CHAPTER 6. SEISMICITY

6.1 Introduction

The seismicity study was carried out for the purpose to determine the design seismic coefficient for this project, on the basis of the earthquake records collected in the course of this study. The geotectonic map of Turkey prepared by the Mineral Research Exploration Institute of Turkey (MTA) was also used for this study.

The study report, ERMENEK BARAJ VE HES YERİ DEPREMSELLIK RAPORU (written in Turkish), has been prepared by the Geophysics Division of EİE in this study. The study results described in this chapter are made mostly based on this EİE report, with some minor additional explanations.

6.2 Geotectonic Condition

According to present plate tectonic theories, the geotectonic condition of the Anatolian peninsula is so complicated and no decisive theory has been authorized for this region. However, the Anatolian peninsula is said to be located in the Anatolian plate, which lies between the Eurasian and Afro-Arabian plates. Most of the earthquake activities appear to be related to the geotectonic movement in the area.

Four earthquake zones are seen in the Anatolian Peninsula, such as northern, central and southeastern Anatolian zones as well as Aegean-Marmara zone in the west as shown in Fig. A2 (Emin Ilhan, Earthquakes in Turkey). These zones are as described below.

(1) Northern Anatolian Zone

The zone extends from the Sea of Marmara (northern Aegean basin) in the west to the borders between Soviet Union, Iran, and Turkey in the east along the North Anatolian Fault zone (N.A.F.). The N.A.F. is seismically active "right-lateral strike-slip fault" and its length is around 1,000 km and the width ranges from a few hundred meters to a few kilometers.

(2) Southeastern Anatolian Zone

This zone is a part of the East African rift system and runs parallel to the East Anatolian Fault zone. The East Anatolian Fault zone consists of a series of parallel or sub-parallel, continuous and/or discontinuous faults and its width is about 2 to 3 km.

(3) Central Anatolian Zone

This zone corresponds to the surrounding area of Ankara, Kirsehir and Kayseri.

(4) Aegean-Marmara Zone

The zone corresponds to the Aegean and Marmara basins and it consists of a number of east-to-west trending grabens intersected by faults trending north-to-south.

These four zones are tectonically active, and the other areas are less active in comparison with these zones. The Project area is located outside these earthquake zones. South of Central Anatolian zone and the area around the Project site are one of the least seismically active areas in Anatolian Peninsula.

6.3 Seismic Analysis

Seismically active zones consisting of complicated patterns of faults correspond to tectonic lineaments in Anatolian Peninsula. A large numbers of tectonic lineaments correspond geomorphologically to valleys and lowland areas where most of the residential areas in Turkey are located.

6.3.1 Seismic data around the site

Those earthquake data having magnitude of more than 4.5 and epicenters within a radius of about 500 kilometers around the Project site were obtained from the Istanbul Bosphorus University. The earthquake data amounted to 695 events for the period from 1901 to 1987.

Epicenters of the collected data are shown in Fig. A5, and the profile indicating their hypocenters are shown in Fig. A6. Details of the collected data are shown in the Attachment A4.

The hypocenters of substantial percentage of earthquakes are located within a depth of 60 km beneath the ground surface in the region.

6.3.2 Seismic analysis

The study was performed by the following methods based on the earthquake record.

(1) Study of probable earthquake in the surrounding area of the site
(2) Kawasumi's method
(3) Study of maximum credible earthquake

(1) Probable earthquake in the surrounding area of the site

Frequency analyses by least square method and probability method are applied for the calculation of seismic activity expected in the future and seismic risk, in the surrounding area within radius of 500 kilometers of the Project site. While the collected earthquake record is 695 events, 614 events which are located in the area within radius of 500 kilometers, are selected for the following calculation. The calculation method explained in the following are based on the EİE Report.

(A) Least square method

The relationship between the magnitude and numbers of events occurred for each magnitude in the radius of 500 kilometers is shown in Table A11, and shown in Fig. A7. From the Table A7, by the least square method, the relation between event numbers (N) and magnitude (M) is given as follows

$$\log N = a - bM = 5.326 - 0.759\ M$$

SEISMIC ACTIVITY EXPECTED IN THE FUTURE

The return period of the earthquake with magnitude of 4.5 in minimum and 7.2 in maximum are calculated by using the following formula.

$M = 4.5$: $N(M, 4.5) = 10^{(a1 - b \times M)}$

$Q(M, 4.5) = 1 / N(M, 4.5)$

$M = 7.2$: $N(M, 7.2) = 10^{(a1 - b \times M)}$

$Q(M, 7.2) = 1 / N(M, 7.2)$

where : $a' = a - \log (b \, Ln(10))$

$a1 = a - Log (T)$

$A1' = a' - Log (T)$

Q : Return period (year)   T = 87 years

The results are as follows.

Magnitude	Frequency	Return Period (year)
4.5	0.581	1.720
7.2	0.005	192.654

SEISMIC RISK

The seismic risk is calculated by the following equation.

$$Risk = 1 - e^{\{-N(M)T\}}$$
$$N(M) = 10^{(a1' - bM)}$$
$$T = \text{time period chosen}$$

Period (Years)	Risk (%) Magnitude = 4.5	Risk (%) Magnitude = 7.2
5	94.5	2.6
10	99.7	5.1
25	100.0	12.2
50	100.0	22.9
75	100.0	32.2
100	100.0	40.5

(B) Probability method

The relation between the magnitude and the event numbers for this study is shown in Table A12. The constants of "a" and "b" are calculated by using the following formula.

$$a = Log\{N(M)\} + Log\{b (Ln 10)\} + bM$$
$$b = (Log e) / Mave - Ms$$

where : Mave = (Total of MN) / (Total of N)
MN: Refer to Table A11.
Ms = (Min.mean value of M) - (dM/2)
dM = 0.5 : Scale of range.

Then, a and b are:

a = 6.953   b = 0.862

SEISMIC ACTIVITY IN THE FUTURE

The return period of the earthquake with magnitude of 4.5 and 7.2 is calculated by using the same formula as that in the former Item (A) Least Square Method. The calculation results are as follows.

Magnitude	Frequency	Return Period (year)
4.5	6.878	0.145
7.2	0.018	55.989

SEISMIC RISK

For the calculation of the seismic risk, the same formula as that in the former Item (A) is used. The results are as follows.

Period	Risk (%)	
(Years)	Magnitude = 4.5	Magnitude = 7.5
5	100.0	8.5
10	100.0	16.4
25	100.0	36.0
50	100.0	59.1
75	100.0	73.8
100	100.0	83.2

(2) Probable maximum acceleration by Kawasumi's method

The probable maximum acceleration at Project site is calculated by the Kawasumi's method as follows.

The relationship between the magnitude and numbers of events occurred for each magnitude in the radius of 500 kilometers from the site is shown in Table A11, and 23 events selected from 614 events in radius of 500 kilometers for estimation of the intensity at site are described in Table A12. The selection of 23 events is made as follows.

(A) Calculation of intensity (Ij) felt at site for all records by the following Kawasumi's formula

(B) Select events which show intensity (Ij) of not less than 0.1 at site

KAWASUMI'S FORMULA

$$Ij = 2M - 4.6052 \times \log d - 0.00183\, d - 0.307 \quad (d > 100\ km)$$

$$Ij = 2 \times (M - \log R) - 0.01668\, R - 3.9916 \quad (d < 100\ km)$$

$$a = 0.45 \times 10(Ij/2) \quad \text{(when } Ij<5.5\text{)}$$

$$a = 20 \times 10(Ij/5) \quad \text{(when } 5.5<Ij<7.0\text{)}$$

Ij: Intensity in JMA (Japan Meteorological Agency) scale

M: Earthquake Magnitude in Richer Scale

d: Epicentral Distance from the damsite (km)

R: Distance from the hypocenter (km)

The relationship between the intensity at the site and numbers of events occurred for each intensity is studied on the basis of mentioned 23 events. The calculation results are shown in Table A13.

Plotting the intensity (Ij) and accumulated frequency (N), and by the least square method, the relation between (Ij) and (N) is given as follows (Gutenberg - Richter's formula).

$$\log N = 1.527 - 0.530\ Ij$$

For the case of N = 1, the expected maximum intensity in a probable return period of 100 years are obtained as Ij = 2.88 in JMA scale.

According to Kawasumi, the relation between the intensity (Ij) and the maximum acceleration (A) of the earthquake is very closely approximated by the following equation.

$$A = 0.45 \times 10^{0.5Ij}\ \text{(gal)}$$

Then, the maximum acceleration at site is estimated to be as follows.

$$A = 12\ \text{gal} = 0.01\ g$$

(3) Maximum credible earthquake

The earthquakes of seven events are selected as maximum credible earthquakes to determine the seismic coefficient for design of the proposed dam.

Recorded earthquakes of three cases (A, B and C) occurred within a radius of 121 kilometers from the damsite. Another three cases of earthquakes (1, 2 and 3), of which locations are shifted to the nearest position to the damsite along the fault lines when the seismic coefficients are calculated, are one of the major earthquakes generated in the major faults. The original and shifted locations of these six cases are shown in Fig. A5.

According to the geotectonic map by MTA, geostructural lineament trending NW-SE direction is mentioned near the Project site. Therefore, project earthquake which would occur at just beneath the Project site is assumed for this study.

