



Fig II -1-6 Geological Map of the Murgul Area

Iskale, the southwestern corner of the survey area. These rocks have undergone mineralization, consisting of pyrite dissemination and quartz veins.

[Microscopic Observation]

Coarse Tuff(Kv) : Consists of altered andesite, basalt and plagioclase fragments, and fine volcanic ash that fills in their fragments. Alteration intensity is high, producing chlorite, calcite, quartz, and clay minerals.

(b) Murgul Formation

The Murgul Formation consists of dacite lava and dacitic pyroclastic rocks. The formation is divided into the lower formation that has undergone volcanogenic massive sulphide mineralization and the upper formation. This formation is correlated to the Kızılkaya Formation, which is the host rock of volcanogenic massive sulphide deposits in the eastern Pontides. It corresponds to the Alemağaç Formation in the Tunca area.

(i) Lower Murgul Formation

This formation is extensively distributed in the Murgul area. It consists of dacite lava and dacitic pyroclastic rocks (Mdcl) in green gray to light gray. The lower formation shows brecciated lava to pyroclastic facies and commonly contains quartz phenocryst. Although the lower formation has various lithofacies, porphyritic dacite and dacite, which consists of dark green vitric fragments, are dominant in the formation. Quartz phenocryst decreases in the lower part of the formation, especially it is hard to observe in vicinities of just above the Kabaca Formation.

The lower formation underlies basic volcanic rocks of the Ardiç Formation directly, because the upper Murgul Formation lacks in the northern Kokolet area. Moreover, there is a conglomerate bed of thickness 10 to 20 meters, consisting of rounded dacite fragments, in the vicinities of uppermost part of the lower Murgul Formation in the northwestern Kokolet area, there is a possibility that the Ardiç Formation unconformably overlies the Murgul Formation.

The lower formation has undergone mineralization, being accompanied with pyrite dissemination, and silicification, producing quartz, sericite and chlorite.

[Microscopic Observation]

Porphyritic dacite(Mdcl) : Quartz and plagioclase phenocrysts shows porphyritic texture. The groundmass show hyalopilitic texture, consisting of microlite and glass of quartz and feldspar. The dacite has undergone silicification, producing quartz, sericite, clay minerals, chlorite and calcite.

Dacitic lapilli tuff(Mdcl) : Contains dacitic lapilli, ash, and quartz and plagioclase fragments. Intense silicification produces quartz, pyrite, sericite, and clay minerals.

(ii) Upper Murgul Formation

This formation mainly is composed of pumice tuff (Mdlt) and fine-grained tuff (Mdu). Pumice tuff is olive gray to yellowish green and flattened dark green pumice fragments show lamina-like appearance. Pumice tuff has become thick around the Murgul Deposit, especially in the eastern side of the Çakmakkaya Deposit, but turns rapidly thinner in the surroundings. This rocks intercalates thin reddish calcareous mudstone layer at the lower part in the western side of the Çakmakkaya Deposit. Alternated minerals such as smectite, kaolinite have been recognized in pumice tuff but mineralization has hardly taken place. Partly, pumice tuff contains a small quantity of pyrite dissemination.

Fine-grained tuff is light green, containing reddish calcareous mudstone, siltstone, and others. Fine-grained tuff is distributed in the upper Kokolet River basin. The thickness of the tuff reaches up to 200 meters.

It is not clear the stratigraphic relationship between pumice tuff (Mdlt) and fine-grained tuff (Mdu), because of their distributions are different. However, it is estimated that they are in contemporaneous heterotopic facies or fine-grained tuff (Mdu) is stratigraphically of above pumice tuff (Mdlt).

[Microscopic Observation]

Pumice tuff (Mdlt) : Consists of hyalopilitic fine-grained tuff that contains a small quantity of rock fragments and quartz fragments. The pumice has intensely undergone silicification, producing quartz, calcite, chlorite and clay minerals.

(c) Ardiç Formation

This formation is characterized by its dominant basic volcanic activity and basic volcanic rocks (Abs) are divided into several layers by intercalated sedimentary layers. The lower part of the formation is mainly composed of basalt while the upper part is mainly composed of andesite. Massive and compact basalt is distributed in mountainsides in the western bank of the Kokolet River toward Ardiç, well jointed. Meanwhile, basaltic to andesitic agglomerate and agglomeratic tuff breccia are distributed in the western side of the Murgul Deposit towards north. The diameters of agglomeratic gravels, being distributed in the slopes of the Murgul Deposit to the Kabaca River, ranges up to several meters. Pillow lava is dominant in the eastern bank of the Kabaca River.

