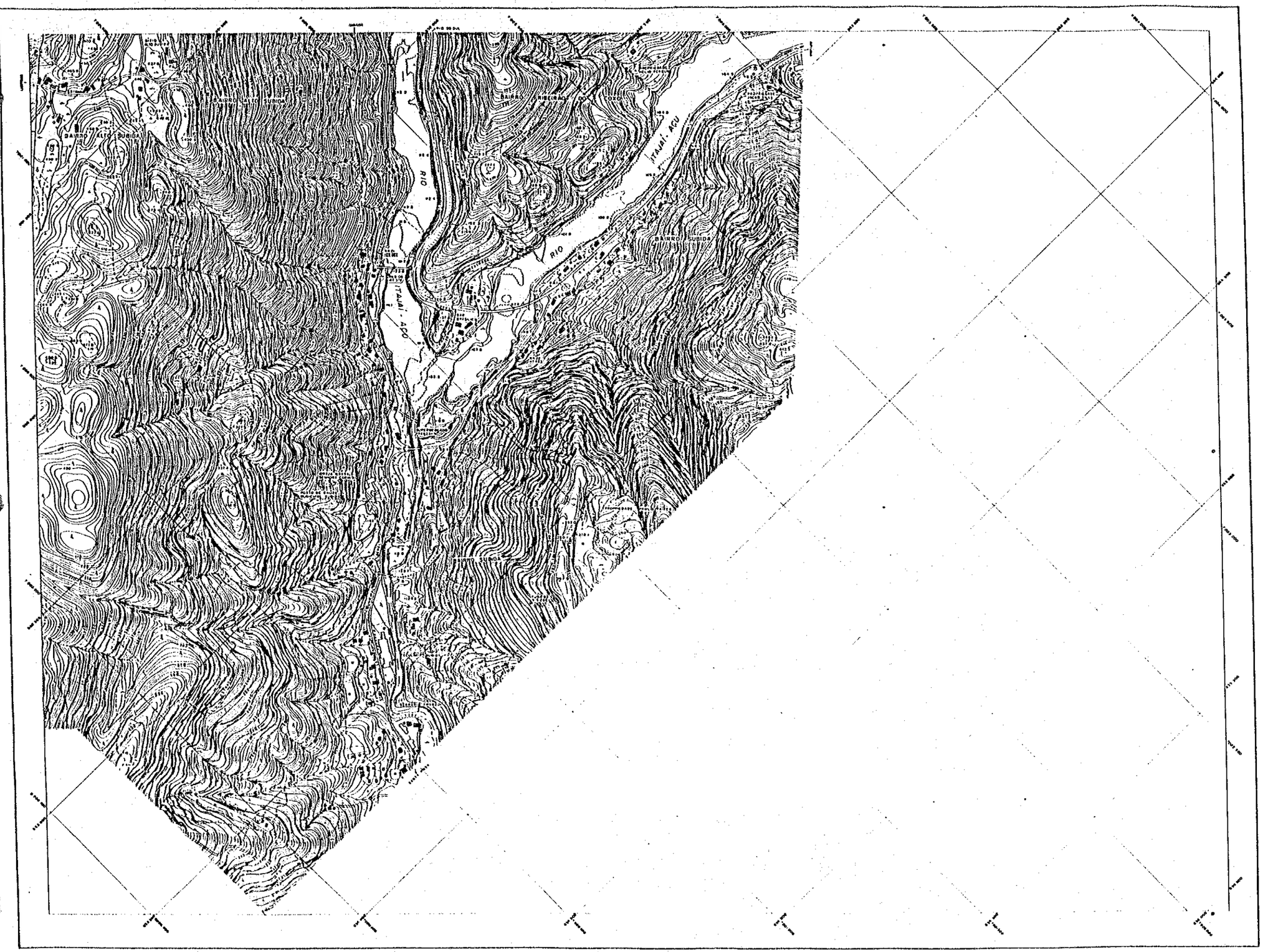
THE SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT

SHEET 8/8



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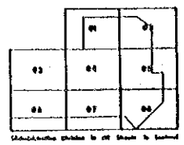

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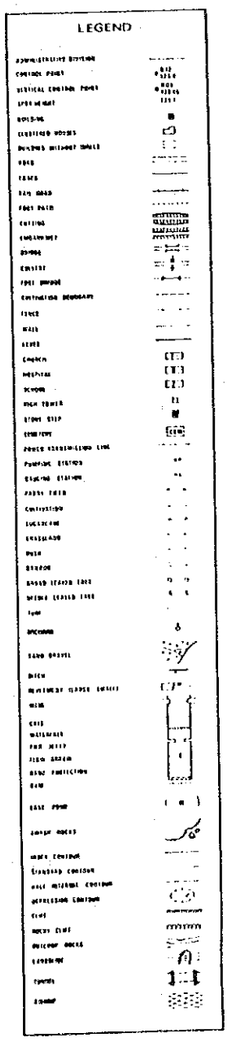

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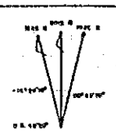
I - A8



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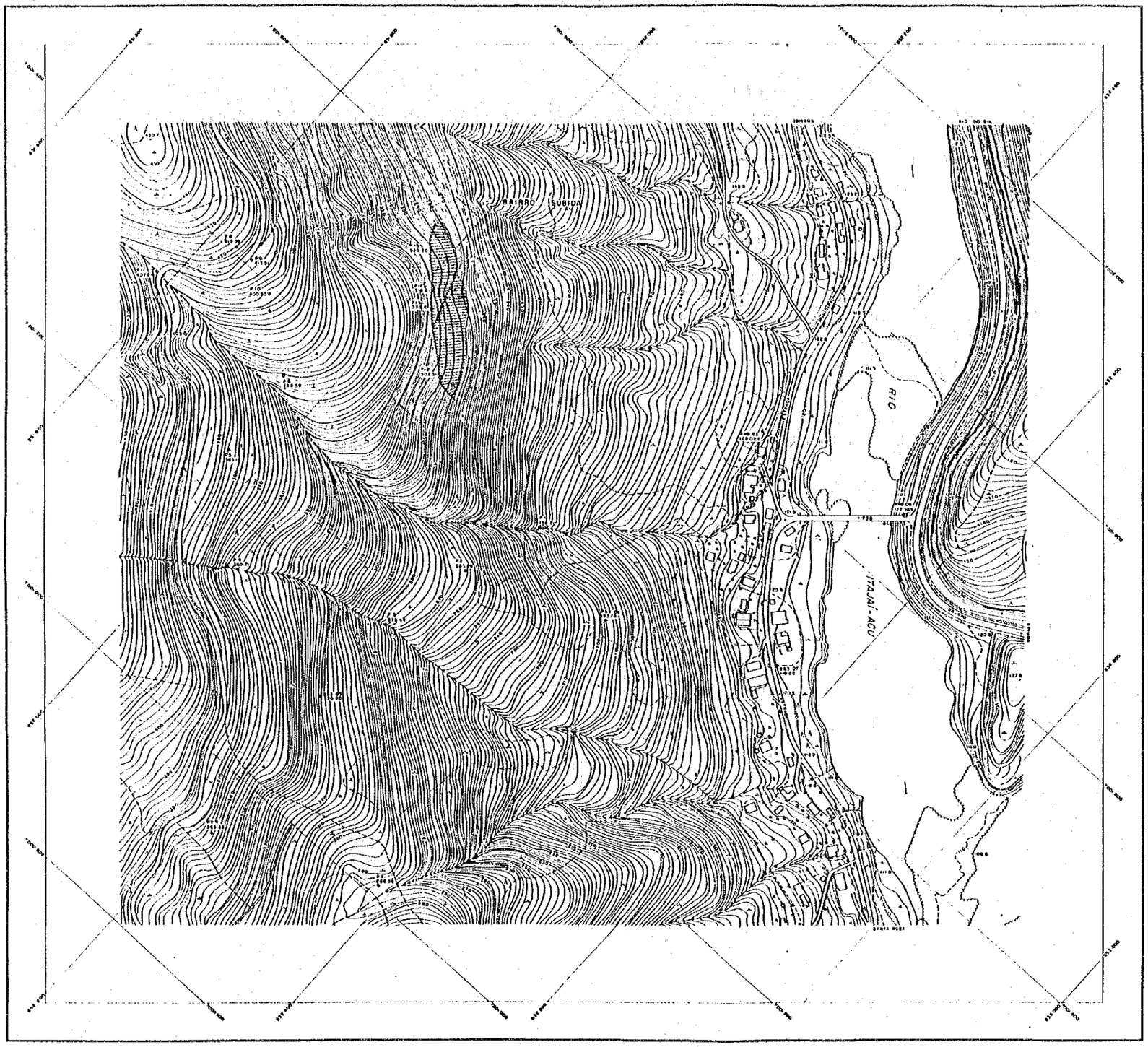
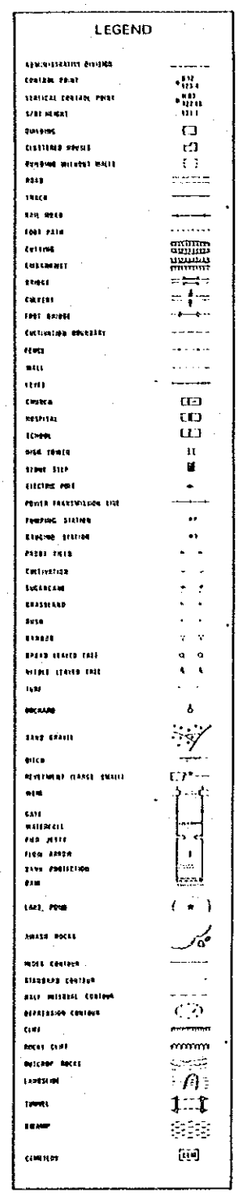
ROTATION

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

THE SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT
POWER STATION SITE





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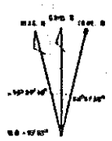

