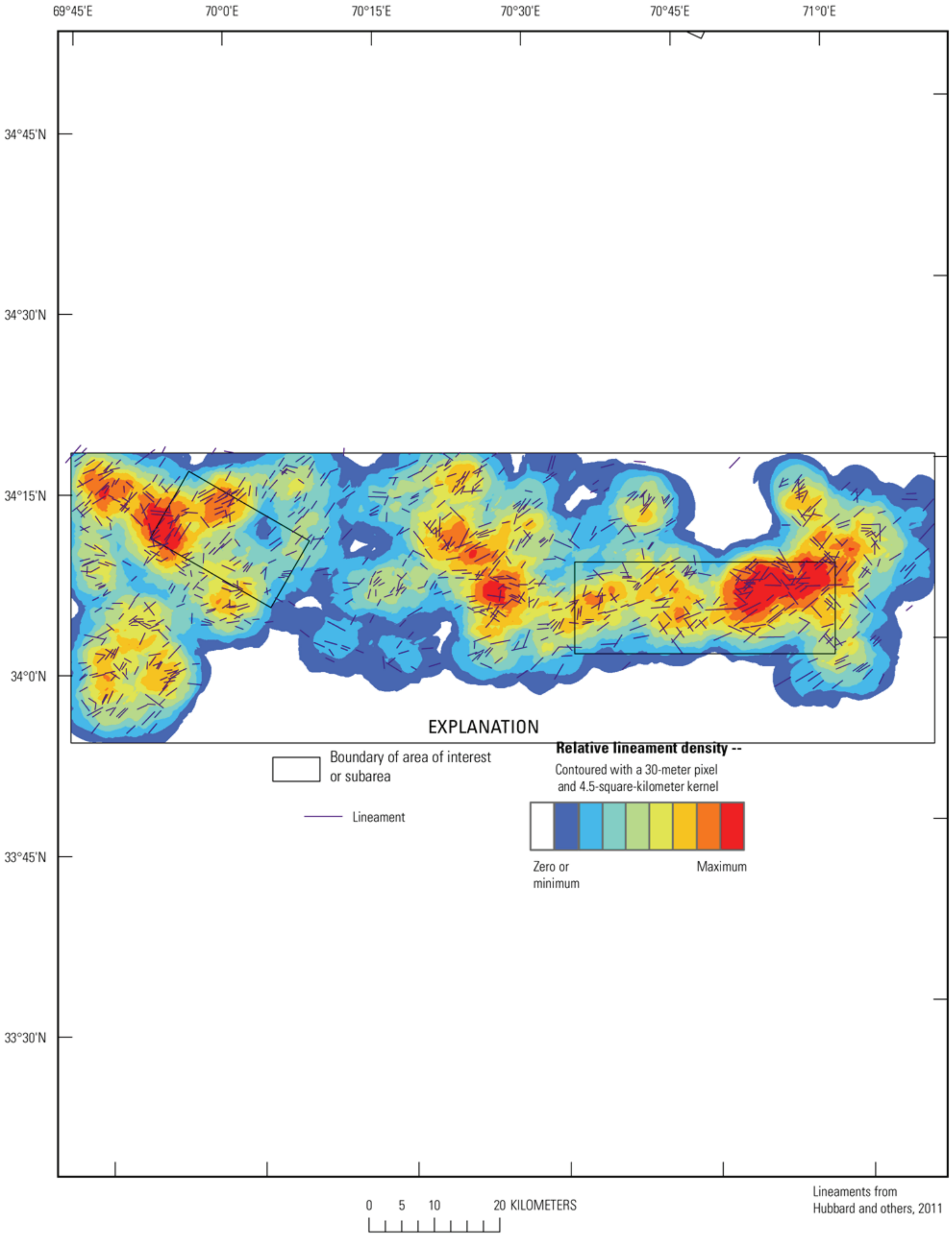
