# Chapter 20A. Summary for the Mineral Information Package for the Ghunday-Achin Magnesite and Talc Area of Interest

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## Abstract

The Achin magnesite and talc and the Ghunday talc deposits occur within an east-west-trending belt of Proterozoic metamorphic rocks in the Ghunday-Achin magnesite and talc area of interest (AOI). At Achin, the talc resources are 1.25 million metric tons, and the speculative magnesite resources are 31.2 million metric tons. At Ghunday, speculative talc resources in the Northern Zone are 356,300 metric tons (t) with an average talc content of 76 volume percent and in the Southern Zone, 113,900 t with an average talc content of 80.67 volume percent. More than 50,000 t of high-grade talc have been mined from Ghunday.

At Achin and Ghunday, the talc deposits occur as elongate bodies subparallel to parallel to the strike and dip of the surrounding dolomitic marble, and at Achin, to nearby magnesite bodies. Amphibolite bodies, which are metamorphosed equivalents of andesite or diabase sills and dikes, crosscut or are subparallel to the talc bodies and have had no apparent effect on whether or not talc is present. The talc bodies probably formed by regional metamorphism of beds of siliceous dolomite.

Large magnesite bodies which occur in dolomitic marble at Achin have the same relation to the strike and dip of the surrounding dolomitic marble as do the talc bodies. In addition, they exhibit no apparent spatial relation other than that observed for the talc bodies. These magnesite bodies probably represent regionally metamorphosed sedimentary magnesite or magnesium-rich dolomitic marble.

The magnesite bodies are similar to the sparry magnesite (Veitsch-type) deposit types described elsewhere in the world. These stratabound magnesite deposits are commonly associated with carbonate-hosted, stratabound talc deposits such as those found at Achin and Ghunday. With these deposit types in consideration, other magnesium-rich dolomitic marble or siliceous dolomitic marble subjected to the same degree of regional metamorphism could be expected in the same age and composition rock unit within this AOI.

Advanced Spaceborne Thermal Emission and Reflection (ASTER) radiometer imagery that identifies dolomite signatures is coincident with the Achin and Ghunday talc and magnesite deposits and with the host dolomitic marble. An additional seven dolomite signatures within the AOI may contain dolomitic marble and associated talc and magnesite mineralization. The relation between ASTER imagery, the talc and magnesite deposits, and the host dolomitic marble could be used elsewhere in Afghanistan to assess the potential for undiscovered deposits of this type.

## 20A.1 Introduction

This chapter summarizes and interprets results for the Ghunday-Achin magnesite and talc area of interest (AOI) from geologic and compilation activities conducted from 2009 to 2011 by the U.S. Geological Survey (USGS), the Task Force for Business and Stability Operations (TFBSO) of the Department of Defense, and the Afghanistan Geological Survey (AGS). Accompanying complementary chapters 20B and 20C address hyperspectral data and geohydrologic assessments, respectively, of the AOI. Additional supporting data for this chapter are available from the Afghanistan Ministry of Mines in Kabul.

Talc and magnesite are important industrial minerals that have unique chemical and physical properties. Magnesite is the main industrial mineral source for magnesia (MgO), which is commonly

used to produce high-temperature refractories, chemicals, fertilizers, and magnesium metal (Harben and Kužvart, 1996a; Orris and Bolm, 2007). Talc is a soft, inert mineral primarily used in ceramics, but it has other applications in paint and varnish, pulp and paper, roofing, cosmetics, rubber, and insecticides (Harben and Kužvart, 1996b; Orris and Bolm, 2007). Usage depends on the grade or purity of the talc. Impurities such as iron can limit its range of uses. Massive, soft talcose rock is often referred to as soapstone and may be used for sculpture.

## 20A.2 Location and Historic Setting

The Ghunday-Achin magnesite and talc AOI lies along the border with Pakistan approximately 16 kilometers (km) south of Jalalabad (figs. 20A–1, 20A–2, and 20A–3) in Nangarhar and Paktya Provinces. The Achin and Ghunday deposits are about 47 to 48 km southeast and southwest of Jalalabad, respectively. Although over 50,000 metric tons (t) of high-grade talc have been artisanally mined from the Ghunday deposit (also known as the Mamahel deposit) (United Nations Economic and Social Commission for Asia and the Pacific, 1995; Peters and others, 2007), the production years are unknown.

## 20A.3 Summary of Previous Work

Geologists from the former USSR and Afghanistan mapped the deposits and parts of the surrounding areas, excavated several trenches and exploration adits, and drilled shallow holes (Lednev, 1977a-o). They collected channel samples from the trenches and adits, which were analyzed for MgO, $SiO_2$, CaO, and talc. Filippov (1974) and Nielson (1976a,b) wrote brief reports on these deposits.

The Economic and Social Commission for Asia and the Pacific published a compilation of the geology and mineral resources of Afghanistan in 1995 based mainly on studies by Soviet and Afghanistan geologists. Orris and Bliss (2002) compiled a database of known Afghan mines and mineral occurrences. Peters and others (2007) wrote preliminary assessments of various non-fuel resources in Afghanistan. In that publication, Peters and others (2007) discussed the industrial uses of talc and magnesite and general models of metasomatic and metamorphic magnesite and talc deposits. They defined a permissive tract for these types of deposits which includes both the Achin and Ghunday deposits based on a lithologic unit that contains both amphibolite dikes and carbonate rocks. Abdullah and others (1977) and Abdullah and Chmyriov (2008) described the general geology of the Achin and Ghunday deposits, as well as the surrounding geologic terrain.

## 20A.4 Geology

The Achin and Ghunday magnesite and talc deposits (fig. 20A–3) occur within the east-west-trending Spinghar Zone (Doebrich and Wahl, 2006; Abdullah and Chmyriov, 2008). The Spinghar Zone consists mainly of Early Proterozoic metamorphic rocks. The largest portion of this zone consists of middle Paleoproterozoic ($X_2$mbg) marble, biotite and garnet-staurolite-biotite gneiss and schist, quartzite, and amphibolites. Smaller portions of this zone consist of early Paleoproterozoic ($X_1$gn) 2-mica, biotite, biotite-amphibole, garnet, garnet-sillimanite-biotite, pyroxene-amphibole, plagioclase, and cordierite gneisses, along with schist, quartzite, marble, and amphibolite. Other Proterozoic rocks (Pgng) consist of granite-gneiss, granite, and plagiogranite and a minor amount of middle Proterozoic metavolcanic lava ($X_2$vl). Early Cretaceous rocks ($K_1$gbm) consist of gabbro, monzonite, diorite, and granodiorite intrusions. The rock unit codes noted above are those from the “Geologic and Mineral Resource Map of Afghanistan” (Doebrich and Wahl, 2006).

