The Achin Magnesite Deposit

Introduction

The Achin magnesite deposit occurs in Nangarhar province at the northern foot of the east - west trending Spinghar Range of mountains, 70 km SE of the Jalalabad. The deposit is located at N34° 03' and E70° 43' about 10 km S of Achin, a small village with a population of several hundred. Generally, the deposit can be divided into two distinct parts. The north-western one is composed of a main, large, oval-shaped magnesite body accompanied by several small ones. The south-eastern part consists of several, relatively small, lensoid magnesite and talc bodies, which are elongated in NW-SE direction. The host rocks of the magnesite and talc bodies are Proterozoic metasedimentary and metavolcanic rocks, predominantly dolomitic marble. A general study in the 1970's demonstrated the potential of the area and estimated resources for the Achin magnesite -talc deposit to be 66 million tonnes of magnesite and 5.5 million tonnes of talc.

Geology of Eastern Afghanistan

Afghanistan has a complex geology due to its position on the junction between the Indo-Pakistan and Asian crustal plates. Its geology is composed of a series of terranes that broke away form the main Gondwana supercontinent before colliding with the Eurasian plate. Ultimately, all the terranes became accreted onto the southern margin of the Eurasian plate. The accretionary events started in the Cretaceous and have continued until recent times.

The eastern part of Afghanistan is composed of the Spinghar, Kunar, Nuristan blocks and the Katawaz basin. The Achin deposit is located in the Spinghar block in eastern part of Afghanistan near the Pakistan border (Figure 1). The Spinghar block forms the western extremity of the Lesser Himalayas zone, which lies immediately to the north of the Main Boundary Thrust of the Indo-Pakistan Plate.

The Spinghar, Kunar, Nuristan blocks and the Katawaz basin each has a different lithostratigraphy, metamorphosis and tectonic evolution. The Spinghar block is composed of dominantly Proterozoic crust and Lower Paleozoic cover sequences. The Nuristan block has similar structures to the Spinghar block but is more strongly affected by Oligocene granite plutonism. Its crust is composed of Proterozoic metasedimentary rock sequences and Proterozoic intrusions covered by Palaeozoic-Mesozoic successions.

The Kunar block, located north-east of the Spinghar block, is characterized by Late Palaeozoic to Early Mesozoic sedimentary sequences which are cut by Lower Triassic intrusions of granodiorite and granite. Outcrops in the Katawaz basin consists of clay, shale, sandstone and conglomerate with sporadic mafic volcanic rocks predominantly of Paleocene and Eocene age.