The magnitude of the project earthquake is estimated to be 6.0 in consideration of the coefficients of the other six cases and records on this lineament. The depth is estimated to be 25 kilometers which is generally applied for such study, but rather shallow compared to the depth of the other six cases. All the cases are listed in Table A15.

The peak ground accelerations of the seven earthquakes are estimated by using the following formulas.

(A) Estiva's method (a)

$$a = 5000 \times e^{0.8 \times M} / (R + 40)^2$$

R: $(D^2 + Z^2)^{0.5}$

R: Hypocentral Distance from the damsite (km)

D: Epicentral Distance from damsite (km)

Z: Depth of Hypocenter (km)

(B) Estiva's method (b)

$$a = 1230 \times e^{0.8 \times M} / (R + 40)^2$$

(C) Analysis method used in the EİE Report.

$$a = 1300 \times e^{0.67 \times M} / (R + 25)^{1.6}$$

R: Hypocentral Distance from the damsite (km)

(D) Cornell's method

$$Imm = 8.0 + 1.5 \times M - 2.5 \times Ln (d^2 + h^2 + 40)^{0.5}$$
$$Log\ a = Imm / 3 - 0.5$$

Imm: Intensity in Modified Mercalli scale
d: Hypocentral Distance from the damsite (km)
h: Depth of the hypocenter (km)

(E) Kawasumi's method : Refer to former Item (2).

The results of calculation are shown in Table A14 and summarized in Table A15. Among five formulas used for the seismic analysis in this study, Estiva's formula (a & b) are applied for the seismicity risk analysis in the foundation of relatively consolidated soil layers. The formula used in the EIE Report (on the basis of the formula used in western US region) can be applied for the analysis of earthquake with a low magnitude. The formulas of Cornell and Kawasumi can be applied for earthquakes with relatively high magnitude. Since the same data are used for estimation by these formulas, the difference in outputs probably relates to different definitions and/or application constraints.

As shown in the above tables, the accelerations estimated except the Project Earthquake are less than 0.0141g and the acceleration estimated in case of the Project Earthquake shows the highest ground acceleration from 0.0361 to 0.2932 g.

6.3.3 Seismic coefficient for design

The seismic coefficient for design is determined on the basis of the probable maximum acceleration obtained in the sections "5.3.2 (3) Peak Ground Acceleration at Damsite", and "5.3.2 (2) Probable Maximum Acceleration by Kawasumi's Method". The probable maximum acceleration by Kawasumi's method is 0.01g in a return period of 100 years, and the Project Earthquake shows the highest ground acceleration from 0.0361 to 0.2932g in the maximum credible earthquake study.

Some lower values of the seismic coefficient are often taken for design in high seismicity zones such as Japan, Philippine and other Pacific rim countries, since the structure failures are often caused by the relatively low acceleration of earthquakes which last in certain duration. Meanwhile, the maximum acceleration of earthquakes rarely lasts more than a few seconds and its impact on the structures appears to be quite limited.

Taking these conditions into consideration, the seismic coefficient of 0.05 to 0.1g will be reasonable for design in this study.

6.3.4 Reservoir-induced earthquakes

Many examples of earthquakes occurred during initial impounding of reservoirs are seen in those reservoirs having depth of more than 100 meters, such as Konya dam in India, Hoover dam in USA, etc. These examples often suggested a interrelation between reservoir filling and earthquake occurrence. The cause of these earthquakes is generally explained by release of preexisting stress, which will be released upon fault movement being caused mainly by increased load of reservoir water and pore pressure in rocks. These earthquakes are small to medium scale in general, mostly of magnitude less than 6. In the case of the Hoover dam, the maximum earthquake was magnitude 5 in the surrounding area of the reservoir (Dictionary of Earthquakes, T.Utsu, 1987, Tokyo).

The maximum depth of the Ermenek reservoir will be about 180 meters and there will, therefore, be a possibility that the impounding of the Ermenek reservoir will induce occurrence of earthquakes. However, the ground acceleration to be anticipated at the damsite would be less than that of the Maximum Credible Earthquakes (refer to Sub-section 6.3.2), since the reservoir-induced earthquakes observed were generally small. Consequently, no specific consideration will be required on the reservoir-induced earthquakes.

CHAPTER 7. FURTHER GEOLOGICAL INVESTIGATIONS

The detailed geological investigations will be required for the following items to be clarified in the further study.

(1) Damsite I-C

(A) Joint system in the damsite.
(B) Weathering condition, permeability and strength of foundation rocks.
(C) Condition of fault F-2 and F-3.
(D) Condition of riverbed and below riverbed.

Core drilling, Lugeon test, test adit excavation, reconnaissance survey (geological mapping by 1:500 scale), in-situ rock test (plate loading and shear tests in test adits), laboratory rock test, geophysical exploration in adits and in boreholes, etc. will be required.

(2) Curtain grouting

The major purpose of investigation is to determine the extension length of the curtain towards mountains and the depth of the curtain grouting in both banks.

(A) Bottom boundary of limestone block.
(B) Permeability in and surrounding area of the limestone block.
(C) Weathering and solution condition.

Core drilling, Lugeon test, test adit excavation, geophysical exploration, etc. will be required.

(3) Headrace tunnel

(A) Geological condition along the route, especially at the inlet and outlet portions, and at the access adits.
(B) Groundwater condition along the route.
(C) Swelling tendency of ophiolitic rocks.

Core boring, Lugeon test, reconnaissance survey, geophysical exploration, laboratory rock test, etc. will be required.

(4) Power house, surge tank and tailrace tunnel

(A) Bottom boundary of limestone block.
(B) Permeability of rock and groundwater condition.
(C) Rock strength and initial stress at the proposed power house.
(D) Joint system.
(E) Rock condition in the contact zone between limestone and ophiolitic rocks, and between marl (Görmel formation) and ophiolitic rocks.

Core boring, Lugeon test, test adit excavation, in-situ rock test (plate loading, shear and initial stress tests in test adit), geophysical exploration, etc. will be required.

(5) Erik intake weir, tunnel and power house

(A) Thickness of riverbed deposit at intake weir site.
(B) Geological condition of tunnel route, especially inlet and outlet portions, and section below landslide area, and the power house area.
(C) Groundwater condition along the tunnel route.

Core boring, Lugeon test, reconnaissance survey, test adit excavation, seismic exploration, etc. will be required.

(6) Construction materials

(A) Available quantity of existing materials and quality in more detail.

Core boring, sampling, seismic exploration, test adit excavation, test blasting, laboratory test, etc. will be required.

(9) Landslide area

Groundwater level measurement will be required in the existing boreholes.

(10) Seepage from the reservoir

Reconnaissance survey and geological mapping by use of 1/5,000 scale map will be required in order to confirm the distribution of limestone block and impervious layer in the limestone block.

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TABLES

Table A1 GEOLOGY OF THE PROJECT AREA

QUATERNARY	ALLUVIUM	Qal	Qalr	River bed deposit	
			Qalt	Talus deposit	
	DILUVIUM	Qtr	Qtrt	Terrace deposit	
TERTIARY	MIDDLE MIOCENE	Te		ERMENEK FORMATION (Mainly chalky limestone.)	
	LOWER MIOCENE	Tg		GÖRMEL FORMATION (Marl, sandstone, conglomerate, limestone.)	
CRETACEOUS	UPPER CRETACEOUS	Ofm		ERMENEK OPHIOLITIC MELANGE (Matrix layers and limestone blocks.)	
	LOWER CRETACEOUS	Jkc		CİHANDERE FORMATION (Limestone.)	ALADAĞ GROUP
JURASSIC		Jkc			ALADAĞ GROUP
TRIASSIC	UPPER TRIASSIC	ÜTrb		BALCILAR FORMATION (Limestone.)	ALADAĞ GROUP

ERMENEK OPHIOLITIC MELANGE

CRETACEOUS	UPPER CRETACEOUS	Of	MATRIX OF MELANGE (Schist, sandstone, conglomerate, diabace, serpentinized peridotite, gabbro, etc.)			
CRETACEOUS / JURASSIC	UPPER CRETACEOUS	Jkn	NADİRE FORMATION			Blocks (Mostly limestone.)
JURASSIC		Ja	AZITEPE FORMATION			Blocks (Mostly limestone.)
TRIASSIC	UPPER TRIASSIC	Trk	KÜKÜRCE FORMATION			Blocks (Mostly limestone.)
TRIASSIC		Trçtt	TAŞDİBİ MEMBER	TAHTACI FORMATION	CİMENE GROUP	Blocks (Mostly limestone.)
TRIASSIC		Trçta	ARDIÇLI MEMBER	TAHTACI FORMATION	CİMENE GROUP	Blocks (Mostly limestone.)
PERMIAN		Pçes	SARIBAYIR MEMBER	ESKİCE FORMATION	CİMENE GROUP	Blocks (Mostly limestone.)
PERMIAN		Pçea	AKARCA MEMBER	ESKİCE FORMATION	CİMENE GROUP	Blocks (Mostly limestone.)
PERMIAN		Pçep	PÜRELİCENİN MEMBER	ESKİCE FORMATION	CİMENE GROUP	Blocks (Mostly limestone.)
		Pg	GÖKÇESEKİ FORMATION			Blocks (Mostly limestone.)
		Pn	NİSA FORMATION			Blocks (Mostly limestone.)
CARBONIFEROUS		Kçb	BALKUSAN FORMATION			Blocks (Mostly limestone.)

