7.4 Savail Slope

7.4.1 General

On the left bank approximately 1 km downstream from the Bayram dam site, there is a distinctive landform which has been referred to as "Savail Landslide" from the past. As a whole, this landform is a gentle slope on the left bank of the Berta river, roughly perpendicular to the Berta river, which has been buried by colluvial debris from the surrounding mountainland. This slope will be comprehensively called "Savail Slope" in this Report. The maximum length of this slope is approximately 1,300 m and maximum width approximately 500 m. The inclination angle of the slope above around EL. 850 m is approximately 20 degree, while below this, angle is 5 to 15 degree. Slope failure has occurred at the end portion facing the Berta river due to scouring by the river, and a steep cliff has been formed.

Geologists of the JICA Survey Team and EİE (Power Resources Surveying Administration) have carried out the investigation works and soil tests below to see whether the deposits at this slope can be used as impervious core material for the Bayram dam, and further, assuming that the material can be used, what kind of behavior the presently stable slope will show when core material is collected from the slope.

- Geological mapping of the entire Savail Slope area.
- Drilling of 7 hoes, total length 490 m, with the aims of soil exploration and checking the thickness of deposits at the slope.
- Seismic prospecting of a total length of 5,000 m with 6 prospecting lines for the entire slope.
- Collection of 9 soil samples from 4 test pits and steeply sloped parts and performance of laboratory soil tests.

Further, as an investigation of impervious core material for the Bayram dam, EİE at the master plan stage selected two candidate sites, A and B, on the left bank approximately 5 to 6 km upstream from the dam site, collected samples, conducted laboratory tests, and presented a report (Çoruh-Berta Kolu Enerji Kademeleri Dogal Yapi Gereçleri Dogal yapı Gereçleri Raporu 1992 March—in Turkish and in English). As the result of studying this report, it is assessed that the soil material from Sites A and B can be amply used as impervious core material for the Bayram dam.

7.4.2 Geology around Savail Slope

As shown in the annexed geological map (Figure 7-6), when the Savail Slope is viewed from the right bank of the Berta river, distribution of limestone and calcareous sandstone of the Berta Formation can be seen in a limited area at EL. 1,000 m and above on the left side of the slope, but other areas are all composed of volcanic rocks of the Berta Formation. A more detailed geological map of the Savail Slope and surroundings is shown in Figure 7-12. This geological map shows the collective range of Area-A, Area-B, Area-C, and Area-D, the so-called Savail Slope, while Area-E is merely a talus deposit distribution area. Details will be given later, but whereas the thickness of deposits in the Savail Slope area is 50 to 70 m, the thickness of the talus deposit in Area-E is estimated to be 1 m to 20 meters.
The reasons for the Savail Slope to be divided into 4 area are as follows:

- Whereas inclination of the slope is approximately 20 degree in Areas-A and-B, inclinations in Area-C are gradual at 5 to 15 degree.
- There is not any size of detached limestone to be seen at the ground surface in Area-B, detached rocks seen here all being volcanic rocks.
- In contrast, detached rocks at the ground surface in Area-A and Area-C (mostly under EL. 750 m) are a mixture of limestone and volcanic rocks.
- Area-D is an area where deposits of Area-C were deposited as a result of slope failure.

Bedrock surrounding these areas consists of volcanic rocks of the Berta Formation at EL. 1,100 m and under, while as previously mentioned, limestone layers are distributed at EL. 1,100 and above at the southwest part of the Savail Slope area. The distribution area of this limestone may be judged to comprise the ranges where detached rocks of limestone can or cannot be seen at the surface layer portions of the above-mentioned areas.

7.4.3 Geology of Savail Slope

The logs of drillholes made in the Savail Slope and geological profiles are shown in Figures 7-13, 7-14, and 7-15. The points paid attention in preparing these drilling logs were as follows:

- The varieties of gravels contained and their degrees of weathering
- The color and grain-size distribution of soil contained

The geology of Savail Slope will be explained referring to the geological profile (Figure 7-14) prepared along the maximum length of the slope (see drilling logs for details).

(1) Area-A

This area is at the left end in the geological profile (Figure 7-14). As shown also on the geological map (Figure 7-12), drilling has not been carried out in this area. The only investigation made has been by seismic prospecting. Consequently, the deposits distributed were estimated from data of geologic mapping on the surface and the results of Drillholes H-1 and H-6.

From the fact that outcrops of the basement volcanic rocks are seen at the upper part gully bed comprising the boundary with Area-B, the fact that hardly any limestone gravels are seen at the bottom parts of Drillholes H-1, H-6, H-2, and H-3, and gravels of volcanic rocks and soil produced from these rocks are found in overwhelmingly large quantity, it may be surmised that the initial fill material was mainly gravels of volcanic rocks. For such reasons it was considered that the bottom material of Area-A consists of deposits originating from volcanic rocks.

These deposits consist of fresh, hard gravels of volcanic rocks 10 to 25 cm in size and reddish brown to pinkish color cohesive soils, but on the whole the quantity of soil is small.

At the uppermost layer of this area, detached rocks of limestone origin may be seen besides volcanic rocks.

(2) Area-B

Two drillholes, H-1 and H-6, have been bored in this area. The logs of the two are given in Figure 7-13, the outlines of which are described below.

H-1 0.5-23.10 m: Dark, gray-sand color, partly black sandy soil. Contains gravels (pebbles) of volcanic rock. No Ls gravel, reddish brown soil but generally little. 42.10-49.85 m: Gray-reddish brown sandy soil contains gravels (pebble size) of volcanic rocks only. 49.85-52.90 m: Gray-blue sandy soil brecciated tuff (weathered zone of bedrock?). 52.90-55.0 m: Blue color tuff, Berta Formation (bedrock).

H-6 0.5-15.60 m: Cobble-boulder-detached rock (max. 140 cm), little soil, no Ls gravel. 15.60-31.95 m: Mainly cobble-pebble size volcanic rock, reddish brown soil, no Ls gravel. 31.95-46.80 m: Cobble-boulder (mainly 40 cm) volcanic rocks, very little soil material. 46.80-51.90 cm: Reddish brown soil of weathered volcanic rock origin, contains pebble size gravel, no Ls gravel. 51.90-54.40 m: Gray, weathered volcanic rock (weathered zone bedrock). 54.40-57.90 m; Slightly weathered volcanic rock (basalt) bedrock.

The features, geological profile-wise, of Area-B, as given above are a) that gravels (regardless of whether large or small in size) do not include any limestone, b) that large boulders of volcanic rock are thickly deposited to thickness of approximately 15 m in the surroundings of H-6, c) that corresponding to the second layers in Drillholes H-1 and H-6, there is a layer with intermixture of volcanic rocks of cobble-boulder size and reddish brown soil 20 to 30 m in thickness, with the distribution in a length of approximately 450 m from H-1 and H-6 to H-2, d) as the third layer there is a layer consisting of sandy soil and pebbles judged to be of weathered volcanic rock origin in a thickness of 5 to 7 m at H-1 and H-6, with this layer being well consolidated, e) that in both H-1 and H-6, soft layers of thickness 3 to 2.5 m are intercalated between the third layer and the basement rock, which with no geological proof making it possible to judge that it is clearly a secondary deposition layer such as the beforementioned layers, was judged to be a weathered zone of the basement rock since it is a soft layer made up of a single material, and f) that below this layer was confirmed to be the basement rock since cores of the same rock were recovered in drilling lengths of 2 to 3 m.

(3) Area-C

The 3 drillholes of H-2, H-3, and H-7 have been made in this area. The outlines of these drillholes are given below.

H-2 0.5-9.55 m: Brown clayey soil, contains granule-pebble size gravel originated from weathered volcanic rock, no Ls gravel. 9.55-41.30 m: Consists of fresh volcanic rock (cobble-boulder) and brown-pinkish clayey soil (generally less soil). (32.55-41.30 m: Greenish gray sandy soil), no Ls gravel. 41.30-49.15 m: Fresh Ls and volcanic rock (mainly 5-10 cm), intermixture with brown-reddish brown silty soil. 49.15-78.05 m:

Reddish brown soil, contains granule-pebble gravel originated from weathered volcanic rock, very little Ls gravel. 78.05-79.95 m: Blue-gray weathered volcanic rock (weathered zone of bedrock), soft. 79.95-85.00 m: Bluish gray volcanic breccia, bedrock.

H-3 0-7.00 m: Fresh Ls gravel (10-20 cm), no volcanic gravel. 7.0-24.60 m: Brown clayey soil originated from weathered volcanic rock, contains granule-pebble size volcanic rock, very little Ls gravel. 24.6-29.97 m: Brown, clayey, soft, contains 5-10 cm fresh Ls gravels (many). 29.97-63.05 m: Gravely zone, much 5-10 cm fresh Ls and volcanic rock gravels, contains reddish brown soil. 63.05-68.50 cm: Brown soil and granule-pebble size gravel originated from volcanic rock. 68.05-69.80 m: Gray-bluish gray clayey soil, soft, weathered zone of bedrock (volcanic rock). 69.8-74.80 m: Bedrock.

H-7 0-1.1 m: topsoil. 1.1-6.40 m: Coffee brown loamy soil, contains volcanic rock and Ls gravel. 6.40-18.90 m: Clayey-sandy soil originated from weathered volcanic rock, contains cobble-boulders of volcanic rock. 18.90-25.45 m: Yellowish brown soil (somewhat sandy), originated from weathered volcanic rock, contains some boulders of volcanic rock, no Ls gravel. 25.45-41.05 m: Reddish brown clayey soil-yellowish brown sandy soil, contains some Ls (cobble) at 25.45-32.1 m and weathered volcanic rock (boulder). 41.05-60.35: Dark gray-chocolate brown soil, partly muddy (41.05-45.50 m), pebble-cobble size gravel consists of weathered volcanic rock only, no Ls gravel. 60.35-62.75 m: Strongly weathered tuffaceous volcanic rock, weathered zone of bedrock. 62.75-70 m: Hard tuff.

The features, geological profile-wise, of Area-C are as follows:

a) In this area, layers having intermixtures of fresh, hard Ls gravels (of various sizes) are distributed.

b) However, the layer (second layer) immediately below the surface deposits has distribution of gravel-bearing cohesive soil consisting of strongly weathered material from volcanic rocks which do not contain any Ls gravels at all. The deposits of this layer on visual inspection were judged to be suitable for the impervious core of Bayram dam and, therefore, 9 samples were collected for soil tests from the second layer. The results of tests are given in detail elsewhere (Clause 7.5), but adapting the Unified Soil Classification System the materials may be classified as GC, CH, CL, and SC, with coefficients of permeability in a range from $6.5x10^{-7}$ to $2.5x10^{-8}$ m/sec. The thicknesses of this layer are approximately 9 m (H-2), 17 m (H-3), and 19 m (H-7), and assuming average thickness to be 10 m and very roughly estimating the deposited volume, it will be 1.5 million cubic meters.

c) At the lower part of Drillhole H-2, from a depth of 49.15 to 78.05 m, a deposited layer of the same quality as the second layer is again encountered, but this material is not an object of consideration as core material for reasons of depth and thickness.

d) The condition of basement rock at Drillholes H-2, H-3, and H-7 are as described before. At these 3 drillholes also there are soft weathered zones of approximately 2 m above the hard bedrock.

(4) Area-D

As previously mentioned, Area-D is a slope where deposits of Area-C collapsed and were redeposited. Consequently, the cores from Drillhole H-5 vary in condition at intervals of 20 cm to several tens of centimeters. The characteristic layer classifications seen in the profiles of Area-A, B, and C are not seen at all in this area. Further, the boundary conditions of deposits and bedrock are also different. Parts corresponding to the weathered zones such as seen before are not recognizable and gravel-bearing dark brown sandy soil is deposited directly in hard basement rock.

(5) Summarization of Savail Slope Area

The geological plan and profiles of the Savail Slope Area have been described in the foregoing. These may be summarized as follows:

a) The bedrock of the Savail Slope Area comprises volcanic rocks belonging to the Berta Formation, and these rocks consist of basalt, tuff, and volcanic breccia.

b) However, at the southeast part of the slope, up the mountain above El. 1,100 m, distribution of limestone can be seen.

c) The reasons the slope area was divided into 4 parts have been described already. At the ground surface and underground (see profile), there are layers where hardly any or completely no limestone are seen. This indicates that the sources of debris comprising the slope and the geologic times of supply were different. For example, the layers distributed as the second layers and bottom most parts (above bedrock) at Drillholes H-1, 6, 2, 3, 7 consist only of clayey soil and strongly weathered gravels originating from volcanic rock, with no supply of limestone gravels and no fresh gravels of volcanic rock at those times, and for weathered material to be deposited in this thickness (10 to 20 m at the second layer) a considerable length of time would have been required. In reality, a number of loam layers which can be judged to have been ground surface layers in the past can be seen in this deposit.

d) On the other hand, at the present ground surface and at middle to bottom levels of Area-C, there are a number of layers with mixtures of limestone gravels and volcanic rock gravels. Moreover, these gravels are all fresh and hard, and there are large numbers of cobble and boulder sizes. Furthermore, the soils contained in this layer may be said to be mostly silty clay of reddish brown-pinkish color.

e) On comparison of c) and d) above, the following conjectures can be done;

- The material of c) was deposited gradually in a considerable length of time from surface of weathered volcanic rocks distributed at the upstream part and western slope of Savail site.

- While the material of d) is a deposit which also contains fresh, hard colluvial rock from the beforementioned limestone distribution area in addition to volcanic rock area. Moreover, it is assumed that the material of d) must be deposited in a short length of time (rather rapidly).

- Furthermore, there is layer in d) consisting only of volcanic rocks as seen in Drillholes H-1 and H-6.

f) Judging from the point of view of impervious core material, the deposit widely distributed as the second layer of Area-C is the most suitable. The results of soil tests on this material will be described in detail in the next chapter.

g) Except for Drillhole H-5, there are soft layers of around 2 m which can be judged as weathered zones of the bedrock at depths touching the bedrock (fresh, hard bedrock) at all drillholes. These layers are somewhat different in color and quality depending on the type of bedrock, but they are definitely weathered zones of bedrock.

(6) Origin of Savail Slope

This site had been called "Savail Landslide" from the past and it is well known as the landslide of largest scale along the Berta river downstream of Şavşat. The investigations described in the foregoing have just been carried out to determine whether the soil material of this slope can be used as impervious core material for Bayram dam, and what had caused this slope to be formed. The results are as already have been described, but to summarize from the viewpoint of the slope's origin, they are as follows:

a) As shown in Figure 7-14, orderly classification as layers having adequate continuity is possible. From this, i) it might be possible that the entire area of this slope, except for the part of the slope facing the Berta river, moved in a quiet mass movement without any great disturbance, or ii) this deposit may have moved somewhat since initial deposition, but there has not been any movement such as may be said to have been a so-called "landslide."