The northern part of the Ghunday-Achin magnesite and talc AOI is covered mainly by Pliocene and Quaternary conglomerate and sandstone (Doebrich and Wahl, 2006). Rocks of the Spinghar Zone may extend under the Pliocene and Quaternary cover.

Detailed geologic maps of the Spinghar Zone are not available; however, detailed maps of the individual deposits are available. In addition to surface geologic maps, adit maps, cross sections, and long sections contain important information regarding the geology and geochemistry of these deposits

(Lednev, 1977a-o; Lednev and others, 1977). Figure 20A–4 is an example of a map and sections prepared for the Achin deposit. Because of a lack of understanding of the grid system used on the Lednev geologic maps, spatial rectification of these maps was difficult and results could not be independently verified.

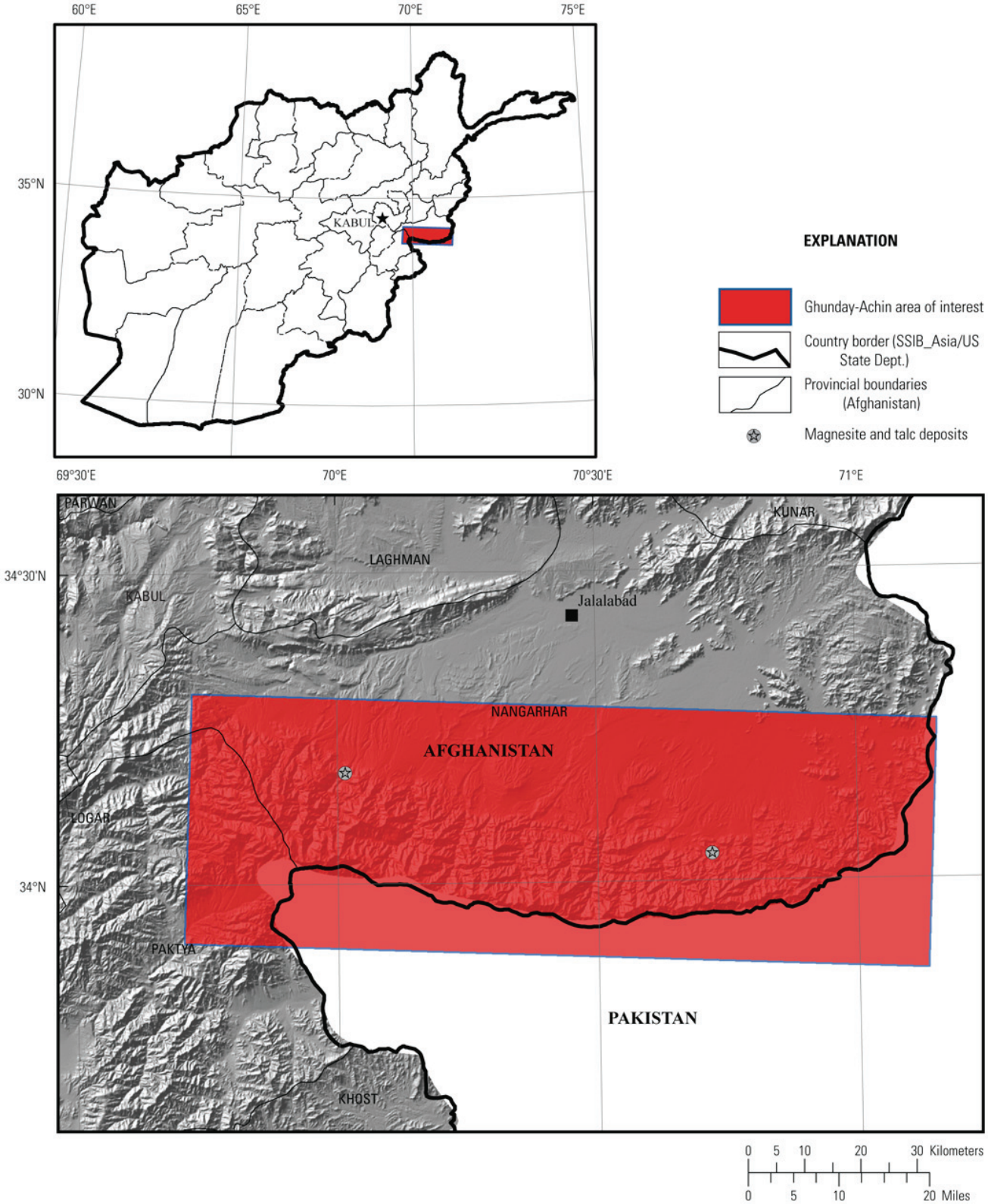


**Figure 20A–1.** Index map showing the location of the Ghunday-Achin magnesite of interest (AOI).

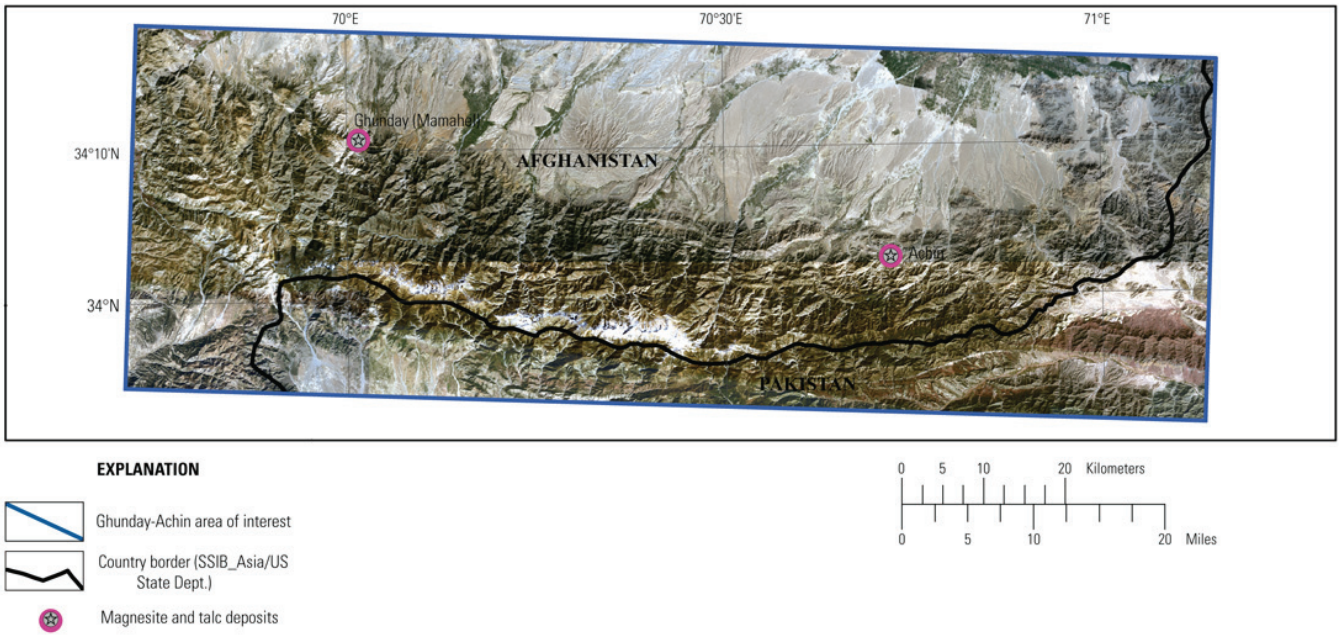


**Figure 20A–2.** Location of the Ghunday and Achin deposits on a shaded relief map of the Ghunday-Achin magnesite of interest (AOI).