(Source: EİE and the JICA Study Team)

Table A2 **WORK QUANTITY OF CORE BORING INVESTIGATION (1/4)**

1. SUMMARY OF WORK QUANTITY

LOCATION		HOLE (nos)	LENGTH (m)	LU.TEST (times)
DAMSITE I-B AND LANDSLIDE AREA				
	PRE F/S STAGE	17	2005.85	223
	F/S STAGE	2	228.00	30
	TOTAL	19	2233.85	253
DAMSITE I-C				
	PRE F/S STAGE	8	2340.65	697
	F/S STAGE	4	1235.90	171
	TOTAL	12	3576.55	868
POWER HOUSE AREA				
	PRE F/S STAGE	0	0.00	0
	F/S STAGE	5	754.80	22
	TOTAL	5	754.80	22
QUARRY SITE				
	PRE F/S STAGE	0	0.00	0
	F/S STAGE	2	109.00	0
	TOTAL	2	109.00	0
LIMESTONE AREA NEAR NADIRE				
	PRE F/S STAGE	2	546.05	48
	F/S STAGE	0	0.00	0
	TOTAL	2	546.05	48
HEADRACE TUNNEL AREA				
	PRE F/S STAGE	1	218.50	0
	F/S STAGE	0	0.00	0
	TOTAL	1	218.50	0
TOTAL	PRE F/S STAGE	28	5111.05	968
	F/S STAGE	13	2327.70	223
	GRAND TOTAL	41	7438.75	1191

Table A2 WORK QUANTITY OF CORE BORING INVESTIGATION (2/4)

2. WORK QUANTITY FOR EACH SITE

(1) DAMSITE I-B AND LANDSLIDE AREA

PRE F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-201	200.00	544.30	4,048,094.87	495,429.37	12
SK-202	150.00	613.50	4,048,392.96	495,401.29	30
SK-203	35.00	516.76	4,047,818.36	495,383.80	6
SK-204	33.00	514.21	4,047,761.60	495,379.33	6
SK-205	150.00	524.89	4,047,958.88	495,399.81	23
SK-206	100.00	538.55	4,048,322.36	494,517.04	33
SK-207	200.00	534.14	4,047,633.45	495,464.86	38
SK-208	127.00	547.35	4,047,443.94	495,457.06	18
SK-209	101.00	619.57	4,048,310.69	495,526.30	9
SK-210	101.00	608.36	4,048,276.01	495,636.52	10
SK-211	50.00	553.43	4,048,136.51	495,337.52	4
SK-212	125.00	602.31	4,047,331.59	495,730.59	16
SK-213	100.00	602.56	4,047,330.54	495,731.04	13
SK-214	160.00	715.51	4,048,587.69	495,564.30	5
SK-217	201.20	713.74	4,048,893.91	495,645.81	0
SK-218	85.00	762.49	4,049,271.13	495,534.45	0
SK-219	87.65	709.72	4,048,914.23	495,933.67	0
SUB TOTAL	2005.85				223

F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-220	150.00	748.78	4,049,165.13	495,701.12	7
SK-221	78.00	628.26	4,048,465.50	496,032.73	23
SUB TOTAL	228.00				30
TOTAL	2233.85				253

Table A2 WORK QUANTITY OF CORE BORING INVESTIGATION (3/4)

(2) DAMSITE I-C

PRE F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-301	178.00	668.85	4,048,239.23	496,925.74	70
SK-302	200.65	614.76	4,048,523.65	496,492.08	53
SK-303	143.75	651.83	4,048,805.27	496,324.60	2
SK-304	499.35	676.73	4,048,126.64	497,011.07	170
SK-305	426.50	750.07	4,047,939.09	497,744.97	93
SK-306	425.00	708.54	4,047,369.51	497,635.14	124
SK-307	220.20	663.85	4,048,430.70	496,826.69	87
SK-308	247.20	578.42	4,048,180.55	496,628.42	98
SUB TOTAL	2340.65				697

F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-309	190.80	674.07	4,047,374.28	496,882.20	16
SK-310	169.75	520.00			23
SK-313	425.00	729.65	4,048,720.74	497,216.38	87
SK-314	450.35	726.73	4,047,124.12	497,414.95	45
SUB TOTAL	1235.90				171
TOTAL	3576.55				868

(3) POWER HOUSE AREA

PRE F/S STAGE: No boring works.

F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-102	341.60	615.25	4,048,303.56	505,971.89	1
SK-106	90.00	369.55	4,048,499.46	506,424.62	6
SK-107	50.00	368.89	4,049,255.17	507,504.22	15
SK-108a	72.00	484.19	4,048,401.81	506,140.73	0
SK-108b	201.20	484.19	4,048,401.81	506,140.73	0
SUB TOTAL	754.80				22
TOTAL	754.80				22

(SK-103, 104 & 105: Canceled.)

Table A2 **WORK QUANTITY OF CORE BORING INVESTIGATION (4/4)**

(4) QUARRY SITE

PRE F/S STAGE: No boring works.

F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-311	59.00	789.27	4,049,783.04	496,566.96	0
SK-312	50.00	864.52	4,049,521.46	496,600.14	0
SUB TOTAL	109.00				0
TOTAL	109.00				0

(5) LIMESTONE AREA NEAR NADIRE

F/S STAGE: No boring works.

PRE F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-215	201.05	739.88	4,049,449.32	481,050.10	1
SK-216	345.00	838.28	4,049,100.35	482,217.01	47
SUB TOTAL	546.05				48
TOTAL	546.05				48

(6) HEADRACE TUNNEL AREA

F/S STAGE: No boring works.

PRE F/S STAGE

HOLE NO.	DEPTH (m)	EL. (m)	LOCATION LAT.	LONG.	LU.TEST (times)
SK-101	218.50	980.61	4,048,252.26	501,596.09	0
SUB TOTAL	218.50				0
TOTAL	218.50				0

Table A3 WORK QUANTITY OF SEISMIC EXPLORATION

LOCATION	LINE	LENGTH(m)
DAMSITE I-C	DA	1,221
	DB	1,098
	DC	934
	DD	717
POWER HOUSE	PB	1,024
TAILRACE TUNNEL	PC	1,062
LANDSLIDE AREA	LA	1,648
	LB	938
	LC	718
TOTAL		9,360

Table A4 SUMMARY OF LABORATORY TEST RESULTS : FOUNDATION ROCKS OF I-C DAMSITE (SK-302, 307 AND 313)

Hole No.	Depth (m)	Physical Test: Compressive strength (kg/cm2)	Physical Test: Water absorption (x10-3 %)	Physical Test: Bulk specific gravity (g/cm3)	Super Sonic Test: Density (g/cm3)	Super Sonic Test: Longt. velocity Vp(m/sn)	Super Sonic Test: Transv. velocity Vs(m/sn)	Poisson's ratio	Dynum. shear modulus G(kg/cm2)	Dynum. elast. modulus E(kg/cm2)
SK-302	21.60 - 21.85	499	1.75	2.69	2.78	5,890	2,896	0.34	245,614	658,534
	21.85 - 22.25	1,036	1.04	2.68	2.85	6,273	2,924	0.36	248,641	676,906
	22.25 - 22.50	726	1.01		2.77	5,847	2,875	0.34	233,630	626,394
	22.70 - 23.00	647	1.67		2.79	5,938	2,836	0.35	228,976	619,264
	Average	727	1.37	2.69	2.80	5,987	2,883	0.35	239,215	645,275
SK-307	40.50 - 40.80	601	0.79		2.83	6,131	2,877	0.36	239,023	649,574
	40.80 - 41.07	338	1.90	2.69	2.85	6,268	2,883	0.37	241,717	660,293
	45.60 - 45.85	561	0.59	2.70	2.89	6,444	2,862	0.38	241,552	665,301
	46.15 - 46.55	632	0.59	2.69	2.80	6,007	2,808	0.36	225,282	612,854
	Average	533	0.97	2.69	2.84	6,213	2,858	0.37	236,894	647,006
SK-313	22.50 - 23.00	712	1.00		2.83	6,143	3,052	0.34	268,986	718,802
	23.15 - 23.35	288	1.90		2.85	6,267	3,091	0.34	277,854	744,242
	26.65 - 27.00	1,301	1.20		2.89	6,458	3,185	0.34	299,151	801,303
	28.00 - 28.25	683	1.30		2.90	6,489	3,210	0.34	304,917	815,959
	29.20 - 29.40	1,060	1.50	2.67	2.90	6,500	3,204	0.34	303,778	813,835
	51.30 - 51.60	1,366	0.79	2.67	2.88	6,402	3,178	0.34	296,807	793,365
	57.50 - 57.70	521	1.70		2.85	6,258	3,108	0.34	280,919	750,780
	74.70 - 75.00	518	1.80		2.84	6,224	3,091	0.34	276,879	739,992
	79.00 - 79.30	1,150	1.40	2.68	2.90	6,475	3,261	0.33	314,683	837,107
	79.30 - 79.50	518	0.57		2.85	6,232	3,116	0.33	282,367	752,978
	Average	812	1.32	2.67	2.87	6,345	3,150	0.34	290,634	776,836
	Average of all	731	1.25	2.68	2.85	6,236	3,025	0.35	267,265	718,749

(Source: EIE and the JICA Study Team)

Table A5 ROCK CLASSIFICATION FOR THE ERMENEK PROJECT

(1) HARDNESS

Class.	Explanation
A	Hard rocks. Very strong.
B	Medium hard rocks. Strong.
C	Soft rocks and moderately friable rocks. Moderately strong.
D	Very soft rocks and highly friable rocks. Weak.
E	Decomposed rocks. Rocks are almost decomposed by weathering, alteration and/or fault fracturing. Very weak.