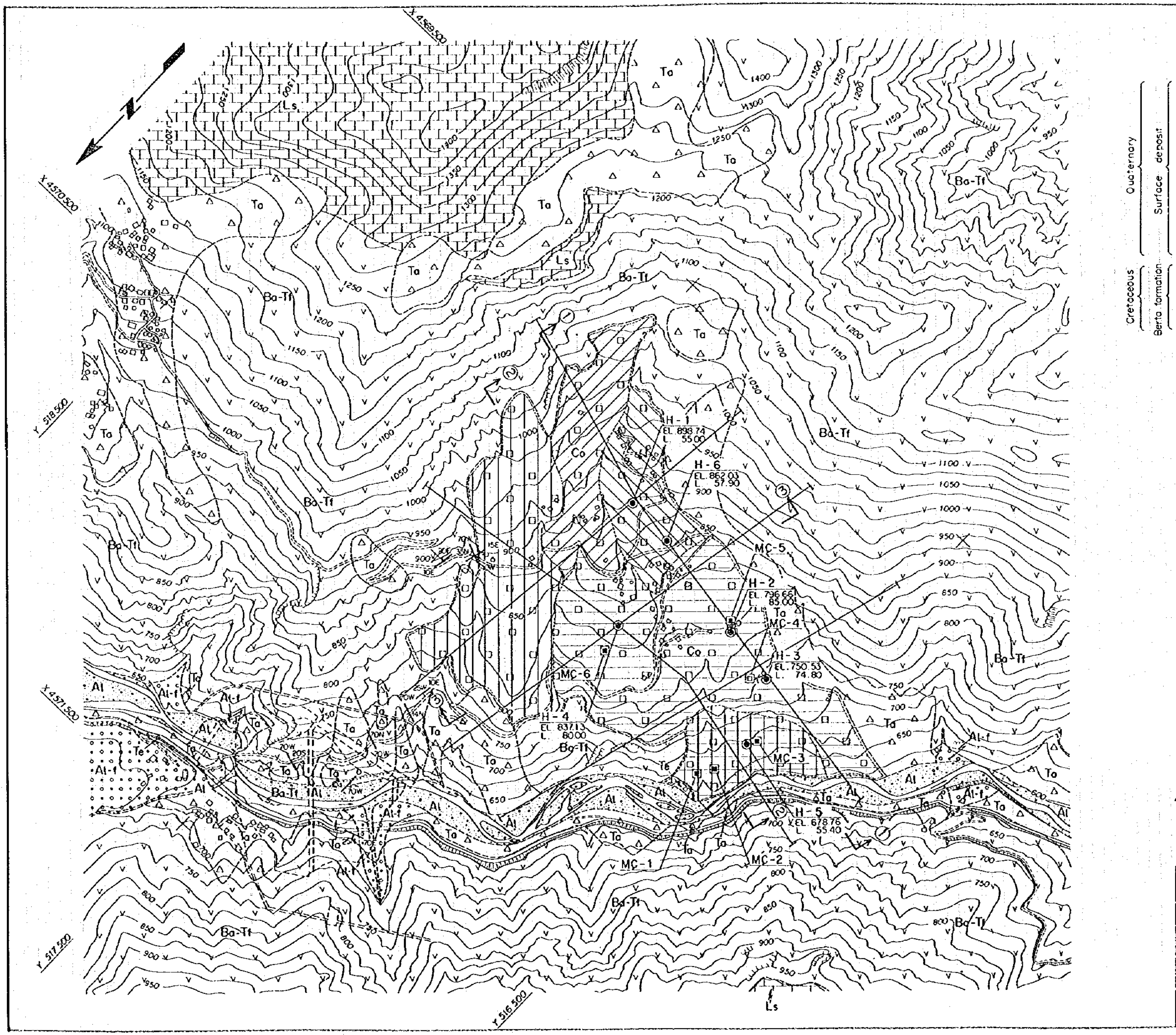
b) The JICA Survey Team estimates that possibility of (6)-a)-ii) is great. The reasons for this are as follows:

i) The soft layer of approximately 2 m sandwiched between bed rock and the deposited layers is dark gray to bluish gray in color and appears at first glance to be landslide clay, but slickensides which are characteristic of landslide clay do not exist.

ii) Clayey parts do exist in the soft layer, but at many drilled cores there are soft zones like residual soil. From this it may be judged that this soft portion was not produced by shearing, but is a weathered zone of the bedrock.

iii) The soft layer of approximately 2 m is too thick for landslide clay. Materials (sand, gravel, etc.) from the overlying deposit are not intermixed at the boundary zone between the soft layer and the overlying deposit. As for the collapsed part facing the Berta river, it is the result of slope failure which occurred due to scouring of the tip of the slope by river water.

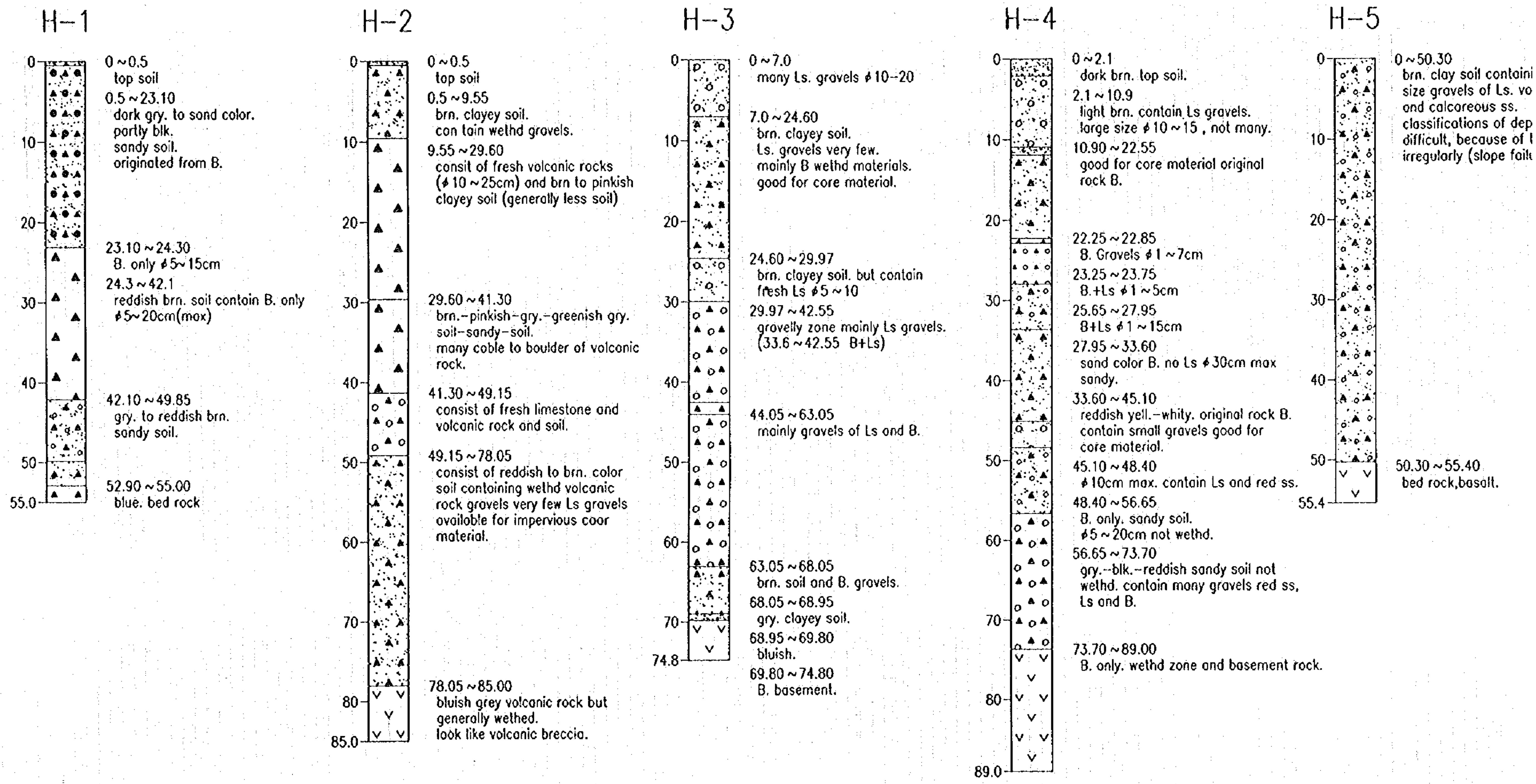
As described above, the JICA Survey Team judges that the Savail Slope Area is not a landform which was made by a landslide in the past, but by colluvial material from the surrounding mountainland which had filled the valley. However, this does not mean that the stability of this slope will be assured even though impervious core material for Bayram dam is collected from this site. The reason is that although a balance is being maintained with the present topographical condition, if, in the future, soil is excavated, the present balance will be altered, or course. It is difficult to estimate what kind of behavior the entire slope will then show. Along with it being necessary for more detailed geological investigations and studies to be made at the stage of detailed design, it will also be necessary for countermeasures to be studied on the predication that landsliding will occur. Measures conceival are village relocation and provision of disposal area at the river side of the proposed borrow area to obtain the effect of counterweight fill.



ÇORUH - BERTA HYDROELECTRIC POWER DEVELOPMENT PROJECT

SAVAİL SLOPE AREA GEOLOGIC PLAN

Figure 7-12



H-1
0~0.5
top soil
0.5~23.10
dark gry. to sand color.
partly blk.
sandy soil.
originated from B.
23.10~24.30
B. only ϕ5~15cm
24.3~42.1
reddish brn. soil contain B. only
ϕ5~20cm(max)
42.10~49.85
gry. to reddish brn.
sandy soil.
52.90~55.00
blue. bed rock
55.0
H-2
0~0.5
top soil
0.5~9.55
brn. clayey soil.
con tain wethd gravels.
9.55~29.60
consit of fresh volcanic rocks
(ϕ10~25cm) and brn to pinkish
clayey soil (generally less soil)
29.60~41.30
brn.-pinkish-gry.-greenish gry.
soil-sandy-soil.
many coble to boulder of volcanic
rock.
41.30~49.15
consist of fresh limestone and
volcanic rock and soil.
49.15~78.05
consist of reddish to brn. color
soil containing wethd volcanic
rock gravels very few Ls gravels
available for impervious coor
material.
78.05~85.00
bluish grey volcanic rock but
generally wethed.
look like volcanic breccia.
85.0
H-3
0~7.0
many Ls. gravels ϕ10~20
7.0~24.60
brn. clayey soil.
Ls. gravels very few.
mainly B wethd materials.
good for core material.
24.60~29.97
brn. clayey soil. but contain
fresh Ls ϕ5~10
29.97~42.55
gravelly zone mainly Ls gravels.
(33.6~42.55 B+Ls)
44.05~63.05
mainly gravels of Ls and B.
63.05~68.05
brn. soil and B. gravels.
68.05~68.95
gry. clayey soil.
68.95~69.80
bluish.
69.80~74.80
B. basement.
74.8
H-4
0~2.1
dark brn. top soil.
2.1~10.9
light brn. contain Ls gravels.
large size ϕ10~15 , not many.
10.90~22.55
good for core material original
rock B.
22.25~22.85
B. Gravels ϕ1~7cm
23.25~23.75
B.+Ls ϕ1~5cm
25.65~27.95
B+Ls ϕ1~15cm
27.95~33.60
sand color B. no Ls ϕ30cm max
sandy.
33.60~45.10
reddish yell.-whity. original rock B.
contain small gravels good for
core material.
45.10~48.40
ϕ10cm max. contain Ls and red ss.
48.40~56.65
B. only. sandy soil.
ϕ5~20cm not wethd.
56.65~73.70
gry.-blk.-reddish sandy soil not
wethd. contain many gravels red ss,
Ls and B.
73.70~89.00
B. only. wethd zone and basement rock.
89.0
H-5
0~50.30
brn. clay soil containi
size gravels of Ls. vo
and calcareous ss.
classifications of dep
difficult, because of t
irregularly (slope failu
50.30~55.40
bed rock,basalt.
55.4

il
.55
layey soil.
in wethd gravels.
29.60
: of fresh volcanic rocks
~25cm) and brn to pinkish
/ soil (generally less soil)

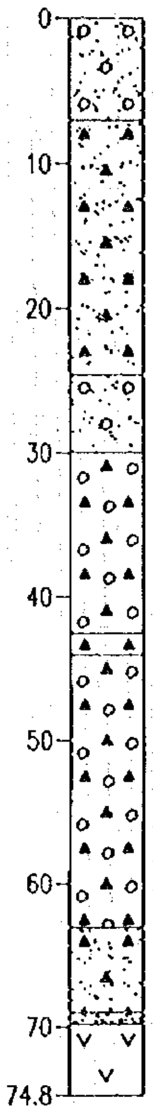
~41.30
pinkish-gry.-greenish gry.
sandy-soil.
coble to boulder of volcanic

~49.15
st of fresh limestone and
nic rock and soil.

~78.05
st of reddish to brn. color
ontaining wethd volcanic
gravels very few Ls gravels
ble for impervious coor
ial.

~85.00
grey volcanic rock but
ally wethed.
ike volcanic breccia.

H-3



0 ~ 7.0
many Ls. gravels ϕ 10-20

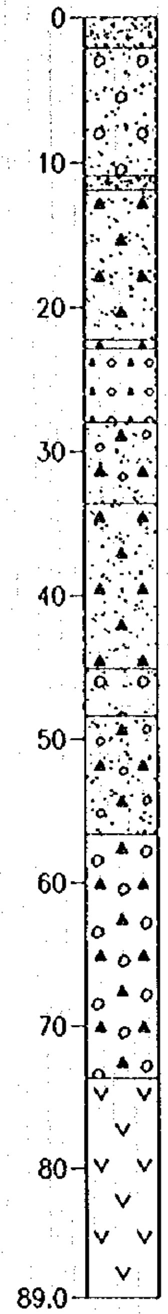
7.0 ~ 24.60
brn. clayey soil.
Ls. gravels very few.
mainly B wethd materials.
good for core material.

24.60 ~ 29.97
brn. clayey soil. but contain
fresh Ls ϕ 5 ~ 10
29.97 ~ 42.55
gravelly zone mainly Ls gravels.
(33.6 ~ 42.55 B+Ls)

44.05 ~ 63.05
mainly gravels of Ls and B.

63.05 ~ 68.05
brn. soil and B. gravels.
68.05 ~ 68.95
gry. clayey soil.
68.95 ~ 69.80
bluish.
69.80 ~ 74.80
B. basement.

H-4

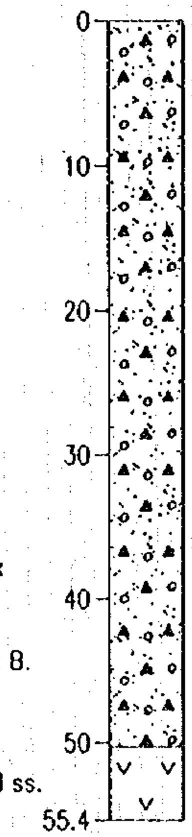


0 ~ 2.1
dark brn. top soil.
2.1 ~ 10.9
light brn. contain Ls gravels.
large size ϕ 10 ~ 15 , not many.
10.90 ~ 22.55
good for core material original
rock B.

