Part I

General Remark

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Chapter 1 Introduction

1-1 Background and Object of the Survey

The coastal area of the Black Sea in Turkey is one of a high potential area for massive sulphide ore deposits similar to the Japanese Kuroko deposits containing multi-metal elements. The head office of MTA, "MADEN TETKİK ve ARAMA GENEL MÜDÜRLÜGÜ: Mineral Research and Exploration Institute" has aggressively conducted many mineral exploration programs. The government of the Republic of Turkey has planned to conduct a new exploration program for metallic minerals in the Hopa area in the eastern part of the coastal area, and requested the cooperation from the Japanese government. In response to the request, the Japanese government has decided to conduct a survey program for the area, to extract potential areas for gold, silver, copper, lead, zinc etc. by means of surveys and interpretations for the geological environment and the status of ore deposits in the area. Another purpose of the program is to transfer the technology for mineral exploration to the Turkish counterpart.

1-2 Conclusions and Proposal of the First Year

1-2-1 Conclusions of the First Year

The survey was composed of existing documents analysis, geological survey and geochemical survey. Conclusion from these surveys are described as follows,

(1) Geology

This area is underlain by the Alemağaç, Çağlayan and Sivrikaya Formations of the upper Cretaceous and the Hamidiya Formation of the Tertiary in ascending order. The Alemağaç Formation consists of strongly brecciated dacite lava at the bottom and its pyroclastic rocks at the top, and the dacite lava forms a lava dome. The pyroclastic rock was formed in phreatic explosion taken place in the slope of the lava dome. The Çağlayan Formation is characterized by its dominant basic igneous activities. The bottom part of the formation is reddish calcareous mudstone, being overlain by thick basalt lavas. The basalt lavas are subdivided into several layers of thin calcareous mudstone and acid tuff layers. The Sivrikaya Formation is distributed in highland of this area mainly composed of acid tuffs, sandstone, and mudstones. The

Hamidiya Formation consists of poorly-sorted sediments such as coarse sandstone. The intrusive rocks are composed of granitic rocks, dacite, andesite and dolerite. The granitic rocks are correlated to the Kaçkar Granitic rocks of the Eocene, which intrude in the southern through the southeastern parts of this area.

(2) Geological Structure

This area has lineaments dominant in the NE-SW and the NW-SE in circular structure. A typical circular structure has an approx. 7km of diameter formed by the water courses of Tunca River and Durak River. The dacite lava in the Alemağaç Formation erupted on the rim of this circular structure and forms a lava dome extending in the NW-SE directions. The upper strata change their strike and dip around the lava dome. As the lava dome becomes distant, the upper strata begin to indicate the WNW-ESE to ENE-WSW strikes at 5 to 20° of northern dip. The intrusive rock is extended in the NE-SW directions.

(3) Mineralization

The volcanogenic massive sulphide mineralization and other mineralization are found in the survey area. The former is more important.

(a) Mineralization and Ore Horizon

Volcanogenic massive sulphide deposit is located in the upper part of dacites in the Alemağaç Formation. The vicinities of the ore horizon has a distribution of tuff breccia called "Tunca dacite" and "layered tuff" which accompanies fragments of pumice in lamina-like structure. Since the "Tunca dacite" and "layered tuff" are similar in their composition, they are identical and lateral change of the "Tunca dacite" seemingly transformed the "Tunca dacite" into "layered tuff."

The Tunca South Occurrence is stratigraphically located in a high place from Tunca Deposit. Since the rock of the Tunca South Occurrence is the same as "Tunca dacite", "Tunca dacite" is located in upper part of the massive sulphide deposit. In other words, the strata of the Alemağaç Formation consists of, from the bottom upward, dacite lava, dacitic pyroclastic rocks, and massive sulphide deposit, "Tunca dacite" ("layered tuff").

The formation of the volcanogenic massive sulphide mineralization as follows:

1.Eruption of a dacite lava and formation of lava dome

2.Phreatic explosion occurred in the slope of the lava dome, forming dacitic pyroclastic rocks. The phreatic explosion caused hydrothermal activities, which formed volcanogenic massive sulphide deposits.

3.Formation of "Tunca dacite"

The above activities occurred in a continuous series without interruption during the activities.