Lithologies that are depicted on the large-scale geologic maps of the two deposits include dolomite marble, magnesite, talc, and amphibolite, plus mica schist, biotite-quartz-graphite schist, amphibole-biotite schist, and a cataclastic granite. The amphibolites are portrayed as andesite-basalt dikes that have been metamorphosed to amphibolite grade. These amphibolites may be sill-like in the Achin area but may be a combination of sills and dikes in the Ghunday area.

### 20A.4.1 Achin

Maps of the Achin deposit (lat. 34.050° N., long. 70.717° E.) show bedding in the dolomite marble generally striking from about N. 40° W. to about N. 85° W. A few strike measurements on the maps are about N. 70° W. to about N. 85° W. Dips range from 50 to 80° S., with steeper dips predominating. The magnesite and talc bodies are elongate with an approximately N. 65° W. strike. These relations suggest that the talc and magnesite bodies are, in part, related to the original sedimentary composition of the rocks. The amphibolite bodies are relatively few in number, are generally large and tabular, and follow the strike and dip of the marble, magnesite, and talc (fig. 20A–4). The geologic maps show the amphibolite to locally cut across the trend of the marble, magnesite, and talc (fig. 20A–4). Although referred to as dikes on the geologic maps, these amphibolite bodies may better be described as sills, with a few dike-like or irregular intrusive masses.

The dolomitic marble unit that contains the magnesite and talc is on the order of 850 meters (m) wide. This marble is bordered on the north and south sides by beds of mica schist, biotite-quartz-graphite schist, and amphibole-biotite schist. The schist unit on the south side is about 190 m thick, with another dolomitic marble to the south of the schist.

Talc bodies are generally narrow lenses, on the order of 1 to 15 m in width, and are generally discontinuous along strike. Most talc bodies are less than 240 m in length. The talc-bearing zone extends for about 2 km along strike. Talc bodies generally occur less than 60 m from an amphibolite body and are commonly adjacent to the amphibolite body. One of the talc bodies at Achin appears to have been worked by a narrow open pit.

### 20A.4.2 Ghunday

The Ghunday talc deposit (lat. 34.183° N., long. 70.017° E.) occurs about 70 km west of the Achin deposit in a similar sequence of Proterozoic schist and dolomitic marble. It differs significantly in

some respects in that the geologic map shows at least 30 separate amphibolite bodies and an absence of large masses of magnesite. Many of the amphibolite bodies appear to be sill-like and are generally short. Some of the amphibolites are large, lobate masses. The thin talc bodies are short and are clustered in two groups. A cross section of the deposit may suggest that the two talc groups are on opposite hinges of an anticlinal structure (Lednev, 1977j). Though similar to the Achin deposit, the Ghunday deposit is smaller in size.

The presence of granitic rocks intruding the Proterozoic dolomite-bearing units may have caused the formation of monomineralic brucite (MgO) ore deposits (Abdullah and Chmyriov, 2008). Palygorskite $(Mg,Al)_5(Si,Al)_8O_{20}(OH)_2 \cdot 8H_2O$)deposits may be expected within the weathered dolomite units (Abdullah and Chmyriov, 2008).