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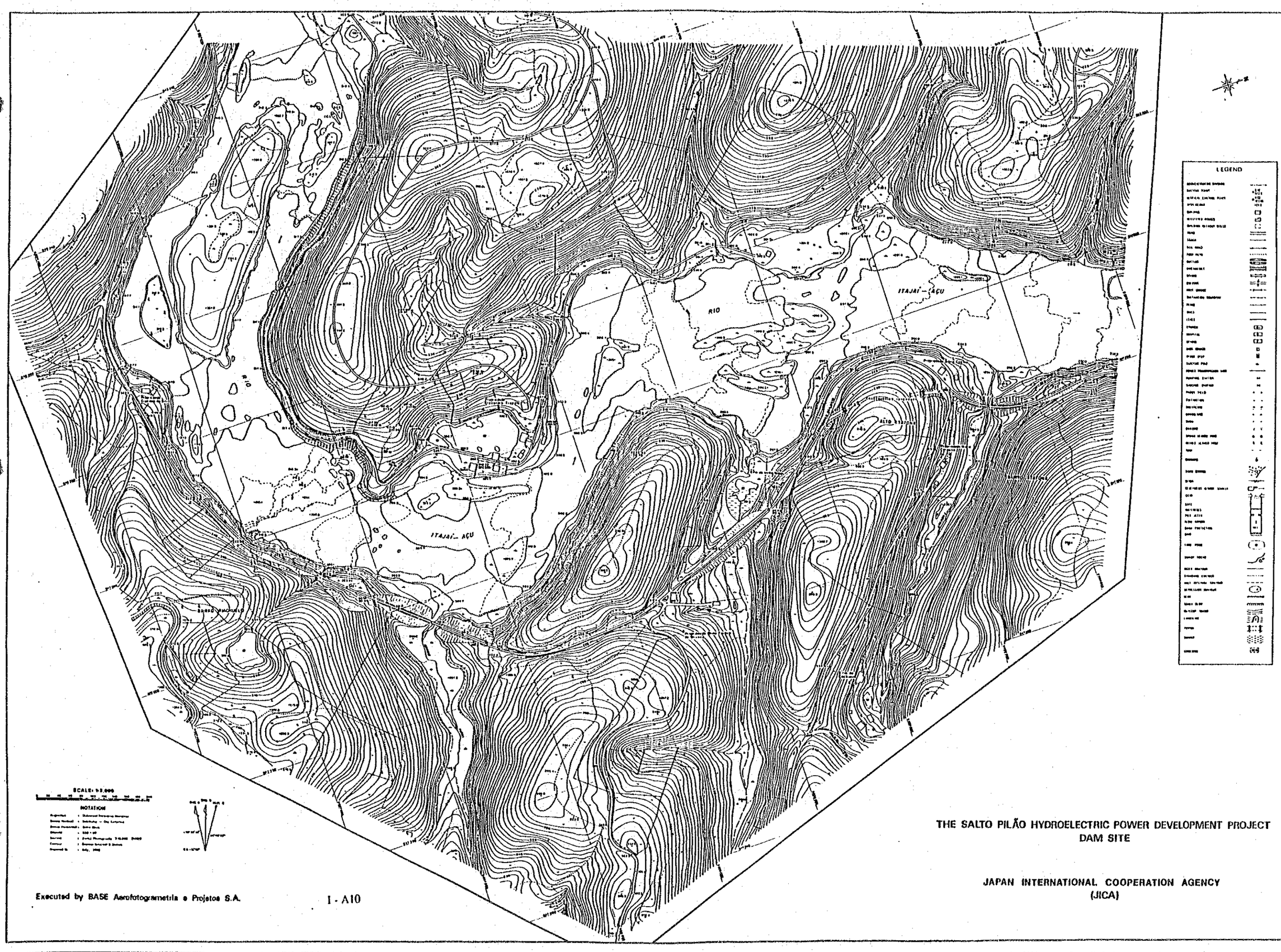
NOTATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)



THE SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT
DAM SITE

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

Executed by BASE Aerofotogrametria e Projetos S.A.

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ANNEX II

GEOLOGICAL INVESTIGATION

ANNEX II GEOLOGICAL INVESTIGATION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The geological investigation in the present study consists core boring, in-situ permeability test, laboratory rock test and geological mapping of the project area. Their work quantities are as follows:

1) Geological Mapping	: 2 areas
2) Field Investigation	
- Core boring	: 10 holes
- In-situ permeability test	: 14 points
3) Laboratory rock test	: 23 samples

The works 2) and 3) were entrusted to the local expert firm (SPT Sondagens). The works were carried out from June to August 1993.

Previous investigations carried out by Canambra E. C. (1969) and by JICA (1990) concentrated on the axis B of the damsite and upstream site of powerhouse. The present investigation were executed mainly on the dam axis C and downstream alternative site for powerhouse. Because, the dam axis C was recommended in the previous Hydro Inventory Study - 1991 and the downstream powerhouse site was considered attractive on the topographic point of view.

2. GEOLOGICAL MAPPING

2.1 Geological Maps and Sections

Surface geology of the project area, especially of the dam area and powerhouse area, was investigated by a geologist of JICA team. The results were indicated on the maps prepared in the present study. Fig. II.2.1 shows the overall geological map of the project area and Fig. II.2.2 shows the geological section between dam site (axis B) and powerhouse along headrace tunnel.

Detailed geological maps and geological sections of damsites and powerhouse site (proposed upstream site) are shown in Figs. II.2.3 to II.2.6. Geological section of alternative penstock route and alternative powerhouse site (downstream site) is shown in Fig. II.2.7.

2.2 Geological Interpretation

As shown on Fig. II.1, the dam and most part of headrace tunnel are situated in the granite body which is called Subida Series. This is normally classified as an intrusive rock with 70 km^2 of area, which is in a discordant contact with the surrounding volcanic and sedimentary rocks of Itajaí Group. In some places, the relationship between these two units is dubious. It can be supposed in principle that the granite is actually intrusive, but

the analysis of specific places shows the granite being cut by other lithologies of effusive sequence.

Generally, the Subida granite is composed of leucogranites, with a reddish-brown colour, with hypidiomorphic granular texture, medium to coarse grain size, isotropic and homogeneous. The essential composition contains alkali-potassium feldspars (mainly orthoclase), quartz and iron-magnesium silicate, with high sodium proportion (sodium amphiboles and pyroxenes). The micaceous minerals are also lacking. The age is about 530 and 550 million years.

The northeast part of the project area including surge tank and powerhouse site show volcanic lithologies from Campo Alegre Formation. In this region were found two kinds of igneous rocks:

- Acid microcrystalline rocks, probably effusive, here classified as rhyolites. They are felsic, with also the same mineralogical composition of the granite, but with imperceptible crystals by naked eye;

- Basic rocks with fine grain size, classified as diabases. They are essentially composed of pyroxenes and calcium-alkali feldspars, containing probably olivine, sulphides and garnet. The colour is dark grey.

3. FIELD INVESTIGATION

3.1 Core Boring

Core boring of 10 holes or 300 m in total length was undertaken. Location of the holes are shown in Fig. II.2.1. Length and ground elevation of each hole are tabulated below:

Hole No.	Length (m)	Ground Height (m)	Site	
B93-1	40	338.37	Dam axis - C	Left abutment
2	25	305.97	Dam axis - C	River bed
3	40	321.56	Dam axis - C	Right abutment
4	20	331.31	Dam site	Diversion Tunnel
5	45	320.0	Surge Tank	Downstream alternative
6	40	193.78	Penstock	Downstream alternative
7	20	119.69	Powerhouse	Downstream alternative
8-1	25	360.0	Quarry - A	
8-2	20	384.0	Quarry - B	
8-3	25	306.0	Quarry - B	
Total 10 holes	300			

Drill logs of the holes are shown in Fig. II.3.1. In classification of rock grade, the two standards were referred: (1) Japanese rock classification standard as shown in Table II.3.1 and (2) Brazilian rock classification index as shown in Table II.3.2.

3.2 In-situ Permeability Test

The field permeability tests on rock layer were executed inside the holes drilled for core boring with numbers of 93-1 to 93-5. The test was made in a section of 5 m length at the selected depth. In each test section, the quantity of injected water was counted at 10 - minute intervals.

From the data obtained during the tests, the P-Q graphs are prepared as shown in Fig. II.3.2. The Lugeon value (lit/min/m at 10 kg/cm^2) is obtained from these graphs.

Exceptionally, in order to check the permeability of overburden soil, water leakage test without pressurization was executed at the right bank of damsite (Hole No. 93-3) at the depth between 0 to 5 m.

The following table shows the results of in-situ permeability tests.

Location	Hole No.	Depth (m)	Rock Type *1	Lugeon Value
Dam site C, Left Abutment	B93-1	25-30	Gr	5.2
Do	B93-1	30-35	Gr	4
Do	B93-1	35-40	Gr	1
Dam site C, River bed	B93-2	10-15	Gr	2.2
Do	B93-2	15-20	Gr	0.8
Do	B93-2	20-25	Gr	4.5
Dam site C, Right Abutment	B93-3	00-05	Ds	$k = 3.1^{-4}$cm/s *2
Do	B93-3	20-25	Gr	0.5
Do	B93-3	25-30	Gr	0.2
Do	B93-3	30-35	Gr	0.1
Do	B93-3	35-40	Gr	5
Dam site C, Diversion	B93-4	15-20	Gr	0.5
Surge Tank	B93-5	30-35	Ry	0.4
Do	B93-5	35-40	Ry	3

Notes: *1 Gr = Granite, Ds = Soil, Ry = Rhyolite
*2 k = Permeability coefficient

4. LABORATORY ROCK TEST

In order to examine the engineering properties of rocks at dam foundation and tunnel and rocks for concrete aggregate, the laboratory rock tests were carried out on samples taken from drilled cores and outcrops in the existing quarry and in the existing tunnel. The sampling in the existing tunnel of abandoned railway near the quarry A was made aiming to represent rock of the headrace tunnel which passes in the similar granite mass. Locations of sampling are listed below:

Sample No.	Rock Type	Sampling Location	Depth (m)	Type of Sample	Nos. of Piece
Dam & Waterway					
Dam - 1	Granite	B93-1	38.3	Boring core	1
- 2	- Do -	B93-1	38.6	- Do -	1
- 3	- Do -	B93-1	39.0	- Do -	1
- 4	- Do -	B93-1	39.3	- Do -	1
- 5	- Do -	B93-2	22.3	- Do -	1
- 6	- Do -	B93-2	24.0	- Do -	1
- 7	- Do -	B93-3	25.0	- Do -	1
- 8	- Do -	B93-3	30.0	- Do -	1
- 9	- Do -	B93-3	33.0	- Do -	1
- 10	- Do -	B93-3	35.0	- Do -	1
Tunnel - 1	- Do -	Existing Tunnel		Angular Blocks	2
- 2	- Do -	- Do -		Angular Blocks	2
- 3	- Do -	- Do -		Angular Blocks	2
- 4	Rhyolite	B93-6	28.5	Boring core	1
- 5	- Do -	B93-6	29.5	- Do -	1
- 6	- Do -	B93-6	37.0	- Do -	1
- 7	- Do -	B93-5	25.0	- Do -	1
- 8	- Do -	B93-5	27.0	- Do -	1
- 9	- Do -	B93-5	28.0	- Do -	1
- 10	- Do -	B93-5	30.0	- Do -	1
Concrete Aggregate Quarry					
Quarry - 1	Granite	Existing quarry *		Angular Blocks	2
Quarry - 2	- Do -	- Do -		Angular Blocks	2
Quarry - 3	- Do -	- Do -		Angular Blocks	2
Total: 23					

*: Upstream portal of the existing tunnel near quarry-A.

The rock pieces sampled were tested at the laboratory in São Paulo on the following test items.