(2) WEATHERING CONDITION

Class.	Explanation
a	Fresh rocks. No visible sign of weathering and discoloration on joint surface.
b	Slightly weathered rocks. Discoloration is generally seen on joint surface.
c	Moderately weathered rocks. Weathering is seen along some joints. Discoloration and thin weathered materials are generally seen on joint surface.
d	Highly weathered rocks. Weathering is seen along most of joints. Discoloration and rather thick weathered materials are observed on joint surface.
e	Decomposed rocks. Rocks are almost decomposed by weathering.

(3) JOINT SPACING

Class.		Spacing(cm)	Nos of joints(/m)
I	Extremely wide	More than 200	0
II	Very wide	60 - 200	0 - 2
III	Wide	20 - 60	2 - 5
IV	Moderately wide	6 - 20	5 - 20
V	Narrow	2 - 6	More than 20
VI	Very narrow	Less than 2	-

Table A6 ROCK CLASSIFICATION (K.KIKUCHI Et. al.) (1/4)

Rock class.	(1) Hard rocks
A	Very fresh in lithologic character. The rock-forming minerals of igneous rocks and the constituent grains of sedimentary rocks are not weathered and altered at all. Few joints are distributed. The rocks as a whole are very solid and densely hard.
B	Fresh in lithologic character. The rock-forming minerals of igneous rocks and the constituent grains of sedimentary rocks are little weathered and altered. Joints are sparsely distributed, assuring close adhesion. The rocks as a whole are solid and densely hard.
CH	Almost fresh, solid and hard in lithologic character. Among the rock-forming minerals of igneous rocks, feldspars and colored minerals such as mica and amphibole may be slightly weathered and altered. In sedimentary rocks feldspars and colored minerals existing secondary as constituent grains may be slightly weathered and altered. Joints are distributed considerably and joint walls are mostly weathered and altered, being discolored. Sometimes, weathered materials adhere thinly to joint walls. However, in general, the joints assure close adhesion. The rocks as a whole are solid and hard.
CM	Generally a little weathered and altered in lithologic character. In igneous rocks, feldspars and colored minerals excluding quartz are weathered, often being brown or reddish brown. In sedimentary rocks, feldspars and colored minerals existing secondarily as constituent grains are weathered and altered, often being brown or reddish brown as in case of igneous rocks. Joints are open and often hold clay or weathered materials. Rocks of this class often have many fine hair-like fissures. Therefore, when hit strongly by a rock hammer, they often collapse, being separated at the hair-like fissures. In addition, rocks which are fresh in lithologic character but have open joints distributed considerably to indicate cracky state are also included in this class.
CL	Since the rock-forming minerals of igneous rocks or the constituent grains of sedimentary rocks are considerably weathered, the rocks as a whole are generally brown or reddish brown. Joints are open, and hold clay and weathered materials considerably. In rocks of this class, fine hair-like fissures are distributed remarkably, and weathering occurs along the fissures. Therefore, even if hit lightly by a rock hammer, they easily collapse or are depressed. In addition, rocks which are fresh in lithologic character but have open joints considerably distributed to indicate masonry state are also included in this class.
D	The rock-forming minerals of igneous rocks or the constituent grains of sedimentary rocks are considerably weathered, and sandy and clayey portions are often seen. With rocks of this class, the distribution of joints is rather unclear.

Table A6 ROCK CLASSIFICATION (K.KIKUCHI Et. al.) (2/4)

Rock class.	(2) Medium hard rocks
A	
B	Fresh in lithologic character. The constituent grains are quite free from secondary weathering and alteration. Fissures of joints, etc. are little distributed. The rocks as a whole are solid and hard. In this case, those close to soft rocks which have the above properties may not belong to this class, but to class C.
CH	Fresh in lithologic character. The constituent grains are free from secondary weathering and alteration. Joints are sparsely distributed, assuring close adhesion. The rocks as a whole are almost solid and hard. In this case, those close to hard rocks may belong to class B.
CM	Feldspars and colored minerals existing secondarily as constituent grains are mostly a little weathered and altered. The weathering is not so intensive, but since the rocks are medium hard, they give a little soft impression in absolute hardness. Joints are distributed considerably, and most of them are a little open. The joints are weathered and altered, being discolored and often hold thin layers and weathered materials. Rocks of this class have hair-like fissures to some extent. Therefore, when hit by a rock hammer, they often collapse, being separated at the hair like fissure.
CL	Constituent grains are weathered and altered, and the degree of consolidation is very low. Since the rocks are medium hard, they give considerably soft impression in absolute hardness. Joints are considerably distributed. They are open, and hold weathered materials and clay layer considerably. Rocks of this class are considerably weathered along hair-like fissures, and when hit lightly by a rock hammer, they collapse easily.
D	Constituent grains are considerably weathered and altered, and the degree of consolidation is considerably low. They are often sandy and clayey. With rocks of this class, the distribution of fissures is rather unclear.

Table A6 ROCK CLASSIFICATION (K.KIKUCHI Et. al.) (3/4)

Rock class.	(3) Soft rocks
A	
B	
CH	Rock of this class are close to medium hard rocks (about 150 kg/cm^2 or more in the dry unconfined compression strength of fresh rocks). Fresh in lithologic character. Constituent grains are quite free from weathering and alteration, and joints are little distributed.
CM	Fresh in lithologic character. Constituent grains are free from secondary weathering and alteration. Joints are little or sparsely distributed, assuring close adhesion. The rocks as a whole are little weathered, but since they are soft, they give soft impression in absolute hardness. In this case, those less than about "60 to 70 kg/cm^2" in the dry unconfined compression strength do not belong to this class, but to class CL.
CL	Constituent grains are a little weathered and altered, and the degree of consolidation is very low. The rocks as a whole give very soft impression in absolute hardness. When the rocks are hit by the spire of rock hammer, the spire often sticks in them.
D	The degree of consolidation of constituent grains is very low, and most are sandy or clayey.

Table A6 ROCK CLASSIFICATION (K.KIKUCHI Et. al.) (4/4)

A. Description of Hard, Medium Hard and Soft Rocks

(1) Hard rocks

As an approximate criterion, rocks of more than "800 to 1000 kg/cm^2" in the unconfined compression strength of test pieces of fresh rocks. When hit by a rock hammer, they produce a metallic sound.

(2) Medium hard rocks

As an approximate criterion, rocks of "200 to 300 kg/cm^2" to "800 to 1,000 kg/cm^2" in the dry unconfined compression test of test pieces of rocks. when hit by a rock hammer, they produce a very tight sound, but generally do not produce a metallic sound. Of the rocks in this range, those rather soft may be depressed slightly on the surface, when hit by the spire of rock hammer.

(3) Soft rocks

As an approximate criterion, rocks of less than "200 to 300 kg/cm^2" in the dry unconfined compression test of test pieces of fresh rocks. When hit by a rock hammer, they produce a thick and loose sound, and may collapse. They are easily depressed on the surface, when hit by the spire of rock hammer.

B. Physical Properties of Rocks Corresponding to Each Rock Classification

Rock class.	Static modulus of elasticity (kg/cm^2)	Modulus of deformation (kg/cm^2)	Cohesion (kg/cm^2)	Internal friction angle (degree)	Elastic wave velocity (km/sec)
B	80,000 or more	50,000 or more	40 or more	55 - 65	3.7 or more
CH	80,000 - 40,000	50,000 - 20,000	40 - 20	40 - 55	3.7 - 3.0
CM	40,000 - 15,000	20,000 - 5,000	20 - 10	30 - 45	3.0 - 1.5
CL - D	15,000 or less	5,000 or less	10 or less	15 - 38	1.5 or less

(K.Kikuchi Et. al. Central Research Institute of Electric Power Industry, Japan.)

Table A7 ROCK PROPERTIES IN THE PROJECT AREA

Rock Classification for Ermenek Project									Rock Classification and Estimated Rock Properties (K.Kikuchi Et.al.)					
Hard Rock: Limestone, etc.			Medium Hard Rock: Sandstone, Conglomerate, etc.			Soft Rock: Marl, Siltstone, Schist, etc.				Static Modulus of Elasticity (kg/cm2)	Modulus of Deformation (kg/cm2)	Cohesion (kg/cm2)	Internal Friction Angle (degree)	Elastic Wave Velocity (km/sec)
Hard.	Weath.	Joint.	Hard.	Weath.	Joint.	Hard.	Weath.	Joint.						
A	a	I							A					
A-B	b	I-III	B	a	I-III				B	80,000 or more	50,000 or more	40 or more	55 to 65	3.7 or more
B	b-c	III-IV	B-C	a-c	III-IV				CH	80,000 to 40,000	50,000 to 20,000	40 to 20	40 to 55	3.7 to 3.0
C	c	IV-V	C	b-c	IV-V	C-D	a-b	I-IV	CM	40,000 to 15,000	20,000 to 5,000	20 to 10	30 to 45	3.0 to 1.5
D	d	V	D	d	V	D	c-d	IV-V	CL	15,000 or less	5,000 or less	10 or less	15 to 38	1.5 or less
E	e	VI	E	e	VI	E	e	VI	D					

Notes.
Hard.: Hardness.
Weath.: Weathering condition.
Joint.: Joint frecuency.

