Ingenieurgesellschaft
von Lieberman
» Bauen und Umwelt «

UTILIZATION OF MABE ASBESTOS MINE AS A DISPOSAL SITE FOR ASBESTOS WASTES

LIFE 03/ENV/GR/000214

toxic register (task 1)

asbestos

(10 attachments, 71 pages)

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- Abstract -

The Asbestos Mine of Northern Greece (MABE) is situated in Zidani (Prefecture of Kozani/Western Macedonia). The Mine is less than 1000 m away from Aliakmonas River, the longest river in Greece, and near the artificial lake of Polyfytou. The premises of MABE encompass the Mining Area, the Disposed Waste Area, Administrative, Production and Utilities Buildings and other flat surfaces, which also contain a 17th century Monastery (Moni Zidaniou) 500 m away the mine, which is still in use and attracts many visitors from all over the country.

The Mining Area (851,000 m^2) in which the mineral exploitation took place applying the open pit method and the use of explosives created levels 10 m high and 5 m wide. The mine, which is 180 m deep, is funnel-shaped. The constant mining for an 18-year period has exposed the water wagon horizon and as a consequent result a lake has been created at the mine bottom.

The EU LIFE Environment Project LIFE 03/ENV/GR000214 has the goal of developing an innovative solution for the mine rehabilitation. Next, the environmental situation in the MABE area, particularly in the area of the mine should be investigated in order to identify the areas contaminated with asbestos, to make possible an evaluation of the remediation priority, and to determine the special requirements for work and emission safety for the planned work. Von Lieberman Ltd, a cooperation-partner of Sakosta Holding AG, with their sworn asbestos experts, is responsible for the proper execution of this work.

On the basis of present knowledge, a significant release of asbestos fibers into the environment occurred during the operation of the mine and processing plant.

The investigation results from von Lieberman Ltd show that

- in all environmental components (rock, soil, water, air), asbestos fibers (chrysotile and in part amphibole) are to be found,
- through weathering or mechanical demands, the asbestos fibers are detached from the rock or soil matrix and spread via the air and/or water ways into the environment,
- a significant release of asbestos fibers (so-called “critical” fibers according to WHO criteria) occurs in the environment, dependent on the climatic conditions and the activities carried out (reconnaissance, traffic, construction) on the MABE premises,
- the asbestos fibers in the rock are to be classified more as strongly bound; those in soil or fine-grained material more as weakly bound,
- without special work and emission safety measures for handling (traffic, reconnaissance, construction: dismantling, loading, transport and unloading) MABE soils or materials containing asbestos, significant additional damage to the environment is to be expected (rough estimate for the airway: 10 to 1,000 times the current load), and
- the air emission of asbestos fibers from the tailings and factory area has a significant influence on the mine.

Under present conditions of use, only the public road without asphalt east of the mine is seen as a "hot spot" in the mine area of MABE. Other than that, no connected areas can be restricted which prove a clearly heightened potential for asbestos release, compared with the mine.

The "wild burials" of pure raw asbestos (on the tailings and by the weather station), the tailings which are not covered with topsoil, as well as the factory with its operational buildings and the pilot plant pose as "hot spots" on the MABE premises, in relation to the mine.

A rough estimate of the hydrological and/or hydro-geological situation (current water level in the mine lake, evaluation of the data base on hand for an initial water balance for the mine lake, permeability of the bedrock etc.) is not available at this time.

1 Introduction

1.1 Task and objectives

The Asbestos Mine of Northern Greece (MABE) is situated in Zidani (Prefecture of Kozani/Western Macedonia). It is located in Northern Greece, 130 km away from the city of Thessalonica and 40 km from the city of Kozani. The Mine is less than 1000 m away from Aliakmonas River, the longest river in Greece, and close to the artificial lake of Polyfytou, through which the river flows (see attachment 1). MABE is a semi-privatised company controlled by the Greek State, which was until recently active in the production of asbestos. The unit was in operation starting in 1982 and ceased its activities in February 2000. Previously, the asbestos deposit had already been made available by underground excavation and processed in a pilot plant.

During the 20 years of its operation the company produced approximately 70 million tones of serpentine, out of which 1 million tones have been purified into asbestos (chrysotile type). The minerals poor in asbestos fibers have been disposed in the Disposed Waste Area. Asbestos fibers have contaminated the whole mining area as well as the surrounding environment to a large extent. The nearby artificial lake of Polyfytou, which supplies the City of Thessalonica (about 1,5 million habitants) with fresh water, has also been contaminated by asbestos fibers, which are emitted mostly from the Disposed Waste Area.

The environmental situation in the MABE area, particularly in the area of the mine, is to be investigated throughout the course of the EU project. The goal of the investigations of the environment (rock, soil, water, air) is to identify the areas contaminated with asbestos and obtain more exact information which will make possible an evaluation of the decontamination urgency. Further, the special requirements for work and emission safety for the planned decontamination work can be determined on the basis of the investigation results.

In the existing report (toxic register), the applied methods, the sampling methods and the necessary investigation methods have been documented. In addition, a systematic description and analysis of the investigation results will be carried out.

Von Lieberman Ltd, a cooperative partner of Sakosta Holding AG, with its sworn asbestos experts (Dipl.-Ing. Arndt von Lieberman, Dipl.-Geol. Andreas Rudnik etc.) is responsible for the systematic carrying out of the work in task 1. All field work took place accompanied and under supervision of a sworn asbestos expert. The sampling and the physical investigations of the samples taken were carried out exclusively by officially recognized posts and accredited laboratories, respectively.

1.2 Description of the location and land use

The Asbestos Mine of Northern Greece (MABE) is comprised of the productions facilities including the administrative building, the tailings and the former surface mine. Within the company property is a monastery originating from the 17th century (Moni Zidaniou). The company property has a total area of 4,135,175 m² and extends around 2.7 kilometers in the North-South and about 1.5 kilometers in the East-West direction. The elevation lies between NN + 660 m and NN + 380 m (see attachment 2).

The area of investigation is accessible by a public road which is asphalted from the North down to the monastery. The adjoining road to the south of the monastery entrance is not sealed, rather is exclusively gravel.

The Mining Area (851.000 m^2) in which the mineral exploitation took place applying the open pit method and the use of explosives that created levels 10 m high and 5 m wide. The mine, which is 180 m deep, is funnel-shaped. The constant mining for an 18-year period has exposed the water table and as a result a lake has been created at the bottom of the mine.

The Waste Disposal Area (532.000 m^2) where the height of the disposed material has reached 170 m with no shaped levels.

Administrative, Production and Utilities Buildings (25.000 m^2) with a total building surface of about 44.000 m^2. The production unit consists of a Crusher House, a Dryer Building, a Transfer House, 3 Wet Silos, 6 Dry Silos, the Mill Building, the Storage Building and the Conveyors System. The administration building has offices and laboratories, whilst the utilities building has a shop floor, dressing rooms, restaurant etc. Near the administration building there is a small village with 17 prefabricated houses that were used for the permanent or temporary residence of MABE employees.

Other flat surfaces (approx. 2.700.000 m^2), which also contain a 17th century monastery (Moni Zidaniou) 500 m away from the mine, which is still in use and attracts many visitors from all over the country.

The asbestos deposit was discovered in 1935. The American company Kennecout Cupper Corporation conducted the first systematic investigations (1955 – 1963). The reconnaissance was continued by Hellenic Asbestos (1965 – 1969), and later by MABE. A total of 150 borings up to a depth of maximum 190 m were drilled. The first mining of rock containing asbestos occurred from the late 50´s through the 70´s in an underground mine at an elevation of 550 mNN and 590 mNN (see attachment no ….) The processing occurred starting in 1957 in the pilot plant which is still there today. Since 1981, the deposit in the strip mine has been exploited and the newly erected industrial facility for asbestos has been converted. The operator of the mine and processing operation was M.A.B.E., an enterprise of the Greek Development Bank. In 1993, MABE passed the production and export of the asbestos over to the HMM (Hellenic Mineral Mining Company). The production was ceased in March 2000 due to European and Greek legislation [11, 13, 16, 22].

In 2002, a contract was closed between the MABE owners and the Prefecture of Kozani in which all rights for the facilities and the land were transferred to the Prefecture [22].

1.3 Mine and factory production figures

The industrial excavation of asbestos in the MABE area was initially begun in 1979 with the clearing off of ca. 2 mill. m³ of overlying strata. The exposed serpentine ore, obtained by processing, exhibited a technically realizable asbestos content of an average of 1.7 %. In total, ca. 60 mill. tons of serpentine rock were processed in the factory. This corresponds to ca. 25.8 mill. m³ of ore extracted from the mine. The amount of the accrued tailings was ca. 19 mill. m³, and includes material from the overlying sedimentary strata, limestone, and material from serpentine rock with a low content (as a rule less than 1%) of technically measurable asbestos. The volume of the strip mine is estimated to be ca. 45 mill. m³. The exact production figures (compare [11] and [13]) can be seen in the following table.

Table 1: Overview of the production figures from the mine and factory

Year	Excavation in the mine		Supply of or to the factory	End production of asbestos fibers
	Ore	Strata		
	[m³]	[m³]	[t]	[t]
1979	-	121.050	-	-
1980	16.562	1.982.652	-	-
1981	246.940	1.827.615	78.449	872
1982	661.618	2.023.037	1.407.765	16.958,78
1983	1.045.968	1.094.597	2.288.620	31.823,40
1984	1.506.372	565.295	3.553.654	45.969
1985	1.481.328	962.770	3.504.890	48.268
1986	1.570.800	810.090	3.831.550	51.240,40
1987	1.353.826	785.310	3.263.400	60.134,60
1988	1.679.132	866.626	4.158.040	71.095
1989	1.814.668	386.600	4.536.670	73.366
1990	1.714.895	303.055	4.449.428	65.993
1991	-	-	295.930	4.790
1992	668.332	307.465	2.180.680	28.592
1993	1.615.444	987.607	3.553.544	56.948
1994	1.858.813	579.860	3.510.500	55.502
1995	2.245.223	1.042.223	4.925.020	75.003
1996	2.216.599	572.313	4.940.030	81.213
1997	1.988.645	422.544	3.970.700	63.294
1998	895.484	-	2.249.880	35.068
1999	929.833	-	2.190.300	32.405
2000	250.000	-	566.460	7.856
Total	**25.760.484**	**19.073.960**	**59.455.510**	**906.391,18**

The mining of exploitable serpentine rock occurred starting at a depth of ca. 620 m NN to a maximum depth of the mine (ca. 475 mNN)

The remediation of the mine has already begun in the operational phase [8]. The mill tailings, mine waste and low grade ore are covered with top soil and planted with trees (e.g. spruce and acacia trees) and other vegetation known to grow well in this area, shortly after disposal.

All top soil excavated from the stripping operations of the ore-body is stock-piled near the dump sites, available for use whenever needed. In Summer 1997, this stock was nearly 200.000 m^3 [8].

According to information from HMM [8], a total of 253,000 m^2 surface area was covered with top soil (331,673 m^3) up until 1997; of this, 242,000 m^2 was planted with 67,000 trees. The average thickness of the soil layer thus amounts to ca. 0.75 m.

1.4 Brief description of the EU LIFE Project

The Prefecture of Kozani has designed a plan to cope with the asbestos problem at the MABE venue, which includes [1]:

a) the construction of a fence that will limit the access to the mine and the surrounding area,
b) the capping of the disposed waste areas with a non-contaminated layer of soil and the planting of toxin-resistant trees,
c) the decontamination of the near-by traditional 17th century monastery, the administration building and asbestos production units,
d) the restoration of the tailings and
e) mine rehabilitation.

These activities will be implemented according to their decontamination urgency and the availability of financial resources.

For activities c) and d), the Prefecture of Kozani has submitted a funding proposal to the Structural Funds of the Ministry of the Environment. The EU LIFE project 03/ENV/GR/00214: “Utilization of MABE asbestos mine as a disposal site for asbestos wastes“ has the goal of developing an innovative solution for the mine rehabilitation (point e). The scope of work of the two proposals mentioned above (LIFE and Structural Funds) is entirely distinct. The limits of the two projects can be seen in the site plan in attachment 2.

This present project proposes the first full-scale rehabilitation of an asbestos mine in Greece in order to accept asbestos wastes of the surrounding area, and the assessment of the mine capacity to be used as a local or national disposal site for asbestos wastes. Quantities of asbestos wastes shall be deposited in the mine. For that reason, all required measurements and analyses will be conducted and all necessary studies will be prepared. The restored area which is to accept the pilot asbestos wastes will be about 3.000 to 4.000 m^2. For the rest of the mine area the project will identify and clean the hot spots of asbestos, so that the mine will not further contaminate the wider area.

1.5 Documents

For the drafting of the report on hand, the following documents were available to us:

[1]: Utilization of MABE asbestos mine as a disposal site for asbestos wastes, consolidated version of requested amendments, December 2004
[2]: Investigation of the tailings. EPPER Project: Rehabilitation and remediation of the polluted area with asbestos at the Asbestos Mines in Northern Greece (MABE) in Zidani, Kozani, von Lieberman Ltd, 02.12.2005
[3]: Initial orienting appraisal of the asbestos mine of Kozani (Western Makedonia, Greece), von Lieberman Ltd, 02.08.2002
[4]: Documentation of occupational and emission safety, expansion of the Altenwerder harbor, BV re-naturalization of the Korbmachersand, von Lieberman GmbH et al, 16.12.2004, unpublished.
[5]: Documentation of the monthly asbestos fiber measurements of the air in the factory, mine, and area surrounding MABE from the years 1986 to 1994. ANKO Research Nr. 25.
[6]: Documentation of asbestos fiber measurements of the air in towns neighboring MABE from the years 1993 to 1997. ANKO Research Nr. 26.
[7]: Analysis of asbestos investigations of the air in MABE from 1989 to 1994. ANKO Research Nr. 27.
[8]: Safety in the use of asbestos - Code of practice. Hellenic Mineral Mining Company SA, 1997. ANKO Research Nr. 15.
[9]: Letter from Zidanio of MABE to the Supervisory Bureau of the mine, Prefecture of Kozani from 02.03.1988. ANKO Research Nr. 8.
[10]: Letter from MABE to the responsible authorities (supervisional bureau) from 20 June 1981. Results of water investigations for asbestos of 17 samples from springs and the river Akiakmon. ANKO Research Nr. 7.
[11]: Technical report. Asbestos mines of North Greece (MABE). Anstasios Kladis (mining engineer), Michalis Michalakopoulos (forester). Athens. October 2000.
[12]: Description of the sampling method for asbestos in the air in the work area with membrane filter. ILO 1973. ANKO Research Nr. 32.
[13]: MABE. Information for Mr Kladi and others. Overview of production in the mine and factory of MABE from the year 1997. ANKO Research Nr. 11.
[14]: MABE. Letter to the responsible bureau of the Prefecture from 23.06.1986. Analyses of five water samples for the presence of asbestos. Sheridan research community. ANKO-Recherche Nr. 7.
[15] Occurrence, detection and origin of asbestos fibres in the waters of the Aliakmon river system. Laboratory on monitoring environmental pollution, Institute for Chemistry, University of Thessaloniki, and the area Mineralogy/Petrology/Sedimentology, Institute for Geology, University of Thessaloniki. Published in Proceedings of the 1st Conference of the Technological Educational Institution (T.E.I.) with the theme “Mineral Wealth and Environment in Macedonia. February 2000.
[16]: Publication of the Greek Department of Labour from 2003, Amiantos
[17]: Power point presentation of the von Lieberman GmbH for the first CRT-meeting in Kozani, 16th June 2005
[18]: Power point presentation of the von Lieberman GmbH for the second CRT-meeting in Kozani, 25th October 2005.
[19]: Macro- and microscopic observations of rocks and serpentine (asbestos) minerals of the Zidani / Kozani quarry. Preliminary report. University of Hamburg, Mineralogical-Petrographical Institute, September 2005.
[20]: Water supply and material transport in the Aliakmonas area (Northwestern Greece). Eleni Zagana. Research results from the areas hydrology and environment. Würzburg 2001.
[21]: Investigation to the development of the MABE property. ANKO, March 2002.
[22] Environmental remediation and possibilities to use the MABE facilities. E.M.P.

1.6 Results of former investigations

The informational research conducted by von Lieberman Ltd and ANKO (42 documents corresponding to checklists from von Lieberman Ltd) have revealed that since 1981, measurements for asbestos fibers in the air and in part in the water on the MABE property and in the region have been conducted (see attachment 7). In addition, during the course of the first orienting survey of the asbestos mine by von Lieberman Ltd in 2002 [3], material and adhesive tape samples were taken and tested for asbestos. In the following sections, the results of these measurements are summarized.

1.6.1 Air measurements for asbestos

The operating company of the asbestos mine and the facilities, the HELLENIC MINERAL MINING COMPANY S A (HMM) and MABE, monitored for the asbestos fiber content in the air at regular intervals in the close surroundings of the mine. It is indicated in a source [8] that the requirements of the European legislation and the ILO Code of Practice were adhered to for the measurements. Thus, the reference method described in the EU Guideline 83/477/EWG, appendix 1 (light optical microscopy method) or an equivalent method (see attachment 9) was presumably used for the monitoring.

The investigations of the outdoor air for asbestos [5, 6, 7, 8] from the years 1982 to 1997 in the close surroundings of MABE (Microvolta, Tranovolta, Rimnio, Eani and Frourio) show asbestos concentration values in the air the size order of 0.018 to 0.076 fibers/cm³. In the air measurements of the near-by cities (Neraida, Servia, Kozani and Lefkopigi) from 1988 to 1990, asbestos contents between 0.025 to 0.052 fibers/cm³ were detected. Thus, the population residing in the surrounding area of the asbestos mine during the operation of MABE was exposed to a similarly high asbestos load as those in the farther-lying cities and towns.