Test Item	Test Specification (ASTM)
1) Specific gravity	C-29-76
2) Water absorption	C-29-76
3) Void ratio	C-29-76
4) Dynamic elastic modulus (Velocity of super sonic wave)	D-2845-89
5) Unconfined compressive strength	C-109-70
6) Los Angeles abrasion test	C-241-51
7) Potential alkali reactivity (Chemical Method)	C-289-81

The test item 7) was applied only to 3 test samples for concrete aggregate. The other test items were applied to all test samples.

The test results are summarized in Table II.4.1. The results of the potential alkali reactivity test is shown in Fig. II.4.1.

Characteristic engineering properties revealed by these tests are as follows:

- As to granite in dam site, dynamic elastic modulus is 65 GPa on an average, unconfined compressive strength ranges from 210 MPa to 140 MPa (average 170 MPa). These figures present that the rock is excellent.

- Granite in relation to headrace tunnel also has very good condition; dynamic elastic modulus and unconfined compressive strength, respectively 62.7 GPa and 150 MPa on an average.

- As to rhyolite in relation to penstock tunnel, dynamic elastic modulus shows nearly equal value 68~70 GPa, average 69 GPa. However there is a large difference in unconfined compressive strength: minimum 73 MPa, maximum 240 MPa and average 170 MPa.

- Granite in quarry site has a sufficient strength; unconfined compressive strength 150 MPa. However the rate of abrasion loss is relatively large; 32% in index of Los Angeles Abrasion. Reaction to alkali aggression is low and quite innocuous.

Table

Table II.2.1 Japanese Rock Classification

Rock Class	Characteristics
A	Hard and fresh rocks. Rock-forming minerals are fresh and not weathered or altered. Joints and cracks are closed tightly, no weathering on their planes. Clear sound is emitted when hammered.
B	Hard and fresh rocks. Rock forming minerals are weathered slightly or partially altered. Joints and cracks are closed tightly, without weathering. Clear sound is emitted when hammered.
CH	Fairly hard and slightly weathered rocks. Rock-forming minerals, except quartz, are weathered or altered. Tightness of joints and cracks is slightly reduced and each block is apt to be exfoliated along joints and cracks which sometimes contain clay and other materials, stained by limonite. Slightly dull sound is emitted when hammered.
CM	Slightly soft and moderately weathered rock. Rock-farming minerals, except quartz, are weathered or altered. Exfoliation occurs along joint and cracks by hammering. Joints and cracks sometimes contain clay and other materials. Slightly dull sound is emitted when hammered.
CL	Soft and weathered rocks. Rock minerals are weathered. Exfoliation occurs easily along joints and cracks by hammering. Joints and cracks contain clay and other materials. Dull sound is emitted when hammered.
D	Very soft, highly weathered, fractured and/or altered rocks. Rock-forming minerals are highly weathered. Joints and cracks are very loose, easily collapse by weak hammering, which contain clay and other materials. Very dull sound is emitted when hammered.

Rock Class	Compressive Strength (qu : kg/cm^2)	Modulus of Elasticity (Es:kg/cm^2)	Modulus of Deformation (Ed: kg/cm^2)	Seismic Velocity (km/sec)	Poisson's Ratio
A & B	more than 800	more than 80,000	more than 50,000	more than 3.7	less than 0.2
CH	800 to 200	80,000 to 40,000	50,000 to 20,000	3.7 to 3	0.2 to 0.3
CM	400 to 200	40,000 to 15,000	20,000 to 5,000	3 to 1.5	0.2 to 0.3
CL	less than 200	less than 15,000	less than 5,000	less than 1.5	more than 0.3
D	less than 100	less than 5,000	less than 5,000	less than 1.5	more than 0.3

Rock Class	Cohesion (kg/cm^2)	Internal Friction Angle (degree)	Borehole test	
			Modulus of Deformation (kg/cm^2)	Modulus of Elasticity: ES (kg/cm^2)
A & B	more than 40	55 to 65	more than 50,000	more than 100,000
CH	40 to 20	40 to 55	60,000 to 15,000	150,000 to 60,000
CM	20 to 10	30 to 45	20,000 to 3,000	60,000 to 10,000
CL & D	less than 10	15 to 35	less than 6,000	less than 15,000

Notes ;

(1) Compressive strength shows the result of rock piece test.

(2) Modulus of elasticity and deformation show the results of in-situ plate loading tests.

(3) Es means static modulus of elasticity.

Source :Standard of Central Research Institute of Electric Power Industry of Japan

Table II.3.1 Brazilian Rock Classification

Hardness			Alteration	Fractureness		Fractures			
						Orientation		Conditions	
H1	Very Hard	A1	Solid Rock	F1	0 to 1 no Fissured	H	0° Horizontal	S1	Rough
H2	Hard	A2	Little Altered	F2	2 to 5 Little Fissured	SH	0° to 20° Sub Horizontal	S2	Little Rough
H3	Moderately Hard	A3	Moderately Altered	F3	6 to 10 Moderately Fissured	I	20° to 70° Inclined	S3	Smooth
H4	Soft	A4	Very Altered	F4	11 to 20 Very Fissured	SV	70° to 90° Sub Vertical	S4	Granular Filling
H5	Very Soft	A5	Saprolite	F5	20 Extremely Fissured	V	Vertical	S5	Clayey Filling

Table II.4.1 Result of Laboratory

Sample No.	Site	Depth (m)	Rock Type	Specific Gravity (g/cm3)	Water Absorption (%)	Void Ratio (%)	Dynamic Elastic Modulus (GPa)	Unconfined Compressive Strength (MPa)	Los Angeles Abrasion (%)	Potential Alkali Reactivity		
										Dissolved Silica (m Mole/L)	Reduction of Alkalinity (m Mole/L)	Result
Dam-1	B93-1	38.3	Gr	2.596	0.07	0.19	66.37	144.84	-	-	-	-
Dam-2	B93-1	38.6	Gr	2.602	0.07	0.19	68.92	155.13	-	-	-	-
Dam-3	B93-1	39.0	Gr	2.602	0.07	0.17	64.61	175.03	-	-	-	-
Dam-4	B93-1	39.3	Gr	2.588	0.10	0.25	61.62	168.27	-	-	-	-
Dam-5	B93-2	22.3	Gr	2.604	0.08	0.20	67.98	195.31	-	-	-	-
Dam-6	B93-2	24.0	Gr	2.582	0.12	0.31	63.23	42.53	-	-	-	-
Dam-7	B93-3	25.0	Gr	2.599	0.09	0.22	60.17	188.06	-	-	-	-
Dam-8	B93-3	30.0	Gr	2.601	0.09	0.25	55.49	186.00	-	-	-	-
Dam-9	B93-3	33.0	Gr	2.591	0.14	0.36	60.88	140.04	-	-	-	-
Dam-10	B93-3	35.0	Gr	2.572	0.28	0.72	58.68	209.23	-	-	-	-
Tunnel-1	Outcrop (Tunnel)*	-	Gr	2.570	0.32	0.82	64.01	137.30	-	-	-	-
Tunnel-2	Outcrop (Tunnel)*	-	Gr	2.581	0.23	0.59	59.05	166.31	-	-	-	-
Tunnel-3	Outcrop (Tunnel)*	-	Gr	2.604	0.22	0.58	61.69	144.84	-	-	-	-
Tunnel-4	B93-6	28.5	Db	2.699	0.06	0.15	68.76	191.98	-	-	-	-
Tunnel-5	B93-6	29.5	Ry	2.660	0.21	0.56	69.93	206.68	-	-	-	-
Tunnel-6	B93-6	37.0	Db	2.734	0.17	0.47	72.29	141.51	-	-	-	-
Tunnel-7	B93-5	25.0	Db	2.752	0.06	0.17	69.10	241.96	-	-	-	-
Tunnel-8	B93-5	27.0	Db	2.756	0.07	0.20	65.73	148.96	-	-	-	-
Tunnel-9	B-93-5	28.0	Ry	2.730	0.14	0.39	66.88	190.61	-	-	-	-
Tunnel-10	B93-5	30.0	Ry	2.745	0.10	0.29	66.78	71.93	-	-	-	-
Quarry-1	Outcrop (Quarry)**	-	Gr	2.588	0.22	0.56	61.50	154.84	32	2.50	75.25	Inoffensive
Quarry-2	Outcrop (Quarry)**	-	Gr	2.598	0.10	0.26	60.70	164.54	32	16.79	37.65	Inoffensive
Quarry-3	Outcrop (Quarry)**	-	Gr	2.590	0.16	0.41	59.81	150.53	32	9.16	37.65	Inoffensive

* : Inside of existing tunnel of abandoned railway near Drill hole B93-8-1.

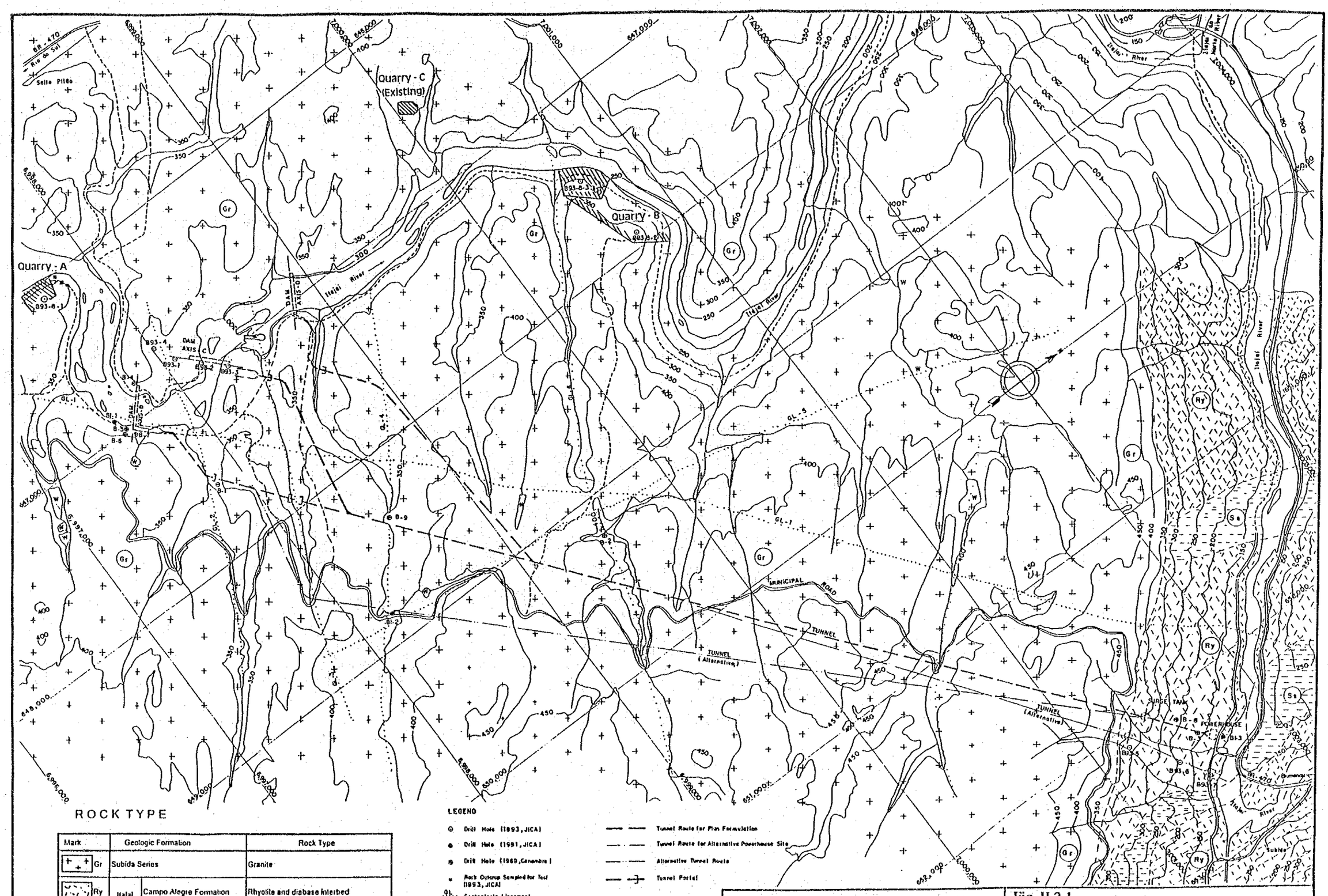
** : Existing quarry at upstream portal of the above existing tunnel.