22.25 ~ 22.85
B. Gravels ϕ 1 ~ 7cm
23.25 ~ 23.75
B.+Ls ϕ 1 ~ 5cm
25.65 ~ 27.95
B+Ls ϕ 1 ~ 15cm
27.95 ~ 33.60
sand color B. no Ls ϕ 30cm max
sandy.
33.60 ~ 45.10
reddish yell.-whity. original rock B.
contain small gravels good for
core material.
45.10 ~ 48.40
ϕ 10cm max. contain Ls and red ss.
48.40 ~ 56.65
B. only. sandy soil.
ϕ 5 ~ 20cm not wethd.
56.65 ~ 73.70
gry.-blk.-reddish sandy soil not
wethd. contain many gravels red ss,
Ls and B.

73.70 ~ 89.00
B. only. wethd zone and basement rock.

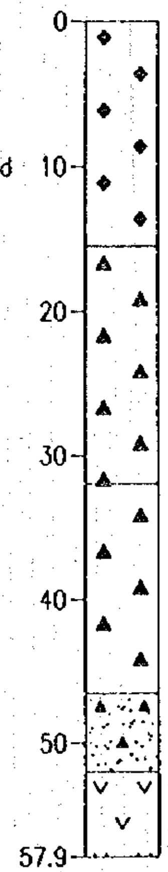
H--5



0 ~ 50.30
brn. clay soil containing various
size gravels of Ls. volcanic rocks
and calcareous ss.
classifications of deposit are very
difficult, because of they are mixed
irregularly (slope failure material).

50.30 ~ 55.40
bed rock,basalt.

H-6



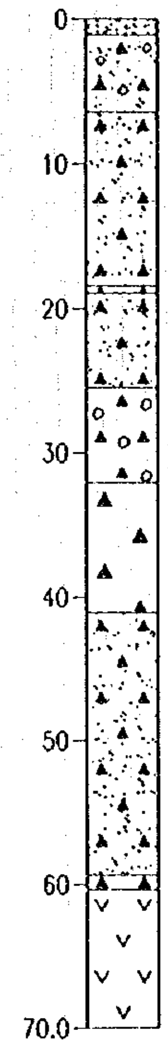
0 ~ 0.6
top soil.
0.6 ~ 15.60
cobble-boulder-detached rock
(max.ϕ 140cm) less soil ; no Ls
gravels.

15.60 ~ 31.95
mainly cobble-pebble size
volcanic rock , reddish brown
soil no Ls gravels.

31.95 ~ 46.80
cobble-boulder (mainly ϕ 30cm)
volcanic rock , very little soil.

46.80 ~ 51.90
reddish brn soil originated from
weathered volcanic rock contain
pebble size gravel no Ls.
51.90 ~ 54.40
grey weathered volcanic rock
(weathered zone of bed rock)
54.40 ~ 57.90
slightly weathered volcanic rock
(basalt) bed rock.

H-7



0 ~ 1.1
coffee brn. top soil.
1.1 ~ 6.4
coffee brn. loamy soil.
contain V.r. and Ls gravels.
6.4 ~ 8.0
WB
8.0 ~ 8.2
loamy (old top soil)
8.2 ~ 8.8
V.r. coble to boulder.
8.8 ~ 18.4
wethd volcanic material.
somewhat sandy. contain som
(coble-boulder)
18.40 ~ 18.90
V.r. boulder yellowish brn.
wethd B. contain some boulde
WB? (18.90 ~ 25.45)
25.45 ~ 32.10
reddish brn. clayey soil.
contain some fresh Ls.
seems to be good material.
32.10 ~ 41.05
yellowish-grayish brn. sandy s
contain B.v.r only. no Ls.
some boulders of V.r.
41.05 ~ 45.50
dark gry color.mudy WB not su
45.50 ~ 59.35
V.r gravels only dark gry to ch
brn soil. seems to be good for
materials. contain some fresh
of V.r.
60.35 ~ 62.75
strong wethd tuffaceous V.r.
wethd zone of bed rock?

<Remarks

op soil.

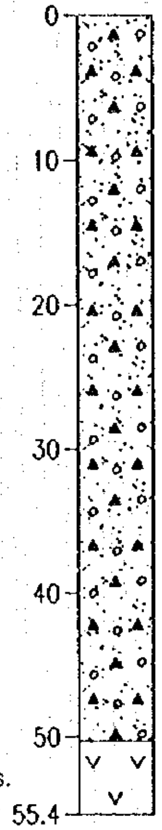
ontain Ls gravels.
ϕ 10 ~ 15 , not many.
55
ore material original

85
ϕ 1 ~ 7cm
75
~ 5cm
95
~ 15cm
60
B. no Ls ϕ 30cm max

10
l.-whity. original rock B.
nall gravels good for
rial.
40
ax. contain Ls and red ss.
65
ndy soil.
not wethd.
70
reddish sandy soil not
tain many gravels red ss,

00
ethd zone and basement rock.

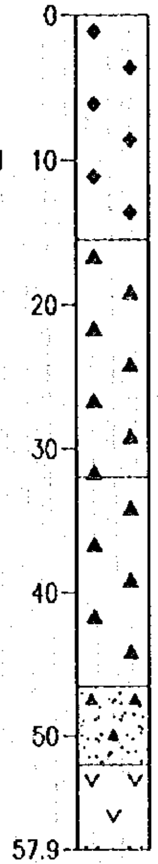
H-5



0 ~ 50.30
brn. clay soil containing various size gravels of Ls. volcanic rocks and calcareous ss.
classifications of deposit are very difficult, because of they are mixed irregulorly (slope failure material).

50.30 ~ 55.40
bed rock,basalt.

H-6



0 ~ 0.6
top soil.

0.6 ~ 15.60
cobble--boulder--detached rock (max.ϕ 140cm) less soil , no Ls gravels.

15.60 ~ 31.95
mainly cobble-pebble size volcanic rock , reddish brown soil no Ls gravels.

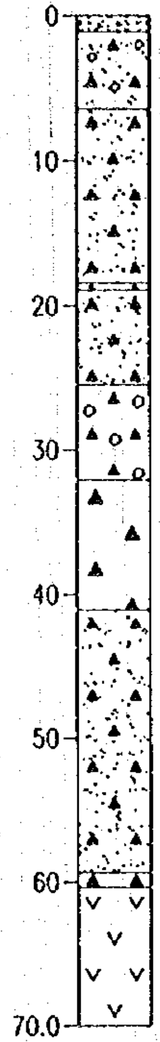
31.95 ~ 46.80
cobble-boulder (mainly ϕ 30cm) volcanic rock , very little soil.

46.80 ~ 51.90
reddish brn soil originated from weathered volcanic rock contain pebble size gravel no Ls.

51.90 ~ 54.40
grey weathered volcanic rock (weathered zone of bed rock)

54.40 ~ 57.90
slightly weathered volcanic rock (basalt) bed rock.

H-7



0 ~ 1.1
coffee brn. top soil.

1.1 ~ 6.4
coffee brn. loamy soil. contain V.r. and Ls gravels.

6.4 ~ 8.0
WB

8.0 ~ 8.2
loamy (old top soil)

8.2 ~ 8.8
V.r. coble to boulder.

8.8 ~ 18.4
wethd volcanic material. somewhat sandy, contain some V.r. (coble-boulder)

18.40 ~ 18.90
V.r. boulder yellowish brn.
wethd B. contain some boulders.
WB? (18.90 ~ 25.45)

25.45 ~ 32.10
reddish brn. clayey soil. contain some fresh Ls. seems to be good material.

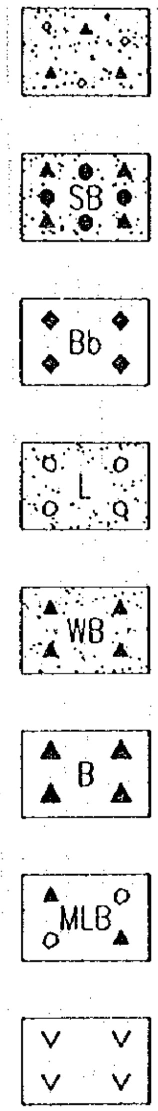
32.10 ~ 41.05
yellowish-grayish brn. sandy soil. contain B.v.r only. no Ls. some boulders of V.r.

41.05 ~ 45.50
dark gry color.mudy WB not suitable.

45.50 ~ 59.35
V.r gravels only dark gry to chocolate brn soil. seems to be good for core materials. contain some fresh gravels of V.r.

60.35 ~ 62.75
strong wethd tuffaceous V.r. wethd zone of bed rock?

LEGEND



Slope failure material : Consisted of gravels of fresh limestone , volcanic rocks and reddish soil. They are mixed irregurarly.

SB : Consisted of fresh volcanic rocks (cobble to boulder). No limestone gravels. Soil is fairly sandy.

Deposit of large blocks of fresh volcanic rocks (Berta F). Their sizes are 1m to several meters. No limestone and no soil.

L : Consisted of fresh limestone gravels (cobble to boulder) and reddish clayey soil. (No gravels of volcanic rocks)

WB : Consisted of strongly weathered gravels of volcanic rocks (Berta F) and coarse to clayey soil. Seems to be good core material.

B : Consisted of fresh gravels (cobble to boulder) of volcanic rocks (Berta F). No or very few limestone gravel. Less soil material.

MLB : Consisted of fresh limestone and volcanic rock gravels (cobble to boulder) and reddish to brown color soil.

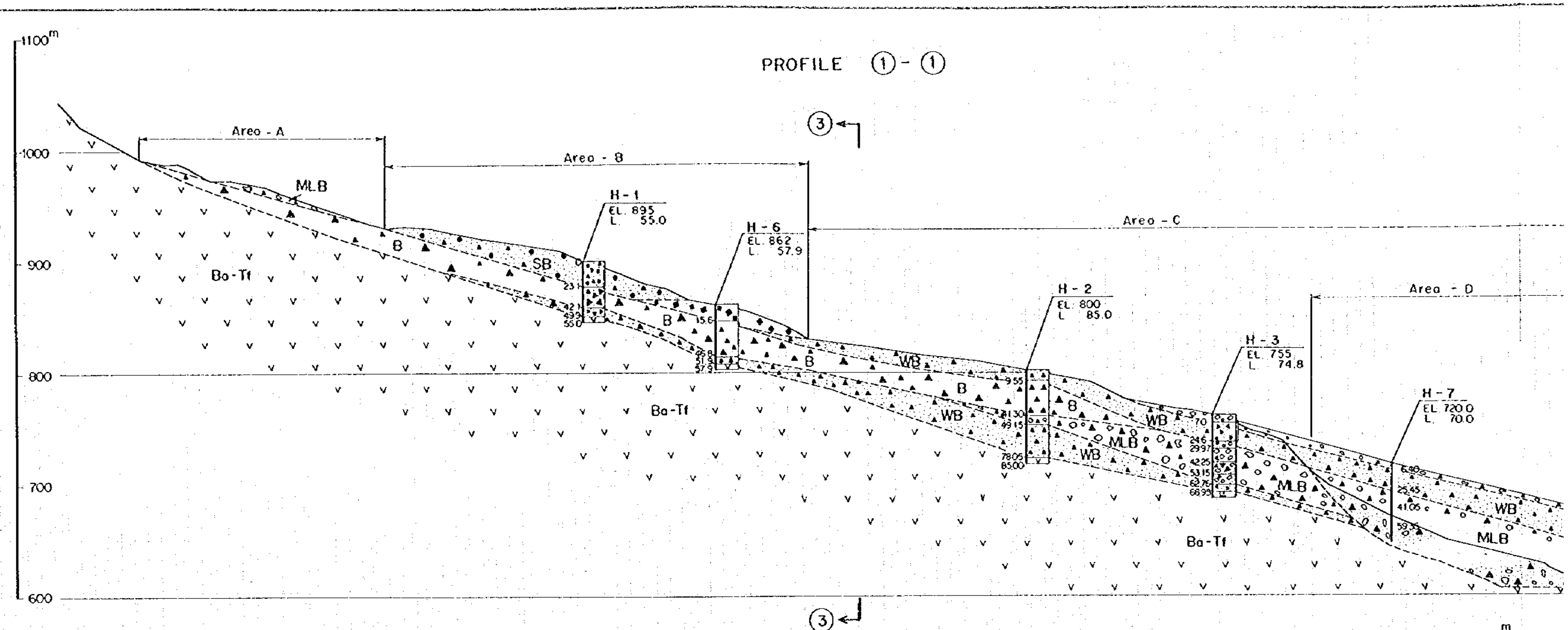
Basement rock : Consisted of volcanic rock belonging to Berta F. Normally grey to bluish color.