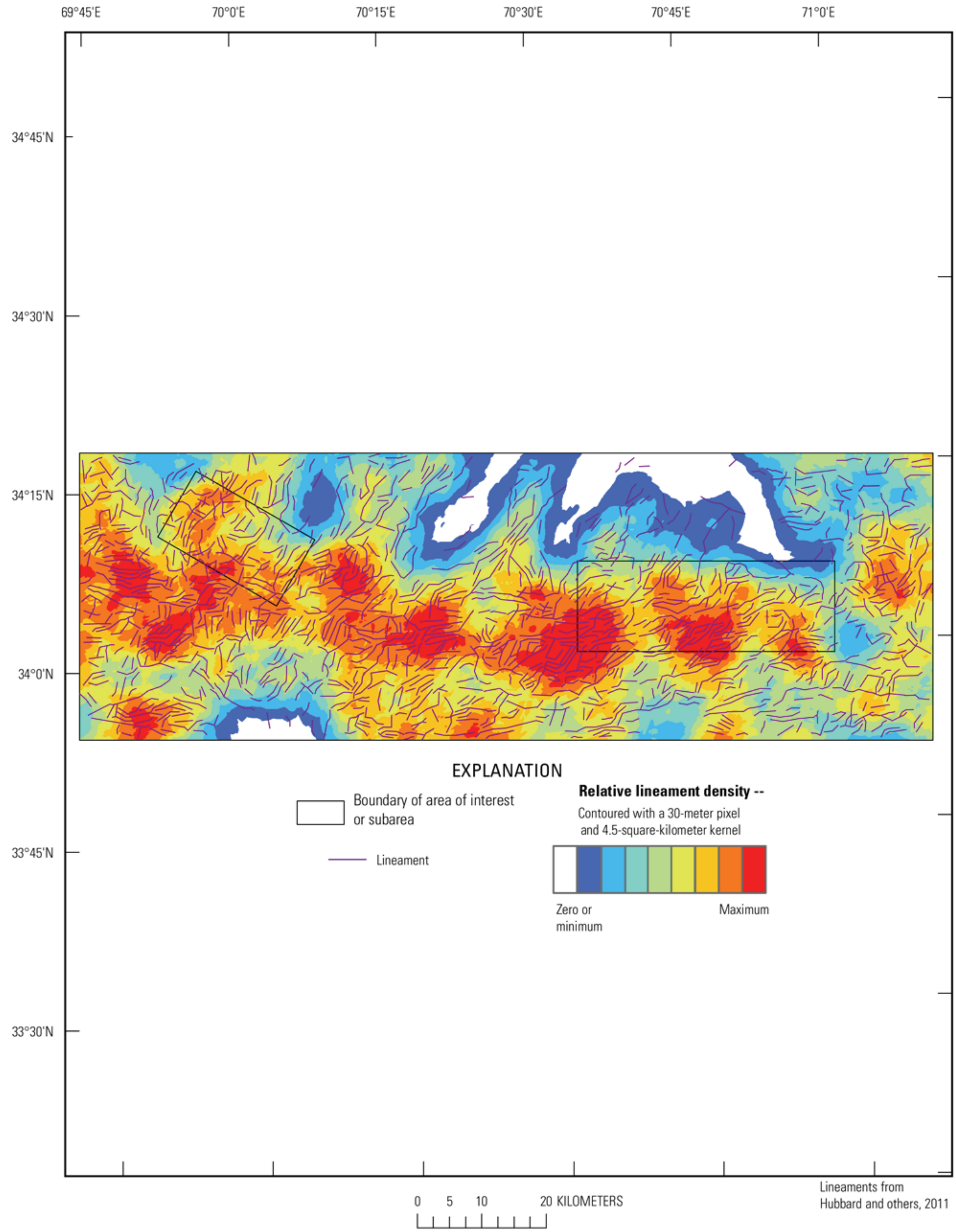


