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AN UPDATED STUDY OF TEMPERATURE BEHAVIOR AND DISTRIBUTION IN CERRO PRIETO I

The Cerro Prieto geothermal field is located on the alluvial plain of the Mexicali Valley between 114°40' and 115°33' longitude west and 32°55' and 32°44' latitude north. The Cerro Prieto Volcano, reaching 225 m a.s.l., is located 6 km north-west of the production field and is the only elevated point.

This thermal correlation study of the wells located in the Cerro Prieto I area is based on the same geological and geophysical studies regarding the composition of the 3 lithostratigraphic units. Unit A, formed by unconsolidated sediments; Unit B, formed by deltaic consolidated and metamorphized sediments and Unit C, composed of crystalline Upper Cretaceous rocks or granitic basement (1).

With the information gathered on each well and the correlation of such information, an attempt has been made to update it regarding the distribution of subsoil temperatures, which will enable us to correctly locate the thermal anomaly, migration and distribution of fluids in the reservoir and thus locate the best areas for exploitation.

ISOTHERMS

In order to gain better knowledge of the temperature distribution in the field and to delineate the closest approximation to the position of the thermal anomaly, isotherms were drawn for different depths as shown in figures 1, 2, 3 and 4.

Isotherms at 1,000 m (Fig. 1).

As may be seen, the maximum temperature is encountered in the isotherm of 250°C, which includes most of the wells that are being exploited or were being exploited, but they are out of line, either for mechanical or economic reasons, to be repaired or replaced.

Isotherms at 1,300 m (Fig. 2).

As may be seen in this figure, almost all the wells that feed steam to units 1, 2, 3 and 4 of the geothermal electric plant are included in 250°C and 300°C isotherms. Also included in this area are wells such as E, M-47 and M-79, that feed steam to the plant and have their producing zone at approximately 1,700 m of depth. These wells were completed at a greater depth in an attempt to find better exploitation zones within the Cerro Prieto I area, and wells with better thermal properties were obtained.

Isotherms at 1,500 m (Fig. 3).

Since most of the wells drilled in this area were completed at depths between 1,200 and 1,600 meters, and were most probably not drilled deeper for technical or economic reasons, some were not completed within the best exploitation area, which is the reason that wells to replace them have been drilled at greater depths and with excellent results.

All of the wells that are currently being exploited at temperatures from approximately 275°C to 335°C are included in the isotherms at 1,500 m.

Isotherms at 1,750 m (Fig. 4).

At depths from 1,750 to 2,000 m (Fig. 5), no pronounced change is noted in the 300°C and 325°C isotherms, so it may be assumed that there are vertical flows in the central area in well E-5, M-73, M-79, M-84, E-2 and E-7 and a rising horizontal spreading in the rest of the wells following the same flow pattern toward the west and the Laguna Volcano.

THERMAL CORRELATIONS

In the temperature logs of the wells with greatest enthalpy, such as M-84, M-48, M-45, E-2 and M-46 (Fig. 6), it was observed that the thermal gradient, as of depth (h) behaves as a straight line with a slope tending toward 1, that is, it is practically isothermal, assuming that there are upward vertical flows through the faults and rock fissures.

To demonstrate that such wells cross zones of great faulting, 4 sections, A, B, C and D, were located (Fig. 7), going from north to south in order to cut through a fault system near the wells previously mentioned.

In Fig. 8, sections A, B, C and D show the correlation of the logs and a great difference may not be noted in the temperature levels because the layers have been affected by intense fracturing caused by constant tectonic movements,

which have changed their original structure.

During the warming up and output evaluation of these wells, their high temperatures and the mass flow obtained, suggest that these faults with a northeast-southwest orientation and secondary lateral fracturing provide the main channels for geothermal fluids.

On the basis of a study of Cerro Prieto II and Cerro Prieto III, it was concluded that the greatest amount of the fluids come from the eastern side of the field and are connected to Cerro Prieto I at the area near wells M-110, M-123 and M-103 and that, although a great deal of grading exists because of the Michoacán Fault, the fluids rise through such layers and the Hidalgo Fault serves as the principal means for their communication and distribution.

The mass flow rates obtained in well M-110 in the first evaluation (460 ton/h) and the chemical concentration of the water extracted from wells E-1, E-2, M-48 and others suggest a feeding source of the same origin (2).

Comparing the temperature logs of wells 0-473, M-105 and M-45 (Fig. 9), it may be established that wells 0-473, M-105 and others located to the west of the field have surface current fluid inlets because they are far from the thermal anomaly both in depth and distance and because the caprock is more shallow and fractured, which causes convective currents as is shown in the same figure.

CONCLUSIONS

On the basis of the information obtained and observations made in Cerro Prieto I, it may be assumed that a significant amount of fluids come from the area near wells M-110, M-123 and M-103.

At a depth of between 1,700 and 2,000 meters in the Cerro Prieto I zone, an important unexplored area with good thermodynamic properties has been detected, which has led to considering the feasibility of drilling adjacent to the existing wells.