Sedimentary rocks, intercalated by basic volcanic rocks, consist of reddish calcareous mudstone (Ams), fine-grained tuff (Atf) and siltstone (Amd).

The upper part of the lower member contains crystalline dacitic tuff, including large quartz and plagioclase phenocryst that is associated with sedimentary rocks. It is presumed that crystalline dacitic tuff is facies change of the Karatepe Dacite.

This formation corresponds to the Çağlayan Formation in the Tunca area.

[Microscopic Observation]

Basaltic lapilli tuff (Abs) : Consists of basaltic fragment and volcanic ash.

Amygdaloidal and porphyritic textures occur in Basalt fragments contain plagioclase phenocryst. It has undergone alteration, producing chlorite, calcite and smectite, etc.

Fine-grained tuff (Atf) : Resedimented tuff consisting of rock, mineral, and glass fragments. The fine-grained tuff contains volcanic glass most, followed by quartz.

Alteration intensity is low, producing quartz, sericite, chlorite, etc.

Reddish calcareous mudstone (Ams) : Consists of mostly clay, being accompanied with altered volcanic glass, including foraminifera fossil.

(d) Küre Formation

This formation is composed of limestone (Kls), marl, thin-layered siltstone and

mudstone (Kmd). The formation is extensively distributed along the Murgul River to the north and northwest of the area. Limestone is light yellow to olive gray and massive. The siltstone and mudstone is dark gray to gray, being associated with basic tuff. This formation overlies the Ardiç Formation. However, to the northwest of the survey area, it lacks the upper basic volcanic rocks of the Ardiç Formation and directly overlies Karatepe dacitic tuff. Therefore it is presumed that the Küre Formation unconformably overlies the Ardiç Formation.

(e) Intrusion Rocks

Intrusion rocks are composed of dacite, granite, andesite, dolerite, and others.

(i) Karatepe Dacite (Kd)

This rock is porphyritic dacite, containing large quartz phenocryst, exposed many places in the area. In the Damar and Çakmakkaya pits, the Karatepe Dacite intrudes between pumice tuff of the upper Murgul Formation and basalt of the Ardiç Formation as sheet. And also, The Karatepe Dacite forms small bodies in the Murgul Formation and the Ardiç Formation in the Ardiç area and the western bank of the Kokólet River. In addition, dacitic crystalline pyroclastic rocks (Kdp) overlie basic volcanic rocks of the lower Ardiç Formation in the northwest direction, from the north of the Ardiç area to the Murgul River.

The Karatepe Dacite is purplish brown to greenish gray, and characterized by large quartz and plagioclase phenocrysts (up to 1 cm) and contains basic rocks as xenoliths. The rock has undergone no mineralization.

Dacitic pyroclastic rock is greenish gray. It is a crystalline tuff containing a lot of quartz and plagioclase phenocrysts, overlying basic volcanic rocks of the lower Ardiç Formation. It is estimated that when the Karatepe Dacite intruded into the lower formation and reached the sea floor, the upper part of the Karatepe Dacite changing to its pyroclastic rocks. It is presumed that the age of the Karatepe Dacite is in the early Ardiç stage. Catalani et al.(1998) reported that the age of the Karatepe Dacite, which was collected in the Damar open pit, was 83 ± 0.2 Ma(U-Pb method. dated minerals: zircon). This age indicates the late Cretaceous.

[Microscopic Observation]

Karatepe Dacite (Kd) : Appears distinct porphyritic texture, containing much quartz and plagioclase phenocryst. The groundmass shows cryptocrystalline texture, consisting of quartz, feldspar, biotite, microlite, and glass. Porphyritic dacite has undergone silicification, producing quartz, sericite, chlorite, calcite.

Dacitic tuff (Kdp) : Consists of dacitic fragment and fine-grained volcanic ash. Dacitic fragment contains much of large quartz and plagioclase fragments. It has undergone silicification, producing quartz, sericite, chlorite, and clay minerals.

(ii) Granites (Gr)

Granites are mainly composed granodiorite, quartzmonzonite and granite porphyry, intruding into the Murgul Formation. Granites are distributed in the Kokolet River basin, forming stock. Although minerals in the central part of the intrusive body are relatively coarse grained, marginals in the marginal part of bodies change to fine-grained or porphyritic. Thus, it is difficult to distinguish granite from dacitic pyroclastic rocks of the lower Murgul Formation. Phenocrysts are consists quartz, feldspar and hornblende, being accompanied with a little pyrite dissemination.