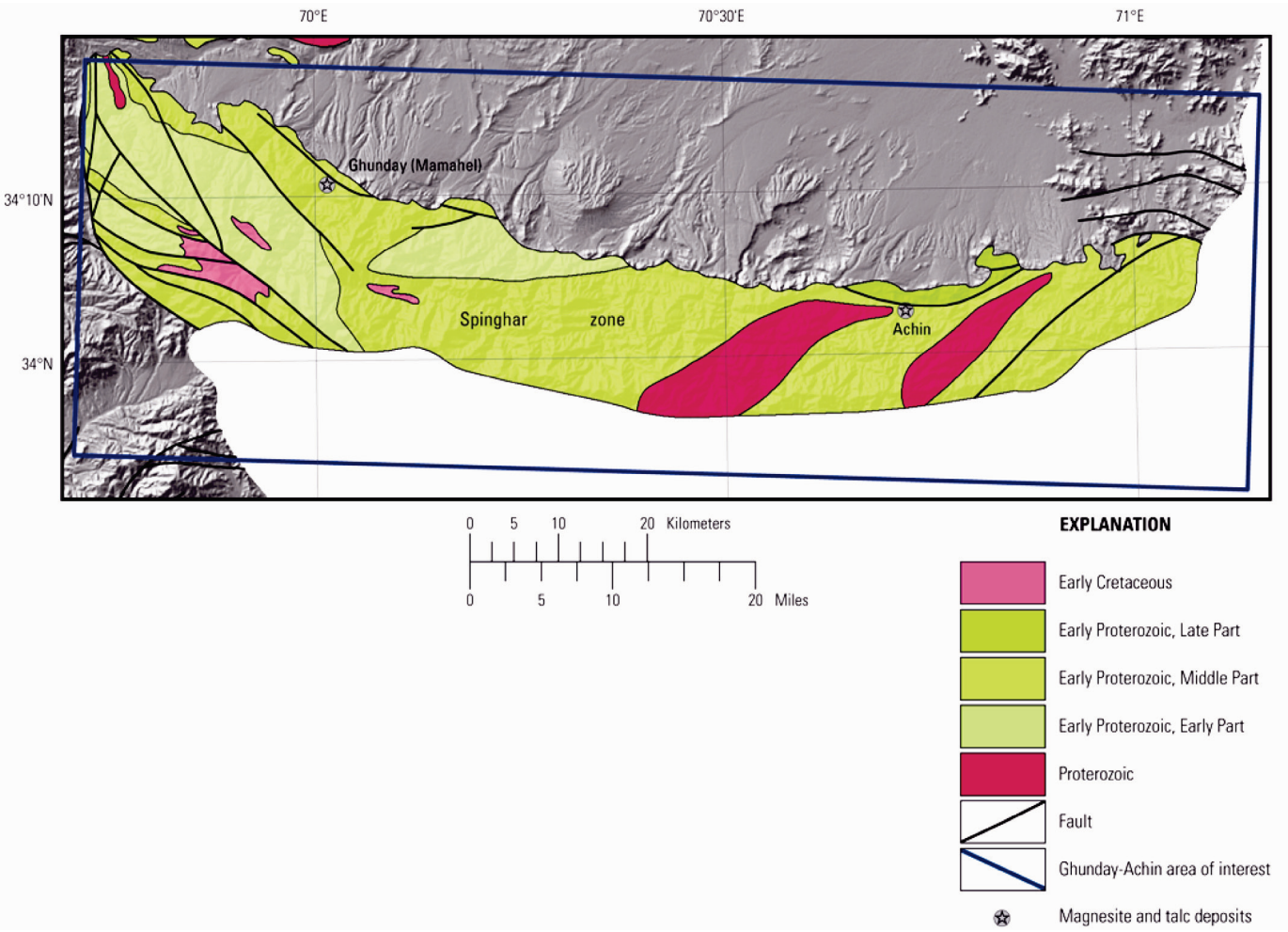


**Figure 20A–3.** Geology of the Ghunday-Achin magnesite and talc area of interest (AOI). Units from Doebrich and Wahl (2006).

## 20A.5 Geologic History

The talc and magnesite deposits are hosted by metamorphic rocks of the early Proterozoic. Evidence, discussed later, suggests that the origin of the talc and magnesite may be related to the original composition of the host rocks. The age of metamorphism of the host rocks, which eventually led to formation of the talc and magnesite deposits, is unknown, but is probably Proterozoic (Peters and others, 2007). However, relative timing of structural, metamorphic, and intrusive events within the Spinghar Zone is unknown.

This part of Afghanistan was involved in the closing of the Paleo-Tethys during the Cimmeride Orogen (Şengör, 1984). Details regarding this area in respect to the whole Cimmeride Orogen have not been studied.

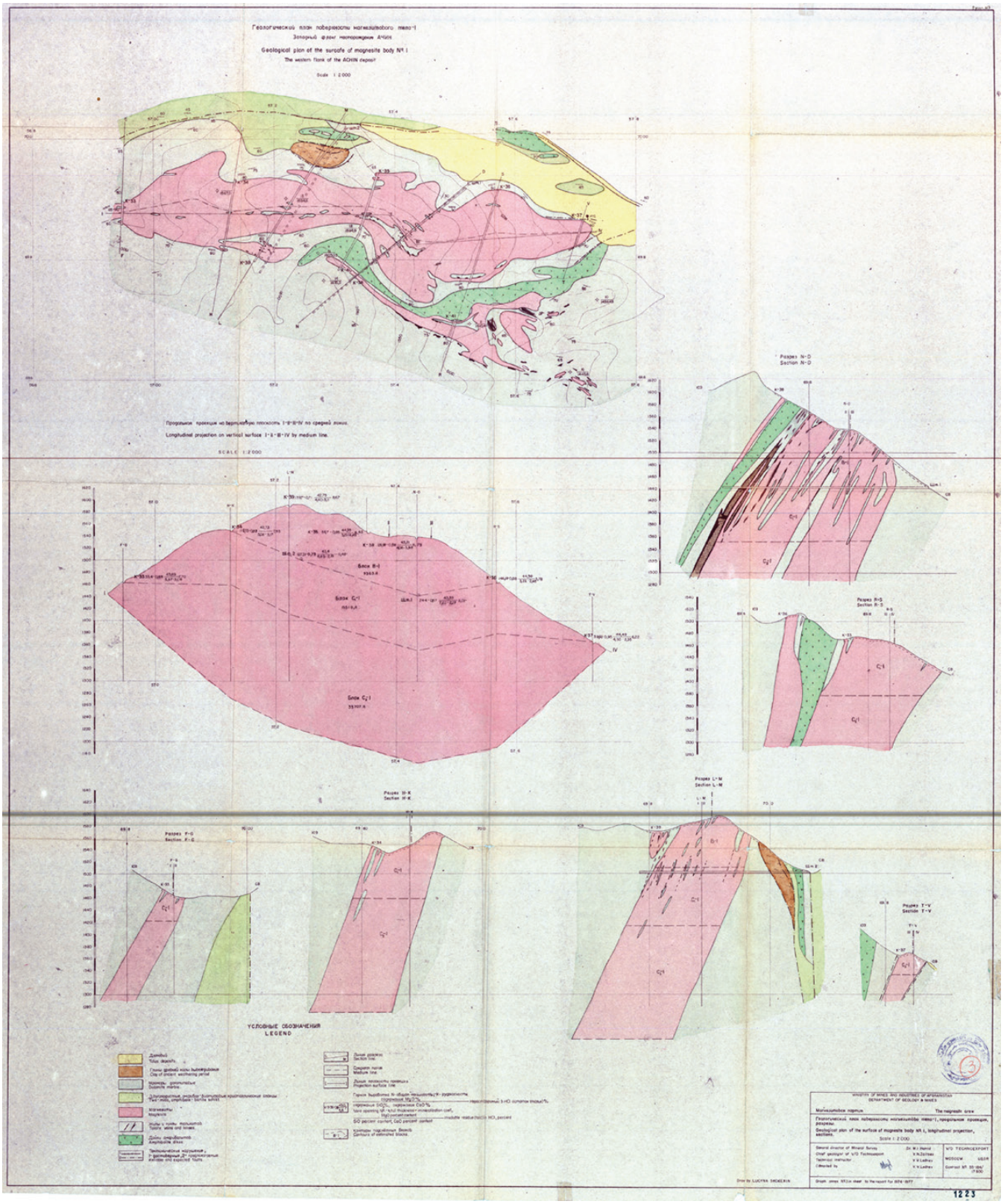


**Figure 20A–4.** Geological plan and sections of Magnesite Body 1, Achin deposit (Lednev, 1977a).

## 20A.6 Structural Geology

Cross sections and strike and dip symbols on the geologic maps indicate bedding of the dolomitic marble and contacts of the magnesite, amphibolite, and talc bodies are roughly subparallel to parallel (Lednev, 1977a-o). The general trend of the bedding at both deposits is to the northwest with bedding at Achin dipping steeply to the south. Bedding at Ghunday dips to the south in the Southern Zone and to the north in the Northern Zone. A cross section through the two zones may indicate that they occupy the opposite limbs of an anticlinal structure (Lednev, 1977j). The northwestern trend of the bedding suggests that the Achin and Ghunday deposits occur within the same stratigraphic sequence and that beds of similar composition and age may occur along that trend between the two deposits.

The geologic map of the Ghunday-Achin magnesite and talc AOI (fig. 20A–3) shows an apparently discontinuous arcuate fault near the northern boundary of the Spinghar Zone. This structure may be continuous but covered by the Pliocene to Quaternary sandstones and conglomerates to the north. Depending on the nature of this structure, the dolomitic marble that hosts the Achin and Ghunday deposits may be repeated beneath the younger sediments to the north of the present surface exposures of the Spinghar Zone rocks.