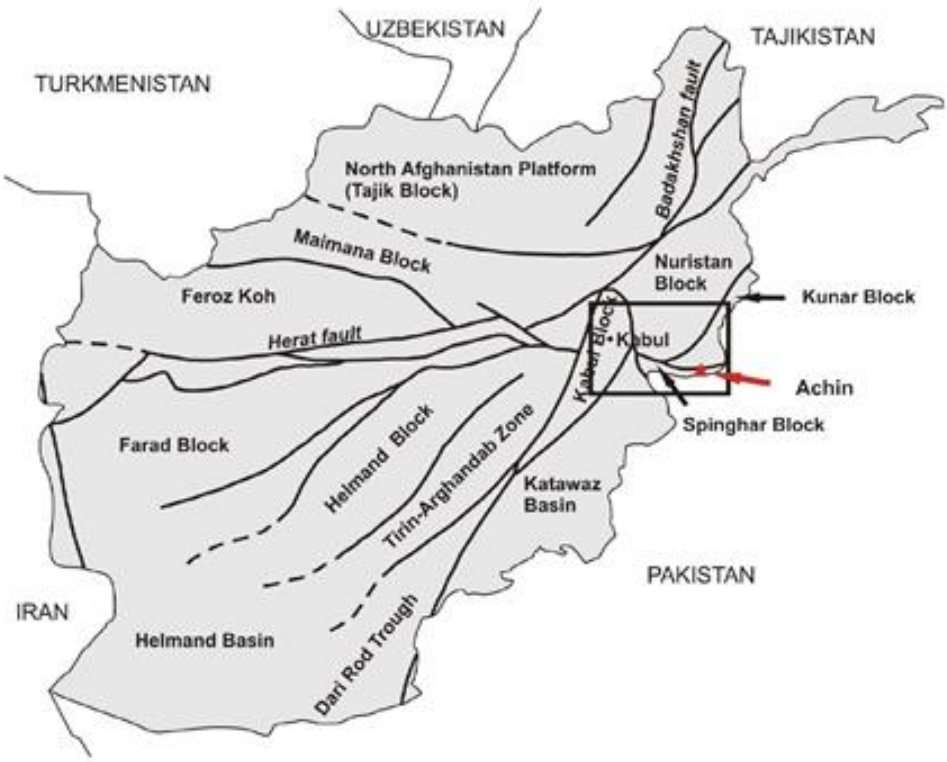

Figure 1. Tectonic sketch of Afghanistan showing major blocks and faults, and the outline of the area shown in Figure 2

Geology of the Achin area

The Achin deposit is located in the Spinghar block, which consists of rocks of Palaeoproterozoic, Ordovician and Silurian-Devonian age (Figure 2). The ca. 2000 Ma Palaeoproterozoic complex, also called the "Lower complex" by Lednev (1977), is composed of three groups (Figure 4). The Lower Group (Early Palaeoproterozoic) is situated in the anticlinal core of the Spinghar block and it crops out predominantly in the western part of the mountains. It consists mainly of dark-grey to grey fine-grained limonitic quartzite alternating with biotite flaser- and leaf-gneisses.

The Lower Group is overlain by a thick metasedimentary sequence of the Middle Group (Middle Palaeoproterozoic), which consists of mainly dark-grey to grey biotite-garnet-graphite schist and schistose amphibolite with intercalations of quartzite, andesite, basalt, and amphibolite bodies. Pyrrhotite occurs in minor amounts in the quartzite and amphibolite bodies of this sequence. In addition, the Middle Group includes dolomitic marble bodies, 50-100 to 400-600 metres thick, which contain magnesite and talc mineralisation in their upper part. The group is cut by Proterozoic gneiss-granite, granite, and migmatite and by Proterozoic ortho-amphibolite, gabbro-amphibolite, and gabbro-diabase. The Upper Group (Late Palaeoproterozoic) crops out at the northern foot of the Spinghar Mountains. and consists of a monotonous sequence of grey, dark-grey to black biotite-garnet-staurolite metamorphosed schist with sporadic intercalation of marble. The boundary between the Middle and Upper Groups is marked by an angular discordance. In the eastern part of the area, Ordovician sequence of siltstone, phyllitic shale and sandstone with common lensoid, dark-grey metamorphosed limestone bodies is overlain by carbonate formation of Silurian-Devonian age.