Compressive Strength in Fresh Rock Condition (kg/cm2)	
Hard rock	More than "800 - 1,000"
Medium Hard Rock	"200 - 300" to "800 - 1,000"
Soft Rock	Less than "200 - 300"

Table A8 LUGEON VALUES OF LIMESTONE IN I-C DAMSITE

	SK-301		SK-302		SK-303		SK-304		SK-305		SK-306		SK-307		SK-308		SK-310		SK-313		SK-314		All Holes	
Above EL.500 m	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Total Nos of Test	69		48		2		76		66		74		73		30		0		56		1		495	
Less than 1.1	48	70	30	63	2	100	61	80	32	48	46	62	25	34	3	10			18	32	1	100	266	54
1.1 -10.0	14	20	7	15	0	0	12	16	16	24	24	32	13	18	20	67			19	34	0	0	125	25
10.1 - 50.0	4	6	4	8	0	0	2	3	7	11	3	4	13	18	3	10			9	16	0	0	45	9
More than 50.0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	3			0	0	0	0	3	1
Gauge Press.=0	3	4	7	15	0	0	1	1	11	17	1	1	20	27	3	10			10	18	0	0	56	11
EL.500-400m	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Total Nos of Test	1		5		0		47		21		46		14		50		15		16		20		235	
Less than 1.1	1	100	5	100			34	72	14	67	24	52	13	93	16	32	14	93	12	75	7	35	140	60
1.1 -10.0	0	0	0	0			11	23	7	33	21	46	1	7	30	60	1	7	1	6	6	30	78	33
10.1 - 50.0	0	0	0	0			2	4	0	0	1	2	0	0	4	8	0	0	0	0	0	0	7	3
More than 50.0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gauge Press.=0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0	0	3	19	7	35	10	4
Below EL.400 m	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Total Nos of Test	0		0		0		47		6		4		0		19		8		15		24		123	
Less than 1.1							47	100	5	83	2	50			18	95	8	100	14	93	5	21	99	80
1.1 -10.0							0	0	1	17	2	50			1	5	0	0	1	7	8	33	13	11
10.1 - 50.0							0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0
More than 50.0							0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0
Gauge Press.=0							0	0	0	0	0	0			0	0	0	0	0	0	11	46	11	9

(Source: EIE and the JICA Study Team)

Table A9 SUMMARY OF MICROPALEONTOLOGICAL AND MINERALOGICAL STUDY (1/2)

Sample	Rock	Age	Formation
Er-1	Cryptocrystalline limestone	Unidentified	Jkc
2	Cryptocrystalline limestone	Upper Cretaceous (probably)	Jkn
3	Microcrystalline limestone	Upper Cretaceous	Jkn
4	Micro & cryptocrystalline limestone	Unidentified	Jkn
5	Cryptocrystalline limestone	Upper Cretaceous (probably)	Jkn
6	Serpentinized ultrabasic rock	Unexamined	Of
7	Brecciated radiolarite	Unexamined	Jkn
8	Micro & mesocrystalline limestone	Upper Cretaceous	Jkn
9	Microcrystalline limestone	Unidentified	Jkn
10	Serpentinized ultrabasic rock	Unexamined	Of
11	Conglomeratic limestone	Unexamined	Tg
12	Sandy limestone	Unexamined	Of
13	Silty limestone	Unexamined	Tg
14	Micritic & sparitic limestone	Upper Cretaceous or younger than that	Jkn
15	Micritic limestone	Upper Jurassic	Jkn
16	Micritic & sparitic limestone	Unidentified	Jkn
17	Biosparitic limestone	Unidentified	Jkn
18	Sandstone	Unexamined	Of
19	Sparitic limestone	Unidentified	Jkn
20	Micritic limestone	Unidentified	Te
21	Micritic limestone	Lower Cretaceous	Jkn
22	Unexamined (Limsetone)	Lower Triassic	Trcta
23	Unexamined (Limsetone)	Permian	Pcep
24	Unexamined (Limsetone)	Unidentified	Trk
25	Unexamined (Limsetone)	Upper Permian	Pcea
26	Unexamined (Limsetone)	Middle Triassic	Trcta
27	Unexamined (Limsetone)	Unidentified	Jkn

Table A9 SUMMARY OF MICROPALEONTOLOGICAL AND MINERALOGICAL STUDY (2/2)

Sample	Rock	Age	Formation
28	Unexamined (Limsetone)	Upper Triassic	Trk
29	Unexamined (Limsetone)	Middle-upper Jurassic	Ja
30	Unexamined (Limsetone)	Upper Cretaceous	Jkn
31	Unexamined (Limsetone)	Carboniferous	Kcb
32	Unexamined (Limsetone)	Middle-upper Jurassic	Ja
33	Unexamined (Limsetone)	Middle-upper Jurassic	Ja
34	Unexamined (Limsetone)	Lower-middle Jurassic	Ja
35	Unexamined (Limsetone)	Unidentified	Jkn
36	Unexamined (Limsetone)	Unidentified	Jkn
37	Unexamined (Limsetone)	Lower-middle Triassic	Trctt
38	Biomicritic sparite	Upper Cretaceous	Jkn
39	Biomicrite	Cretaceous	Jkn
40	Silicified & chlorite	Unexamined	Tg
41	Micrite	Unidentified	Tg
42	Biomicrite	Cretaceous	Jkn
43	Biosparitic micrite	Upper Cretaceous	Jkn
44	Mesocrystalline limestone	Unidentified	Jkn
45	Crypto & microcrystalline limestone	Unexamined	Pcea
46	Crypto & microcrystalline limestone	Unexamined	Jkn
47	Cryptocrystalline limestone	Unexamined	Pces
48	Cryptocrystalline limestone	Unexamined	Tg
49	Sandstone	Unexamined	Tg
50	Cryptocrystalline limestone	Unexamined	Tg
51	Crypto & microcrystalline limestone	Unexamined	Te
52	Unexamined (limestone)	Unidentified	Jkn
53	Microcrystalline limestone	Unidentified	Jkn

Table A10 **RESULTS OF X-RAY DIFFRACTION METHOD**

Minerals	S/C	Sme	Chl	M	K	Qz	Serp	Spi	Cm
Sample No.3	x	x	xx	xxx	x	xxxx	n	n	n
Sample No.4	n	n	n	n	n	n	xxxx	x	x

Notes:

Contents

n	Not detected
x	Very small amount
xx	Small amount
xxx	Middle amount
xxxx	Large amount

Minerals

S/C	Smectite/chlorite
Sme	Smectite
Chl	Chlorite
M	Mica clay minerals
K	Kaoline
Qz	Quartz
Serp	Serpentine
Spi	Spinel
Cm	Chromite

Sample No.3: Green schist
Sample No.4: Serpentinite

(Source: EIE and the JICA Study Team)

Table A11 **RELATION BETWEEN MAGNITUDE AND NUMBER OF EVENTS LEAST SQARE METHOD**

Magnitude (M) (dM=0.1)	Event Nos. (n)	M x n
4.50	113	508.5
4.60	89	409.4
4.70	65	305.5
4.80	78	374.4
4.90	39	191.1
5.00	46	230.0
5.10	26	132.6
5.20	35	182.0
5.30	19	100.7
5.40	17	91.8
5.50	16	88.0
5.60	7	39.2
5.70	17	96.9
5.80	8	46.4
5.90	11	64.9
6.00	6	36.0
6.10	3	18.3
6.20	2	12.4
6.30	2	12.6
6.40	2	12.8
6.50	4	26.0
6.60	1	6.6
6.70	0	0.0
6.80	3	20.4
6.90	2	13.8
7.00	0	0.0
7.10	2	14.2
7.20	1	7.2
Total	614	3041.7

(Source: EİE and the JICA Study Team)

Table A12 RELATION BETWEE MAGNITUDE AND NUMBER OF EVENTS PROBABILITY METHOD

Magnitude (M) (dM=0.5)	Mean Value of M	Event Nos. (N)	Log N
4.5 - 4.9	4.7	384	2.584
5.0 - 5.4	5.2	143	2.155
5.5 - 5.9	5.7	59	1.771
6.0 - 6.4	6.2	15	1.176
6.5 - 6.9	6.7	10	1.000
7.0 - 7.4	7.2	3	0.477
Total	35.7	614	9.164

Xave. = 35.7 / 6 = 5.950
Yave. = 9.164 / 6 = 1.527

(Source: EIE and the JICA Study Team)