Gr : Granite

Ry : Rhyolite

Db : Diabase

Figure



ROCK TYPE

Mark	Geologic Formation		Rock Type
Gr	Subida Series		Granite
Ry	Itajaí Group	Campo Alegre Formation	Rhyolite and diabase interbed
Ss		Garcia Formation	Sandstone, slate and partly hornfels

LEGEND

- Drill Hole (1993, JICA)
- Drill Hole (1991, JICA)
- Drill Hole (1969, Canambra)
- Rock Outcrop Sampled for Test (1993, JICA)
- Geotectonic Lineament
- Tunnel Route for Plan Formulation
- Tunnel Route for Alternative Powerhouse Site
- Alternative Tunnel Route
- Tunnel Portal

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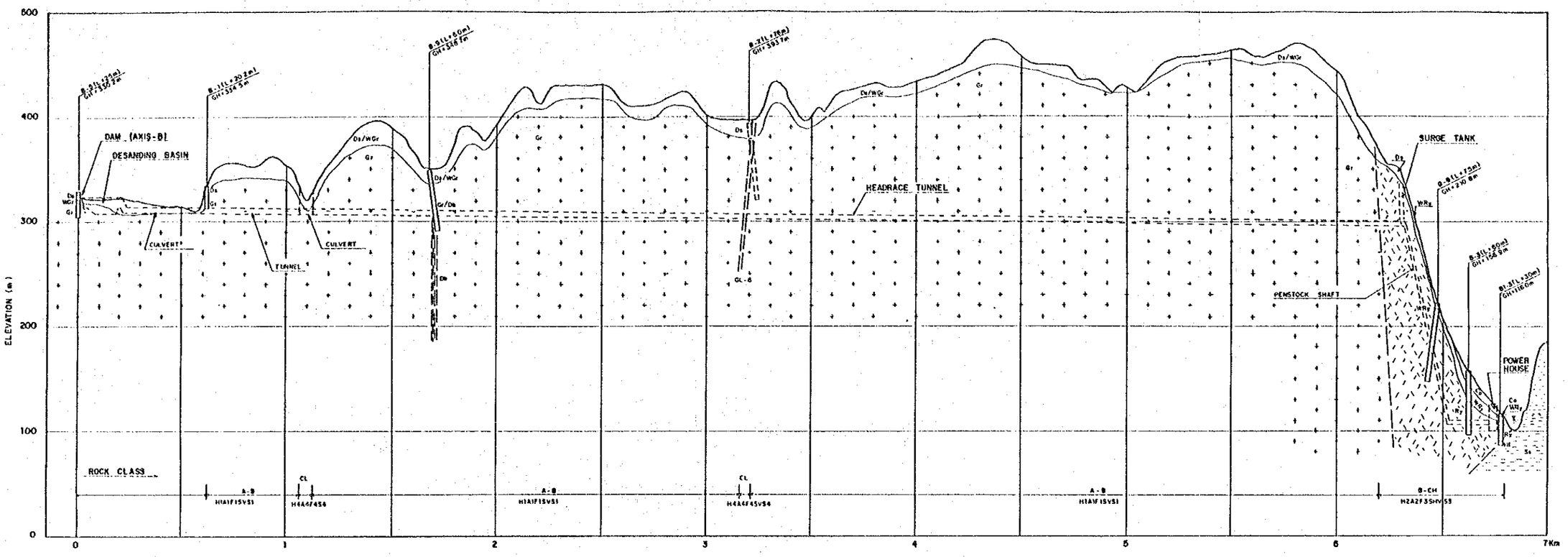
Fig. II.2.1
Geological Map of Project Area



LONGITUDINAL SECTION ON TUNNEL ROUTE FROM DAM (AXIS-B) TO POWERHOUSE

LEGEND

- Al: Alluvium, Clayey Soil
  Co: Colluvium, Clayey Soil with Boulders
  Ds: Clay, Soft Decomposed Rock
- Gr: Granite
- Ry: Rhyolite with Diabase Interbed
- Db: Diabase Intrusion
- Ss: Sandstone, Slate, Partly Hornfels

DRILL HOLE

Hole No. (Hole Length)
El. of Top of Hole

No. B-□ by Canambra, 1969
No. B1-□ by JICA, 1991
No. B93-□ by JICA, 1993

ROCK PROPERTIES

Mark	Geologic Formation		Rock Type	Rock Classification (1)	Rock Classification (2)	Engineering Properties
Gr	Subida Series		Granite	A - B	H1A1F1SVS1	Very hard. Massive. Joints closed tightly and spaced only with 3 to 5 m.
WGr			Weathered Granite	CL	H3A4F4SVS5	Stained into brown. Fragile and soft.
Ry	Itajai Group	Campo Alegre Formation	Rhyolite	B - CH	H1A1F2SVS3	Complex of rhyolite, rhyodacite, interbedded with diabase. Very hard but cracky. Joints develop in some places.
WRy			Weathered Rhyolite	CM - CL	H3A3F4SVS4	Colour altered. Stained. Moderately hard. Many open cracks with clay film.
Db			Diabase	CH	H2A2F3SVS3	Intrusive rock. Hard but cracky.
Hf		Garcia Formation	Hornfels	CH	H2A2F3SVS3	Hard. Thermo-metamorphic. Joints develop with spacing of 10 cm.

Note: Rock Classification (1): Japanese classification
Rock Classification (2): Brazilian index

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Fig. II.2.2
Geological Section along Tunnel Route from Dam Axis B

N

LEGEND

- Al — Alluvium
- Em — Embankment
- Slid Material
- Outcrop, Fresh Granite
- W — Outcrop, Cliff, Weathered Granite
- Outcrop, Cliff, Soft Decomposed Granite
- Boulders, Granite
- Joint Dip
- Geotectonic Lineament
- Drill Hole

SCALE

0 500m

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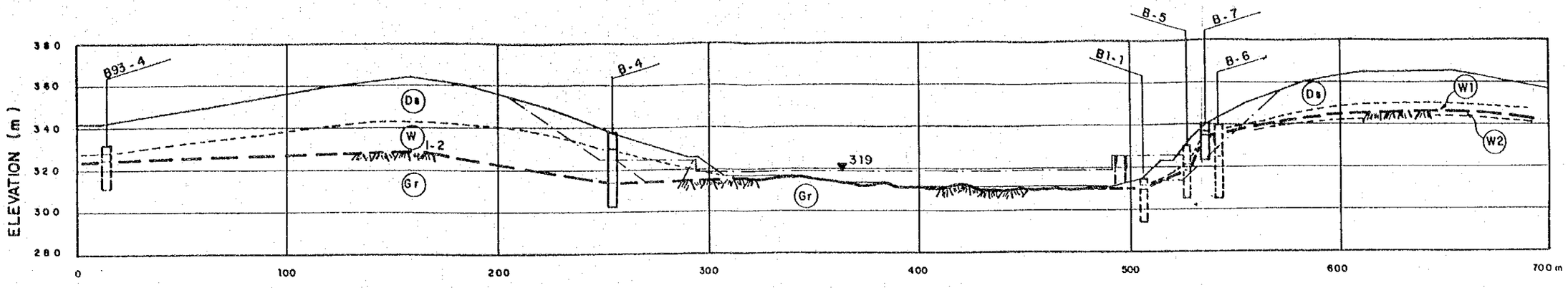
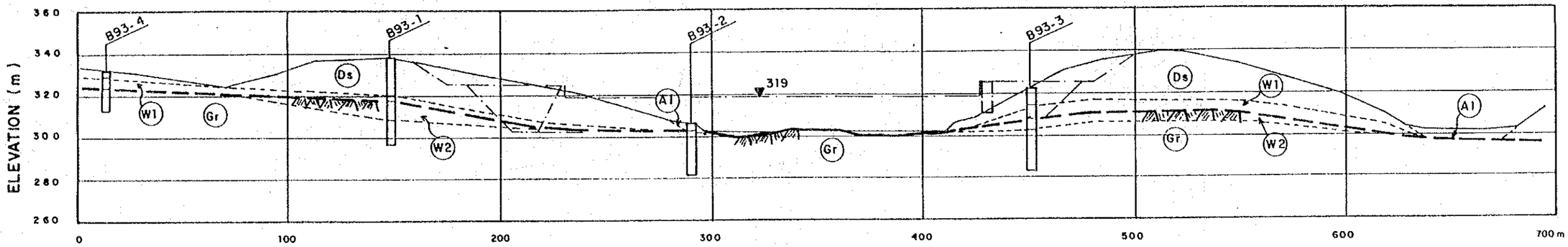
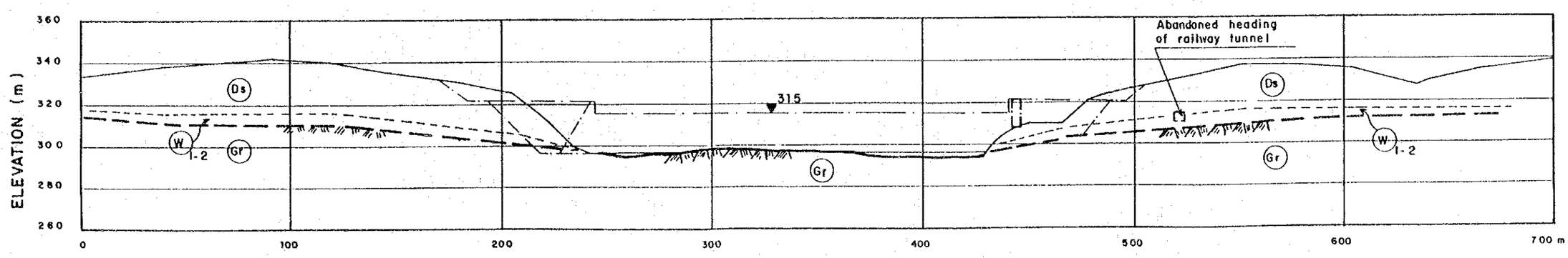
Fig. II.2.3
Geological Map of Dam Area



AX IS - B



AXIS - C



AXIS - D

LEGEND

Mark	Rock Type	Rock Classification (1)	Rock Classification (2)
Al	Alluvium	-	-
Ds	Clayey soil and soft decomposed granite	-	-
W1	Highly weathered granite	D	H5A5F5S5
W2	Slightly or moderately weathered granite	CM to CL	H3A3F3S3
Gr	Hard, massive granite	A to B	H1A1F1SVS1

Note : W 1-2 means complex of W1 and W2 , boundary not clear.