[Microscopic Observation]

Biotite granodiorite (Gr) : Indicates equigranular texture, consisting of plagioclase, quartz, potassium feldspar, and biotite. The texture suggests that biotite granodiorite forms intrusive body, intruding into relatively shallow zone. The rock has weakly undergone alteration, producing chlorite, sericite, and others.

(iii) Andesite (Ad)

Andesite intrudes into the Murgul Formation and the Ardiç Formation in the western bank of the Kokolet River, the middle reaches of the Kabaca River, and vicinities of Kızılkaya, forming small intrusive bodies and dykes. Andesite is a green to greenish gray compact and massive rock. It contains plagioclase phenocryst.

(iv) Dolerite(Dol)

Dolerite is distributed in vicinities of the Murgul Deposit, intruding into the Murgul Formation and the Ardiç Formation. Some dolerite cuts the formations as

dykes with several meters in widths, while the other dolerite intrudes concordantly into the Murgul Formation as sheet concordant. Small mass of dolerite occurs in the middle stream of the Kabaca River. Dolerite is dark olive to dark green and compact rock with strong magnetism.

Under microscopic observation, phenocryst is composed of small quantity of plagioclase shows ophitic texture. The pyroxene has all changed to another minerals because of the alteration. The groundmass is composed of plagioclase, augite, and glass.

(2) Geological Structure

(a) Structure in Satellite Image Data

Fig. I-3-1 shows the extracted lineaments from LANDSAT's TM image and MTA's extraction result using the same images (MTA, 2002). The image indicates a circular structure in a diameter of 20 km that is identified by water paths of the Murgul River and Çorh River, and an inner circular structure in a diameter of about 6 km that surrounds the Kokolet area. The Murgul Deposit swarm exists along the western rim of the outer circular structure.

(b) Structure from Geological Survey

The east-northeast to west-southwest and west-northwest to east-southeast structures are dominant in the survey area. Strikes of the stratum are also dominant in these directions, dips 10 to 30° N. The Murgul Formation strikes northwest to southeast direction and dips 10 to 30° N in the upper stream of the Kokolet River. The Murgul Formation is in fault contact with the Ardiç Formation by the Murgul fault in the south of the Ardiç area. It strikes east-northeast to west-southwest. A fault in the same direction exists in the east of Kabaca area, which also borders the Murgul Formation and the Ardiç Formation.

There are landslide topography and the collapse ground around the survey area. There exist large-scale collapse topographies in the upper stream of the western Kokolet River and of the eastern Kabaca River.

(3) Mineralization and Alteration

(a) Ore Horizon

The area is divided into the Kokolet, Ardiç and Kabaca areas, and the altered and mineralized dacite bodies are spread over the areas. All dacitic rocks, except the Karatepe Dacites, are stratigraphically situated below the Ardiç Formation and belong to the Murgul Formation.

The upper Murgul Formation is composed of pumice tuff (Mdl) and fine-grained tuff (Mdu). The Çakmakkaya Deposit has undergone mineralization, consisting of dissemination and stockwork, in dacitic rocks of the lower Murgul Formation (Mdcl) and underlies pumice tuff (Mdl) of the upper Murgul Formation. Pumice Tuff has undergone mineralization of last stage, being accompanied with pyrite dissemination and smectite. Alteration intensity is low. Except the Karatepe Dacites, pumice tuff (Mdl) overlies reddish calcareous mudstone or basic rocks of the Ardiç Formation there are no evidence that another dacitic activities and mineralization.

There expose fine-grained tuff (Mdu), and the boundary between the lower Murgul Formation and the Ardiç Formation is not identified in the Kokolet area. But it is impossible to estimate another dacitic activities and mineralization in the Kokolet area, because all the formation strikes EW and dips about 10 to 30° N. For these reasons, the volcanogenic massive sulfide mineralization has occurred only in the lower member's dacitic rocks of the Murgul Formation and there are little possibility of existence of another dacitic rocks, being similar to those of the lower Murgul Formation and volcanogenic massive sulphide mineralization.

(b) Alteration

(i) Alteration Mineral

Table II -1-3 shows the results of X-ray diffraction and Fig. II -1-9 shows the distribution map of alteration zones. The assemblages of alteration minerals classified in the area are as follows.

- 1) quartz-kaolinite-sericite
- 2) quartz-sericite-chlorite
- 3) quartz-sericite-(sericite/smectite mixed layer mineral)
- 4) quartz-chlorite