Table 2 Results of the monitoring of the air, vicinity [5, 6 and 7]

Date	Microvalto	Tranovalto	Rimnio	Eani	Frourio	Neraida	Servia	Kozani	Prefecture	Lefkopigi	Factory property
	fibers/cm³										
4/1982	0,29	-	-	-	-	-	-	-	-	-	-
8/1983	0,060	-	-	-	-	-	-	-	-	-	-
2/1985	0,030	-	-	-	-	-	-	-	-	-	-
7/1985	0,060	-	-	-	-	-	-	-	-	-	-
7/1986	0,04	-	-	-	-	-	-	-	-	-	-
7/1987	0,026	0,019	0,02	0,021	0,018	-	-	-	-	-	-
2/1988	-	-	-	-	-	0,035	0,034	0,025	-	0,025	-
1989	0,050*	-	-	-	-	0,039	0,047	0,052	-	0,042	-
6/1990	0,064	0,065	-	0,053	0,037	0,030	0,034	0,036	0,073	0,040	-
8/1990	02.8.: 0,056 25.8.: 0,076 31.8.: 0,040	3.8.: 0,068 31.8.: 0,040 31.8.: 0,043	-	-	-	-	-	-	-	-	-
5/1993	-	-	-	-	-	-	-	-	-	-	0,19
6/1993	07.6.: 0,025 07.6.: 0,036	07.6.: 0,030 07.6.:0,026	0,021	-	-	-	-	-	-	-	-
9/1993	0,026	0,030	-	-	-	-	-	-	-	-	0,18
4/1994	-	0,041	-	-	-	-	-	-	-	-	-
5/1994	0,022	0,023	0,021	-	-	-	-	-	-	-	-
9/1994	0,026	0,030	-	-	-	-	-	-	-	-	-
4/1995	0,032	-	0,030	-	-	-	-	-	-	-	-
8/1995	0,051	0,061	-	-	-	-	-	-	-	-	-
6/1996	0,066	0,071	0,061	-	-	-	-	-	-	-	-
8/1996	0,061	0,061	0,051	-	-	-	-	-	-	-	-
11/1996	-	-	-	-	-	-	-	-	-	-	0,086
6/1997	0,026	0,036	0,031	-	-	-	-	-	-	-	-
9/1997	0,040	0,046	-	-	-	-	-	-	-	-	-

* Measurement results from 02/1990

Table 3: Results from the monitoring of the air, factory premises (as a rule, weighted average results of measurements) [8]

Date	Mine	Crusher	Dryer	Mill	Quality control labora-tory	Fiber storage	work-shop	Garage	Admini-stration	Scale	Gate	Mine Camp
	Fibers/cm³											
8/1990	-	-	-	-	-	-	-	-	-	0,11 0,20	0,12 0,33	-
1993	5/93: 0,19 9/93: 0,18	0,25	0,38	1,04	0,75	0,37	0,18	0,18	0,09	-	-	0,1
1994	0,27	0,20	0,27	0,85	0,32	0,25	0,14	0,13	0,10	-	-	0,1
1995	0,27	0,15	0,16	0,53	0,56	0,13	0,13	0,13	0,08	-	-	-
1996	0,086 0,20	0,14	0,12	0,47	0,59	0,15	0,12	0,13	0,08	-	-	0,09
1997	0,14	0,11	0,10	0,44	0,58	0,14	0,12	0,13	0,08	-	-	0,09

On the MABE factory premises, asbestos measurements in the air were carried out in the outside region (on the Scale, Gate and undifferentiated) in 1990 and from 1993 to 1996 [8]. The asbestos content of the air was on average between 0.086 to 0.33 fibers/ cm³. Within the buildings, the monitoring showed average asbestos concentrations of between 0.08 to 1.04 fibers/ cm³ in the air. As a rule, the lowest values were determined to be in the administrative building (0.10), the workshop (0.18) and in the garage (0.18). The highest average asbestos loading in the air was detected in the area of the mill (1.04) and the quality control laboratory (0.75).

In the mine camp on the MABE premises, ca. 0.09 to 0.1 fibers/ cm³ were measured in the air in the years 1993 to 1997.

In the mine, the air measurements from 1993 to 1997 produced middle asbestos contents the extent of between 0.086 to 0.27 fibers/ cm³.

Generally, the depiction of the air measurements in the buildings [8] listed above are weighted averages from selected areas

In contrast to these results, the summarizing analysis from 1989 to 1994 [7] shows clearly higher asbestos contents in the air in the MABE work areas. The statistical analysis is based on ca. 1,500 asbestos measurements (1989: 419, 1990: 382, 1992: 275, 1993: 209 and 1994: 209) and showed that more than 30 % of all measurement values lay above 1.0 fibers/ cm³.

In the work areas administration, general work, fiber storage and mine, the asbestos exposure was primarily categorized as below 0.5 fibers/ cm³. The investigated areas of production, quality control, and on maintenance of the factory exhibited a workplace concentration in the air which, in ca. 2/3 of the measurements, lay between 1.0 and 2.0 asbestos fibers/ cm³.

In 1996, according to a statistical analysis [7], an asbestos content of 1.0 fibers/ cm³ was surpassed in ca. 29 % of the total 283 workplace measurements. Consequently, it can be inferred that the values in Table 2 do not reflect the real percentages in that magnitude. Merely a relation between the asbestos loading of the individual work areas is to be derived from this.

1.6.2 Investigation of the water

The research of von Lieberman Ltd and ANKO has yielded the results of three different investigation campaigns for asbestos in the area of MABE and the Aliakmon (see attachment 9). This is mainly asbestos investigations from 1981 using scanning electron microscopy (SEM) and analysis of five water samples for the presence of asbestos by Sheridian Research Community (Canadian company) from 1985, as well as investigations of laboratory on monitoring environmental pollution, Institute for Chemistry and Mineralogy/Petrology/Sedimentology, Institute for Geology, University of Thessaloniki from the years 1997 to 2000 with transmission electron microscope (TEM).

1. Results from the water investigations using scanning electron microscopy (SEM) from 1981:

core from MABE:	0,03 * 10^6 fibres/litre
Stream at the source of the old disposal point of MABE:	8,00 * 10^6 fibres/litre
Rymnio bridge:	3,10 * 10^6 fibres/litre
Servia bridge:	2,76 * 10^6 fibres/litre
Spring 245 m SW of the monastery fence:	**35,91 *10^6 fibres/litre**

In the investigation results, only the „critical“ fibers in accordance to WHO (greater than 5 µm fiber length) were accounted for. During sample preparation, a mesh width of 0.8 µm was used for filtration. A fraction of the “critical” fibers which had a fiber width smaller than 0.8 µm were not analytically measured.

2. Results from the water analyses from Sheridan Research Community from 1985 (TEM):

In the Sheridan Research Community investigation report, it is not documented whether exclusively asbestos fibers with a particular fiber geometry (WHO etc.) were counted. For this reason it is to be assumed that **all fibers** were accounted for which could be separated in the filter with a mesh width of 0.1 µm. The results are summarized in the following Table 4.

Table 4: Summary of results of analysis for asbestos fibres, Sheridan Research Community

sample	fibre concentration 10^6 fibres/litre		fibre type
	mean*	95% confidence interval	
water sample A (Aliakmon, W MABE)	3,100	2,300 – 3,900	**Chrysotile**
	ND	0 – 11.5	Amphibole
water sample B (Aliakmon, NW MABE)	2,400	1,800 – 3,000	**Chrysotile**
	NSS	0 – 14.2	Amphibole
water sample C (Aliakmon, NE MABE)	2,300	1,600 – 2,900	**Chrysotile**
	NSS	0 – 14.7	Amphibole
water sample D (Aliakmon, NE Rymnio)	3,700	2,400 – 5,100	**Chrysotile**
	15.5	8 – 27.0	**Amphibole**
water sample K (MABE streams)	ND	0 – 2.36	Chrysotile
	NSS	0 – 3.56	Amphibole

* No mean value is reported if fewer than 5 fibres were detected in the portion of sample examined
ND no countable fibres detected
NSS Not statistically significant

3. Results of the water analyses from the Institute for Chemistry, University of Thessaloniki from 1997 to 2000 (TEM):

The asbestos fibre content of **short (< 5 µm) and long (> 5 µm) fibres** in water was determined in accordance with the publication [15] by means of TEM. Sampling occurred within a three-year time period during various seasons. Fibre contents were given as a sum. In publications, the component of long fibres is described as amounting to 10 to 20% on average, and that no fluctuations in asbestos content throughout the various seasons were to be observed. Only measurement results from water samples taken from the middle of the river show elevated values near the river banks. The following results from the investigation were described:

- Aliakmon, upstream flow north of the embankment dam marginal to construction:
  Total fraction: $0.9 * 10^6$ fibres/litre
- Downstream of the tailings, north of MABE:
  Total fraction: max. $3.4 * 10^6$ fibres/litre
- Polifito, Rymnia bridge :
  Total fraction : $1.5 * 10^6$ fibres/litre

In the documentation it is inferred from the results given that the following sources are responsible for asbestos fiber loading in the water of the Aliakmon / Polifitou:

- The main fraction is determined through the influence of the mine,
- a fraction through the serpentine rock which is present in the region,
- a small fraction through water conduits containing asbestos and other anthropogenic influences.

1.6.3 Investigation of material and adhesive tape samples

Throughout the course of the initial orienting investigation of the asbestos mine by von Lieberman Ltd in 2002 [3], selected material and dust swab samples were taken from the area of MABE and analysed for asbestos.

The goal of the investigation was to render proof that there are respirable fiber types of chrysotile asbestos fibers, particularly in the secondary contaminated dusts in the inner and outer areas of the factory premises. The critical fiber geometry of WHO was to be proven. Further, the presence of secondary contaminated dusts also in the area of the monastery buildings was to be proved by means of adhesive tape and dust samples (P1). The sample P2 poses as a mid-quality mixed sample of packaged goods which, at the time of the sampling, was made available for sale in large amounts externally. Sample P3 originates from mud cores which were produced during the exploratory borings and the production of boreholes for the placement of explosives. The secondary contaminated dusts in the mill building were collected with sample P4. The dust mixture sample P5 is from the area of the steel construction next to the end of conveyer belt in the outside area. Material sample P6 comes from the area of the mine and represents various asbestos rocks.

All mixed samples P1 through P6 contained significant amounts of respirable chrysotile asbestos fibers. The also went for the serpentinite rock sample P6. In all dusts, the count of free fibers (WHO fibers) was significant.

1.7 Results of the first preliminary hazard assessment

The results of the old investigations were pulled up for the creation of an initial preliminary hazard assessment [17]. This serves as a basis for the planning of the technical investigations in the asbestos mine and the bordering surroundings in the EU LIFE Project.

The endangerment of the workers and environment through asbestos was assessed by von Lieberman Ltd in their first presentation at the CRT meeting on June 16th 2005, as follows [17]:

1. During the mining operation a **significant release of asbestos fibers in the air** occurs
    a. during mining (mine),
    b. during transport (construction roads, conveyor belts),
    c. in the production facilities (processing, packing),
    d. in the waste water treatment (sludge basin) and
    e. at the waste disposal (filter material, tailings).

2. The asbestos fibers have been **deposited** in the immediate **surroundings** and until present have been transported according to predominant climatic conditions (wind direction, wind strength, humidity, etc.)

3. Presently, an **elevated release of asbestos fibers into the air** can be anticipated from the area of the production facilities, the acclivities and the basins, depending on the weather conditions.

    a. Secondary dusts in the buildings in asbestos processing and packing.
    b. Release of asbestos fibers from particularly fine-grained tailings and former filter material.
    c. High wind exposure on the exposed surfaces and wind-exposed slopes.
    d. Increased weathering rates and drying-out for areas exposed to sun.

4. The **potential for a release** of asbestos fibers into the air from the mine area is, in contrast, estimated to be **low.**
    a. Primarily coarse-grained detrital material or rock.
    b. Binding of asbestos fibers into the rock matrix.
    c. Wind exposure and sun exposure (creation of shade) is low due to the basin form.

5. A **moderate potential for release** lies in the upper soils contaminated with secondary dusts, which in large part have a natural cover.

    a. Asbestos fibers are predominantly bound into the soil matrix by the prevailing ground moisture and roots.
    b. The vegetation and the humus minimizes the effects of wind and weather (drying-out, weathering).

6. The **unpaved roads** and their edges likely display heightened free asbestos fiber contents.

7. Below and bordering the **conveyor belts,** free asbestos fibers are to be accounted for in abundance.

8. In areas which served to **leach** the precipitational water (mine, surface anchorage), a high content of free asbestos fibers is to be reckoned with.

9. Areas which served to **treat production water** (sludge basin) can be contaminated with asbestos fibers.
10. In the water of the Aliakmon, an asbestos fiber content of ca. 2 to 3 * 10^6 fibers/liter was found in 1981.

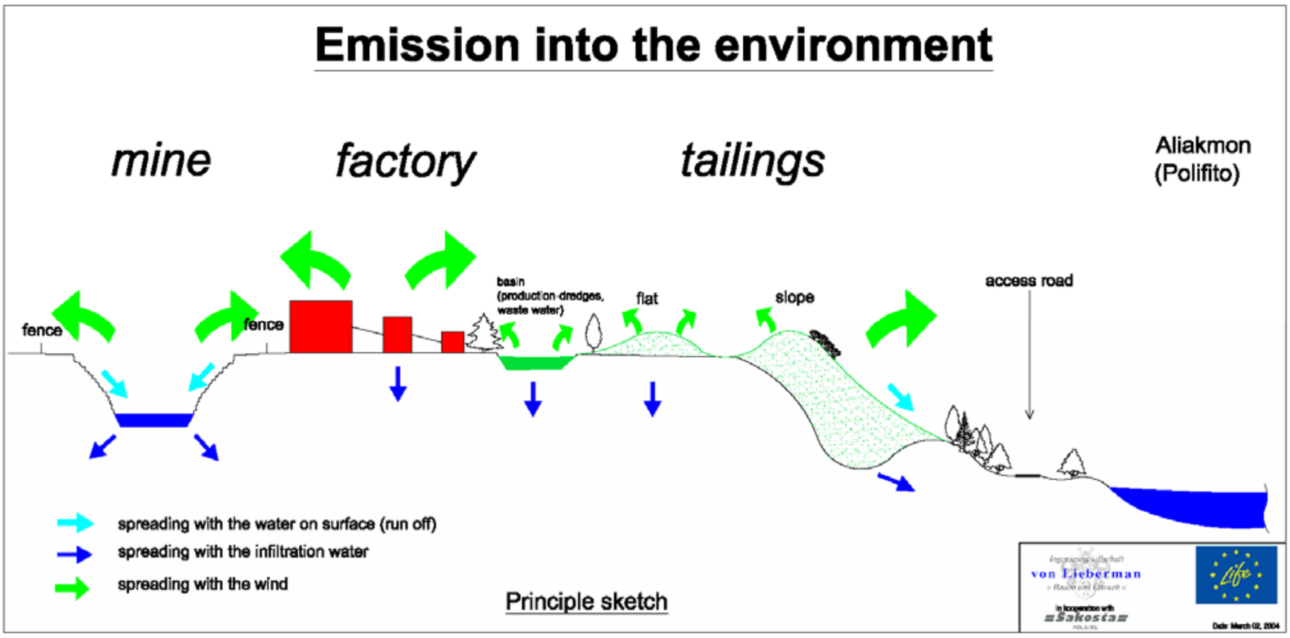
    Water investigations in 1985 resulted in asbestos contents of 2,300 to 3,700 * 10^6 fibers/liter.

    The **sediments of the surface water** in and around the surrounding area of the asbestos mine (mine, springs, Politifou etc.) have likely been accumulating asbestos fibers over the entire time span of operation. Through dry spells/drying out of the partially fine-grained sediments, a **significant release of asbestos fibers** can come about.

In the considerations mentioned above, solely the hazardous material „asbestos" is addressed. Other hazardous materials are conceivable due to the mineral composition of the rock outcome and the production operation.

The potential paths for emission of asbestos fibers into the environment are summarily depicted in the following diagram [17].

Figure 1: Principle sketch of emission into the environment.



1.8 Preliminary planning for technical reconnaissance

The evaluation of the documents and maps mentioned above and the environmental investigations already carried out by a TRGS-knowledgeable engineer or geologist and a sworn asbestos expert served as the basis for the reconnaissance program regarding asbestos. The emphasis of the investigations lay in the immediate area of the mine (see attachment 2). In addition, orienting investigations in the surroundings (tailings, factory, runoff, vegetation, Aliakmon/Polifito) were carried out.

The technical exploration of the mine and the immediate surroundings were aimed at identifying the areas contaminated with asbestos in the rock, soil, water and air, and to obtain more exact information on them which could make an assessment of the decontamination urgency possible. Furthermore, on the basis of the investigation results, the special requirements for work and emission safety for the planned decontamination work should be established.

In addition, the needs for the work and emission safety were documented in a work plan prior to the planned work. This was agreed upon with the responsible authorities (Prefecture of Kozani) and the work was properly registered before its commencement. The work plan describes the special asbestos-specific requirements for the reconnaissance work. Included in this are, for example, the erection of a provisional site facility (changing, washing and shower rooms, sluice technology, waste collection, particularly for protective clothing etc.), the transport of the employees in a vehicle furbished for use in the area contaminated with asbestos, and the wearing of personal safety gear (disposable suits, respirators).

The reconnaissance took place in various seasons (summer, autumn, winter) in order to judge seasonal fluxes in asbestos content, particularly in the water and air.

In the following, the individual investigation areas are summarized.

1.8.1 Air investigations

The determination of asbestos fibers in the air followed in conjunction with the task by means of three different methods. In addition, adhesive tape samples from leaf, rock and building surfaces were taken and tested for asbestos (indirect method).

The direct investigation methods are personal measurements, stationary measurements without resuspension and stationary measurements with resuspension (simulation of use).

- The stationary measurements without resuspension reflect the wind and weather-influenced asbestos fiber contents in the air. The measurement locations were placed so that the influence of the factory facilities, the tailings, the monastery and the mine can be eliminated. In addition, the results should make an estimated of the geogenic background loading in the investigation area possible.
- Personnel measurements reflect the activity-related asbestos fiber contents in the potenial breathing air of the employees during the exploratory activity. The results serve to test and establish the activity-related work safety for the reconnaissance work in the mine.

- The stationary air measurement with the resuspension of near-surface soil material simulates the potential release of asbestos fibers in the construction area. From these results, the scope of the measures can be deduced which are necessary out of work and emission safety reasons for the safe handling of materials containing asbestos

In the investigation time period, partly continual climate data (wind direction and speed, humidity, air pressure and temperature) were recorded for the interpretation of the measurement results.

1.8.2 Rock investigations

The rock investigations should give an overview of the type and spread of the rock containing asbestos in the mine. It is to be clarified, for example, whether aside from chrysotile other asbestos minerals (amphibole asbestos) also occur, how the asbestos mineral is spread throughout the rock matrix, which structural characteristics and relationships are present in the rock and which processes (mechanical stresses, weathering, mineral alteration etc.) on/in the rock can potentially lead to a release of respirable fibers.