(b) Volcanogenic massive sulphide mineralization, deposit and occurrence

The Tunca Deposit, Tunca South Occurrence, Muskale Occurrence, Şenyuva Occurrence, Isina Occurrence, and Garimani Occurrence in the distribution area of the Alemağaç Formation were formed in a series of the volcanogenic massive sulphide mineralization. The Tunca South Occurrence, being found in the "Tunca dacite," was formed in volcanogenic massive sulphide mineralization that occurred at the end. These deposits and occurrences, except for the Garimani Occurrence, are formed in the same dacite lava dome. The Garimani Occurrence has undergone lead and zinc mineralization in a dacite lava, which is different from this lava dome.

i) Tunca Deposit

The Tunca Deposit is an allochthonous deposit, consisting of huge massive sulphide block. Parts of ores in the main body of the deposit were separated by landslide and became block, which was then moved to the present place. The main body of the deposit is located in the north direction. It is estimated that the location of the deposit is not so distant from the present outcrops.

The massive pyrite that we used for analysis had a low grade of ore, namely Cu stood at 0.12 to 0.28%. A drilling conducted by MTA in the past reached 7.65m thick massive ore (average grade: 1.43% Cu, 1.26% Zn). The massive pyrite boulder is cut by Cu, Pb, and Zn quartz veins with high grades (0.91% Cu, 2.18% Pb, 13.30% Zn). Thus, it is expected that future explorations could lead to findings of large-scale main bodies of deposits with higher grade.

ii) Muskale Occurrence

This occurrence is distributed in an area of approx. 1,100 × 600m where

disseminations and network of pyrite are observed. The vicinities of the occurrence have a broad distribution of quartz-sericite-chlorite- (sericite/ smectite mixed layer minerals) zone. In addition, some points indicated over 90% of alteration index (AI). There is a possibility that massive sulphide deposit was once existed.

In the vicinities of the Isina Occurrence in the southern part of this occurrence, the gravel of polymetallic sulphide (Todroviç et al., 1973. 1.8% Cu, 25.5% Zn, 1.7% Pb) was found in a talus. The gravel is estimated to have been derived from a massive sulphide deposit in the Muskale Occurrence that has been depleted.

(c) Alteration

i) Alteration zoning

With volcanogenic massive sulphide mineralization, the center and the vicinities formed alteration zoning which consists of 1) quartz-potash feldspar-sericite, 2) quartz-sericite-chlorite- (sericite/smectite mixed layer minerals), 3) quartz-(chlorite)-sericite/smectite mixed layer minerals- (smectite), 4) quartz- (sericite)-laumontite. The Tunca Deposit and the Muskale Occurrence are found in the quartz-sericite chlorite -(sericite/smectite mixed layer minerals) zone. These deposit and occurrence indicate a trend in the NW-SE directions, independent from each other. The alteration zone in the vicinities of the Tunca Deposit extends to the northern side that covers the Çağlayan Formation.

ii) Alteration index

The alteration index (Al) from analytical values of alkaline metals indicates that a strong alteration index distribution area is found in the vicinities of the Muskale Occurrence in the NNE-SSW directions, and in the vicinities of the Tunca Deposit in the EW directions along Tunca River. The strong alteration index distribution area in the vicinities of the Tunca Deposit extends to the northern side that covers the Çağlayan Formation.

iii) Oxygen isotope

Owing to isotope exchange reactions among water/rock that followed after mineralization, oxygen isotope ratios ($\delta^{18}O$) in dacites of the Alemağaç Formation indicated +12.6 to +14.0‰ in the Tunca River basin that has weak mineralization and

alteration. On the other hand, the proximity of the Tunca Deposit indicated rather light values of +9.2 to +11.4‰ and that the Muskale Occurrence indicated +8.7 to +12.4‰.

(4) Geochemical Survey

As a result of stream sediment survey and rock bed survey, geochemical anomalies of the major element (Au, Ag, Cu, Pb, Zn, As, Ba) were detected in the Muskale Occurrence through the Tunca Deposit to the Şenyuva Occurrence. In particular, rock bed survey revealed that geochemical anomalies of the major elements were detected in the vicinities of the Şenyuva Occurrence. The vicinities of the Garimani Occurrence also had distributions of geochemical anomalies of the major elements. These geochemical anomalies are results of the volcanogenic massive sulphide mineralization.

1-2-2 Recommendations for the Second Year's Program

First year survey has revealed the geological structure, the strata of the volcanogenic massive sulphide deposit, and the characteristics of the distribution of the horizon found in this area.

- A circular structure is found along the water courses of Tunca River and Durak River. Along the weak linear of the circular structure, dacite lava in the Alemağaç Formation erupted, forming a lava dome. Phreatic explosion occurred in the slope of the lava dome, forming dacitic pyroclastic rocks. Hydrothermal activities also occurred, forming a volcanogenic massive sulphide deposit.
- Garimani in the western part of this area has mineralization in a dacite lava, independent from this lava dome.
- The Tunca Deposit is an allochthonous deposit moved by landslide. The main body of the deposit is located in northern direction.
- Geochemical anomalies concentrate in the vicinities of the Şenyuva Occurrence.