## 20A.7 Economic Geology

### 20A.7.1 Talc Deposits

The Ghunday talc deposit (lat. 34.183 °N., long. 70.017° E.) consists of the talc-bearing Northern and Southern Zones located within Proterozoic dolomitic marble. Each talc zone consists of a series of elongated lenticular talc bodies and talc veinlets. In the 200-m-long Northern Zone, the talc bodies are 0.5 to 12 m thick and up to 60 m long. In the 240-m-long Southern Zone, the talc bodies are 1 to 3 m in thickness and 8 to 20 m in length. The talc is white, more rarely pink, commonly occurring as steatite (United Nations Economic and Social Commission for Asia and the Pacific, 1995; Abdullah and Chmyriov, 2008).

The Achin talc deposit consists of a 2-km-long talc-bearing zone. The talc-bearing zone consists of a series of closely spaced en-echelon talc veins, pods, or deformed sheet-like bodies that are oriented subparallel to the layering in the marble. The talc bodies are intricately shaped with numerous swells and necks. The talc bodies extend for several meters to 150 m and are intersected in drill holes or adits to a depth of 100 to 160 m. The economically valuable portion of the zone is 860 m long (United Nations Economic and Social Commission for Asia and the Pacific, 1995; Abdullah and Chmyriov, 2008). Although commonly adjacent or close to amphibolite bodies, talc bodies may be absent where diabase is present, and talc may be present where diabase is absent.

### 20A.7.2 Magnesite Deposits

Large bodies of magnesite are present at Achin, but not at Ghunday. These magnesite bodies referred to as Magnesite Bodies 1 and 2, average 33 to 70 m thick and 328 to 765 m long. These are lens-shaped and consist of magnesite with talc, dolomite, calcite, and quartz inclusions (United Nations Economic and Social Commission for Asia and the Pacific, 1995; Abdullah and Chmyriov, 2008). Magnesite Body 1, to the northwest, is thicker and more lobate (fig. 20A–4) than Magnesite Body 2, to the southeast. Geologic maps of several adits (Lednev, 1977c, d, g, h) show numerous, small (less than 1 m wide) talc bodies as selvages between magnesite and marble and lens-like or vein-like bodies (Abdullah and Chmyriov, 2008) in both the magnesite and dolomitic marble. The extent of talc mineralization associated with Magnesite Body 1 is significantly less than the extent of Magnesite Body 2. Although commonly close to amphibolite bodies, magnesite bodies, like the talc bodies, may be present with or without adjacent diabase.

## 20A.8 Mineralogy and Geochemistry of the Talc Deposits

The Ghunday talc deposit consists of 60 to 96 volume percent (vol. %) (about 78 vol % average) talc, with 26 to 35 weight percent (wt. %) (about 32 wt. % average) MgO, 0.5 to 14 wt. % (about 5 wt. % average) CaO, and 33 to 60 wt. % (about 57 wt. % average) $SiO_2$ (Abdullah and Chmyriov, 2008).

At Achin, the chemical composition of the talc rock which contains 50 to 95 vol. % (70 vol. % average) talc, is as follows: 26 to 40 wt. % (31 wt. % average) MgO, 31 to 61 wt. % (57 wt. % average) $SiO_2$, and 0.2 to 16 wt. % (about 8 wt. % average) CaO (Abdullah and Chmyriov, 2008). Talc bodies are composed of gray and white foliated talc and more rarely steatite with minor dolomite, magnesite, quartz, and calcite inclusions (Abdullah and Chmyriov, 2008).

## 20A.9 Mineralogy and Geochemistry of the Magnesite Deposits

Channel samples of nine trenches across the two magnesite bodies at Achin produced 231 analyses for MgO, $SiO_2$, and CaO. Weighted averages of all samples for each of the trenches were calculated (table 1). A few thin lenses of dolomitic marble, which were encountered in the trenches and sampled, were included in the calculations. The magnesite bodies showed a range of 40.0 to 44.3 wt. % MgO. The lower numbers reflect the inclusion of more dolomitic marble in those trenches. In general, the MgO content is relatively uniform across the magnesite bodies and does not show any trends in the composition zonation. Abdullah and Chmyriov (2008) noted that the magnesite bodies contain magnesite with talc, dolomite, calcite, and quartz inclusions. Talc content of the magnesite ore ranges from 3.6 to 14.4 vol. %. Compositions of the magnesite bodies do not show any relation to near or adjacent amphibolite units or to talc bodies. Abdullah and Chmyriov (2008) suggest that the magnesite bodies have dolomite-magnesite selvages with slightly lower MgO contents. According to the analytical data obtained after baking, the magnesite quality is characterized by the following contents: 81.9 to 83.5 wt. % MgO, 7.8 to 12.3 wt. % $SiO_2$, and 3.5 to 7 wt. % CaO (Abdullah and Chmyriov, 2008).

**Table 20A–1.** Weighted average chemical composition of 231 trench samples in the Achin magnesite bodies.

| Total interval sampled (meters) | MgO (weight percent) | $SiO_2$ (weight percent) | CaO (weight percent) | Magnesite body |
|---|---|---|---|---|
| 35.4 | 44.0 | 6 | 3.9 | 1 |
| 121.3 | 42.3 | 5.6 | 4.6 | 1 |
| 27.6 | 44.3 | 5.4 | 1.7 | 2 |
| 20.3 | 43.8 | 5.7 | 1.1 | 2 |
| 19.3 | 41.3 | 5.8 | 4.8 | 2 |
| 32.4 | 40 | 6.4 | 5.3 | 2 |
| 69 | 40.3 | 8.2 | 5.4 | 2 |
| 60.8 | 41.7 | 5.7 | 4.6 | 2 |
| 30 | 42.5 | 7.9 | 0.4 | 2 |

## 20A.10 Ore Reserve Estimation, Reserves and Resources

At Achin, the talc resources are 1.25 million metric tons (Mt), and the speculative magnesite ore reserves are 31.2 Mt (Chmyriov and others, 1977; United Nations Economic and Social Commission for Asia and the Pacific, 1995; Peters and others, 2007; Abdullah and Chmyriov, 2008). Cross sections (Lednev, 1977a,c,i) show the talc and magnesite extending at least to a depth of 190 m (fig. 20A–4). Talc and magnesite resources were calculated using different baselines. The talc resources were only calculated to depths of 50 to 60 m, and the magnesite resources were calculated to an altitude of 1,295 m above sea level This results in talc resources with a uniform thickness and magnesite resources with a varyiable thickness. Table 20A–2 summarizes the physical aspects and resources of the Achin and Ghunday deposits.