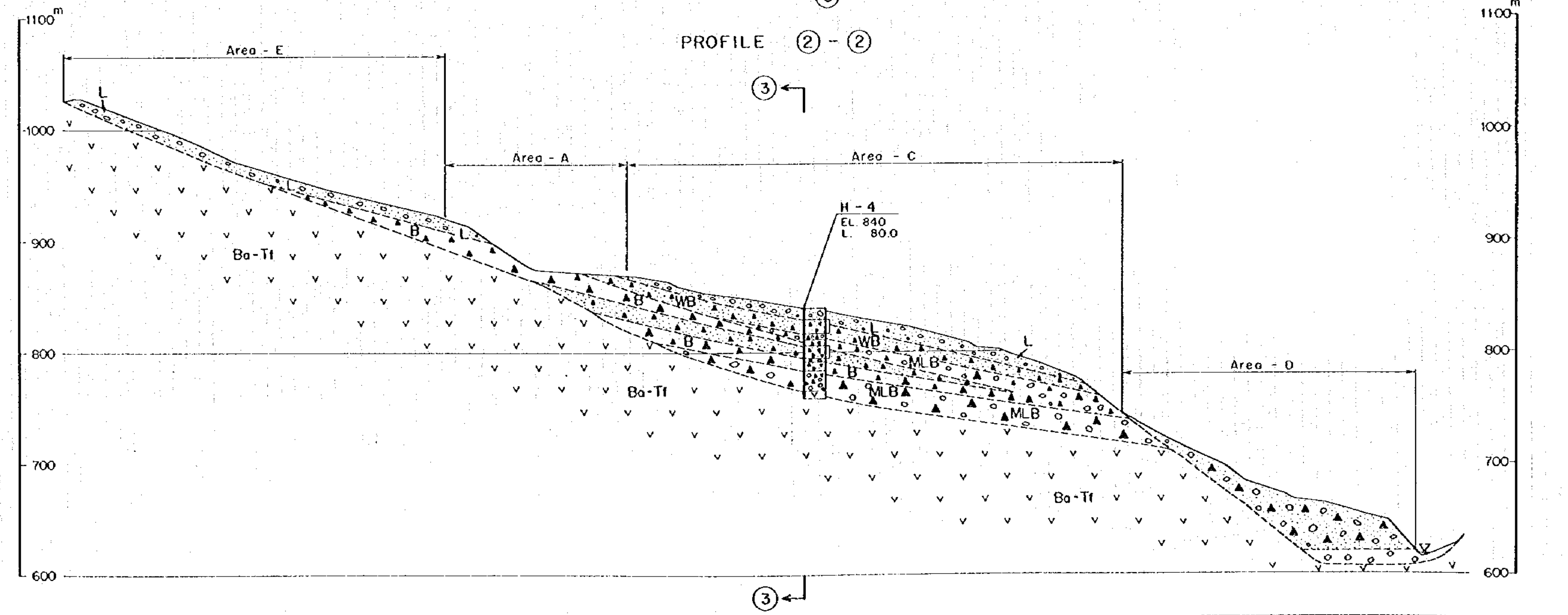
<Remarks>
Wb : weathered Berta formation
B. : Berta formation
Ls : limestone
V.r. : volcanic rocks
Wethd : weathered
ss : sandsotne
blk : black
gry : grey
brn : brown

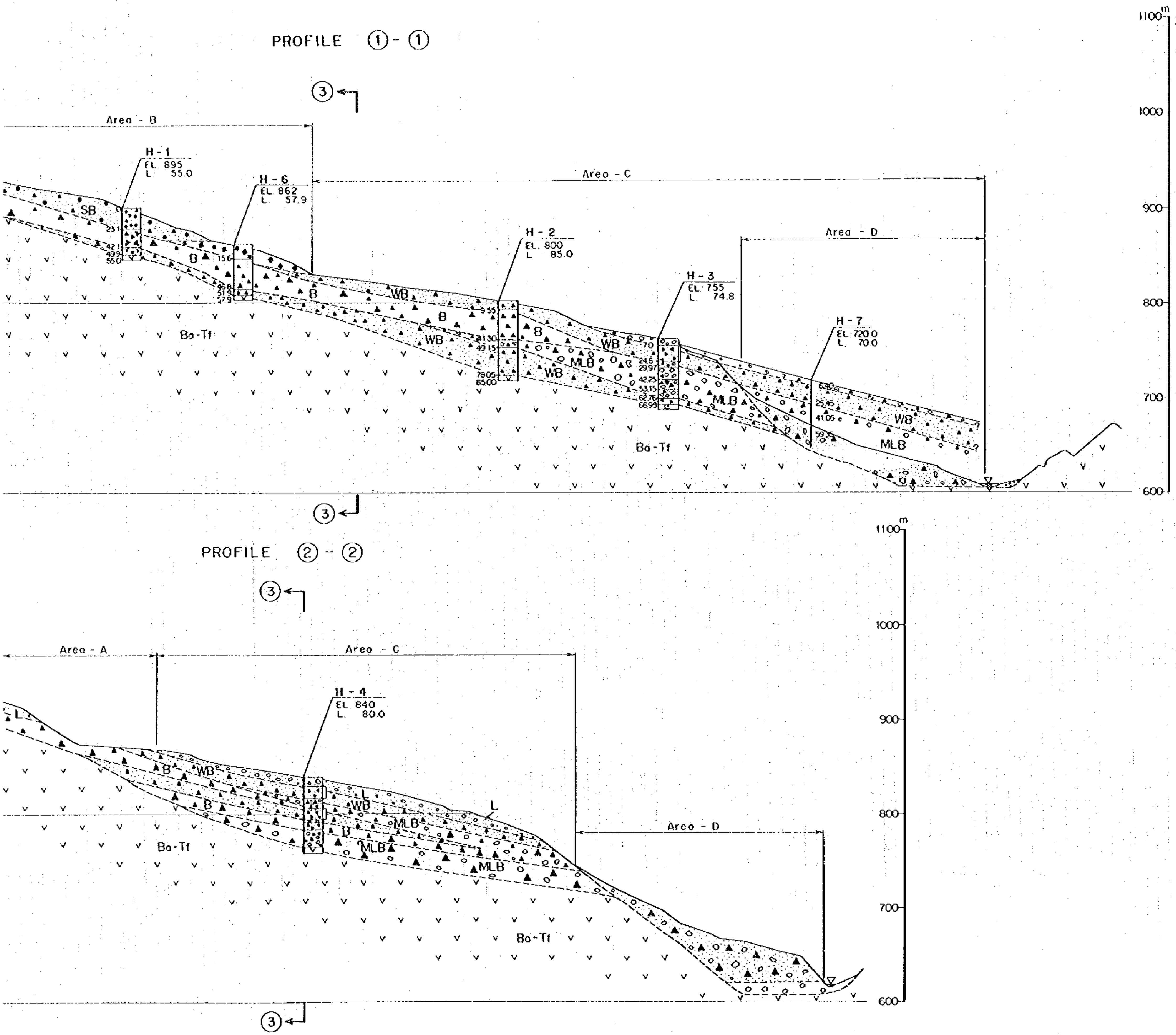
ÇORUH-BERTA HYDROELECTRIC POWER DEVELOPMENT PROJECT

SAVAİL SLOPE AREA
GEOLOGIC LOG

Figure 7 - 13


PROFILE ① - ①
1100m
1000
900
800
700
600
③
Area - A
Area - B
Area - C
Area - D
MLB
B
SB
WB
Ba-Tf
H - 1
EL. 895
L. 55.0
H - 6
EL. 862
L. 57.9
H - 2
EL. 800
L. 85.0
H - 3
EL. 755
L. 74.8
H - 7
EL. 720.0
L. 70.0


PROFILE ② - ②
1100m
1000
900
800
700
600
③
Area - E
Area - A
Area - C
Area - D
L
B
WB
MLB
Ba-Tf
H - 4
EL. 840
L. 80.0



LEGEND

Slope failure material: Consisted of gravels of fresh limestone, volcanic rocks and reddish soil. They are mixed irregurarly.

SB: Consisted of fresh volcanic rocks (cobble to boulder). No limestone gravels. Soil is fairly sandy.

Bb: Deposit of large blocks of fresh volcanic rocks (Berta F). Their sizes are 1 m to several meters. No limestone and no soil.

L: Consisted of fresh limestone gravels (cobble to boulder) and reddish clayey soil. (No gravels of volcanic rocks).

WB: Consisted of strongly weathered volcanic rocks (Berta F) and coarse to clayey soil. Seems to be good impervious core material.

B: Consisted of fresh gravels (cobble to boulder) of volcanic rocks (Berta F) No or few limestone gravel. Less soil material.

MLB: Consisted of fresh limestone and volcanic rock gravels (cobble to boulder) and reddish to brown color soil.

Basement rocks (Ba-Tf): Consisted of volcanic rock belonging to Berta F. Normaly grey to bluish color.

Geologic boundary

Drill hole

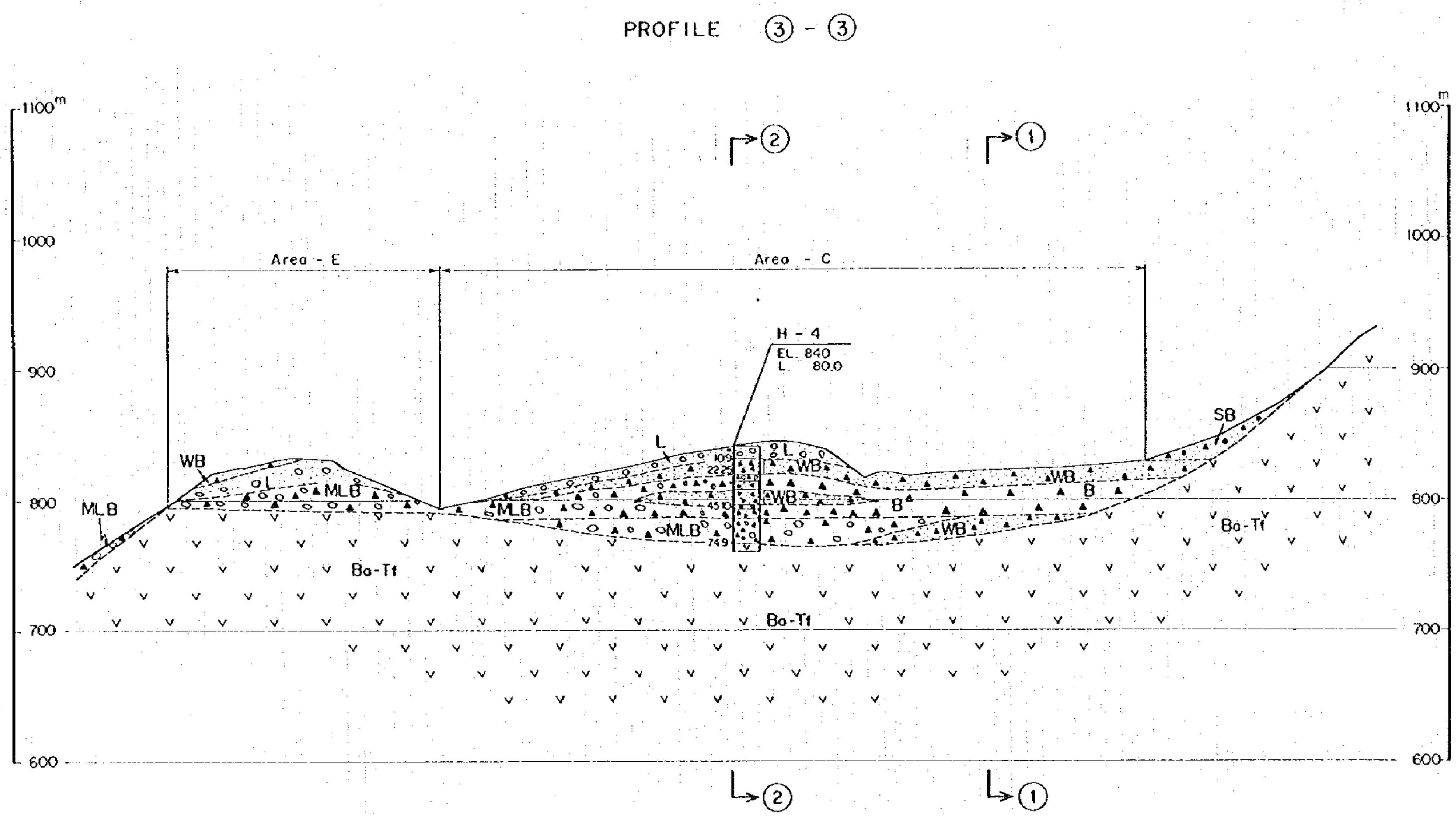
Location of profile

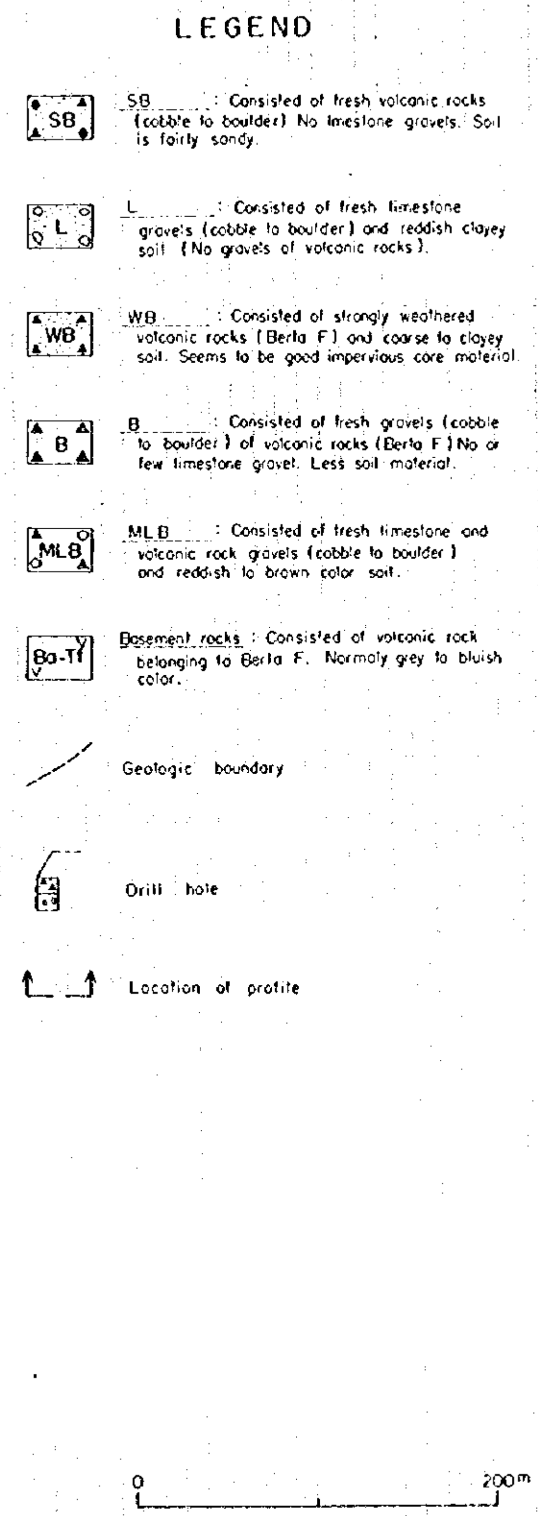
0 — 200 m

ÇORUH - BERTA HYDROELECTRIC POWER DEVELOPMENT PROJECT

SAVAİL SLOPE AREA GEOLOGIC PROFILE (1 of 2)

Figure 7 - 14





ÇORUH - BERTA HYDROELECTRIC POWER DEVELOPMENT PROJECT

SAVAİL SLOPE AREA

GEOLOGIC PROFILE (2 of 2)