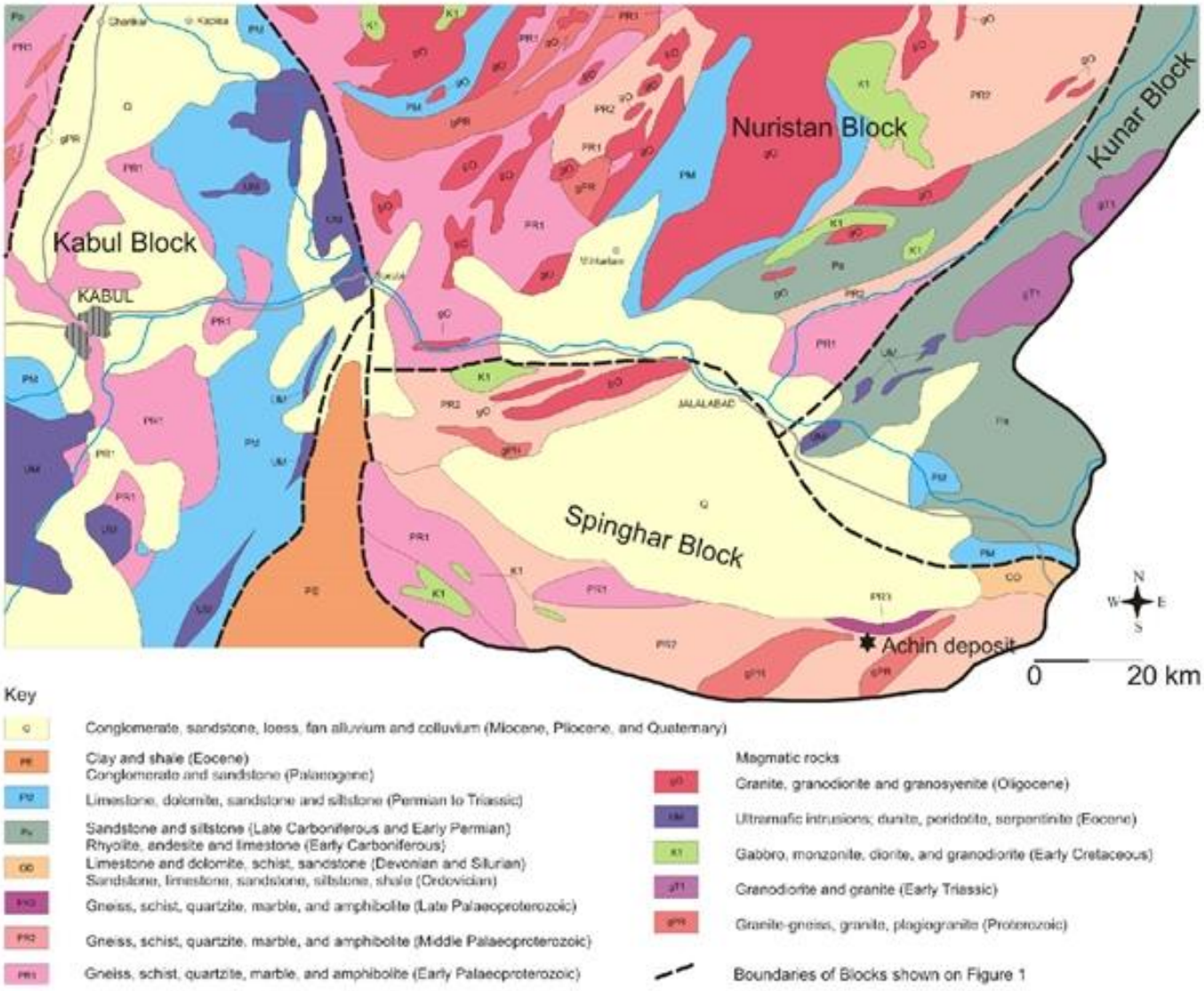

Figure 2. Regional geology of Eastern Afghanistan with the location of Achin.