The results serve as the basis for a hazard assessment of wind and weather-related releases and the potential construction-related release of asbestos fibers.

1.8.3 Soil and mud investigations

The laboratory analysis of soil and sludge samples is necessary to determine:

- whether soil at the site has been contaminated by the leachate or out-wash through precipitation as well as spreading by the wind and if, so, to what extent,
- how far the released product has spread in the soil and
- the depth to which the released product has spread in the soil.

1.8.4 Water investigations

The investigation regarding asbestos of representative water samples from up- and downstream of the Aliakmon/Polifitou as well as from the surface water of MABE serves to judge the influence of the mine and the processing plant, including the tailings. In order to determine a seasonal influence, the investigations are to be carried out in the runoff-poor seasons (summer, fall and winter) as well as during the runoff-rich time (spring).

Evidence for the potential asbestos contamination of the surface water is likewise to be deduced from the results of the investigations (see previous chapter) of representative mud samples from the receiving water (mine lake, drainage, Aliakmon).

1.8.5 Meteorological investigations

The evaluation of the results from the air investigations regarding asbestos in the outer area require additional meteorological investigations (temperature, humidity, wind speed and direction etc.). Knowledge of the regional and local climate data (see attachment 10) make it possible to deduce, with some limits, potential sources of asbestos fibers from the asbestos contents determined in the air, and to estimate the degree of release at the time of the measurement in relation to the time periods not covered by measurements. In addition, the quality of the measurement results is dependent on the local weather conditions at the time of sampling.

2 Field work, sampling technology

2.1 Extent of the field work (soil, mud and rock)

The work to obtain samples necessary for the task was carried out in three investigation phases in July (23.7. to 26.7.2005), in September (13.09. and 14.09.2005) and in December (15.11. and 11.12.2005) in the investigation area under the expert supervision of a sworn asbestos expert and geologist from von Lieberman Ltd.

In the first investigation phase, a total of 15 exploratory borings (EB 1 to EB 15) were drilled to a maximum depth of 2 m below ULG (upper limit of the ground) in the grown or filled-out soil horizons, and the extracted core thoroughly sampled for asbestos for the orienting investigation. In the area of the strip mine, a total of four hand test pit were installed up to a depth of ca. 0.30 m below ULG, and samples were taken from the soil material. In the area of the mine, a probe could not be taken due to the bedrock close to the surface.

From the area of occasional water discharge and from the sediment from the Aliakmon, a total of 8 mud/soil samples were taken from the banks with a hand shovel. An additional 6 mud/soil samples were taken from the mine land (edge of the mine lake and in the area of the conveyor belts) and from the tailings.

The boring points were statistically distributed throughout the entire investigation area so that there was no definable area which could be categorized as potentially not asbestos-suspicious due to the old documents.

The conducting of informational work served to determine the near-surface soil types and soil construction as well as the sampling and concluding analytic for asbestos.

The boring points and hand-crafted test pit were closed again after completion of the work and furnished with a wooden marking on which the number of the sampling point is noted. The site of the sampling points for reconnaissance can be seen in attachment 2.

In the following table, data (identification, situation, starting point, depth etc.) of the exploratory borings and hand-crafted test pit carried out are listed:

Table 5: Overview of the reconnaissance work carried out (exploratory boring)

Bore-point identification	Situation		ULG*	Depth of sampling	Comments
	Y	X	[m]	[m u. ULG]	
Investigation in the area of the mine					
EB 1	4439366	315660	610	0,90	Aborted due to elevated bore resistance (lime-stone)
EB 2	4439783	315916	588	1,00	Aborted due to elevated bore resistance (large rocks)
EB 3	4439688	315840	596	0,75	Aborted due to elevated bore resistance (large rocks)
EB 4	4439412	315808	609	0,60	Aborted due to elevated bore resistance (limestone)
EB 5	4439058	315801	631,5	1,00	Aborted due to elevated bore resistance (large rocks)
EB 6	4438711	316078	695,5	0,70	Aborted due to elevated bore resistance (limestone?)
EB 7	4438595	315832	658,5	2,00	
EB 8	4438642	316316	662	0,80	Aborted due to elevated bore resistance (large rocks)
EB 9	4438665	316623	623,5	2,00	
EB 10	4438604	316731	640	0,95	Aborted due to elevated bore resistance (large rocks)
EB 11	4438971	316857	598	0,80	Aborted due to elevated bore resistance (limestone)
EB 12	4439433	316902	586	0,90	Aborted due to elevated bore resistance (large rocks)
EB 13	4439584	316711	587	1,00	Aborted due to elevated bore resistance (large rocks)
EB 14	4439477	316459	570,5	0,50	Aborted due to elevated bore resistance (large rocks)
EB15	4439692	316235	587,5	2,00	
EB 16	4439401	315986	565	0,30	Hand-crafted test pit
EB 17	4439077	316213	510,5	0,30	Hand-crafted test pit
EB 18	4439000	316645	536,5	0,30	Hand-crafted test pit
EB 19	4439316	316578	560	0,30	Hand-crafted test pit

Table continued on the following page

Continuation of table 5:

Bore-point identification	Situation		ULG*	Depth of sampling	Comments
	Y	X	[m NN]	[m u. ULG]	
Investigation of the tailings					
EB 20	4439655	316860	586	0,30	Hand-crafted test pit
EB 21	4439720	316770	587	0,30	Hand-crafted test pit
EB 22 (formerly SS13)	4440265	316803	566	0,30	Hand-crafted test pit

EB exploratory boring
u. ULG: under upper limit of the ground

The borings EB 1 - EB 6, EB 8 and EB 10 – EB 14 could not be carried out down to the planned depth due to obstacles (in situ rock or large boulders).

2.2 Results of the field work carried out

2.2.1 Geological structure of the investigation area

The following section will go into the regional and local geology of the investigation area. Subsequently, the results of the soil investigations will be summarized.

Regional and local geology

The mountains in the region around Kozani can be attributed to the Alpide orogeny which took place in the Miocene. The Alpide orogeny was the result of the collision between the African and European continents. The asbestos mine lies in an area which can be assigned to the Rhodope Massive. This is a part of the Balkan mountain range, which is interpreted as a continuation of the South Carpathian Mountains.

The lithology of the region Greek Macedonia is accordingly characterized. Crystalline material from para- and orthogneiss, as well as anatextites crop up as base rock at the bottom, and show a high grade of metamorphism. Above these, gneisses, amphibolite and marbles are found. The highly metamorphosed gneiss and amphibolite deposits of the region suggest a great sinking depth of the outcome rock and with that high pressure and temperature. The temporal origin of the rock lies in the Palaeozoic. Individual deposits of ophiolites, plutonic and other volcanic rock appear as well, for example on Vourinos Mountain, lying about 10 km to the West of the investigation area.

In the investigation area, gneiss and metamorphic schist appear on the horizontal. Above this is an extensive serpentinite complex which contains asbestos. The asbestos occurs here as so-called chrysotile (fiber serpentine), a form which displays a high grade of regularity in the alignment of the mineral fibers. The rock material is very fine-grained in both cases, and occurs as a powerful layer complex. Then, sedimentary overlying strata composed of Jurassic carbonate sandstone banks follow, above which Quaternary sediments have been deposited in morphologically lower areas. In contrast to the base rock, neither the carbonate sandstone banks nor the Quaternary sediments display metamorphic modification.

The area is located in a wide tectonically active zone. Multiple parallel-running faults and fractures with easterly directions occur. In the geological profile (see attachment 3.2), the thrust fault character of the faults is evident. Through tectonic movement, the serpentinite complex was lifted. Serpentinite is a rock which is produced as the product of the reaction between plutonic rock olivine and water. Olivine as outcome material points to originating at a great depth (upper mantle). At some spots in the serpentinite complex, inclusions of magnetite several meters in diameter containing chromate occur. At other locations, opaque grains, likely made of olivine as relict of the transformation from olivine to serpentine are present.

The horizontal gneiss and schist layers were pushed above the serpentinite complex. This is interpreted as a secondary system of faults and fractures within the primary system, also originating from the tectonic activity of the region.

<u>Results of the soil investigations</u>

The soil classification carried out on the soil material from the seven hand-dug holes and 15 cores (EB) indicates, based on the top ground level down to the end depth of the core of maximum 2.0 m below GOK, the following general picture of the geological structure of the underground:

in-fill:	primarily sandy, in part pebbly **in-fill or detritus, with significant fiber component in part.** (EB2, EB3, EB8 to EB22), exposed up to a depth of about 1 m below GOK.
grown soil:	**in situ, in part silty and lightly humus sands**, bored in the probes EB1, EB4, EB5, EB6, EB7, EB9, EB11 and EB15. These sands were dug up on the edge of the property, predominantly near the surface and below a strong in-fill up to ca. 1 m. In one probe (EP4), in situ limestone from a depth of 0.3 m below GOK was met.

The stratigraphic sequence taken from the individual cores by our geologists can been seen in the bore profiles in attachment 6.

On the basis of the results available from the cores, an in part significant fraction of asbestos fibers in the in-fill is given in the area of the investigation.

The large part of the samples conducted were discontinued due to bore hindrances (in situ rock or larger boulders).

2.2.2 Water levels and hydro-geological relationships

In the region, karstification occurs in the carbonate sandstone as a result of washing out. These appear in the rock as caves and a system of depressions and holes on the surface. In the caves, a build-up of natural groundwater reservoirs can come through time. In southern Vermio, a part of the region, a connected aquifer is well-known, though not in the investigation area. In the northern part of the mine, karst springs are present which, from current knowledge, display great run-off/drainage potential. The karstification in the form of caves entails a higher rate of water seepage, and should it appear on the surface, raises the rate of runoff of the water. In both cases, the erosive potential of the water increases. Data on the discharge amount and information on the types of karstification is, however, not on hand to von Lieberman Ltd.

Bordering, a well, at about 150 m depth, was erected to supply the monastery with water. Currently, we do not have any data on the productivity and type of the aquiferous layer. According to investigations by Soulios [from: 20], the permeability of ophiolithic rock (here: serpentinite complex and the gneiss-schist complex) lies between 10^{-6} m/s to 10^{-8} m/s. A aquiclude effect is possible depending on the formation of faults and fissures. Resulting from the tectonic activity it can be inferred that lea can be formed underground through existing fissures.

In the deepest area of the asbestos mine, water is present in the form of a lake on the surface. At the time of the investigations, the lake displayed a water level of about 494.5 m NN, which corresponds to a maximum water depth of about 17 m and an average water depth of about 10 m above the floor.

No sample was bored into the groundwater. The extracted material was generally earth-moist to dry. Coarse-grained in-fill soils proved to be generally less moist than fine-grained soils, particularly the grown upper soil.

Throughout the course of the investigations by von Lieberman Ltd, low permeable silty sediment was dug up exclusively in one core (EB 9) on the edge of the mine in the grown soil layer. In the remaining unearthed in-fill sediments and grown soils, sand and pebbles were come across with varying silt components up to the end depth.

2.2.3 Sensory characteristics of the soil samples

The following description of the sensory characteristics of the soil samples (see table 4) is limited, due to the question/problem, fundamentally to indication of the mineral composition of the horizons unearthed and the recognizable asbestos fiber component.

Table 4: Overview of the visual findings (component of macroscopically recognizable fibers, rock)

Core label	Site	Depth, Thickness [mNN / m]		Fiber component	Other evidence of asbestos
		ULG	Thickness		
EB 1	Westerly edge region	610	> 0,90	n. d.	grown Sand
EB 2	Construction road, NW of the mine	588	0,50	**high**	In-fill
			> 0,50	n. d.	Strongly weathered **Serpentine**
EB 3	Tailings, NW of the mine	596	> 0,75	**high**	In-fill
EB 4	west. edge of the mine	609	0,35	n. d.	grown Sand
			> 0,60	n. d.	In situ limestone
EB 5	west. edge of the mine	631,5	> 1,00	n. d.	grown Sand
EB 6	southwest. edge of the mine	695,5	> 0,70	n. d.	grown Feinsand
EB 7	Southwest of the mine, entrance to the marble quarries	658,5	> 2,00	n. d.	grown Sand
EB 8	Southern edge of the mine	662	> 0,80	**high**	In-fill
EB 9	Southern edge of the mine	623,5	0,15	n. d.	In-fill
			1,10	**medium**	In-fill
			> 1,10	n. d.	grown Schluff
EB 10	Public road, South of mine	640	0,35	n. d.	In-fill
			> 0,60	n. d.	**Serpentine** in the in-fill
EB 11	Southeastern edge of mine	598	0,40	**high**	In-fill
			> 0,40	n. d.	grown Sand
EB 12	Public road, East of mine	586	> 0,90	**high**	In-fill
EB 13	Public road, East of mine	587	0,30	***minimal***	In-fill
			>0,70	**high**	In-fill
EB 14	Eastern entrance to mine	570,5	0,50	n. d.	In-fill
EB 15	Vantage point with guard rail	587,5	1,00	**high**	In-fill
			> 1,00	n. d.	grown Sand
Continuation of the table on the following page					

Table 4 continued:

Core label	Site	Depth, Thickness [mNN / m]		Fiber component	Other evidence of asbestos
		ULG	Thickness		
EB 16	Western entrance to mine	565	> 0,30	**high**	In-fill
EB 17	Excavation level 510 m	510,5	> 0,30	**high**	In-fill
EB 18	Eastern mine entrance	536,5	> 0,30	**high**	In-fill
EB 19	Eastern mine entrance	560	> 0,30	**high**	In-fill
EB 20	Eastern stockpile with covering material	586	> 0,30	n. d.	Former overlying strata
EB 21	Northeastern stockpile with covering material	587	> 0,30	n. d.	Former overlying strata
EB 22 (formerly SS 13)	tailing material, top of the new factory tailings	566	> 0,30	**high**	Material of the new factory tailings

ULG Upper limit of the ground EB exploratory boring n. d. not discernible

2.3 Sampling of rock

The investigations of the rock were carried out by the University of Hamburg, Mineralogical/Petrographical Institute, Dr. habil. Arikas. During the field work in July and September 2005, the sampling in the southern half of the quarry took place. The excavation levels in this area are relatively wide and are therefore particularly suited to be the first places for deposition in the pilot-scale landfill to be planned.

Table 5: Overview of the rock samples taken

Sampling location	Date	Characterization of the rock	Visual evidence of asbestos
rock samples			
1	25.07.2005	Transition from dark to green serpentinite	No fibers
2	25.07.2005	green serpentinite	**Fine fibers**
3	26.07.2005	Dark grey to grey and brown rock varieties on quarry wall	**Long fibers**
4	26.07.2005	Dark „fresh“ serpentinite and transition to weathered and easily breakable rock	No fibers
Continuation of the table on the following page			

Table 5 continued:

Sampling location	Date	Characterization of the rock	Visual evidence of asbestos
		rock samples	
5	26.07.2005	picked-up stone on the main path of the quarry	No fibers
6	26.07.2005	picked-up stone, some meters further on the main path of the quarry	No fibers
7	26.07.2005	Serpentinite on the quarry wall, varyingly weathered	**Fibers on fissure surfaces**
9	26.07.2005	Various varieties of serpentinite on the quarry wall	**Long fibers**
11	26.07.2005	Unusual picked-up stone	No fibers
12	26.07.2005	Unusual picked-up stone	No fibers
13	26.07.2005	Amphibolite "dike(?)" on the quarry walls	No fibers
16	13.09.2005	Broken boulders of various varieties of serpentinite	**Fibers on fissure surfaces**
17	13.09.2005	Serpentinite with drastic formation of long-fibered chrysotile	**Long fibers**
18	13.09.2005	Contact of the serpentinite with the overlying Plio-Pleistocene sandstone	No fibers
19	13.09.2005	picked-up stone of a dark grey and compact serpen-tinite	No fibers
21	13.09.2005	Transition from dark gray to green serpentinite and formation of fibrous chrysotile	**Long fibers**
22	13.09.2005	Amphibolite, exposed on the main path of the quarry	No fibers
23	13.09.2005	Transitions from green serpentinite to fiberous chry-sotile and carbonate formation	**Fibers on serpentinite**
		sediment samples	
8	26.07.2005	Washed up and deposit weathering material	**Fine fibers**
10	26.07.2005	Washed up and deposit weathering material	**Fine fibers**
20	13.09.2005	tailing – Material from the new stockpile of the processing plant	No fibers

Rock samples for the light optical microscopy and x-ray diffraction were taken from 21 selected points. Hammer and chisel served as sampling devices. The samples were packed air-tight, labeled, and brought to the mineralogical laboratory for thin section preparation. The sampling points can be seen in the layout in attachment 2.1.

2.4 Sampling of the soil

For the extraction of soil samples, cores and in part hand-dug holes at selected points, due to previous knowledge from the old documents (see chapter 1.7), were selected as the methods for obtaining soil samples, in accordance with the preplanning of the reconnaissance work.

For the exploratory borings (EB), a DN 50 scope was driven into the soil and pulled out again by means of a hammer drill in the coring method. The hand-crafted test pit were applied in the areas where the bedrock was too near the surface for a coring to make sense.

After taking the core or producing the hand-crafted test pit, and taking the core profile and/or soil pictures as well as the sensory assessment of the core in accordance with DIN 4022, homogenized individual samples were taken, depending on the alternation of layers or sensory distinctive features, and filled into 500 ml PE containers with air-tight lids. A thin layer of the core was removed perpendicular to the scope shaft with the appropriate tool, because by pulling the scope, the succession of layers became covered by transported particles. Separate areas were sampled where there were changes in layering or distinctive sensory sequences. Using hydrochloric acid (HCl 7 %), the carbonate content of the core was determined.

The samples were immediately transferred to the accredited laboratory. The storage and disposal of the soil samples was carried out in accordance to the specifications of DIN EN 45001. From the data obtained, a core profile was created according to DIN 4023 (attachment 5). The samples are labeled with EB and then with the scope number as well as the depth interval from which the sample was taken (e.g.: EB 1/000-0.30 means 1st EB; sample from the sample interval from 0.00 to 0.30 m below ULG).

2.5 Sampling of the surface water

To determine the influence of the mine and the factory, including the tailings, on the water quality of the Aliakmon and the Polifitou reservoir, orienting water samples were taken up- and downstream of the potential discharge area. At the time of sampling, a new reservoir dam (Ilariona) was erected in the upper reaches. The water from the Aliakmon was partly retained by the dam body already built. In addition, accumulated river water has been redirected in a controlled fashion in the construction operation. To construct the dam, very large amounts of sediment from the Aliakmon river bed have been removed. A sand/pebble removal also occurred at the time of the sampling. Due to the conditions described above (dam construction), a significant sediment loading in the surface water was to be expected.