Figure 7 - 15

7.5 Materials

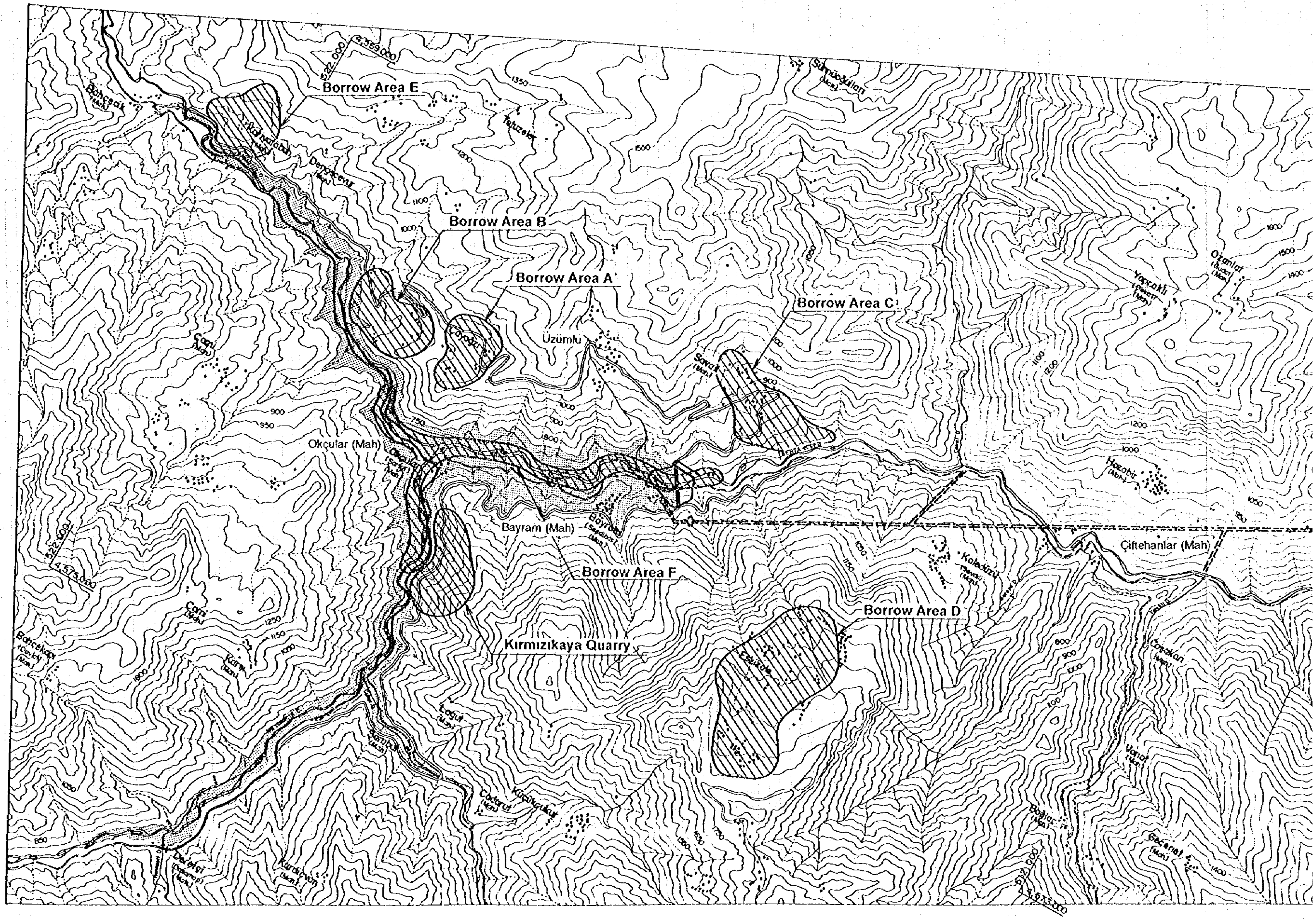
As materials investigations (including laboratory tests) concerning the Project, surface explorations of sites where materials collection would be possible were carried out by the JICA Survey Team and EIE, with conducted by EIE. The laboratory tests were carried out on impervious material (core material), semi-pervious material (filter material), concrete aggregate and rock material. The results of overall evaluation of those materials will be described here. The locations of the construction materials investigation areas are shown in Figure 7-16 and the names of the investigation areas and the kinds of construction materials investigated are given in Table 7-7. And the volume of dam embankment and concrete aggregate are given in Table 7-8.

Table 7-7 Investigation Areas for Construction Materials

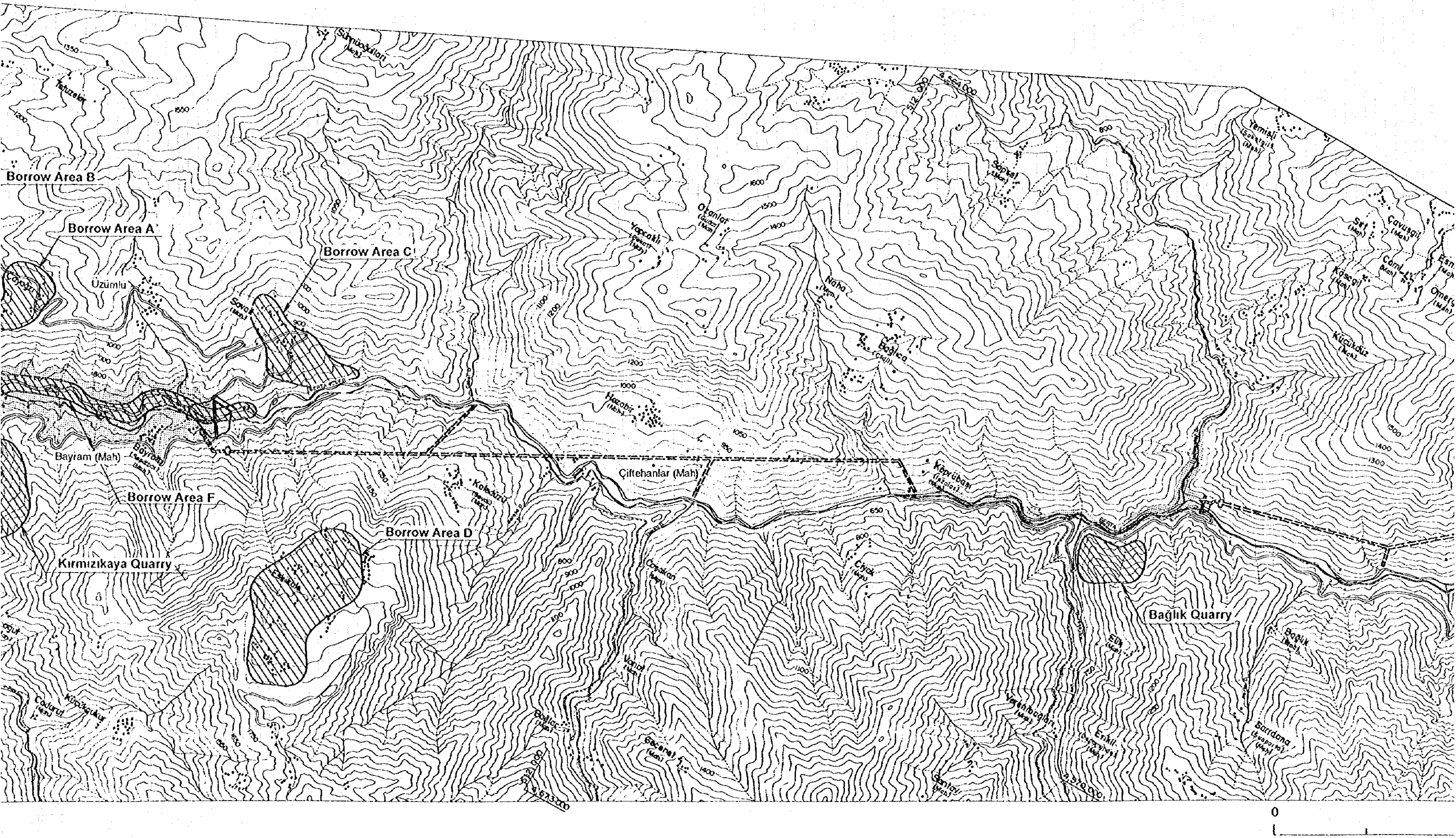
Name of Investigation Area	Kind of Construction Material
Borrow Area A, B, C, D, E	Impervious Material (Core Material)
Borrow Area F	Semi-Pervious Material (Filter Material)
Borrow Area F	Concrete Aggregate
Kırmızıkaya Quarry	Rock and Riprap Material

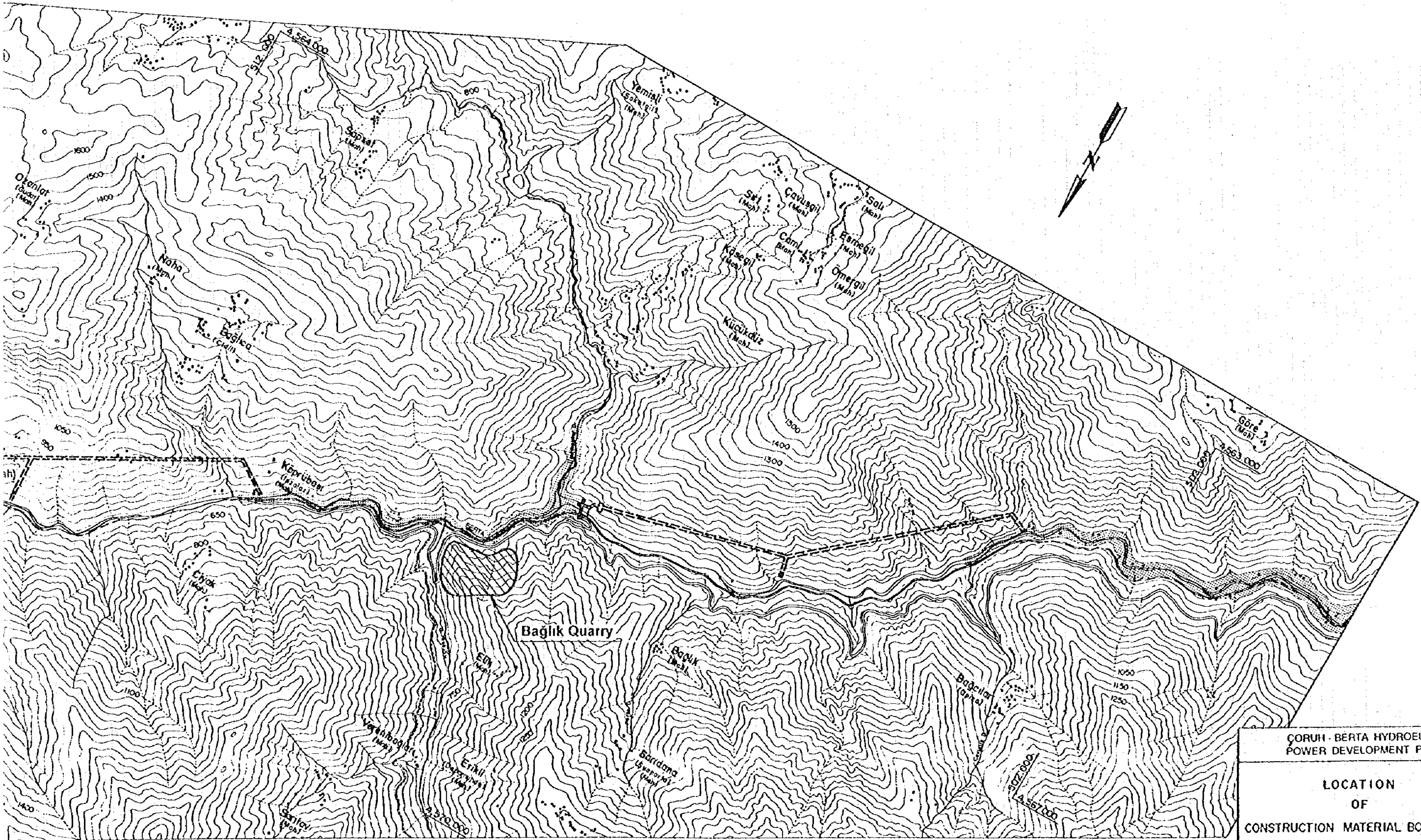
Table 7-8 Volume of Dam Embankment and Concrete Aggregate

Work Item	Unit	Design Volume	Required Volume (ground volume)
Embankment			
Impervious Core	m^3	868,000	1,310,000
Fine Filter	m^3	270,000	410,000
Coarse Filter	m^3	532,000	800,000
Rockfill•Riprap	m^3	4,476,000	3,840,000
Concrete Aggregate	m^3	425,000	850,000



Borrow Area E
Borrow Area B
Borrow Area A
Borrow Area C
Borrow Area F
Borrow Area D
Kırmızıkaya Quarry
Okçular (Mah)
Bayram (Mah)
Çiftehanlar (Mah)
Üzümlu


Borrow Area B
Borrow Area A
Borrow Area C
Üzümlü
Bayram (Mah)
Borrow Area F
Çiftehanlar (Mah)
Borrow Area D
Kırmızıkaya Quarry
Bağlık Quarry
0



ÇORUH - BERTA HYDROELECTRIC POWER DEVELOPMENT PROJECT

LOCATION OF CONSTRUCTION MATERIAL BORROW AREA

Figure 7-16

7.5.1 Soil Material

(1) Outline

The total volume of core material for Bayram Dam is approximately 870 x 10^3 m^3.

As a result of investigations by EİE and the JICA Survey Team, the soil material borrow area in the Savail Slope Area at the left bank immediately downstream of the dam site was selected as Candidate Site No. 1 (Borrow Area C), and the soil material borrow areas at EL. 700 to 1,000 m at the left bank approximately 5 to 6 km upstream of the dam as Candidate Site No. 2 (Borrow Area A, B).

There are 5 candidate borrow areas, A, B, C, D, and E in the vicinity of the dam site. All of the candidate sites are in the form of deposits consisting of gravel, sand, silt, and clay originating from gravel and weathered material of the Berta Formation. Of these, for A and B, EİE has already dug 14 test pits, performed laboratory tests, and prepared a report (Construction Material Report for Çoruh River Berta Creek Dam and HPP Projects 95-28 Aralık 1995). With regard to Borrow Area C, EİE and the JICA Survey Team have carried out investigations and EİE has prepared a report (Çoruh Berta Kolu Bayram Baraj Yeri ve HES Projesi Gecirimsiz Malzeme Deney Sonuçları 96-9 Agustos 1996).

Borrow Area C selected as Candidate Site No. 1, as described in 7.4, is a gentle slope formed by colluvial material from the surrounding mountainland at the left bank approximately 1 km downstream of the Bayram dam site. The tip facing the river has been subjected to slope failure due to scouring by the Berta River, and forms a steep cliff.

Colluvial deposit, slope wash, and talus deposit are distributed at this gentle slope. These are made up of gravels of volcanic rocks and limestones of the Berta Formation and sand, silt, and clay filling the interstices, the compositions differing according to location, and a continuation of layers is seen.

As for the two other areas, D and E, the former is located at an elevation of approximately 1,200 m at the right bank of the dam site, and a transportation road would be a problem so that it was dropped for the moment, while the latter is to be considered as reserve candidate site in the event the volume available at Borrow Area C is found to be insufficient.