Drill hole

Drill hole (off section)

Hard rock surface

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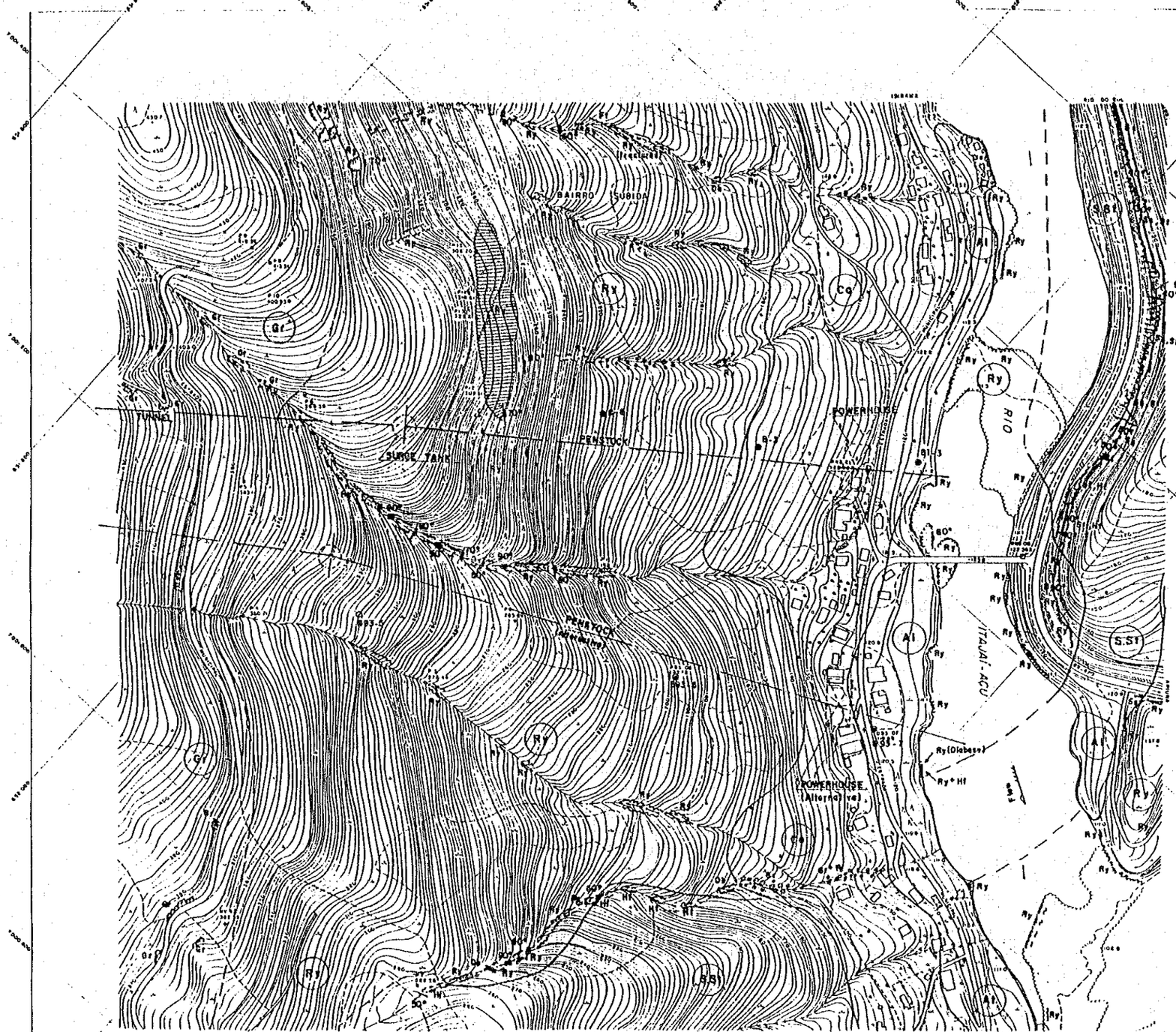
Fig. II.2.4

Geological Section along Dam Axes B, C, and D



LEGEND

Al	:	Alluvium
Co	:	Colluvium
Ry	:	Rhyolite, Ryodacite, Diabase Interbed
Gr	:	Granite
S.St	:	Sandstone, Slate, Hornfels
		Outcrop
		Bedding
		Joint, Crack
		Drill Hole

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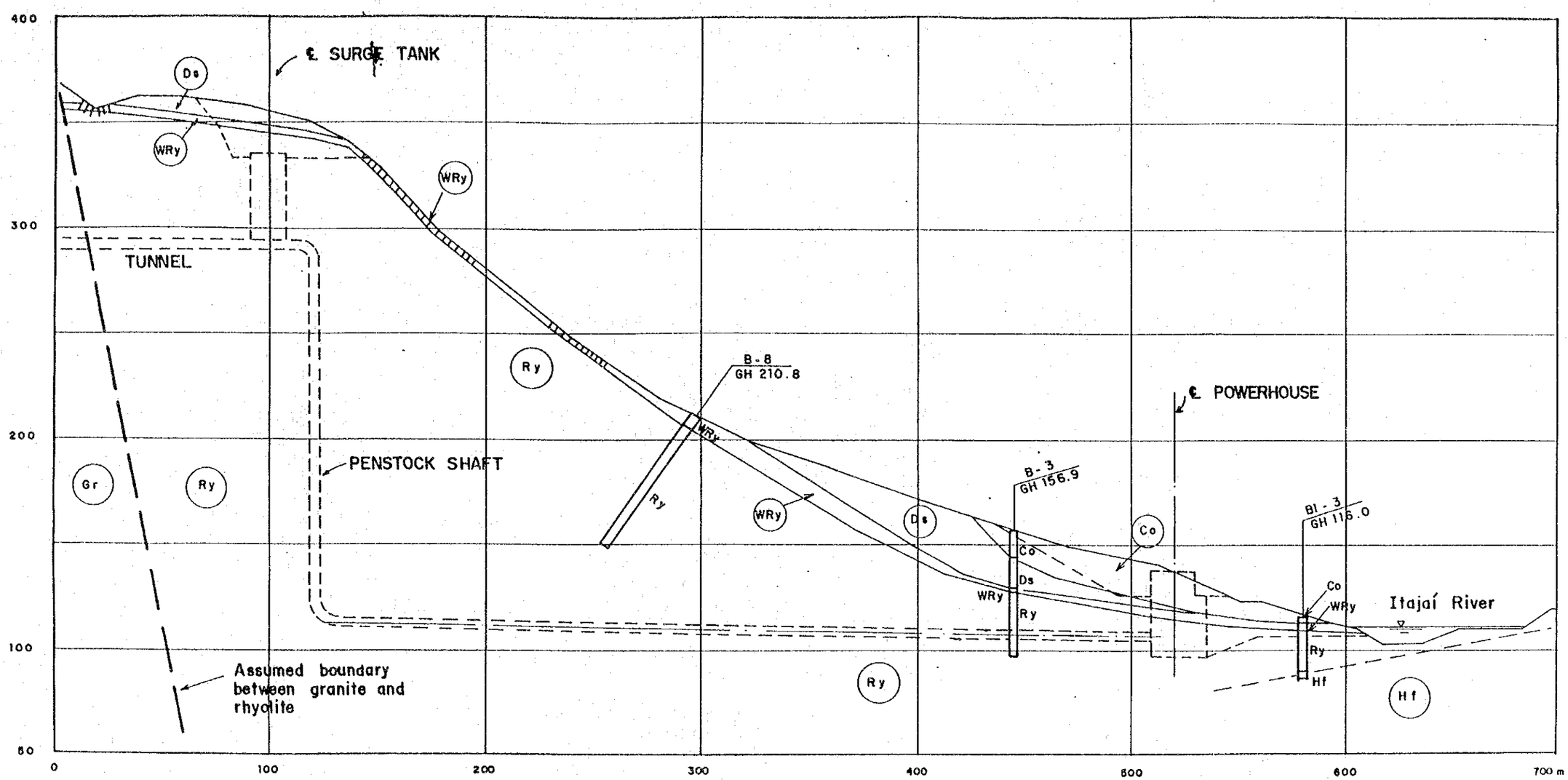
Fig. II.2.5
Geological Map of Powerhouse Area



LEGEND

Co	:	Colluvium
Ds	:	Clay (Decomposed Rhyolite)
WRy	:	Weathered Rhyolite
Ry	:	Rhyolite
Gr	:	Granite
Hf	:	Hornfels

