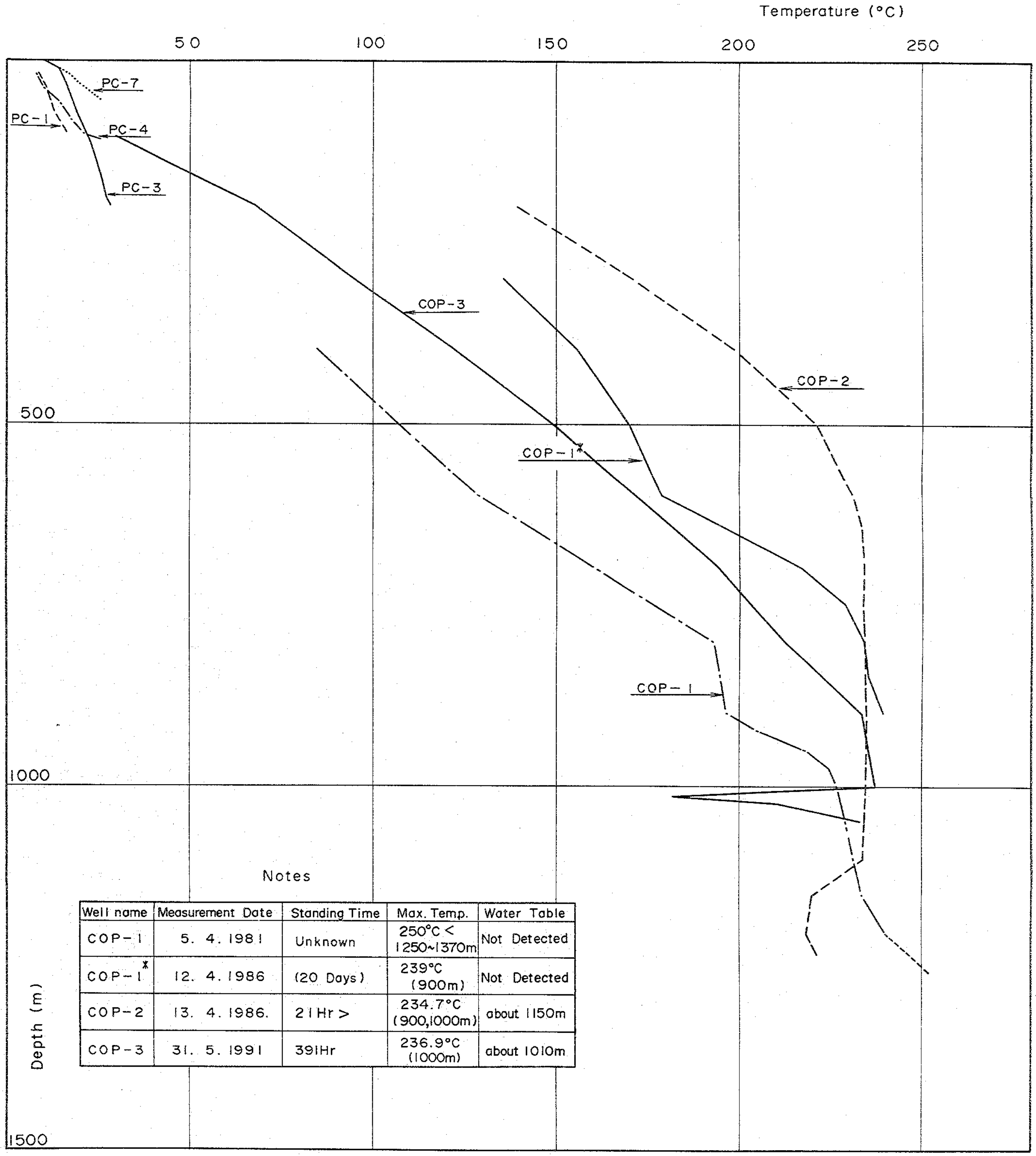


Notes

Well name	Measurement Date	Standing Time	Max. Temp.	Water Table
COP-1	5. 4. 1981	Unknown	250°C < 1250~1370m	Not Detected
COP-1*	12. 4. 1986	(20 Days)	239°C (900m)	Not Detected
COP-2	13. 4. 1986.	21Hr >	234.7°C (900,1000m)	about 1150m
COP-3	31. 5. 1991	391Hr	236.9°C (1000m)	about 1010m