(2) Soil Material of Borrow Areas A and B

(a) Laboratory Test

(I) Location of Sample Collection Sites

Site A: Area at EL. 900 - 1,000 m approximately 5 - 6 km upstream from Bayram dam site (Borrow Area A)

Site B: Area at EL. 700 - 850 m approximately 5 - 6 km upstream from Bayram dam site (Borrow Area B)

(II) Number of Samples

Site A and B: 7 pits/site, total of 14 pits, depth 2 - 4 m

(III) Soil Volume Available

Site A: Maximum 2×10^6 m^3, Minimum 8×10^5 m^3

Site B: Maximum 2×10^6 m^3, Minimum 8×10^5 m^3

(IV) Outline of Test Results

Table 7-9 Result of Gradation Analysis

(A Area)

	Grain Size (passing from sieve, %)			
	+ 75 mm	75 mm	4.76 mm	0.075 mm
min	0	90	77	27
max	10	100	99	77
Ave.	6	94	88	61

(B Area)

	Grain Size (passing from sieve, %)			
	+ 75 mm	75 mm	4.76 mm	0.075 mm
min	0	93	68	28
max	7	100	98	82
Ave.	3	97	88	54

Atterberg limits
- Liquid limit (LL) : 39.3-59.4%
- Plastic limit (PL) : 21.4-31.9%
- Plastic index (PI) : 13.9-33.2%

Specific gravity (Gs) : 2.51-2.69

Standard compaction
- Optimum water content : 16-26%
- Maximum dry density : 1.51-1.80 ton f/m^3

Direct shear strength
- Cohesion (C) : 50-87.5 kN/m^2
- The angle of internal friction (ϕ) : 10° - 35°
- The coefficient of permeability (K) : 2.7×10^{-7}-3.2×10^{-8} cm/s

Details of the above test results are given in Table 7-10.

(b) Evaluation

The results of laboratory tests would be evaluated as follows:

- Unified Soil Classification

These is a broad distribution from inorganic clay (CH) to inorganic silt and clay (CL) and clayey sand (SC), but on average the classification is inorganic silt and clay (CL), and would be ranked highly as a soil material.

- Gradation Analysis
- • In general, gradation is not uniform, and rather, it is variable.
- • In general, the soil material is slightly fine-grained.

Table 7-10 Test Results of Impervious Core Material of Borrow Area A and B

Area Name		Grain Size (passing from sieve, %)				Consistency			Soil Class	Specific Gravity Gs	Optimum Water Content (%)	Max. Dry Density tf/m^3	C		Ø (°)	Perme-ability (cm/sec)
		+75 mm	75 mm	4.76 mm	0.075 mm	LL (%)	PL (%)	PI (%)					KN/m^2	kgf/cm^2		
A	CM-1	10	90	80	27	39.3	25.4	13.9	SM-SC	2.57	18	1.74	50	5.1	35	$5.5x10^{-7}$
	CM-2	5	95	87	66	51.6	27.7	23.9	CH	2.66	24	1.58	82	8.4	13	$3.2x10^{-8}$
	CM-3	10	90	77	53	39.5	21.4	18.1	CL	2.69	18	1.71	87.5	8.9	21	$1.1x10^{-8}$
	CM-4	0	100	99	70	47.7	26.8	20.9	CL	2.65	24.5	1.56	67	6.8	18	$1.9x10^{-8}$
	CM-5	5	95	90	60	59.4	31.9	27.5	OH-MH	2.51	26	1.51	77	7.9	18	$4.9x10^{-7}$
	CM-6	5	95	94	72	58.5	25.3	33.2	CH	2.63	26	1.51	67	6.8	22	$2.6x10^{-8}$
	CM-7	5	95	92	77	53.5	23.0	30.5	CH	2.67	25	1.58	87	8.9	10	$2.0x10^{-8}$
A	Min	0	90	77	27	39.3	21.4	13.9		2.51	18	1.51	50	5.1	10	$1.1x10^{-8}$
	Max	10	100	99	77	59.4	31.9	33.2		2.69	26	1.74	87.5	8.9	35	$5.5x10^{-7}$
	Ave	6	94	88	61	49.9	25.9	24.0		2.63	23	1.60	74	7.5	20	$1.6x10^{-7}$
B	CM-8	7	93	68	39	42.6	20.7	21.9	SC	2.57	16	1.77	50	5.1	24	$2.7x10^{-7}$
	CM-9	5	95	77	28	37.6	22.3	15.3	SC	2.55	16	1.80	38	3.9	27	$2.8x10^{-7}$
	CM-10	0	100	98	63	47.5	24.6	22.9	CL	2.69	23	1.59	53	5.4	14	$1.4X10^{-8}$
	CM-11	0	100	97	82	48.3	22.6	25.7	CL	2.64	22	1.59	75	7.6	17	$1.8x10^{-8}$
	CM-12	0	100	95	58	48.7	29.1	19.6	OH-MH	2.53	20	1.57	70	7.1	20	$5.0x10^{-7}$
	CM-13	5	95	91	47	47.9	29.4	18.5	OH-MH	2.55	22	1.61	65	6.6	16	$4.3x10^{-7}$
	CM-14	5	95	87	60	53.2	29.5	23.7	CH	2.66	23	1.57	68	6.9	17	$2.4x10^{-8}$
B	Min	0	93	68	28	37.6	20.7	15.3		2.53	16	1.57	38	3.9	14	$1.4x10^{-8}$
	Max	7	100	98	82	53.2	29.5	25.7		2.69	23	1.80	75	7.6	27	$5.0x10^{-7}$
	Ave	3	97	88	54	46.5	25.4	21.1		2.60	20	1.64	60	6.1	19	$2.2x10^{-7}$

• Gravels larger than 150 mm are slightly small compared with standard soil.

- Atterberg limits

Liquid limit is average 49.9% (Site A), 46.5% (Site B), Plastic index average 24.0% (Site A), 21.1% (Site B) and no problem.

- Specific gravity

Specific gravity is average 2.63 (Site A), 2.60 (Site B) and no problem.

- Optimum water content

Optimum water content is average 23% (Site A), 20% (Site B) and no problem.

- Permeability

Impermeable.

• Site A is at EL. 900 to 1,000 m, and considered from the EL. 720 m of the existing road along the Berta River, the elevation of this site is too high, and the transportation condition is not favorable.

• According to the EIE report, both Sites A and B are said to have from 8×10^5 m^3 (min.) to 2×10^6 m^3 (max.), but the respective volumes should be estimated again and checked it.

(3) Soil Material of Borrow Area C

(a) Laboratory Test

(I) Location of Sampling Collection Sites

The area at EL. 600 - 850 m on the left bank approximately 1 km downstream of the Bayram dam site (Borrow Area C).

(II) Number of Samples

Total of 9 pits.

(III) Soil Volume Available

Approx. 1.5×10^6 m^3

(IV) Outline of Test Results

Table 7-11 Result of Gradation Analysis

	Grain Size (passing from sieve, %)			
	+ 75 mm	75 mm	4.76 mm	0.075 mm
min	0	100	62	26
max	0	100	95	61
Ave.	0	100	77	41

Atterberg limits
- Liquid limit (LL) : 30.6-51.6%
- Plastic limit (PL) : 18.6-27.7%
- Plastic index (PI) : 10.4-23.9%

Specific gravity (Gs) : 2.68-2.75

Standard compaction
- Optimum water content : 11-19%
- Maximum dry density : 1.70-1.92 ton f/m^3

Direct shear strength
- Cohesion (C) : 35-82 kN/m^2
- The angle of internal friction (ϕ) : 12° - 35°
- The coefficient of permeability (K) : 6.5×10^{-7}-2.5×10^{-8} cm/s

Details of the above test results are given in Figure 7-17 and Table 7-12.

(b) Evaluation

The results of laboratory tests would be evaluated as follows:

- Unified Soil Classification

From gradations and Atterberg limits, the material on average belongs to clayey sand (SC), and is favorable as a soil material.

- Gradation

- In general, there is little scatter in gradation.

- In general, both fine-grained material and coarse-grained material are in the range of soil material.

- Nothing is reported concerning the content of gravels 150 mm and larger.

- Atterberg limits

Liquid limit (LL) is average 39.5%, which is slightly low, but the Plastic index (PI) is average 17.1% which poses no problem.

- Specific gravity

Specific gravity is average 2.71 and no problem.

- Optimum water content

Optimum water content is average 15.4% and no problem.

- Coefficient of Permeability

Impermeable

- The location of the borrow area is 1 km from the dam site and near, while the elevation is not very much different from the dam crest of EL. 745 m. Regarding the small collapse area near the river bed, after soil material was collected, it would be desirable that a disposal area could be provided there for slope stability and that space used for temporary stockyard.

- The available volume is put as approximately 1.5 x 10^6 m^3, but to confirm this volume, and quality as well, and to determine the area of borrowing, it will be necessary for investigations to be made by test pits on a grid of 100 m spacing and by dry boring.

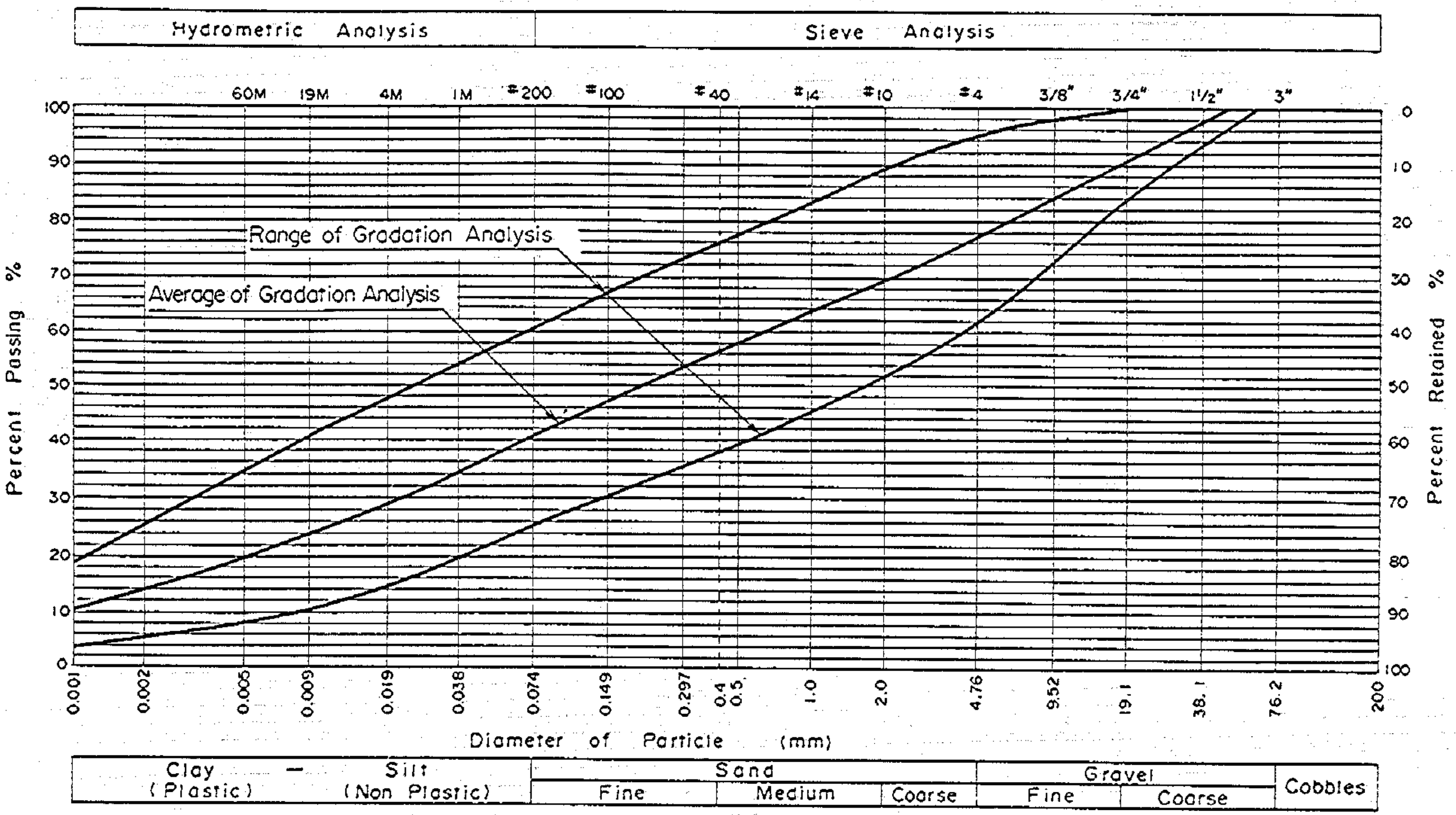


Figure 7-17 Gradation Analysis of Test on Borrow Area C

Table 7-12 Test Result of Impervious Core Material of Borrow Area C

Test Pit No.	Sieve Analysis		Atterberg Limits			Soil	Specific	Natural Water	Standard Compaction		Direct Shear Strength		Coefficient of
	Retained	Passing	LL	PL	Pi	Classifi-	Gravity	Content	Opt. Moist. Cont.	Max. Dry Dens.	C	Ø	Permeability
	No.4	No.200	%	%	%	cation	Gs	%	%	tf/m^3	kN/m^2	Degree	cm/sec.
MC-1	34	35	41	22.6	18.4	GC	2.74	-	14	1.84	82	20	$1.5x10^{-7}$
MC-2	11	61	51.6	27.7	23.9	CH	2.75	-	16.5	1.67	76	12	$2.5x10^{-8}$
MC-3	38	26	37.8	18.6	19.2	GC	2.71	-	13	1.87	64	20	$1.8x10^{-7}$
MC-4	6	58	37.8	23.6	14.2	CL	2.72	-	15	1.73	35	22	$3.0x10^{-7}$
MC-5	31	26	30.6	20.2	10.4	SC	2.72	-	11	1.92	50	35	$5.5x10^{-7}$
MC-6	22	46	39.5	22.2	17.3	SC	2.7	-	17	1.72	65	21	$6.1x10^{-7}$
MC-7	22	37	41.2	23.2	18	SC	2.68	-	19	1.7	62	16	$5.9x10^{-7}$
MC-8	23	29	34.4	20.4	14	SC	2.68	-	15	1.85	42	31	$6.5x10^{-7}$
MC-9	20	48	42	23.2	18.8	SC	2.7	-	18	1.74	67	16	$6.0x10^{-7}$
Average	23	41	39.5	22.4	17.1	SC	2.71		15.4	1.78	60	21	$4.1x10^{-7}$

- As a result of additional investigations by EIE and the JICA Survey Team, Site C is suitable as the soil material borrow area when quality, volume, location, etc. are considered. However, when carrying out the previously-mentioned investigation, triaxial shear test for dam stability analysis would be necessary to be conducted to determine design values.

7.5.2 Rock Material

(1) Outline

The total volume of rock material for Bayram dam is approximately 4.5 x 10^6 m^3. As a result of the investigations carried out by EİE and the JICA Survey Team, Kırmızıkaya quarry (east slope of Kırmızıkaya hill) on the right bank 3-4 km upstream from the dam site was selected as the candidate site for obtaining rock material. This candidate site consists of basalt and volcanic breccia of the Berta formation, and it has been confirmed through surface geological explorations and two exploratory drillholes that the rock mass is hard and dense.

(2) Rock Material of Kırmızıkaya Quarry

(a) Laboratory Test

Specific gravity (Gs)	:	2.65-2.77
Water absorption	:	0.12-1.14%
Observed porosity	:	0.32-2.97%
Los Angeles abrasion		
100 period	:	3.8%
500 period	:	15.8%
Na_2SO_4 soundness	:	5%
Direct shear strength	:	1,339-1,815 kgf/cm^2

(b) Evaluation

- According to the results of laboratory tests, the materials of this site are satisfactory as rockfill material.

- Consequently, surface geological reconnaissance, exploratory boring, and seismic prospecting would be necessary for making an accurate evaluation of the volume available.

7.5.3 Filter Material and Concrete Aggregate

(1) Outline

The candidate site for filter material and concrete aggregate material consists of the alluvial deposits distributed in the upstream area of the Bayram dam site. these deposits are mainly composed of gravel and sand. The thickness of the alluvial deposits is very large and approximately 33 m. these deposits exist in a range of approximately 4 km including parts upstream and downstream of the dam, and the volume deposited is estimated at approximately 4×10^6 m^3. This river-bed sand-gravel is planned to be excavated for filter material (Bayram dam) and concrete aggregate (Bağlık dam and Bayram-Bağlık concrete structures) and used upon classification.

Regarding the applicabilities of alluvial deposits as filter material and concrete aggregate, there is no problem concerning filter material, but as concrete aggregate, there were test results in part where a problem remained about soundness. However, it was judged that this was of a degree which could be coped with by adjustments in concrete mix proportions at the stage of construction, and therefore, at this stage, the alluvial deposits are considered as comprising the first candidate site for collecting filter material and concrete aggregate.

Further, material from the rock material quarry at the right bank upstream of the dam can be used for concrete aggregate, and this location is to be the second candidate site.

(2) Filter and Concrete Aggregate Materials from Alluvial Deposits around Bayram Dam

(a) Laboratory Test and Evaluation

(I) Location of Sampling Site
Site F: Immediately upstream of Bayram dam site (Borrow Area F)
(II) Number of Tests: Total of 3 pits
(III) Soil Volume Available: Approx. 4×10^6 m^3

(VI) Outline of Test Results

Table 7-13 Result of Gradation Analysis

	Grain Size (passing from sieve, %)			
	+ 75 mm	75 mm	4.76 mm	0.075 mm
min	0	100	50	2
max	0	100	57	4
Ave.	0	100	54	3

			Japanese Standard
Specific gravity (Gs)			
sand	:	2.63~2.64	>2.50
gravel	:	2.50~2.61	>2.50
Water Absorption			
sand	:	2.5~2.7%	<3.0
gravel	:	2.4~2.8%	<3.0
Percent passing No.200 Sieve			
sand	:	1.4~4.2%	<7.0
gravel	:	0.1%	<1.0
Clay Lumps			
sand	:	0.44 ~1.38%	
gravel	:	0.21~0.42%	
Organic Impurities			
sand	:	pale yellow	
gravel	:	pale yellow	
Na_2SO_4 Soundness			
sand	:	18.3~21.9%	<10
gravel	:	11.6~15.9%	<12
Los Angeles Abrasion			
100 period	:	3.5~3.7%	
500 period	:	18.3~20.6%	<40
Alkali Reactivity		260~350 mmol/L	To be harmless
Dissolved Silica		91~92 mmol/L	To be harmless

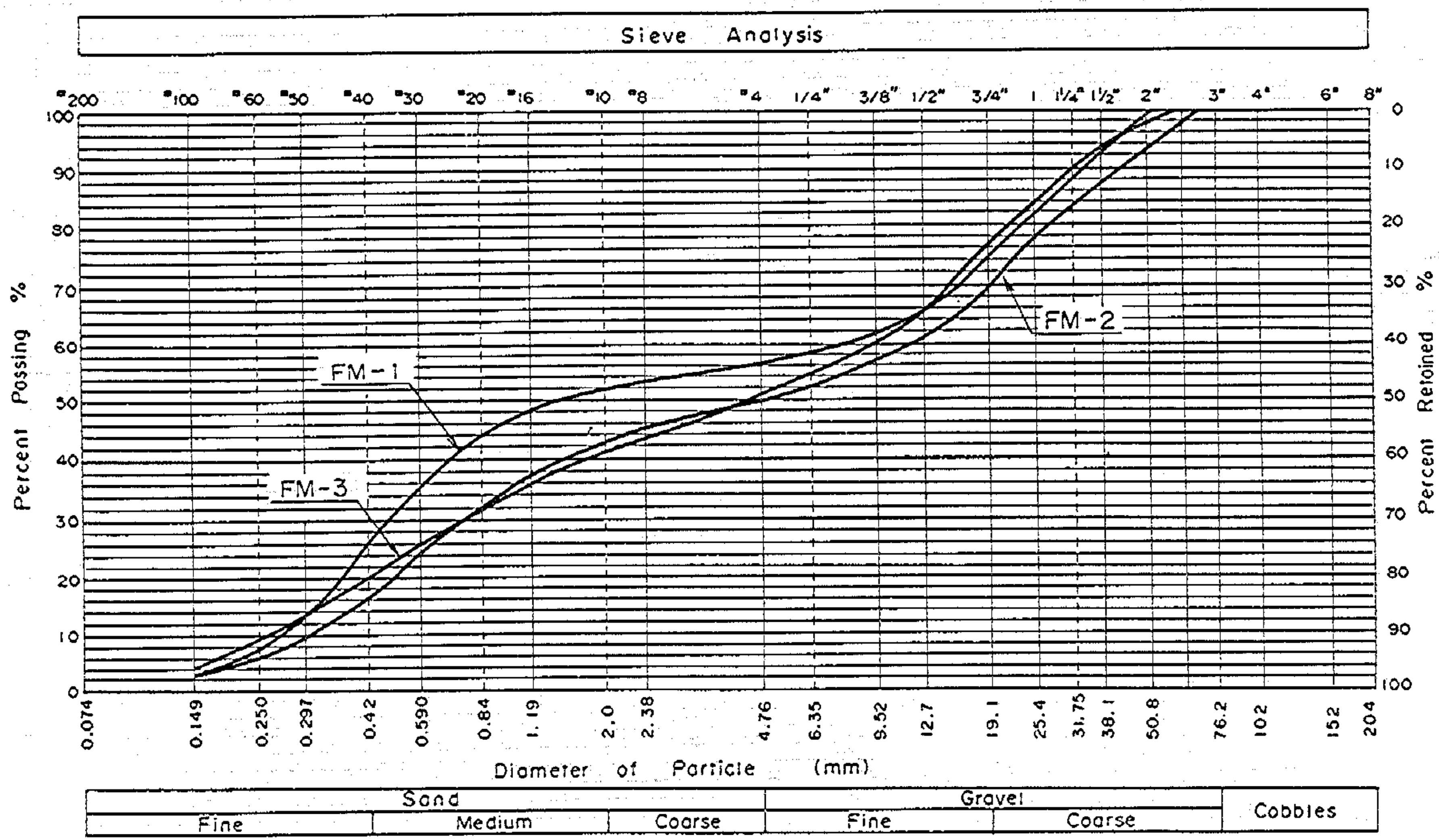


Figure 7-18 Gradation Analysis of Test on Borrow Area F

(V) Evaluation

- Judged by the above-mentioned laboratory test results, the quality is good as a filter material. However, as concrete aggregate, satisfactory results were obtained for organic content, Los Angeles abrasion tests, and alkali-aggregate reactivity tests, but specific gravity is comparatively low, while in soundness tests, large values of over 18% for sand and over 12% for gravel were obtained.

But number of tests are few, so, it would be necessary to make additional tests to check the quality.

- Although there is a wide margin in the volume available, the volumes required for concrete aggregate and filter material are 8.5 x $10^5 m^3$ and 12.1 x $10^5 m^3$, respectively. Consequently much volume seem to be in reserve, but it would be necessary to confirm the volume possible to collect by carrying out additional investigations hereafter to judge the volume available, collection plan.

(3) Other Material Collection Areas

(a) Concrete Aggregate Material at Kırmızıkaya Quarry

As mentioned in 7.5.2 (2) on rock material, the material can be used as concrete aggregate without any problem. Regarding available volume, it was found at the time the reconnaissance was made that the necessary volume could be secured roughly, and furthermore, the land for temporary facilities could be obtained with comparative ease.

Accordingly, at the present stage, this is to be made the second candidate site for concrete aggregate next to the alluvial deposits in the surroundings of Bayram dam.

(b) Concrete Aggregate Material at Bağlık Quarry

The location of this quarry is at the right bank approximately 1.0 km upstream of Bağlık dam.

EİE has already conducted laboratory tests on materials from this quarry, and prepared a report (95-28).

Unit weight		
sand	:	1,520 kgf/m^3
gravel	:	1,615 kgf/m^3
Specific gravity and water absorbsion		
sand	:	2.69, 0.8%
gravel	:	2.63, 1.0%
Na_2SO_4 Soundness		
sand	:	13.2%
gravel	:	4.4%
Los Angeles abrasion		
100 period	:	3.9%
500 period	:	16.0%
Alkali reactivity	:	120 mmol/L
Dissolved Silica	:	4 mmol/L

According to the above test results, the material at this quarry is of good quality for use as concrete aggregate.

Location-wise, this quarry is close to the Bağlık dam site, and there are no problem on quality but topographically, it would be difficult to secure land for temporary facilities such as an aggregate plant and aggregate stockyard. Also, the number of sets performed so far are still small, and investigations and detailed laboratory tests for determining the area of collection would be necessary to be carried out.

Consequently at the present stage, this is to be omitted from candidate sites for concrete aggregate.

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8.1 Structural Geology of Turkey

8.1.1 Geological Outline

The Anatolian Peninsula region has been subjected to the repeated organic movements since the beginning of Paleozoic age, and presents a complex geology. Concerning the structural geology of Turkey, it can be classified into four east-west oriented tectonic zones. Namely, they are in order from the north, the Pontids, Anatolids, Taurids, and Border Folds as shown in Figure 8-1.

In the Pontids, Cretaceous to Paleogene rhyolitics-basaltic volcanic rocks are predominant, while there is partial distribution of Jurassic to Cretaceous ophiolite. In the Anatolids, strongly deformed Eocene to Miocene marine clastic rocks and Quaternary volcanic rocks are distributed on the basement rocks of Jurassic to Cretaceous ophiolite and slightly metamorphosed rock. The continental deposits of Pliocene to Quaternary are distributed at the mountainland basins. The basement of the Taurids consists mainly of Precambrian to Mesozoic strata and ophiolite, while Eocambrian to Pliocene neritic sedimentary rocks are predominant in the Border Folds.

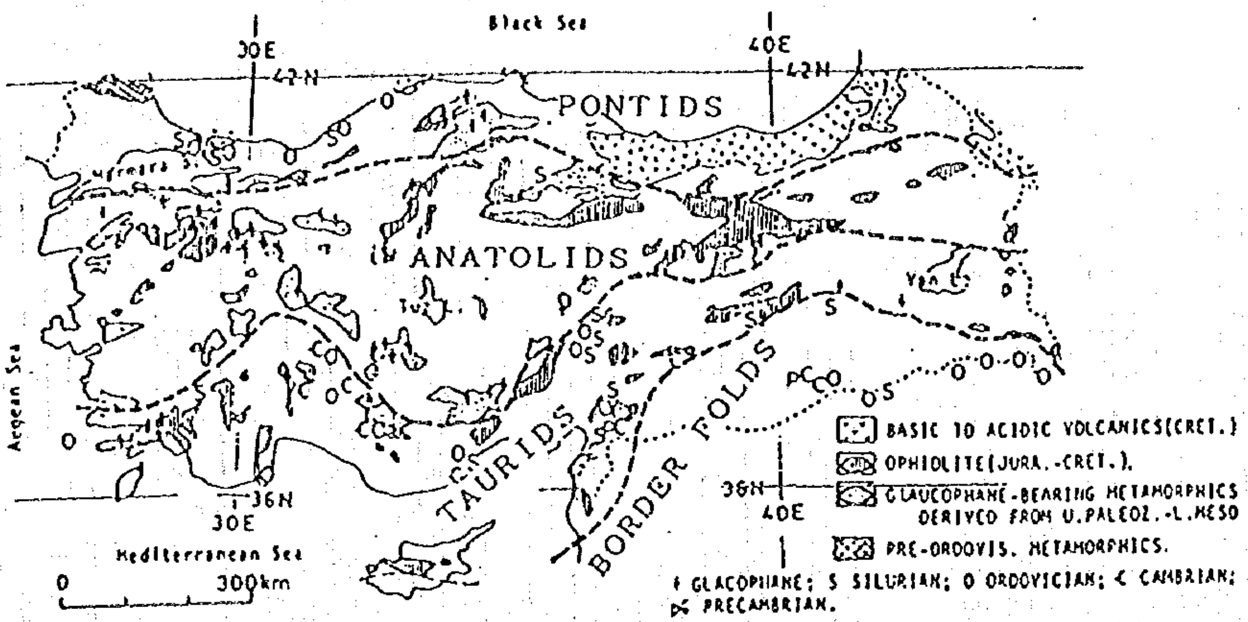


Figure 8-1 Tectonic Zone of Turkey (after Hirano, 1981)

8.1.2 Neotectonics of Turkey

Various plate tectonics models around Turkey have been proposed by Mckenzie (1972), Alpekin (1973), Papazachos (1974), Dewey & Sengor (1979), and others.

Turkey is surrounded by three macro-plates, i.e. Eurasian Plate, Arabian Plate and African Plate, as shown in Figure 8-2. Basically, Arabian and African Plates are drifting toward north relatively against Eurasian Plate causing the tectonic compressive stress field.

Moreover, many micro-plates such as Aegean Plate, Iran Plate, Anatolian Plate (Turkey Plate) and Black Sea Plate are located in Republic of Turkey surrounded by the three macro-plates which are mentioned above.

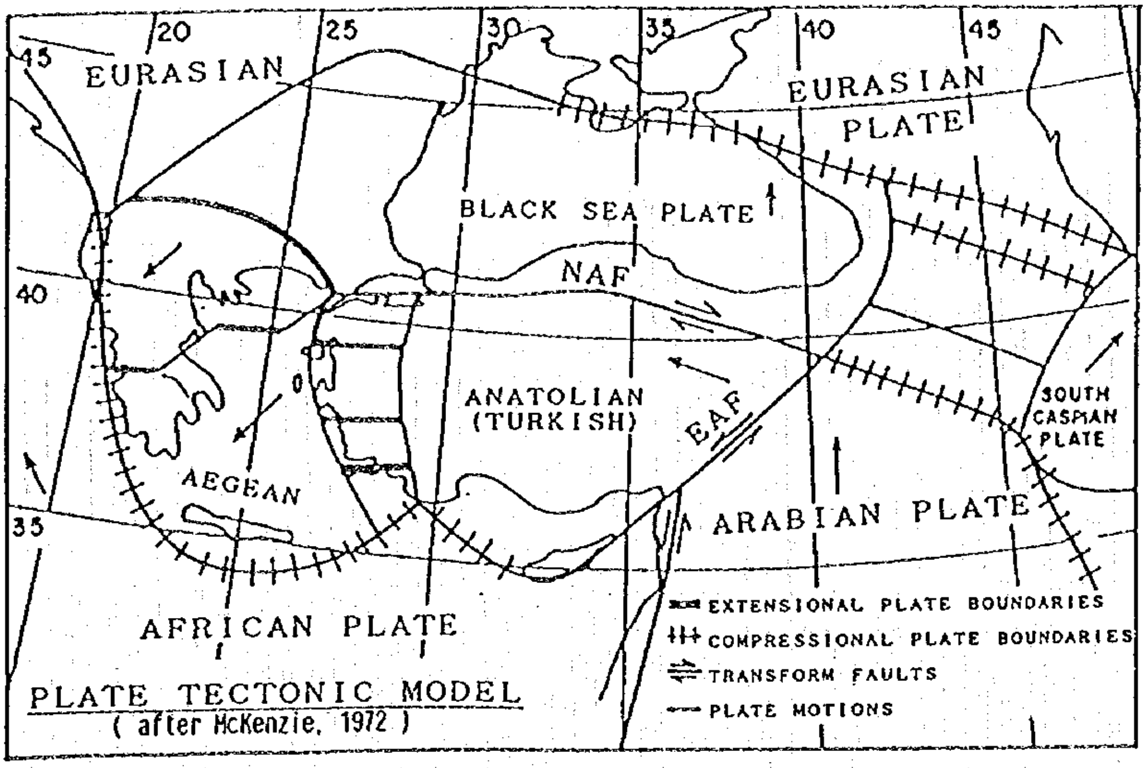


Figure 8-2 Typical Plate Tectonics Model

8.1.3 North Anatolian Fault and East Anatolian Fault

The Anatolian Peninsula region is divided by two transform faults named North Anatolian Fault and East Anatolian Fault, which make up the plate boundaries. Particularly, these two transform faults prominently divide the previously-mentioned tectonic zones.

The North Anatolian Fault extends east-west, presenting a gentle arc bulging northward at the northern part of Turkey and its total length is in excess of approximately 1,000 km. It is a morphologically distinct and seismically active right lateral strike-slip fault. The accumulated horizontal displacement of it was considered to be 70 to 80 km in the past, but recently, some researcher says that it should be 20 to 30 km, and this subject requires further study. The occurrence of the North Anatolian Fault is said to have been 10 to 12 million years ago, but the direction of displacement has not always been consistently right-handed horizontal and it appears there was a time in the middle of Pliocene Epock when a left-handed horizontal displacement was indicated. Many active faults, earthquake faults and mountainland basins are distributed along this fault, while there have been also volcanic activities, and it may be seen that this is a first-class structure of the Quaternary Period.

The East Anatolian Fault divides the Taurids, and on land it has a length of approximately 560 km with a strike of N60°E - S60°W. It shows a thrust-fault nature at the southwestern part, but a left-handed lateral displacement is prominent on the whole. It is covered by Quaternary volcanic rocks and the displacement topography is not always distinct, while the degree of activity is slightly lower compared with the North Anatolian Fault, but this is also a paramount structure of this region. The fault intersects the North Anatolian Fault east of Karliova to comprise a triple junction. As a consequence, the Anatolian Plate sandwiched by the two faults would apparently shift westward.

As described in the foregoing, the neotectonics of Turkey are made complex reflecting the mutual movements between the plates in the field of tectonic stress from north-south compression caused by the northward-drifting Arabian Plate since the late Miocene Epoch.

8.2 General Seismicity of Turkey

8.2.1 Seismological Outline

It is well known that many earthquakes have occurred in Turkey, which is located in Alphine-Himalayan seismic zone. As explained before, three macro-plates, i.e. Eurasian Plate, Arabian Plate and African Plate, develop the mutual movements around Turkey. And moreover, Micro-Plates such as Aegean Plate, Iran Plate, Anatolian Plate and Black Sea Plate develop the mutual complicated movements, in Turkey.

These micro-plates are small, but move rapidly. The cause of the local increase in seismic activity of this region is attributed to the existence of these small but rapidly moving micro-plates.

Figure 8-3 clearly shows the distribution of the major fault systems in Turkey. It can be understood that the major faults are running along the border zone of the micro-plates which are mentioned above.

Shortly speaking, earthquakes in Turkey occur as a result of relative movements among the many macro/micro plates i.e. Eurasian Plate, African Plate, Arabian Plate, Aegean Plate, Iran Plate, Anatolian Plate (Turkey Plate) and Black Sea Plate.

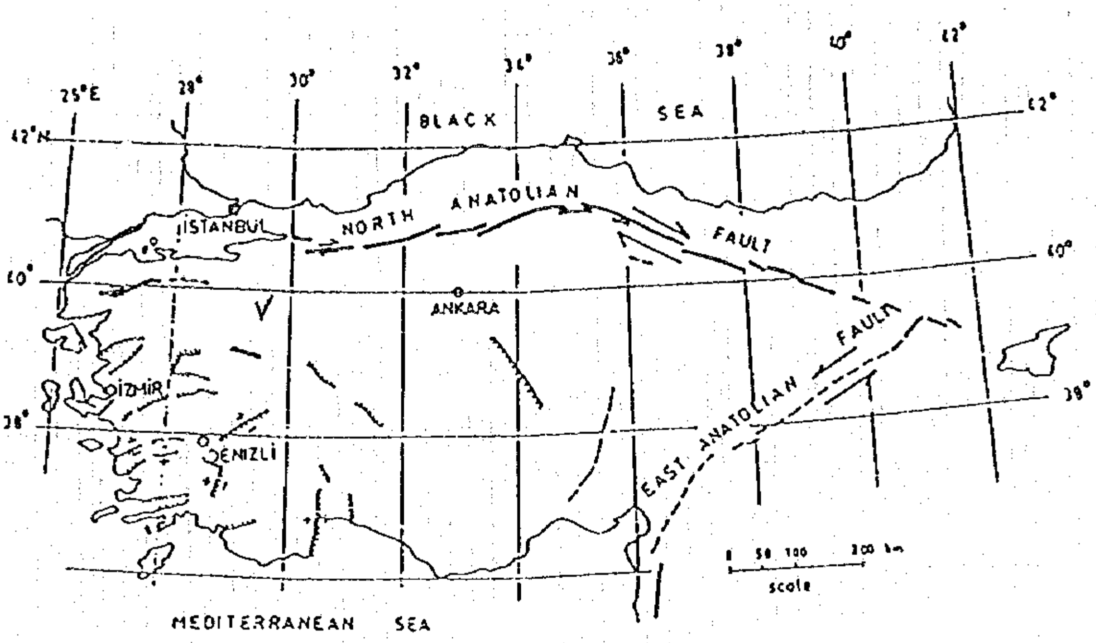


Figure 8-3 Major Fault Systems in Turkey

8.2.2 Seismic Activities

Epicenters of 5,980 earthquakes which occurred in Turkey during the period 1901 - 1985 are indicated in Figure 8-4. The location map of the larger earthquakes (Ms ≥ 6) of the period 1899 - 1983 is also given in Figure 8-5.

By the way, the seismic active zone for Turkey can be classified into four groups as follows, taking plate tectonics model, distribution of active faults, and occurrence of historical earthquakes into consideration.

(1) North Anatolian Fault Region

The North Anatolian Fault is a transform fault which is situated in the boundary between the Black Sea Plate and the Anatolian Plate (Turkey Plate). The number of earthquakes larger than magnitude 5.5 ($M \geq 5.5$) in the North Anatolian Fault region has exceeded 60 since 1900. They are the shallow-focal-depth earthquakes conforming to the right-lateral fault.

Meanwhile, the earthquake which occurred at Erzincan in 1939 at the eastern part of the North Anatolian Fault registered M 7.9, which is the strongest in this century in Turkey. Since then, earthquakes in this region have occurred every so many years, and it is well-known that the epicenters of these earthquakes have shifted westward in a remarkably orderly manner.

According to the investigations thus far, the earthquake faults which were produced as results of these earthquakes do not strictly coincide in cases, but approximately, they are produced by repeated cycles of motion of the active faults running roughly parallel in the vicinity of the North Anatolian Fault. In view of the cumulative vertical displacement of the active faults and the vertical displacements of the individual earthquake faults the return period can be estimated to be of the order of several hundred or several thousand years (< 5,000 yr).

The earthquake faults are in a number of multiple echelon arrangements composed of segments made of echelon fissures, the smallest of which are ten and several centimeters. Small-scale echelon arrangements with segment lengths of less than several hundred meters are arrayed in correspondence with the lateral displacement of related transform faults. On the other hand, large-scale echelon arrangements of segment lengths ten and several kilometers do not necessarily correspond with related transform faults. This is because they are affected by geological anisotropies near the ground surface such as existing fissures and volcanic rock mass.

(2) East Anatolian Fault Region

The East Anatolian Fault is a transform fault which is situated in the boundary between the Anatolian Plate (Turkey Plate) and the Arabian Plate. Shallow earthquakes conforming to the left-lateral fault are predominant in the East Anatolian Fault region. Most of them have occurred less than 25 km in focal depth. The recurrence of the earthquakes larger than magnitude 5.5 ($Ms \geq 5.5$) in this region is around 12 years.

(3) West Anatolian Region

Rather deeper earthquakes conforming to the normal faults along the east-west graben are predominant in the West Anatolian region.

(4) Other Regions

They have relatively low seismic activities in the area except for the regions (1), (2) and (3) in Turkey.

Total Number of Plots in the Area of $\Delta \leq$ 1,000.0 (km) is 5,980.

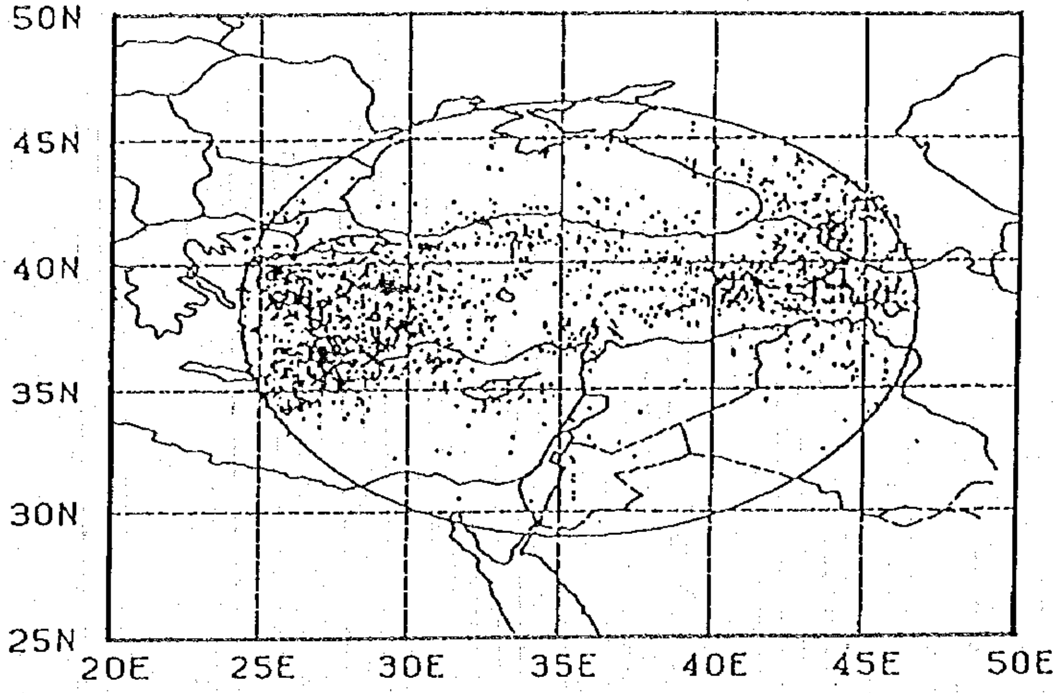
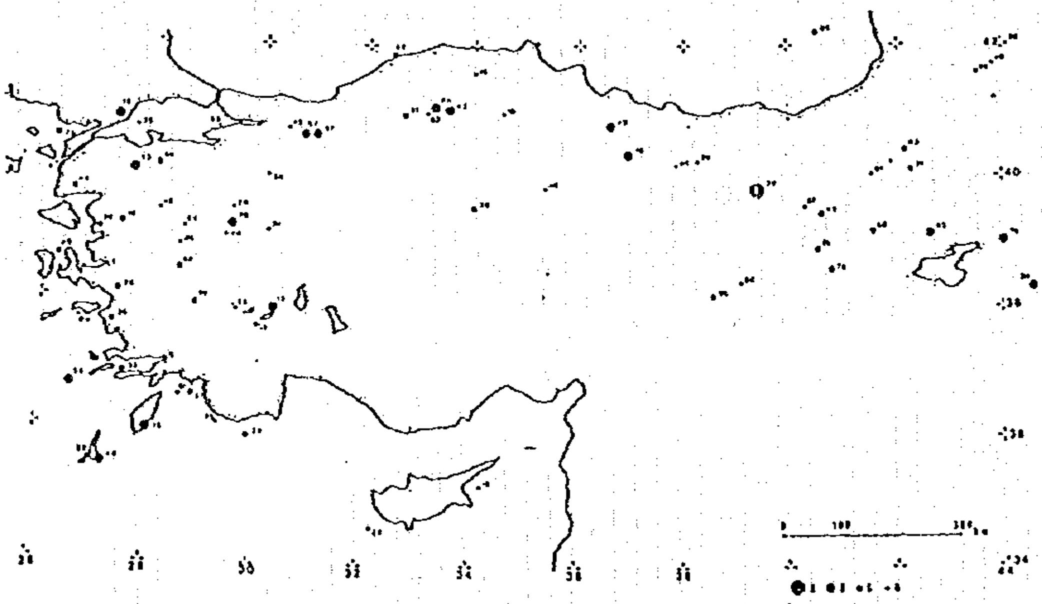


Figure 8-4 Seismicity of All Data from 1901 - 1985



Map of the northeast Mediterranean region under study (34° N to 42° N and 26° E to 44° E), i.e. Turkey, Cyprus, northern Syria, Lebanon, Iraq, frontiers of Iran and the USSR. The map shows the location of the larger earthquakes ($M_s \geq 6$) of the period 1899-1983. Numbers refer to the last two figures of the year in which a particular earthquake occurred. A implies $8.0 > M_s \geq 7.5$; B: $7.5 > M_s \geq 7.0$; C: $7.0 > M_s \geq 6.5$; D: $6.5 > M_s \geq 6.0$.

Figure 8-5 Location of the Larger Earthquakes (Ms ≥ 6)

of the Period 1899 - 1983