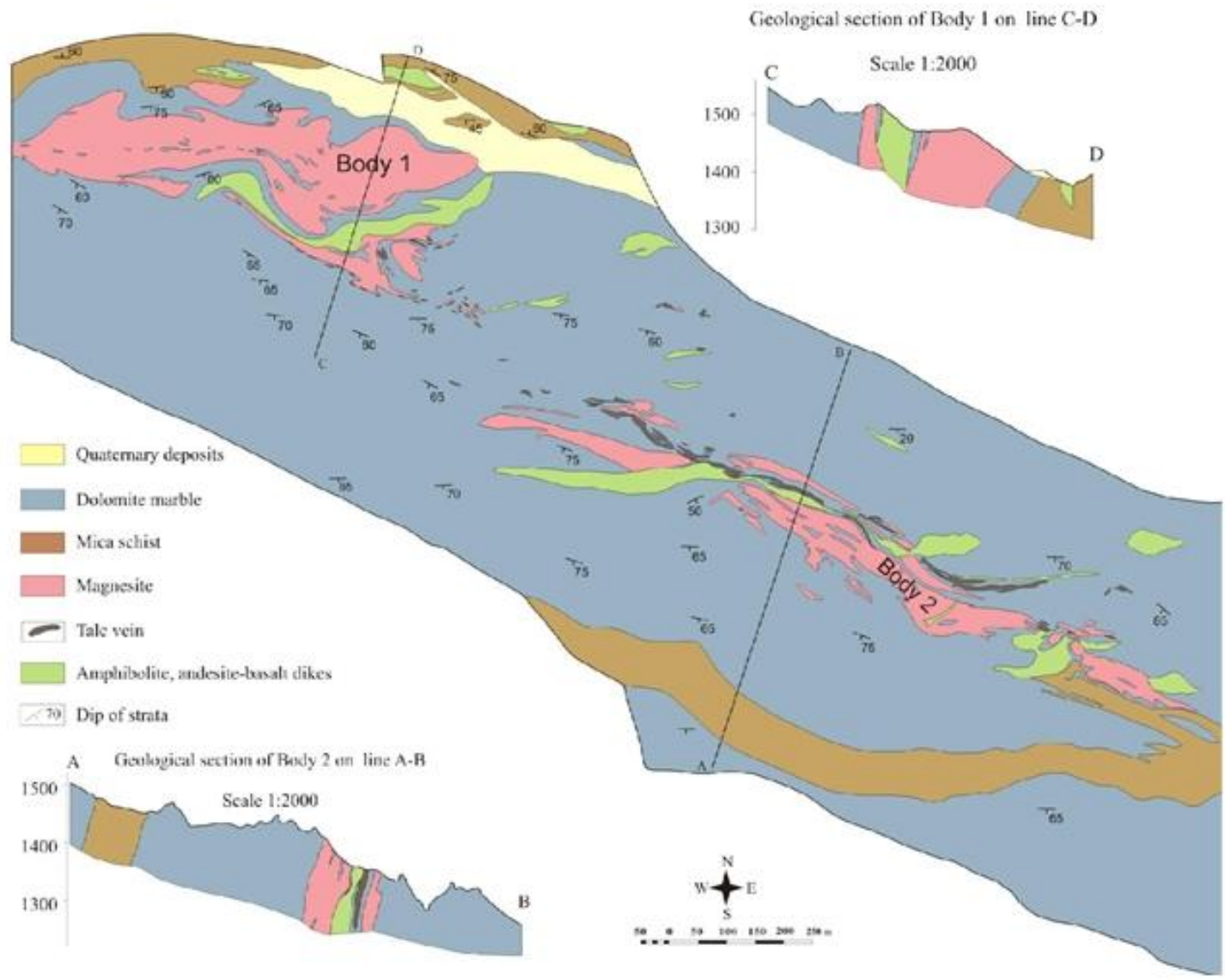

Figure 3 Detailed geological map and cross sections of the Achin magnesite deposit

Mineralisation

The Achin magnesite deposit is composed of stratiform lenses and layers (Figure 3). In addition to magnesite, the deposit also contains talc and dolomite. On the basis of summary mineralogical and chemical analysis there are two types of magnesite-rock:

Type 1. Sparry and medium grained crystalline magnesite, often cataclastic and recrystallized, with a small talc content

magnesite (I. and II. generation)	97-99.5 %
talc	0.3-2.5 %
dolomite	0.2-1.0 %
calcite	0.1-0.2 %

Type 2. Sparry crystalline magnesite, often with talc, recrystallized, dolomitized with marked admixture of fine grained magnesite of II. generation

magnesite (I. and II. generation)	80-90 %
talc	10-15%
dolomite	2-4 %
calcite	0.3-0.5 %

Exploration

The first geological observations in the area were carried out by C. L. Griesbach during 1880-1892, who sketched a geological map of the Spinghar Range. However, the magnesite and talc deposits first became known in the 1920's when artisanal mining of talc in the Achin deposit started. The Achin deposit was then known as the Tanga deposit and for a long period it was not the object of serious research and prospecting. The Achin deposit was studied in detail during the 1970's by Afghan and Soviet geologists who wrote a number of reports on the area. These reports are documented in a final report (V. V. Lednev, 1977), which is archived in the Afghanistan Geological Survey. The Afghan-Soviet work included two adits (adit No. 1 - 340 m; and No. 2 - 281 m), 39 trenches on a grid of 80-120 m and a surface geological mapping survey (Figure 3).

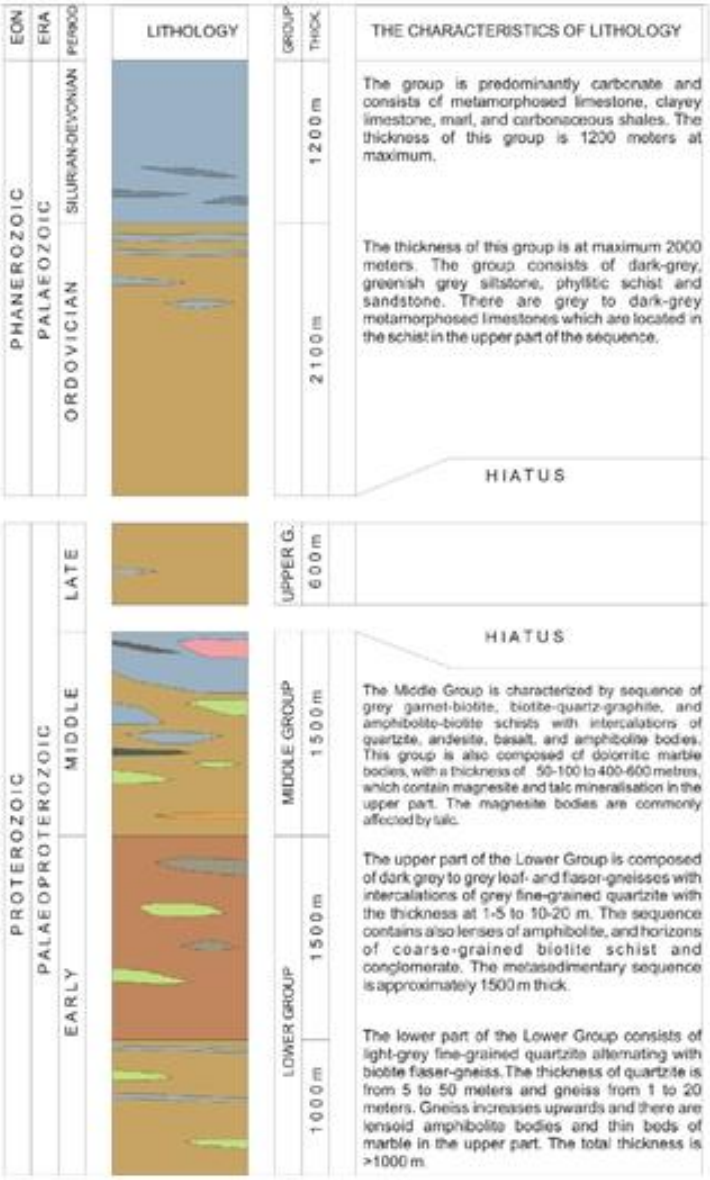

Figure 4. Stratigraphic succession of the Spinghar Block. (for key to colours see Figure 3)

Table 1. Chemical composition of the two magnesite bodies

Components		Ore Bodies	
		Magnesite Body 1	Magnesite Body 2.
MgO	from	40.01	40.10
	to	47.12	46.57
	mean	43.86	43.68
SiO_2	from	0.10	1.71
	to	25.00	12.59
	mean	5.38	5.89
CaO	from	0.10	0.30
	to	8.10	7.51
	mean	2.58	2.19
R_2O_3	from	0.10	0.40
	to	0.93	1.40
	mean	0.87	0.82
insoluble in HCl remaining solid (talc)	from	0.97	6.64
	to	37.84	14.40
	mean	8.03	9.33

Note: Values were calculated from selected samples with more than 40% MgO.