Fig. 5-26 Temperature vs Depth Diagram of Exploratory Wells

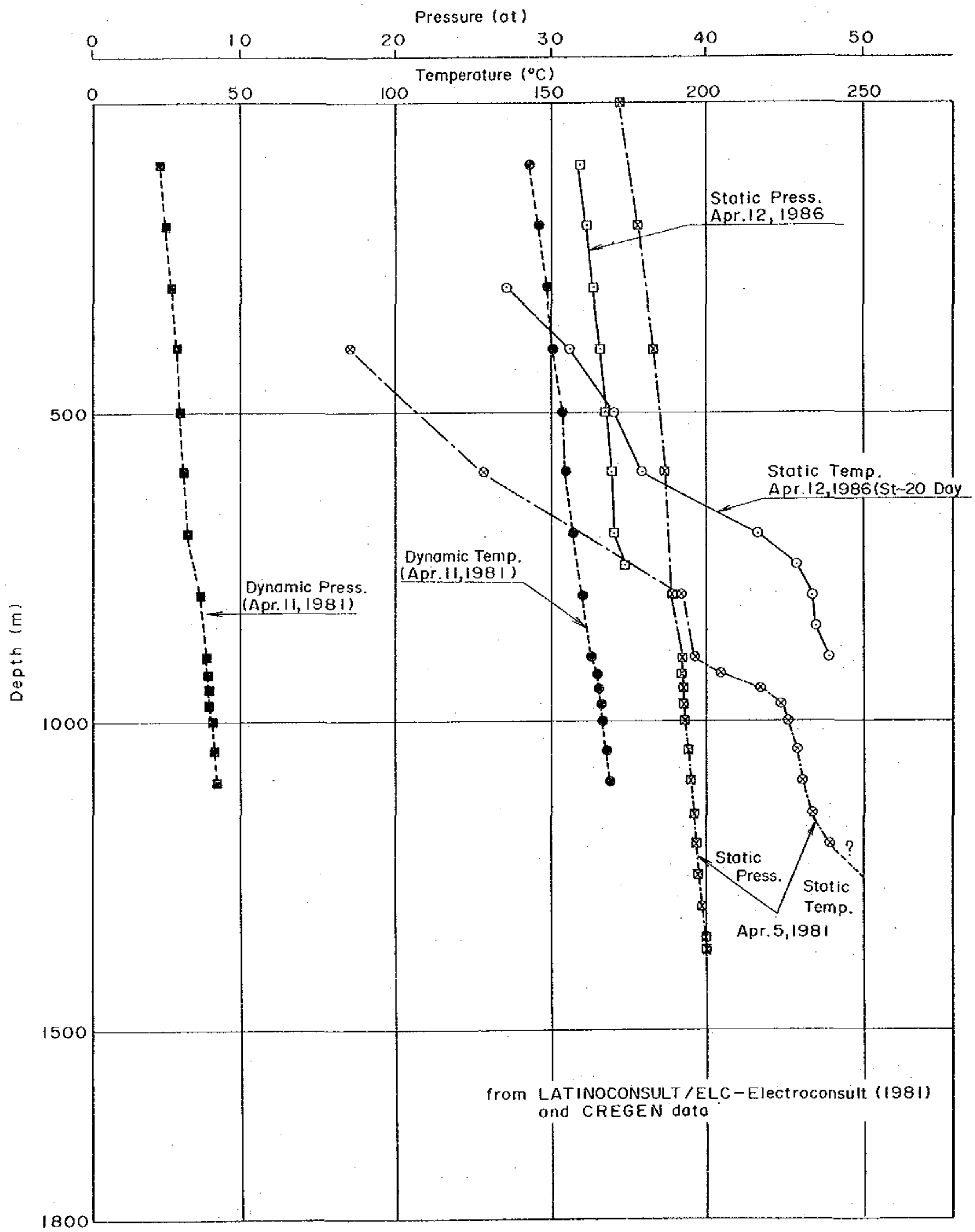


Fig. 5-27 Pressure and Temperature Profiles for COP-1

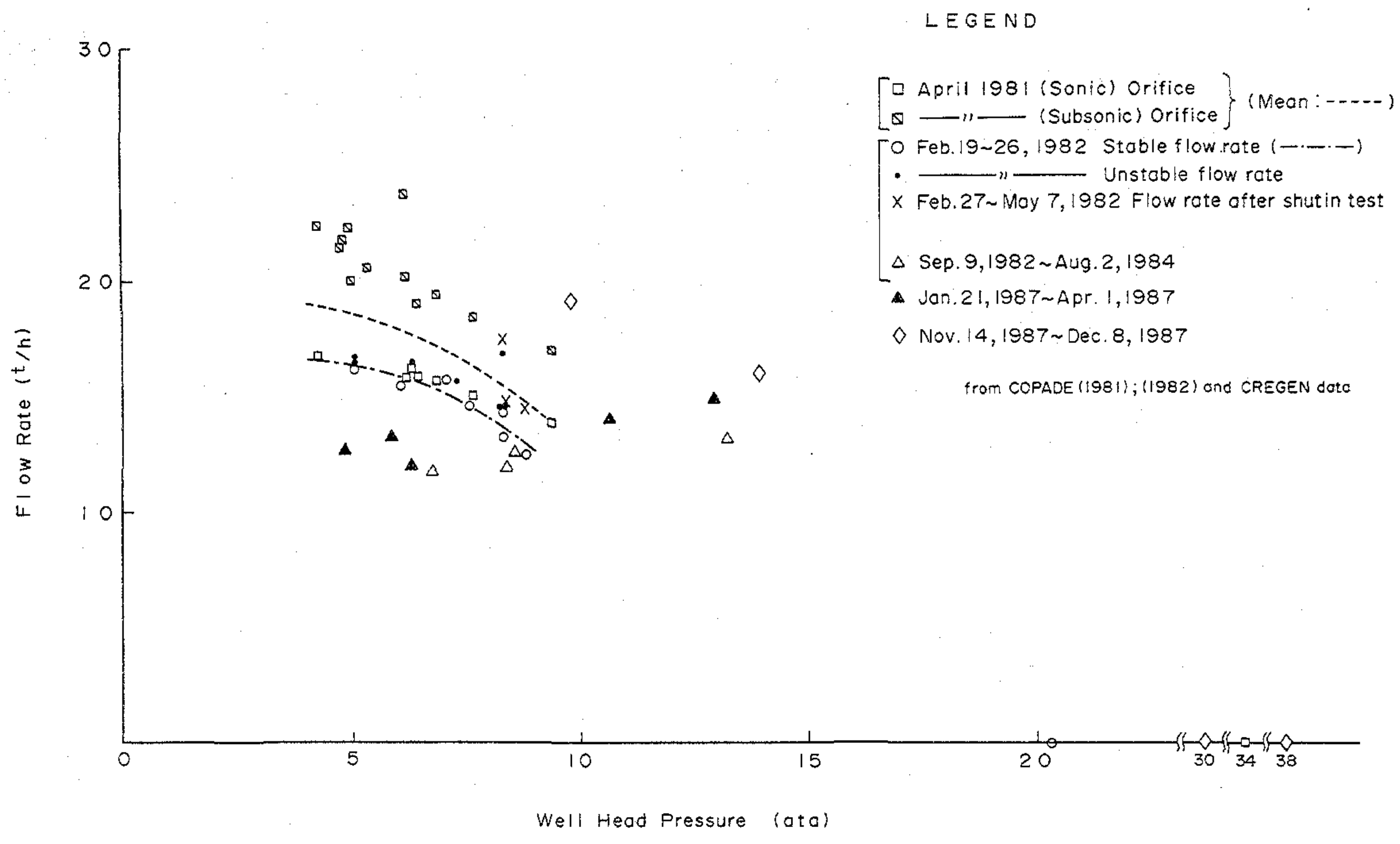


Fig. 5-28 COP-1 Well Characteristic Curve

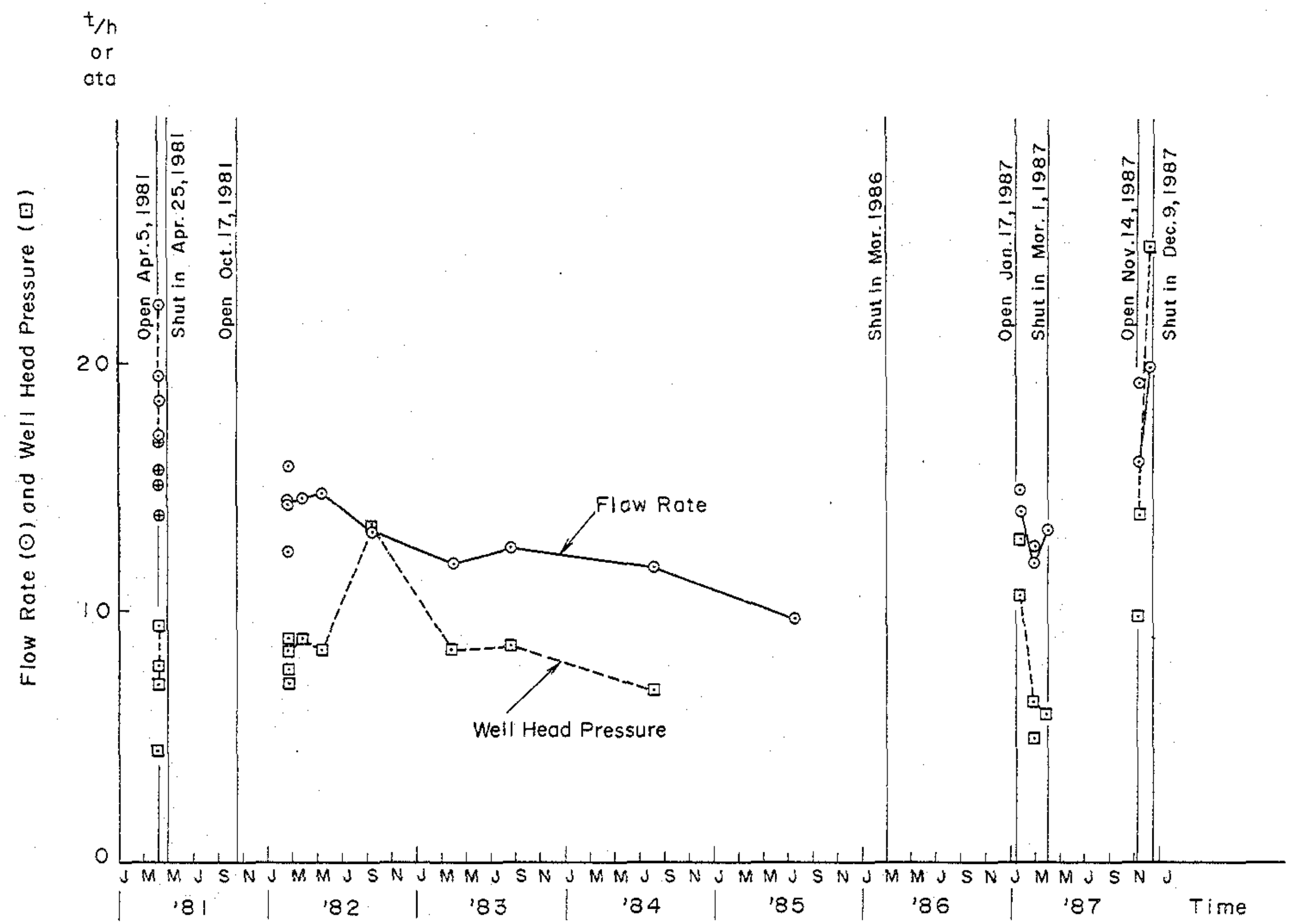


Fig. 5-29 COP-1 Production History

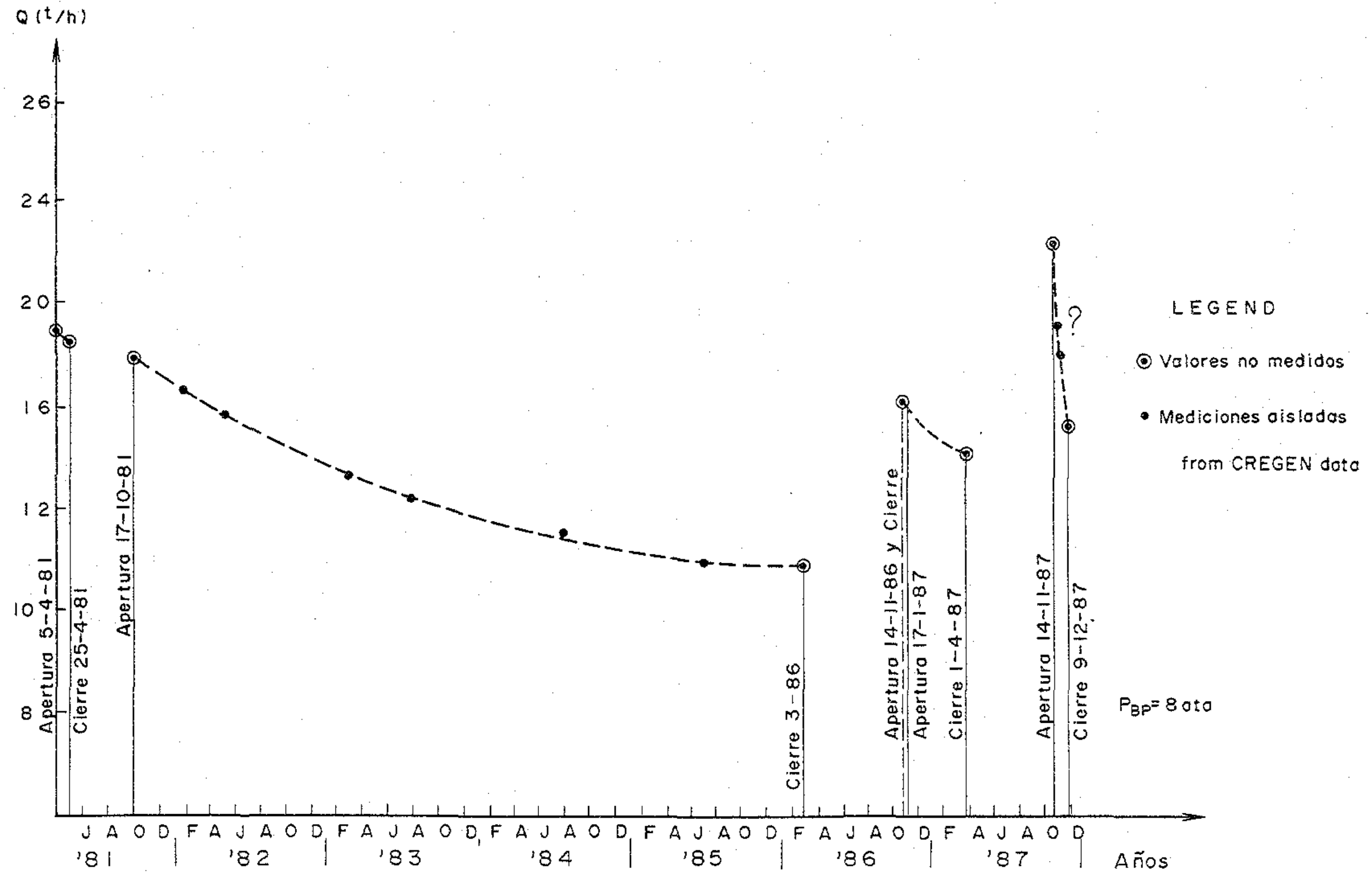


Fig. 5-30 COP-1 Schematic Production Curve

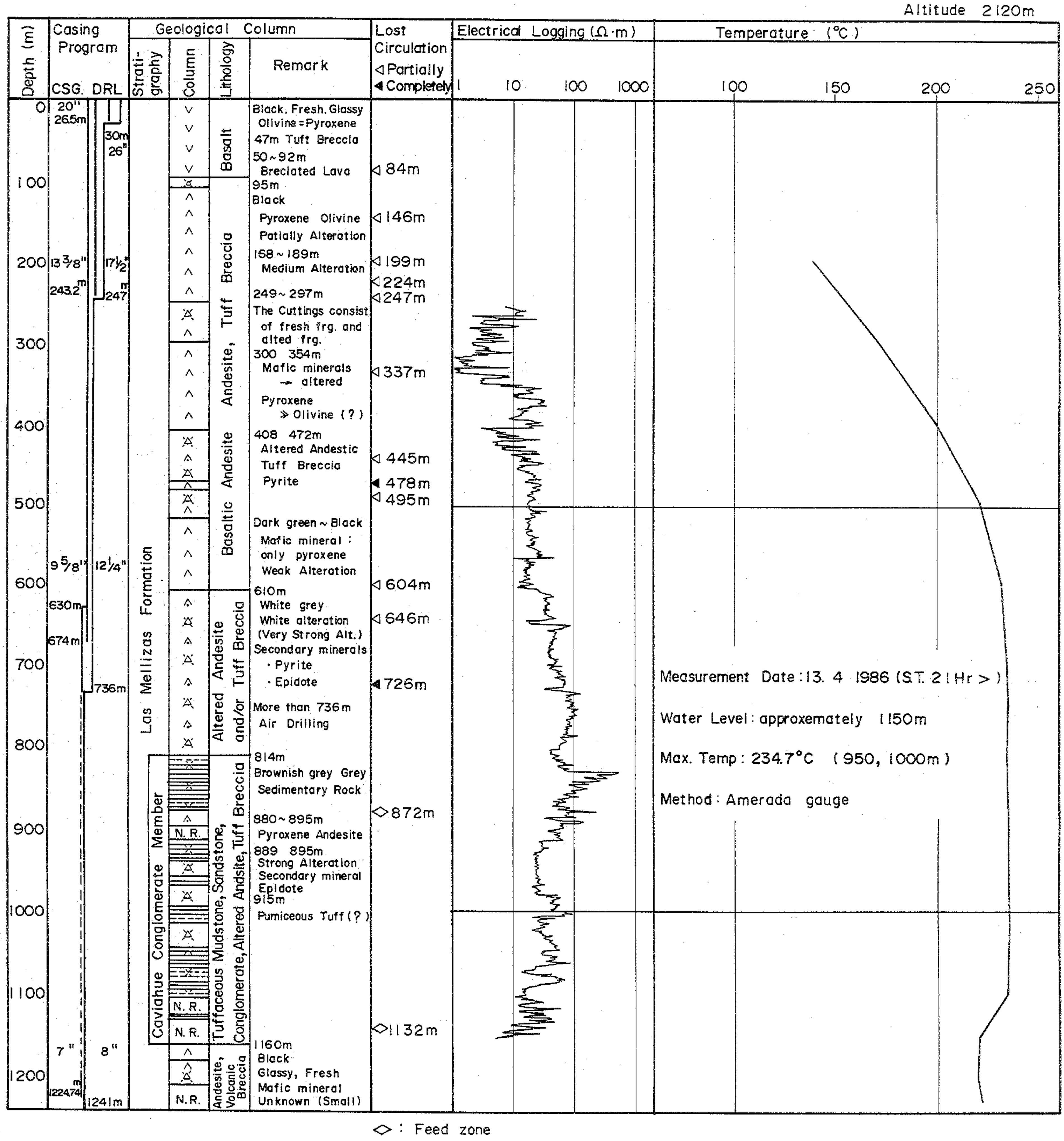


Fig. 5-31 Integrated Columnar Section of COP-2

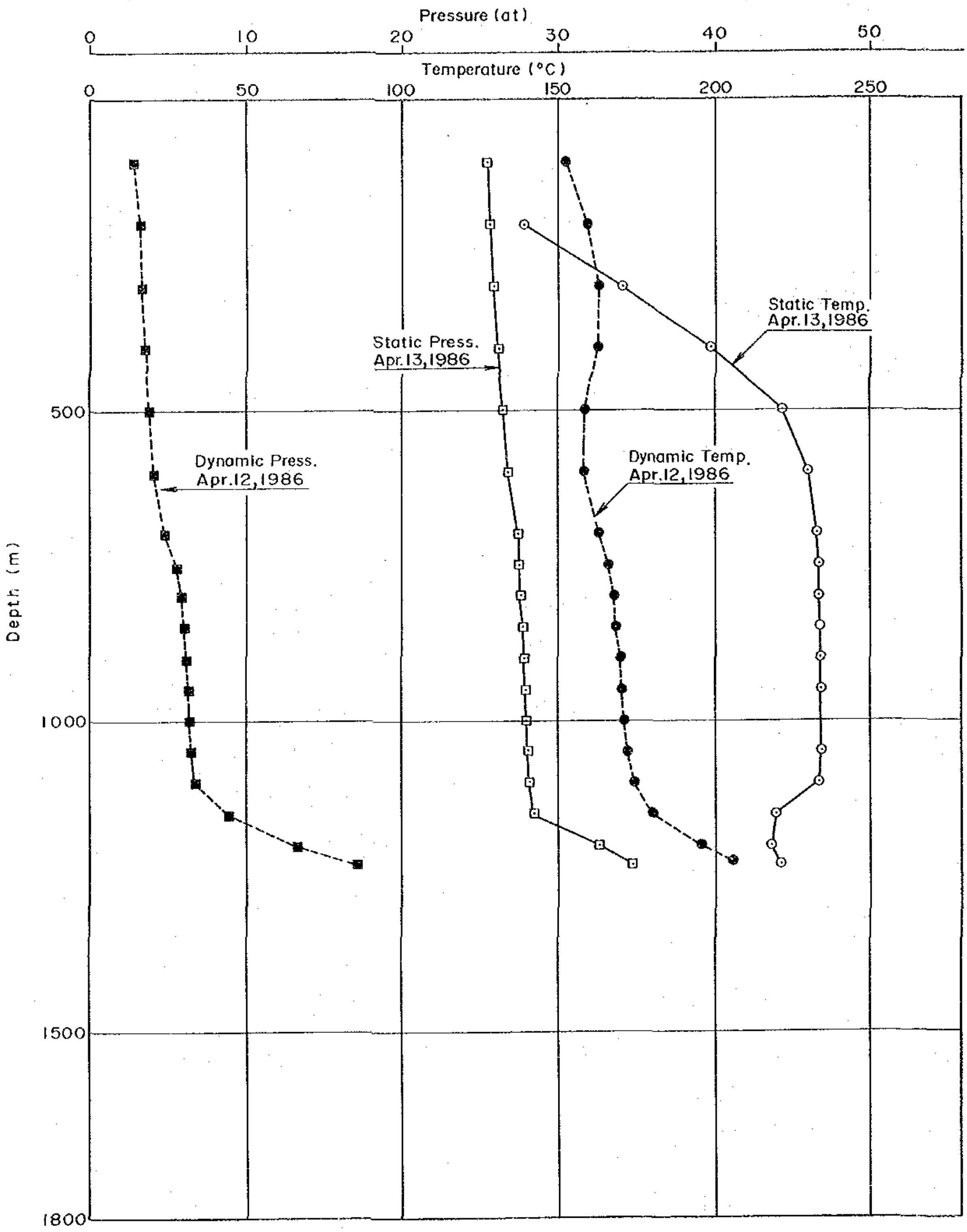


Fig. 5-32 Pressure and Temperature Profiles for COP-2

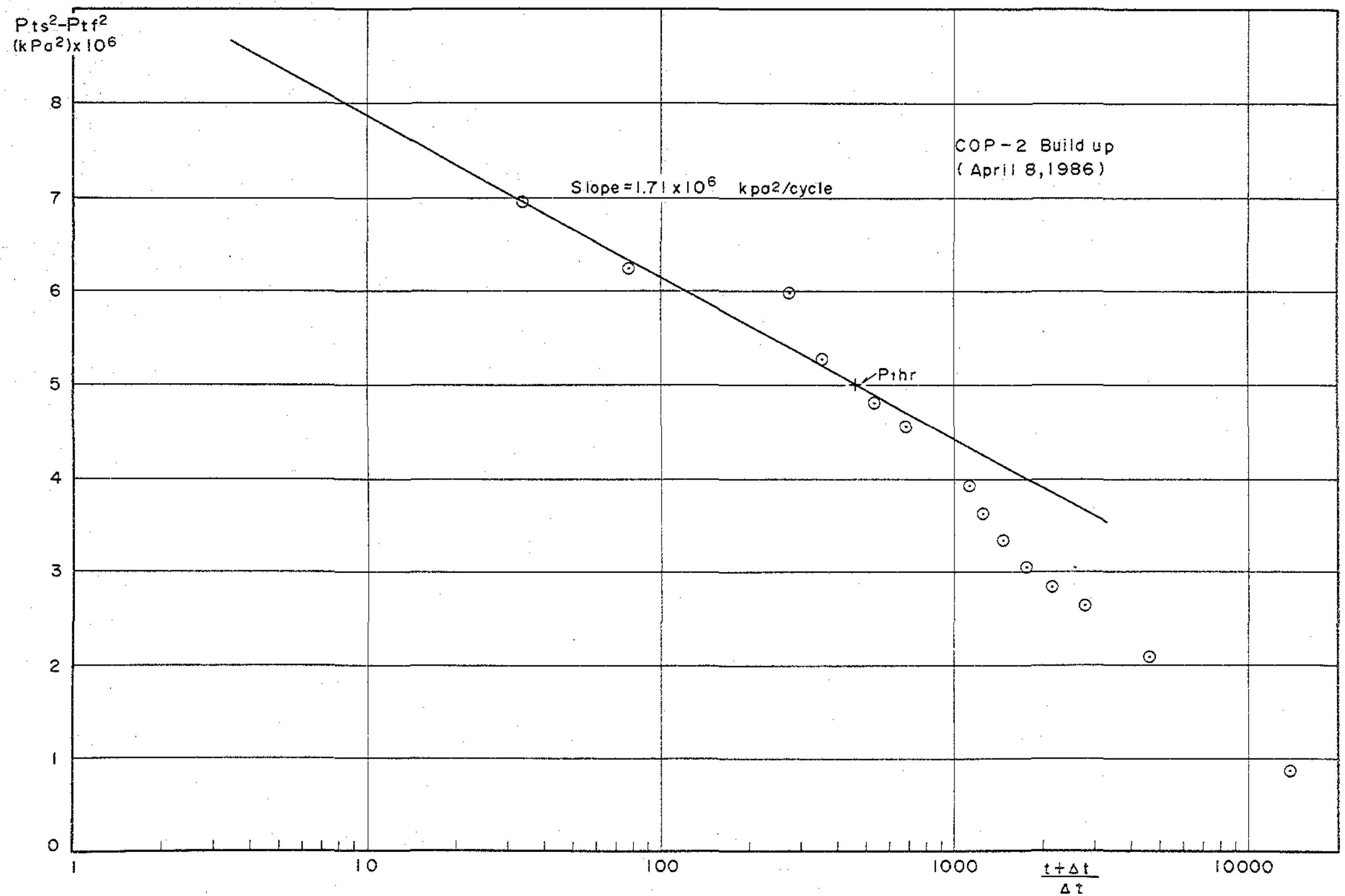


Fig. 5-33 Horner Buildup Graph for COP-2

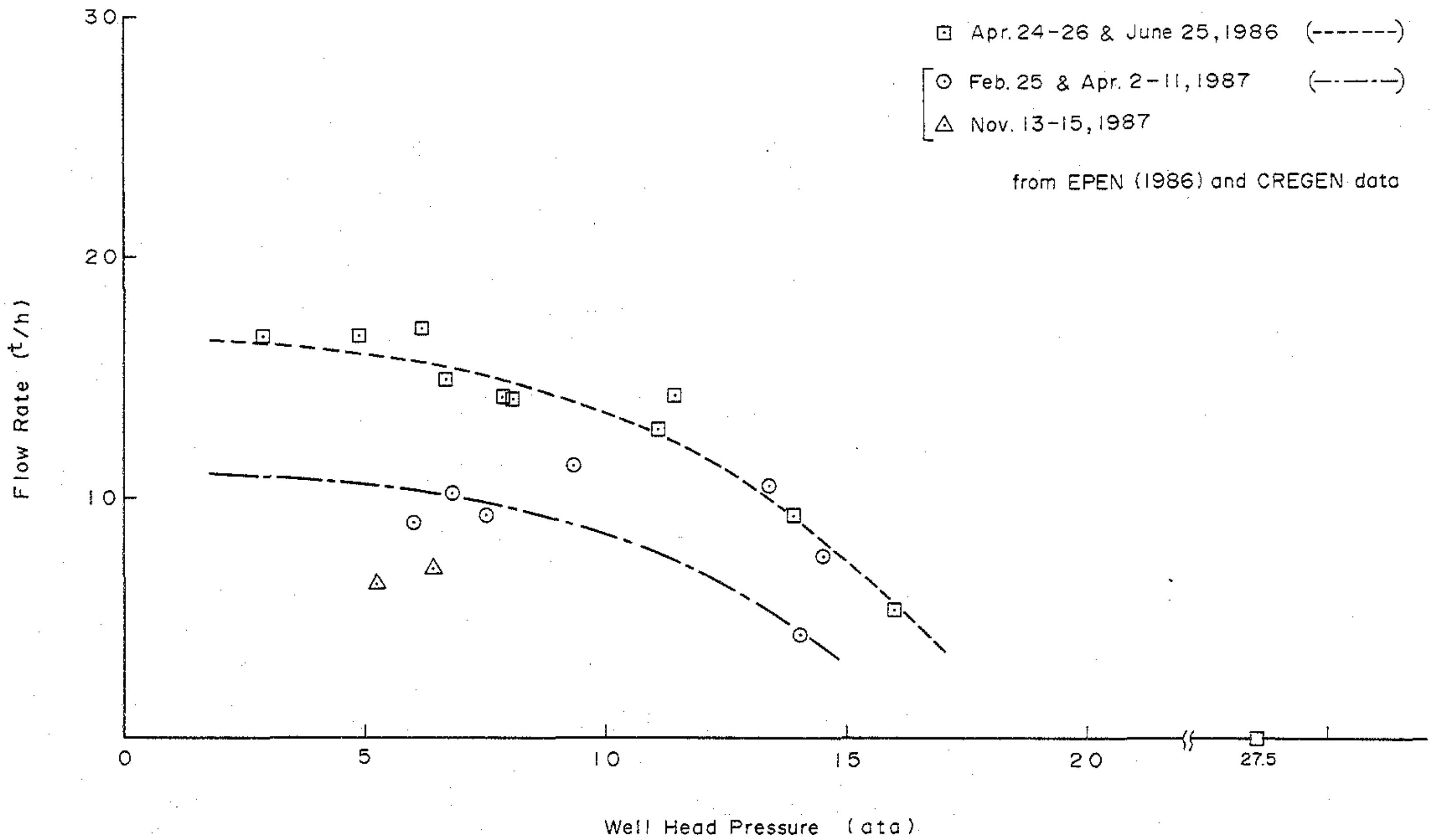


Fig. 5-34 COP-2 Well Characteristic Curve

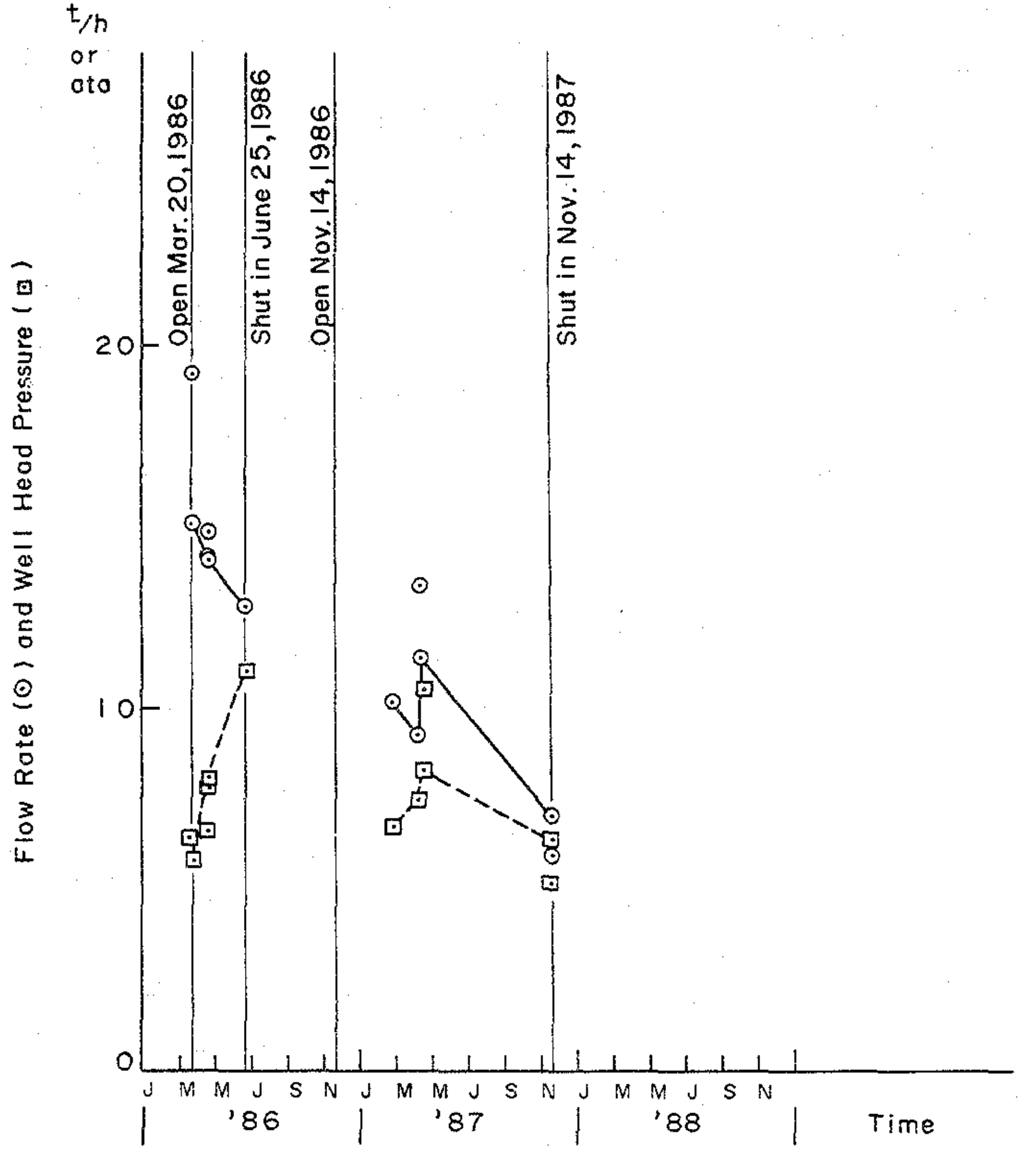


Fig. 5-35 COP-2 Production History

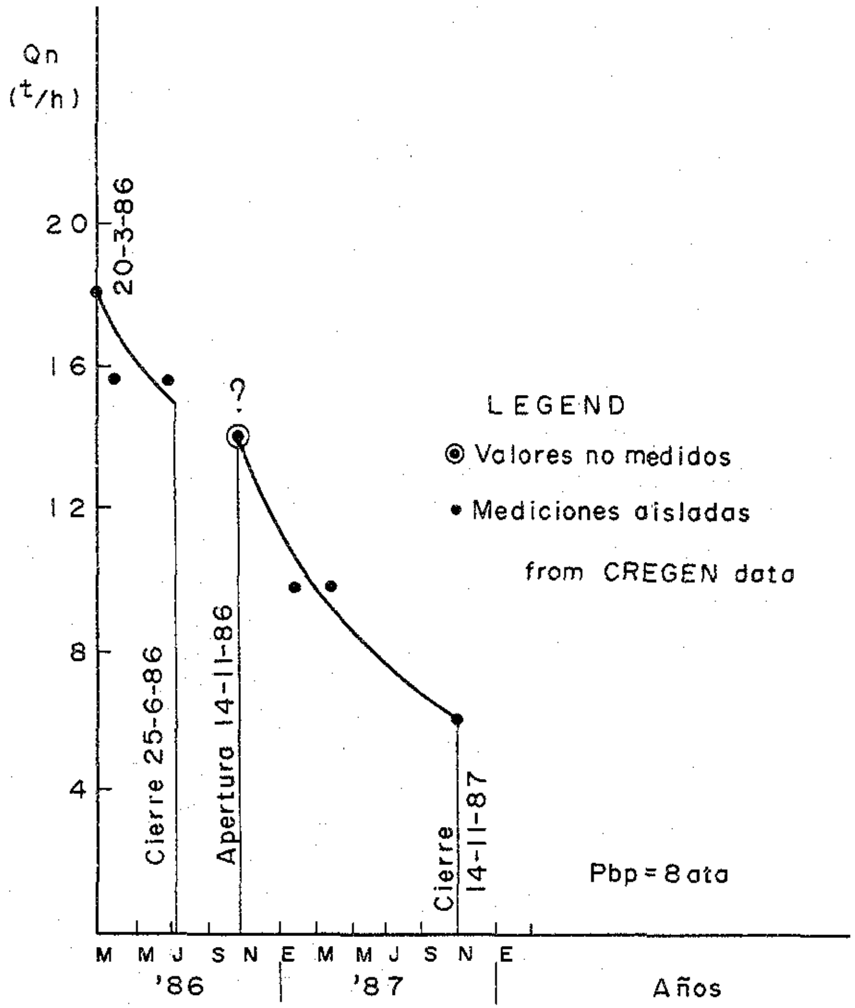


Fig. 5-36 COP-2 Schematic Production Curve

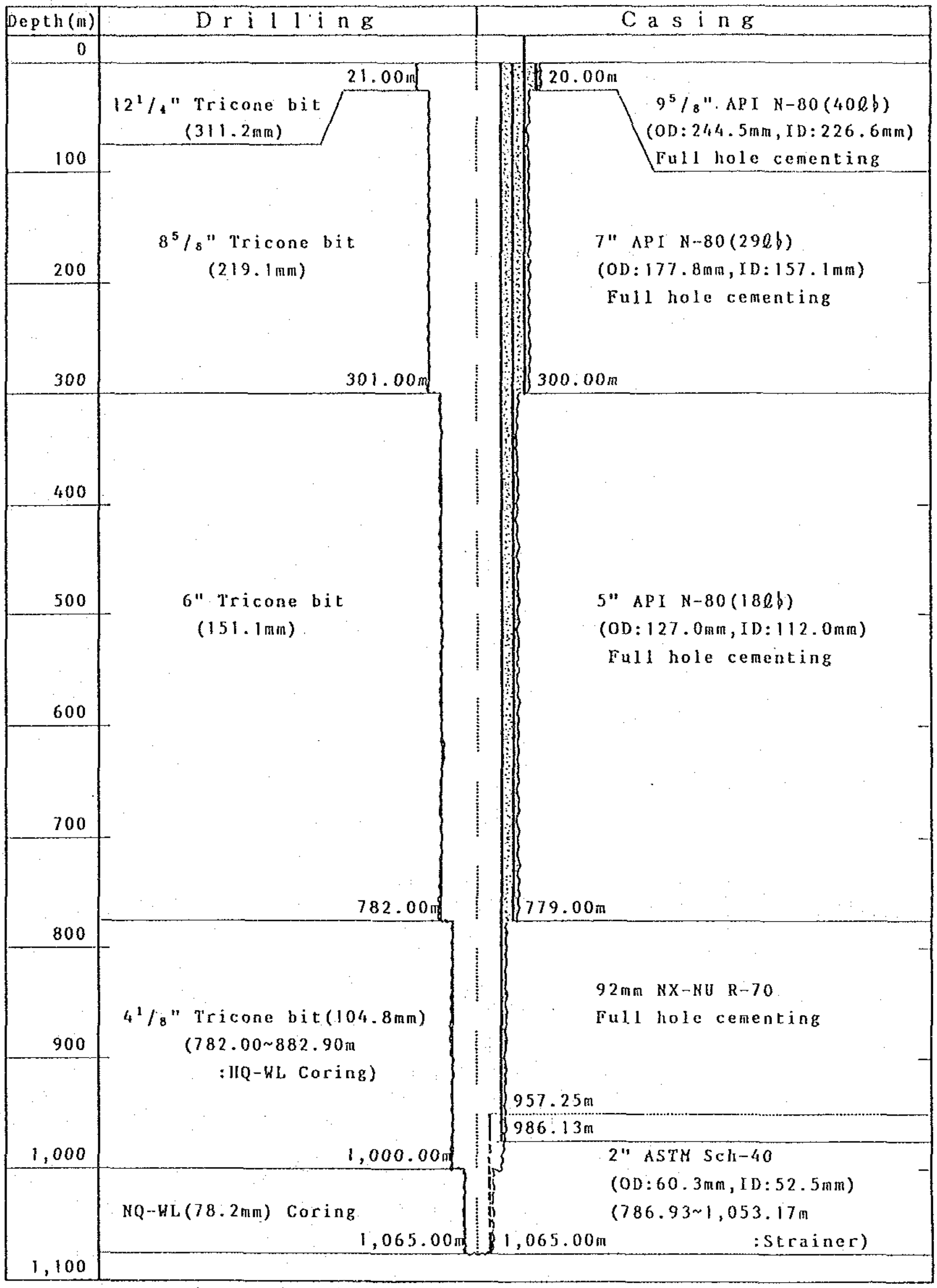
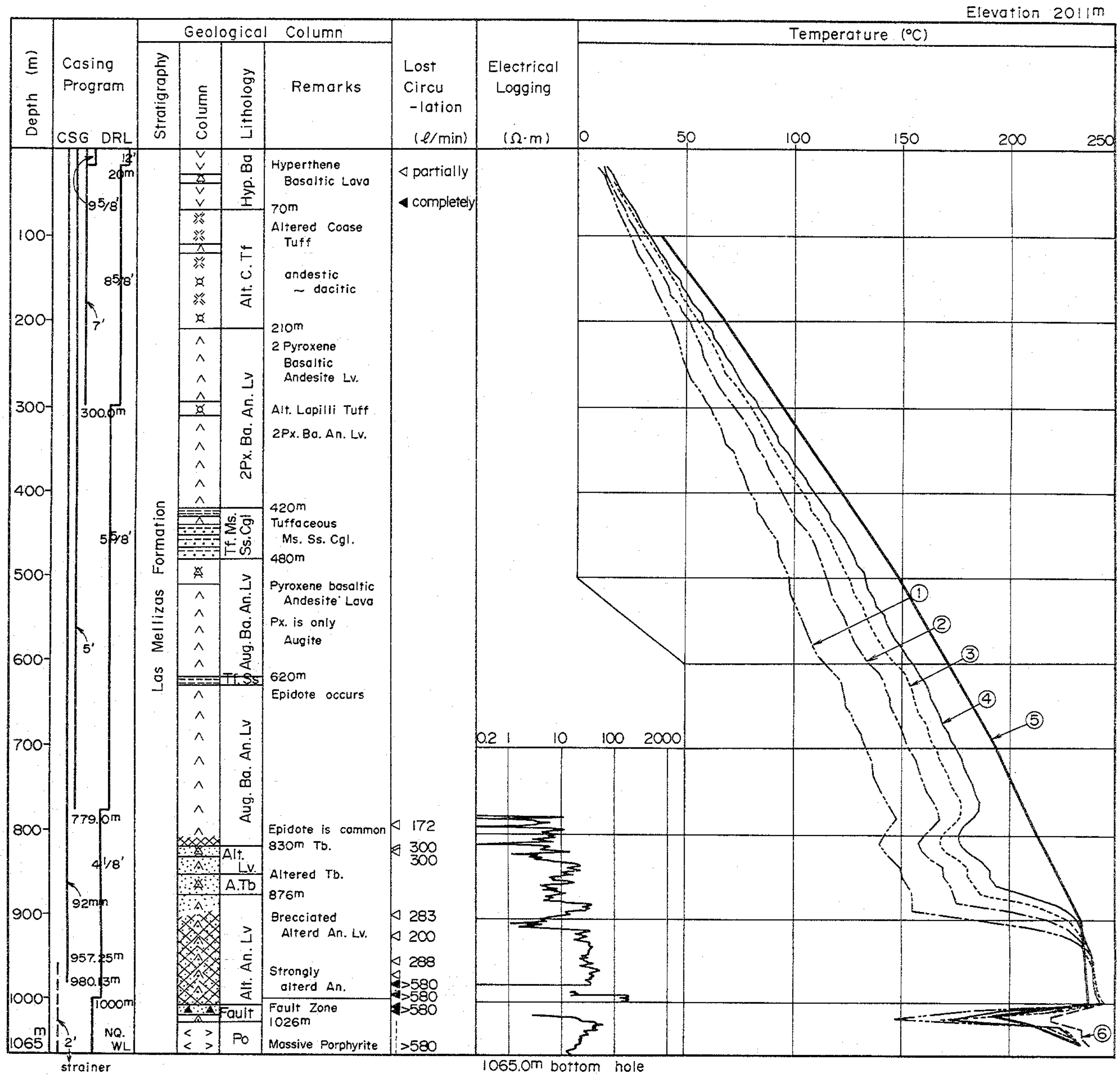


Fig. 5-37 Casing Program of COP-3



① Measurement Date : May 15, 1991 (ST. 8hr)
Water Level : 900m
Max Temp : 240°C (1.002m)

② Measurement Date : May 16, 1991 (ST. 24hr)
Water Level : 887m
Max Temp : 241°C (1.002m)

③ Measurement Date : May 17, 1991 (ST. 48hr)
Water Level : 875m
Max Temp : 242°C (1.002m)

④ Measurement Date : May 9, 1991 (ST. 96hr)
Water Level : 870m
Max Temp : 242°C (1.002m)

⑤ Measurement Date : May 31, 1991 (ST. 390hr50m)
Water Level : about 1.010m
Max Temp : 236.9°C (1.000m)

⑥ Equilibrium Temperature Calculated by ①, ②, and ③ (1.000m ~ 1.065m)

Fig. 5-38 Columnar Section of COP-3

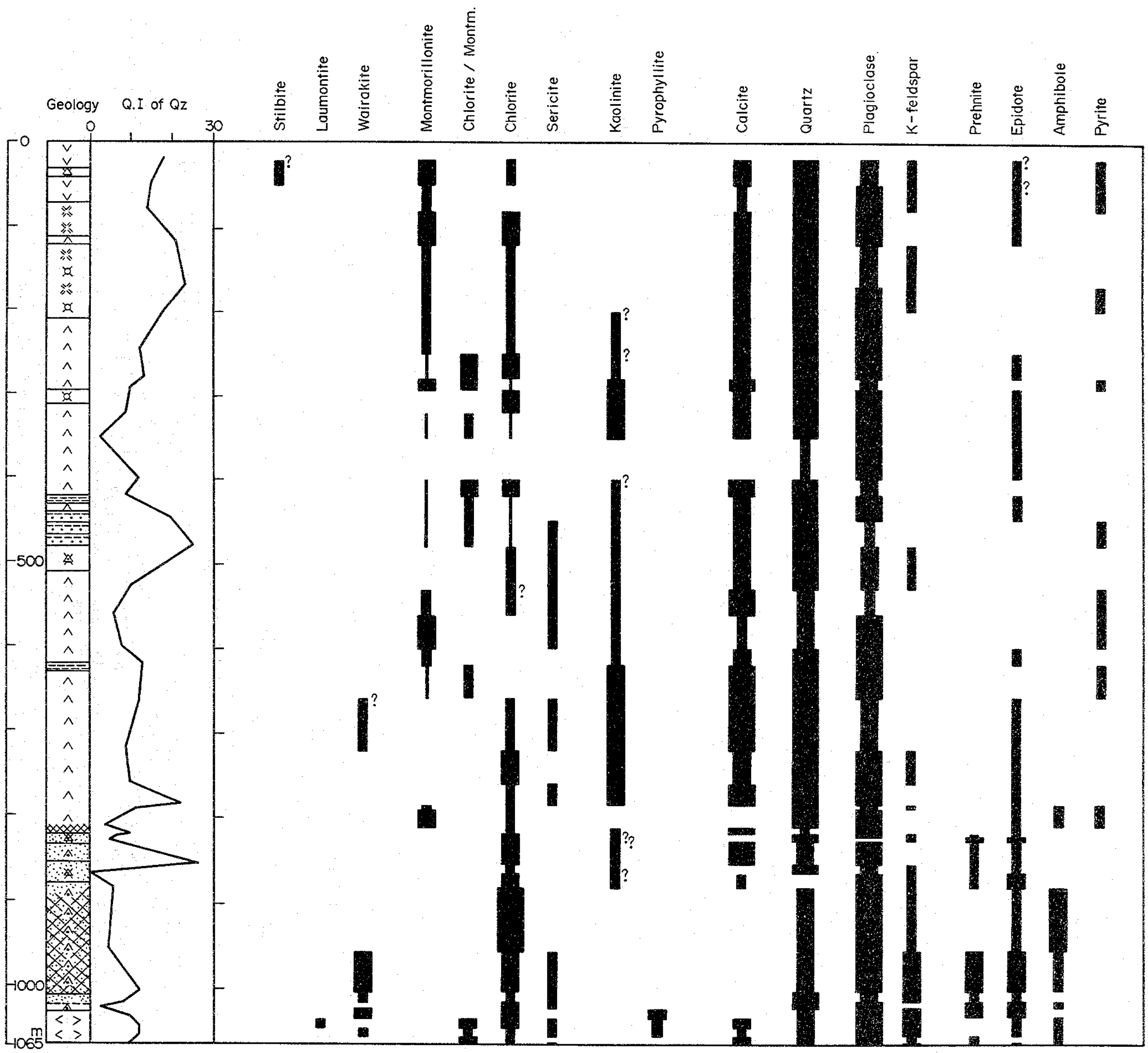


Fig. 5-39 Distribution of Alteration Minerals from COP-3, Detected by X-ray Diffractmeter