Figure 20B–6. Lineaments and lineament density based on 30-meter digital-elevation-model data and natural-color Landsat imagery in the Ghunday-Achin magnesite and talc area of interest in Afghanistan.

a


69°45'E
70°0'E
70°15'E
70°30'E
70°45'E
71°0'E
34°45'N
34°30'N
34°15'N
34°0'N
33°45'N
33°30'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

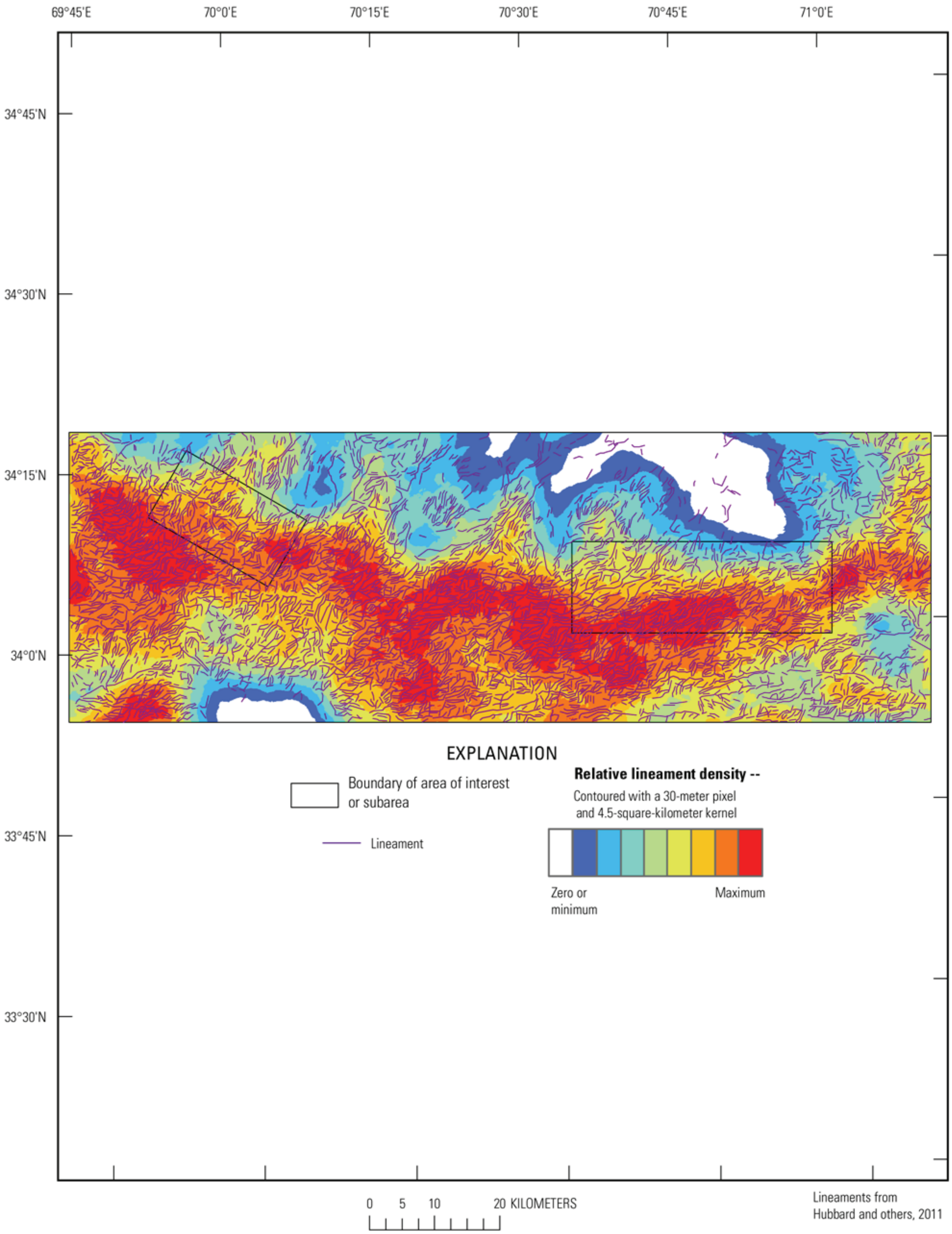


Figure 20B–7. (*a*) Lineaments and lineament density based on 30-meter multispectral Landsat imagery, and (*b*) lineaments and lineament density based on 15-meter multispectral Landsat imagery in the Ghunday-Achin magnesite and talc area of interest in Afghanistan.

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