At Ghunday the speculative talc resource in the Northern Zone is 0.36 Mt with the average talc content of 76 vol .%, and in the Southern Zone, 0.11 Mt with an average talc content of 81 vol. % (Chmyriov and others, 1977; Peters and others, 2007; Abdullah and Chmyriov, 2008). Cross sections

show the talc extending at least to a depth of 200 m, well below the depth for the calculated reserves (Lednev, 1977a, c, i).

**Table 20A–2.** General comparison of the Achin and Ghunday areas.

[Dimensions of the talc, magnesite, and amphibolites bodies could not be measured directly from the geologic maps, as no bar scales were available and the maps could not be rectified well enough. Dimensions are from Abdullah and Chmyriov (2008). Abbreviations: m, meters; wt. %, weight percent; vol. %, volume percent; Mt, million metric tons; NA, not available]

| | Achin | Ghunday |
|---|---|---|
| Number of magnesite bodies | 15 (6 large) | 0 |
| Lengths of largest magnesite bodies | 328 to 765 m | NA |
| Widths of the largest magnesite bodies | 33 to 70 m thick | NA |
| Speculative resources - magnesite | 31.2 Mt @81 to 83 wt. % | NA |
| Number of talc bodies | 20 (plus numerous small bodies) | 12 (plus numerous small bodies) |
| Speculative resources - talc | 1.25 Mt | 0.36 Mt @76 vol. %;<br>0.11 Mt @80.67 vol. % |
| Lengths of zones of talc bodies | 2,000 m with 860 m economic zone<br>NA | Northern Zone – 200 m<br>Southern Zone – 240 m |
| Widths of talc bodies | NA<br>NA | Northern Zone – 1 to 3 m<br>Southern Zone – 8 to 20 m |
| Number of amphibolite bodies | 7 | 40 plus |

## 20A.11 Genesis of the Talc and Magnesite Deposits

Magnesite deposits may occur in association with ultramafic rocks, in sedimentary rocks, or in metasedimentary rocks. Magnesite deposits in sedimentary or metasedimentary rocks may be called sparry (Veitsch-type) magnesite, carbonate-hosted magnesite, or crystalline magnesite (Pohl, 1989, 1990; Pohl and Siegl, 1976; Harben and Kuzvart, 1996; Page, 1998a, b; Simandl and Handcock,1999; Orris and Bolm, 2007), and talc deposits in these rocks are referred to as carbonate-hosted or dolomite-hosted talc deposits (Simandl and Paradis, 1999; Orris and Bolm, 2007). In the sparry magnesite deposits, talc and magnesite may occur together in metasediments, especially dolostone or dolomitic marble. Descriptions and classifications of carbonate-hosted magnesite and talc deposits and their origin are found in Pohl (1989, 1990), Pohl and Siegl (1986), Harben and Kužvart (1996a,b), Page (1998a, b), Simandl and Handcock (1999), and Simandl and Paradis (1999). Preferred hypotheses regarding the genesis of these types of deposits are (1) metasomatic replacement of dolomitized, permeable carbonates by magnesite and (2) diagenetic recrystallization of a magnesia-rich chemical sediment in a marine or lacustrine setting (Simandl and Hancock, 1999). In British Columbia, both sediment-hosted talc and Mississippi Valley-type deposits are spatially associated with the magnesite deposits (Simandl and Hancock, 1999).

Sparry magnesite (Veitsch-type) deposits are stratabound lenses or irregular masses, typically on the order of a few hundred meters to several kilometers in strike length and meters to tens of meters thick (Simandl and Hancock, 1999). In a metamorphic environment, a dolomitic limestone and magnesite become dolomitic marble and recrystallized magnesite, respectively. Deposits of this type range from tens of thousands of tons to over 100 Mt in size and may extend several kilometers along strike (Simandl and Handcock, 1999).

The geology of the Achin magnesite bodies suggests they should be classified as sparry magnesite deposits. Details regarding descriptive mineralogy or contact relations are not presently available, but the occurrence of the magnesite bodies as apparent stratabound deposits within dolomitic marble, the relatively consistent composition across the bodies, the lack of evidence for a hydrothermal system related to intrusive activity, and the lack of associated ultramafic or mafic intrusions are all consistent with such a classification.

Carbonate-hosted talc deposits are generally found in dolomitic marbles and dolomites and may be crosscut by minor intrusions, such as diabase (Simandl and Paradis, 1999). Talc generally forms by decarbonation according to: 3 dolomite + 4 $SiO_2$ + $H_2O$ = 1 talc + $CO_2$. Siliceous carbonate layers, adjacent quartz-bearing rocks, or hydrothermal fluids may be the sources of silica for formation of talc

in carbonate rocks. Heat for the reaction may come from regional metamorphism, contact metamorphism, or hydrothermal fluids (Simandl and Paradis, 1999). Talc is unstable in upper amphibolite- facies marbles, thus it should only be expected in staurolite grade or lower or under retrograde metamorphic conditions.

At Achin, talc occurs both as relatively large bodies within the dolomitic marble and as small, lens-like masses within the magnesite bodies and dolomitic marble. The elongate talc zone is crosscut by amphibolite bodies which are believed to be metamorphosed equivalents of andesite or diabase intrusions. Talc deposits located within the dolomitic marble appear to be stratabound, as they are subparallel to parallel with bedding in the dolomitic marble and with the magnesite bodies. The presence, absence, or proximity to the amphibolite bodies is not related to the spatial distribution of the talc bodies. Thus, these larger bodies are probably formed by the process noted above by regional metamorphism of beds of siliceous dolomite. The small lenses or pods of talc located within the magnesite may have formed by the reaction: 3 magnesite + 4 $SiO_2$ + $H_2O$ = 1 talc + 3 $CO_2$.

The talc deposits at Ghunday probably also represent metamorphosed siliceous dolomite. Although numerous amphibolite bodies are present, the amount of talc and the size of the talc bodies is relatively small. As noted with the Achin talc deposits, the presence, absence, or proximity to the amphibolite bodies is not related to the spatial distribution of the talc bodies. Talc may also form by alteration of mafic or ultramafic rocks. Because no ultramafic rocks are present, no contact or hydrothermal alteration is evident, and the talc is stratabound within a dolomitic marble, these deposits are all of the stratabound, carbonate-hosted type. These deposits are all of the stratabound type, because (1) no ultramafic rocks are present, (2) no contact or hydrothermal alteration is evident, and (3) the talc is stratabound within a dolomitic marble.