Metallogenetic model

The magnesite bodies are hosted by dolomitic marbles and form a series of 1 to 120 m-thick bodies within the approximately 2000 Ma (Middle Palaeoproterozoic) formation of the Spinghar block. These marbles are a consequence of greenschist to amphibolite grade metamorphism. The marbles is considered to be an altered sequence of stromatolites formed in a complex combination of shallow-marine and non-marine, evaporitic environments (Melezhik et al., 2001). The depositional environment is thought to be similar to the Holocene magnesite deposit at Lake Walyungup, Australia coastal playa magnesite described by Coshell, Rosen and McNamara (1998). In this sabkha to playa-lake environment primary dolomite was deposited under evaporitic conditions, but later altered to magnesite, by reaction with Mg-bearing, hypersaline brines derived from seawater. The Achin deposit includes two generations of magnesite. Initially laminated and structureless, micritic magnesite replaced primary dolomite during early diagenesis before the major phase of burial. Late in the diagenetic/metamorphic history crystalline and coarsely crystalline magnesite replaced the micritic magnesite. It is thought that the magnesite bodies were not derived by carbonation of serpentinite bodies or by deposition from groundwaters derived by surface weathering of serpentinite.

Future development

The earlier exploration as described above was very detailed and comprehensive in nature. One main body of the Achin deposit is very attractive for open-pit mining. It is situated at the north-western part of the deposit, dips at 60° to 75° to the south and has a constant thickness of approximately 120 m. The south-eastern part of the Achin deposit is composed of several magnesite bodies and talc veins, which are roughly parallel to the bedding in the host dolomitic marble. This part of the deposit is rich in talc and the magnesite bodies have irregular lensoid shapes. A number of resource calculations were carried out to Soviet standards (Table 2) but these do not easily conform to modern Western resource classifications.

Table 2. Summary of resources of the Achin deposit.

Body	Soviet Category	Length [m]	Width [m]	Height [m]	Projection plane [m^2]	Volume [Mm^3]	Resources [Mt]
No. 1	B-I	440	136	69	30160	4.1	9.3
No. 1	C_1-I	660	118	84	55330	6.5	15.5
No. 1	C_2-I	820	118	147	120160	14.2	33.7
No. 2	C_2-I	320	21	140	44880	1.0	2.6
No. 2	C_2-II	565	44	90	50840	2.2	5.1
Total						**28.0**	**66.2**

Explanation: Bodies 1 and 2 shown on Figure 3.
B-I category - measured or proved; C_1-I category - indicated or probable; C_2-I and C_2-II - inferred or possible resources.
Source: Lednev, 1977

References

Coshell L., Rosen M.R. and McNamara K.J. 1998. Hydromagnesite replacement of biomineralized aragonite in a new location of Holocene stromatolites, Lake Walyungup, Western Australia. Sedimentology, 45 (6), 1005-1018.

Lednev V. V. 1977. Report on results of prospecting exploration works in 1974-1977 at talc-magnesite deposit Achin and talc deposit Mamokhel with evaluation of reserves. 2 volumes. 198 p. (in Russian).

Melezhik V. A., Fallick A. E., Medvedev P. V. and Makarikhin V. V. 2001. Palaeoproterozoic magnesite: lithological and isotopic evidence for playa/sabkha environments. Sedimentology, 48, 379-397.

Plate 1 View from the NW towards magnesite body No.1. The white magnesite dumps from adits 1 and 2 can be seen near the col.

Plate 2 View from the W towards the eastern talc-bearing zone of the Achin deposit. Visible lower centre are the white areas of small quarries in the talc and host marble.

Summary of the Achin deposit

- **estimated resources of 66 million tonnes of magnesite and 5.5 million tonnes of talc**
- **one main magnesite body and a number of smaller lenses**
- **amenable to open pitting**
- **convenient location for transport by road to Pakistan (30km to border at Torkham)**

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