Drill Hole

Rock Outcrop

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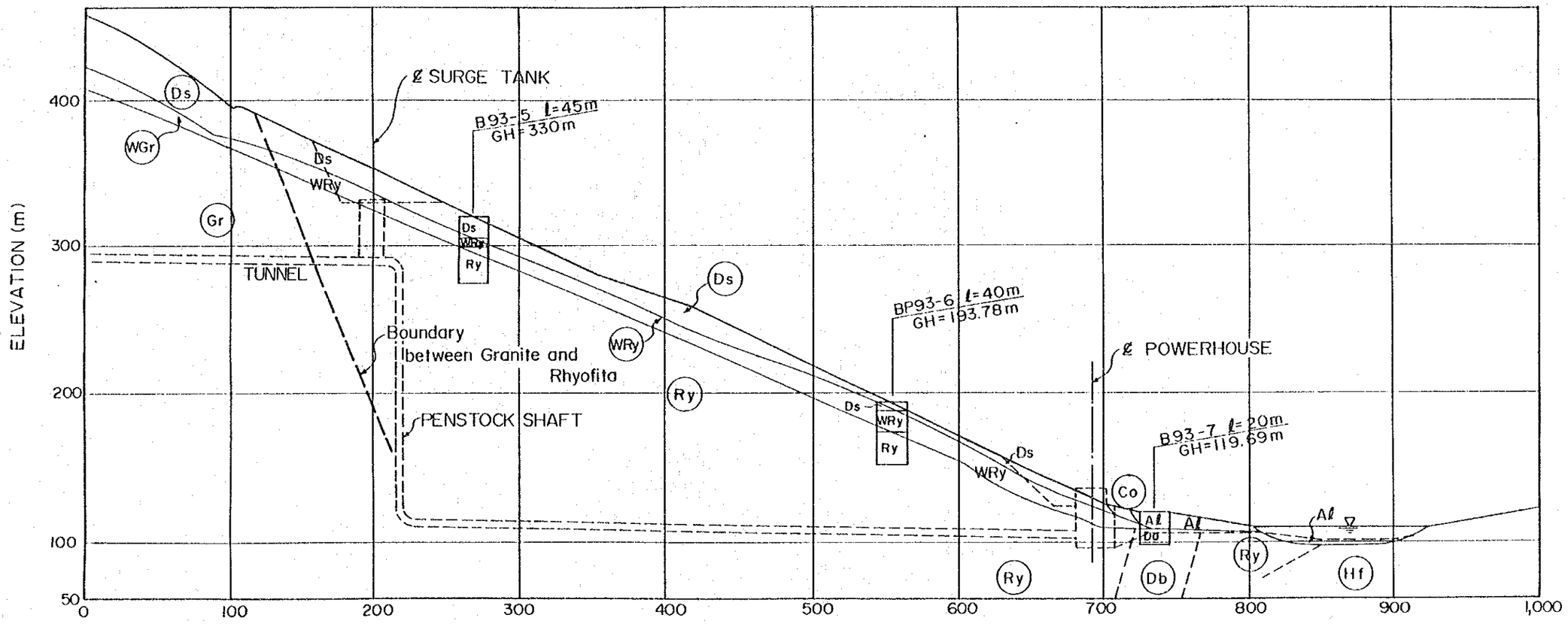
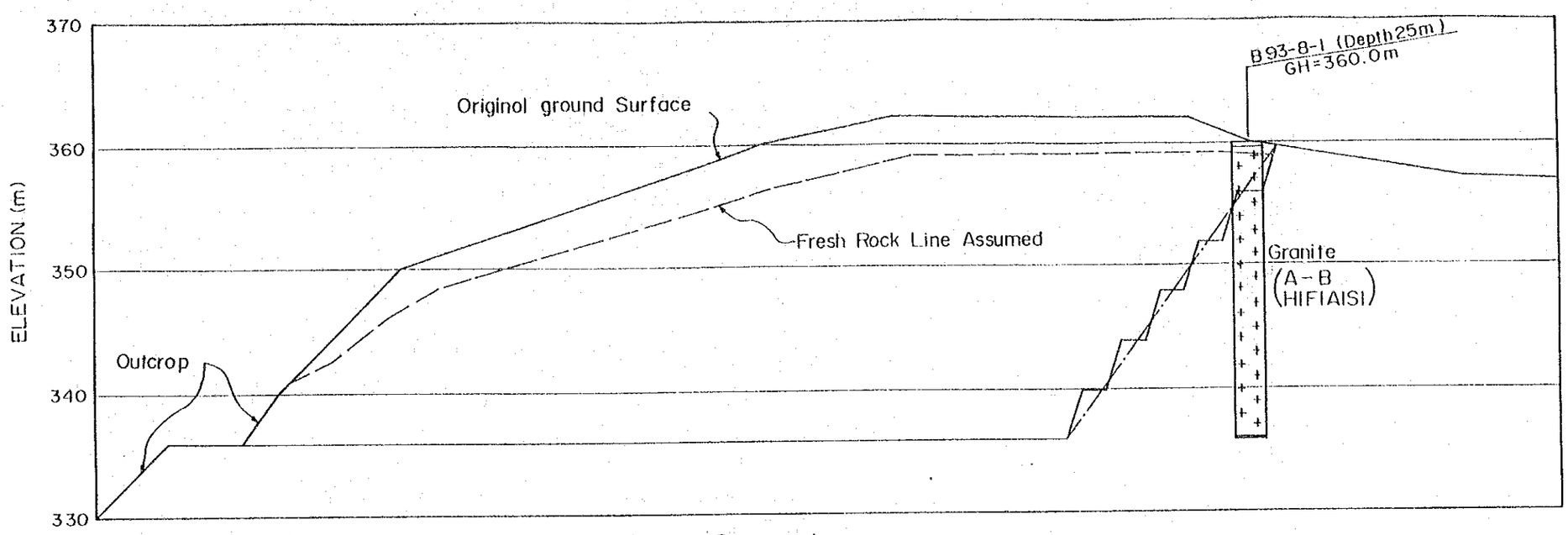
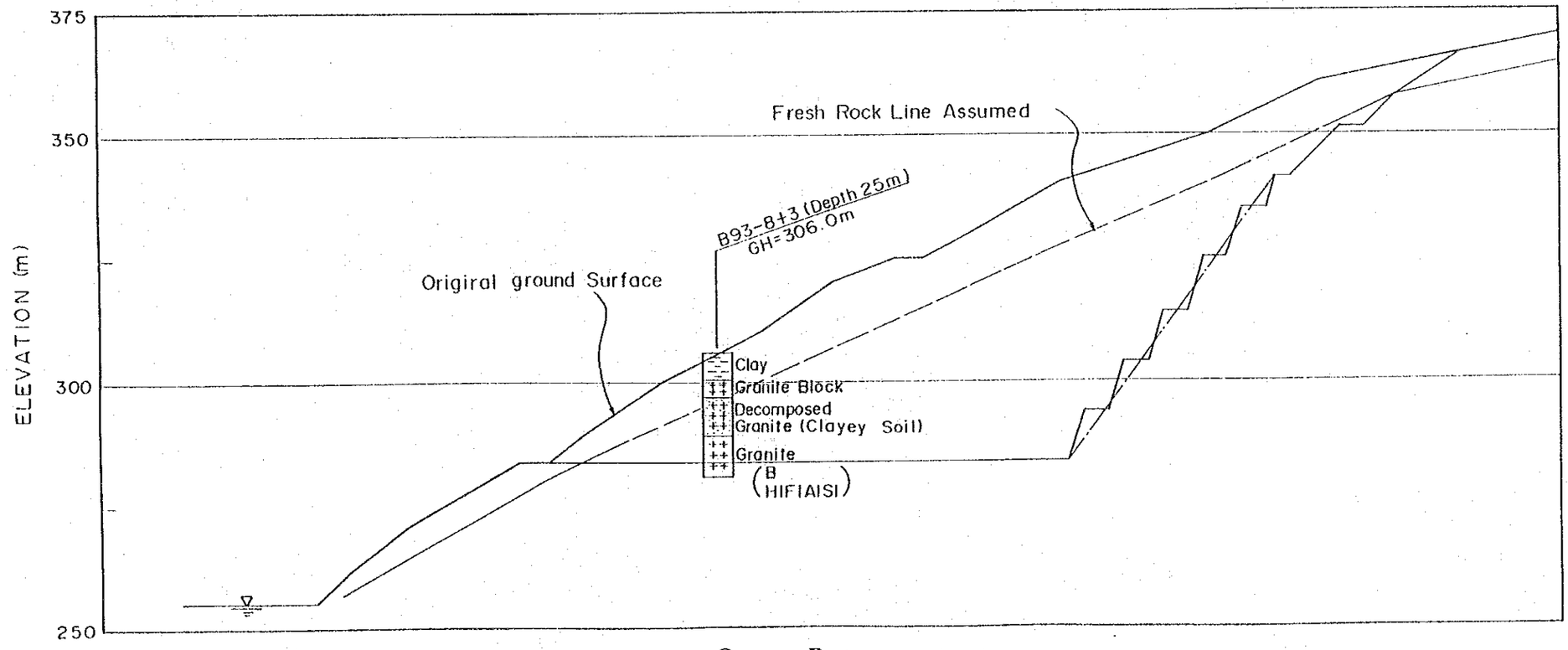
Fig. II.2.6
Geological Section along Penstock to Powerhouse
(Proposed Site)



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. II.2.7 Geological Section along Penstock to Powerhouse (Alternative Site)