## 20A.12 Prospects and Anomalies

The east-west-trending Spinghar Zone has not been well studied but does include other occurrences of talc and magnesite mineralization (Abdullah and Chmyriov, 2008). Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data can be an accurate and cost-effective tool to identify and map minerals, particularly in areas with little or no cover (Rockwell and Hofstra, 2008). ASTER imagery of the Achin and Ghunday deposits displays distinct areas that contain dolomite and clay-carbonate signals (figs. 20A–5, 20A–6). These dolomite and clay-carbonate areas can be directly related to the dolomitic marble and perhaps to the magnesite. The talc bodies are too small to be identified with this imagery. ASTER imagery of the Proterozoic rocks throughout the Ghunday-Achin magnesite and talc AOI shows seven large areas, labeled A through G in figure 20A–7, that indicate the presence of dolomite plus clay-carbonate. Areas A, B, and C may indicate the same or similar horizon as the Achin deposit within map unit $X_2$mbg. Located to the south, anomaly D extends from map unit $X_2$mbg across Proterozoic granitic rocks (map unit Pgng). This area is very pronounced, and map unit $X_2$mbg may extend through the mountainous area mapped as Pgng. ASTER areas E, F, and G are associated with small inliers of map unit $X_2$mbg in the westernmost part of the AOI.