Table A13 LIST OF SELECTED EARTHQUAKES (1901 - 1987)
KAWASUMI'S METHOD

No.	Date Year	Month	Day	Epicenter Latitude	Longitude	Depth (km)	Magnitude (M)	Distance (km) from Site to Epicenter	Intensity felt at the Site
1	1911	4	30	36.00N	30.00E	180.00	6.10	273	0.2
2	1914	10	3	37.70N	30.40E	14.00	6.90	260	1.9
3	1918	9	29	35.20N	34.70E	0.00	6.50	218	1.5
4	1921	1	16	38.33N	32.79E	10.00	5.70	197	0.2
5	1922	8	29	37.37N	32.73E	30.00	4.90	92	0.1
6	1926	3	18	35.84N	29.50E	10.00	6.80	321	1.2
7	1927	6	5	36.19N	31.08E	10.00	5.50	174	0.1
8	1930	9	11	37.39N	31.18E	80.00	5.90	183	0.7
9	1938	4	19	39.44N	33.79E	10.00	6.60	327	0.7
10	1941	1	20	35.00N	34.00E	100.00	6.50	198	1.8
11	1945	3	20	37.11N	35.70E	60.00	6.00	251	0.2
12	1947	12	9	36.52N	34.34E	10.00	5.60	123	1.0
13	1948	4	30	36.05N	31.14E	80.00	5.80	173	0.7
14	1951	8	13	40.88N	32.87E	10.00	6.90	479	0.3
15	1953	9	10	34.80N	32.50E	0.00	6.30	201	1.3
16	1957	4	24	36.43N	28.63E	80.00	6.80	388	0.7
17	1957	4	25	36.42N	28.68E	80.00	7.10	383	1.3
18	1957	5	26	40.67N	31.00E	10.00	7.10	487	0.6
19	1959	6	13	34.78N	32.51E	60.00	5.70	203	0.1
20	1961	9	15	34.98N	33.83E	33.00	6.00	193	0.8
21	1970	3	28	39.21N	29.51E	18.00	7.20	422	1.2
22	1975	4	30	36.19N	30.74E	61.00	5.90	204	0.5
23	1979	5	28	36.46N	31.72E	111.00	5.20	112	0.5

(Source: EİE and the JICA Study Team)

Table A14 **RELATION BETWEEN INTENSITY AND FREQUENCY KAWASUMI'S METHOD**

Intensity (Ij)		Frequency in 87 years	Frequency in 100 years	Cumulative Number for 100 years (N)
0	(0.0 - 0.5)	9	10.34	26.43
1	(0.6 - 1.5)	12	13.79	16.09
2	(1.6 - 2.5)	2	2.30	2.30
3	(2.6 - 3.5)	0	0.00	0.00
4	(3.6 - 4.5)	0	0.00	0.00
5	(4.6 - 5.5)	0	0.00	0.00
6	(5.6 - 6.5)	0	0.00	0.00
7	(6.6 - 7.5)	0	0.00	0.00

(Source: EIE and the JICA Study Team)

Table A15 **GROUND ACCELERATION AT PROJECT SITE ON MAXIMUM CREDIBLE EARTHQAKES**

Formula	1. Project Earthquake	2. Linear No.1	3. Linear No.2	4. E.A.F No.3	5. Earthquake A	6. Earthquake B	7. Earthquake C
(1) Estiva's Formula (a)	0.1467	0.0119	0.0062	0.0075	0.0089	0.0069	0.0103
(2) Estiva's Formula (b)	0.0361	0.0029	0.0015	0.0018	0.0022	0.0017	0.0025
(3) From EIE Report	0.1413	0.0141	0.008	0.0093	0.0109	0.0089	0.0123
(4) Cornell's Formula	0.2932	0.0058	0.0027	0.0048	0.0039	0.0028	0.005
(5) Kawasumi's Formula	0.1147	0.0006	0.0007	0.0035	0.0009	0.0005	0.0017
Min. - Max.	0.0361-0.2932	0.0006-0.0141	0.0007-0.0080	0.0018-0.0093	0.0009-0.0109	0.0005-0.0089	0.0017-0.0123

(Source: EİE and the JICA Study Team)

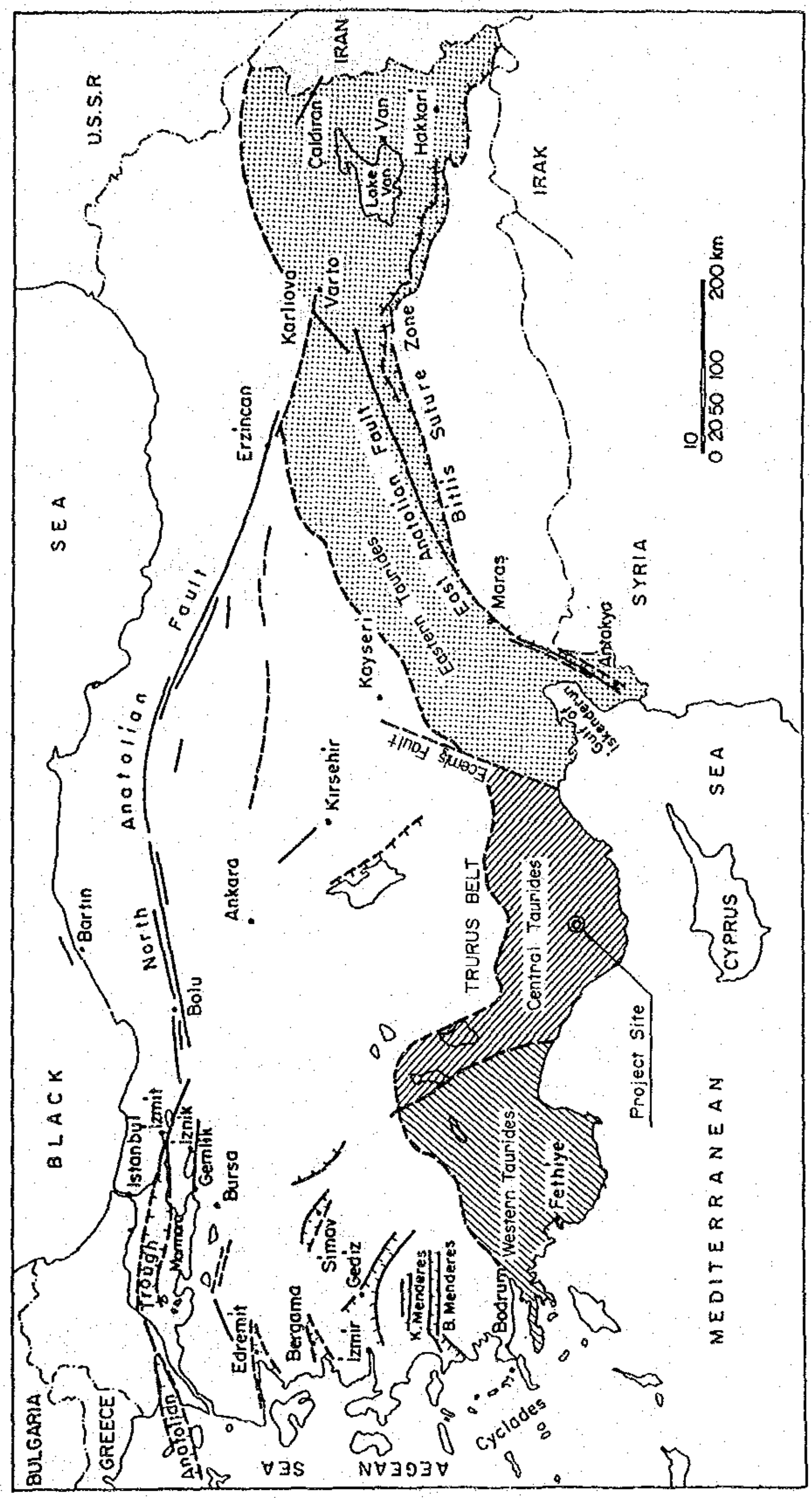
Table A16 **SUMMARY OF GROUND ACCELERATION AT PROJECT SITE ON MAXIMUM CREDIBLE EARTHQUAKES**

Reference	Maximum Magnitude M	Epicneral Distance d (km)	Deth of Hypocenter R (km)	Ground Acceleration
1.Project Earthquake	6.0	0	25	0.0361-0.2932
2.Linear No.1	5.4	97	100	0.0006-0.0141
3.Linear No.2	5.5	154	156	0.0007-0.0080
4.E.A.F No.3	6.8	252	253	0.0018-0.0093
5.Earth-quake A	5.2	106	109	0.0009-0.0109
6.Earth-quake B	5.0	112	115	0.0005-0.0089
7.Earth-quake C	5.6	118	121	0.0017-0.0123

(Source: EIE and the JICA Study Team)