FIGURES

Fig.1. Cerro Prieto Geothermal Field Isotherms at a depth of 1,000 m.

Fig.2. Cerro Prieto Geothermal Field Isotherms at a depth of 1,300 m.

Fig.3. Cerro Prieto Geothermal Field Isotherms at a depth of 1,500 m.

Fig.4. Cerro Prieto Geothermal Field Isotherms at a depth of 1,750 m.

Fig.5. Cerro Prieto Geothermal Field Isotherms at a depth of 2,000 m.

Fig.6. Temperature Logs in Static Wells.

Fig.7. Cerro Prieto Geothermal Field Sections of Thermal Correlations.

Fig.8. Thermal Correlations.

Fig.9. Distribution of Temperatures and Convective Flows.

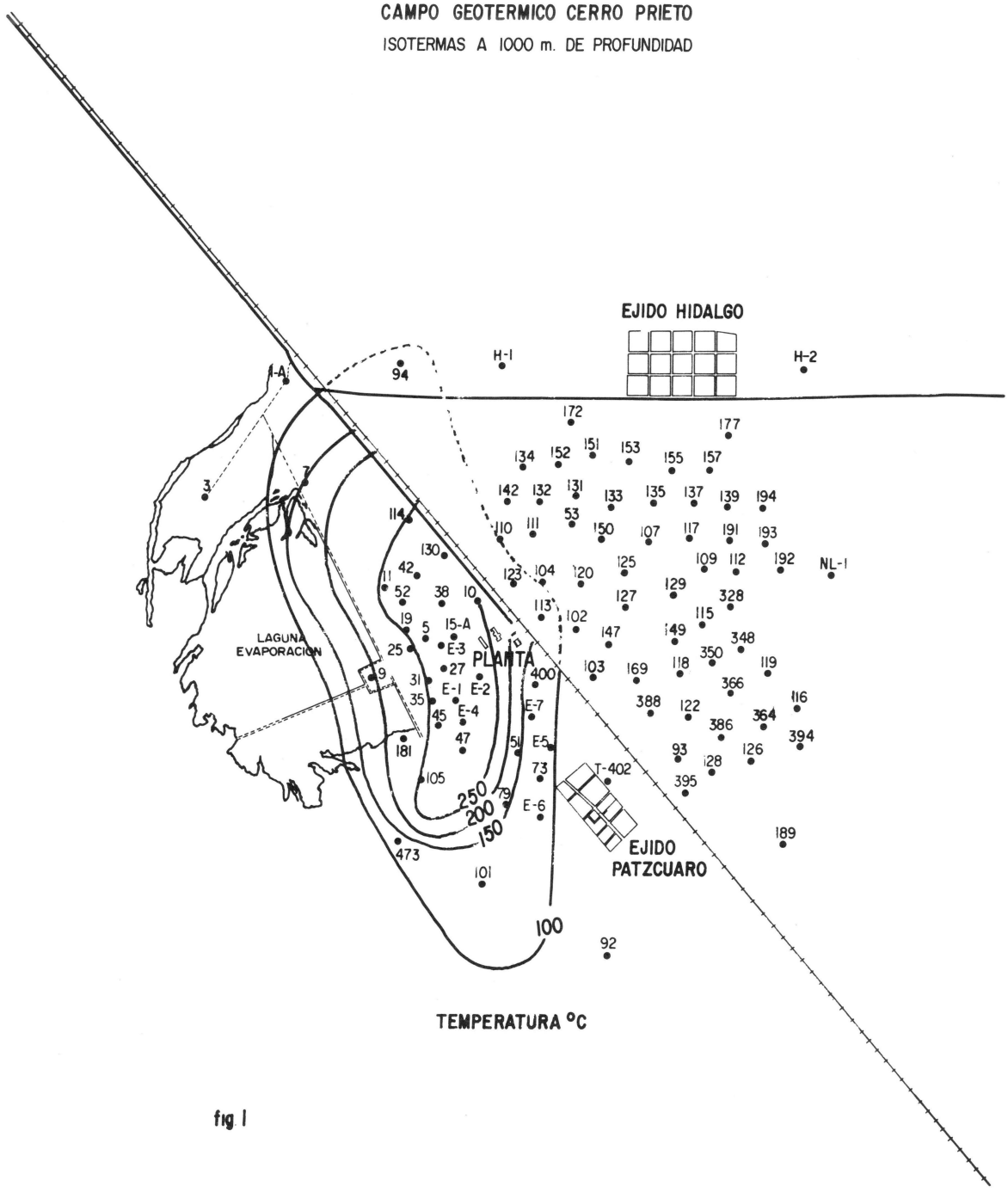

CAMPO GEOTERMICO CERRO PRIETO
ISOTERMAS A 1000 m. DE PROFUNDIDAD
EJIDO HIDALGO
H-1
H-2
1-A
94
172
177
134
152
151
153
155
157
3
142
132
131
133
135
137
139
194
114
53
110
111
150
107
117
191
193
130
42
11
123
104
120
125
109
112
192
NL-1
52
38
10
129
328
19
5
15-A
113
102
115
147
149
348
LAGUNA EVAPORACION
25
E-3
PLANTA
27
350
119
9
31
E-1
E-2
400
103
169
118
366
35
E-7
388
122
116
45
E-4
386
364
47
E-5
93
126
394
181
51
73
T-402
128
105
395
250
200
150
79
E-6
189
EJIDO PATZCUARO
473
101
100
92
TEMPERATURA °C