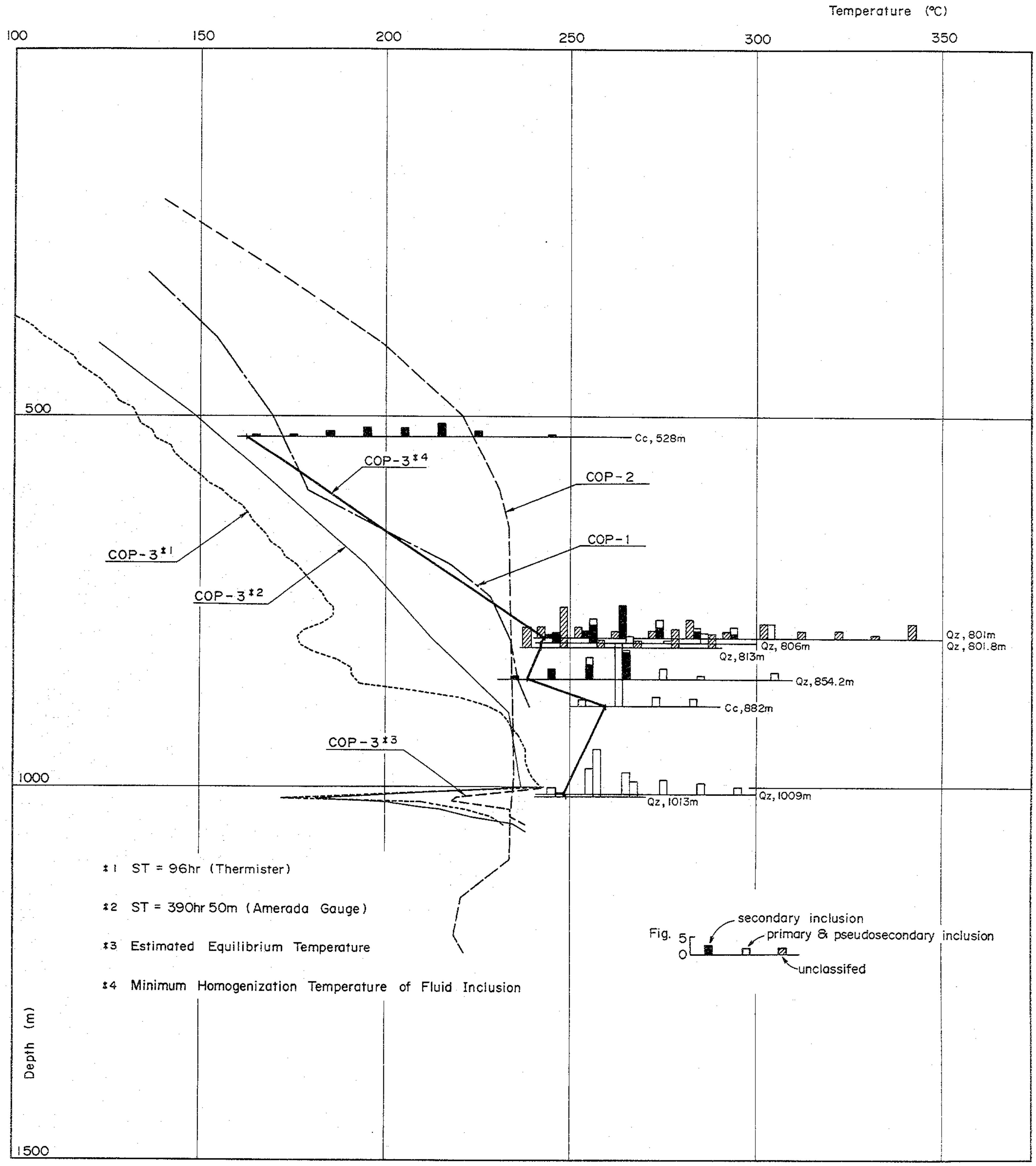


Fig. 5-40 Homogenization Temperature of Fluid Inclusion of COP-3

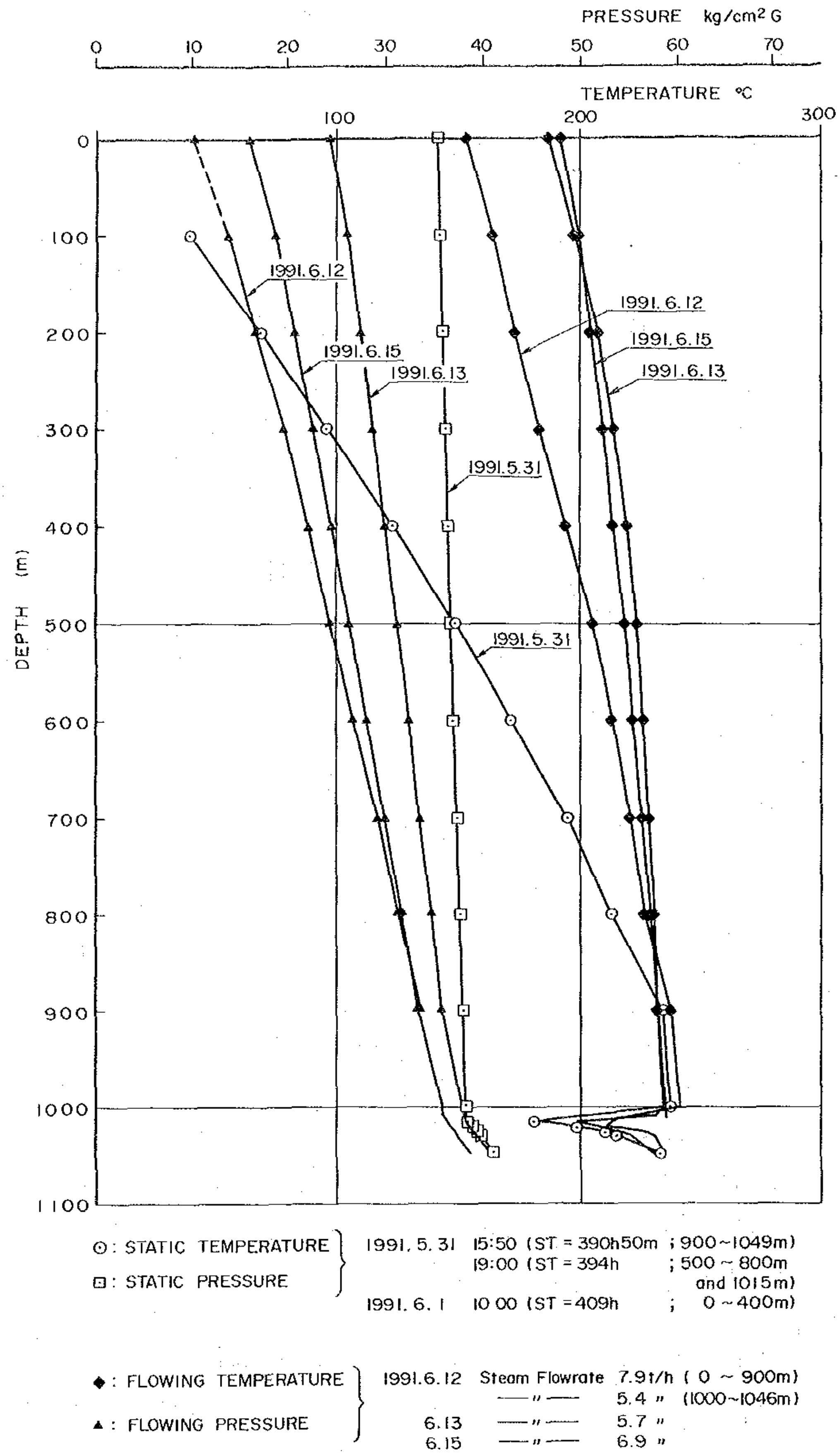


Fig. 5-41 Pressure and Temperature Profiles for COP-3

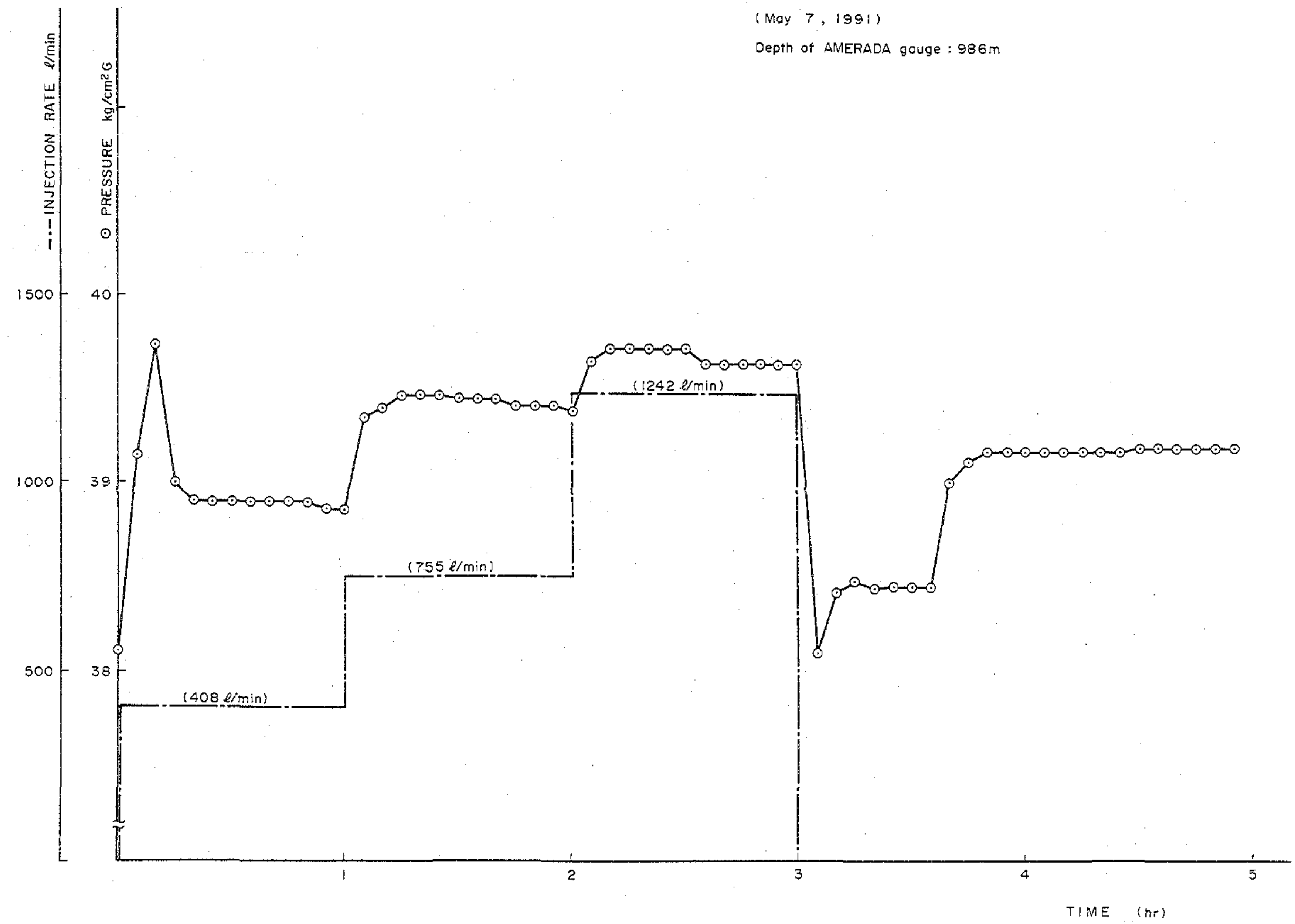


Fig. 5-42 Pressure Transient during Injection on COP-3

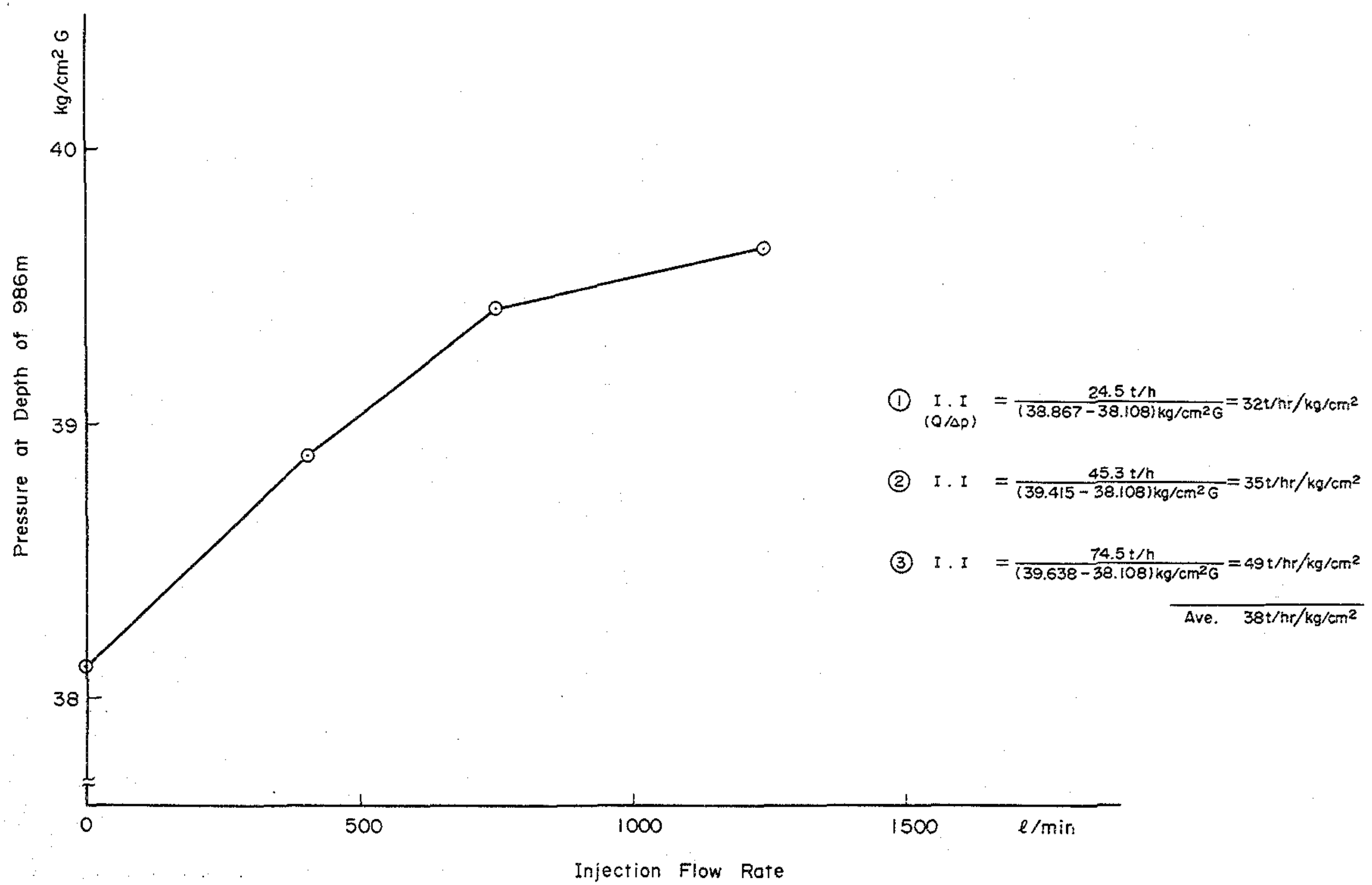


Fig. 5-43 Injectivity of COP-3

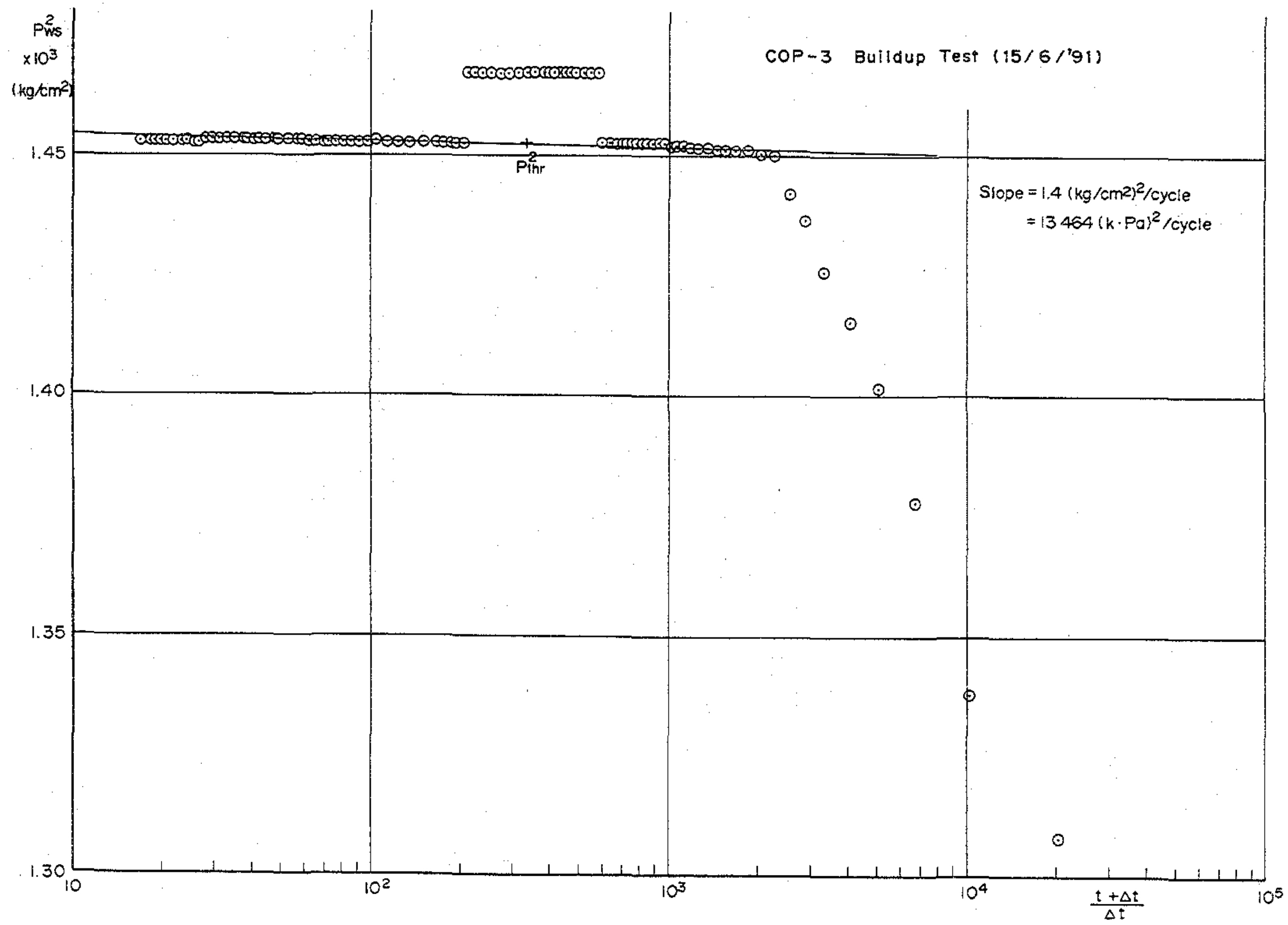


Fig. 5-44 Horner Buildup Graph for COP-3

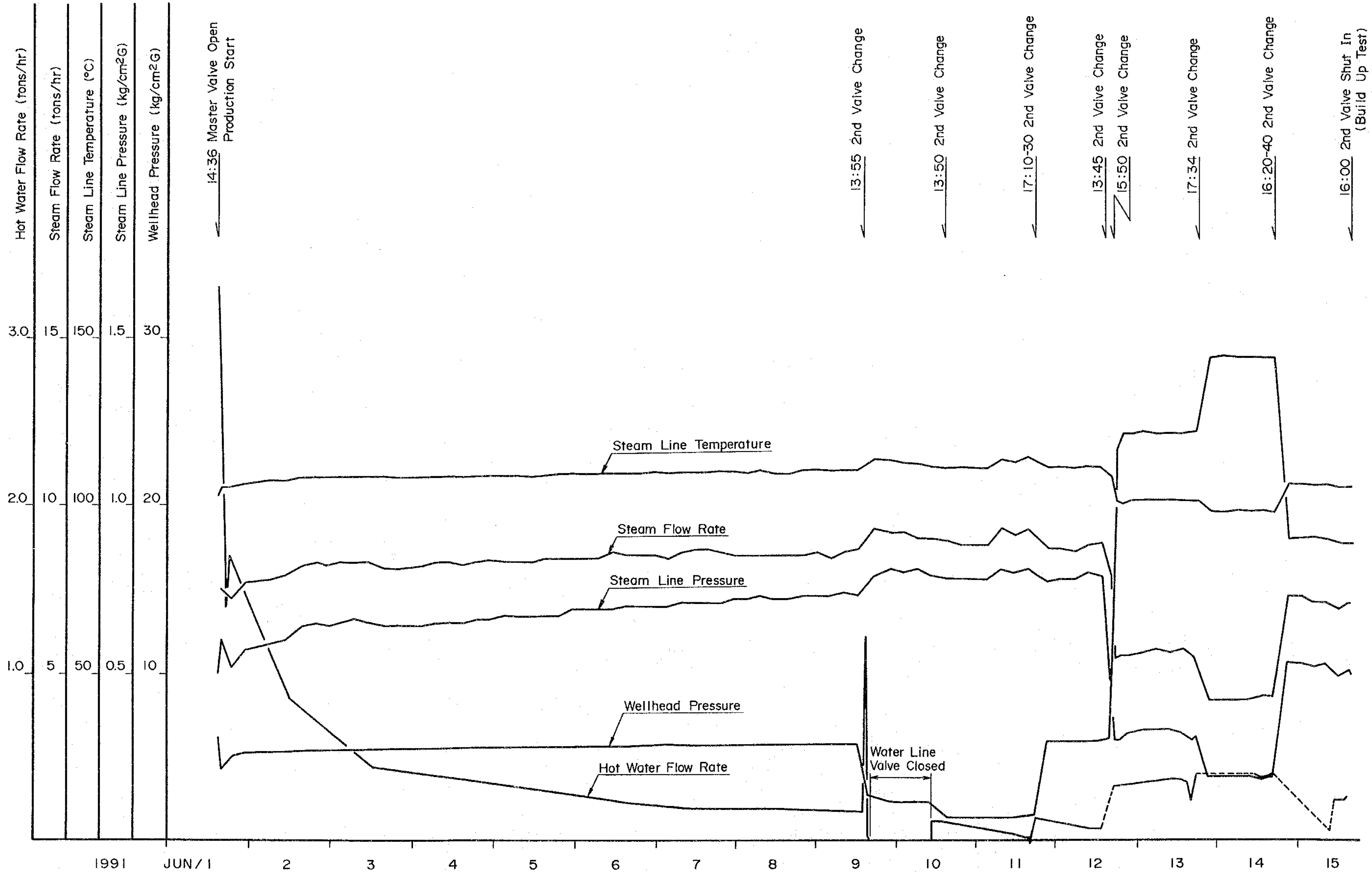


Fig. 5-45 COP-3 Production History

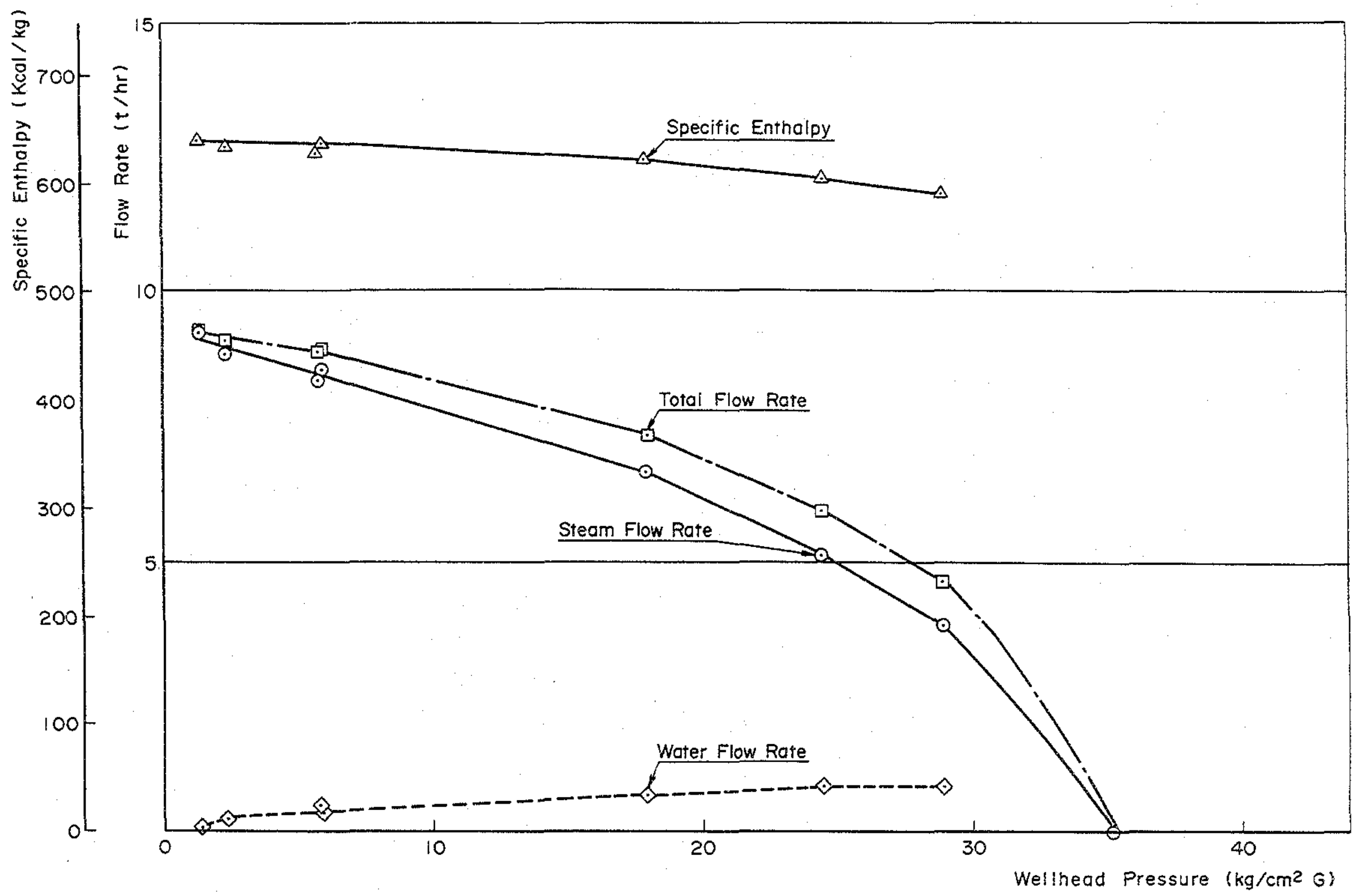
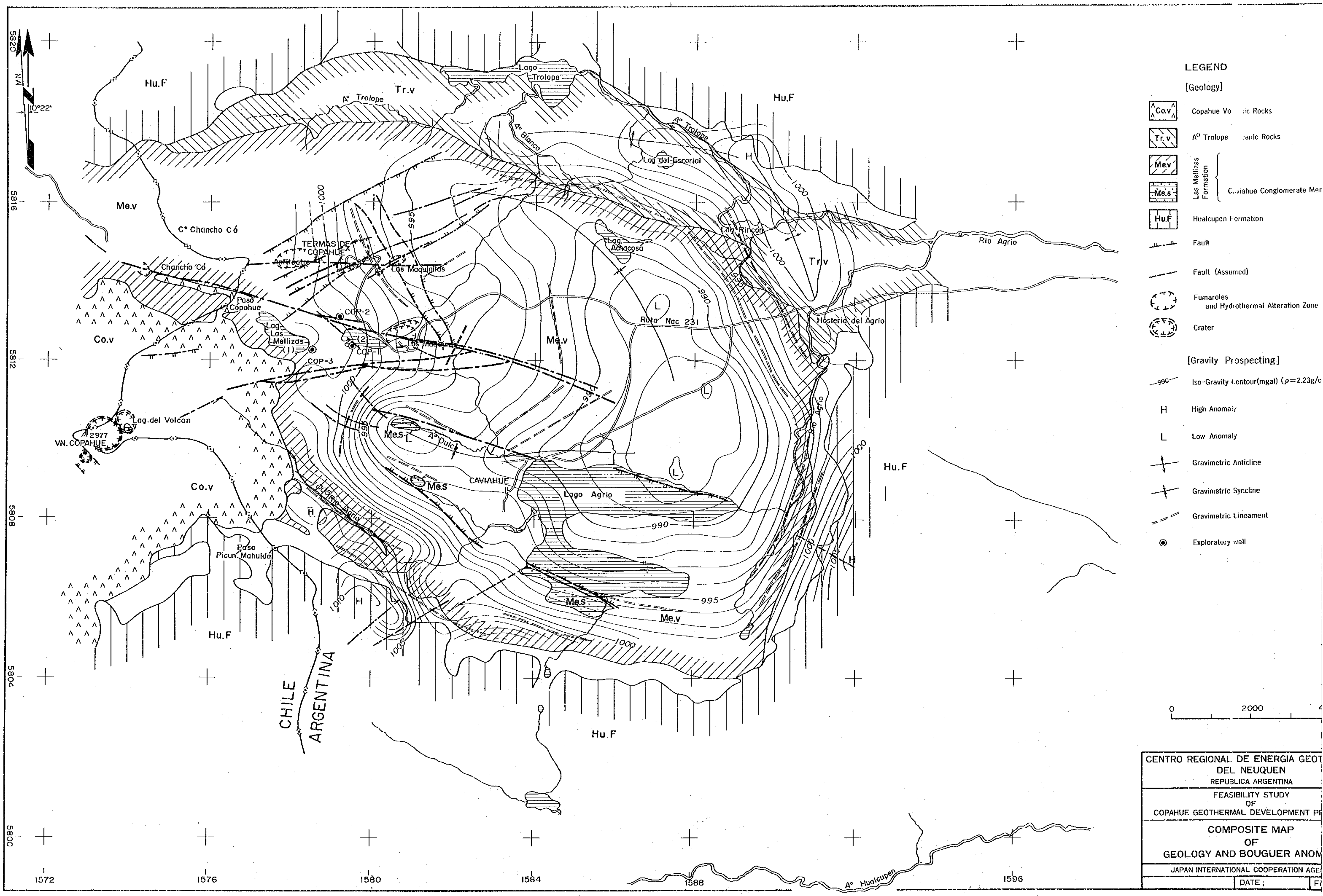
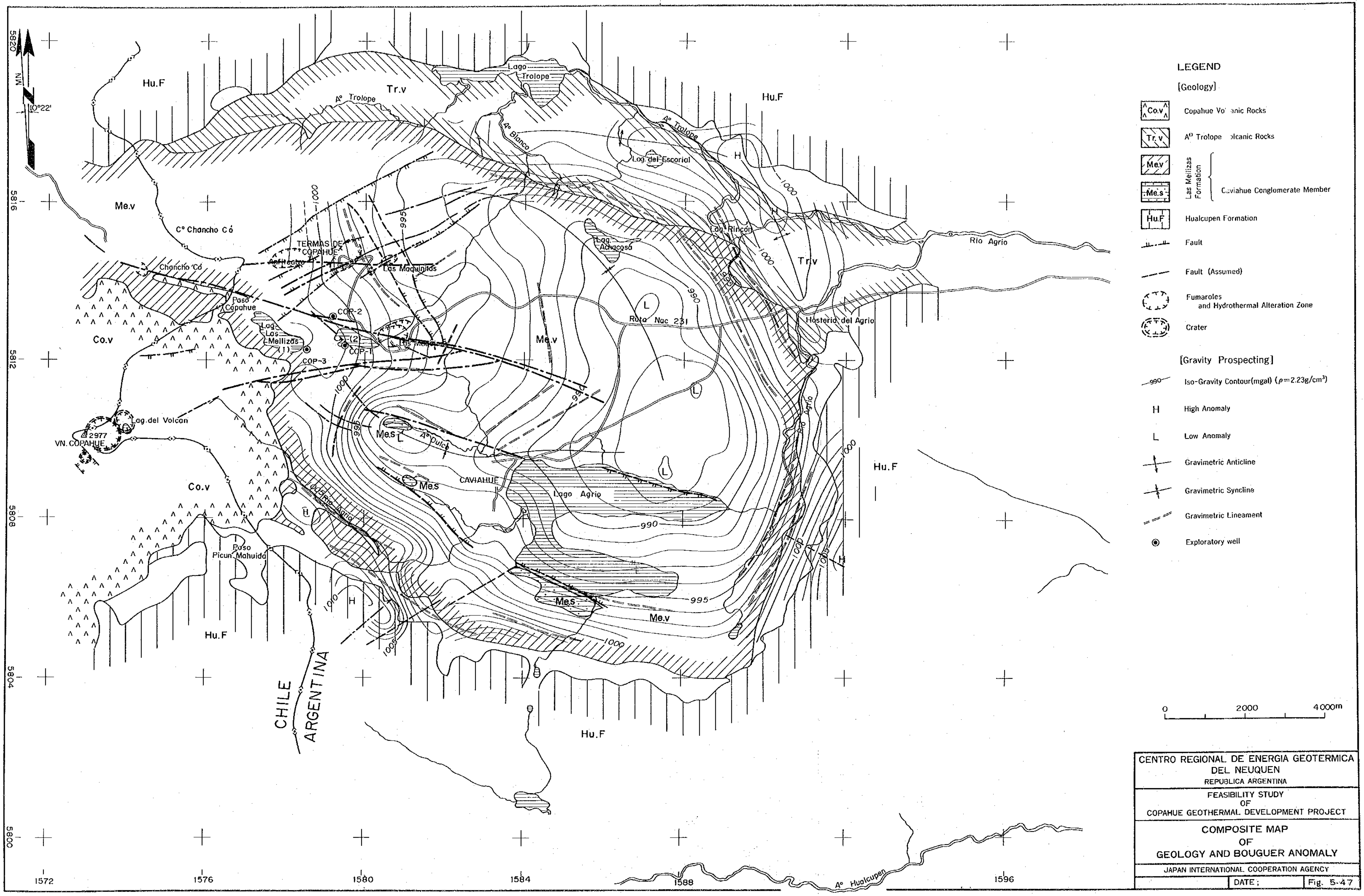


Fig. 5-46 COP-3 Well Characteristic Curve


LEGEND
[Geology]
Hualcupen Formation
Fault
Fault (Assumed)
Fumaroles
and Hydrothermal Alteration Zone
Crater
[Gravity Prospecting]
High Anomaly
Low Anomaly
Gravimetric Anticline
Gravimetric Syncline
Gravimetric Lineament
Exploratory well
CENTRO REGIONAL DE ENERGIA GEOT
DEL NEUQUEN
REPUBLICA ARGENTINA
FEASIBILITY STUDY
OF
COPAHUE GEOTHERMAL DEVELOPMENT P
COMPOSITE MAP
OF
GEOLOGY AND BOUGUER ANOM
JAPAN INTERNATIONAL COOPERATION AGE
DATE ;



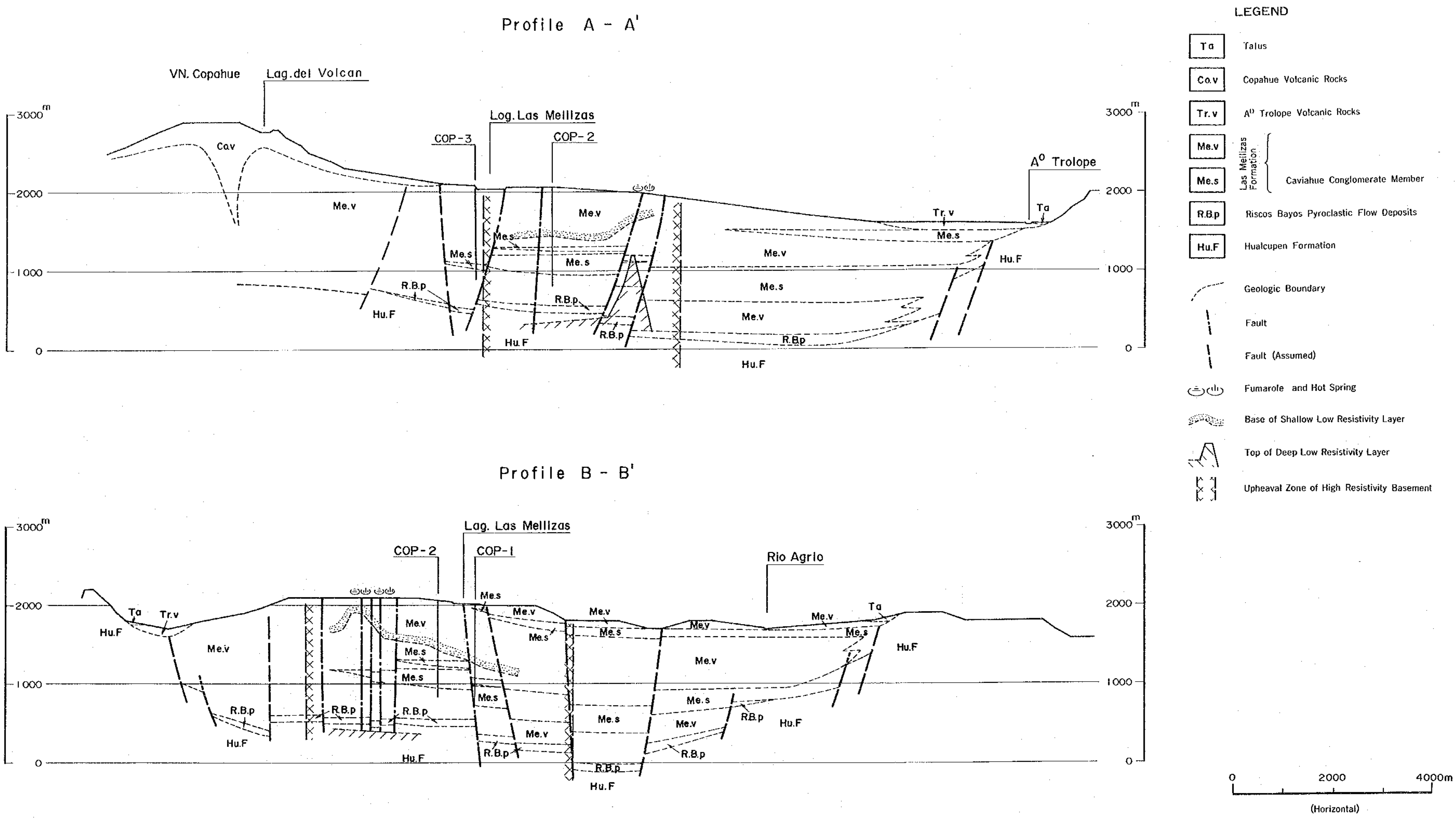
CENTRO REGIONAL DE ENERGIA GEOTERMICA DEL NEUQUEN
REPUBLICA ARGENTINA

FEASIBILITY STUDY OF COPAHUE GEOTHERMAL DEVELOPMENT PROJECT

COMPOSITE MAP OF GEOLOGY AND BOUGUER ANOMALY

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE ; | Fig. 5-47



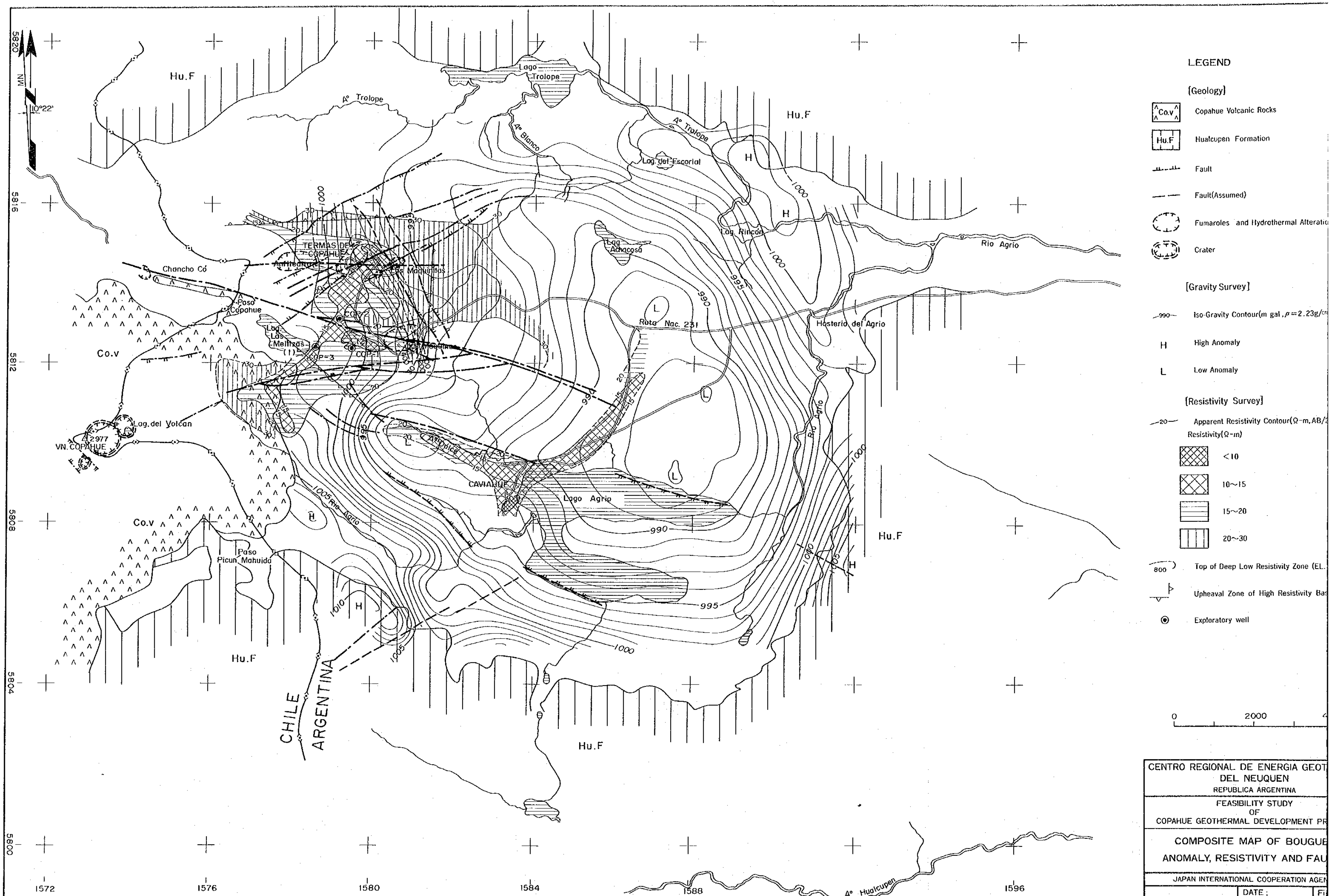
CENTRO REGIONAL DE ENERGIA GEOTERMICA DEL NEUQUEN
REPUBLICA ARGENTINA

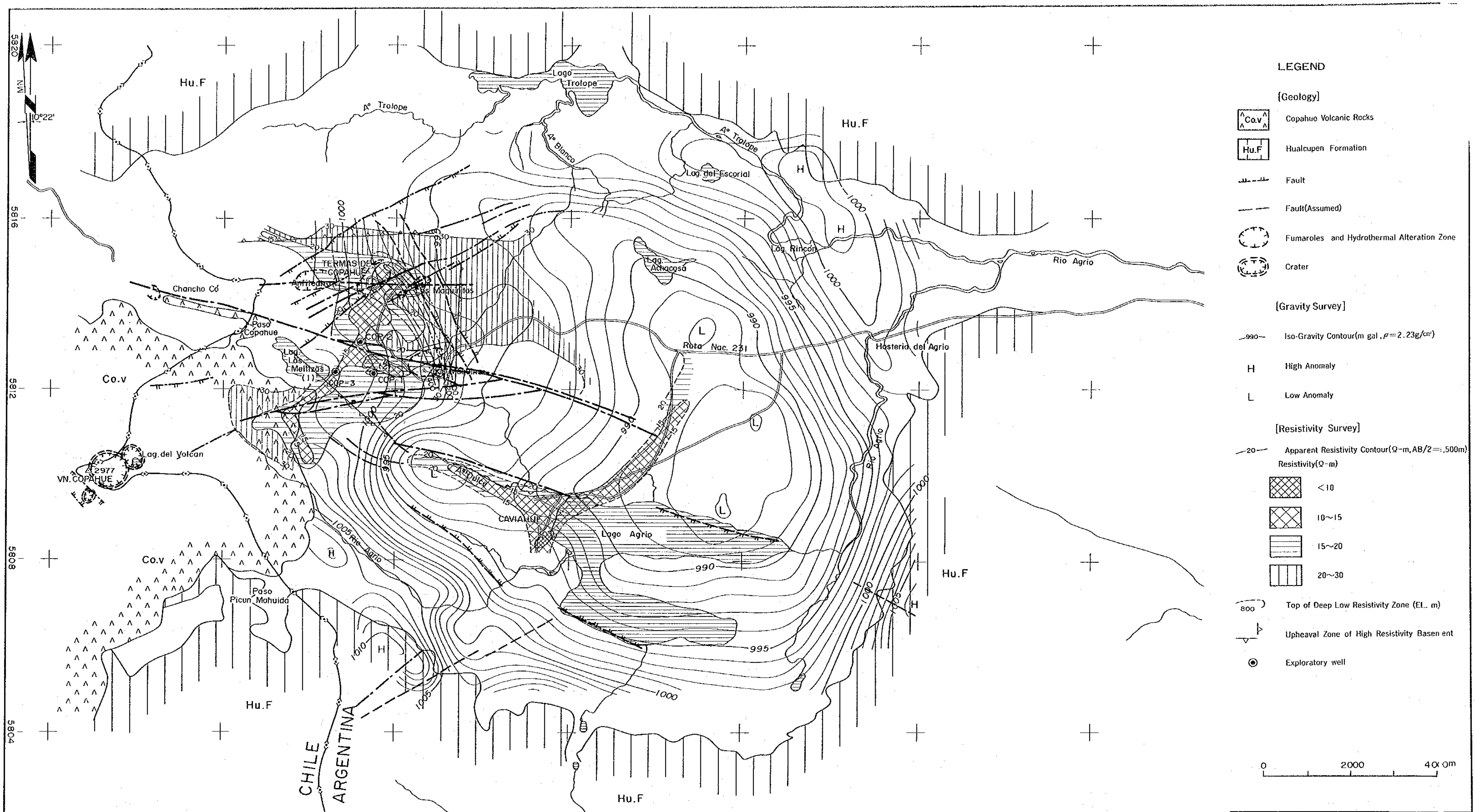
FEASIBILITY STUDY OF COPAHUE GEOTHERMAL DEVELOPMENT PROJECT

GEOLOGY AND RESISTIVITY PROFILE

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE; | Fig. 5-48


LEGEND
[Geology]
Co.v Copahue Volcanic Rocks
Hu.F Hualcupen Formation
Fault
Fault(Assumed)
Fumaroles and Hydrothermal Alteratio
Crater
[Gravity Survey]
-990- Iso-Gravity Contour(m gal, ρ=2.23g/cm
H High Anomaly
L Low Anomaly
[Resistivity Survey]
-20- Apparent Resistivity Contour(Ω-m, AB/
Resistivity(Ω-m)
<10
10~15
15~20
20~30
800 Top of Deep Low Resistivity Zone (EL.
Upheaval Zone of High Resistivity Ba
Exploratory well
0 2000
CENTRO REGIONAL DE ENERGIA GEOT
DEL NEUQUEN
REPUBLICA ARGENTINA
FEASIBILITY STUDY
OF
COPAHUE GEOTHERMAL DEVELOPMENT PR
COMPOSITE MAP OF BOUGUE
ANOMALY, RESISTIVITY AND FAU
JAPAN INTERNATIONAL COOPERATION AGEN
DATE ;
Lago Trolope
Aº Trolope
Aº Blanco
Log. del Escorial
Log. Rincon
Log. Achacoso
Rio Agrio
Hosteria del Agrio
Ruta Nac. 231
TERMAS DE COPAHUE
Anfiteatro
Las Maquinitas
Chancho Co
Paso Copahue
Log. Los Mellizos
COP-1
COP-2
COP-3
Lag. del Volcan
VN. COPAHUE
2977
CAVIAHUE
Lago Agrio
Paso Picun Mahuida
CHILE
ARGENTINA
Aº Hualcupen
Hu.F
Co.v
1572
1576
1580
1584
1588
1596
5820
5816
5812
5808
5804
5800
10°22'
MN
990
995
1000
1005
1010