FIGURES

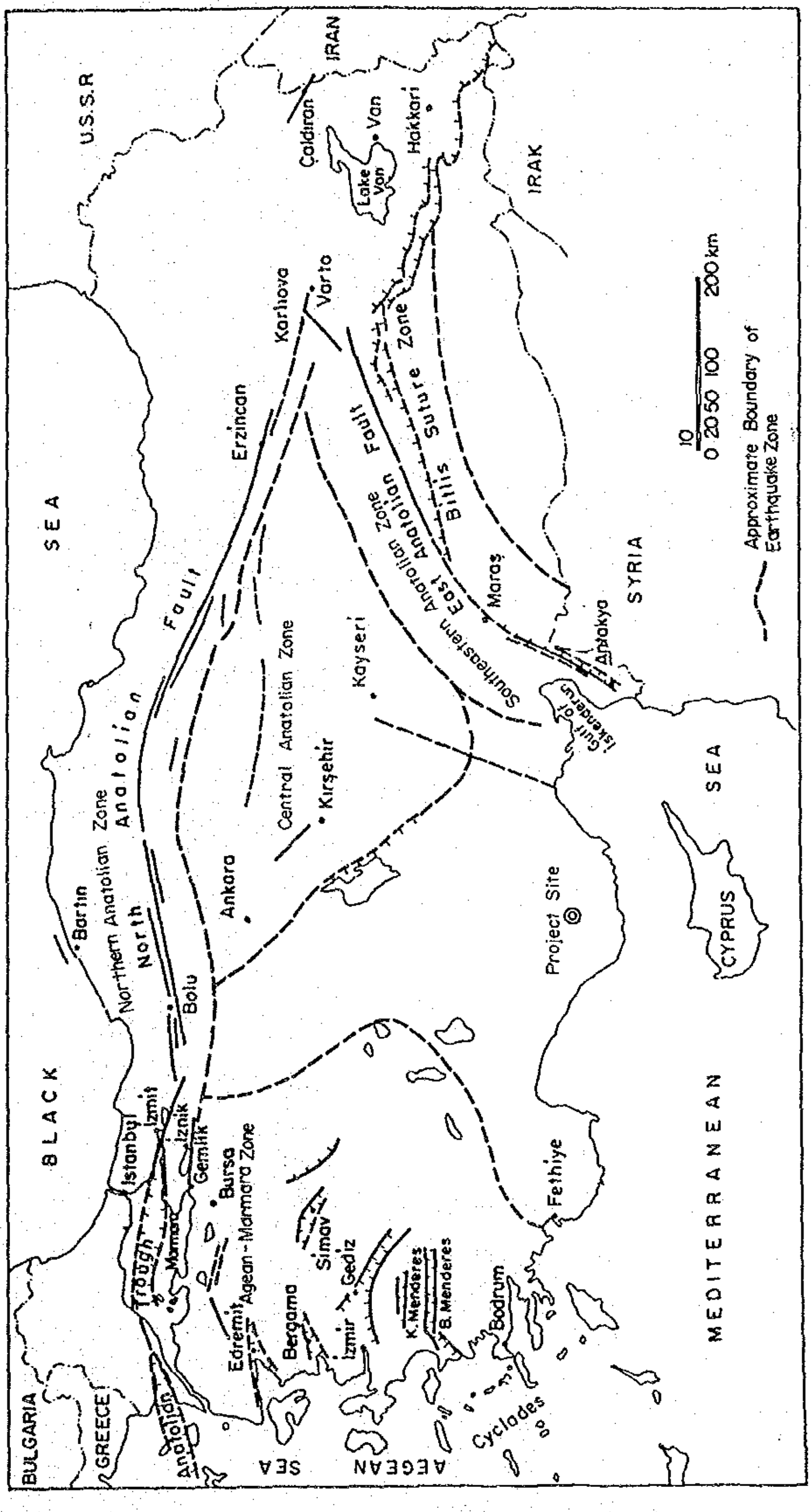
FIG NO.



(Source : Refference No.3 and 6)

THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜGÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE **Fig. A1** **The Broad Geographical Subdivision of the Taurus Belt**

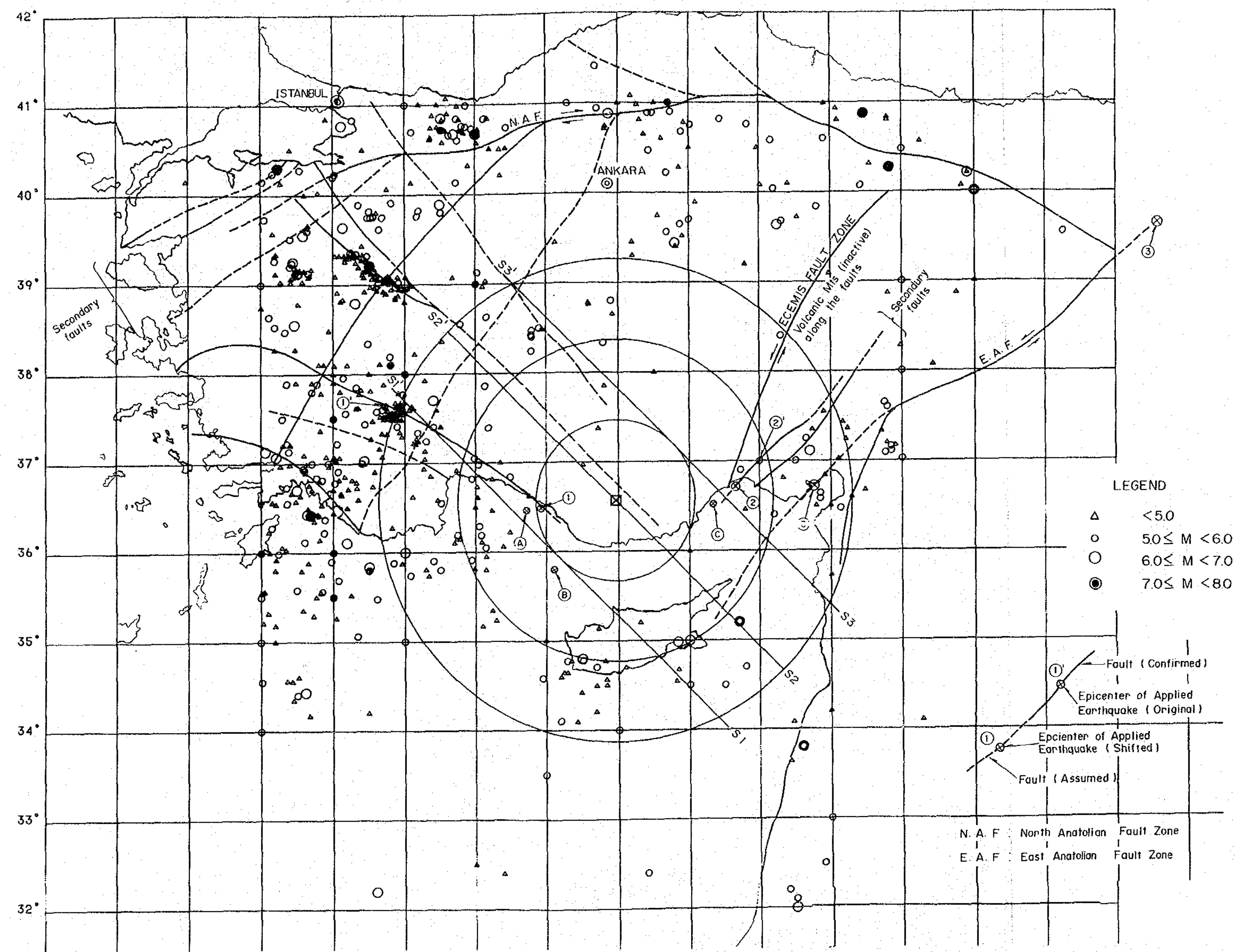
FIG NO.



(Source: Refference No.4 and 6)

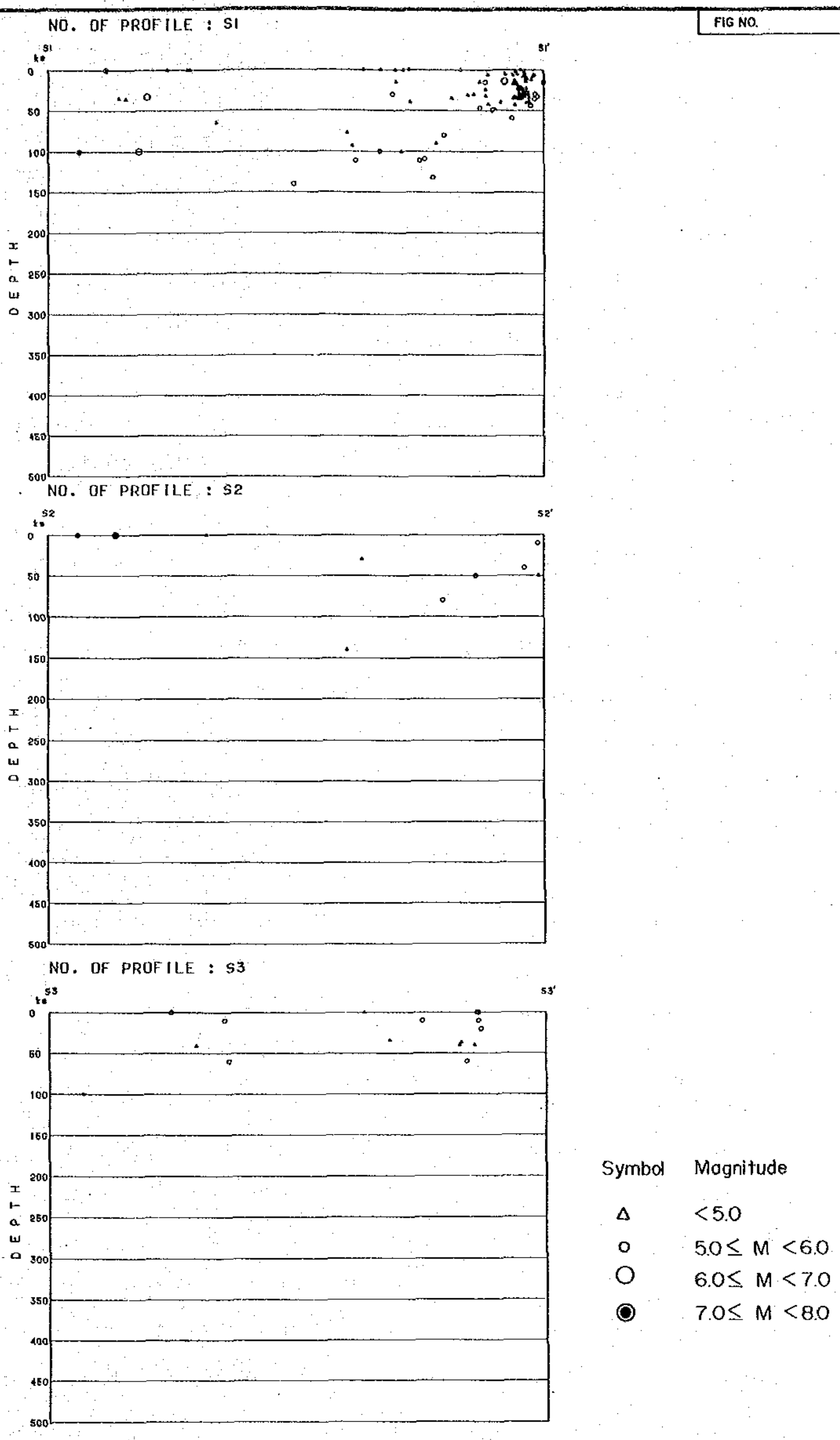
	THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE **Fig. A2** **Geotectonic Map of Anatolian Peninsula**

PLATE NO.