fig 1

REGISTROS DE TEMPERATURA EN POZOS ESTATICOS

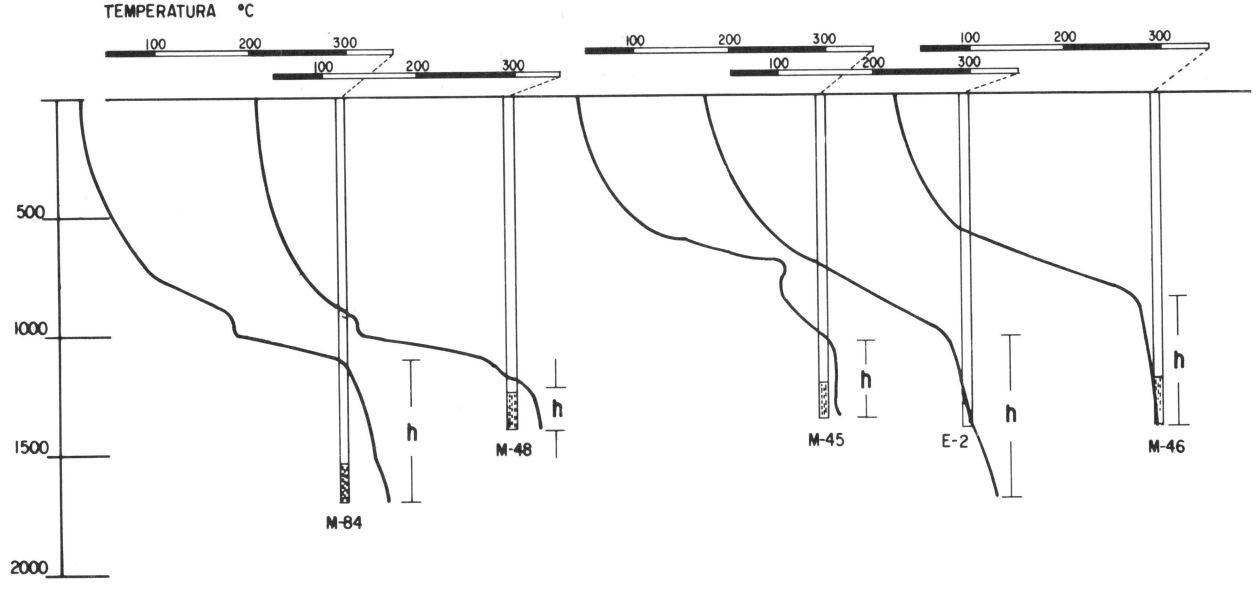


fig. 6

CAMPO GEOTERMICO CERRO PRIETO