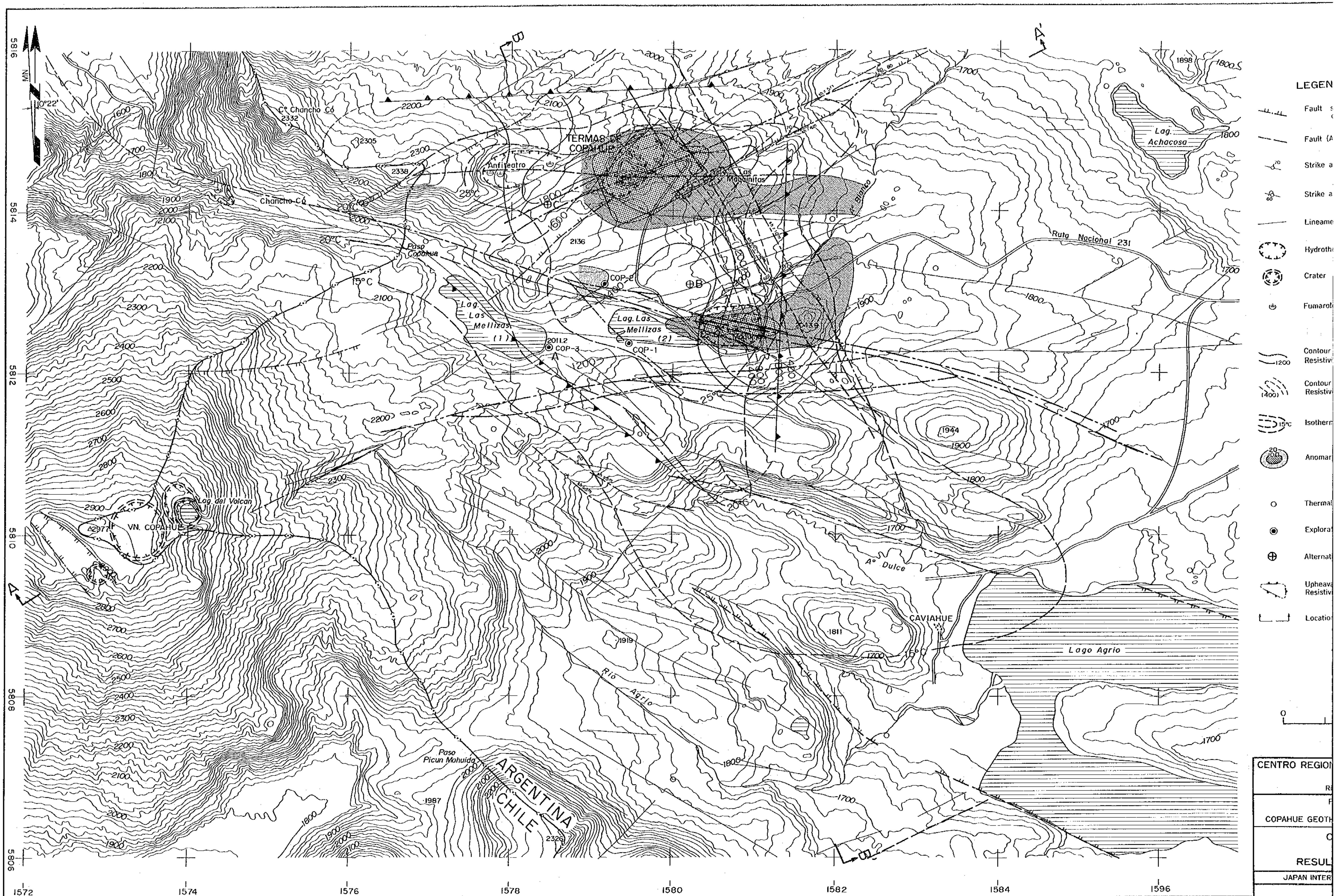
CENTRO REGIONAL DE ENERGIA GEOTERMICA DEL NEUQUEN
REPUBLICA ARGENTINA

FEASIBILITY STUDY OF COPAHUE GEOTHERMAL DEVELOPMENT PROJECT

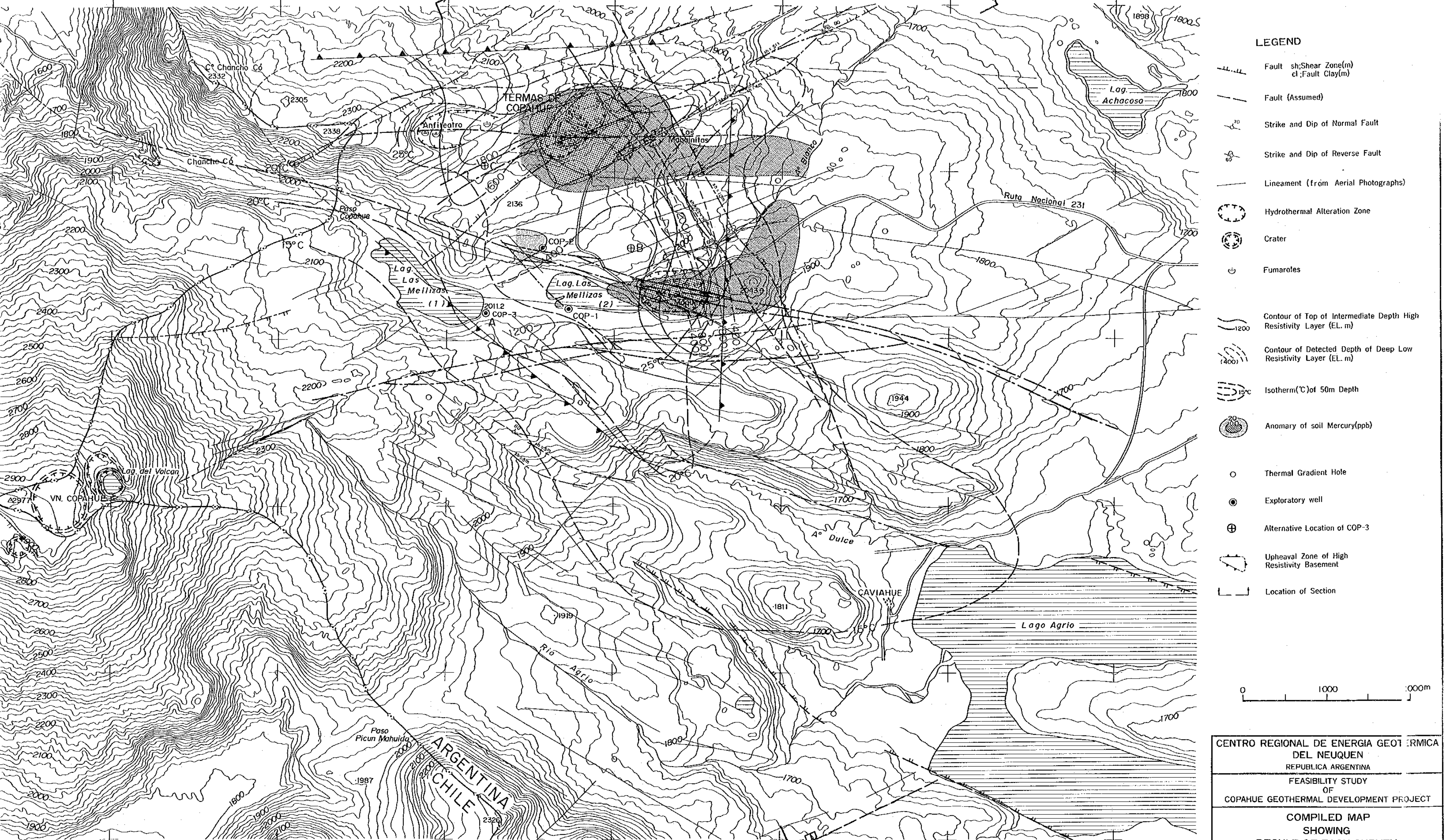
COMPOSITE MAP OF BOUGUER ANOMALY, RESISTIVITY AND FAULTS

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE; Fig. 5-49



LEGEND
Fault
Strike
Lineament
Hydrothermal
Crater
Fumarole
Contour Resistivity
Isotherm
Anomaly
Thermal
Exploration
Alternative
Upheaval Resistivity
Location
CENTRO REGIONAL
COPAHUE GEOTH
RESUL
JAPAN INTER
TERMAS DE COPAHUE
Las Maquinitas
Anfiteatro
Cº Chancho Có
Chancho Có
Paso Copahue
Lag. Las Mellizas (1)
Lag. Las Mellizas (2)
COP-1
COP-2
COP-3
Ruta Nacional 231
Lag. Achacosa
Lag. del Volcan
VN. COPAHUE
Aº Dulce
CAVIAHUE
Lago Agrio
Rio Agrio
Paso Picun Mahuida
ARGENTINA
CHILE
1572
1574
1576
1578
1580
1582
1584
1596
5806
5808
5810
5812
5814
5816



CENTRO REGIONAL DE ENERGIA GEOTERMICA DEL NEUQUEN
REPUBLICA ARGENTINA

FEASIBILITY STUDY OF COPAHUE GEOTHERMAL DEVELOPMENT PROJECT

COMPILED MAP SHOWING RESULT OF EACH SURVEY

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE ;

Fig. 5-50

Profile A – A'

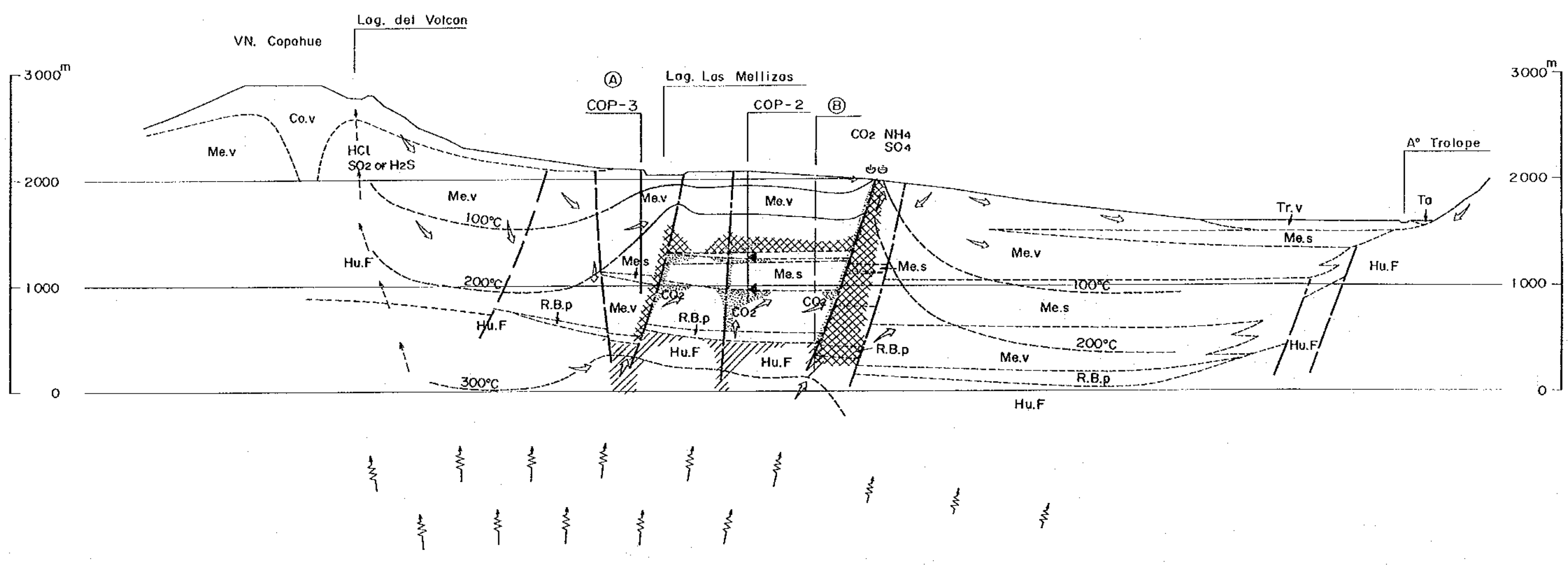
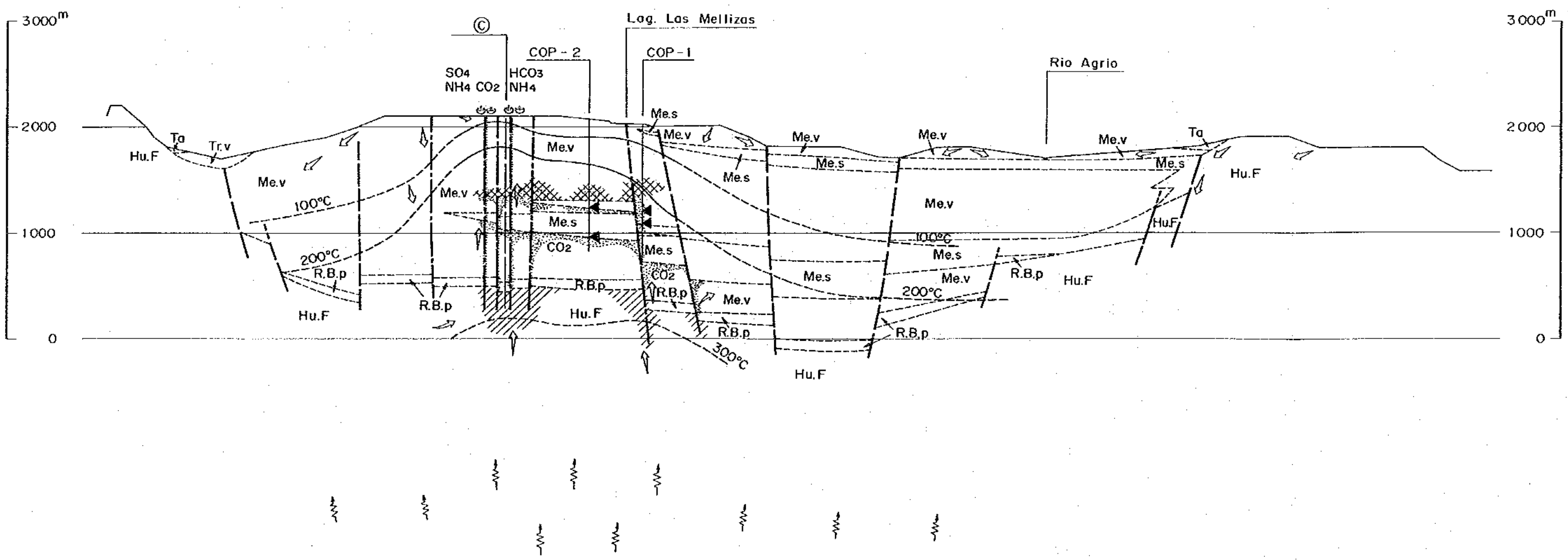
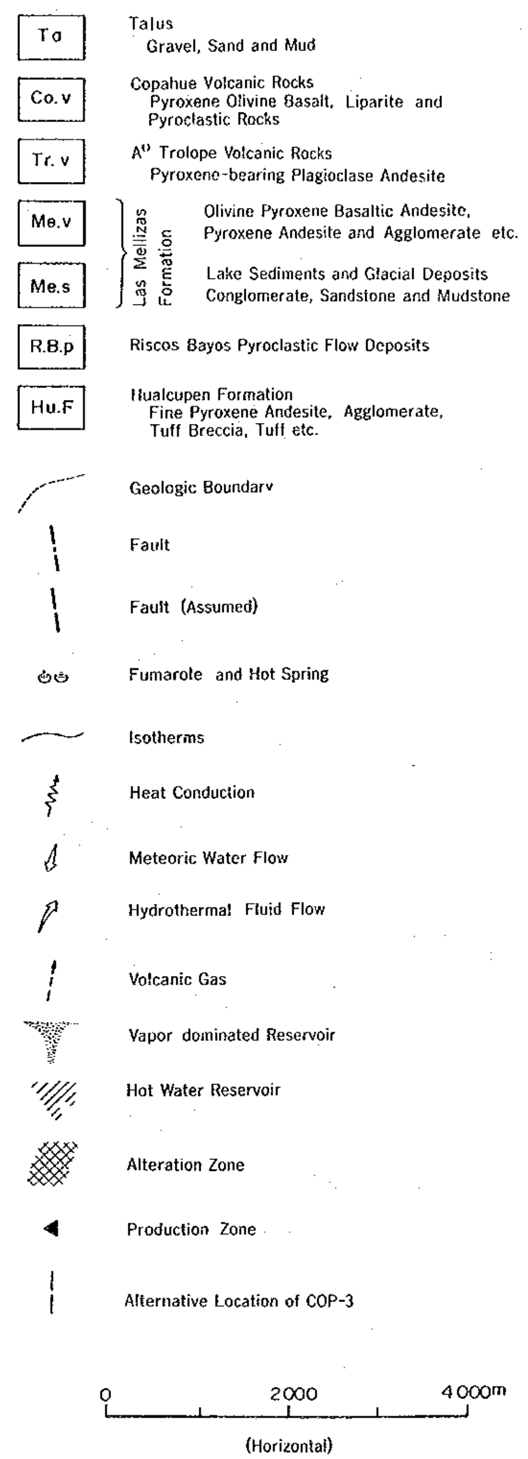


Fig. 2-1

Profile B – B'



LEGEND



CENTRO REGIONAL DE ENERGIA GEOTERMICA DEL NEUQUEN
REPUBLICA ARGENTINA

FEASIBILITY STUDY
OF
COPAHUE GEOTHERMAL DEVELOPMENT PROJECT

MODEL OF GEOTHERMAL SYSTEM

JAPAN INTERNATIONAL COOPERATION AGENCY

DATE: | Fig. 5-51

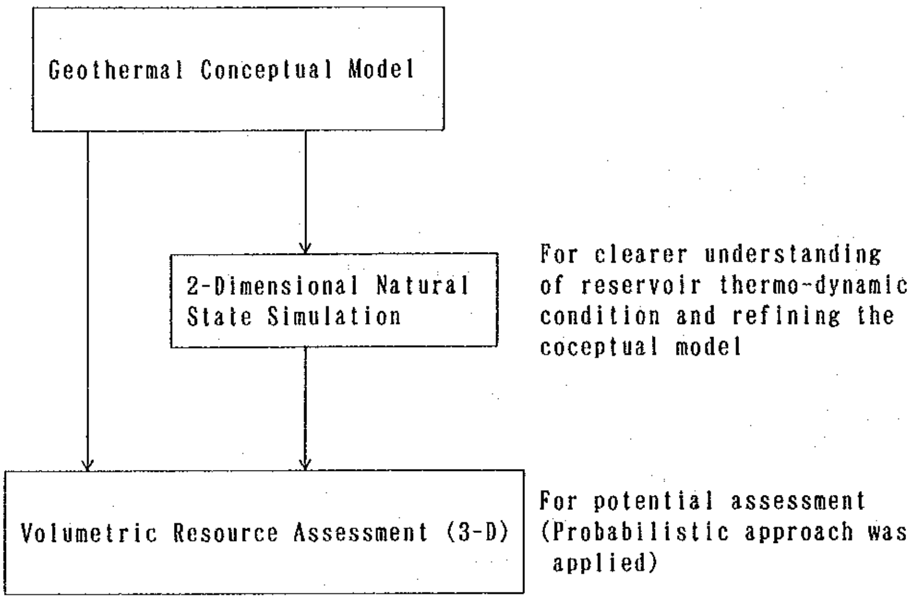


Fig. 5-52 Conceptual flow of resource assessment in Copahue Study

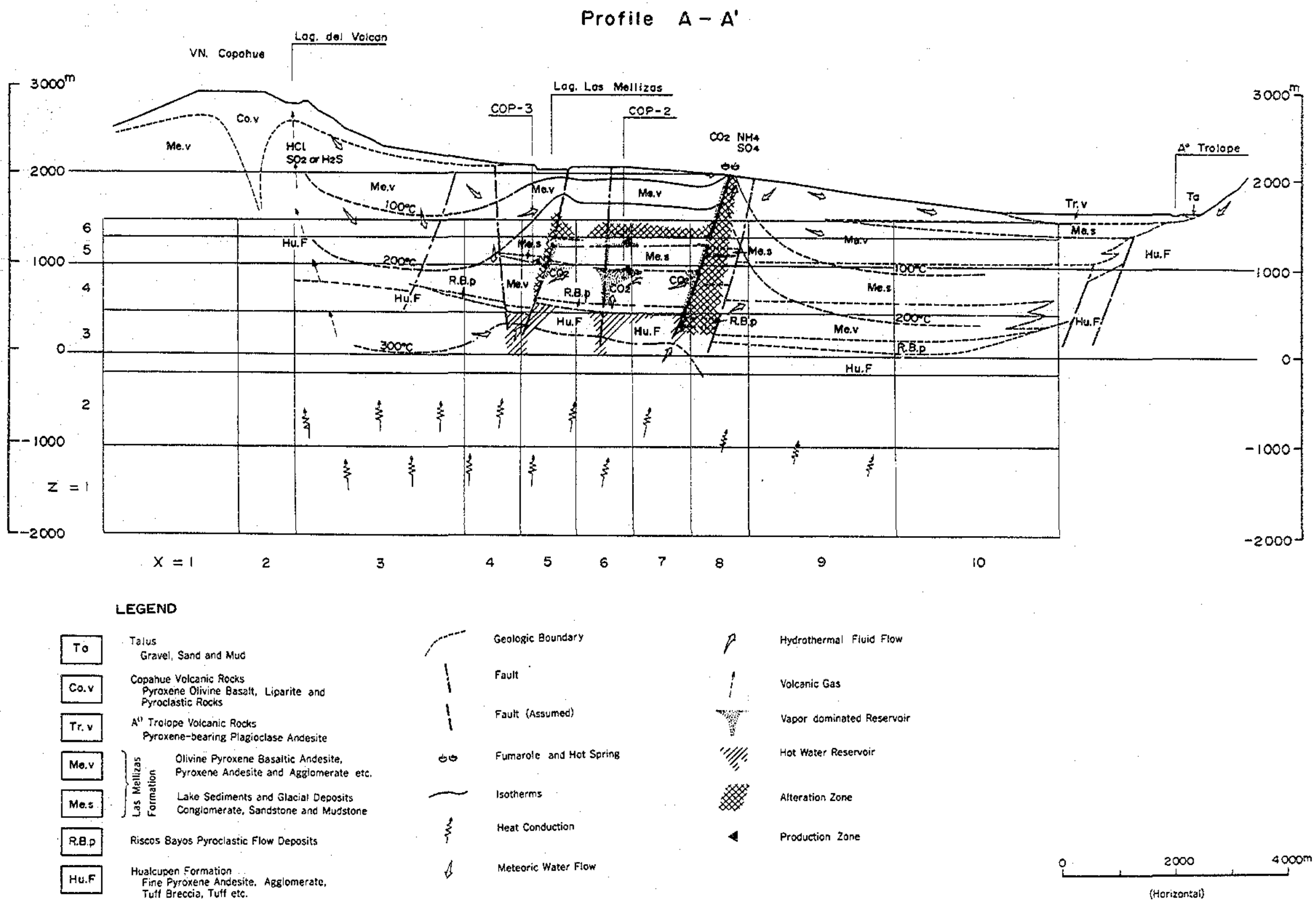


Fig. 5-53 Simulation Model

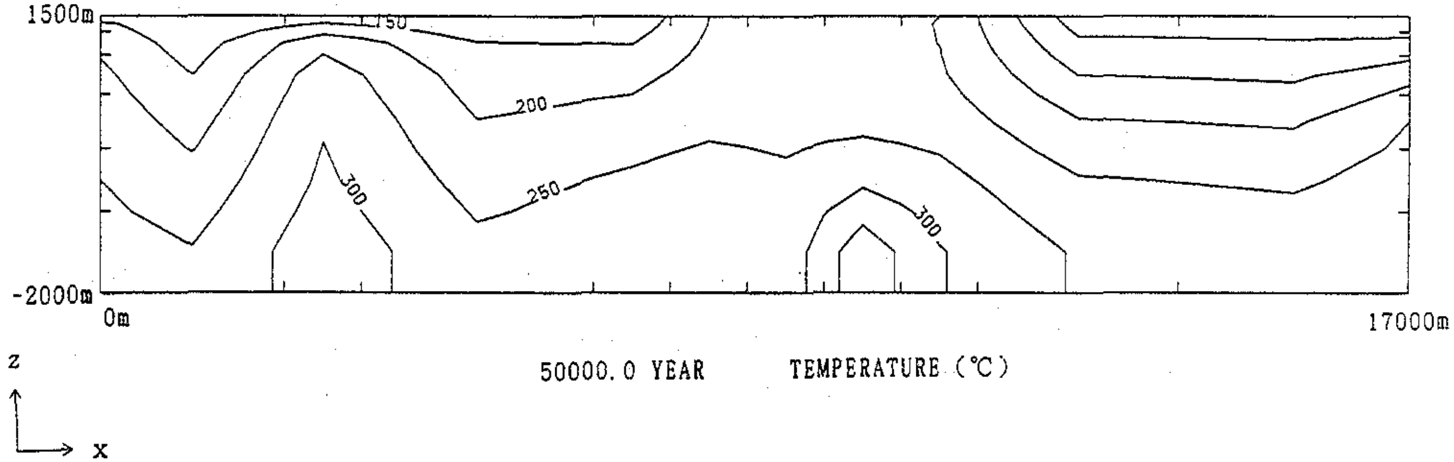


Fig. 5-54 Computed Temperature Distribution

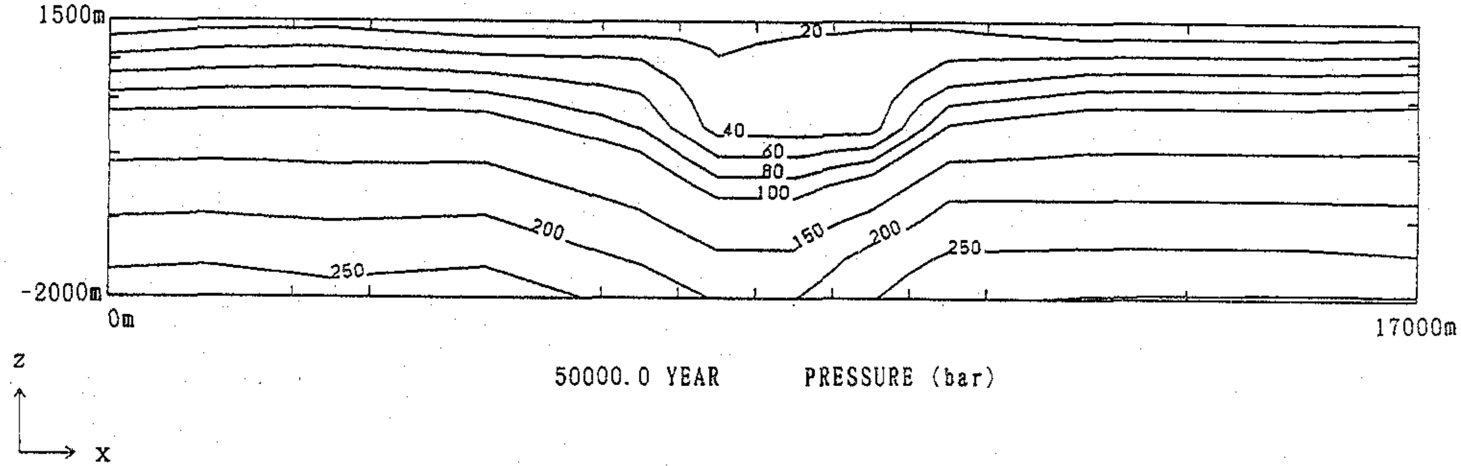


Fig. 5-55 Computed Pressure Distribution

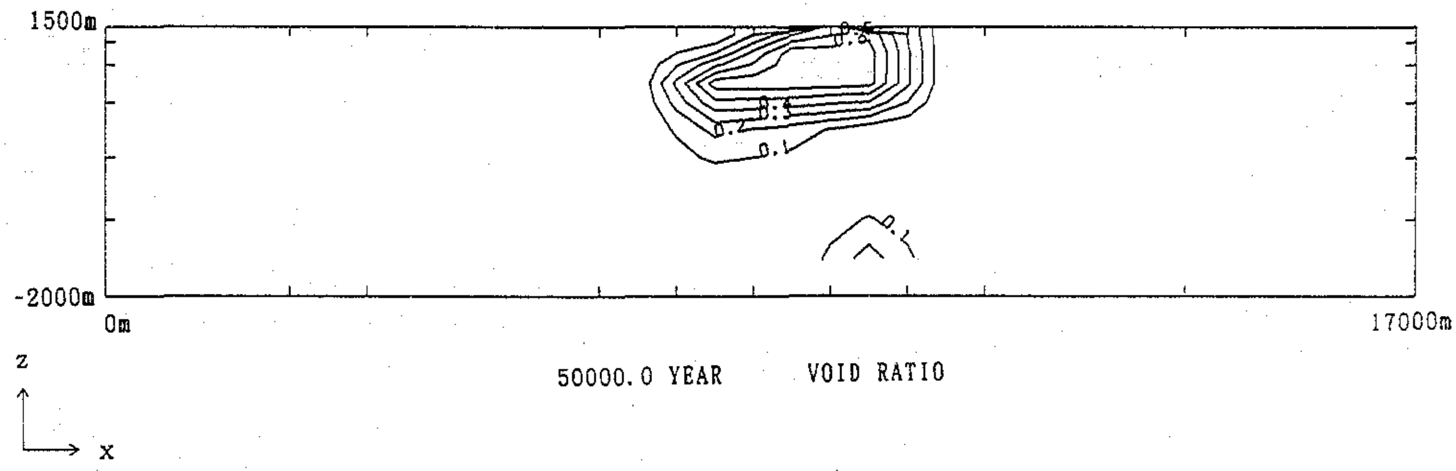


Fig. 5-56 Computed Steam Saturation Distribution

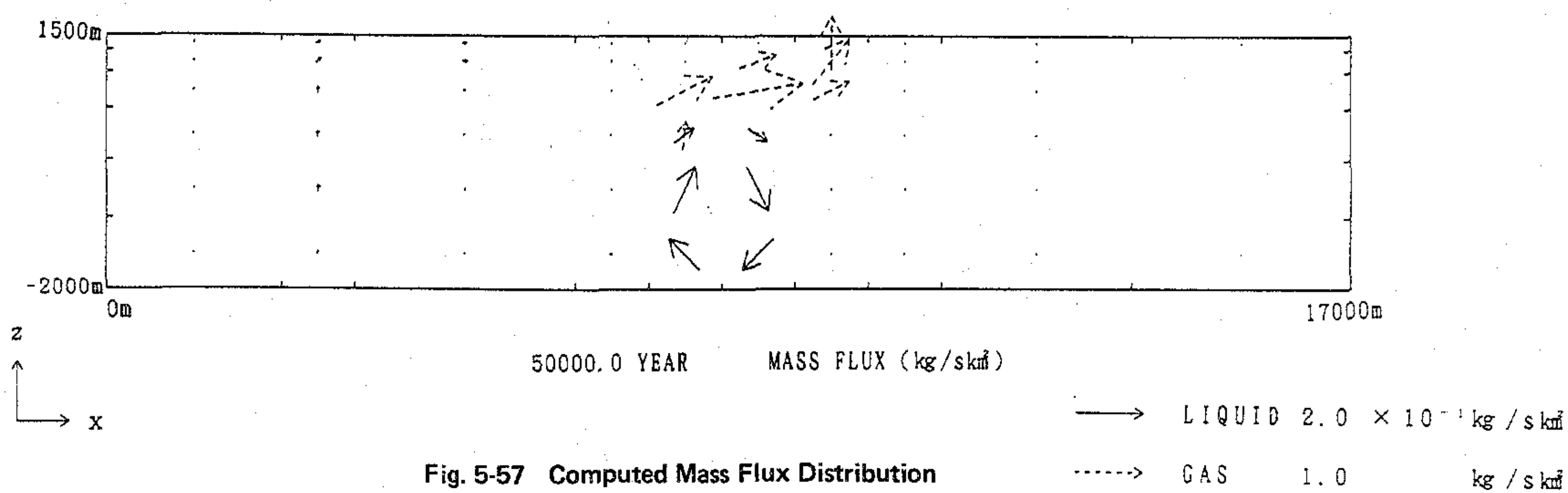


Fig. 5-57 Computed Mass Flux Distribution

Z \ X	1	2	3	4	5	6	7	8	9	10
Z = 6	0.1	5.0	1.0	1.0	0.001	0.001	0.5	0.001	0.1	0.1
5	0.1	5.0	1.0	1.0	0.001	50.0	50.0	0.001	0.1	0.1
4	0.1	5.0	0.1	0.001	50.0	50.0	50.0	0.001	0.1	0.1
3	0.1	5.0	0.1	0.001	50.0	50.0	50.0	0.001	0.1	0.1
2	0.1	5.0	0.1	0.001	50.0	50.0	0.001	0.1	0.1	0.1
1	0.1	5.0	0.1	0.01	50.0	50.0	0.001	0.1	0.1	0.1
	X = 1	2	3	4	5	6	7	8	9	10

permeability (10^{-15} m^2)