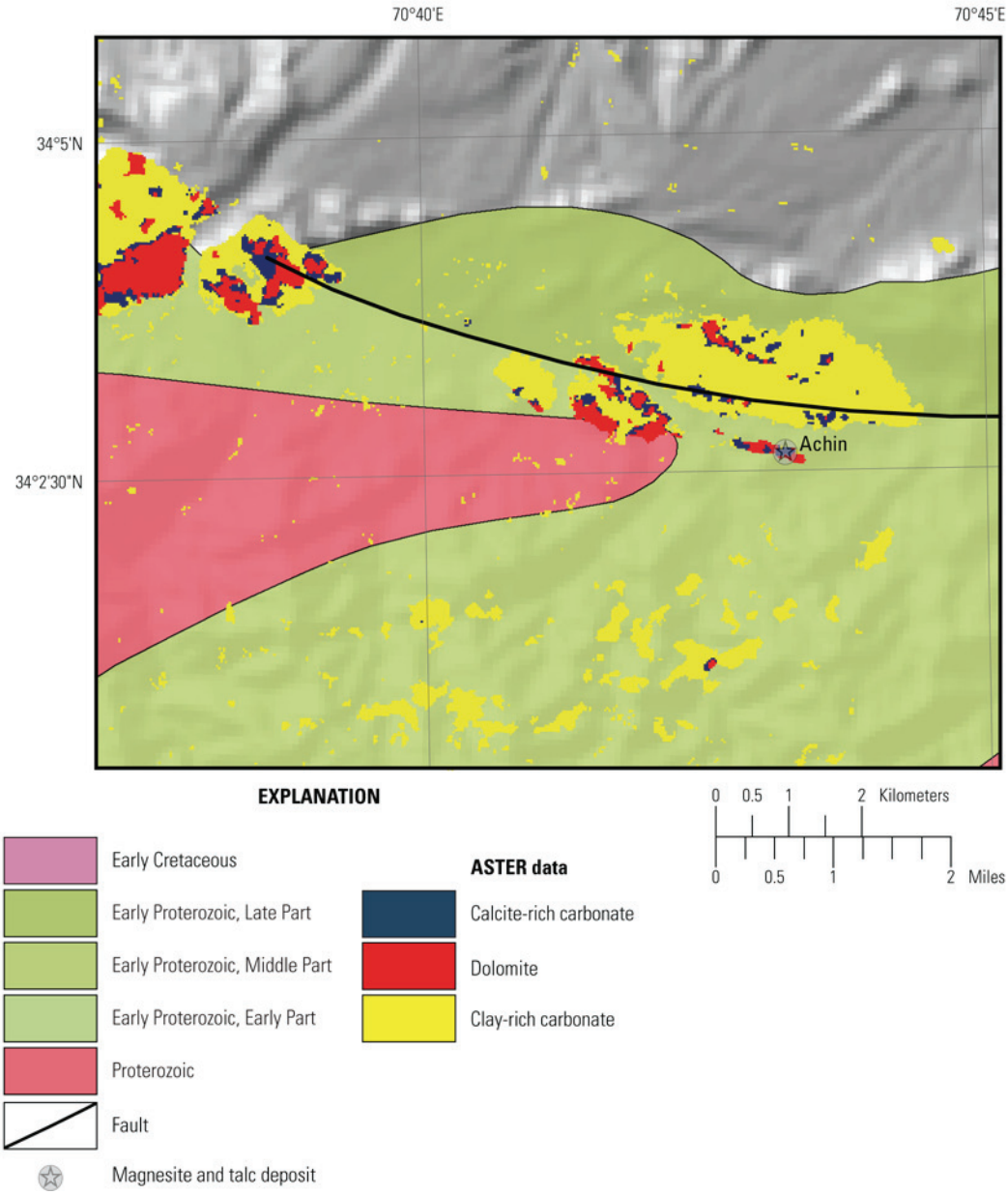


**Figure 20A–5.** ASTER dolomite anomalies at Achin and surrounding areas. Geologic units from Doebrich and Wahl (2006).

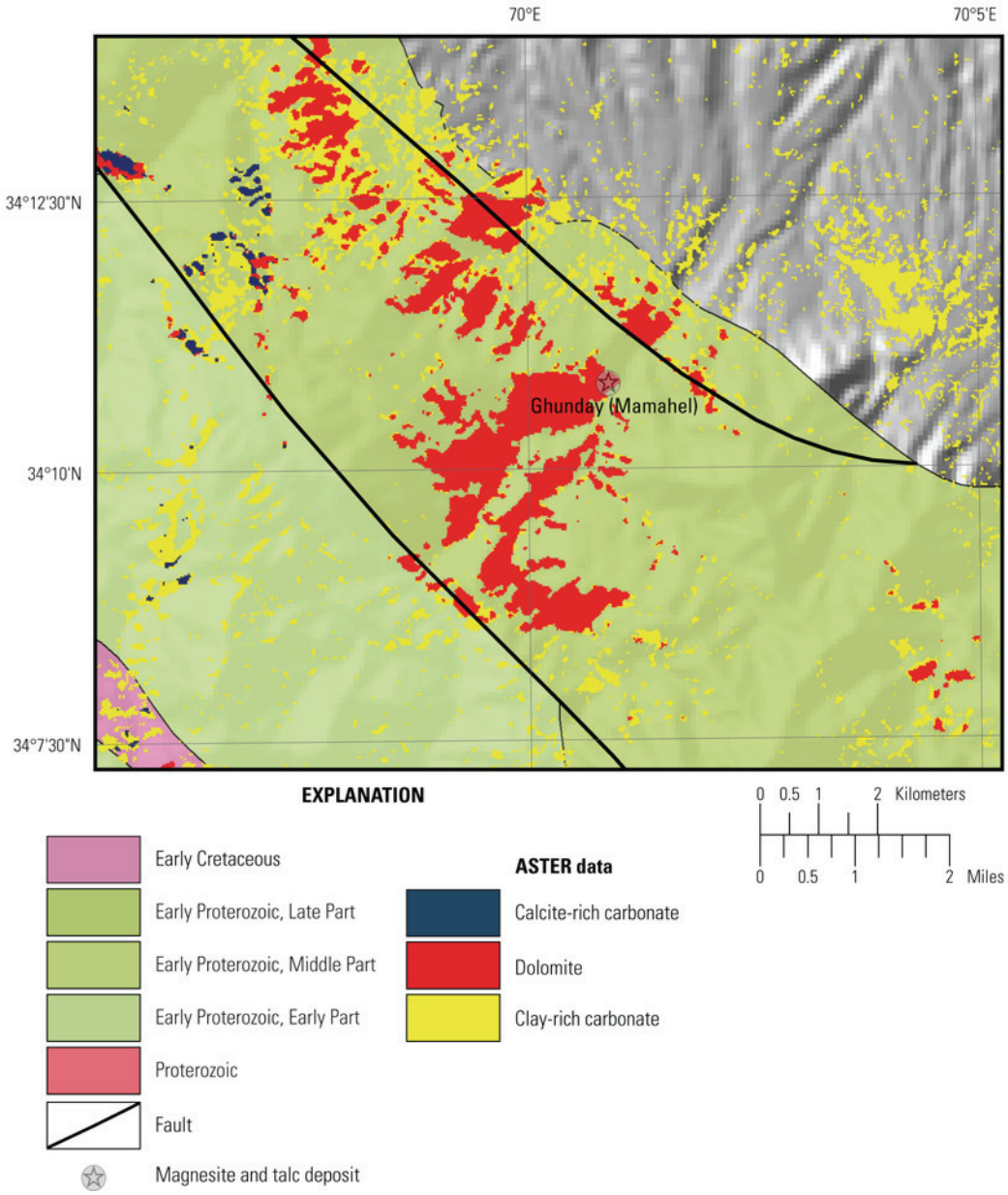


**Figure 20A–6.** ASTER dolomite anomalies at Ghunday and surrounding areas. Geologic units from Doebrich and Wahl (2006).

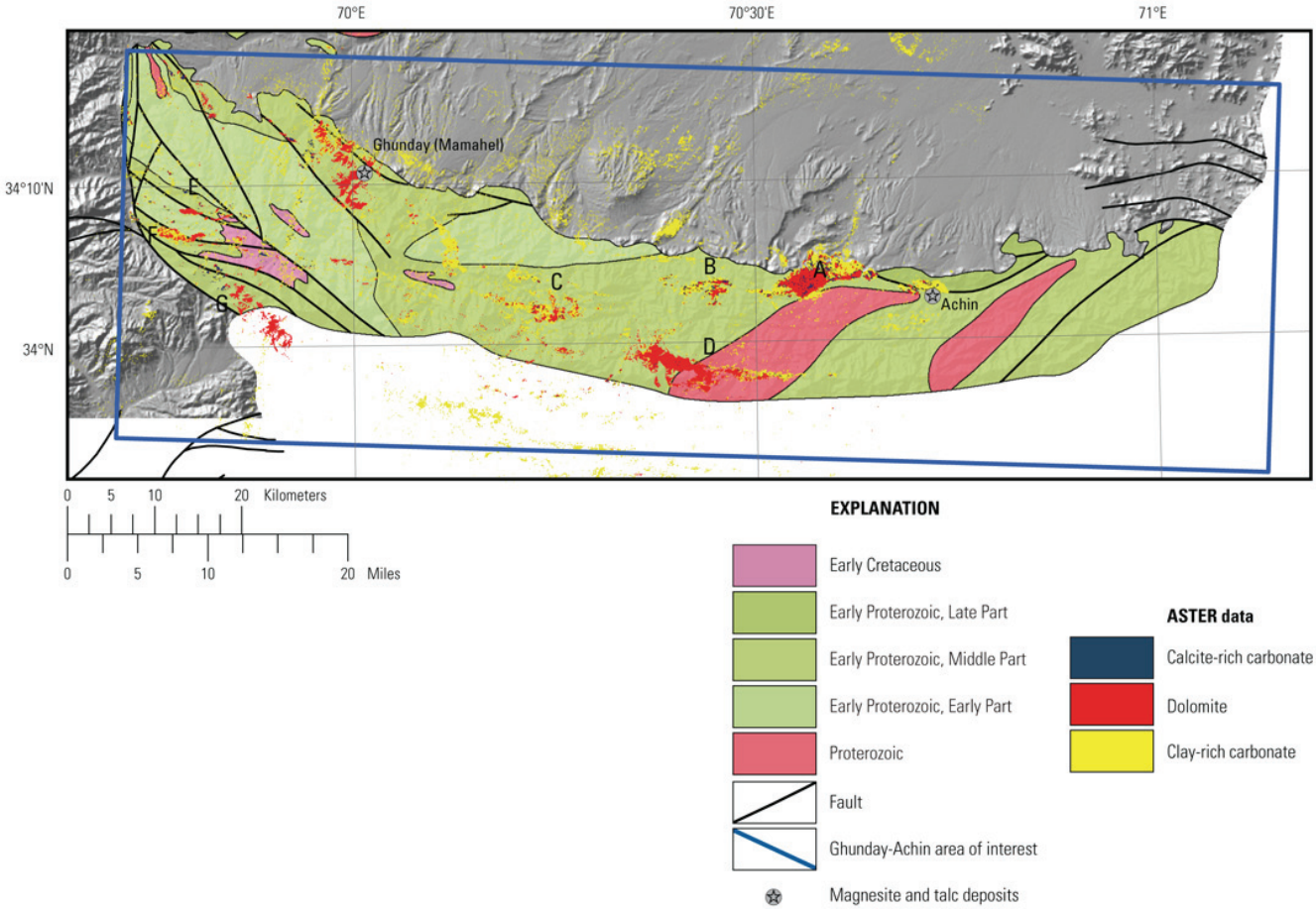


**Figure 20A–7.** ASTER dolomite anomalies (A-G) in the Ghunday-Achin magnesite and talc area of interest (AOI) that may indicate dolomitic marble and associated talc or magnesite deposits. Geologic units from Doebrich and Wahl (2006).

## 20A.13 Summary of Potential

Only the Achin and Ghunday areas have had any recorded mineral exploration. The Achin area has a high potential for undeveloped talc and magnesite resources. The ASTER anomalies in the unexplored mountainous terrain between and to the south of the Ghunday and Achin areas may indicate a high potential for undiscovered magnesite and talc deposits. The relation between ASTER imagery, the talc and magnesite deposits, and the host dolomitic marble could be used elsewhere in Afghanistan to assess the potential for undiscovered deposits of this type.

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