The surface water to be sampled was standing water (mine lake, Polifitou) as well as moving water (Aliakmon).

The sampling was carried out randomly using acquire sample from the area near the bank (ca. 3 m to 5 m away). During this, caution was particularly taken that as little sediment as possible was stirred up during the sampling. The acquired water was poured bubble-free into a 1 l PE bottle and closed off air-tight. In DIN EN ISO 5667-3, no special sample preservation is planned for the preservation and handling of water samples for the physical analyses for asbestos. Because the presence of aquatic organisms can pose a problem for the analysis, there is the possibility to preserve the sample for a longer standing time, until the analysis, using a cell toxin ($HgCl_2$). Such sample preservation was not carried out. The sample storage and transport occurred dark and cool, in accordance with DIN EN ISO 5667-3.

In order to determine a seasonal influence, the sampling took place in Summer (25th and 26th of July 2005) and in Winter (11th of December 2005). Sampling during the high runoff time of year (Spring) could not yet be carried out due to the EU Project schedule. A total of nine water samples (WS) were taken, and of these, five were transferred to the physical laboratory for analysis.

Table 6: Overview of the water sampling conducted

Label	Date of sampling	Time	Sampling location	Sampling depth [m bel. WL]	Comments (moving or standing water, turbidity)
WS 1	25.07.2005	11:30	Aliakmon, downstream from dam in construction	0,5	Moving water, **visible turbidity**
WS 2	25.07.2005	11:00	Aliakmon, upstream from dam in construction	0,5	In part standing water, no turbidity
WS 3	25.07.2005	12:30	Aliakmon / Polifito Rimnio bridge (SE-side)	0,5	Standing water, no turbidity
WS 4	25.07.2005	15:00	MABE mine lake, SE-entrance	0,5	Standing water, no turbidity
WS 5	26.07.2005	9:30	Aliakmon / Polifito, discharge from MABE	0,5	Moving water, no turbidity
WS 7	09.12.2005	14.30	Aliakmon, Zavordas bridge, upstream from dam in construction	0,5	Moving water, **visible turbidity**
WS 8	09.12.2005	16.45	Aliakmon / Polifito, discharge from MABE	0,5	Moving water, **visible turbidity**
WS 9	09.12.2005	15.00	Aliakmon / Polifito Polifito dam	0,5	Standing water, **visible turbidity**

WL water level
WS water sample

Only the water samples which showed no visible clouding were brought for physical analytic. The testing of the clouded samples would have meant significant additional expenses in sample preparation, and for that would likely have worsened the detection limit for critical asbestos fibers (WHO fibers) to follow. For this reason, the turbulent water samples were eliminated for the testing.

The random water sampling only gives evidence for a hazardous substance load (here: asbestos) which is only representative for the time and place where the sample was taken.

2.6 Sampling of mud

The sampling of muddy deposits generally happened parallel to the water sampling described above. The samples taken give evidence of the composition of the suspended load in the surface water investigated. Contrary to the random-type probes of the surface water itself, these samples are representative of longer periods of time.

In dried-up runoff areas, the mud samples are the only source for an analytic determination of an estimation of the asbestos fiber loading in the surface water. Selected samples were brought to the accredited laboratory for physical analysis. The remaining samples have been reserved for potential later testing. In the following table, all mud samples taken are listed. Reserved samples have been additionally labeled with an “R”.

Table 7: Overview of the mud sampling carried out

Label	Sampling date	Sampling location	Sampling depth [m bel. ULG]	Comments, evidence of asbestos, Reserved samples (R)
SS 1	25.07.2005	Aliakmon, downstream of the dam in construction	0,2	Mud from moving water, no visible fibers (R)
SS 2	25.07.2005	Aliakmon, upstream of the dam in construction	0,2	Mud from partly standing water, no visible fibers (R)
SS 3	25.07.2005	Dried-up easterly runoff area of the tailings, ca. 100 m away from MABE entrance	0,2	Dry deposit, no visible fibers
SS 4	25.07.2005	Aliakmon / Polifito, Rimnio bridge (SE side)	0,2	Mud from standing water, no visible fibers (R)
SS 5	25.07.2005	MABE mine lake, SE entrance	0,1	Mud from standing water, **some fibers** visible
SS 6	26.07.2005	Dried out easterly run-off from the tailings, accessible from MABE service road	0,2	Dry deposit, no visible fibers (R)
SS 7	26.07.2005	Dried out northerly run-off from the tailings, entrance to the quarry next the MABE road	0,2	Dry deposit, no visible fibers
SS 8	26.07.2005	Dried-up westerly run-off from the tailings, next to the MABE access road	0,2	Dry deposit, no visible fibers (R)
SS 9	26.07.2005	Aliakmon / Polifito, runoff from MABE	0,3	Dry deposit, no visible fibers
SS 10	26.07.2005	MABE, excess detritus from conveyor belt	0,2	Fine-grained dry deposits, **fibers clearly** visible (R)
Continuation of the table on the following page				

Table 7 continued:

Label	Sampling date	Sampling location	Sampling depth [m bel. ULG]	Comments, evidence of asbestos, Reserved samples (R)
SS 11	26.07.2005	MABE, public road	0,2	Moist mud deposit, **fibers clearly** visible (R)
SS 12	26.07.2005	MABE, top of the new factory tailings	0,3	Fine-grained moist deposit, **fibers clearly** visible

ULG Upper limit of the ground ss soil/sludge sample

2.7 Sampling of outside air

The sampling of the air for asbestos was generally carried out following the methods which were published in 1997 by the WHO in „Determination of airborne fibre number concentrations, a recommended method, by phase-contrast optical microscopy (membrane filter method)".

Three different methods of measurement to determine the asbestos fiber content in the air were applied with regards to the task (see chapter 1). These were stationary measurements with and without resuspension in accordance with VDI Guideline 3492 and hand-held measurements complying with the method for the separate determination of asbestos and other organic fibers: scanning electron microscopic method (BGI 505-46, formerly ZH1/120/46). The instructions for the sampling methods can be found in attachment 9. In addition, an indirect determination occurred by sampling adhesive tape samples on surfaces (buildings, rock, plants).

2.7.1 Stationary measurements

For the planning of the sampling locations, all available information on emission sources, meteorological conditions and the local conditions/factors were evaluated. The variability of the climatic conditions in particular (humidity, wind factors, etc.) can lead to significant differences in the precision of the determination of the middle asbestos fiber concentrations in the air.

The volume flow of the sampling was generally 8 l/min. The sampling occurred at a height of 1.5 m above the ground surface. In order to prevent an overloading of the filter, the sampling length of 8 hours usual for asbestos remediation success inspection in Germany was not allotted in part. This led to a reduction in the detection limit reachable under standard conditions of the investigation methods (300 fibres/m³ or 0.0003 fibres/cm³).

The constraints for the stationary measurements without resuspension were constructed so that primarily the asbestos fiber contents in the air determined by wind and weather were measured. The influences of the bordering reconnaissance work were reduced to a minimum.

The stationary air measurements with resuspension of near-surface soil material simulates the potential possible release of asbestos fibers by significant mechanical stressing of the material. This occurs, for example, through construction with machines (loading of transport vehicles, moving soil material, driving over the surfaces, etc.) or through working with material containing asbestos by hand (pickaxes, shovels, etc.)

For the simulation, a representative amount of near-surface loose material was then loosened and piled up. The piled material was relocated using shovels, during which at the same time, within a time period of maximum ten minutes, a stationary sampling of the air was conducted in the downwind area (see attachment 8, photo-documentation).

Parallel to the stationary sampling, the climate data (wind direction and strength, humidity, air pressure and temperature) were intermittently taken at the sampling location.

In the following table, the data from the air sampling, including the evidence for the constraints (climate, activity in the surrounding area) are listed.

Table 8: Overview of the stationary air measurements (with and without resuspension)

Sampling location	**Label**	**Date**	**Start time**	**Duration**	**max. temperature**	**max. humidity**	**Wind**	**Comments**
				[hr]	[°C]	[%]	Direction Beaufort	
without resuspension								
site facility	A P 1	22.07.05	15:38	6,3	30	40	NNW 1-3	**Little traffic** public road, asphalted
AS 1	A 1.1	23.07.05	9:10	7,4	30	46	N-NE 1-3	NW surroundings of the mine
	A 1.2	13.09.05	9:30	4,0	38	55	NW-NE 1-2	
AS 2	A 2.1	23.07.05	8:45	7,9	33	60	N-NW 1-3	N surroundings of the mine
	A 2.2	14.09.05	13:05	2,4	26,8	60	N-NW 1-2	
AS 3	A 3.1	23.07.05	9:06	7,4	30	57	NE 1-2	N entrance to the mine, **occasional sampling vehicle**
	A 3.2	13.09.05	9:05	4,0	36	48	changing, 1-2	No traffic
AS 4	A 4.1	25.07.05	8:47	8,0	30	57	E 1	NE surroundings of the mine, public road, gravel, **very little traffic**,
	A 4.2	13.09.05	14:03	3,8	32	32	changing, 1-2	**Occasional truck traffic**
AS 5	A 5.1	26.07.05	9:25	7,8	40	58	NE 1-3	SE surroundings of the mine
	A 5.2	14.09.05	12:33	3,5	26,8	60	changing, 1-2	
Continuation of the table on the following page								

Table 8 continued:

Sam-pling location	Label	Date	Start time	Dura-tion	max. tempera ture	max. humid-ity	Wind	Comments
				[hr]	[°C]	[%]	Direction Beaufort	
without resuspension								
AS 6	A 6.1	26.07.05	10:00	7,6	40	48	NE 2	SW surroundings of the mine
AS 7	A 7.1	23.07.05	11:08	4,7	42	30	changing 0-3	in the mine
	A 7.2	25.07.05	9:36	6,7	30	38	changing 1	
	A 7.3	26.07.05	11:00	0,5	34	58	W 1	in the mine, **parallel reconnaissance work** (material sampling)
AS 9	A 9.1	14.09.05	9:52	0,5	23	67	still	On the factory tailings
with resuspension								
AS 7	A 7.4	14.09.05	16:47	0,15	32,7	30	still	In the mine
AS 8	A 8.1	14.09.05	11:41	0,05	26,9	45	NE 1-2	On the company property, next to main building
AS 9	A 9.2	14.09.05	10:11	0,15	23	67	S-SE, 1	On the factory tailings
AS 10	A 10.1	13.09.05	14:53	0,1	32,3	28	W 2-3	in the mine, LF 1
AS 11	A 11.1	13.09.05	16:26	0,1	32,5	30	NW 1-2	in the mine, LF 2

AS air sample

2.7.2 Personnel measurements

To determine the activity-related asbestos fiber contents in the air breathed by the workers during the reconnaissance work, personnel measurements were conducted.

The volume flow during the sampling was generally 2 l/min. The sampling took place immediately bordering the area where workers would respire. For the personnel measurements, the constraints of the sampling were configured so that the influences of the various reconnaissance work could be determined for the breathable air.

Parallel to the personnel measurement sampling, the climatic data (wind direction and strength, humidity, air pressure and temperature) were intermittently taken at the sampling location (see attachments 4 and 10).

In the following table, the data for the air sampling, including evidence for the constraints (climate, reconnaissance activity) are listed.

Table 9: Overview to the hand-held air measurements

Label	Date	Start time	Duration	max. temperature	max. humidity	Wind	Comments
			[hr]	[°C]	[%]	Direction Beaufort	
AP 3	22.07.05	16:50	1,75	30	40	NNW 1	MABE factory, administrative building, truck repair, outside area, inspection
AP 4	25.07.05	8:21	1,9	28	60	NE-NW 1-3	N surroundings to the mine, inspection and air sampling
AP 5	26.07.05	9:15	1,9	34	58	E-NE 1-3	S surroundings of the mine, inspection and air sampling
AP 6	13.09.05	14:05	1,9	32,3	28	W 2-3	in the mine, LF 1
AP 7	13.09.05	15:52	1,8	32	32	changing 1-2	N surroundings of the mine, inspection and air sampling
AP 8	14.09.05	13:13	1,9	26,8	60	N-NW 1-3	N surroundings of the mine, inspection and air sampling
AP 9	14.09.05	13.15	1,8	28,3	46	changing, 1	in the mine, inspection
AP 10	14.09.05	10:03	1,4	22	67	changing 1	top of the factory tailings, inspection and air sampling
AP 11	15.11.05	13:06	1,9	15	55	n.d.	top of the mine tailings, inspection and soil sampling

LF landfill area n.d. no data
AP personal air sample

2.7.3 Indirect measurement (adhesive tape samples)

To determine the spread of asbestos fibers over the airway, adhesive tape samples from leaf, rock and building surfaces were taken and tested for asbestos (indirect method). For this, the surface to be tested was dabbed with a piece of tape, which was packed into a dust-proof plastic container, and taken to the accredited laboratory. In the following table, the sample label, sampling location and type of material sampled is listed.

Table 10: Overview of the adhesive tape samples taken

Sample label	Date	Sampling location	Material (adhesions/secondary dusts)
TS 1	23.07.05	Rock surface by sampling point AS 7	Rock surface
TS 8	26.07.05	Vegetation next to drainage area SS 8, ca. 100m before E-Station	Leaf surface
TS 9	26.07.05	Vegetation next to quarry entrance, by drainage area SS 7	Leaf surface
TS 10	26.07.05	Vegetation next to outlet by drainage area SS 6	Leaf surface
TS 11	26.07.05	Vegetation on the new factory tailings	Leaf surface
TS 12	26.07.05	Vegetation on the new factory tailings	Leaf surface
TS 13	26.07.05	refuge next to the mine; vantage point with guard rail	Wood surface
TS 14	26.07.05	Vegetation next to construction road in the mine	Plant surface
TS 15	14.09.05	By administrative building; Road in outer area	Concrete surface
TS 16	14.09.05	Vegetation in the area of the new factory tailings	Leaf surface
TS 17	14.09.05	Cross-beam next to conveyor belt in area of the tailings	Steel surface
TS 18	14.09.05	In factory building, packing, Floor area	Concrete surface
TS 19	14.09.05	Vegetation next to northerly mine en-trance	Leaf surface
TS 20	14.09.05	Vegetation next to northerly mine en-trance	Leaf surface
TS M1	26.07.05	Vegetation in monastery courtyard	Leaf surface
TS M2	26.07.05	Chapel in the monastery	Rock surface
TS M3	26.07.05	baseboard in the monastery chapel	Wood surface
TS M4	26.07.05	baseboard in the monastery chapel	Wood surface
TS M5	26.07.05	Wood parts of exterior facade, NW-side of the monastery	Wood surface
TS M6	14.09.05	SW. windowsill on outer facade, residential buildings in monastery	Concrete surface
TS M7	14.09.05	Brook in monastery courtyard	Clinker surface
TS M8	14.09.05	SE. windowsill of exterior facade, residential buildings in monastery	Concrete surface

TS adhesive tape sampling

2.7.4 Climatic data

The climate data (air pressure, temperature, precipitation, wind speed and direction, humidity) were gathered intermittently analogously and partly digitally. The predominant air pressure in the region at the time of the sampling was obtained by digital media (Kozani climate station, http://www.wetteronline.de/).

The parameters air temperature and air humidity were recorded with a measuring device including a data log (testo 751) for two hour intervals. The measuring device was positioned at investigation point AS 2 over the entire measuring time period. The values of the two-hourly temperature and humidity measurements can be seen in the diagram in attachment 10.

For the analysis of the regional weather conditions within the time period of June to December 2005, the climate data (average daily values) from the Kozani climate station (http://www.wetteronline.de/) were adducted. The temperature (min/max values), humidity and air pressure, as well as an overview of the weather data (temperature and humidity) reported from 1969 to 2000 can be seen in the diagrams in attachment 10.

In addition, the precipitation measurements for the neighboring weather station Ilariona at the dam under construction for the time period December 2003 to September 2005 are available. The daily and monthly precipitation amounts are likewise depicted in a diagram (see attachment 10).

3 Investigation of samples suspected of containing asbestos (description of methods)

3.1 Sample selection and composition

3.1.1 Soil samples

Within the scope of the task, a total of 43 disturbed soil samples were taken from the 15 exploratory borings and 7 hand-crafted test pits. Of these, 10 individual samples which showed no recognizable asbestos fibers or other evidence for asbestos (serpentinite rock etc.) and five individual samples which represent excavated material suspected of containing asbestos were selected for the physical investigations for asbestos. The remaining soil samples were kept as reserve samples for possible follow-up investigations which may be necessary.

An overview of the individual samples subjected to the physical investigation can be seen in the following table 11.

Table 11: Overview of the individual samples tested (soil material)

Bore point label	**situation**	**Depth range** [m u. GOK]	**sensorically recognizable fiber compo-nent**	**Other evidence for asbestos**	**Comments** (sensoric estimation regarding asbestos, asbestos source)
EB 1	west. border	0-0,3	n. d.	grown Sand	Surface sample, airway
EB 4	west. border of the mine	0-0,3	n. d.	grown Sand	Surface sample, airway
EB 5	west. border of the mine	0-0,3	n. d.	grown Sand	Surface sample, airway
EB 6	southwest. border of the mine	0-0,3	n. d.	grown fine sand	Surface sample, airway
EB 7	southwest. of the mine, entrance to the marble quarries	0-0,3	n. d.	grown Sand	Surface sample, airway
EB 9	Southern border of the mine	0-0,15	n. d.	In-fill	Surface sample, air- or soil-way
EB 10	Public road, S mine	0-0,3	n. d.	In-fill	Surface sample, air- or soil-way
EB 12	Public road, E mine	0-0,3 0,3-0,9	**high**	In-fill	Material containing asbestos
EB 14	Eastern entrance to mine	0-0,3	n. d.	In-fill	Surface sample, airway
EB 15	Vantage point with guard rail	0-0,3	**high**	In-fill	Material containing asbestos
EB 17	Excavation level 510 m	0-0,3	**high**	In-fill	Material containing asbestos
EB 20	eastern acclivity with covering material	0-0,3	n. d.	Former cover layer	Surface sample, airway
EB 21	northeastern acclivity with covering mate-rial	0-0,3	n. d.	Former cover layer	Surface sample, airway
EB 22 (formerly SS 13)	Tailing material, top of the new fac-tory tailings	0-0,3	**high**	Material of the new factory tailings	Material containing asbestos

n. d. not detectable

3.1.2 Rock samples

The determination of mineral and rock was carried out with polarization microscopy and confirmed by numerous x-ray pictures. For the microscopic investigation, 26 thin sections were prepared. The samples investigated are listed in the following table.