SECCIONES DE CORRELACIONES TERMICAS

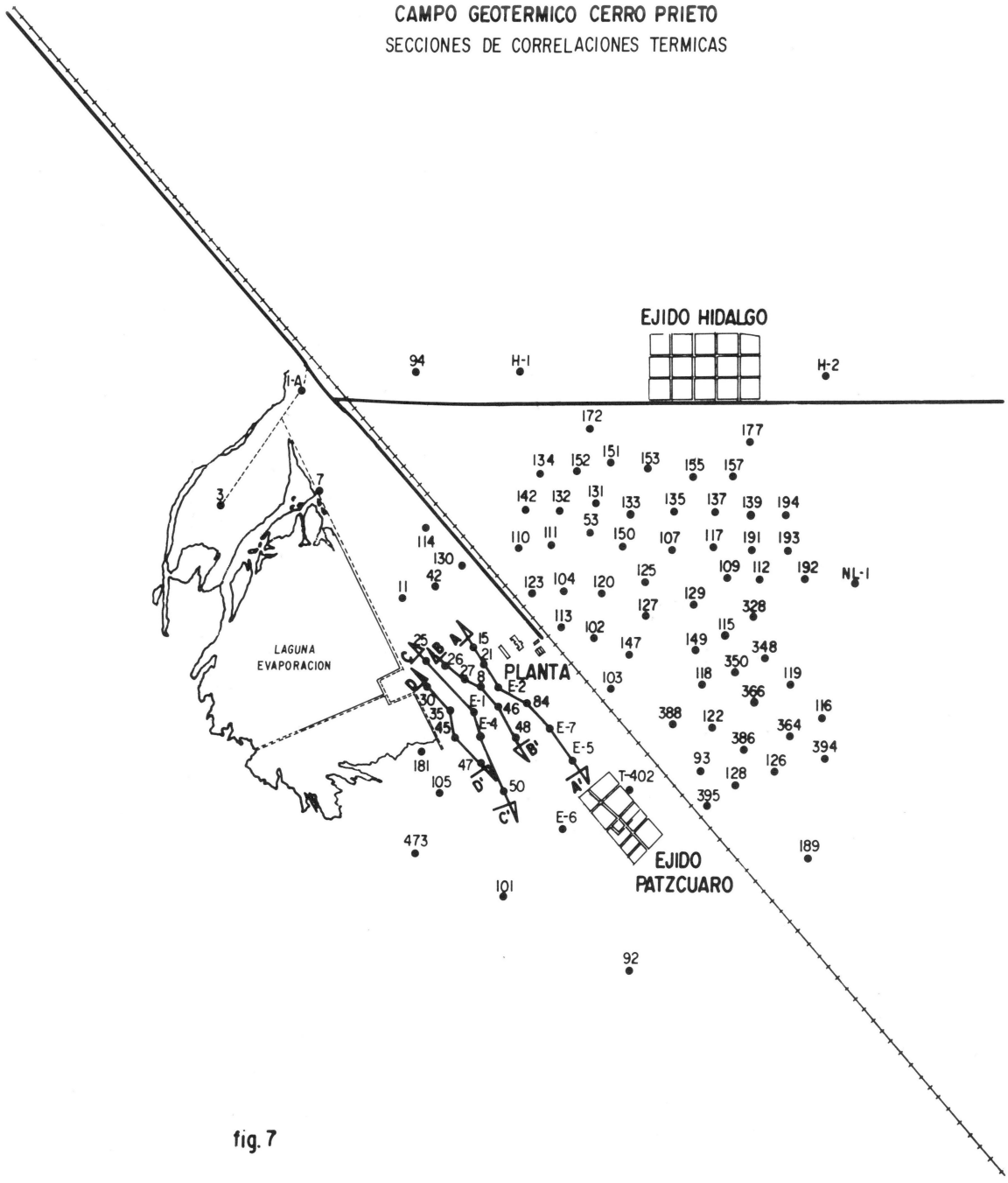
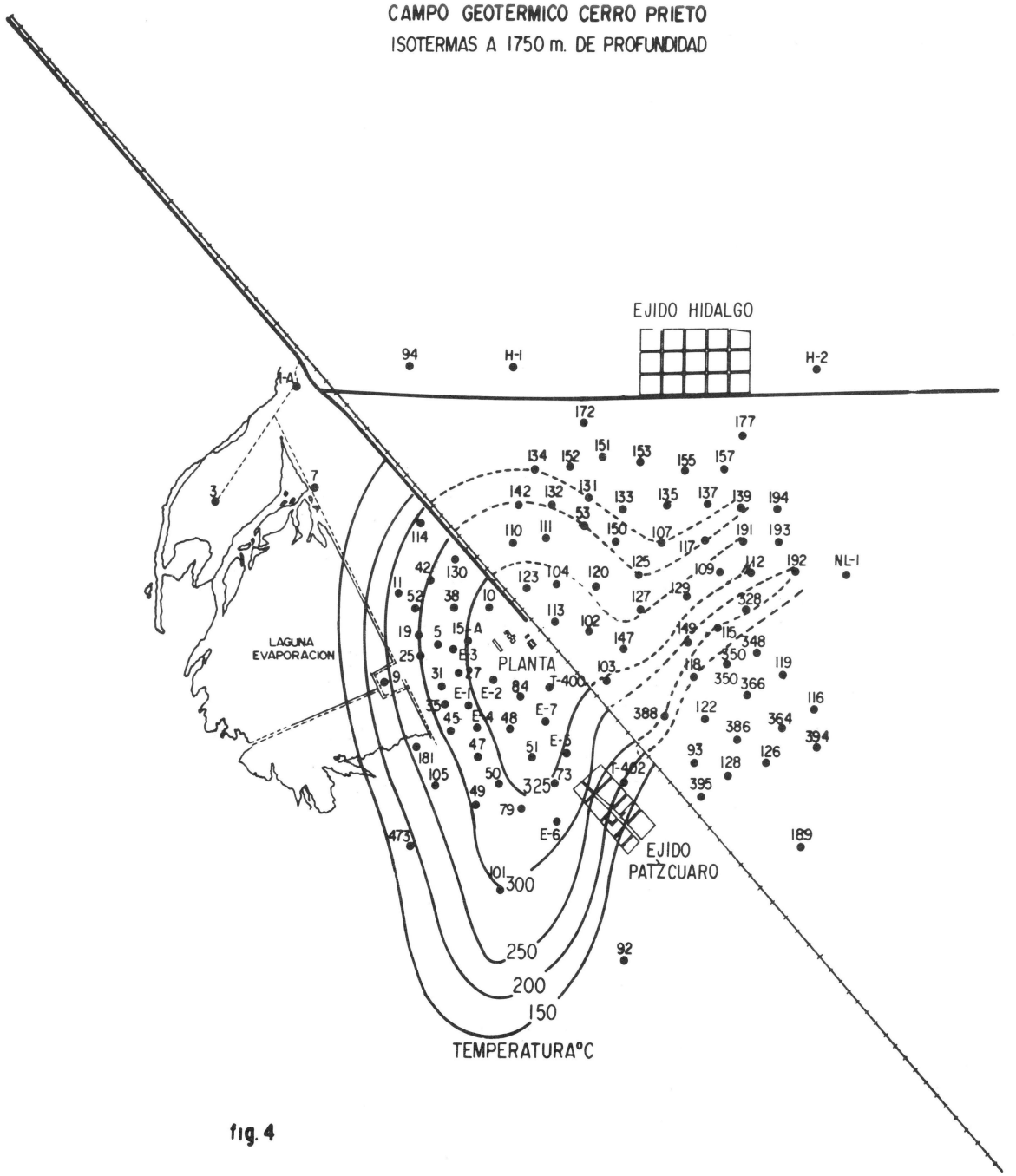


fig. 7


CAMPO GEOTERMICO CERRO PRIETO
ISOTERMAS A 1750 m. DE PROFUNDIDAD
EJIDO HIDALGO
H-1
H-2
94
1-A
3
7
LAGUNA EVAPORACION
PLANTA
J-400
T-402
E-1
E-2
E-3
E-4
E-5
E-6
E-7
EJIDO PATZCUARO
NL-1
172
177
134
152
151
153
155
157
142
132
131
133
135
137
139
194
53
150
107
191
193
114
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111
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42
130
123
104
120
125
109
112
192
11
52
38
10
129
127
328
113
102
147
149
19
5
15-A
348
25
350
119
31
27
84
103
118
350
366
9
116
35
45
48
122
388
386
364
47
51
394
181
93
126
105
50
73
325
128
49
395
79
189
473
101
300
92
250
200
150
TEMPERATURA°C

fig. 4

CAMPO GEOTERMICO CERRO PRIETO

ISOTERMAS A 2000 m. DE PROFUNDIDAD

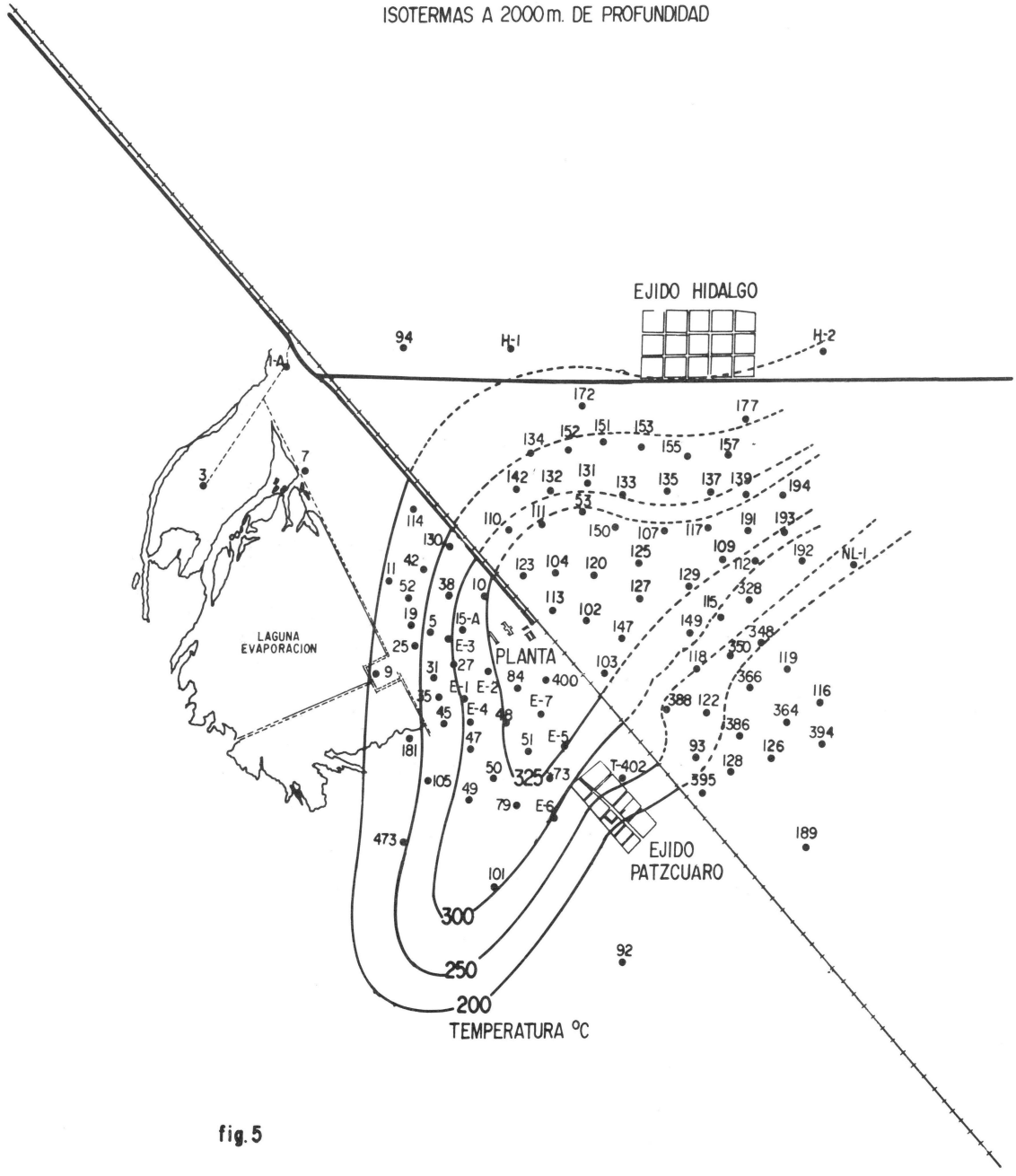

fig. 5

CAMPO GEOTERMICO CERRO PRIETO

ISOTERMAS A 1300 m. DE PROFUNDIDAD

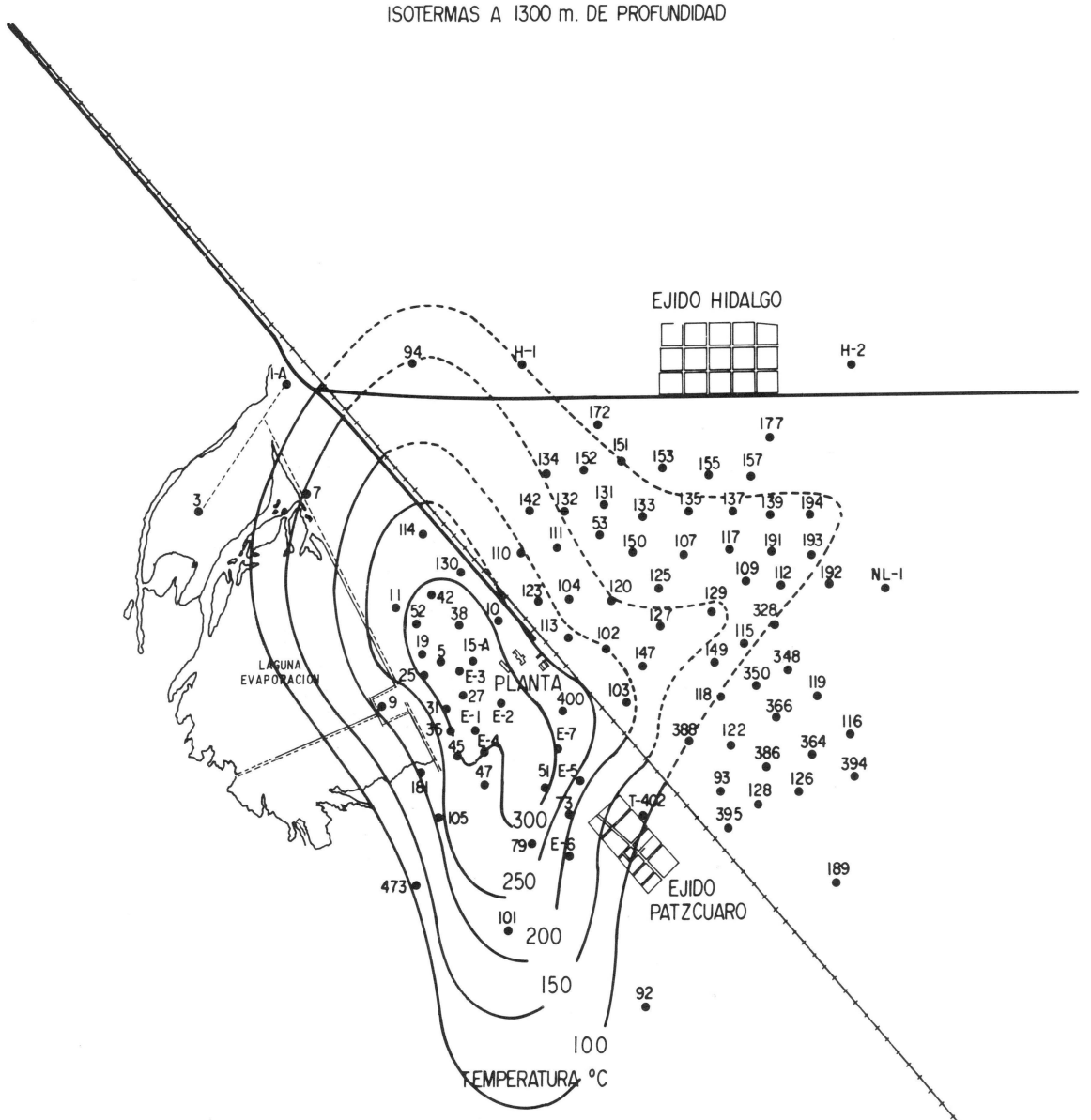

fig. 2

CAMPO GEOTERMICO CERRO PRIETO

ISOTERMAS A 1500 m. DE PROFUNDIDAD

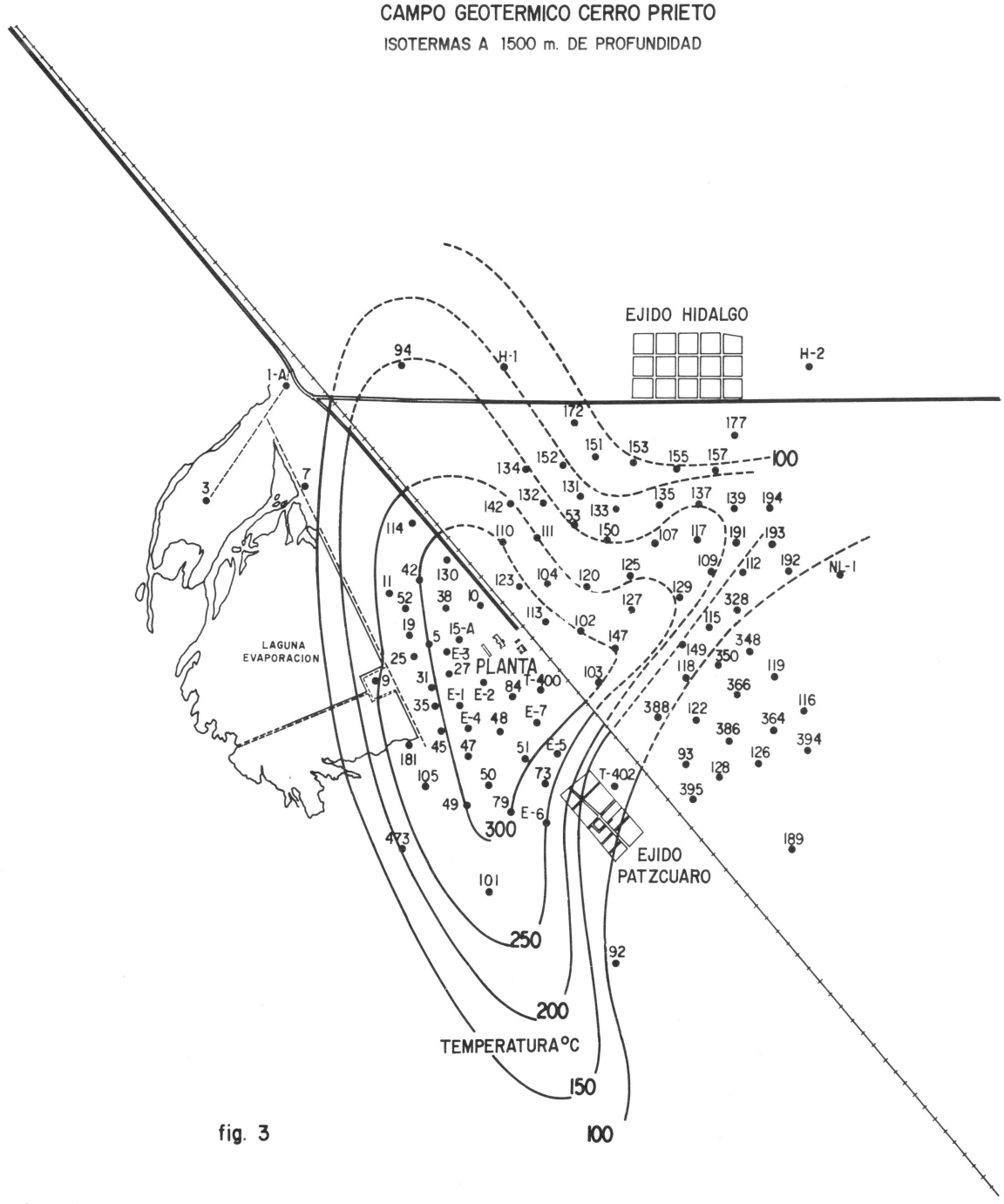

fig. 3

CORRELACIONES TERMICAS

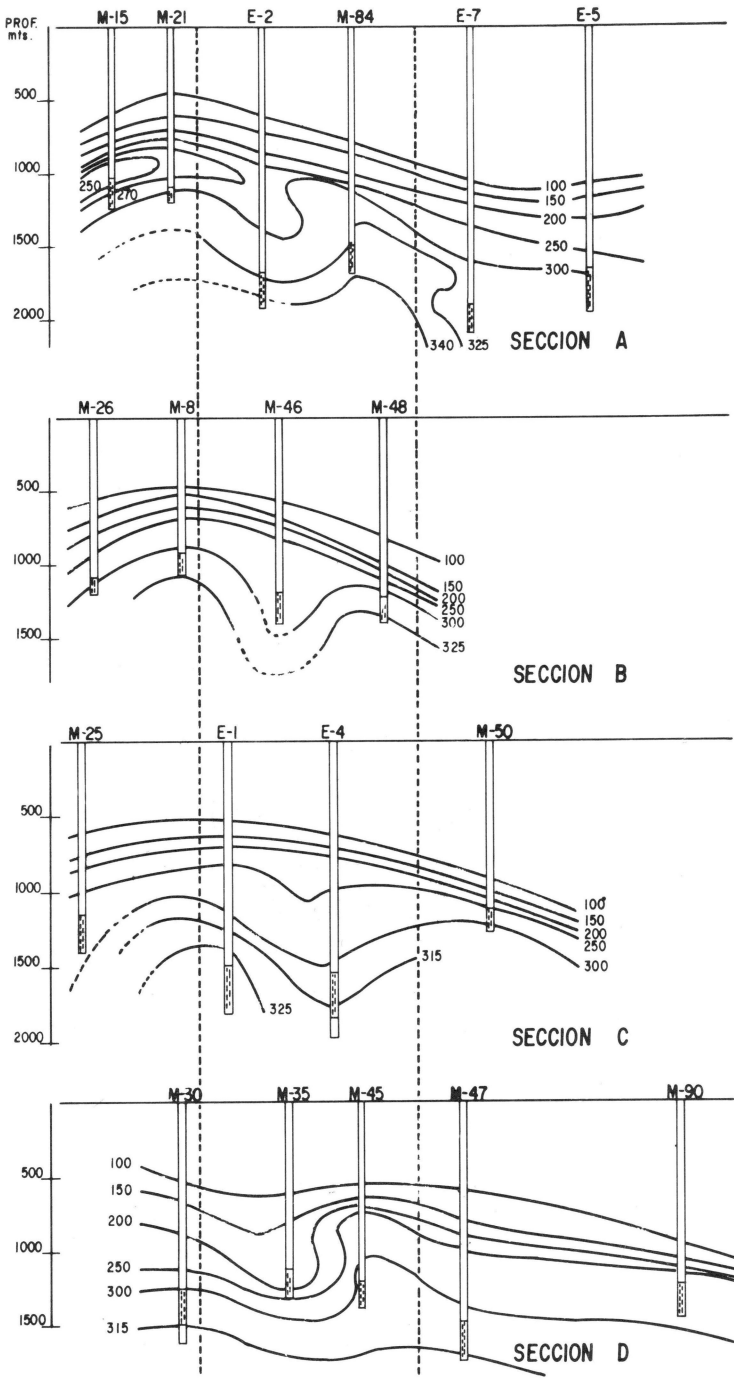

fig.8

DISTRIBUCION DE TEMPERATURAS Y FLUJOS CONVECTIVOS

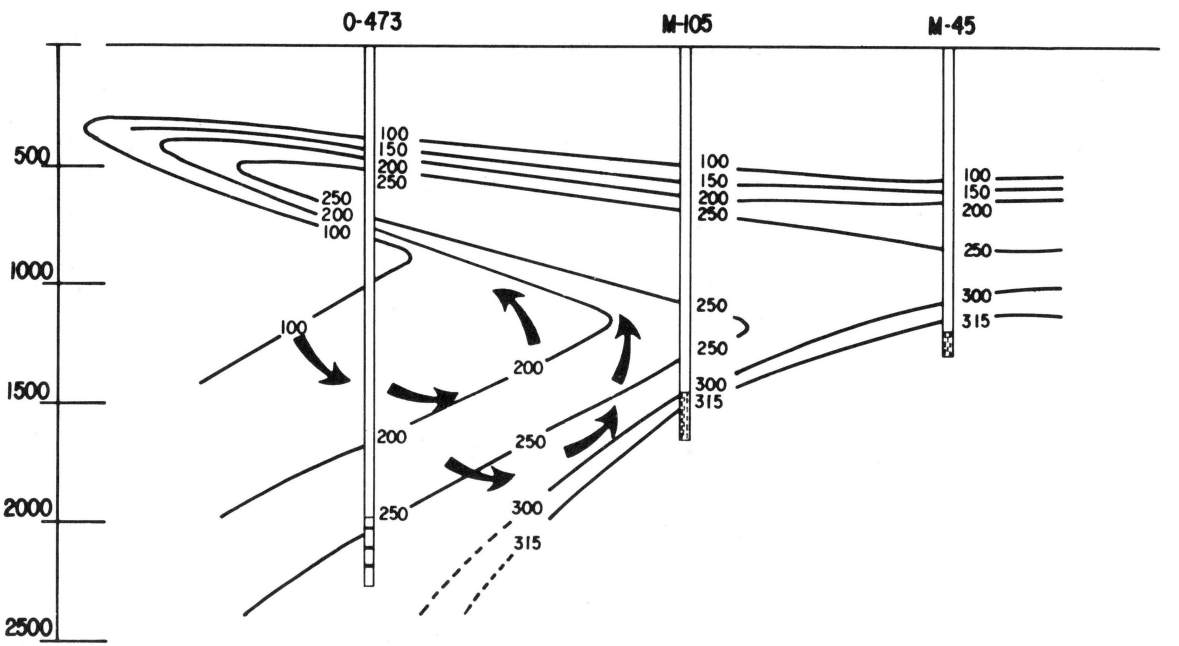

fig. 9