Fig. 5-58 Permeability Distribution

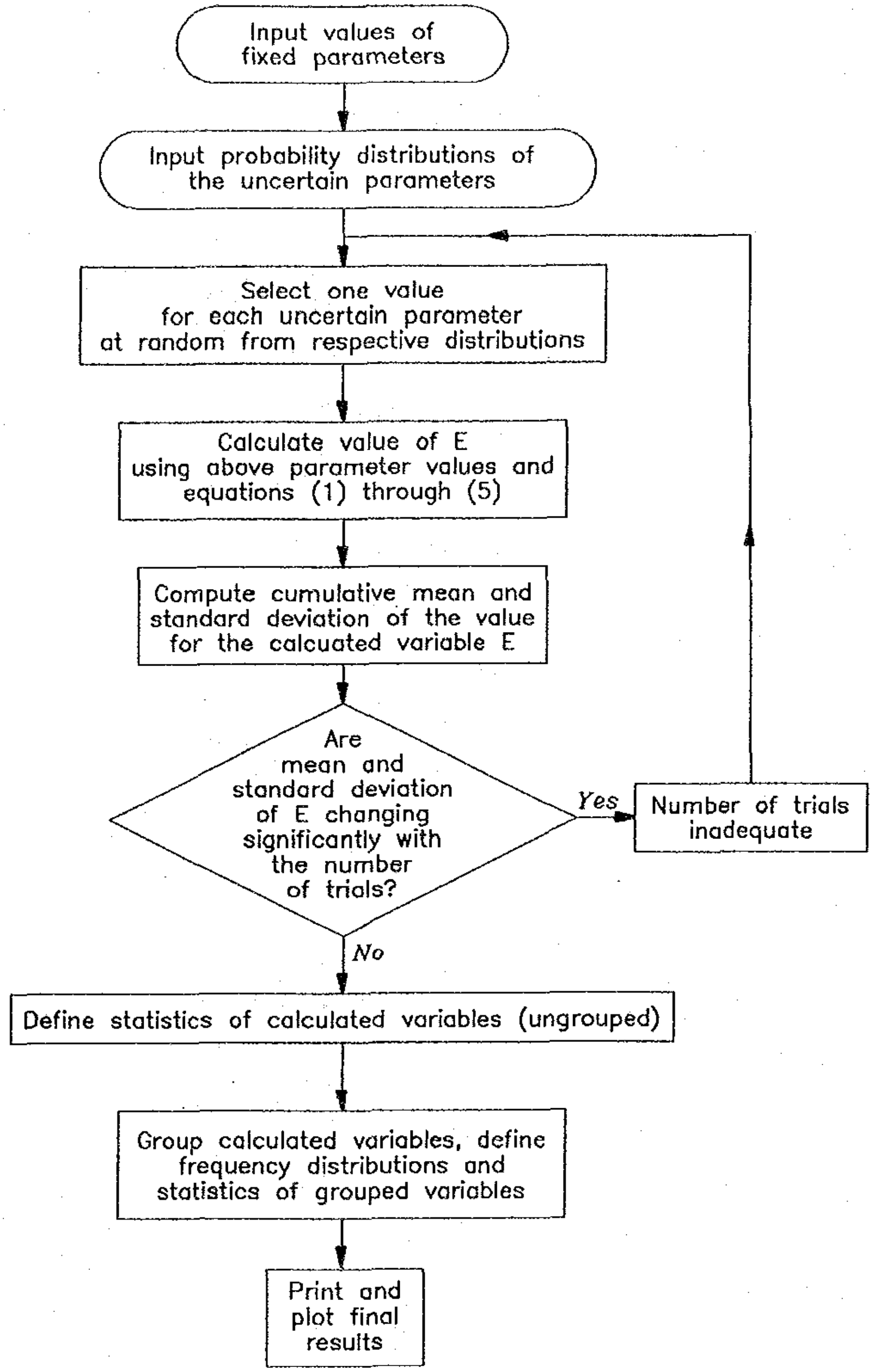


Fig. 5-59 Schematic Representation of the Monte Carlo Simulation Process

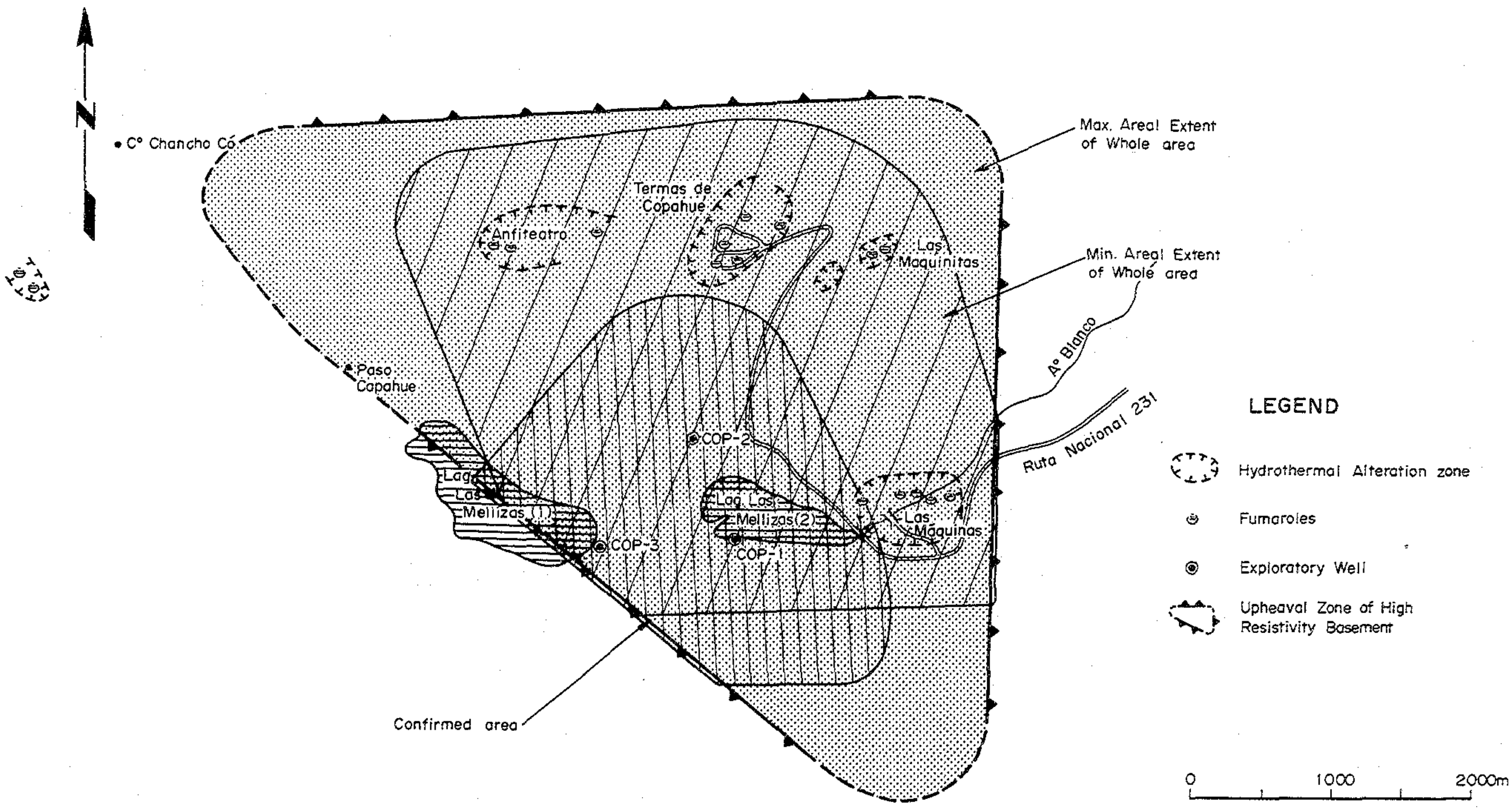


Fig. 5-60 Map of confirmed and whole areas

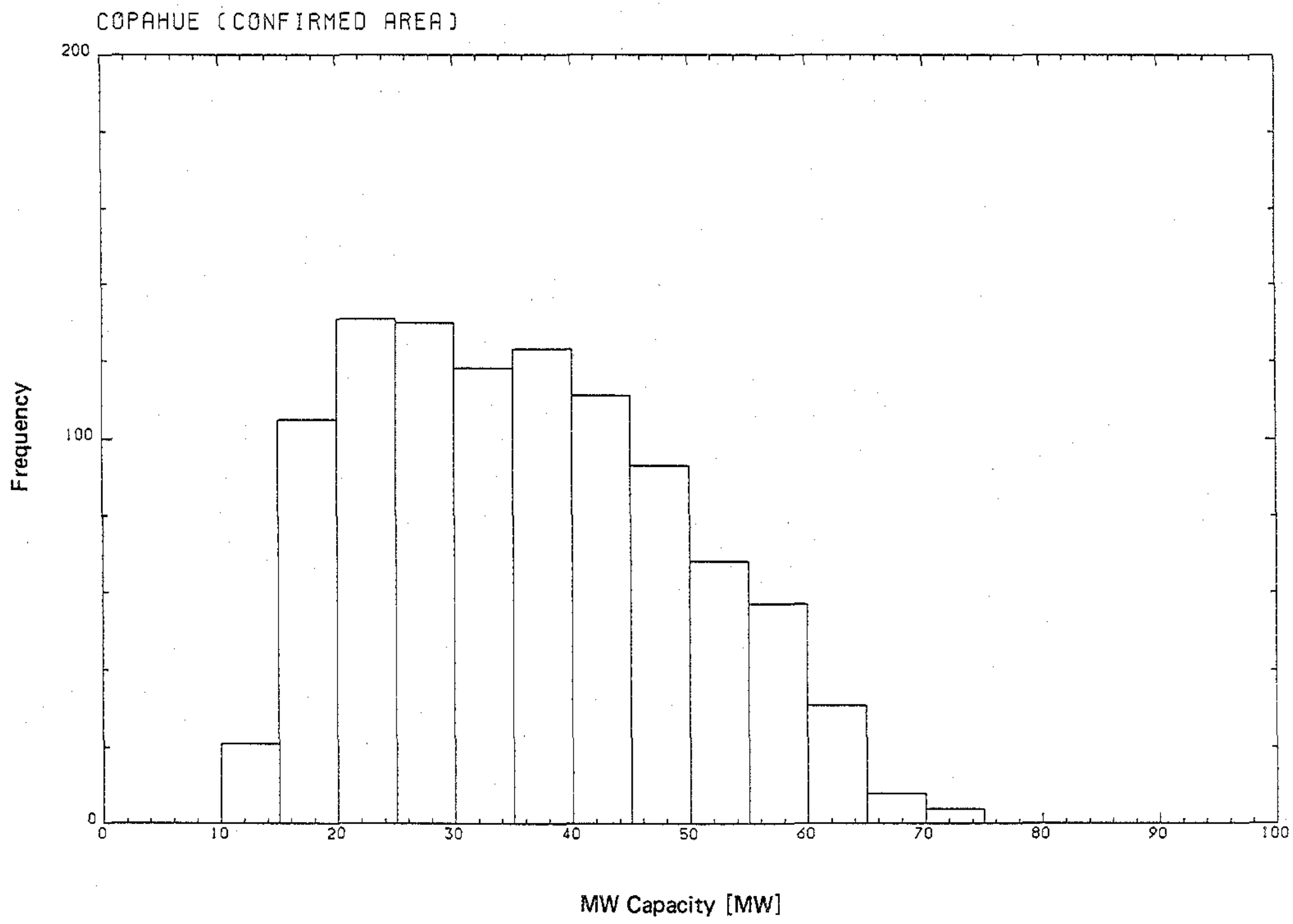


Fig. 5-61 Histogram of MW Capacity, Confirmed Area

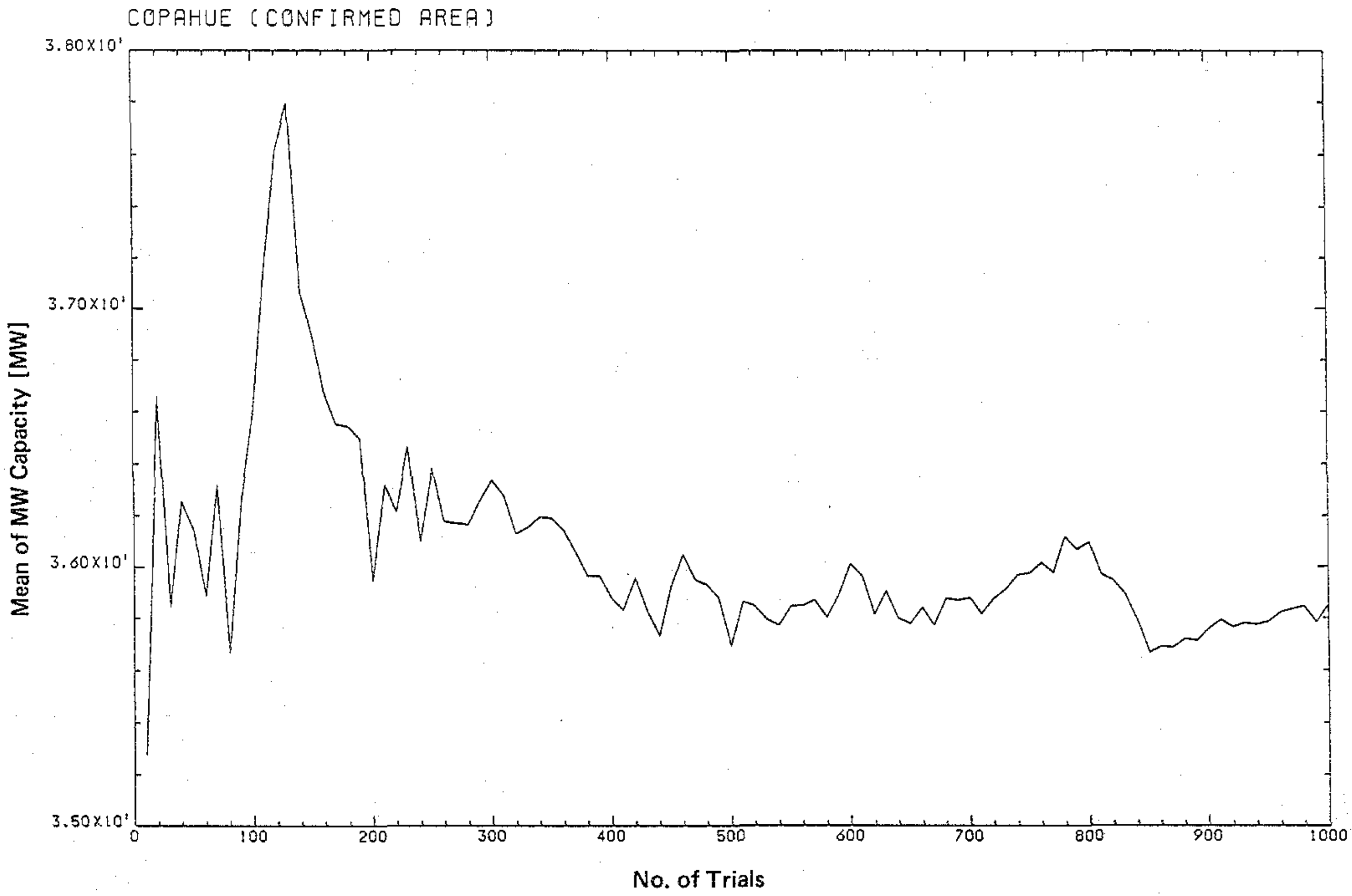


Fig. 5-62 Mean of MW Capacity vs. No. of Trials, Confirmed Area

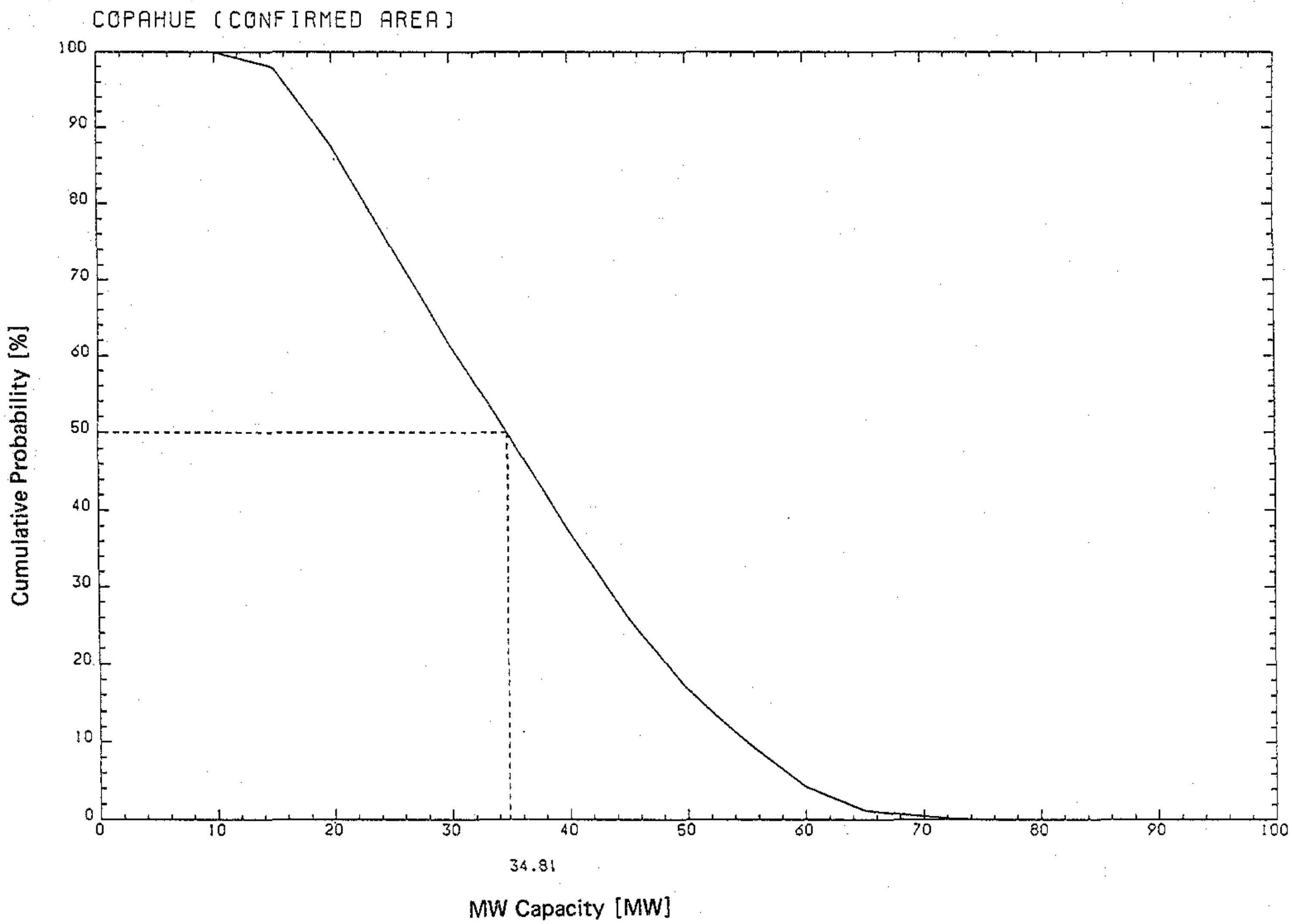


Fig. 5-63 Cumulative Probability of MW Capacity, Confirmed Area

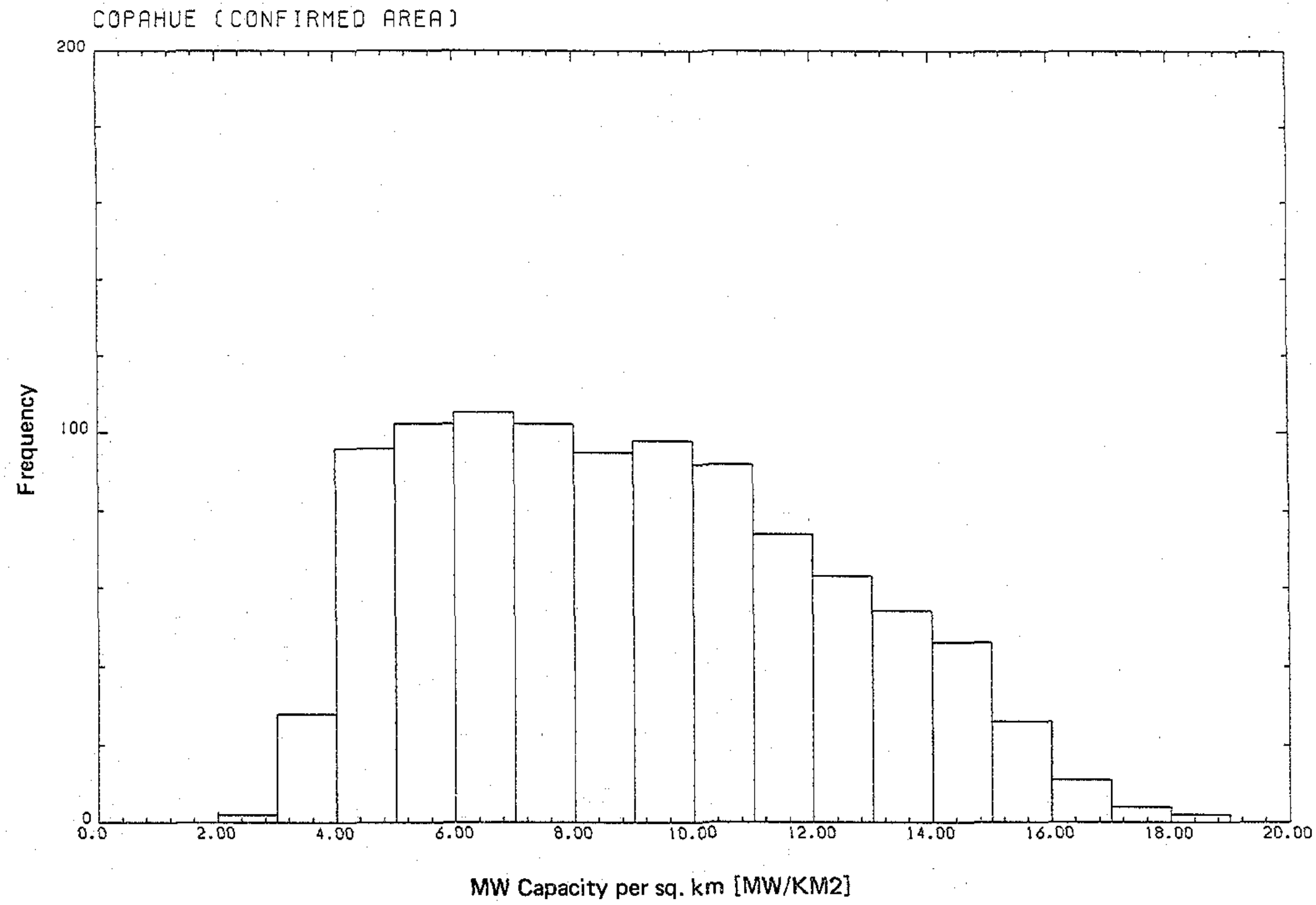


Fig. 5-64 Histogram of MW per Square Kilometer, Confirmed Area

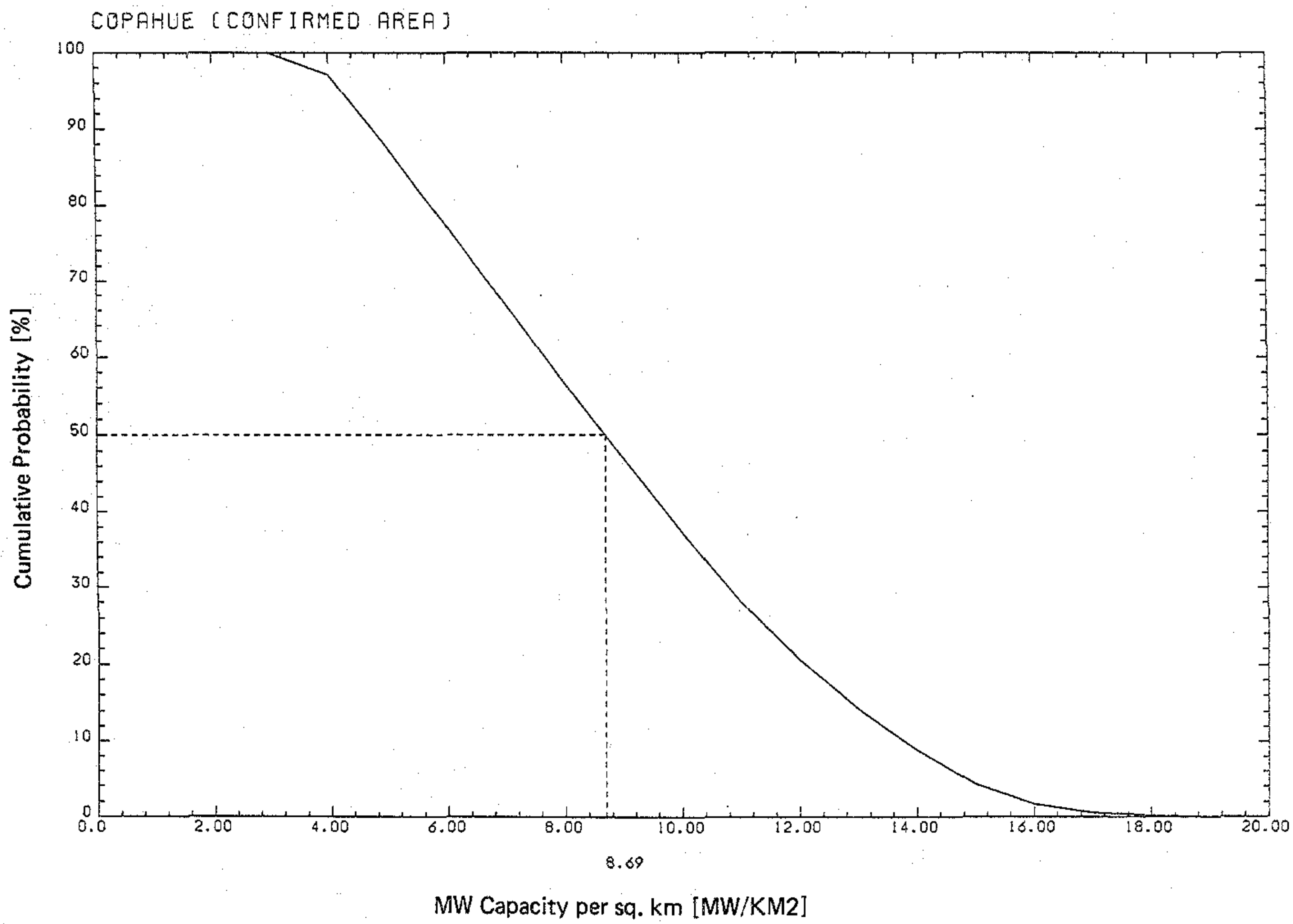


Fig. 5-65 Cumulative Probability of MW per Square Kilometer, Confirmed Area

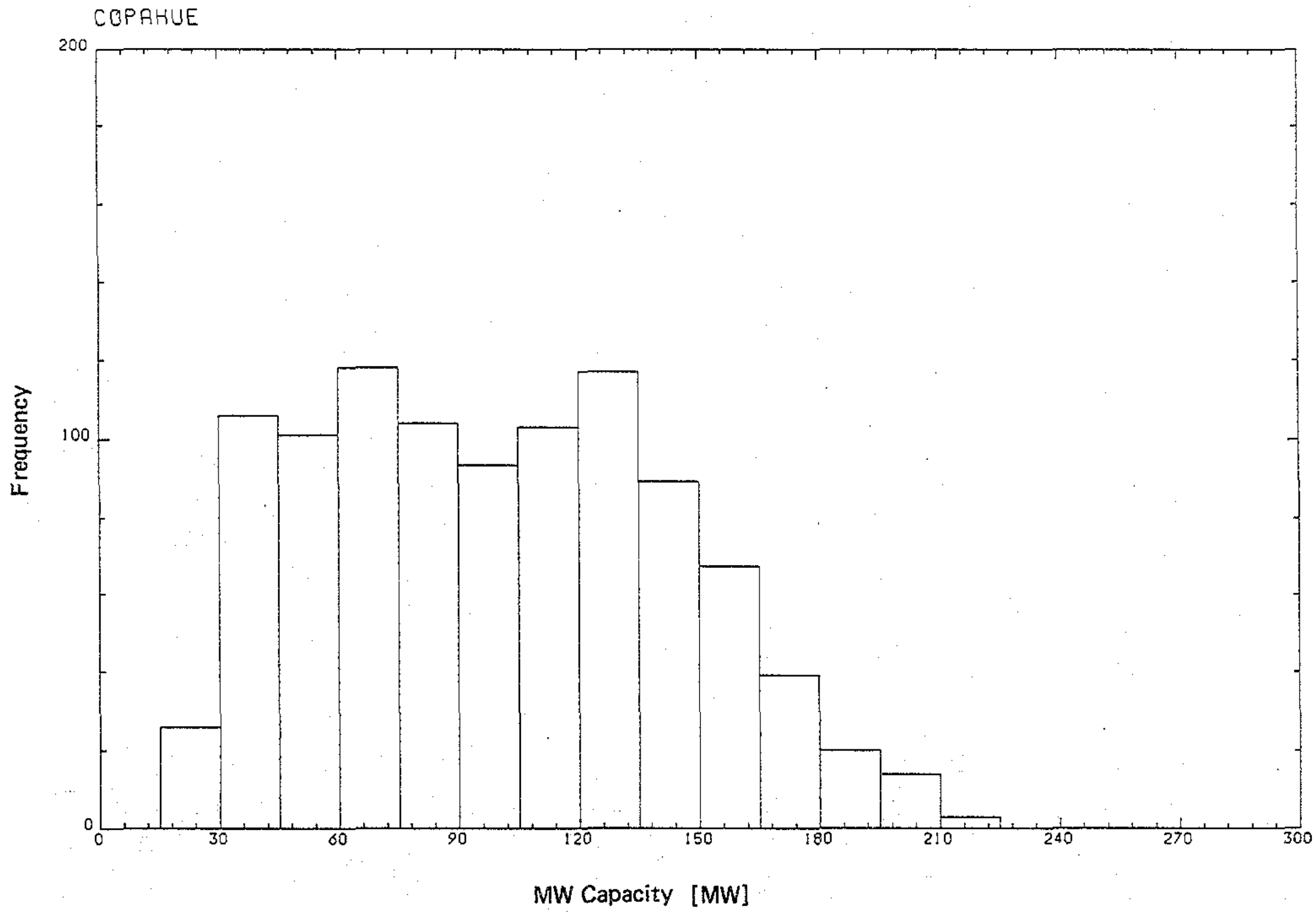


Fig. 5-66 Histogram of MW Capacity, Whole Area

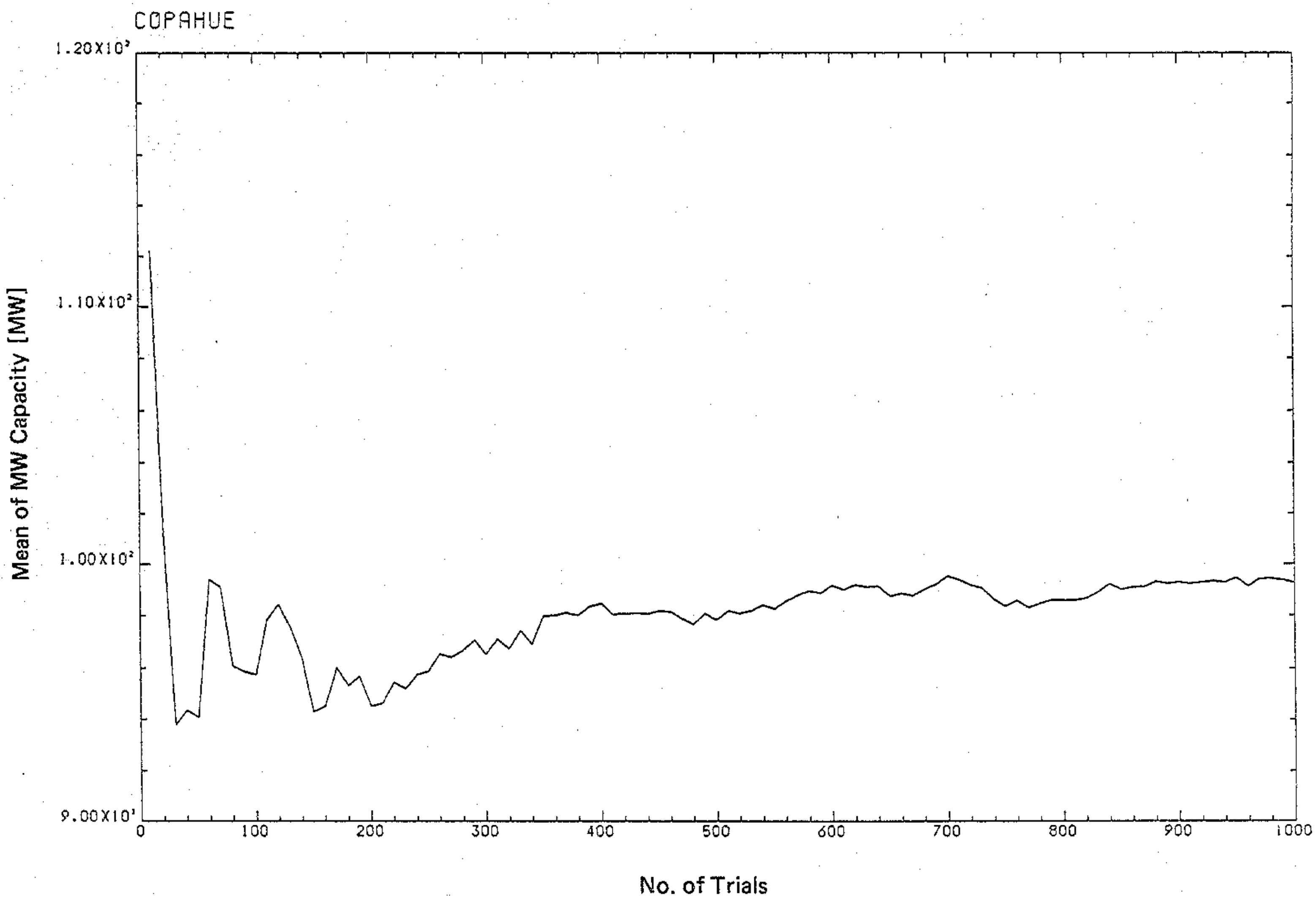


Fig. 5-67 Mean of MW Capacity vs. No. of Trials, Whole Area

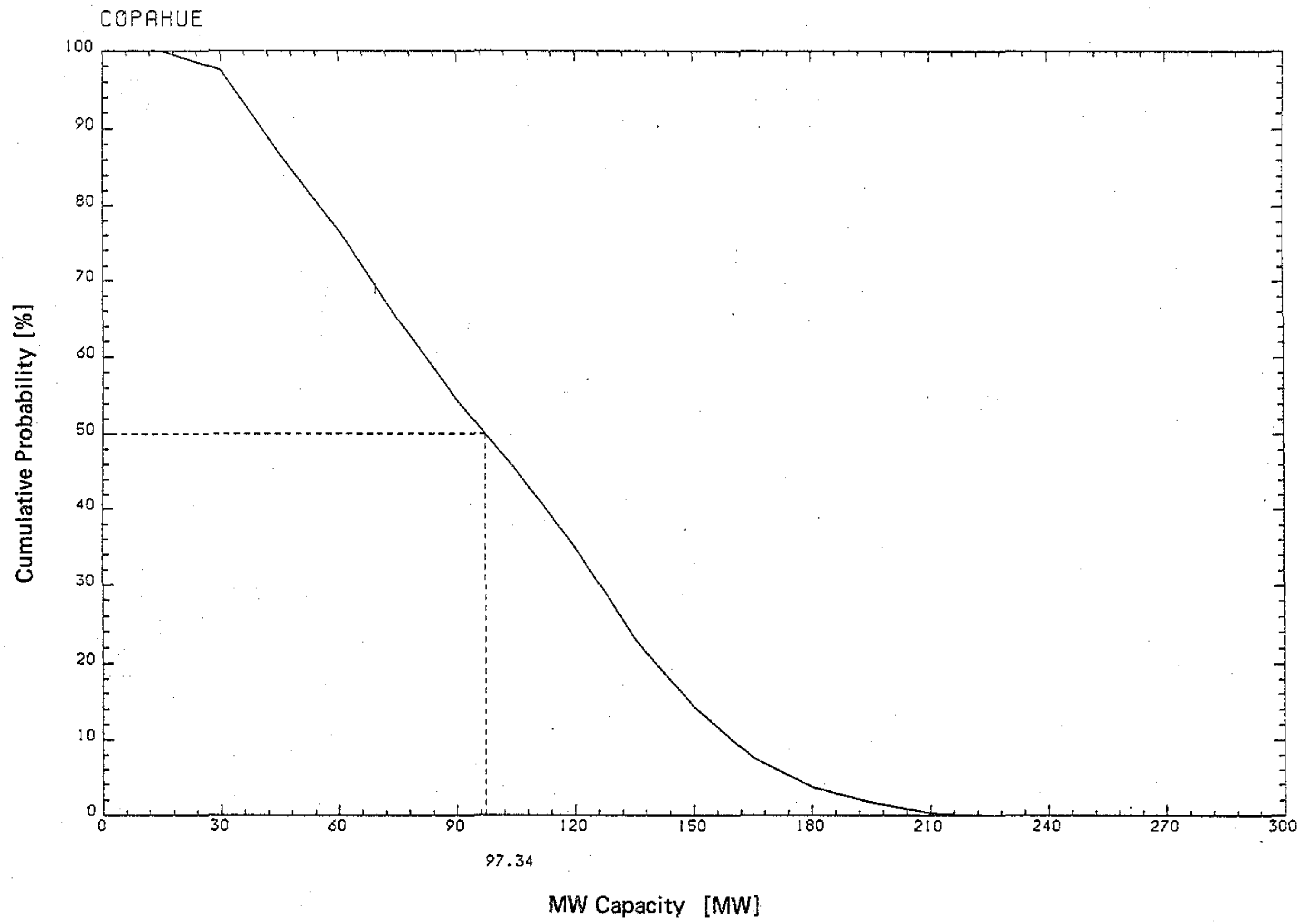


Fig. 5-68 Cumulative Probability of MW Capacity, Whole Area

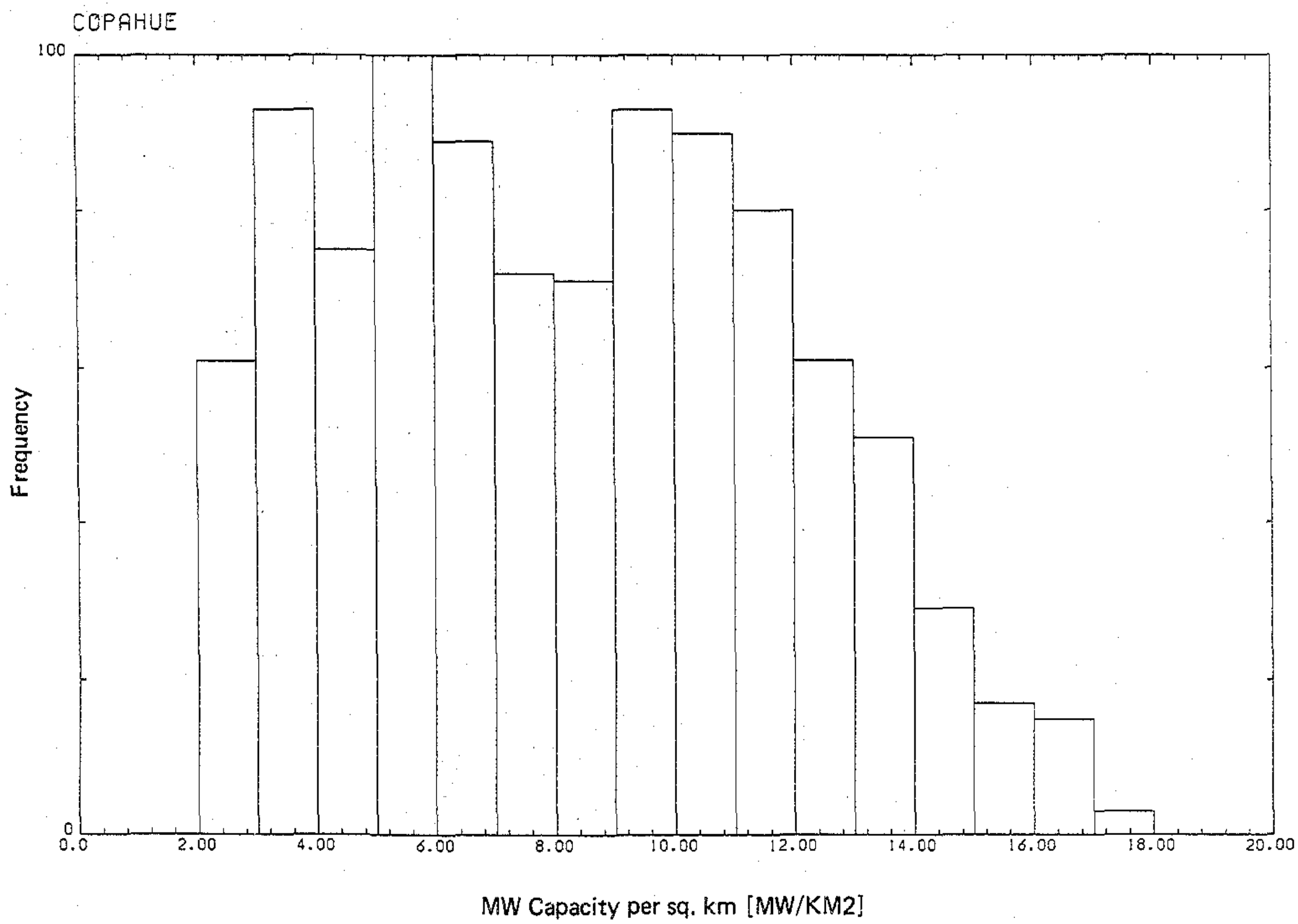


Fig. 5-69 Histogram of MW per Square Kilometer, Whole Area

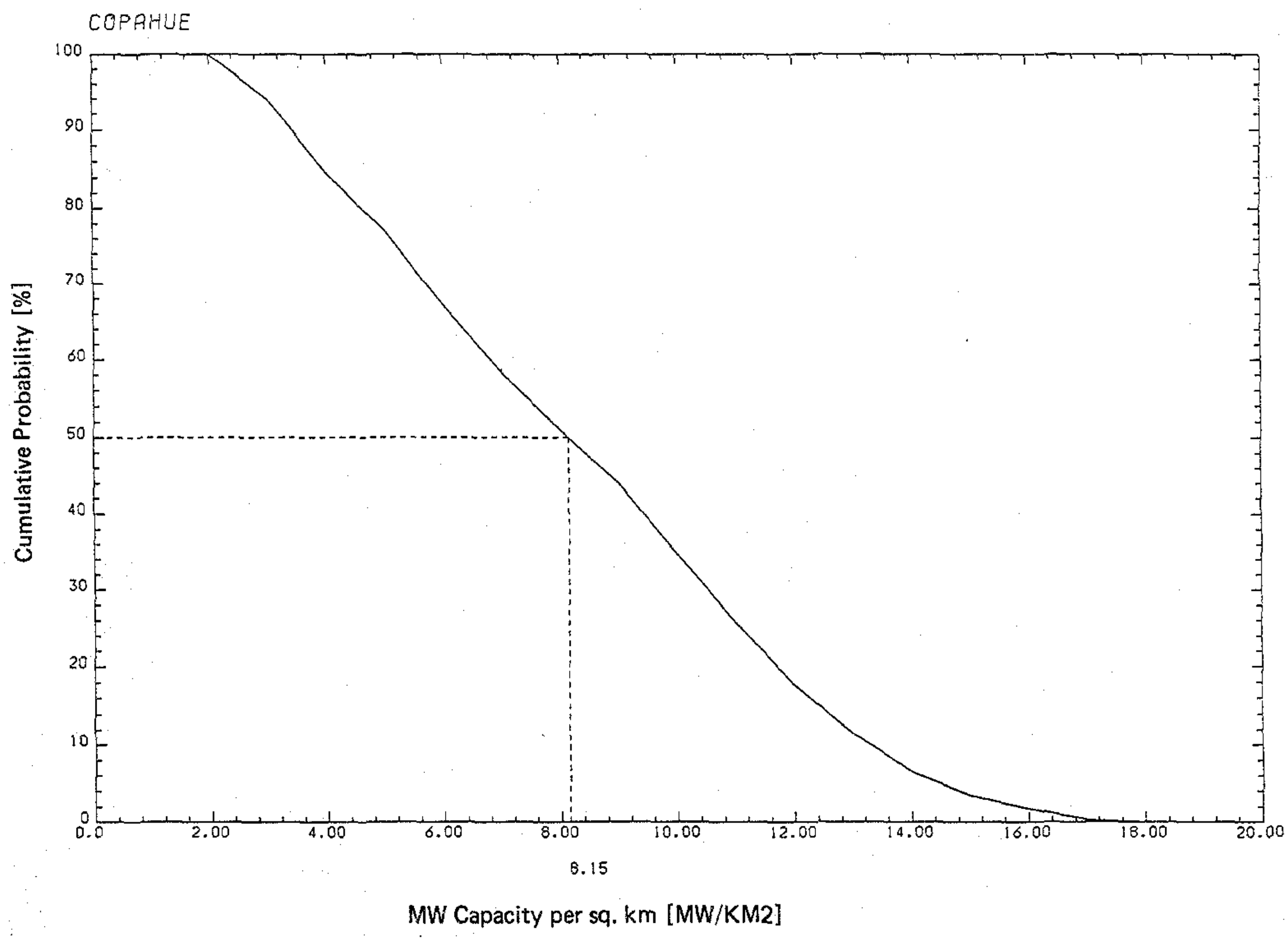


Fig. 5-70 Cumulative Probability of *MW* per *Square* Kilometer, Whole Area

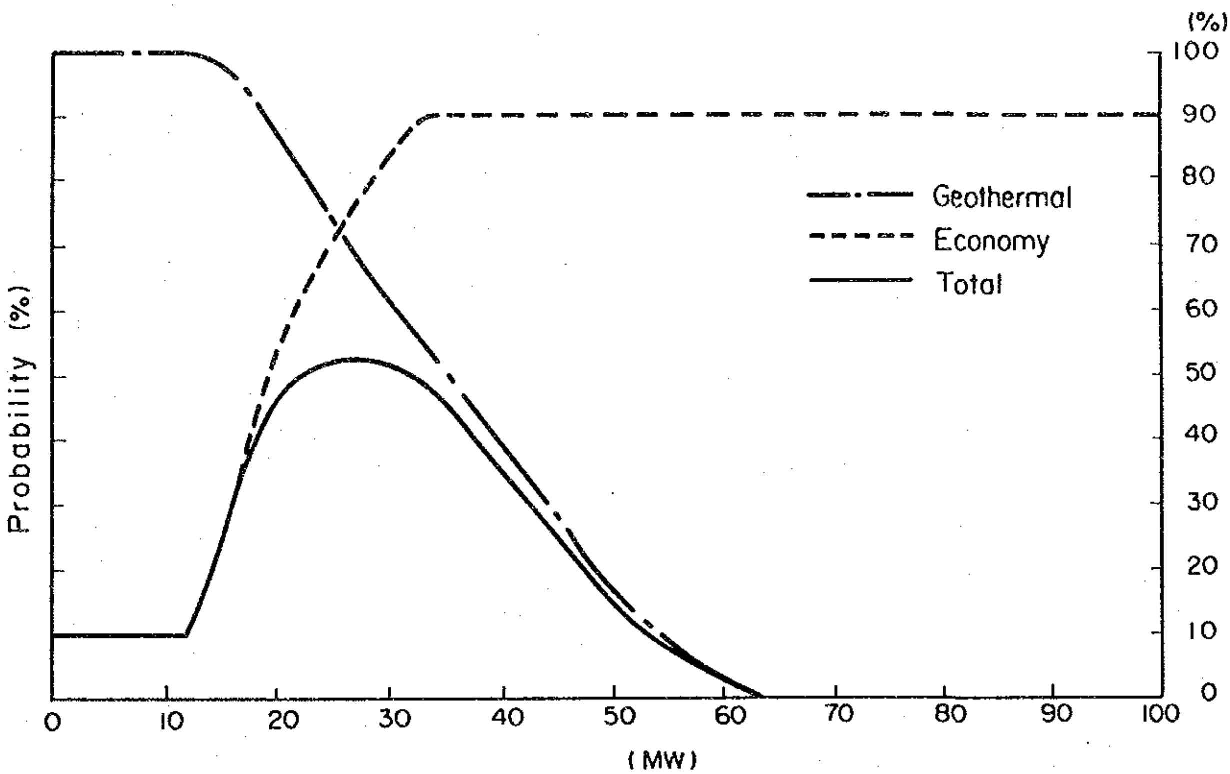


Fig. 5-71 Evaluation Curve of Plant Capacity

Table 5-1 List of Geothermal Investigation Works in Copahue Area

Investigation Works	Year	Administration *1	Executer	Scope of Investigation Works	No. of Data *2
Geological survey	1974	CNEG	YPF	regional survey	-
	1980	COPADE	L-ELC	detailed survey	C1, 13
	1987		A. H. Pesce	volcano-tectonics	C6
Geophysical prospecting					
Gravity prospecting	1975	CNEG	YPF	180 km^2, 285 points	C26-27
Electrical prospecting	1980	COPADE	L-ELC	AB/2=2000m, 56 points 69 lines	C1
	1981	"	"	AB/2=5000m, 7 points 15 lines	C3
	1987	CREGEN	CREGEN	AB/2=1500m, 11 points	
Geochemical survey	1974	CNEG	YPF		-
Soil geochemistry	1986	CREGEN	CREGEN	Hg, CO_2, 1m depth temperature 10km^2, 70 points + 8 km^2, 50 points	C7
Fluid geochemistry	1980-87	COPADE CREGEN	L-ELC CREGEN	surface water, fluids of fumarole, well fluid, analysis of chemical conposition and isotope	C1,18-23
Well survey					
Thermal gradient hole	1975-76	CNEG	YPF	11-200m, 17 wells	C28,29
Exploratory well COP-1	1976	CNEG	YPF	954m, logging	C2,4,31,
"	1981	COPADE	YPF	deepen to 1414m	32,34
Exploratory well COP-2	1986	CREGEN	CREGEN	1241m, logging	C5,33, 34,35
Well test (COP-1, 2)	1981-87	COPADE CREGEN	L-ELC CREGEN	production test, hole temperature. pressure	C2,4,5, 31,36,37 38

*1 Administration
CNEG : Comision Nacional de Estudios Geotermicos
COPADE: Consejo de Planificacion para el Desarrollo
CREGEN: Centro Regional de Energia Geotermica del Neuquen
L-ELC : Latinoconsult/ELC-Electroconsult

*2 List of Collected Dates

Table 5-2 Stratigraphic Correlation between this Report and Other Reports

Age		LATINOCONSULT/ELC-Electroconsult (1980)	Pesce (1987)	This report
Quaternary	Holocene	Productos del Volcan Copahue	Centro Efusivo Copahue	Copahue Volcanic Rocks
	Pleistocene	Formación Palao-Co	Efusiones de Fondo de Valle	A° Trolope Volcanic Rocks
			Centro Efusivo Las Mellizas	Las Mellizas Formation Caviahue Conglomerate Member
Tertiary	Pliocene		Depositos Fondo de Caldera	Riscos Bayos Pyroclastic Flow Deposits
			Formación Hualcupen	Hualcupen Formation
	Miocene		Formación Trapa Trapa Formación Epulaufquén	?
Pre-Tertiary		Sedimentos de la Cuenca Neuquina	?	

Table 5-3 Chemical Composition of Ground Surface Water and Hot Spring Water

No.	Sample No.	Date	Temp. °C	pH	Conductivity µS/cm	Na	K	Ca	Mg	NH_4	HCO_3	SO_4	Cl	SiO_2 mg/l	No. of colle. data
						mg/l					mg/l				
						meq/l					meq/l				
1	Agrio 1	7.'80	12.3	5.25	260	6.7	0.8	9.2	1.5		20.0	60.0	20.0	3.0	C.1
						0.29	0.02	0.46	0.12		0.33	1.25	0.56		
2	Agrio 2	"	10.4	4.97	1,520	48.9	17.4	113.6	186.0		20.0	690.0	190.0	4.0	"
						2.13	0.45	5.67	15.31		0.33	14.35	5.36		
3	Agrio 3	"	11.2	4.48	4,400	141.0	36.5	393.0	765.0		0	2,360.0	5,040.0	27.0	"
						6.13	0.93	19.61	62.96		0	49.09	142.13		
4	CAV 1	"	13.5	1.80	11,500	25.2	14.9	7.8	45.0		0	2,100.0	520.0	12.0	"
						1.10	0.38	0.39	3.70		0	43.68	14.66		
5	CAV 2	"	14.6	2.60	1,520	7.4	1.2	2.8	12.5		0	250.0	50.0	4.0	"
						0.32	0.03	0.14	1.04		0	5.20	1.41		
6	CAV 5	"	12.6	5.42	260	8.9	1.2	21.1	15.0		30.0	90.0	20.0	10.0	"
						0.39	0.03	1.05	1.23		0.49	1.87	0.56		
7	CAV 6	"	11.0	5.52	260	9.6	2.3	11.4	16.0		0	100.0	50.0	6.0	"
						0.42	0.06	0.57	1.32		0	2.08	1.41		
8	CAV 7	"	11.1	6.98	350	7.4	0.3	18.5	21.0		30.0	80.0	20.0	7.0	"
						0.32	0.02	0.92	1.73		0.49	1.66	0.56		
9	ARA 2	"	12.1	7.25	24	2.8	0.3	1.4	1.2		40.0	10.0	10.0	8.0	"
						0.12	0.02	0.07	0.10		0.66	0.21	0.28		
10	ARA 4	"	9.0	6.00	390	11.9	1.2	12.8	33.0		30.0	120.0	20.0	12.0	"
						0.52	0.03	0.64	2.72		0.49	2.50	0.56		
11	ARA 6	"	14.0	0.75	20,000	95.0	99.6	14.2	87.0		0	9,140.0	4,870.0	38.0	"
						4.20	25.5	0.71	7.16		0	190.11	137.33		
12	HU 5	"		6.36	18	0.6	0.4	1.1	0.9		40.0	10.0	10.0	3.0	"
						0.03	0.01	0.05	0.07		0.66	0.21	0.28		
13	HAC 3	"	10.1	6.30	250	8.9	1.2	11.1	15.0		20.0	30.0	20.0	5.0	"
						0.39	0.03	0.55	1.23		0.33	1.66	0.56		
14	1T	"	12.3	6.75	20	0.7	0.4	0.7	0.9		50.0	10.0	10.0	12.0	"
						0.03	0.01	0.03	0.07		0.82	0.21	0.28		
15	3T	"	12.4	6.47	28	0.7	0.4	0.7	0.9		30.0	10.0	4.6	6.0	"
						0.03	0.01	0.03	0.07		0.49	0.21	0.13		
16	CO 1	"	7.6	6.05	20	0.7	0.4	0.7	0.3		30.0	10.0	10.0	12.0	"
						0.03	0.01	0.03	0.02		0.49	0.21	0.28		
17	CO 2	"	8.0	6.10	3	0.4	0.4	0.7	0.3		0	20.0	20.0	8.0	"
						0.02	0.01	0.03	0.02		0	0.42	0.56		
18	CO 4	"	8.9	6.35	12	0.4	0.4	0.7	0.3		30.0	10.0	10.0	9.0	"
						0.02	0.01	0.03	0.02		0.49	0.21	0.28		
19	CO 5	"	12.0	6.20	8	0.7	0.4	0.7	0.3		30.0	10.0	20.0	7.0	"
						0.03	0.01	0.03	0.02		0.49	0.21	0.56		
20	CO 7	"	10.1	6.31	16	0.5	0.4	0.7	0.3		0	170.0	20.0	8.0	"
						0.02	0.01	0.03	0.02		0	3.54	0.56		
21	CO 8	"	9.5	6.20	9	0.4	0.4	0.7	0.3		30.0	10.0	10.0	6.0	"
						0.02	0.01	0.03	0.02		0.49	0.21	0.28		
22	CO 10	"	10.2	6.35	116	5.9	1.2	5.7	8.7		30.0	10.0	30.0	5.0	"
						0.26	0.03	0.28	0.72		0.49	0.21	0.85		
23	CO 11	"	11.2	6.10	114	6.7	1.2	6.0	7.3		30.0	10.0	30.0	7.0	"
						0.29	0.03	0.30	0.64		0.49	0.21	0.85		
24	CO 12	"	10.5	5.04	230	9.6	1.7	9.2	15.0		20.0	100.0	30.0	9.0	"
						0.42	0.04	0.46	1.23		0.33	2.08	0.85		
25	CO 15	"	10.4	4.20	26	0.7	0.4	1.1	0.3		20.0	10.0	20.0	4.0	"
						0.03	0.01	0.05	0.02		0.33	0.21	0.56		
26	RHCP 3	"	12.1	6.55	34	2.2	0.4	2.1	1.6		40.0	10.0	10.0	10.0	"
						0.10	0.01	0.10	0.13		0.66	0.21	0.28		
27	HA 3	"	11.2	7.48	55	3.0	0.3	2.5	2.7		30.0	10.0	10.0	14.0	"
						0.13	0.02	0.12	0.22		0.49	0.21	0.28		
28	MA 2	"	84.6	5.82	1,720	2.7	4.5	0.6	3.6	206.0	146.4	350.0	20.0	18.0	"
						0.12	0.12	0.03	0.30	11.45	2.40	7.28	0.56		
29	MA 3	"	91.2	6.55	1,980	1.0	1.2	0	0	227.0	194.0	374.0	23.0	24.0	"
						0.04	0.03	0	0	12.62	3.18	7.78	0.65		
30	MA 5	"	17.4	4.24	68	3.7	0.7	3.6	3.0	0	14.6	12.0	16.0	7.0	"
						0.16	0.02	0.18	0.25	0	0.24	0.25	0.45		
31	MA 7	"	84.0	4.32	1,640	5.8	6.3	1.6	8.3	189.0	0	342.0	13.0	11.0	"
						0.25	0.16	0.08	0.68	10.51	0	7.11	0.37		
32	MA 9	"	91.8	6.95	380	12.8	5.1	0.6	0.6	0	230.0	52.0	16.0	19.0	"
						0.56	0.13	0.03	0.05	0	3.77	1.08	0.45		
33	MAT 4	"	80.5	4.01	2,800	15.7	17.7	1.6	5.4	276.0	0	530.0	40.0	21.0	"
						0.68	0.45	0.08	0.44	15.35	0	11.02	1.13		
34	MAT 6	"	87.0	2.45	4,220	12.8	11.9	2.9	11.4	147.0	0	636.0	23.0	6.0	"
						0.56	0.30	0.14	0.94	8.17	0	13.23	0.65		
35	ANF 3	"	82.6	5.72	1,480	1.0	1.0	0	0	189.0	0	330.0	21.0	9.0	"
						0.04	0.03	0	0	10.51	0	8.68	0.59		
36	ANF 5	"	36.4	6.30	660	63.8	4.8	8.0	26.4	0	256.0	97.0	16.0	15.0	"
						2.78	0.12	0.40	2.17	0	4.20	2.18	0.45		
37	ANF 6	"	11.2	5.36	31	1.0	0	2.1	1.1	0	13.4	10.0	18.0	18.0	"
						0.04	0	0.10	0.09	0	0.22	0.21	0.51		
38	COPA 5	2.'85	61	6.6		53	23	51	30		474	13	2	90	C.18
						2.30	0.59	2.55	2.50		7.90	0.27	0.06		
39	COPA 6	"	51.5	5.9		38	19	39	13		282	23	1	100	"
						1.65	0.49	1.95	1.08		4.70	0.48	0.03		
40	COPA 7	"	34	5.9		19	6.2	61	9.5		287	12	2	80	"
						0.83	0.16	3.05	0.79		4.78	0.25	0.06		

Note: No. 1 - No. 27: Ground surface water
No. 28 - No. 40: Hotspring water

Table 5-4 Gas Composition and Geochemical Temperature

Sample No.	Date	Gas Composition (Vol %)					Geochemical Temperature			No. of Collected data
		CO_2	H_2S	H_2	N_2	CH_4	α	β	T (°C)	
Chancho Có	'77	66.93	16.75	16.22		0.06	–0.60	–7	(598)★	C.20
〃	〃	75.69	10.75	13.25		0.31	2.31	0	(373)★	〃
Anfiteatro	'77	95.04	0.32	2.06		2.65	14.72	0	215★	C.20
〃	7.'80	93.14	n.d.	3.72	0.50	2.62	12.69	0	235	C.1
〃	〃	〃	〃	1.31	〃	〃	15.37	0	209	〃
〃 2	6.'82	95.36	0.1	1.34	0.51	2.68	17.00	0	194	C.4
Rio Blanco	11.'86	92.66	0.52	1.86	2.55	2.41	13.77	0	224★	C.22
〃	〃	92.24	0.41	1.91	2.85	2.62	14.07	0	221★	〃
B° de Copahue	'77	96.30	0.003	2.29		1.41	19.59	0	172★	C.20
〃	〃	95.59	0.04	2.45		1.93	16.29	0	200★	〃
〃	〃	96.55	0.46	1.14		1.85	15.10	0	211★	〃
〃	〃	96.34	0.26	2.10		1.26	13.91	0	223★	〃
Termas de Copahue 2	7.'80	89.63	n.d.	5.89	2.19	2.32	12.78	0	234	C.1
〃 2	〃	〃	〃	3.24	〃	〃	14.34	0	218	〃
〃 6	〃	93.81	n.d.	4.59	tr	1.61	13.25	0	229	〃
〃 6	〃	〃	〃	2.25	〃	〃	15.11	0	211	〃
Copahue (COT 6)	6.'82	95.94	0.1	2.30	tr	1.64	15.13	0	211	C.4
〃 (COT 2)	〃	91.94	0.1	3.32	2.24	2.37	14.36	0	218	〃
Termas de Copahue	11.'86	94.56	0.62	1.62	2.15	1.02	13.18	0	230★	C.22
〃	〃	94.19	0.56	1.57	2.57	1.11	13.49	0	227★	〃
Aqua de Lemon	11.'86	91.73	0.64	1.54	4.92	1.17	13.33	0	229★	〃
Las Maquinitas	'77	96.13	0.50	1.74		1.63	13.76	0	224	C.1
〃	〃	94.69	0.17	2.60		2.74	14.53	0	217	〃
〃 1	7.'80	94.80	n.d.	3.50	0.23	1.42	13.88	0	223	〃
〃 1	〃	〃	〃	1.85	〃	〃	15.53	0	207	〃
〃	'81	94.8	n.d.	1.8	0.2	1.4	15.60	0	206	C.2
〃 1	6.'82	96.39	0.1	1.83	0.23	1.44	15.63	0	206	C.4
〃	11.'86	95.4	0.53	1.45	1.32	1.3	13.94	0	222★	C.22
〃	〃	95.6	0.44	1.7	1.96	1.3	13.74	0	224★	〃
Las Maquinas	'77	93.46	0.15	2.7		3.65	14.50	0	217	C.1
〃	〃	93.95	0.65	2.34		3.05	13.12	0	230	〃
〃 1	7.'80	92.68	n.d.	2.57	3.08	2.45	15.09	0	211	〃
〃 1	〃	〃	〃	2.08	〃	〃	15.04	0	206	〃
〃 4	〃	91.85	n.d.	3.00	2.57	2.77	14.75	0	214	〃
〃 4	〃	〃	〃	2.35	〃	〃	15.39	0	208	〃
〃	'81	92.7	n.d.	2.1	3.1	2.5	15.63	0	206	C.2
〃 1	6.'82	92.68	0.1	2.08	3.08	2.45	15.63	0	206	C.4
〃 4	〃	91.87	0.1	2.35	2.57	2.77	15.39	0	208	〃
〃	11.'86	93.29	0.62	1.68	2.23	2.18	13.74	0	224★	C.22
COP-I	'81	94.0	0.3	2.0	1.2	2.5	14.37	0	218	C.2
〃 (No. 1)	6.'82	94.02	0.24	1.89	1.03	2.53	14.81	0	214	C.4
〃 (No. 2)	〃	93.62	0.15	1.92	1.53	2.43	15.34	0	209	〃
〃 (No. 3)	〃	93.35	0.17	1.87	1.30	3.01	15.42	0	208	〃
〃 (No. 4)	〃	93.72	0.16	2.01	0.9	2.96	15.31	0	209	〃
〃 (No. 5)	〃	92.31	0.15	1.89	2.5	2.76	15.45	0	208	〃
〃 (No. 6)	〃	91.97	0.14	1.92	2.81	2.55	15.42	0	208	〃
〃 (No. 7)	〃	93.63	0.28	2.62	1.81	1.63	13.37	0	228	〃
Pozo Copahue 1	11.'86	93.7	0.51	1.6	2.45	1.7	13.92	0	223★	C.22
〃 2	〃	94.2	0.80	1.2	2.6	1.2	13.79	0	224★	C.22
COP-I steam	6.'91	90.49	0.76	2.98	2.44	3.27	12.24	0	240★	JICA
COP-3 steam	〃	95.79	0.39	0.93	2.35	0.52	14.72	0	215★	JICA
〃	〃		0.45							CREGEN

★ : Calculated by JICA

Table 5-5 Isotope Analysis of Meteoric Water and Geothermal Fluid

No.	Sample No.	Date	Temp °C	Type of Sample	EL. of Sampling Point m	$\delta^{18}O$ ‰	δD ‰	^3H TU	No. of Collected Data
I-1	COP-I	2.'82		Vapor (COP-I)	2,000	–10.5	–84.0		C 18
I-2	COPA-2	2.'85	242	"	"	–9.6	–82.7	0.6 ± 0.7	"
I-3	COP-I	11.'86		"	"	–8.2	–74 –76		
I-4	COP-II	2.'85		Vapor (COP-II)		–10.8	–85		
I-5	COP-II	11.'86		"		–7.7	–80 –83		
I-6	COPA-1	2.'85	130	Vapor (MAT)		–10.8	–84.2	0.8 ± 0.7	C 18
I-7	COPA-3	"	85	Vapor (MA)		–10.6	–85.1	0.0 ± 0.6	"
I-8	COPA-20	"		Vapor (COP)	2,010	–12.8	–90.2		"
I-9	COPA-5	"	61	Hot spring	2,020	–11.9	–84.2	2.5 ± 0.7	"
I-10	COPA-6	"	51.5	"	2,020	–11.9	–84.3		"
I-11	COPA-4	"	51	"	2,020	–11.9	–84.7	1.7 ± 0.7	"
I-12	COPA-7	"	34	"	2,010	–12.0	–84.3	3.3 ± 0.7	"
I-13	COPA-9	"	26	"		–12.2	–83.3		"
I-14	CAVI-4	"	12	River	1,670	–11.3	–81.9	3.6 ± 0.5	"
I-15	COPA-8	"		"	2,040	–11.8	–84.3	2.4 ± 0.7	"
I-16	COPA-12	"		Spring	2,310	–11.9	–84.6	3.6 ± 0.7	"
I-17	CAVI-1	"	13	Spring water for drinking		–11.5	–81.7	3.9 ± 0.4	"
I-18	VAF-1	4.'85	8	Spring	2,050	–12.5	–90.1	4.8 ± 0.7	"
I-19	CAVI-3	2.'85	10	River	1,420	–12.9	–92.5	4.5 ± 0.4	"
I-20	VAF-2	4.'85	7	Spring	1,820	–13.5	–97.2	1.8 ± 0.4	"
I-21	CAVI-2	2.'85	10	"	1,660	–12.9	–93.5	3.2 ± 0.7	"
I-22	VAF-3	4.'85	11	"	1,674	–13.6	–94.5	1.8 ± 0.7	"
I-23		6.'91		Vapor (COP-1)	2,000	–11.5	–100.1		JICA
I-24		6.'91		Vapor (COP-3)	2,011	–9.4	–85.3	< 0.3	"
I-25		6.'91		Hot water (")	2,011	–4.3	–62.4		"

Table 5-6 Quantity of Geochemical Survey in Wells

Well name	Analysis Item	Sampling Date
COP-1	Gas Vapor Ratio	13 JUNE 1991
	Chemical Composition of Gas	13 JUNE 1991
	Chemical Composition of Condensate Water	13 JUNE 1991
COP-3	Gas Vapor Ratio	11 & 15 JUNE 1991
	Chemical Composition of Gas	11 JUNE 1991
	Chemical Composition of Condensate	9-14 JUNE 1991
	Chemical Composition of Hot Water	15 JUNE 1991

Table 5-7 Chemical Analysis of Geothermal Fluid from COP-1 and COP-3 Wells

Well	Sampling Date	Gas Vapor Ratio (Volume%)	Chemical Composition: Gas (Volume%), Vapor (mg/l)			
COP-1	June 1991	Gas 5.28	Gas	91.25	CO_2	90.49
					H_2S	0.76
			Residual Gas	8.75	Ar	0.05 *
					CH_4	3.27
					H_2	2.98
					He	0.00
					N_2	2.44
		Vapor 94.72	pH	5.6		
			EC	470	(μs/cm)	
			TSM	24	(mg/ℓ)	
			Na^+	0.23	Cl^-	11
			K^+	0.1	SO_4^{2-}	13
			Ca^{2+}	0.58	HCO^{3-}	90
			Mg^{2+}	0.05	CO_3^{2-}	0
			B	<0.1		
			NH_4^+	<0.1		
COP-3	June 1991	Gas 5.0 **	Gas	96.18	CO_2	95.79
					H_2S	0.39 ***
			Residual Gas	3.82	Ar	0.02
					CH_4	0.52
					H_2	0.93
					He	0.00
					N_2	2.35
		Vapor 95.0 **	pH	5.8		
			EC	830	(μs/cm)	
			TSM	17	(mg/ℓ)	
			Na^+	0.31	Cl^-	18
			K^+	0.1	SO_4^{2-}	11
			Ca^{2+}	0.21	HCO^{3-}	83
			Mg^{2+}	0.01	CO_3^{2-}	0
			B	1		
			NH_4^+	21		

* Air contamination is high percentage.
** Average of 10times mesuring.
*** CREGEN's value is 0.45%.

Table 5-8 Chemical Analysis of Hot Water from COP-3 Well

Sampling Date	Chemical Composition	(mg/l)				
June. 1991	pH	7.7				
	EC	300 (μs/cm)				
	TSM	150 (mg/ℓ)				
	Na^+	3.1	T-Fe	0.81	F^-	1.0
	K^+	0.9			T-Hg	0.02
	Ca^{2+}	2.1	Cl^-	2.2	H_2S	<1
	Mg^{2+}	0.16	SO_4^{2-}	11	As^{3+}	0.15
	B	40	HCO^{3-}	178		
	NH_4^+	<0.8	CO_3^{2-}	0.5		
	Mn^{2+}	<0.2	Br^-	<0.5		
	Li	<0.1	I^-	<0.1		

Table 5-9 Isotope Analysis of Geothermal Fluid from COP-1 and COP-3

Loc.		δD (‰)	$\delta^{18}O$ in H_2O (‰)	$^{13}C/^{12}C$ in CO_2 (‰)	$^{34}S/^{32}S$ (‰)	^3H (TU)
COP-1	Condensate	-100.1	-11.5	-8.9	+ 3.6	–
COP-3	Condensate	- 85.3	- 9.4	-9.3	- 3.6	<0.3
COP-3	Hot Water	- 62.4	- 4.3 *	-14.1	+12.3	–

* $\delta^{18}O$ value in SO_4 is not mesured for it's low content

Table 5-10 Results of X-ray Analysis on COP-1 and -2

Well No.	Depth	Lm	Wa	Mo	Ch/Mo	Se/Mo	Ch	Se	Ka	Cc	Qz	Pl	K-f	Pr	Ep	Hem	Remarks
COP-1	130m			1								3	1			1	Cuttings
	230m			1								3				1	"
	360m			1						1		3					"
	458-463m			1	1	1	1			1	3	3				1	Core
	541m			1	1		1				3	3				1	Cuttings
	630-631m	1			1	1				1	2	3				1	Core
	720m			1	1						1	3					Cuttings
	801m		?	1			1	1		1	3	3					"
	930m		?				1			1	1	3	2	1			Core
COP-2	415m			1	1		2			1	3	3					Cuttings
	602m			1	1		1			1	3	3					"
	643m		2	1			1	1	1		3	3		1	1		"
	844m						2				3	3		?	1		"
	883m						2				3	3		?	1		"
	970m						1				3	3			3		"
	1030m						2				3	3		2	2		"
	1160m			1			2			?	3	3			1		"
	1205m			1			1				3	3		?	1		"

Abbriviation Lm: Laumontite, Wa: Wairakite, Mo: Montmorillonite Ch/Mo: Chlorite/Montmorillonite mixed-layer mineral, Se/Mo: Sericite/Montmorillonite mixed-layer mineral, Ch: Chlorite, Se: Sericite, Ka: Kaorinite, Cc: Calcite, Qz: Quartz, Pl: Plagioclase, K-f: K-feldspar, Pr: Prehnite, Ep: Epidote, Hem: Hematite

Number in this table means a relative intensity of detected minerals (3 > 2 > 1).

Specimens of COP-2 between 844 m and 1205 m were not able to be analyzed by the oriented X-ray analysis because of the scarcity of specimens.

Table 5-11 Characteristics of Alternative Location of COP-3

Item \ Site	A	B	C
1. Geology			
° Structure	Graben/Horst	Horst	Horst
° Formation	Las Mellizas F./Hualcupen F.	Las Mellizas F./Hualcupen F.	Las Mellizas F./Hualcupen F.
° Fault and Lineament	WNW-ESE; Predominant continuous fault NW-SE ; Lineament	NW-SE ; Reverse fault ENE-WSW; Lineament	NE-SW; Consentrated Parallel fault system
2. Gravity Prospecting			
° Bouguer Anomaly	High anomaly area	High anomaly area	High anomaly area
° Depth of Gravity Basement	About 1,600 m	About 1,600 m	About 1,600 m
3. Temperature Gradient of Shallow Zone	High	High	High
4. Electrical Prospecting			
° Depth to Top of High Resistivity Basement	About 650 m	About 750 m	About 400 m
° Deep Low Resistivity Layer and Depth	Detect (Measurement Point D-I) About 1,800 m	Detect (Measurement Point D-II) About 1,800 m	No detect (Measurement Point D-14)
° Electrical Fault	Between No. 65/66 and No. 39 (concordant with geology)	None	None
5. Geochemical Survey			
° Temperature from Geothermometer	205 - 230°C	205 - 230°C	205 - 230°C
6. Topography			
° Accessibility	Good	Good	Bad
° Altitude	About 2,010 m	About 2,040 m	About 2,090 m
7. Distance from the Site to Manifestation	2.2 km (to Copahue) 2.2 km (to Maquinas)	0.6 km (to Maquinas) 1.8 km (to Copahue)	1.2 km (to Copahue)

Table 5-12 Result of Microscopic Observation for COP-3

(Observation : Lic. Ana María Casé)

PROF. No	GRADO DE ALTER.	ROCA	TEXTURA	MINERALES FORMADORES DE ROCA							MINERALES DE ALTERACION															
				Qz	Pl	Bi	Au	Hy	Ho		Qz	M	Ch	Se	Ch/M	Ka	Cc	Ep	Pr	Ap	Ga	Ze	Wa	Ac	Le	Py
* 10 m	2	LAVA ANDESITICA			4		1	1			1		1							1		1			2	1
* 50	3	LAVA ANDESITICA			4		1	1			1		1		3		1			1						2
* 80	4	TOBA ANDESITICA		1	4						1		4		1	1									2	
* 110	4	LAVA BRECHADA			3								4			1	1						1		2	1
* 160	4	TOBA		2	3						1		3		1		1			1					3	1
* 210	3	ANDESITA		1	3		1						2		2		2			1						2
* 290	3	ANDESITA			3		2						3	1		1	2								2	2
293.3	5	LAVA BRECHADA	IRRECONOCIBLE								3		2		1-2		2			1					3	1
* 350	1	ANDESITA			3	1	2						1			1				1						1
* 430	1 − 2	ANDESITA			3		2				1			1												
* 490	4	TOBA										4	2		2	2	2									2
* 528	1	BASALTO			3	1		2									1									1
* 560	2	ANDESITA			3		1	1	2		1	1	2	2	2	1				1					1	1
* 670	4	TOBA		2	2								2	1		3	2	1							2	
* 710	3	ANDESITA			3						1		3				2								2	2
* 740	4	TOBA ANDESITICA		1	3								3				2	2							2	2
801.7	3	ANDESITA			3						1		3				1	2	1						2	1
* 811	3	ANDESITA			3						2		3			2		2	2						2	1
* 819	4	ANDESITA			3						2		3					2	2	1			1		2	
824.7	3	LAVA ANDESITICA		3	3								3					2							2	
* 838	4	ANDESITA									2	3	3					2	1					1	2	1
862.2	4	ANDESITA			4								2				2	3	1					1	3	2
882.1	3	ANDESITA			4						1		2		3			2	1						3	
956.8	3	ANDESITA	PORF. PASTA: INTERSERTAL		4						1		2					2							2	
1002.9	3	BRECHA		4	1						3		1					2	1				2	3	2	
1015.0	3	ANDESITA	PORFIRICA		4						1		3		1			2	2				1		1	
1022.2	3	AND. QZOSA	PORF. PASTA: HIPIDIOM GRANU	1	4						1		2					2	1		?			1	2	
1035.0	2	AND. QZOSA	INTERSERTAL	1	4	1	1						2					2						1	1	
1045.86	2 − 3	AND. QZOSA	INTERSERTAL	1	4		1						2					1			1			1	1	
1055.35	1 − 2	AND. QZOSA	INTERSERTAL	1	4	1	1						2					2							1	
1064.26	2 − 3	AND. QZOSA	INTERSERTAL	1	4		1						2					2							1	

* : CUTTING

Table 5-12 Result of Microscopic Observation for COP-3 (continued)

(Observation : JICA)

PROF. No	GRADO DE ALTER.	ROCA	TEXTURA	MINERALES FORMADORES DE ROCA							MINERALES DE ALTERACION													
				Qz	Pl	Bi	Au	Ol	Ho	Op	Qz	M	Ch	Ch/M	Se/M	Ka	Cc	Ep	Pr	Ga	Wa	Ac	Le	Py
293.2 m	4	TOBA	CLASTICO	4	?						1	2	3		2	2	3							1
528.8	2	BASALTO	PORFIRITICA		4/4	/1	?/4			1/2	1		/1				3/2							
783.0	2	OLIVINA BASALTO	PORFIRITICA		4/4		?/2	4/?		1/3	1	4/4												
1005.9	3 − 4	ANDESITA ALTERADA	PORFIRITICA		3/3		?		?	?	/2		2/3					1/1			/1		/2	
1020.6	3 − 4	ANDESITA ALTERADA	PORFIRITICA		3/3		?		?	(1)/(1)	/3		2/2					2/1	2/				1/1	
1027.7	3	ANDESITA ALTERADA	PORFIRITICA		4/3		?		?	?	/2		/3				/1	1/1	1/1				/1	
1030.6	3	PORFIDO ALTERADA	HOLOCRISTALINO	1	4		2		?	(1)			3	2			1	1	1			1	1	
1040.5	3	PORFIDO ALTERADA	HOLOCRISTALINO	1	4		2		?	1			2	2				1		1		1	1	
1053.1	3	PORFIDO ALTERADA	HOLOCRISTALINO	1	4		2		?	1			1	3				1		1		2	1	
1064.3	3	PORFIDO ALTERADA	HOLOCRISTALINO	1	4		2		?	1			2	2			1	1		1		1	1	

GRADO DE ALTERACION

1 : FRESCO

|

5 : FUERTE

CANDIDAD DE MINERALES

1 : POCO

|

5 : MUCHO

PORFIDOBLASTO/PASTA

2/3

MINERALES FORMADORES DE ROCA

- Qz : CUARZO
- Pl : PLAGIOCLSA
- Bi : BIOTITA
- Au : AUGITA
- Hy : HIPERSTENO
- Ol : OLIVINA
- Ho : HORNBLENDA
- Op : OPACO

MINERALES DE ALTERACION

- Qz : CUARZO
- M : MONTMORILLONITA
- Ch : CLORITA
- Se : SERICITA
- Ch/M : CLORITA/MONTMORILLONITA
- Se/M : SERICITA/MONTMORILLONITA
- Ka : CAOLINITA
- Ap : APATITA
- Cc : CALCITA
- Ep : EPIDOTO
- Pr : PREHNITA
- Ga : GRANATE
- Ze : CEOLITA
- Wa : WAIRAKITA
- Ac : ACTINOLITA
- Le : LEUCOXINO
- Py : PIRITA

Table 5-13 Result of X-ray Analysis of COP-3

Depth	Sample	Stilbite	Laumontite	Wairakite		Montmorillonite	Chlorite/Mont	Chlorite	Sericite/Mont	Sericite		Kaolinite	Pyrophyllite		Calcite		Quartz	Plagiclase	K-feldspar		Prehnite	Epidote	Garnet	Pyrite		Pyroxene	Amphibole
20 m	BULK	2?				4		2							9		18	4	3			2?		3			
	ORIENT	?				○									◎		◎	◎	•					○			
	E. G.	?				○																					
	HCL																										
50 m	BULK					2									3		15	21	3			3?		3			
	ORIENT					•									○		◎	◎	○			•					
	E. G.					•																					
	HCL					•																					
80 m	BULK					4		4							5		14	18				3?					
	ORIENT					•		•							○		◎	◎									
	E. G.					•		•																			
	HCL					•																					
120 m	BULK					3		3							6		21	7	3								
	ORIENT					•		•							○		◎	○	•								
	E. G.					•		•																			
	HCL					•																					
170 m	BULK					2		3							5		23	22	3					2			
	ORIENT					•		•							○		◎	◎	•					•			
	E. G.					•		•																			
	HCL					•																					
200 m	BULK					3		3				3?			6		18	15									
	ORIENT					•		•							○		○	◎									
	E. G.					•		•																			
	HCL					•																					
250 m	BULK						3	3				3?			5		12	10				2?					
	ORIENT						○	○							○		◎	◎									
	E. G.					•		•																			
	HCL																										
280 m	BULK					3	○	3				3			10		13	5						2			
	ORIENT					○	○					•			◎		◎	○						•			
	E. G.					○		•				•															
	HCL					○						•															
294.2 m	BULK							3				4			5		10	9				•					
	ORIENT							○				○			○		◎	◎									
	E. G.							○		•		○															
	HCL							•				○															

Analyzed by Dra. Graciela Mas

Figure of Bulk : Quartz Index

◎ : Large Volume

○ : Medium Volume

• : Small Volume

Table 5-13 Result of X-ray Analysis of COP-3 (continued)

Depth	Sample	Stilbite	Laumontite	Wairakite		Montmorillonite	Chlorite/Mont	Chlorite	Sericite/Mont	Sericite		Kaolinite	Pyrophyllite		Calcite		Quartz	Plagioclase	K-feldspar		Prehnite	Epidote	Garnet	Pyrite		Pyroxene	Amphibole
m 320	BULK						3					3			5		9	12				2?					
	ORIENT						•					•			○		◎	◎									
	E.G.					•		•				•															
	HCL											•															
m 350	BULK														4		3	15				•					
	ORIENT																○	◎				○					
	E.G.																										
	HCL																										
m 400	BULK						3	3				?			8		12	6									
	ORIENT						○	○							◎		◎	◎									
	E.G.					•		•																			
	HCL					•																					
m 420	BULK						3	3				?			4		9	11				2?					
	ORIENT						•					•			•		○	◎									
	E.G.					•		•				•															
	HCL					•						•															
m 450	BULK						3			2		3			10		20	4						2			
	ORIENT						•			•		•			○		◎	•						•			
	E.G.					•		•				•															
	HCL					•						•															
m 480	BULK							3		2		3			10		25	9	3								
	ORIENT							•		•		•			○		◎	○									
	E.G.							•		•		○															
	HCL									•		○															
m 528	BULK					3		?		2		3			39		10	2						4			
	ORIENT					•						•			◎		○	•						•			
	E.G.					•						•															
	HCL					•						•															
m 560	BULK					3				2		3			3		6	17						2			
	ORIENT					•				•		•			•		○	◎						•			
	E.G.					•						•															
	HCL					•						•															
m 600	BULK					3						2			6		8	12				2					
	ORIENT					•						•			○		○	◎				•					
	E.G.					•						•															
	HCL					•						•															

Analyzed by Dra. Graciela Mas

Figure of Bulk : Quartz Index

◎ : Large Volume

○ : Medium Volume

• : Small Volume

Table 5-13 Result of X-ray Analysis of COP-3 (continued)

Depth	Sample	Stilbite	Laumontite	Wairakite		Montmorillonite	Chlorite/Mont	Chlorite	Sericite/Mont	Sericite		Kaolinite	Pyrophyllite		Calcite		Quartz	Plagioclase	K-feldspar		Prehnite	Epidote	Garnet	Pyrite		Pyroxene	Amphibole
m 620	BULK						3			2		4			9		13	8						2			
	ORIENT						•					○			◎		◎	◎						•			
	E.G.					•		•				•															
	HCL					•		?				•															
m 660	BULK			2?				2		2		4			9		12	7				2					
	ORIENT			?				•		•		○			◎		◎	○				•					
	E.G.							•		•		○															
	HCL							?				○															
m 720	BULK							4				3			6		9	10	3			2					
	ORIENT							○				○			◎		◎	◎									
	E.G.							○				○															
	HCL							•				○															
m 760	BULK							3		2		4			9		10	9				3					
	ORIENT							•				○			◎		◎	◎				•					
	E.G.							•				○															
	HCL							•				○															
m 785	BULK					3		3									22	8	3			3		3			2
	ORIENT					•		•									◎	○	•			•		•			•
	E.G.					•		•																			•
	HCL					•																					•
m 789.4	BULK					4		3							3		11	8				3		3			2
	ORIENT					○		•							•		○	◎						•			•
	E.G.					○		•																			•
	HCL					•																					•
m 812	BULK							3				5			15		4	20				3					
	ORIENT							•				•			○		•	◎				•					
	E.G.							•				•															
	HCL							•				•															
m 819.8	BULK							6				5					10	7	4		3	3					
	ORIENT							○				•					◎	○	•			•					
	E.G.							○				•															
	HCL							•				•															
m 822	BULK							5				?					7		3		5	4					
	ORIENT							◎									◎		•		◎	○					
	E.G.							◎																			
	HCL							○																			

Analyzed by Dra. Graciela Mas

Figure of Bulk : Quartz Index

◎ : Large Volume

○ : Medium Volume

• : Small Volume

Table 5-13 Result of X-ray Analysis of COP-3 (continued)

Depth	Sample	Stilbite	Laumontite	Wairakite		Montmorillonite	Chlorite/Mont	Chlorite	Sericite/Mont	Sericite		Kaolinite	Pyrophyllite		Calcite		Quartz	Plagioclase	K-feldspar		Prehnite	Epidote	Garnet	Pyrite		Pyroxene	Amphibole
m 827.8	BULK							4				?			11		5	13			2	3					
	ORIENT														◎		○	◎			•						
	E.G.																										
	HCL																										
m 854.5	BULK							4				3					26	12	3		2	2					
	ORIENT							○				•					◎	◎			•						
	E.G.							○				•															
	HCL							?				•															
m 866	BULK							5				4?			3			14	3		3	5					
	ORIENT							•							•			◎	•		○						
	E.G.							•																			
	HCL							•																			
m 882	BULK							8									6	10	4			5					5
	ORIENT							○									○	◎	•			•					•
	E.G.							○																			
	HCL																										
m 956	BULK			2				4		1							5	8	3		2	3					1
	ORIENT							○									○	◎	○		○	○					
	E.G.							○																			
	HCL																										
m 1002	BULK			2				2		1							12	6	3		2	2					
	ORIENT			•				•									◎	○	○		•	•					
	E.G.							•																			
	HCL																										
m 1015	BULK							2		1							9	7			3	8					1
	ORIENT							○									◎	◎				○					•
	E.G.							○																			
	HCL																										
m 1022	BULK			2				4					2?				3	6	2		3	4					
	ORIENT			○				○					?				○	◎	○		○	○					
	E.G.							○																			
	HCL												?														
m 1034	BULK		1				2	2		2			2?		2		5	9	2		2	2					2
	ORIENT						•	•							•		○	◎	•			•					•
	E.G.						•	•																			
	HCL																										

Analyzed by Dra. Graciela Mas

Figure of Bulk : Quartz Index

◎ : Large Volume

○ : Medium Volume

• : Small Volume

Table 5-13 Result of X-ray Analysis of COP-3 (continued)

Depth	Sample	Stilbite	Laumontite	Wairakite		Montmorillonite	Chlorite/Mont	Chlorite	Sericite/Mont	Sericite		Kaolinite	Pyrophyllite		Calcite		Quartz	Plagioclase	K-feldspar		Prehnite	Epidote	Garnet	Pyrite		Pyroxene	Amphibole
1045 m	BULK			2			2	2		1			1?		2		7	14	4			3					2
	ORIENT						•	•							•		○	○				•					•
	E.G.						•	•																			
	HCL																										
1055 m	BULK						2	2							2		7	11			2	2					1
	ORIENT						•	•							•		○	○									•
	E.G.						•	•																			
	HCL																										
1064 m	BULK						2	2		1					2		5	12	4		2	2					2
	ORIENT						•	•							•		○	○				•					•
	E.G.						○	•																			
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										

Analyzed by Dra. Graciela Mas

Figure of Bulk : Quartz Index

◎ : Large Volume

○ : Medium volume

• : Small Volume

Table 5-13 Result of X-ray Analysis of COP-3 (continued)

Depth	Sample	Stilbite	Laumontite	Wairakite		Montmorillonite	Chlorite/Mont	Chlorite	Sericite/Mont	Sericite		Kaolinite	Pyrophyllite		Calcite		Quartz	Plagioclase	K-feldspar		Prehnite	Epidote	Garnet	Pyrite		Pyroxene	Amphibole
m 298.2	BULK					2		4	?			2			22		27	4						1			
	ORIENT					◎		◎	•			◎			•		•	•									
	E.G.					○		○	•			○															
	HCL					◎			•			○															
m 529.2	BULK						?	8							3		25	10						<1		1?	
	ORIENT						•	◎							•		•	•									
	E.G.						•	○																			
	HCL																										
m 866.0	BULK					?	?	9									11				3	1		<1		?	?
	ORIENT					•	•	◎																		?	?
	E.G.					•	•	◎																			?
	HCL					•																					?
m 1005.9	BULK			<1				1									8	8					<1				<1
	ORIENT							○									•	•									
	E.G.							○																			
	HCL																										
m 1020.6	BULK							<1									12	8	3		1		<1			?	
	ORIENT							○									•	•	•								•
	E.G.							•																			•
	HCL																										•
m 1027.7	BULK							2									7	9	2				<1			?	1
	ORIENT							○									•	•									•
	E.G.							○																			•
	HCL																										•
m 1030.6	BULK						1	2									8	15					<1			1	<1
	ORIENT						•	◎									•	•									•
	E.G.						•	○																			•
	HCL																										•
m 1040.5	BULK																5	14					<1			1	<1
	ORIENT						○	○									•	•									•
	E.G.						•	•																			•
	HCL																										•
m 1053.1	BULK						<1	<1									5	15					<1			1	<1
	ORIENT						○	•									•	•									•
	E.G.						•	•																			•
	HCL																										•

Analyzed by JICA

Figure of Bulk : Quartz Index

◎ : Large Volume

○ : Medium volume

• : Small Volume

Table 5-13 Result of X-ray Analysis of COP-3 (continued)

Depth	Sample	Stilbite	Laumontite	Wairakite		Montmorillonite	Chlorite/Mont	Chlorite	Sericite/Mont	Sericite		Kaolinite	Pyrophyllite		Calcite		Quartz	Plagioclase	K-feldspar		Prehnite	Epidote	Garnet	Pyrite		Pyroxene	Amphibole
m 1064.3	BULK						1	<1									5	14					<1			1	<1
	ORIENT						◎	○									•	•									•
	E.G.						○	•																			•
	HCL																										•
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
	ORIENT																										
	E.G.																										
	HCL																										
m	BULK																										
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	E.G.																										
	HCL																										

Analyzed by JICA

Figure of Bulk : Quartz Index

◎ : Large Volume
○ : Medium volume
• : Small Volume

Table 5-14 Physical Properties of Cores of COP-3

Depth	γ_s	γ_d	Gs	ϕ	Rock Type
293.1m	2.40	2.237	2.674	16.35%	Altered Lapilli Tuff
293.2m	2.387	2.212	2.608	17.46%	Altered Lapilli Tuff
528.7m	2.778	2.772	2.788	0.60%	Basaltic Andesite
528.8m	2.770	2.746	2.813	2.40%	Basaltic Andesite
794.4m	2.735	2.697	2.803	3.76%	Basaltic Andesite
810.6m	1.976	1.815	2.164	16.11%	Basaltic Andesite (Fractured Zone)
821.7m	2.701	2.653	2.786	4.76%	Altered Lava
848.7m	2.521	2.425	2.684	9.66%	Altered Tuff Breccir
848.8m	2.524	2.387	2.766	13.69%	Altered Tuff Breccir
882.0m	2.525	2.446	2.655	7.85%	Altered Lava
1011.6m	2.68	2.64	2.76	4.3 %	Andesite Lava
1059.8m	3.50	3.45	3.62	4.8 %	Porphyrite

γ_s: Bulk specific gravity (saturated-surface-dry) = B/(B–C)
γ_d: Bulk specific gravity (Dry) = A/(B–C)
Gs: Apparent specific gravity (Particle density) = A/(A–C)
ϕ: Effective porosity = (B–A)/(B–C) x 100

Here A: Weight of oven-dry sample in air (g)
B: Weight of saturated-surface-dry sample in air (g)
C: Weight of saturated sample in water (g)

Table 5-15 Homoginization Temperature of Fluid Inclusion of COP-3

Depth	Homogenization Temperature (℃) by Dra. G. MAS							
180 m Quartz	251.6P	282.5P	311.5P	369.9P	367.8P	328.5P	303.0P	382.5G
	213.9S	229.1S	207.0S	320.3P	209.0S	217.4S	223.2S	216.8S
	237.4S	238.8S	238.0S	272.7P	225.3S	226.7S		
210 Quartz	226.6S	216.7S	212.1S	224.7S	287.9P	247.4P	210.7S	212.5S
	216.7S	283.9P	282.3P	228.6S	271.6P	212.8S	207.1S	209.3S
	208.5S	239.3S	230.5S	260.7P	219.3S	218.9S	213.0S	210.6S
	220.8S	230.0S	280.7P	216.7S	213.2S	215.4S	209.5S	211.8S
320 Quartz	265.7P	222.9S	237.5S	233.4S	253.4S	254.1S	252.4S	236.6S
	317.5P	228.7S	246.6S	318.3P	315.2P	339.2P	325.1P	326.0P
	259.4S	238.4S	244.3S	221.6S	245.0S	242.1S	220.7S	227.0S
	238.4S	239.3S	238.2S					
528 Calcite	209.1S	192.4S	216.8S	212.5S	219.0S	209.6S	227.3S	201.4S
	215.6S	178.2S	192.4S	187.7S	181.3S	196.4S	223.6S	213.8S
	246.3S	162.6S						
801 Quartz	257.0S	276.9S	278.9S	280.4S	294.5C	274.4C	276.0C	303.0P
	264.0S	261.2S	265.1S	266.7S	264.9S	291.4S	287.0S	277.3S
	301.5P	285.7P	260.1S	261.5S	265.4S	245.4S	252.9S	260.5S
	308.5P	301.9P	296.9S					
806 * Quartz	252.9S	285.9P	289.1P	251.3S	251.5S	246.3S	248.4S	252.1C
	260.8C	254.1C	274.9P	287.1P	241.8S	252.3S	259.9S	260.9S
854.2 Quartz	307.1P	245.6S	238.5S	242.4S	245.3S	273.6C	263.5C	259.5C
	260.8C	279.8P	258.9C	261.3C	263.4C	262.2C	303.4P	261.0S
	258.8S	257.6S	287.2C	271.5P	251.8C	260.7C	258.4C	261.1C
882 Calcita	269.0T	275.4T	264.9T	270.9T	268.4T	269.6T	274.5T	269.1T
	283.1T	259.6T	268.9T	263.8T	260.2T	262.0T	260.4T	265.9T
	265.3T	266.1T	282.3T	262.1T	269.6T	259.7T	268.3T	265.4T

P : Primary Inclusion   C : Cluster

S : Secondary Inclusion   T : Trail or Cluster

G : Gaseous Inclusion

* : Gaseous inclusions in the sample are avaiable.

Table 5-15 Homoginization Temperature of Fluid Inclusion of COP-3 (continued)

Depth	Homogenization Temperature (℃) by Dra. G. MAS							
1009 m Quartz	258.9	268.5	248.0	266.7	270.7	286.2	278.1	258.4
	266.4	257.8	254.1	262.0	268.8	271.3	253.0	268.3
	287.3	285.6	279.5	297.7	299.5	248.9	253.5	256.8
1013 m * Quartz	251.3	252.4	256.5	261.3	257.1	259.5	255.1	252.3
	260.2	254.5	255.7	248.5	254.1	262.3	256.4	251.6
	256.5	262.5						
Depth	Homogenization Temperature (℃) by JICA							
801.8 m Quartz	283.0	281.0	243.0	270.0	243.0	244.0	304.0	275.0
	311.0	329.0	339.0	304.0	296.0	342.0	343.0	344.0
	349.0	330.0	263.0	251.0	281.0	283.0	259.0	276.0
	309.0	312.0	282.0	309.0	257.0	293.0		
813.0 m Quartz	243.0	243.0	242.0	265.0	252.0	252.0	262.0	237.0
	273.0	279.0	240.0	239.0	246.0	242.0	238.0	241.0
	242.0	239.0	243.0	273.0	266.0	272.0	243.0	274.0
	243.0	281.0	281.0	244.0	280.0			

All inclusions in the samples of 1,009 and 1,013 m are primary or pseudosecondary.

* : Gaseous inclusions in the sample are avaiable.

Table 5-16 Pressure and Temperature Values Measured at Feed Zone for COP-3

Depth of Feed Zone	Pressure (Measured Depth)	Temperature	Remarks
	kg/cm^2G		Measured Date
1010m	38.13 (at 1000m)	236.9°C (at 1000m)	31/05/91 (ST=391hr)
		241.7°C (at 1000m)	12/06/91 (flowing temp.)
	38.156* (at 1010m)		31/05/91 (ST=391hr)

*: Estimated pressure calculated by pressure gradient between 900m and 1000m

Table 5-17 Parameters in calculation of reserve for confirmed area

Parameter	Unit	Type of Probability (or fixed)	Minimum Value	Maximum Value	Most Likely Value
areal extent	km²	fixed	—	—	4
thickness	m	triangular	600	1200	900
temperature	℃	triangular	230	250	240
porosity		uniform	0.04	0.1	—
water saturation		uniform	0.3	0.5	—
recovery factor		uniform	0.04	0.15	—
volumetric specific heat of rock	kJ/m³℃	fixed	—	—	2360
rejection temperature	℃	fixed	—	—	10
utilization factor		fixed	—	—	0.6
power plant load factor		fixed	—	—	0.85
power plant life	years	fixed	—	—	30

Table 5-18 Parameters in calculation of reserve for whole area

Parameter	Unit	Type of Probability (or fixed)	Minimum Value	Maximum Value	Most Likely Value
areal extent	km²	uniform	11	13	–
thickness	m	triangular	600	1200	900
temperature	℃	uniform	230	250	–
porosity		uniform	0.04	0.1	–
water saturation		uniform	0.3	0.5	–
recovery factor		uniform	0.04	0.15	–
volumetric specific heat of rock	kJ/m³℃	fixed	–	–	2360
rejection temperature	℃	fixed	–	–	10
utilization factor		fixed	–	–	0.6
power plant load factor		fixed	–	–	0.85
power plant life	years	fixed	–	–	30

CHAPTER 6 PRELIMINARY DESIGN OF POWER PLANT

Chapter 6 PRELIMINARY DESIGN OF POWER PLANT

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Chapter 6 PRELIMINARY DESIGN OF POWER PLANT

6.1 Design Conditions

6.1.1 Site Conditions

The Project site is located at an altitude of nearly 2,000 m in the Andes in the west of the Province of Neuquén close to the Argentine-Chilean border. It lies on a gently sloping mountainside where there is no inhabitation and no vegetation. The community nearest to the site is Copahue located about 2 km north. It is a summer resort and is almost abandoned during the winter months. Caviahue, located some 5 km southeast of the site, is the nearest community which is inhabited at all times.

The temperature is 20°C during the summer and -10°C during the winter and averages 7°C annually. Meteorologically, the site is characterized by strong west direction winds of 20 to 30 m/sec in speed which blow throughout the year. There lies a lake near the site and it is easy to obtain water from the lake. The annual rainfall is approximately 1,200 mm and there is snowfall of 3 to 4 m during the winter.

6.1.2 Selection of the Plant Site

The plant site needs to be selected by taking into account the following requirements.

(1) It is favorable to select a plant site in a flat land to minimize excavation required for site reclamation, because there are many outcrops of rocks in the Project site.

(2) The power plant is better to be located as close as possible to bases "A" and "B" of production wells to minimize the length of the pipeline.

(3) The power plant is necessary to be in proximity to Lago Las Mellizas (2) from which water will be obtained, with the least practicable pumping head.

As shown in Fig. 6-1, three alternative sites are selected in the course of the field survey. The result of comparison is shown in Table 6-1. Overall evaluation taking into account the above requirements and other factors indicates that Alternative III is the most suitable site, followed by Alternatives II and I.

6.1.3 Design Conditions and Fundamental Characteristics

Output	:	30 MW x 1 unit
Production Well	:	1,200 m x 7 (directional drilling; well length 1,340 m)
No. of Well Bases	:	2
Well End Spacing	:	500 m or more
Well Diameter	:	Final diameter 8 in. Well head 12 in.
Properties of Steam	:	Steam-dominated type (saturated steam)
Gas Content of Steam	:	6% by weight (as CO_2)
Well Characteristics	:	Fig. 6-2
Well Damping Factor	:	First 2 years 15% 3 - 5 years 8% 6 years and more 3%

6.1.4 Operating Conditions of Power Plant

The geothermal power plant is to be operated at a base load with a 85% utilization factor. The plant service ratio is estimated to be 6%. Therefore, the annual generated energy is to be 2.1×10^8 kWh. The plant operation is to be monitored constantly from the central control room. The operators are planned to be working on three shifts of 2 persons x 4 turns. Two operators are needed to be on duty at all times, but they will be assisted by day service personnel during plant startup and shutdown. The total plant staff is estimated to be 20 persons consisting of 8 operators and 12 maintenance/repair and control personnel.

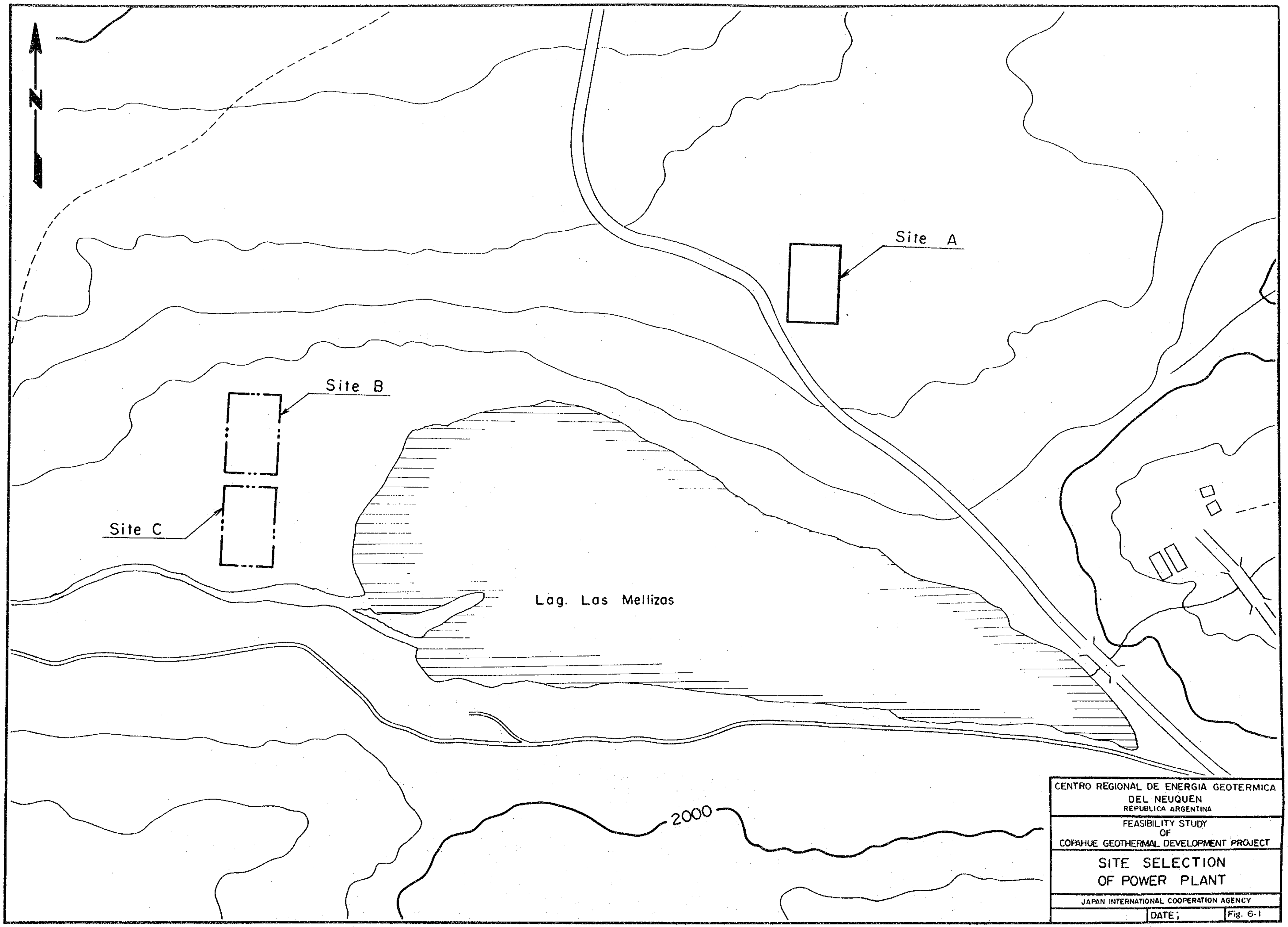

N
Site A
Site B
Site C
Lag. Las Mellizas
2000
CENTRO REGIONAL DE ENERGIA GEOTERMICA
DEL NEUQUEN
REPUBLICA ARGENTINA
FEASIBILITY STUDY
OF
COPAHUE GEOTHERMAL DEVELOPMENT PROJECT
SITE SELECTION
OF POWER PLANT
JAPAN INTERNATIONAL COOPERATION AGENCY
DATE;
Fig. 6-1

Table 6-1 Comparison Study of Power Plant Site

Category	Alternative I	Alternative II	Alternative III
Location	East side of production well drilling base "A" (Site C)	Northeast side of production well drilling base "A" (Site B)	Southwest side of production well drilling base "B" (Site A)
Access Road	Passing the south side of Lago Mellizas (2) and approaching from the south side of the site.	Passing the south side of Lago Mellizas (2) and approaching from the south side of the site.	Approaching from the south side of the site through a road to Copahue village.
Transmission Line	Extended from the south side	Extended from the north side	Extended from the south side
Location of receiver	West side of the main building	West side of the main building	West side of the main building
Main building and cooling tower	Main building south side and cooling tower north side	Main building north side and cooling tower south side	Main building south side and cooling tower north side
Advantages	• Plant water can be obtained from nearby Lago Mellizas (2) with little difference in level	• Plant water can be obtained from nearby Lago Mellizas (2) with little difference in level.	• Access road is shortest compared to other alternatives. • Transmission line is shortest compared to other alternatives. • Steam pipelines from bases "A" and "B" do not cross the access road.
Disadvantages	• Located at the foot of the south slope to have snowdrift. • Located in the path of west wind, subject to strong wind. • Flood protection is required for a small river between Lagos Mellizas (1) and (2). • Access road is relatively long, crossing a small river between Lagos Mellizas.	• Located at the foot of the south slope to have snowdrift. • Located in the path of west wind, subject to strong wind. • Access road is relatively long, crossing a small river between Lagos Mellizas (1) and (2).	• The maximum allowable load is needed to be checked for existing bridges to Copahue. • The water intake point is relatively far from Lago Mellizas (2), requiring the pumping up of around 50 m.

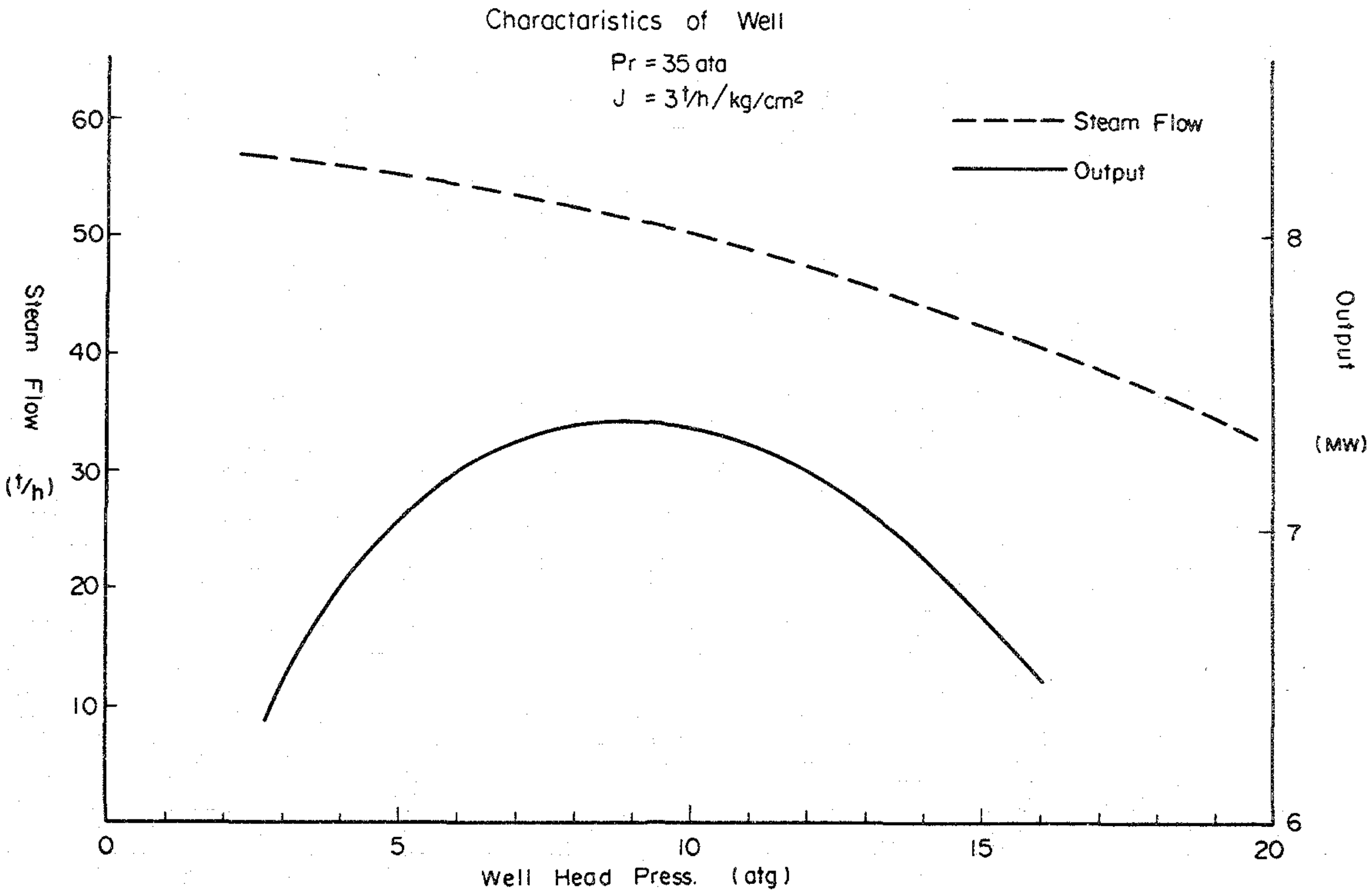


Fig. 6-2 Well Characteristics

6.1.5 Fundamental Characteristics of Power Plant

The geothermal power plant is planned to directly use saturated steam from steam dominated geothermal wells for operation of a condensing steam turbine.

The steam condenser is of direct contact type and uses a circulated mixture of condensed water cooled by a cooling tower as well as cooling water for cooling purposes. Surplus water in the cooling water system is to be returned to soil layers through reinjection wells.

Noncondensing gases (mostly CO_2) from the condenser is extracted from it by means of a vacuum pump and then released into the air from the cooling tower fan stack for diffusion. The generated power is boosted to 132 kV and then supplied to the EPEN power system.

6.2 Preliminary Design of Power Plant

6.2.1 Basic Layout

The power plant consists of the main building, cooling tower, switchyard, steam pipeline connecting production wells "A" and "B" with the power plant, and the freshwater intake and supply facilities. The layout is illustrated in Fig. 6-3. The power plant location and layout of the structures and equipment within the power plant yard have been determined with due consideration given to the topography and climatic conditions of the project area.

The power plant yard is 120 m long by 80 m wide. The layout of the major facilities in the power plant yard is as illustrated in Fig. 6-4. The main building is located in the center of the power plant yard and the cooling tower is installed parallel to the north side of the main building in consideration of the predominant wind direction. On the south of the main building is located a switchyard which transmits geothermal power to the Loncopue substation through a 132 kV transmission line. A parking house and a warehouse are also provided in the power plant yard.

6.2.2 Access Road and Land Reclamation

The power plant is to be located adjacent to the north side of the provincial road. The access road connects the provincial road with the power plant. For the construction of the power plant, an existing road leading to a point near production well site "A" is to be improved and used. A new access road to well site "B" is to be branched off from the power plant yard. It is planned to construct a new road about 4 m wide along the steam pipeline for the purpose of inspection and maintenance.

The plant site is located in flatland scattered with stones and the site reclamation is consisted mainly of excavation works for the purpose of securing adequate bearing capacity of the foundations for structures and equipment. The yard is to be reclaimed in such a way as to achieve the maximum possible balance between excavations and fills.

6.2.3 Production Well Drilling

Drilling of the steam production wells is to be undertaken in accordance with drilling plan including the location, depth, inclination and direction of the wells and the casing program, which is to be based on the results of exploratory works described in Chapter 11.

Drilling is to be carried out on a base system and seven wells are estimated to be necessary to be drilled in Bases "A" and "B". The average drilling depth is 1,200 m; average drilling length 1,340 m; maximum deviation distance 500 m; and well end spacing, 500 m or more.

6.2.4 Freshwater Intake Facilities

The pump is installed on the north shore of Lago Mellizas (2) to intake the water which is conveyed to the power plant through a pipeline. The water thus obtained is to be used primarily for cooling purposes and partly for drinking and other purposes.

Since a maximum snowfall of 4 m is anticipated at the Project site during the winter, the power plant building, switchyard, parking house, access road and other major facilities of the plant are planned to be provided with sprinklers for melting snow.

6.2.5 Steam Pipeline and Related Facilities

Two production well drilling bases are assumed. One base located at some 1,200 m southwest from the power plant is called Base "A", and the other at some 400 m east-northeast from the power plant is called Base "B". Four wells are planned to be drilled at Base "A" and three wells at Base "B". The minimum steam flow of each well averages 30 t/h and the maximum steam flow is 1.2 times larger (36 t/h).

Two pipelines each from the four wells at Base "A" are unified into two pipelines. Three wells at Base "B" are unified into one pipeline. The capacity of each pipeline is 60 to 72 t/h for Line "A" and 92 to 110 t/h for Line "B".

The well head pressure capable of providing the maximum output is nearly 9 ata when estimated from the well characteristics. Therefore, the preliminary plant design is based on a well head pressure around 9 ata. Assuming a pipeline diameter of 400 mm for all pipelines, the velocity is to be 32 to 38 m/sec for Line "A" and 50 to 60 m/sec for Line "B" and the pressure loss is calculated to be 1 to 1.4 kg/cm^2 for Line "A" and 0.9 to 1.2 kg/cm^2 for Line "B". Therefore, if the turbine inlet pressure is 8 ata, then the well head pressure is to be 8.9 to 9.4 ata.

An optimization check has been undertaken in respect of the pipeline diameter with the steam cost assumed to be 50,000 US$/t/h. The check has revealed the following:

- If the pipeline diameter is 450 mm, pressure loss decreases with a resulting increase in the amount of steam obtainable, but this advantage is outweighed by an increase in the pipeline construction cost.

- If the pipeline diameter is 350 mm, the pipeline construction cost decrease, but this advantage is offset by increased pressure loss and a consequential reduction in the amount of steam generated.

The optimization study has revealed that the optimum pipeline diameter is 400 mm.

A line (1.200 m)						
D m	Cost 1 1,000%	P.loss kg/cm^2	W.H.P. ata	Product t/h	Cost 2 1,000$	Total 1,000$
350	-59	2.1	10.1	61.0	+75	+16
400	Base	1.1	9.1	62.5	Base	Base
450	+61	0.7	8.7	62.8	-15	+46
B line (400 m)						
350	-20	1.7	9.7	90.6	+70	+50
400	Base	0.9	8.9	92.0	Base	Base
450	+20	0.6	8.6	92.3	-15	+5

A cyclone type separator is installed at each well head to prevent the intrusion of water and the eruption of rock powder and other solids. The maximum working pressure and the maximum working temperature are set at 12 kg/cm^2g and 190°C, respectively, with a certain allowance.

Before the junction of main steam lines of each well a flowmeter and two selector valves are installed to permit changeover of main steam lines and air release pipes. A simple silencer is installed as necessary in the air release pipes to lower the noise level during the release of steam into the air.

The principal specifications of the steam pipelines and related equipment are as indicated below:

Route	Base "A" - P/S	Base "B" - P/S	Total
No. of Wells	4	3	7
No. of Trains	2	1	3
Capacity (t/h)	60-72 (x2)	92-110	220-260
Velocity (m/s)	32-38	54-64	-
Pressure Loss (kg/cm^2)	1-1.4	0.9-1.2	-
Well Head Pressure (ata)	9.0-9.4	8.9-9.2	-
Pipe Diameter (mm)	400	400	-
Pipe Length (m)	1,200 x 2	400	2,800
Separator (unit)	4	3	7
Silencer (unit)	4	3	7
Approx. Weight (t)	302	63	365

6.2.6 Turbine and Related Facilities

Basic Design

The optimum position for installing a turbine is selected on the basis of the data available and with some design changes predicted for the future.

Turbine Inlet Steam Pressure

On the basis of the characteristics of COP-3, a simulation study has been carried out in which the well diameter is changed to the diameter of a production well, a 10% reduction is assumed in the reservoir pressure, and a productivity index of 1/2 is assumed. Under these conditions, the maximum output point is found in the vicinity of the well head pressure of 9 ata. Accordingly, the value of 8 ata has been taken for the turbine inlet pressure with a pressure loss in the pipeline assumed to be 1 kg/cm^2.

Turbine Outlet Steam Pressure

From COP-1 and COP-2, it is assumed that the gas content of steam is 6% by weight. The maximum exhaust pressure is calculated as approximately 0.1 ata.

As a result, the value of 0.1 ata is taken for the turbine outlet steam pressure.

Attempts have been made to work out a minimum cost assuming a gross turbine output of 30,000 kW, taking the required amount of steam, vacuum pump installation cost and plant power requirement as variable factors, and with the exchange rates for construction cost assumed to be 50,000US$/t/h, 500US$/kW and 1,500US$/kW, respectively, for these factors.

An economic efficiency analysis made in respect to the back-pressure turbine has shown that only if the gas content is eatimated to be 13% or more, the type of turbine has been concluded economically more advantageous than the condensing type turbine.

Condenser type

The possibility is considered of using the water of a lake located near the site by means of a surface condenser. It is found, however, that the surface condenser is more expensive than the direct contact type of condenser because of the higher costs of the pump power, cooling water pipes and condenser tube. The surface condenser has a technical problem with cleaning the tube surfaces of scales.

Design Atmospheric Temperature for Cooling Tower

The average annual temperature is 7°C, but it rises to 20°C during the summer months of January and February. The design temperature of 10°C is taken to keep an output drop during the summer at a level lower than 5%.

Cooling Tower Type

Considering that the cooling tower is exposed to a high wind speed, the mechanical draught counterflow type has been selected for the cooling tower.

The number of cells has been fixed at four to facilitate adjustment of the fan operation to cope with temperature fluctuation.

Gas Extractor Type

For the gas extractor, an electric vacuum pump has been selected in preference to a steam ejector which is lower in operating efficiency and requires a larger quantity of steam. The number of gas extractors to be installed has been set at three to facilitate adjustments to changes in the amount of gas required.

The following are the principal specifications considered on the basis of the foregoing analyses for the turbine and associated equipment.

(1) Turbine

Model:	Single-flow condensing steam turbine
Rated output:	30,000 kW
No. of unit:	One
Inlet steam pressure:	8 ata
Inlet steam temperature:	Saturated
Outlet steam pressure:	0.1 ata
Rate of steam flow:	214.3 t/h

(2) Condenser

Model:	Direct contact low level type
No. of unit:	One
Internal pressure:	0.1 ata
Cooling water temperature (inlet/outlet):	16°C/42.9°C
Amount of cooling water:	3,916 t/h
Amount of exchange heat:	1,055 x 10^8 kcal/h

(3) Cooling Tower

Model:	Suction/induction ventilating counterflow type
No. of cell:	4
Fan:	85 kW x 4

Approx. dimensions:	11 m x 44 m x 10 m H
Amount of cooling water:	4,000 tons/hr
Inlet water temperature:	42.9°C
Outlet water temperature:	16°C
Design atmospheric temperature:	10°Cwb

(4) Gas Extractor

Model:	Electric vacuum pump
No. of units:	3
Capacity:	73 kg/min
Electric motor:	340 kW

(5) Circulating Water Pump

Model:	Vertical single-stage centrifugal pump
No. of units:	2
Capacity:	2,000 t/h
Lift:	35 m
Electric motor:	250 kW

6.2.7 Electrical Equipment

Principal specifications of the electrical equipment are as follows:

(1) Generator

Model:	Horizontal shaft revolving-field 3-phase AC air-cooled type
Capacity:	33,400 kVA
Power factor:	90%
Voltage:	11 kV
No. of unit:	One

(2) Main Transformer

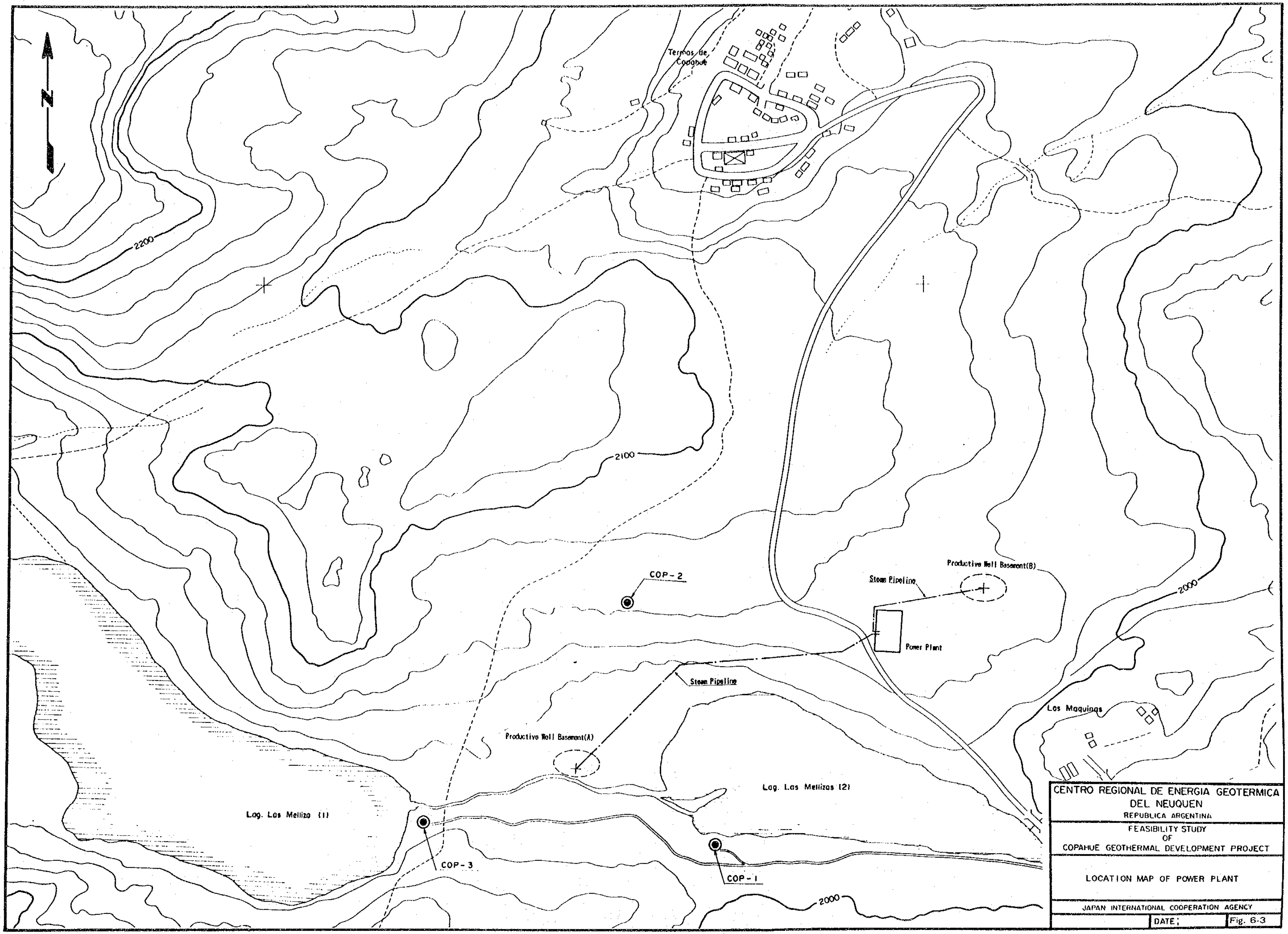
Model:	Outdoor oil-immersed air-cooled type
No. of unit:	One
Capacity:	33,400 kVA

6.2.8 Powerhouse and Related Buildings

It is planned that the powerhouse consists of a three-story building measuring 20.8 m wide, 32.4 m long and 21.5 m high. The first floor consists of pump rooms (vacuum pump and cooling water circulating pump), a tank room, a reserved power room, etc. A battery room, a relay room and an office are arranged on the second floor. The third floor is the main floor where a turbine generator room and a central control room are located.

The entrance for delivered equipment is located at the southwest corner of the main building and an air well is provided from the first to the third floor.

The powerhouse is designed to be of steel frame structure combined with steel sheet walls in consideration of long beams required and large design wind and snow loads. The related buildings in the power plant yard, including a parking house and warehouse, are also designed to be of steel frame and steel sheet wall.


N
Termas de Copahue
2200
2100
2000
COP-2
Productive Well Basement(B)
Steam Pipeline
Power Plant
Steam Pipeline
Productive Well Basement(A)
Los Maquinas
Lag. Las Mellizas (2)
Lag. Las Mellizo (1)
COP-3
COP-1
CENTRO REGIONAL DE ENERGIA GEOTERMICA
DEL NEUQUEN
REPUBLICA ARGENTINA
FEASIBILITY STUDY
OF
COPAHUE GEOTHERMAL DEVELOPMENT PROJECT
LOCATION MAP OF POWER PLANT
JAPAN INTERNATIONAL COOPERATION AGENCY
DATE;
Fig. 6-3