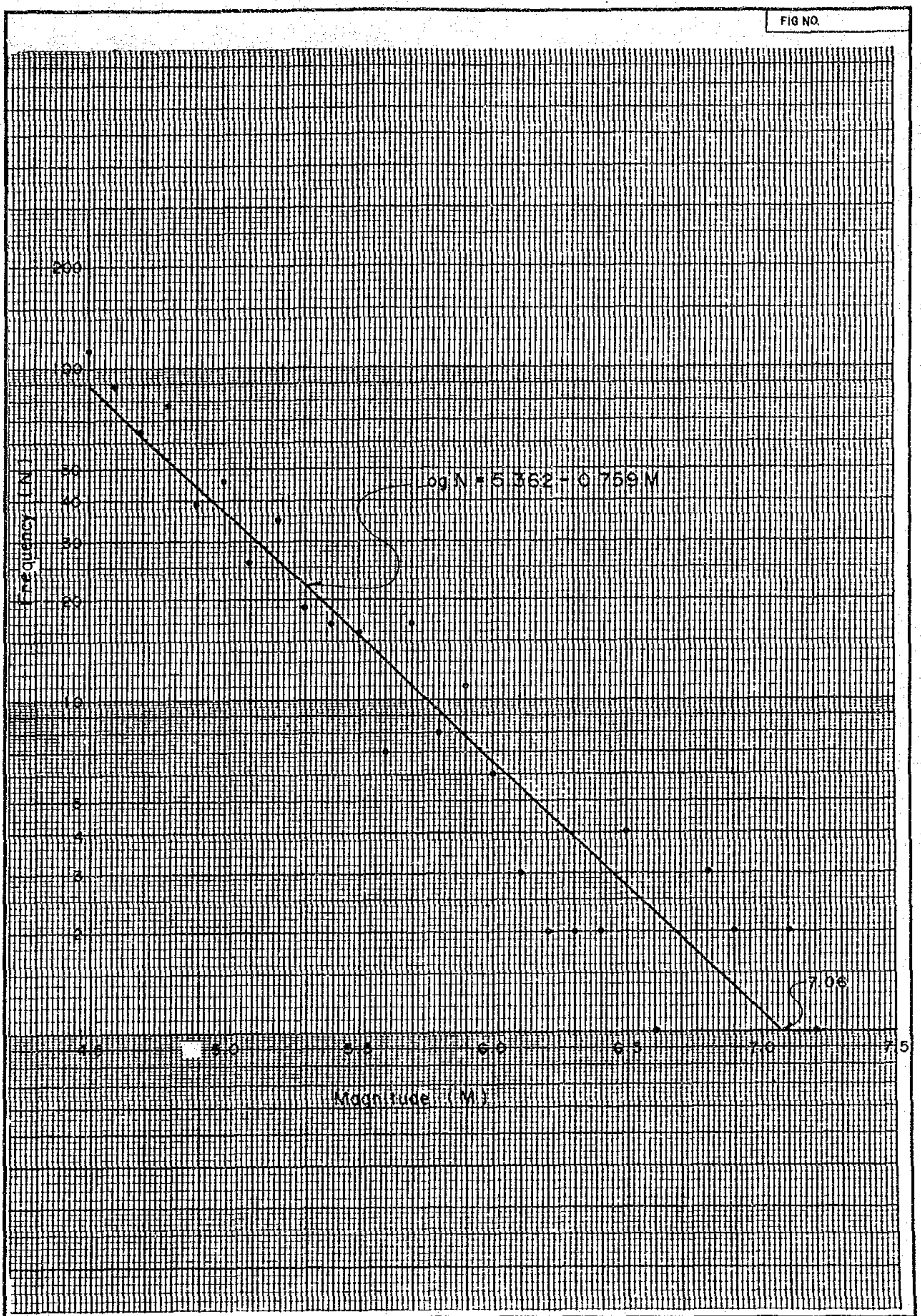


THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Fig. A3 Epicenters around Project site

FIG NO.



THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜGÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE **Fig. A4** **Hypocenters around Project Site**



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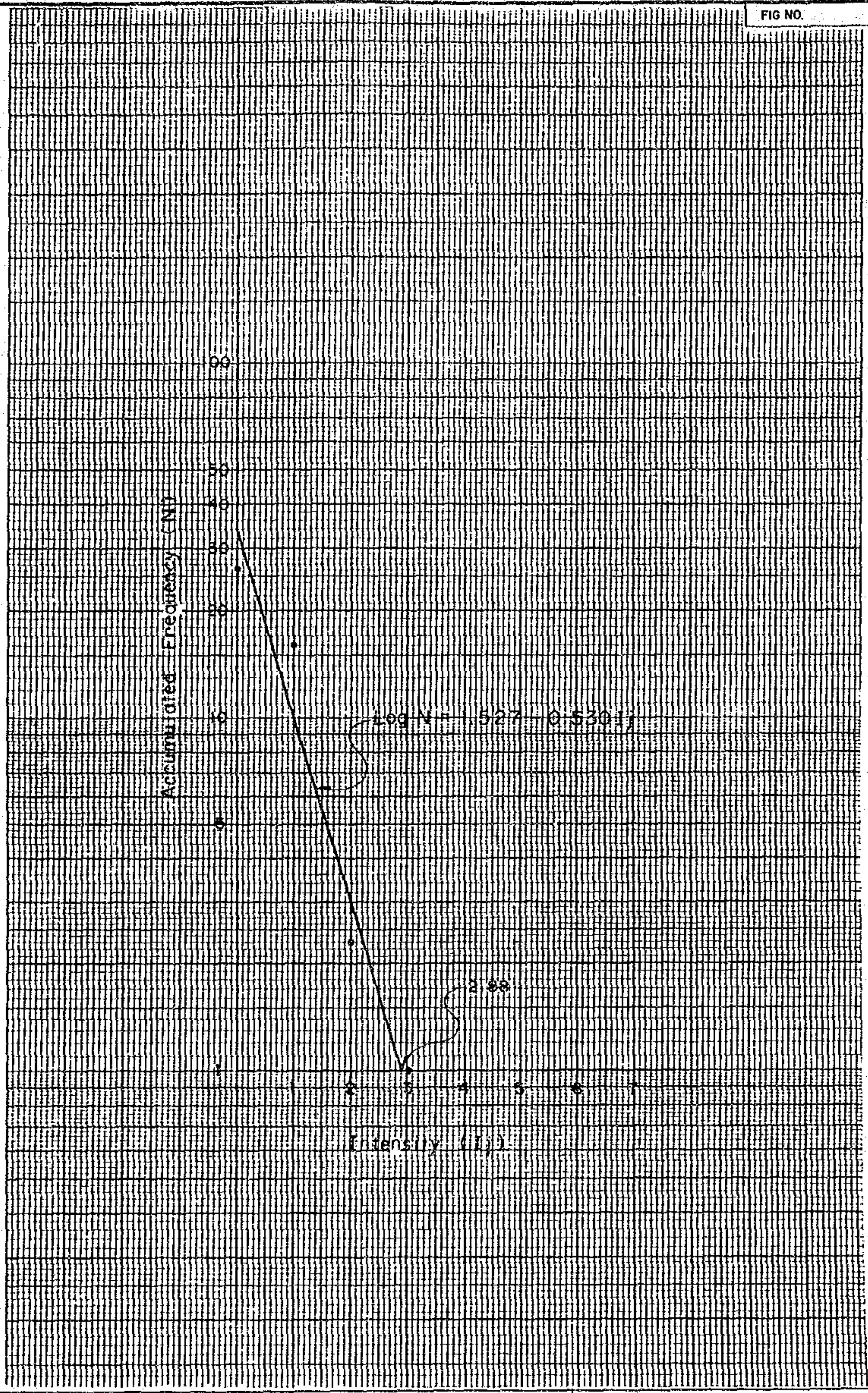
GENEL MÜDÜRLÜĞÜ

ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE **Fig. A5**
Relation between Frequency and Magnitude
Least Square Method

FIG NO.



THE REPUBLIC OF TURKEY ELEKTRİK İŞLERİ ETÜD İDARESİ GENEL MÜDÜRLÜĞÜ	ERMENEK HYDROELECTRIC POWER DEVELOPMENT PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE **Fig. A6** **Relation between Accumulated Frequency and Intensity of Earthquakes, Kawasumi's Method**