Second year survey will, based on the result of the first year survey, analyze the Tunca Deposit, and seize mineralization in the vicinities of the Garimani and Şenyuva Occurrence. In addition, in the vicinities of the southern Isina Occurrence, it is important to survey the unsettled origin of the polymetallic sulphide gravel, which was once reported by Todroviç et al. (1973).

The following surveys are recommended in order of higher priority.

(1) Surveying the vicinities of the Tunca Deposit

- IP survey between Tunca village and vicinities of the Tunca Deposit
- Conducting structural drilling in the hanging wall area

(2) Surveying the surroundings of the Garimani Occurrence

- Geological survey
- Geochemical survey

(3) Surveying the surroundings of the Şenyuva Occurrence

- Geological survey

(4) Surveying the surroundings of the Isina Occurrence

- Geological survey

1-3 Outline of Phase Ⅱ Survey

1-3-1 Survey Area

The survey area was established in the areas concluded to the hopeful by Phase Ⅰ Survey. That is the Tunca area, from the Tunca Deposit to the Şenyuva Occurrence. The Murgul area, east of the Hopa area, was also selected for Phase Ⅱ Survey.

1-3-2 Purpose of Survey

The purpose of geological survey in the Tunca area was to define drilling points after checking geological data and drilling surveys were to clarify geological structure, mineralization and the continuity of ore horizon. The purpose of geological survey in the Murgul area was to establish stratigraphy around the Murgul Deposit and investigate the possibility of new volcanogenic massive sulphide deposits.

1-3-3 Method and Content of Survey

Geological survey and drilling surveys have been carried out in the Tunca area and geological survey has been carried out in the Murgul area. Contents and amounts of field work, laboratory test are shown Table Ⅰ-1-1 and Table Ⅰ-1-2.

Table I -1-1 Contents and Amounts of Field Survey

Method and Contents	Amount of Survey			
Geological Survey				
Tunca area				
Survey area	6km^2			
Survey routes	30km			
Geological Survey				
Murgul area				
Survey area	25km^2			
Survey routes	70km			
Drilling Survey Tunca area	Drilling No.	Depth	Inclination	Direction
Şenyuva area	MJTH-1	314.15m	-90°	—
Tunca area	MJTH-2	401.00m	-90°	—
Beyazsu area	MJTH-3	308.40m	-90°	—
TOTAL		1,023.55m		

Table I -1-2 Contents and Amounts of Laboratory Test

Contents of Laboratory Test	Amounts
Geological Survey (Tunca area)	
① Thin Section	30
② Polished Section	10
③ Ore assay (Au, Ag, Cu, Pb, Zn, Ba, S, Ga, Ge, In, As)	10
④ X-ray diffraction	30
⑤ Whole Rock Analysis (28elements)	60
(Au, Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sr , Ti, V, W, Zn)	
Geological Survey (Murgul area)	
① Thin Section	30
② Polished Section	10
③ Ore assay (Au, Ag, Cu, Pb, Zn, Ba, S, Ga, Ge, In, As)	10
④ X-ray diffraction	30
⑤ Whole Rock Analysis (28elements)	60
(Au, Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sr , Ti, V, W, Zn)	
Drilling Survey (Tunca area : MJTH-1,MJTH-2,MJTH-3)	
① Thin Section	30
② Polished Section	30
③ Ore assay (Au, Ag, Cu, Pb, Zn, Ba, S, Ga, Ge, In, As)	30
④ X-ray diffraction	30
⑤ Whole Rock Analysis (28elements)	30
(Au, Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Sb, Sr , Ti, V, W, Zn)	
Ore Isotope Analysis	
Pb Isotope (SIMS Measurement)	7

1-3-4 Survey Team

Members participating in this survey are as follows,

Japanese side

Koichi Hisatani	Geotechnos Company Limited (Geotechnos)
Hiroshi Miyamoto	Geotechnos
Takuya Nishikawa	Geotechnos
Hiroyasu Muraoka	Geotechnos

Turkish side

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Mustafa Kemal Revan	MTA
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Baki Yılmazer	MTA

(1) Supervisor in Turkey

Hiroyuki Takahara	Metal Mining Agency of Japan(MMAJ)

1-3-5 Tears of the Survey

Field survey was carried as follows.

Geological Survey in the Tunca area

July, 2nd, 2003～ August, 1st, 2003

Geological Survey in the Murgul area

October, 1st, 2003～ Nobember, 16th, 2003

Drilling Survey in the Tunca area

September, 24th, 2003～ December, 2nd, 2003