Quarry A



Quarry B

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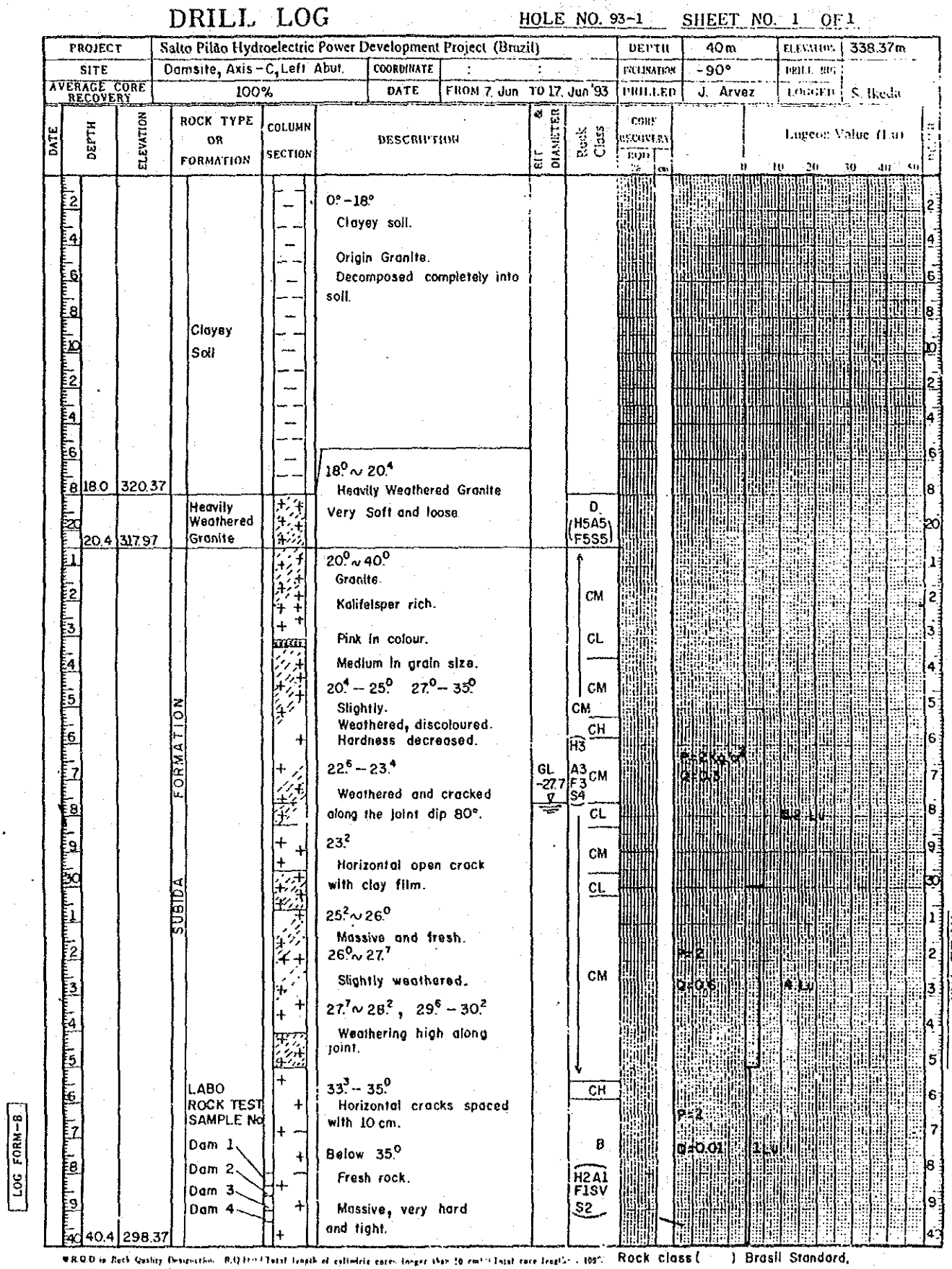
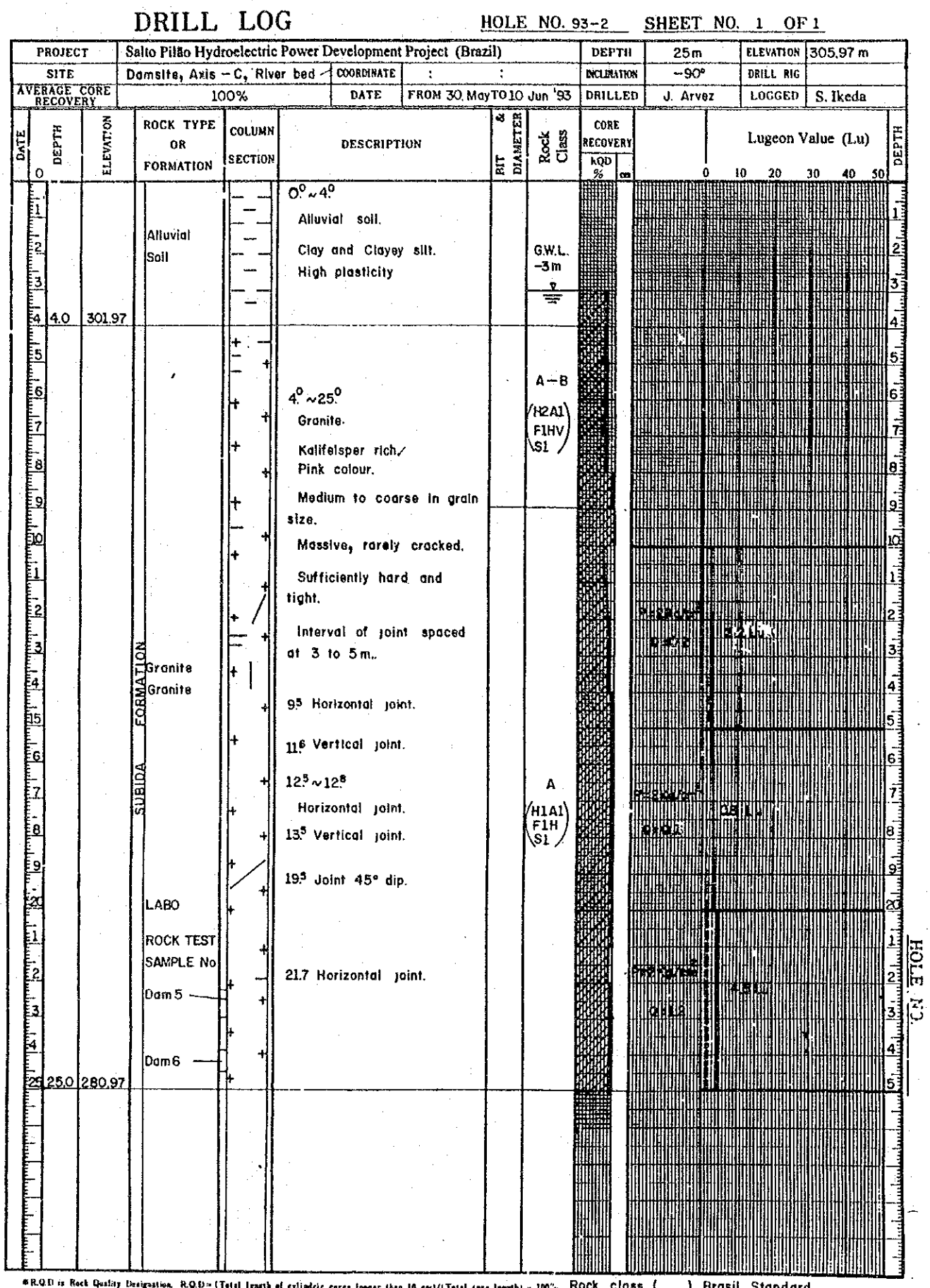
Fig. II.2.8
Sections of Quarries Aand B

Fig. II.3.1 Drill Logs (Present Investigation) 1/12



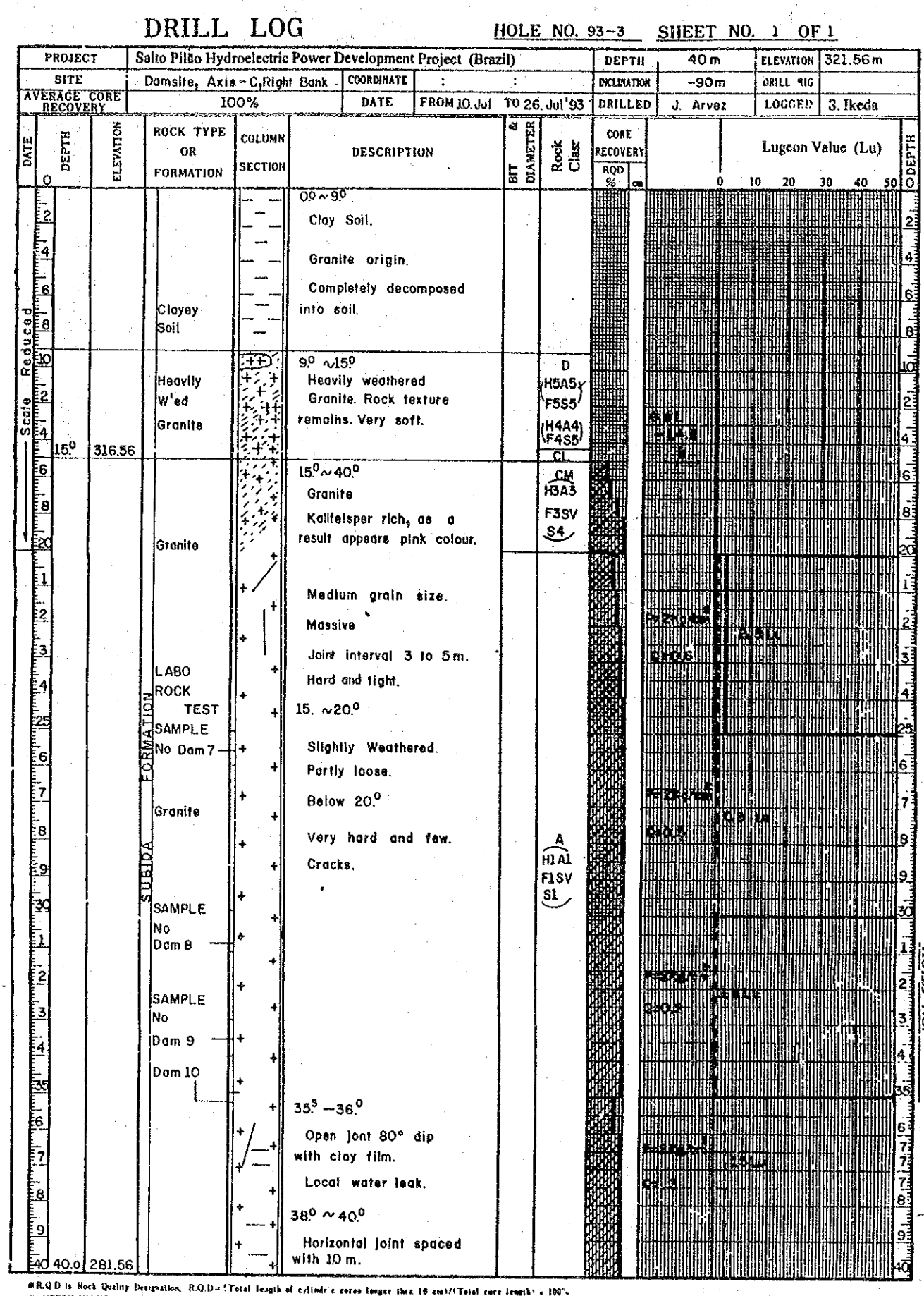
*R.Q.D is Rock Quality Designation. R.Q.D = Total length of collected core longer than 10 cm / Total core length × 100%. Rock class ( ) Brasil Standard.
*LUGEON VALUE is Lu/m/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 2/12



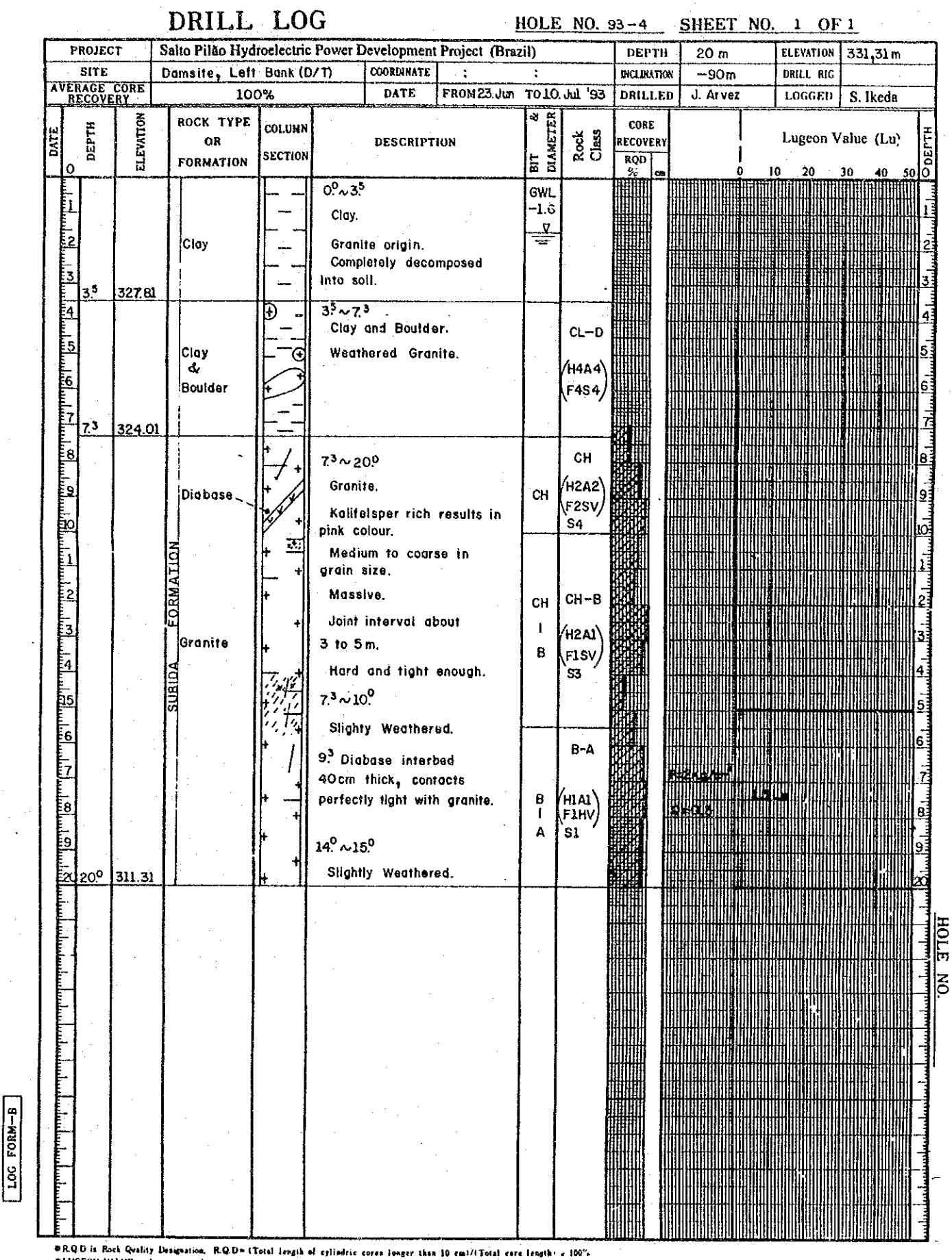
* R.Q.D is Rock Quality Designation. R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%. Rock class ( ) Brasil Standard
* LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
* DEPTH and ELEVATION are in meter
* DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 3/12