Table 12: Overview of the rock samples investigated and prepared thin sections

Samp-ling location	Date	Characterization of the rock in the sampling location	Characterization of the sample (incl.Thin section labels)
rock samples			
1	25.07.2005	Transition from dark to green serpen-tinite	*1.1: dark grey next to green serpentinite*
2	25.07.2005	Green serpentinite	*2.1: green serpentinite with weathered sur-faces and release of finely fibered chrysotile*
3	26.07.2005	Dark gray to gray and brown rock varieties on a quarry wall	*3.1: dark grey serpentinite* *3.2: like 3.1* *3.3: Transition to grey variety* *3.4a: weathered serpentinite, grey* *3.4b: long-fibered chrysotile in fissure area*
4	26.07.2005	Dark „fresh“ serpentinite and transition to weathered and easily breakable rock	*4.1: dark serpentinite variety* *4.2: weathered, grey rock variety* *4.3. strongly weathered (crumbly) variety*
5	26.07.2005	picked-up stone on the main quarry path	5.1: picked-up stone; green serpentinite with spotty/patchy dark areas
6	26.07.2005	picked-up stone, some meters further on the main quarry path	*6.1:* picked-up stone*, represents a very com-pact dark grey serpentinite*
7	26.07.2005	Serpentinite on the quarry wall, vari-ously weathered	*7.1: dark grey serpentinite* *7.2: grey, weathered variety and transition to fibrous chrysotile on fissure surfaces*
9	26.07.2005	Different varieties of serpentinite on the quarry wall	*9.1: dark grey - green serpentinite and long-fibered chrysotile on fissure surfaces* *9.2: fibrous chrysotile crusted and hardenned by carbonate* *9.3: long-fibered chrysotile, soft, ductile*
11	26.07.2005	Unusual picked-up stone	11.1: coarse-grained "Gabbro", compact and hard
12	26.07.2005	Unusual picked-up stone	12.1: "Gabbro", compakt und hard
13	26.07.2005	Amphibolite on the quarry wall	*13.1: Amphibolite* *13.2: Amphibolite, chloritized*
16	13.09.2005	Broken boulders of various varieties of serpentinite	*16.1:dark grey and green variety of serpen-tinite and formation of fibrous chrysotile on fissure surfaces*
17	13.09.2005	Serpentinite with drastic formation of long-fibered chrysotile	*17.1: Serpentinite (grey) with fibrous chrysotile on fissure surfaces* *17.2: long-fibered chrysotile*
18	13.09.2005	Contact of serpentinite with the overly-ing Plio-Pleistocene sandstone	*18.1: sandstone sample*
Table continued on following page			

Table 12 continued:

Sam-pling location	Date	Characterization of the rock in the sampling location	Characterization of the sample (incl. Thin section label)
rock samples			
19	13.09.2005	picked-up stone of a dark grey and compact serpentinite	*19.1: dark grey and compact serpentinite*
21	13.09.2005	Transition from dark grey to green serpentinite and formation of fibrous chrysotile	21.1: long-fibered chrysotile
22	13.09.2005	Amphibolite, exposed on the main quarry road	22.1: Amphibolite sample
23	13.09.2005	Transitions from green serpentinite to fibrous chrysotile and carbonate formation	23.1: green serpentinite with fibrous chrysotile
sediment samples			
8	26.07.2005	Washed up und sedimented weathering material	*8.1: upper-most, 5-10 mm thick "sediment" crust*
10	26.07.2005	Washed up und sedimented weathering material	*10.1: upper-most 5 mm „sediment" crust* *10.2: layer up to 3 cm below the crust*
20	13.09.2005	Tailings of the factory	*20.1: fine-grained acclivity material (greenish-gray)* *20.2: washed up material from tailings (light grey)*

Italics represent Selection for light-microscopic and/or x-ray investigation

3.1.3 Water samples

A total of nine water samples (WS) were taken from the surface waters present in the investigation area, and of these, five were sent for analysis in the physical laboratory.

Only those water samples which did not display any visible clouding were brought for physical analysis. The testing of the clouded samples would have mean significant additional costs in sample preparation, and likely further deterioration of the detection limit for critical asbestos fibers (WHO fibers) as a result. For this reason, clouded water samples were eliminated from the investigation.

Table 13: Overview of the water samples selected for the investigation

Label	Sampling date	Time	Sampling location	Sampling depth [m bel. WL]	Comments (moving or standing water, turbidity)
WS 2	25.07.2005	11:00	Aliakmon, upstream of the dam under construction, **Upstream from MABE**	0,5	Partly standing water, no turbidity
WS 3	25.07.2005	12:30	Aliakmon / Polifito Rimnio bridge (SE side), **downstream from MABE**	0,5	Standing water, no turbidity
WS 4	25.07.2005	15:00	MABE mine lake, SE entrance	0,5	Standing water, no turbidity
WS 5	26.07.2005	9:30	Aliakmon / Polifito, discharge from MABE; **downstream from the tail-ings**	0,5	Moving water, no turbidity

WL water level

The random-type water sampling only provides evidence for a hazardous substance load (here: asbestos) which is only representative of the time and place of the sampling.

3.1.4 Mud samples

Within the scope of the task, a total of 12 mud samples were taken. Of these, five mud samples were selected and tested for asbestos. Two different methods were applied (BIA method: quantitative, and Marburger method: qualitative, method description see following chapter). The mud sample SS 9 was tested using both method techniques in order to estimate the detection limit of the Marburger method.

Table 14: Overview of the selected mud samples

Label	Sampling date	Sampling location	Sensoric findings	Testing method
SS 3	25.07.2005	Dried-up eastern runoff from the tailings, ca. 100 m away from the MABE access road	No recognizable fibers	Marburger method
SS 5	25.07.2005	MABE mine lake, SE entrance	**few** fibers recognizable	Marburger method
SS 7	26.07.2005	Dried-up northern runoff from the tail-ings, entrance to the quarry next to the MABE road	No recognizable fibers	Marburger method
SS 9	26.07.2005	Aliakmon / Polifito, runoff from MABE	No recognizable fibers	BIA method and Marburger method
SS 12	26.07.2005	MABE, top of the new factory tailings	**obvious** fibers recognizable	BIA method

3.1.5 Air samples

Within the scope of the task, a total of 21 stationary (16 samplings without resuspension and 5 with resuspension) and nine hand-held air samples were taken. Of these, all of the samples from the stationary sampling and six from the sampling accompanying the workplace were brought to the lab for physical investigation. An overview of the selected hand-held air measurements can be seen in the following table.

Table 15: Overview of the analysis of selected hand-held air measurements

Label	Date	Start time	Comments
AP 5	26.07.05	9:15	S surroundings of the mine, inspection und air sampling
AP 6	13.09.05	14:05	in the mine, LF 1, **Air sampling with resuspension**
AP 7	13.09.05	15:52	N surroundings of the mine, inspection und air sampling
AP 9	14.09.05	13:15	in the mine, inspection
AP 10	14.09.05	10:03	top of the factory tailings, inspection und air sampling
AP 11	15.11.05	13:06	top of the mine tailings, inspection und **soil sampling**

LF landfill area
AP personal air sample

3.1.6 Adhesive tape samples

A total of nineteen adhesive tape samples (indirect air sampling) were taken in addition to the air samples mentioned above, and sixteen samples were selected for asbestos analysis.

Table 16: Overview of the adhesive tape samples selected for analysis

Sample label	Date	Sampling location	Material (adhesions/secondary dusts on)
Rock and vegetation surfaces in the mine			
TS 1	23.07.05	Rock surface by Sampling point AS 7	Rock surface
TS 14	26.07.05	Vegetation next to construction road in the mine	Plant surface
TS 19	14.09.05	Vegetation next to northern mine en-trance	Leaf surface
TS 20	14.09.05	Vegetation next to northern mine en-trance	Leaf surface
Table continued on following page			

Table 16 continued:

Sample label	Date	Sampling location	Material (adhesions/secondary dusts on)
Building, road and vegetation surfaces of the company premises			
TS 15	14.09.05	On administrative building; Road in outer area	Concrete surface
TS 17	14.09.05	Cross-beam next to conveyor belt in the area of the tailings	Steel surface
TS 18	14.09.05	In factory, packing, Floor area	Concrete surface
Vegetation surfaces in surrounding area			
TS 8	26.07.05	Vegetation at runoff area SS 8, ca. 100m in front of E-Station	Leaf surface
TS 9	26.07.05	Vegetation next to quarry entrance, at runoff area SS 7	Leaf surface
Vegetation surfaces on the tailings			
TS 12	26.07.05	Vegetation on the new factory tailings	Leaf surface
TS 16	14.09.05	Vegetation in the area of the new factory tailings	Leaf surface
Monastery			
TS M1	26.07.05	Vegetation in monastery courtyard	Leaf surface
TS M3	26.07.05	floorboard in monastery chapel	Wood surface
TS M5	26.07.05	Wooden components on outer facade, NW-side of the monastery	Wood surface
TS M7	14.09.05	Clinker surface next to brook in monastery	Clinker surface
TS M8	14.09.05	SE. windowsill on outer facade, residential building in monastery	Concrete surface

TS adhesive tape sampling

The samples not listed in tables 11 to 16 were put back, properly stored and can be tested if needed.

3.2 Scope of the analyses

3.2.1 Scope of the investigation of rock, soil and mud, water, air and adhesive tape samples

The determination of the physical investigations on the rock, soil and mud, water, air and adhesive tape samples was carried out with previous knowledge of the potentially asbestos-contaminated areas in the mine at hand, the sensory characteristics determined on the samples and with regard to the planned remediation and landfilling of materials containing asbestos.

3.2.2 Rock investigations

The determination of mineral and rock was carried out using polarization microscopy and x-ray diffraction.

For the microscopic investigation, 26 thin sections were prepared from the solid rock samples from the quarry in the preparation laboratory of the Mineralogical-Petrographical Institute of the University of Hamburg. The optical qualities of the minerals are generally obtained at a thickness of 25 µm of the sliced rock.

The microscopy of the thin sections occurred with a Zeiss research microscope which is equipped with a camera. Aside from the determination of minerals, the structural characteristics of the mineral associations were also investigated. For the investigation of some loose material (e.g. from the tailings), microscopic observations were made on grain preparations.

Through the x-ray diffraction investigation, the microscopic mineral determinations were made more precise. The x-ray diffraction investigative method is above all essential for very fine-grained rocks and loose materials.

3.2.3 Soil and mud samples

Generally, two recognized investigation methods for soil and mud samples have been used in Germany. These are a quantitative method developed by the Institut of employers liability insurance association for work safety (BIA) (method for analytic determination of low amounts of asbestos fibers in powders and dusts with SEM/EDX; the so-called BIA Method, see attachment) and a qualitative method which was published in March 1992 by the Magistrate of the city of Marburg – Environmental Administration (Marburger or “wind look” method). In the following, the applied investigation and analysis methods of the Marburger Method and the deviations in the sample preparation and analysis due to the general conditions will be explained.

Description of the Marburger Method

The Marburger method for the physical testing of soil samples for asbestos was selected and further developed by von Lieberman Ltd, a Cooperating partner of Sakosta Holding AG, in collaboration with the accredited laboratory. The material samples are analyzed with the actual “wind look” method for the presence of asbestos after the sample preparation using a light optical microscope.

The soil material is filled into sample holders and brought to the officially recognized lab. The soil samples are dried at 60°C in the oven, carefully milled in a ball mill and lastly sieved with a screen with a mesh width of 0.1 mm from DIN 4188.

A part of the soil sample prepared is placed into in a GIII “reversal frite (Umkehrfritte)”. The “Frite” is clamped in a 50 Hz shaker with 1 mm per pass and a acceleration of 0.125 g (Earth’s acceleration). During shaking, a fluid dust bed is built. On the Frite, a vacuum-sealed filter head with a Nucleopore filter with a pore width of 0.8 µm is attached. Lastly, pre-purified air is moved through the Frite. The respirable dust particles are pulled out of the fluid dust bed and thrown against the Nucleopore filter.

The loaded filter is inserted into a cold ashing equipment. Through cold ashing, the organic material is largely removed from the filter. After this, 1 mm² of the loaded filter is examined in the scanning electron microscope (SEM) for respirable fibers. All occurrences found containing asbestos (single fibers, fiber agglomerates, fiber bundles and particle-bound fibers) are counted. Detected fibers are investigated with the EDXA (e.g. Ortep 2000) for their elementary composition.

Using the analysis methods mentioned above, asbestos is detected in the sample. A quantitative determination of the measurement results is not possible in general. For this reason, the determination of the asbestos component is carried out only with a three-step evaluation matrix on hand (no asbestos, individual asbestos, much asbestos).

Deviations in the sample analysis using the Marburger Method

The evaluation of the sample using a light microscope lead to no easily differentiable results. For this reason, the scanning electron microscopic method was used for analysis.

Deviations in the sample preparation using the BIA Method

Deviating from the BIA Method, the samples were not ground to the grain size < 100 µm, rather to < 1 mm. The component < 200 µm was sieved out and taken for further sample preparation.

Explanation: In the samples tested it was apparent that predominantly all components display a chrysotile-like chemical composition (so-called “cleavage fragments”: antigorite, chrysotile.) Therefore, by far the morphological appearance should be used as asbestos indicator. Particularly the sample preparation is problematic. If the samples are ground, a whole array of fibers are produced which match the WHO definition, however with an L : D relationship only slightly larger than 3 : 1, which must be valued as asbestos due to the chemical composition. During sieving, a part of the asbestos, particularly the long and therefore fibers with high mass are lost. Therefore, sieving the < 200 µm fraction instead of the < 100 µm fraction according to the BIA method was selected as a compromise.

The component of the < 200 µm fraction sieved and investigated in the scanning electron microscope betrayed ca. 70 to 80 % of the outcome sample. The comparative analysis on the < 1 mm and the sieved < 200 µm fraction of sample EP22 yielded a component of 30 % chrysotile asbestos from the < 1 mm fraction by direct determination. The extrapolation from the < 200 µm fraction resulted in a somewhat higher component of asbestos (35 %) in the sample.

3.2.4 Water investigation

The investigations on selected water samples for asbestos were conducted using transmission electron microscopy (TEM Method) after sample preparation.

The investigation method is described in the investigation report in attachment 9.

3.2.5 Filter samples in scanning electron microscope (SEM)

The air samples obtained using stationary and hand-held sampling methods were analyzed within the scope of the physical investigations using scanning electron microscopy. Both investigation methods (stationary: DIN 3492 and hand-held: ZH1/120.46, today BGI 504-46) can be found in attachment 9.

3.2.6 Adhesive tape samples

The investigation of adhesive tape samples should bring evidence of whether soil material containing asbestos or secondary dust adhere to the construction material, rock or vegetation surfaces. From this, evidence of sources with weakly bound asbestos are to be deduced which release or have released the asbestos fibers.

The sample is investigated after preparation (Sputter, coater, Edwards S1O5B) in the SEM (Zeiss OSM 940) at 200 to 5,000 times magnification. Suspected fibers are investigated with attached, energy-dispersing electron beam microanalysis for their elementary composition (EDX Ortec EEDS II).

The following evaluation scheme applies to lying dust in construction facilities and is limited to evaluation of the investigation results.

All occurrences containing asbestos found (individual fibers, fiber agglomerates, fiber bundles and particle-bound fibers) are counted. The number of the occurrences so counted are evaluated in an evaluation scheme from 0 to 5 as follows:

0 = no asbestos	no fibers/occurrence found on 4 mm²
1 = very little asbestos	1 or 2 fibers/occurrences found on 4 mm² (traces or coincidental finds)
2 = little asbestos	3 to 4 fibers/occurrences found on 4 mm² (regular, lowly loaded)
3 = distinct asbestos	5 to 10 fibers/occurrences found on 4 mm² (regular asbestos fiber load, significant loading)
4 = much asbestos	> 10 fibers/occurrences found on 4 mm²
5 = very much asbestos	asbestos fibers found on almost every field of view many agglomerates/material pieces

The Free and Hanseatic City of Hamburg evaluates lying dust in the „Guideline for the investigation of construction facilities for the presence of asbestos (minimum requirement)" under Position IV, Point 2. According to the guideline mentioned, asbestos dust deposits are defined as significant if more that 1 fiber/mm² is found. This matches a classification level of 2 or above, according to the previously mentioned evaluation scheme.

3.3 Results of the physical investigations

The physical investigations for asbestos were conducted, excepting the rock and water investigations, only for asbestos fibers which fulfill the WHO criteria for "critical" fibers (fiber length: $L \geq 5\ \mu m$, fiber diameter: $D < 3\ \mu m$ and a ratio of fiber length to fiber diameter $L : D > 3 : 1$).

3.3.1 Rock

The solid rocks in the quarry are generally antigorite serpentinite. The predominant serpentine mineral is then antigorite. In the microscope photos (see photo documentation), various antigorite forms are presented.

On an overall view of the quarry walls, one can recognize an irregular alternation from darker to lighter color in the rock. In the darker rock sections, the serpentinite is "fresh", dark grey and compact. The antigorite is microcrystalline here, finely foliated, and often, finely dispersed ore (magnetite) is mixed in. The microcrystalline ore dispersal also enhances the dark coloring of the antigorite serpentinite.

Frequently, millimeter- to centimeter- and even decimeter-large, green rock areas develop within the dark gray rock which are composed of relatively coarsely-foliated antigorite in places. The green rock color is then also dependent on the grain size of the antigorite. The change in color or the transition from dark gray to green serpentinite also occurs through dissolution of the ore finely distributed in the rock, i.e. through "purification" of the antigorite. The formation of green serpentinite varieties apparently occurs next to and near rock fissures in a later phase of the serpentinisation process.

At the transition from dark gray to green serpentine, often the fine-grained ore along fine lineaments is dissolved, at which a fibrous chrysotile runs through the rock in a vein-like manner. Green rock varieties textured in this manner are easily weatherable and capable of being rubbed off, whereupon the finely fibered chrysotile is released (length of the fibers under 10 µm to about 1500 µm). This makes a significant part of the finely fibered material between the rock detritus and blocks, as well as in the washed up and sedimentary weathering products on the excavation levels of the quarry.

On fissure surfaces of the „green antigorite serpentinite“, there is frequently a macroscopically visible “striping” and furthermore a fibrous formation of green serpentine crusts. Under the microscope, various forms of the fiber bundles and the progressive loosening and splitting up of fiber bundles can be seen. The formation of the long-fibered serpentine, namely the chrysotile, is initiated on fissure surfaces. Carbonate (most often dolomite) forms here often, which leads to a white coloring and hardening of the long-fibered crusts. If the carbonate is not there, or is dissolved through weathering, the fiber bundles are soft and ductile and easily removed from the rock.

The lighter (brownish) rock colorings in the quarry are attributed to secondary weathering events. The “purity” of the antigorite serpentinite is “clouded” by a fine distribution of carbonate (dolomite) and “Fe(III) oxides”. Through this the rock develops a lighter, grey color. Because the weathering is stronger on the fine lineaments surfaces, a lighter (more brownish) coloring as a whole appears on the quarry walls. In this context it is to be mentioned that long-fibered serpentine (chrysotile) no longer appears in green, rather in bleached, light grey colors on these weathered fissure surfaces.

<u>Deposits of washed up weathering products:</u>
The fine weathering products deposited on all surfaces of the excavation levels which are washed out of the quarry and its surroundings by rain water play a special role. The x-ray diffraction-investigated samples showed various amounts of fibrous serpentine, carbonate (calcite) and vermiculite as the main minerals. The fibers build a framework which holds and flexibly binds the weathering products into deposits.

<u>Plio-Pleistocene sandstone:</u>
The serpentinite in the area of the quarry is overlain by a widespread sedimentary layer of sandstones containing limestone. They appear from far away in light brown colors. Right at the outcrop, however, the soft sandstone shows a light, almost white color in places.

Under the microscope, the quartz and feldspar grains show a moderately good to poor rounding and a somewhat loose structure, in which solely carbonate (= dolomite, from the x-ray diffraction findings) is present in the pore space. The sandstone has a large pore space, as the dolomite patchily fills out the space between, and is therefore fairly soft, easily ground and consequently easily weathered. It can be assumed that a great deal of carbonate is transported to the surroundings and even to the quarry by weathering processes on this sandstone.

Tailings of the asbestos works:
The samples made of the fine-grained material from the gray-green tailings investigated by x-ray diffraction resulted in having chrysotile / antigorite as main minerals and carbonate (calcite, dolomite) and vermiculite in relatively small amounts. The finer, light grey material washed out and deposited in multiple areas also shows approximately the same mineral composition.

Tailings of the excavation operation:
Two samples (EB-E1 and EB-E3), in which amphibole (actinolite) aside from chrysotile was determined using the Marburger Method, were also investigated microscopically and with x-ray diffraction. Amphibole was detected with both methods. In grain preparations under the microscope, the amphibole appears however in short rods and is comparable with the amphibole from the amphibolite-phase rocks which have been localized, sampled and even mentioned in the literature.

3.3.2 Soil and mud

In the selected soil and mud samples, the following asbestos fiber contents were detected using Marburg and/or BIA Methods:

Table 17: Overview to the individual samples investigated (soil or mud material)

Label	Situation	Depth range	Asbestos component and comments	
		[m bel. ULG]	Asbestos component (total)	Comments
grown soil and mud in the area surrounding the mine				
EB 1	western area bordering the Mine	0-0,3	**+**	Very little **chrysotile asbestos**
EB 4		0-0,3	**-**	
EB 5		0-0,3	**+**	individual **chrysotile asbestos**
EB 6	southwestern area bordering the mine	0-0,3	**-**	No asbestos
EB 7	Southwest of the mine, entrance to the marble quarries	0-0,3	**-**	No asbestos
SS 3	Eastern drainage from the tailings, ca. 100 m away from the access road to MABE	0-0,3	**+**	individual **actinolite and chrysotile asbestos rods**
SS 7	Northern runoff from the tailings, entrance to the quarry next to the MABE road	0-0,3	**+**	individual **chrysotile asbestos**
Table continued on the following page				

Table 17 continued:

Label	Situation	Depth range	Asbestos component and comments	
		[m bel. ULG]	Asbestos component (total)	Comments
SS 9	Aliakmon / Polifito, MABE runoff	0-0,3	**+**	individual **Chrysotile asbestos**
			< 0,1 %	**Chrysotile asbestos** (BIA Method)
Filling material and mud in the mine				
SS 5	MABE mine lake, SE-	0-0,1	**1,3 %**	**Chrysotile asbestos** (BIA Method)
EB 9	Southern area bordering the mine	0-0,15	**++**	**Chrysotile asbestos**
		0,3-0,9	**++**	**Chrysotile asbestos**
EB 14	Eastern mine entrance	0-0,3	**++**	**Chrysotile asbestos**
EB 15	Vantage point with guard rail	0-0,3	**+(+)**	individual **chrysotile asbestos** and **rods with chrysotile spectrum** but no spliced fibers
EB 17	Excavation level 510 m	0-0,3	**++**	**Chrysotile asbestos**
Filling material next to the public road				
EB 10	Public road, S mine	0-0,3	**(++)**	**rods with chrysotile spectrum** but no spliced fibers
EB 12	Public road, E mine	0-0,3	**++**	**Chrysotile asbestos**
Table continued on the following page				

Table 17 continued:

Label	Situation	Depth range	Asbestos component and comments	
		[m bel. ULG]	Asbestos component (total)	Comments
Tailing material				
SS12	MABE, top of the new factory tailings	0-0,3	**2,9 %**	**Chrysotile asbestos** (BIA Method)
EB 20	eastern tailings with covering material	0-0,3	**+**	individual **actinolite rods**, individual **chrysotile asbestos**
EB 21	northeastern tailings with covering material	0-0,3	**+**	individual **actinolite rods**, individual **chrysotile asbestos**
EB 22 (formerly SS 13)	Tailing material, top of the new factory tailings	0-0,3	**30 bis 35 %**	**Chrysotile asbestos** (BIA Method)

- no asbestos **+** individual asbestos **++** much asbestos (here bundles)
ULG Upper limit of the ground

Within the scope of the investigations, a comparative investigation of a soil sample using both methods (BIA Method: quantitative and Marburger Method: half-qualitative) was conducted to assess the two methods. The results show that for a detection of asbestos and a weight component of < 0.1 % w/w according to the BIA Method using the Marburger Method asbestos fibers (individual) are likewise to be detected. This way it can be roughly assumed that the detection limit of the BIA Method approximates that of the Marburger Method. Should many asbestos fibers be detected according to the evaluation matrix in the Marburger method, it is to be presumed that the weight component lies clearly above 0.1 % w/w.

The grown soil in the southwestern to western area bordering the mine display very little to individual asbestos (chrysotile) near the surface (0 to 0.3 m). In the mud samples from the runoff area of the tailings and the Aliakmon, individual asbestos fibers (chrysotile) were likewise detected. It is to be inferred from this that the asbestos component in all samples does not significantly exceed 0.1 % w/w.

In the filling material and the mud in the mine, much asbestos (chrysotile) was detected as a rule. The mud sample displayed an asbestos content of 1.3 % w/w. In the soil sample EB 15 (0-0.3), rods were also identified next to fibrous components. These are likely particles from the antigoritic outcome rock (antigorite displays the same analytic spectrum as chrysotile). These particles fulfill the WHO criteria concerning fiber geometry, but are not to be classified as chrysotile due to their morphology (not spliced).

In the area of the public road, near-surface soil material containing asbestos was identified. This is material which displays many fibrous components and/or rod-shaped particles (see above).

In the area of the tailings, near-surface materials of the new factory tailings (fine-grained waste from the production operation) and the piled up soil for covering was investigated. The fine-grained wastes show an asbestos fraction of maximal 35 % w/w. In the soil made ready for covering, individual asbestos fibers (chrysotile) were likewise detected. It is to be inferred then that the asbestos fraction in both samples does not significantly exceed 0.1 % w/w.

3.3.3 Water

In the selected water samples, the following contents of asbestos fibers were detected using the TEM Method:

Table 18: Overview of the investigation results of selected water samples

Label	**Sampling date**	**Sampling location**	**mean fibre concentration** [Mio fibres/litre]		**Asbestos type**
			Greater than 5 µm	Less than 5 µm	
Aliakmon / Polifito					
WS 2	25.07.2005	Upstream from the dam under construction, **upstream from MABE**	NSS ND NSS (**15.8**)	1,800 ND 1,800	Chrysotile Amphibole Total (sensitivity)
WS 3	25.07.2005	Rimnio bridge (SE side), **downstream from MABE**	NSS ND NSS (**3.16**)	310 NSS 320	Chrysotile Amphibole Total (sensitivity)
WS 5	26.07.2005	Runoff from MABE; **downstream of the tailings**	NSS ND NSS (**16.0**)	1,700 140 1,800	Chrysotile Amphibole Total (sensitivity)
Mine lake					
WS 4	25.07.2005	MABE mine lake, SE entrance	**24** ND **24** **(4,8)**	800 ND 800	Chrysotile Amphibole Total (sensitivity)

WS water sample
ND no countable fibres detected
NSS not statistically significant (1 to 3 countable fibres)

The identification of asbestos fibers in TEM occurs with a sample volume of 0.3 to 1.0 ml and requires significant thinning due to the very high load of short fibers (smaller than 5 µm). Between ca. 100 and 170 fibers of all fiber lengths (larger than 0.5 µm) were counted in all samples. In each water sample, at least one asbestos fiber with a fiber length longer than 5 µm was identified. The evaluation method does not allow for a calculation of an average on the basis of one fiber found. A statistical evaluation (95 % confidence interval) of one fiber found for the thinning factor used would lead as calculated to a possible asbestos fiber concentration in the water samples of the Aliakmon **of a maximum 18 to 90 Mill. fibers/liter**. The middle asbestos fiber concentration (statistically not insured) corresponds to the analytic sensitivity (see Table 18) of the individual investigation for one fiber found.

In the water sample from the mine lake, a statistically secure middle asbestos concentration of **24 Mill. fibers/liter** (95 % confidence interval: **maximal 57 Mill. fibers/liter**) was determined for the "critical" fiber lengths.

3.3.4 Air

In the selected air samples of the stationary measurements, the following contents of asbestos fibers were detected in accordance with VDI 3492:

Table 19: Overview of the investigation results from stationary air measurements (without resuspension)

<table>
<tr><th rowspan="2">Sam-pling location</th><th rowspan="2">Label</th><th rowspan="2">Date</th><th rowspan="2">Comments</th><th>Wind</th><th colspan="2">Asbestos content [fibers/m³]</th><th rowspan="2">Asbestos type</th></tr>
<tr><th>Direction Beaufort</th><th>Measure-ment value</th><th>Upper limit (95%-confidence interval)</th></tr>
<tr><td>site facility</td><td>A P 1</td><td>22.07.05</td><td>Little used
public road,
asphalted</td><td>NNW
1-3</td><td>< 130</td><td>380</td><td>Chrysotile</td></tr>
<tr><td colspan="8">Downwind of the factory</td></tr>
<tr><td rowspan="2">AS 1</td><td>A 1.1</td><td>23.07.05</td><td rowspan="2">NW surrounding area of the mine</td><td>N-NE
1-3</td><td>> 100</td><td>310</td><td>Chrysotile</td></tr>
<tr><td>A 1.2</td><td>13.09.05</td><td>NW-NE
1-2</td><td>790</td><td>2.030</td><td>Chrysotile</td></tr>
<tr><td rowspan="2">AS 2</td><td>A 2.1</td><td>23.07.05</td><td rowspan="2">N area surrounding the mine</td><td>N-NW
1-3</td><td>300</td><td>890</td><td>Chrysotile</td></tr>
<tr><td>A 2.2</td><td>14.09.05</td><td>N-NW
1-2</td><td>1.300</td><td>3.330</td><td>Chrysotile</td></tr>
<tr><td colspan="8">Downwind of the tailings / on the tailings (1)</td></tr>
<tr><td rowspan="2">AS 3</td><td>A 3.1</td><td>23.07.05</td><td>N entrance to mine,
occasional sampling vehicle</td><td>NE
1-2</td><td>1.010
3.790
4.790</td><td>1.940
5.620
7.930</td><td>Amphibole
Chrysotile
Total</td></tr>
<tr><td>A 3.2</td><td>13.09.05</td><td>No traffic</td><td>changing,
1-2</td><td>790</td><td>2.030</td><td>Chrysotile</td></tr>
<tr><td rowspan="2">AS 4</td><td>A 4.1</td><td>25.07.05</td><td>NE area surrounding mine,
public road,
gravel</td><td>E
1</td><td>120</td><td>680</td><td>Chrysotile</td></tr>
<tr><td>A 4.2</td><td>13.09.05</td><td>Occasional truck traffic</td><td>changing,
1-2</td><td>n.a.</td><td>> 100.000</td><td>Chrysotile</td></tr>
<tr><td>AS 9</td><td>A 9.1</td><td>14.09.05</td><td>On the factory tailings</td><td>still</td><td>< 880</td><td>2.650</td><td>Chrysotile</td></tr>
<tr><td colspan="8">Table continued on the following page</td></tr>
</table>

Table 19 continued:

Sam-pling location	Label	Date	Comments	Wind	Asbestos content [fibers/m³]		Asbestos type
				Direction Beaufort	Measure-ment value	Upper limit (95%-confidence interval)	
Downwind of the mine / in the mine							
AS 5	A 5.1	26.07.05	SE surroundings of the mine	NE 1-3	850	1.700	**Chrysotile**
	A 5.2	14.09.05		changing, 1-2	< 230	680	**Chrysotile**
AS 6	A 6.1	26.07.05	SW surroundings of the mine	NE 2	> 100	310	**Chrysotile**
AS 7	A 7.1	23.07.05	in the Mine, work surface 510 m	changing 0-3	170	940	**Chrysotile**
	A 7.2	25.07.05		changing 1	> 120	370	**Chrysotile**
	A 7.3	26.07.05	in the Mine, **parallel reconnaissance work** (material sampling)	W 1	1.580	**8.820**	**Chrysotile**

AS air sample

(1) The sampling location AS 3 is found in the downwind area of a „hot spot“ (wild asbestos deposit next to the measurement station)

* The filter sample A 4.2 was over-allocated according to investigation regulation VDI 3492 (filter allocation more than an eighth of the counting field). Due to the visible asbestos fibers, the concentration can be roughly estimated.

Due to the prevailing winds during air sampling in the area of the site facility (AP 1), it can be inferred that the asbestos content of 380 fibers/m^3 (0.00038 fibers/cm³) determined only reflects the background loading of the MABE surroundings without significant influence of the former mining operation.

In the area downwind of the factory (AS 1 and AS2), a maximum asbestos concentration of 3,300 fibers/m^3 (0.0033 fibers/cm^3) was determined. The influence of the tailings cannot be assessed for certain, as on one side a gravel public road and a wild asbestos deposit (asbestos product with damaged packaging) are also located in the wind. The investigations resulted in a maximal value of greater than 100,000 asbestos fibers/m^3 (> 0.1 fibers/cm³). The increased values were likely affected by the truck traffic on the gravel road. Through the influences of traffic, less influenced measurements produced a maximal concentration of 7,930 fibers/m^3 (0.00793 fibers/cm³).

For the investigations in the mine (depth of 510 mNN), a maximal asbestos content in the air of 8,820 fibers/m^3 (0.00882 fibers/cm^3) was determined. For the air investigations in the area bordering the mine, asbestos contents the same level as the background loading were determined in part.

The simulation of work conditions in various areas of the MABE property resulted in the following investigation results:

Table 20: Overview of the investigation results from stationary air measurements (with resuspension)

Sam-pling location	Label	Date	Comments	Wind	Asbestos content [fibers/m³ (fibers/cm³)]		Asbestos type
				Beaufort	Measure-ment value	Upper limit (95%-confidence interval)	
AS 7	A 7.4	14.09.05	in the mine work level 510 m	still	278.860 (0.279)	**399.260** (0.399)	**Chrysotile**
AS 8	A 8.1	14.09.05	On the property, next to main building	NE 1-2	n. a.	**> 3 Mio*** (3)	**Chrysotile**
AS 9	A 9.2	14.09.05	On the factory tailings	S-SE, 1	144.630 (0.145)	**212.690** (0.213)	**Chrysotile**
AS 10	A 10.1	13.09.05	in the mine, LF 1	W 2-3	442.910 (0.443)	**684.450** (0.684)	**Chrysotile**
AS 11	A 11.1	13.09.05	in the mine, LF 2	NW 1-2	163.610 (0.164)	**267.720** (0.268)	**Chrysotile**

AS air sample

* The filter sample A 8.1 was over-allocated according to investigation regulation VDI 3492 (filter allocation more than one eighth of the counting field). Due to the visible asbestos fibers, the concentration can be roughly estimated.

The highest release of asbestos fibers into the air was determined in the area surrounding the factory building, with a fiber concentration of over 3 mill. fibers/m³ (> 3 fibers/cm³). In the remaining measurements, the content of asbestos fibers in the air lay clearly above 200,000 fibers/m³ (0.2 fibers/cm³).

In the air samples from the personal measurements selected, the following contents of asbestos fibers were determined according to ZH1/120-46 (today: BGI 506-46):

Table 21: Overview of the investigation results from selected personal air measurements

Label	Date	Comments	Asbestos content [fibers/m³ (fibers/cm³)]		Asbestos type
			Measurement value	Upper limit (95% confidence interval)	
AP 5	26.07.05	S area surrounding mine, inspection and air sampling	1.670 (0.00167)	9.290 (0.00929)	**Chrysotile**
AP 6	13.09.05	in the mine, LF 1, **air sampling with resuspension**	78.710 (0.07871)	113.050 (0.11305)	**Chrysotile**
AP 7	13.09.05	N area surrounding mine, inspection and air sampling	12.550 (0.01255)	25.850 (0.02585)	**Chrysotile**
AP 9	14.09.05	in the mine, inspection	9.500 (0.0095)	21.360 (0.02136)	**Chrysotile**
AP 10	14.09.05	top of the factory tailings, inspection and air sampling	2.290 (0.0029)	12.750 (0.01275)	**Chrysotile**
AP 11	15.11.05	top of the mine tailings, inspection and **soil sampling**	13.330 (0.01333)	26.440 (0.02644)	**Chrysotile**

LF landfill area
AP personal air sample

During the reconnaissance work, a maximal workplace concentration (asbestos) of 113,050 fibers/m³ (0.113 fibers/cm³) was determined. The highest values were reached in combination with the work to simulated the construction operation. The remaining investigation results are on the size order of ca. 10,000 to 26,000 fibers/m³ (0.001 to 0.0026 fibers/cm³) and reflect workplace concentrations for field work (inspection, air and soil sampling) which in contrast to the simulation produce clearly lower releases of asbestos fibers.

In the selected adhesive tape samples, the following asbestos fiber contents were detected in the SEM investigation:

Table 22: Overview of the investigation results of selected adhesive tape samples

Sample label	**Date**	**Sampling location**	**Classification of the asbestos fraction** (Hamburg evaluation scheme)	**Comments**
Rock and vegetation surfaces in the mine				
TS 1	23.07.05	Rock surface by sampling point AS 7	1 (1)	**Two large bundles, chrysotile asbestos**
TS 14	26.07.05	Vegetation next to construction road in the mine	0	No asbestos
TS 19	14.09.05	Vegetation next to northern mine entrance	0	No asbestos
TS 20	14.09.05	Vegetation next to northern mine entrance	0	No asbestos
Building, road and vegetation surfaces of the factory property				
TS 15	14.09.05	Next to administrative building; Road in outer area	3	**Obvious chrysotile asbestos**
TS 17	14.09.05	Cross-beam next to conveyor belt in the area of the tailings	5	**Much chrysotile asbestos**
TS 18	14.09.05	In factory building, packing, floor area	5	**Very much chrysotile and amphibole asbestos (2)**
Vegetation surfaces in surroundings				
TS 8	26.07.05	Vegetation next to runoff area SS 8, ca. 100m in front of E-Station	0	No asbestos
TS 9	26.07.05	Vegetation next to quarry entrance, at runoff area SS 7	0	No asbestos
Vegetation surfaces on the tailings				
TS 12	26.07.05	Vegetation on the new factory tailings	0	No asbestos
TS 16	14.09.05	Vegetation in the area of the new factory tailings	4	**Much chrysotile asbestos**
Monastery				
TS M1	26.07.05	Vegetation in the monastery courtyard	0	No asbestos
TS M3	26.07.05	Foot board in the monastery chapel	0	No asbestos
TS M5	26.07.05	Wooden components of exterior facade, northwest side of monastery	0	No asbestos
TS M7	14.09.05	Clinker surface next to brook in monastery	2	**few chrysotile asbestos**
TS M8	14.09.05	southeastern windowsill of exterior facade, residential building in monastery	0	No asbestos

TS adhesive tape sampling

continue table 22:

(1) Except for two large asbestos bundles on the edge, practically no other particles of the same type could be found on sample TS 1. There is certainly more asbestos on this sample than on sample TS 15 with clearly smaller but multitudinous asbestos occurrences.
(2) In sample TS 18, blue asbestos (crocydolite) was found aside from chrysotile asbestos. The origin of the blue asbestos in the dust of the factory building is currently unknown.

The investigations on selected adhesive tape samples in the MABE area (mine, factory premises, tailings and monastery) and in the surrounding area, depending on the climatic conditions at the time, resulted in a significant secondary asbestos loading in the area of the factory property (roads, conveyor belt, in the factory building), a significant primary or conditional secondary asbestos load on the vegetation of the tailings and occasionally a secondary asbestos loading in the area of the monastery. At the time of the sampling (July 2005), no secondary asbestos dust was detected on the surfaces in the farther surroundings of MABE (vegetation next to access road) and in the monastery. Sensoric fibrous components could be recognized on the vegetation in the area of the mine (see photo documentation, attachment 8). The adhesive tape samples taken however show no secondary asbestos dust deposits.

3.4 Results of the meteorological investigations

The climate in Greece can generally be characterized as a subtropical winter rain climate. The winters are moist and relatively mild, and the summers are warm and dry. The climate region of northern Greece corresponds to a Mediterranean to continental climate type.

3.4.1 Precipitation

The average amount of precipitation lies between ca. 450 and 600 mm/year [20]. In 2004, an annual precipitation amount of 440 mm/year was determined in the near-by measurement station Ilariona (attachment 10). The largest part of the precipitation is determined through the cold winds (N to NE winds) which come from middle to eastern Europe in the winter half-year.

Prior to the first measurement campaign (July 2005), 17.6 mm of precipitation fell in a thunderstorm after a ca. one month dry spell in the investigation area. Before the start of the reconnaissance work in September 2005 (13.09. to 14.09.), precipitation of 3.5 mm was measurement in the measurement station Ilariona on 12.09.2005, after more than a month-long precipitation-free period. This fell during the early morning hours on 14.09.2005 before the start of the measurements (see attachment 10). The precipitation dates for the measurement time period of November 2005 were not available to us.

At the time of the air measurements in July and September 2005, there were no prevailing representative conditions for these times of year as a rule, on the basis of the above-mentioned data.

3.4.2 Wind direction and speed

The prevailing cold winds (N to NE winds) from middle and eastern Europe in the winter half year can exhibit wind speeds up to 6 Beaufort (ca. 50 km/h) (http://www.wetteronline.de/).

The location of the Pindos to the West of MABE influence the appearance of Foehn wind (mainly west winds). The prevailing wind direction in the investigation area is North to Northwest, according to the Kozani weather station records (http://www.wetteronline.de/). In the Summer months, the lowest wind speeds are measured (ca. 2 to 3 Beaufort: maximum ca. 20 km/h) as a rule.

During the field work in July 2005, mainly winds from the Northwest to Northeast direction were observed locally, the wind speeds of which changed from between 1 to 3 Beaufort (ca. 1 to 20 km/h). In the mine on the other hand, changing wind directions with low wind speeds could be determined. The sampling in September 2005 is marked by seasonally and locally varying winds (at the time NW to NE, S to SE and W) with a wind speed lower compared to the July measurement in general (1 to 2 Beaufort: maximum ca. 10 km/h) and still winds in part.

Due to the strongly varying wind conditions, only limited clues to asbestos sources can be derived from the September measurements. During still winds, generally no weather-influenced asbestos fiber release into the air is to be accounted for.

3.4.3 Temperature

The average annual temperature fluctuation in the region is more than 20 °C, whereas in Winter a monthly average value of ca. 7 °C (maximum) and marginally below zero degrees prevails. As a result, frost and snow must be taken into consideration in the winter months (see attachment 10).

The following min. and max. temperatures were determined during the reconnaissance at the vantage point at the edge of the mine (measurement point AS 2):

Table 23: Overview of the temperatures during the field investigations

Investigation time period	minimum temperature	maximum temperature
25.07. to 27.07.2005	21 °C	32,5 °C (42° C in strip mine)
13.09. to 14.09.2005	20 °C	30° C
15.11.2005	7°C	15 °C

3.4.4 Humidity

The relative humidity reaches on average from 1969 to 2000 the highest values (ca. 80 %) in the Winter months. In the Summer months, a minimum an average of 50 % humidity is reached.The middle annual humidity is ca. 60 to 65 % [20].

The following minimum and maximum humidity values were determined during the reconnaissance at the vantage point on the edge of the mine (AS 2):

Table 24: Overview of humidity during the field investigations

Investigation time period	Minimum humidity [%]	Maximum humidity [%]
25.07. to 27.07.2005	34°rF	76 rF
13.09. to 14.09.2005	27 rF	71 rF
15.11.2005	52 rF	85 rF

The humidity reached its maximum during early morning and decreases continually with increasing air temperature until late afternoon. The humidity values prevailing in July 2005 are somewhat higher in contrast to the long-standing mean of the Summer months (50 % rF). The values determined in September 2005 (ca. 49 %) lie in the range of the Summer mean values. The humidity during November measurements (ca. 70 %) is classified as below average in contrast to the long-standing mid values (ca. 78 %) (see attachment 10).

4 Summary of the investigation results

Von Lieberman Ltd investigated the environmental components water, soil, air and rock for asbestos in three phases (July, September and November 2005). The focus of the investigations concentrated mainly on the immediate area of the asbestos mine.

An assessment of the results concerning the potential source and emission into the environment of asbestos fibers can only occur, however, if the entire situation (area surrounding the mine: factory premises, tailings, Aliakmon (Polyfito) etc.) are measured metrologically. For this reason, representative water samples, among others, were taken from the Aliakmon (Polyfito) up- and downstream from MABE, and were tested for asbestos fiber content. In addition to this, near-surface material samples (mud and factory residues) were taken from the top of the tailings with finely broken material and sediments of the Aliakmon runoff, and likewise tested for asbestos content. Furthermore, dust swab samples of vegetation-, rock- and building surfaces were taken and the presence of asbestos fibers was determined.

4.1 Investigation of rock

The serpentinite rock mined in the mine can generally be classified as antigorite serpentinite. The predominant mineral is antigorite. In the photo-documentation (appendix), various forms of antigorite are reproduced under the microscope.

On a comprehensive survey of the quarry walls, one can recognize an irregular alternation of darker and lighter colors in the rock (see appendix). In the darker components of the rock, the serpentinite is “fresh”, dark grey and dense. The antigorite here is microcrystalline and finely foliated. Frequently, green areas of the rock millimetre- to centimetre-, even decimetre-thick develop within the dark grey rock. The green parts are composed of relatively coarsely foliated antigorite. The color of the rock is then dependent on the grain size of the antigorite. Pure, relatively coarsely foliated antigorite leads to green serpentinite varieties. Their formation likely occurred during a later phase of the serpentinisation process in rock fissures.

On fissure surfaces of this „green serpentinite“, a „striping“ frequently occurs and subsequently a fibrous formation of green serpentinite crusts. With this, the formation of the fibrous serpentine, namely chrysotile, is triggered (see appendix, Fig. 4 and 9 through 11).

The lighter (brownish) rock colourings in the quarry (see appendix, Fig. 1 and 2) can be attributed to occurrences of secondary weathering. The “purity” of the antigorite serpentinite is “clouded” by fine distribution of carbonate (magnesite and/or dolomite) and “Fe(III) oxides”. From this, the rock has a lighter grey colour. Because the weathering is stronger on the fissure surfaces, an all-around lighter (brownish) colouring appears on the quarry walls (see appendix, Fig. 1 and 2). It should be mentioned in this summary that long-fibered serpentine (chrysotile) does not occur in green tones, rather in yellowish and light grey tones on these weathered surfaces (see appendix).

The fine weathering products displaced from all surfaces of the excavation steps, which are washed out of the quarry and surrounding area by rainwater, play a special role. The x-ray testing of mud samples revealed varying amount of fibrous serpentine, carbonate (calcite) and chlorite as the main minerals (see appendix, Fig. 14). The “clayey” weathering material displaced shows a fine coating, and a thinly layered crust building up on the surface which, due to the interweaving of fine serpentine fibers, is very stable and elastic.

4.2 Soil and mud investigations

The following connections arise from the reconnaissance of the soil ratios in the surrounding area of the mine (tailings, runoff sediments):

- In the filling materials (outcome rock: serpentinite) and mud of the mine, much asbestos was generally found. The mud sample showed an asbestos content of 1.9 % w/w.
- In the area of the public road, near-surface soil materials containing asbestos were identified.
- The sediments of the new factory tailings have a near-surface asbestos component of maximal 35 % w/w. In the residues from production (tailing material), a significant asbestos component has remained. The issue here is fibrous components not technically realizable: short fibers or fibers bound in the rock which still meet the WHO criteria.
- Asbestos fibers were found in the near-surface area in the soils built up for covering (no serpentinite) in the surrounding area of the mine. Asbestos fibers were also found in the sediments from the runoff of the tailings and of the Aliakmon. The asbestos component of 0.1 % w/w is not clearly exceeded in the samples tested.
- It can be assumed that the sediments in the runoff areas which border the tailings have asbestos contents clearly higher than 0.1 % w/w; they lie more in the size-order of 1.7 % w/w.
- The asbestos fibers in the soil and mud are to be classified **generally as weakly-bound.**

4.3 Air investigations

From the stationary and personell air investigations for asbestos in July, September and November 2005, the following conclusions for the asbestos load (excluding WHO fibers) in the environment and for the air pathway can be drawn:

- The background load of the surrounding area of MABE, without substantial influence of the former mining operation, lies below 380 fibers/m³ (0.00038 fibers/cm³) in the air.
- In the mine, without substantial influence of human activities, a maximal asbestos fiber content of 8,820 fibers/m³ (0.008820 fibers/cm³) in the air was determined. Reconnaissance activity and/or a possible construction operation leads to an additional release of asbestos fibers the size order of about 26,000 fibers/ m³ (0,026 fibers/cm³) and ca. 690,000 fibers/m³ (0.69 fibers/cm³).
- The influence of the factory causes a maximal increase of the asbestos fiber load in the air, measured on the periphery of the mine on the size order of 3,300 fibers/m³ (0.0033 fibers/cm³) in the air. A possible construction operation leads, where applicable, to an additional release of asbestos fibers in the area of the factory on the size order of more than 3 mill. Fibers/m³ (> 3 fibers/cm³).
- The influence of asbestos fibers released on the tailings (chrysotile and amphibole) determined on the bordering area of the mine is estimated at a maximum 7,930 fibers/m³ (0,00793 fibers/cm³). Reconnaissance work or a possible construction operation leads to, where applicable, an additional release of asbestos fibers in the area of the tailings on the size order of ca. 26,500 fibers/m³ (0.0265 fibers/cm³) or ca. 213,000 fibers/m³ (0.213 fibers/cm³). The asbestos release cause by construction was determined immediately after moisture penetration (3.5 mm precipitation).
- Through the occasional truck traffic on the gravel public road next to the mine, at times more than 100,000 fibers/m³ (>0.1 fibers/cm³) were released.

Due to the climatic conditions at the time of the sampling, it is to be assumed generally that the asbestos fiber contents in the air are not representative for the respective time of year. Under worse wind and weather conditions (drying out over a longer period of time), clearly higher fiber contents can be expected in the air. This goes equally for times without and with activity (reconnaissance, construction, road traffic).

The results of the dust swab samples in the region of the mine, the construction zone, the tailings and monastery confirm the climatic dependence of fiber release, particularly through precipitation. On the surfaces of rock, of buildings, paved roads and vegetation, a significant secondary asbestos load was found during times of low precipitation.

4.4 Factors which influence the release of asbestos fibers

The following factors which influence a release of asbestos fibers into the environment are deduced, with limitations, from the previously mentioned results of the rock, soil, water and air investigations:

- A mechanical demand on the rock and/or soil through, for example, traffic-, construction- and reconnaissance work increases the release of fibers into the environment significantly.
- Ground moisture minimizes the release of fibers into the air.
- The binding of asbestos fibers in a rock or soil matrix reduces the potential of release due to wind and weather conditions.
- The covering of fine-grained to coarse-grained material containing asbestos minimizes the potential for release due to wind and weather conditions.
- A closed vegetation cover on top of soil containing asbestos minimizes the release of asbestos fibers.
- A location exposed to wind increases the release of asbestos fibers.
- The weathering of the rock releases asbestos fibers, depending on the prevailing climatic conditions.
- Asbestos fibers are spread by the air- and waterways including the sediments (mud) also carried along in the runoff.
- Influencing factors in the spread of asbestos fibers through the groundwater cannot be deviated from the state of investigations at this time.
- The asbestos aggregates, fiber bundles, and fibers disintegrate into the waterway in increasingly smaller constituents and in the end do not fulfill the WHO criteria (fiber length greater than 5 µm.)

4.5 Comparison of the potential for release of asbestos fibers in the airway with data from literature

4.5.1 Planned construction in the mine

The asbestos contents determined throughout the course of the reconnaissance work (July, September and November 2005), and the asbestos contents in the air expected by construction will be compared in the following with reference values from the literature (background values in Germany, work place-related asbestos contents in German quarries) and to old investigations.

By the mining and processing of certain naturally occurring rocks (ultrabasite/ peridotite, alkaline extrusive, alkaline intrusive, metamorphic and metasomatic rock), the occurrence of asbestos in fissures or in the rock itself, and with that an exposure to asbestos of the employees working in the quarries cannot be excluded. In the EU, the operation of such a mine is not allowed if the asbestos content of free fibers falls below a weight component of 0.1 % w/w.

In order to determine the workers´ exposure to asbestos in these quarries in Germany when handling the mineral raw material, the determination of the asbestos fiber concentration in the air in work areas in accordance with BGI 505-46 is to be applied.

In the following table, measurement results from quarries from 1992 on for selected work (mining, loading, transport etc.) with overview to the conditions of exposure and to the asbestos contents in breathable dust is listed.

Tab. 25: Emission-obtained asbestos fiber concentration in quarries, rock type serpentinite.

Work Area	Concentration in F/m³	Comments
Mining: In quarry, 15 m away from excavator. Caving level at loading.	2 800*) (5 600) 34 500	*) The values listed are amphibole asbestos fiber concentrations. The values in parentheses also contain chrysotile asbestos and fragments of antigorite and lizardite in unknown amounts.
Loading: Next to the dump/waste dump Parking area end of conveyer belt end of conveyer belt Loading of material	4 000*) (23 800) 30 000*) (66 600) 46 500 11 600 11 100	

Tab. 26: Asbestos exposure measurement values in quarries, rock type serpentinite.

Work Area	Concentration in F/m³	Comments
Mining: Excavator Excavator Excavator Excavator Drilling machinery Drilling machinery, cabin Drilling machinery, outside	 5 600 9 200 21 600 41 600 50 000*) (224 900) 0 45 500	*) The values listed are amphibole asbestos fiber concentrations. The values in parentheses also contain chrysotile asbestos and fragments of antigorite and lizardite in unknown amounts. NWG [1]) 15 000 F/m³
Delivery/Transport: Wheel loader Wheel loader Wheel loader Wheel loader Freight truck Freight truck	 18 800 10 800 255 300 0 207 200 100 900	NWG 15 000 F/m³
Loading: Transit scale room scale room	 0 0 15 600	 NWG 16 200 F/m³ NWG 7 000 F/m³

[1]) NWG – Limit of detection

continue table 25 and table 26:

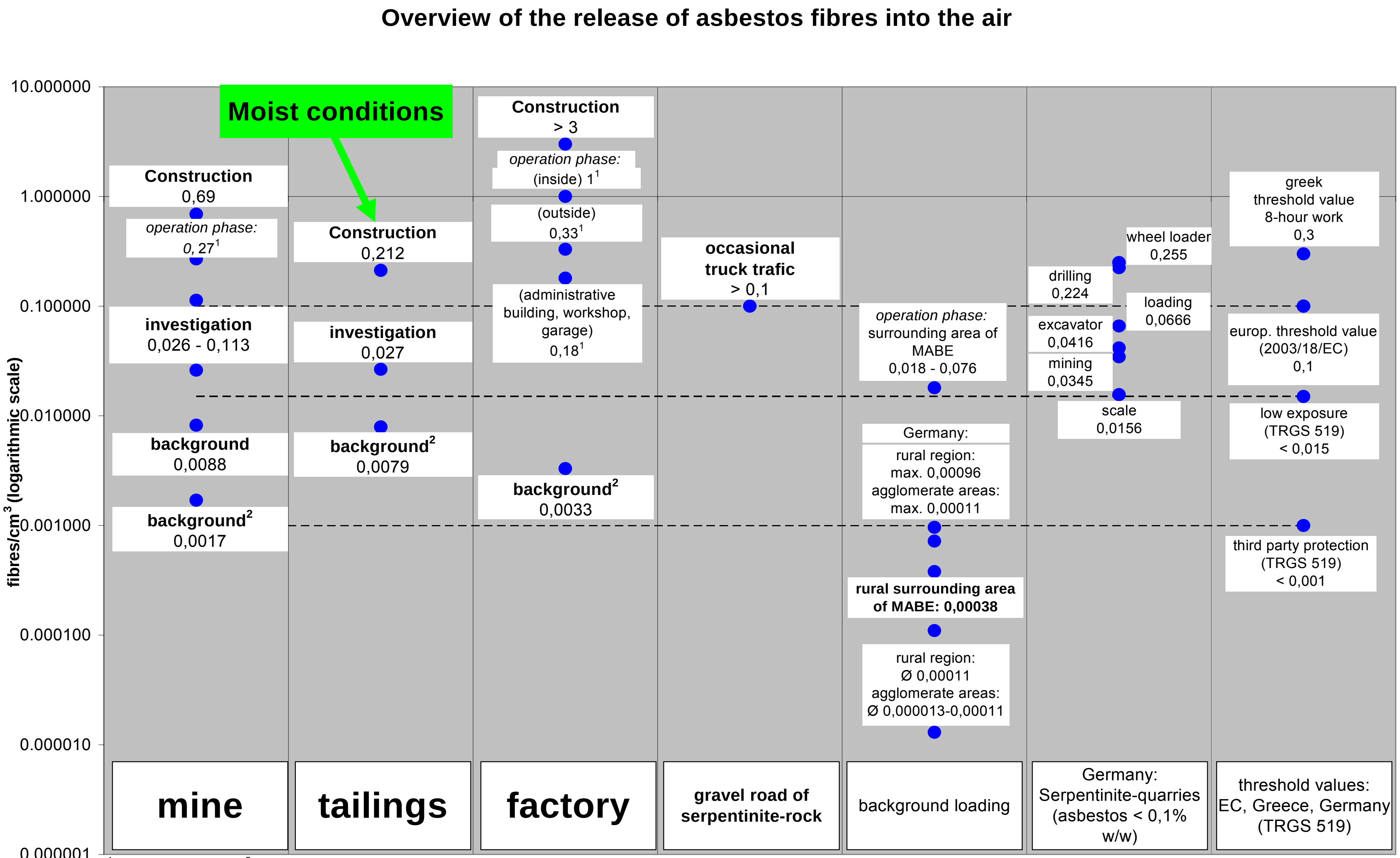
Source of Tables: Instructions on the use of TRGS 954 “Empfehlungen zur Erteilung von Ausnahmegenehmigungen von § 15 a Abs. 1 GefStoffV für den Umgang mit asbesthaltigen mineralischen Rohstoffen und Erzeugnissen in Steinbrüchen” in: Gefahrstoffe – Reinhaltung der Luft 61 (2001) Nr.6 – Juni

The asbestos content in the serpentinite ground and rocks of MABE lies, as a rule, clearly above 0.1 weight %. From the above-mentioned comparison data it is to be inferred that the results of the simulation, that is the asbestos fiber concentration to be expected throughout the course of the construction, can still be clearly surpassed. Even on handling materials containing asbestos in the area of MABE during construction, the asbestos component of which lies below 0.1 weight %, a significant release of asbestos fibers can come about.

The air measurements in the mine during the production phase (until 1997) produced asbestos contents which generally lay below 500,000 fibers/m³ (0.5 fibers/cm^3), on average at 270,000 fibers/m³ (0.27 fibers/cm^3). This confirms the size order of the asbestos fiber release to be expected during construction.

In the following figure, an overview of the investigation results and data for comparison regarding the release of asbestos fibers into the air is depicted.

figure 2: Overview on results of investigation and comparative data (air)



[1] weighted average [2] determinated at the border to the mine

g12653-2_toxic register_(060413)

4.5.2 Background values of the asbestos load

The research of the background loading of asbestos in the air in the surrounding area of MABE has resulted that exclusively measurement results from the surrounding districts are on hand. Rural background values were not available. From the results of the air measurements in the cities in the closer (0.018 to 0.076 fibers/cm³) and farther surroundings (0.025 to 0.052 fibers/cm³), only in the maximum values can an influence of MABE, with limitations, be deduced. Because the evaluation of the air samples was possibly carried out in the already strongly asbestos-loaded quality laboratory of MABE, or no information to the quality of the investigation laboratory is available, the previously mentioned measurement results are not useable for the determination of the general background loading in the region, and depict only very coarse orientating values.

The asbestos load in the air is, contrary to comparable values in Germany, categorized generally as very high. In Germany in agglomeration rooms, for example, a maximum of 760 fibers/ m³ (0.00076 fibers/cm³) and in rural areas maximum of 960 fibers/m³ (0.00096 fibers/ cm³) was determined. On the basis of these background values, a generally applicable remediation success values of 1,000 fibers/m³ (0,001 fibers/cm³) can be applied.

The background loading (asbestos) of the surrounding region during the reconnaissance on the MABE grounds lay below 380 fibers/m³ (0.00038 fibers/cm³). Due to the precipitation which occurred in the investigation area prior to the measurements, this value is to be viewed as too low. Meaningful values for the background loading in the air with asbestos fibers can only be obtained over an extensive regional measurement program.

4.6 Comparison of the potential release of asbestos fibers in the waterway with data from literature

The asbestos contents in surface waters determined during the course of the reconnaissance work (July, September and November 2005) will be compared with comparative values from the literature (asbestos contents in Canadian waters) and old investigations in the following section.

Raw water investigations in Canada [21] have shown that asbestos fiber concentrations in the water the amount of 5 mill. fibers/l are common. Here, these are generally short fibers. The occurrence of longer fibers (> 5µm) in drinking water was commonly connected with areas where rock containing asbestos was present and/or asbestos mines were in operation. In the asbestos mining region of Quebec, the asbestos contents in the surface water lay for example at 1.000 mill. fibers/l. The component of asbestos fibers with a fiber length of > 5µm varied in the above-mentioned investigations between 0.01 and 5% of all fibers found. The results were confirmed by American and Swedish investigations.

The asbestos concentrations found in the surface water of the MABE mine (800 mill. fibers/l) lie in the above-mentioned size order of waters from the area of asbestos mines. The component of longer fibers (24 mill. fibers/l) belied ca. 0.03 % of all fibers found and likewise represents the results of the comparative investigations.

The background loading of the Aliakmon regarding asbestos fibers (all fiber lengths) was determined to be 2,300 to 3,100 mill. fibers/l in 1985 in an investigation by a Canadian institute. The physical investigations by a Greek laboratory (University of Thessaloniki) in 1997 to 2000 resulted, on the other hand, in a background loading of the Aliakmon of ca. 0.9 mill. asbestos fibers per liter.

The asbestos loading in the Aliakmon (ca. 1.700 mill. fibers/l) determined during the reconnaissance (July 2005) is more on the size order of the Canadian investigation results in the surrounding area of MABE from 1985 (3.700 fibers/l).

From the previously mentioned comparative values and the results from the reconnaissance, it should be inferred that the Greek investigation results for asbestos in water samples can generally be classified as very low. The input area of the Aliakmon is in the MABE area, and in its upstream flow, ophiolitic rock can be recognized, which characterize for example significantly higher chrome concentrations in the chemistry of the Aliakmon [20]. The elevated concentration of longer asbestos fibers (up to 20 % of all fibers found) in the Greek investigation indicates the presence of rock containing asbestos in the input area, which cause clearly higher asbestos concentrations in the surface water to be expected.

On the basis of both investigations, an increase in the asbestos load and, with limitations, the influence of MABE in the operational phase can be eliminated through the comparison with the water samples taken up-stream from MABE in the Aliakmon. In addition, in the Canadian investigation, amphibole fibers (ca. 0,4 %) were found only up-stream from MABE.

Throughout the course of the reconnaissance (July 2005), an asbestos fiber load in the Aliakmon was determined (1,800 mill. fibers/l) which is more along the size order of the Canadian investigation results (max. 3,700 mill. fibers/l). The investigation did not permit any statistically validated conclusion with regard to the “critical” asbestos fibers (fiber length larger than 5 µm). On the basis of the size order of the asbestos load (all fiber lengths) of the water, no influence from MABE could be determined. Solely the evidence of amphibole fibers downstream from MABE, if so, suggests such an influence. A possible source for the amphibole fibers found in the Aliakmon could be the amphibole fibers carried from the mine tailing materials through the air- and/or waterway, which were found in this material next to chrysotile.

An influence of the asbestos-loaded water of the mine lake on the Aliakmon cannot be determined due to the lack of groundwater measurement sites downstream. A rough estimate of the hydrological and hydrogeological situation (current water level of the mine lake assessment of the database on hand for an initial water balance of the mine lake, permeability of the bedrock etc.) is not available at this time.

Only a renewed investigation in Spring 2006 with adjusted sampling and modified directions for analysis (use of a filter with a mesh width of 0.1µm) will bring a statistically validated conclusion concerning the presence of “critical” asbestos fibers (chrysotile and amphibole) in the Aliakmon. During the course of the Spring investigation, ground water surfacing (brooks, springs, etc.) in the surroundings of MABE can be tested and investigated regarding their asbestos fiber load.

The asbestos load in sediments from the runoff area of the MABE tailings indicates, however, that generally, asbestos fibers from the MABE area are carried through the waterway in the Aliakmon. The extent of the effect on the water quality in the Aliakmon cannot be quantified at the moment on the basis of the investigations, but is estimated to be significant, particularly at times of sudden strong rains and snow melts.

In addition, if construction occurs on the tailings and large amounts of the mine material is loosened, precipitation can lead to a significant avulsion of asbestos fibers in the discharge system. On the tailings, asbestos concentrations were determined to be 2.9 % w/w in the mud. The suspended load of the runoff caused by the construction causes an asbestos load of similar size order to be expected, due to the above-mentioned information.

4.7 Conclusions

The EU LIFE Environment Project LIFE 03/ENV/GR000214 has the goal of developing an innovative solution for the mine rehabilitation. Next, the environmental situation in the MABE area, particularly in the area of the mine should be investigated in order to identify the areas contaminated with asbestos, to make possible an evaluation of the remediation priority, and to determine the special requirements for work and emission safety for the planned work.

On the basis of present knowledge, a significant release of asbestos fibers into the environment occurred during the operation of the mine and processing plant.

The investigation results from von Lieberman Ltd show that

- in all environmental components (rock, soil, water, air), asbestos fibers (chrysotile and in part amphibole) are to be found,
- through weathering or mechanical demands, the asbestos fibers are detached from the rock or soil matrix and spread via the air and/or water ways into the environment,
- a significant release of asbestos fibers (so-called “critical” fibers according to WHO criteria) occurs in the environment, dependent on the climatic conditions and the activities carried out (reconnaissance, traffic, construction) on the MABE premises,
- the asbestos fibers in the rock are to be classified more as strongly bound; those in soil or fine-grained material more as weakly bound,
- without special work and emission safety measures for handling (traffic, reconnaissance, construction: dismantling, loading, transport and unloading) MABE soils or materials containing asbestos, significant additional damage to the environment is to be expected (rough estimate for the airway: 10 to 1,000 times the current load) and
- the air emission of asbestos fibers from the tailings and factory area has a significant influence on the mine.

Under present conditions of use, only the public road without asphalt east of the mine is seen as a **“hot spot”** in the mine area of MABE. No other areas are identifiable wich show a heightened potential for release of asbestos fibers, compared with the mine.

The “wild burials” of pure raw asbestos (on the tailings and by the weather station), the tailings which are not covered with topsoil, as well as the factory with its operational buildings and the pilot plant pose as “hot spots” on the MABE premises, in relation to the mine.

The asbestos concentration **of all fibres** (fiber length larger than 0.5 μm) of the lake`s water is comparable to the asbestos concentration of the Aliakmon.

On the basis of the size order of the asbestos load (all fiber lengths) of the Aliakmon water, no influence from MABE could be determined. Solely the evidence of amphibole fibers downstream from MABE, if so, suggests such an influence. A possible source for the amphibole fibers found in the Aliakmon could be the amphibole fibers carried from the mine tailing materials through the air- and/or surface waterway, which were found in this material next to chrysotile.

An influence of the asbestos-loaded water of the mine lake on the groundwater and the Aliakmon cannot be determined due to the lack of groundwater measurement sites downstream. A rough estimate of the hydrological and/or hydrogeological situation (current water stand in the mine lake, evaluation of the data base on hand for an initial water balance for the mine lake, permeability of the bedrock, etc.) is not available at this time.

Only a renewed investigation in Spring 2006 with adjusted sampling and modified directions for analysis (use of a filter with a mesh width of > 0.1μm) will bring a statistically validated conclusion concerning the presence of “critical” asbestos fibers (chrysotile and amphibole) in the Aliakmon. During the course of the Spring investigation, wells on the MABE premises and ground water surfacing (brooks, springs, etc.) in the surroundings of MABE can be tested and investigated regarding their asbestos fiber load. A concluding assessment of the decontamination urgency kann only be given on the basis of the aforementioned results.

von Lieberman GmbH
A co-operative partner of Sakosta Holding AG

A. von Lieberman, Dipl.-Ing.
sworn asbestos expert

i.A. A. Rudnik, Dipl.-Geol.
sworn asbestos expert

Ingenieurgesellschaft
von Lieberman
» Bauen und Umwelt «

Attachment 1

Layout of MABE
(scale 1 : 200.000)

[1 map]

Attachment 2

site plans

[5 maps]

Ingenieurgesellschaft
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» Bauen und Umwelt «

Attachment 2.1

Sampling points and results of rock investigation
(scale 1 : 5.000)

[1 map]

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» Bauen und Umwelt «

Attachment 2.2

Sampling points and results of soil investigation
(scale 1 : 5.000)

[1 map]

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Attachment 2.3

Sampling points and results of air measurements
(scale 1 : 5.000)

[1 map]

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Attachment 2.4

Investigation points and results of adhesive tape sampling
(scale 1 : 5.000)

[1 map]

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» Bauen und Umwelt «

Attachment 2.5

**Investigation points and results of
water-, soil, sludge- and
adhesive tape sampling measurements
in the surroundings
(without scale)**

[1 map]

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Attachment 3

geological maps

[2 maps]

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» Bauen und Umwelt «

Attachment 3.1

geological map,
1 : 50.000

(ANKO Research)

[1 map]

Ingenieurgesellschaft
von Lieberman
» Bauen und Umwelt «

Attachment 3.2

**geological map,
geological cross-section,
without scale**

(Kozani asbestos mine, von Lieberman GmbH from July 17 2002)

[1 map]

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Attachment 4

Sampling protocol
water and air

[36 pages]

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» Bauen und Umwelt «

Attachment 4.1

Sampling protocol
water

[6 pages]

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Attachment 4.2

**Sampling protocol
air**

[30 pages]

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Attachment 5

Analysis of water samples
by transmission electron microscopy
for the presence of asbestos

[30 pages]

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» Bauen und Umwelt «

Attachment 6

Exploratory boring profiles in accordance with DIN 4022/23

[22 pages]

Ingenieurgesellschaft
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» Bauen und Umwelt «

Attachment 7

Former investigations

excerpts from:

[5]: Documentation of the monthly asbestos fiber measurements of the air in the factory, mine, and area surrounding MABE from the years 1986 to 1994. ANKO Research Nr. 25.
[6]: Documentation of asbestos fiber measurements of the air in towns neighboring MABE from the years 1993 to 1997. ANKO Research Nr. 26.
[7]: Analysis of asbestos investigations of the air in MABE from 1989 to 1994. ANKO Research Nr. 27.
[8]: Safety in the use of asbestos - Code of practice. Hellenic Mineral Mining Company SA, 1997. ANKO Research Nr. 15.
[14]: MABE. Letter to the responsible bureau of the Prefecture from 23.06.1986. Analyses of five water samples for the presence of asbestos. Sheridan research community. ANKO-Recherche Nr. 7.
[15] Occurrence, detection and origin of asbestos fibres in the waters of the Aliakmon river system. Laboratory on monitoring environmental pollution, Institute for Chemistry, University of Thessaloniki, and the area Mineralogy/Petrology/Sedimentology, Institute for Geology, University of Thessaloniki. Published in Proceedings of the 1st Conference of the Technological Educational Institution (T.E.I.) with the theme "Mineral Wealth and Environment in Macedonia. February 2000.

[45 pages]

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Attachment 8

Photo documentation

Asbestos investigation (task 1), July 2005 [21 pages, 39 pictures];
rock investigation (task 1), July and September 2005 [12 pages, 22 pictures];
Asbestos investigation (task 1), Sseptember 2005 [7 pages, 11 pictures]

[40 Pages]

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Attachment 9

Regulations for the analysis methods

[132 pages]

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Attachment 9.1

Determination of airborne fibre number concentrations, WHO 1997

[53 pages]

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Attachment 9.2

Method for the separate determination of asbestos and other organic fibres: scanning electron microscopic method (ZH1/120/46)

[13 pages]

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Attachment 9.3

Measurement of inorganic fibrous particles.
Scanning electron microscopy method.
VDI 3942

[58 pages]

Attachment 9.4

Methods for the analytic determination of low mass amounts of asbestos fibers in powders and dusts with SEM/EDX

(BIA-Arbeitsmappe 18. Lfg. IV/97, Nr. 7487)

[8 pages]

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Attachment 10

Regional and local climate data

Average weather data between 1996 to 2000
for temperature and humidity -Kozani- [11]

Weather data (June – Nov 2005),
humidity / air pressure
min- and max.- temperature -Kosani- [wetteronline.de]

Daily rainfall, single measurements (Dec 03 to Sept 05)
weather station Ilariona [DEI]

Monthly rainfall (Dec 03 to Sept 05)
weather station Ilariona [DEI]

[5 figures]