*R.Q.D is Rock Quality Designation, R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%.
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 4/12



DRILL LOG

HOLE NO. 93-4 SHEET NO. 1 OF 1

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)			DEPTH	20 m	ELEVATION	331.31 m
SITE	Damsite, Left Bank (D/T)	COORDINATE	: :	INCLINATION	−90m	DRILL RIG	
AVERAGE CORE RECOVERY	100%	DATE	FROM 23.Jun TO 10.Jul '93	DRILLED	J. Arvez	LOGGED	S. Ikeda

DEPTH	ELEVATION	ROCK TYPE OR FORMATION	DESCRIPTION	BIT & DIAMETER	Rock Class
0				GWL −1.6	
3.5	327.81	Clay	0.0~3.5 Clay. Granite origin. Completely decomposed into soil.		
7.3	324.01	Clay & Boulder	3.5~7.3 Clay and Boulder. Weathered Granite.		CL-D (H4A4) (F4S4)
20.0	311.31	SUBIDA FORMATION: Diabase / Granite	7.3~20.0 Granite. Kalifelsper rich results in pink colour. Medium to coarse in grain size. Massive. Joint interval about 3 to 5 m. Hard and tight enough. 7.3~10.0 Slighty Weathered. 9.3 Diabase interbed 40cm thick, contacts perfectly tight with granite. 14.0~15.0 Slightly Weathered.	CH CH CH I B B I A	CH (H2A2) (F2SV) S4 CH-B (H2A1) (F1SV) S3 B-A (H1A1) (F1HV) S1

CORE RECOVERY / RQD %

Lugeon Value (Lu) 0 10 20 30 40 50

HOLE NO.

LOG FORM-B

*R.Q.D is Rock Quality Designation. R.Q.D= (Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%.
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 5/12

DRILL LOG

HOLE NO. 93-5 SHEET NO. 1 OF 2 (0 to 30m)

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)			DEPTH	45m	ELEVATION	320.0 m
SITE	Surge Tank, (alternative)	COORDINATE	: :	INCLINATION	-90m	DRILL RIG	
AVERAGE CORE RECOVERY	100 %	DATE	FROM 10.Jul TO 27.Jul '93	DRILLED	J. Arvez	LOGGED	S. Ikeda

DEPTH	ELEVATION	ROCK TYPE OR FORMATION	DESCRIPTION	BIT & DIAMETER	Rock Class	CORE RECOVERY / RQD %	Lugeon Value (Lu) 0 10 20 30 40 50
0			0.0 ~ 20.0 Clayey Soil. Rhyolite origin. Completely decomposed into soil. Rock texture can be seen locally. Weathered rocks like dice are found in some places.				
		Clayey Soil					
16.5	303.5						
		Weathered Rhyolite	16.5 ~ 20.0 Weathered Rhyolite Heavily weathered cracked into dice.		D (H5A4 F4HV S5)		
20.0	300.0		20.0 ~ 30.0 Rhyolite Gray colour appears	GWL 22.4	CM (H2A3 F3S4)		
		Rhyolite	Rhyodacite. Fine and compact.		CH (H2A2 F2S3)		
		CAMPO ALEGRE FORMATION SAMPLE No Tun1-7 Tun1-8 Tun1-9	Hard rock. Joints develop at interval of 10 to 50 cm. 20.0 ~ 24.0 Vertical joint at interval of 50 cm.		B H1A1 (F1SV S1)		
30			Conitue to SHT No 2				

HOLE NO.

LOG FORM-B

*R.Q.D is Rock Quality Designation. R.Q.D= (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%.
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 6/12

DRILL LOG

HOLE NO. 93-5 SHEET NO. 2 OF 2 (30-45m)

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)			DEPTH	45m	ELEVATION	320.0 m
SITE	Surge Tank. (alternative)	COORDINATE	: :	INCLINATION	-90°	DRILL RIG	
AVERAGE CORE RECOVERY	100%	DATE	FROM 10.Jul TO 27.Jul '93	DRILLED	J. Arvez	LOGGED	S. Ikeda

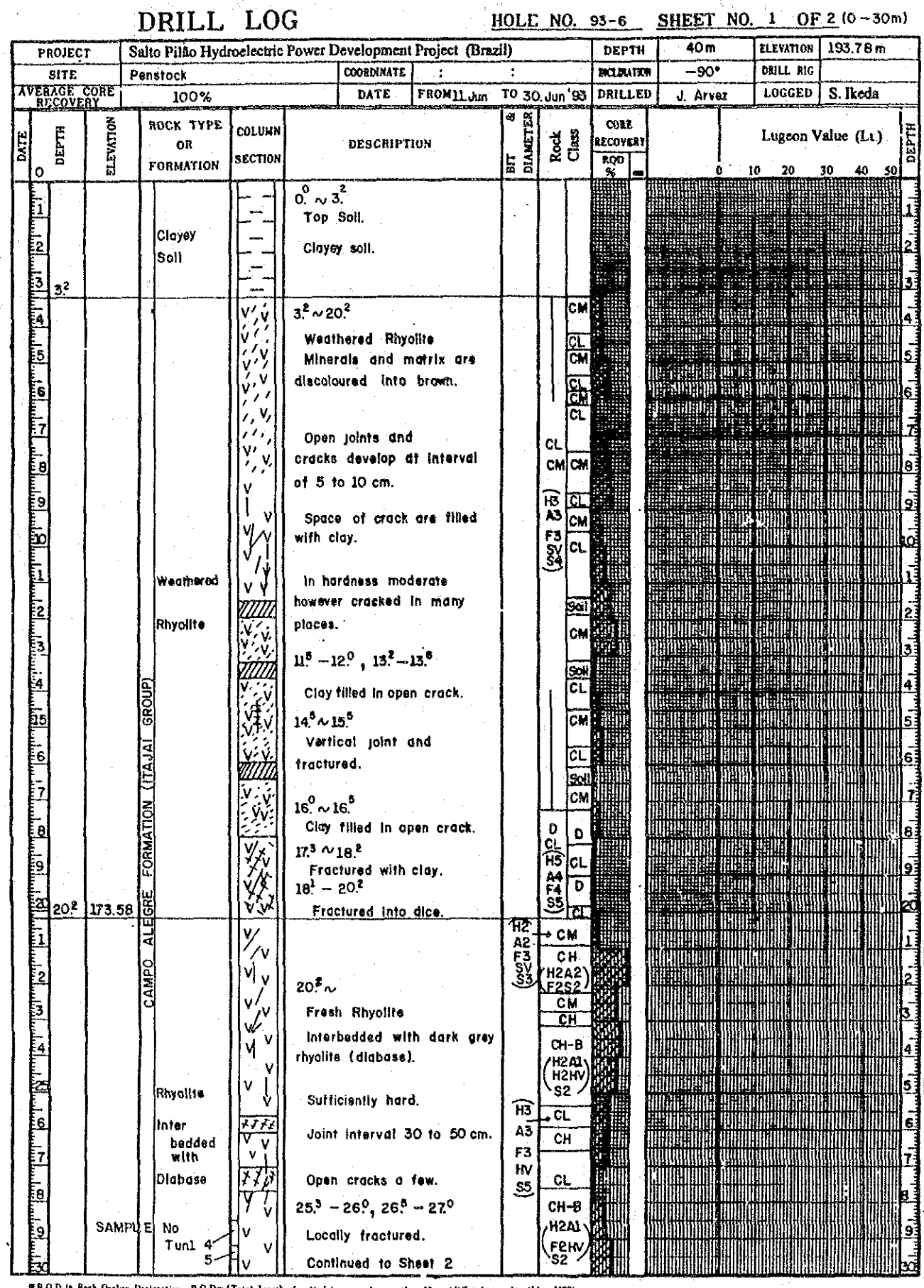
DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	BIT & DIAMETER	Rock Class	CORE RECOVERY RQD %	Lugeon Value (Lu) 0 10 20 30 40 50	DEPTH
	30									
			SAMPLE No Tun1 10		Continue from SHT No 1		CM			
					$30^0 \sim 45^0$		(H2A3 F2SV) S4			
					Rhyolite.					
					Hard rock, joint develop in some places.		CH-B (H2A1 F2SV) S2			
					$30^0 \sim 32^0$		CM			
					Diagonal and horizontal joint spaced with 20 cm, and cracked.		CH-B (H2A1 F2SV) S2			
			Rhyolite		34^3 Joint 60° dip and cracked.		CL			
					37^0 Joint 70° dip cracked into dice.	H2 A2 F2 SV S2	CM CH CM			
					$37^3 \sim 40^5$ Vertical joint, 10 to 20 cm interval.					
					Cracked match box size.					
					Below 40^3		B			
					Joint a few. Good rock condition.		(H1A1 F1SV) S1			
	45	45° 274.0	CAMPO ALEGRE FORMATION		Hole Bottom					45

HOLE NO.

LOG FORM-B

*R.Q.D is Rock Quality Designation. R.Q.D= (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 7/12



*R.Q.D is Rock Quality Designation, R.Q.D= (Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter