

# ESTUDIOS DE NIVELACION DE PRIMER ORDEN EN CERRO PRIETO

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## RESUMEN

Se presentan los resultados obtenidos por el 2° Levantamiento de Control Vertical realizado en los meses de noviembre y diciembre de 1978, y los resultados del cálculo de los desniveles de campo, así como los datos comparativos de los Levantamientos de 1977 y 1978 y su graficación.

## INTRODUCCION

El presente documento es el 2° de un total de 3 reportes de Levantamiento de Control Vertical realizados por DETENAL en base al Contrato GEIP-CCP-014/78, firmado por la Comisión Federal de Electricidad (CFE) y la Secretaría de Programación y Presupuesto (SPP). De acuerdo al contrato citado, la DETENAL se encarga de efectuar el Levantamiento de Control Vertical de dos circuitos localizados en el Valle de Mexicali, B.C.N. (Fig. 1), con un desarrollo de aproximadamente 160 km y considerando las especificaciones establecidas en el documento a que se hace referencia.

En la realización de los trabajos se siguieron los mismos procedimientos de campo, se tocaron los mismos Bancos de Nivel, y se adoptó la misma forma para la presentación de información que en el 1er. Levantamiento de 1977.

## OBJETIVO DEL PROYECTO

El objetivo del proyecto es determinar los movimientos relativos de la corteza terrestre en la zona de estudio, por lo cual DETENAL aporta los datos a los movimientos verticales relativos.

## PRESENTACION DE RESULTADOS

TABLA 1

La tabla 1, denominada "DESNIVELES DE CAMPO", muestra las tolerancias de acuerdo a las especificaciones del trabajo y comparativamente las discrepancias obtenidas en el 2° Levantamiento, con objeto de comprobar que se han cumplido las especificaciones establecidas en el contrato.

TABLA 2

La tabla 2, denominada "ELEVACIONES", contiene los resultados de los cálculos de las elevaciones del 2° Levantamiento, incluyendo las elevaciones topográficas, ortométricas y definitivas cuyos procedimientos de cálculo son detallados en el 1er. reporte.

TABLA 3

En la tabla 3, denominada "COMPARACION DE RESULTADOS ENTRE LOS LEVANTAMIENTOS DE 1977 Y 1978", en la columna "Desniveles", "elevaciones topográficas" y "elevaciones ortométricas" están las diferencias de los levantamientos, utilizando como base cero el levantamiento realizado en 1977.

Para el cálculo de las elevaciones definitivas se utilizaron dos métodos, el de Reducción de circuito y el Método de Cholesky. Para el levantamiento de 1977 sólo se utilizó el Método de Reducción de Circuito ya que no se tenía implementado el Método de Cholesky; sin embargo, este método se empleó en el segundo levantamiento con objeto de probar su bondad, y en las columnas denominadas "Solución por Reducción de Circuito" y "Solución Cholesky" se citan las diferencias entre las elevaciones definitivas del primer levantamiento como base cero y el segundo levantamiento utilizando los dos métodos mencionados.

## ANALISIS Y REPRESENTACION DE LAS VARIACIONES VERTICALES DETECTADAS

Utilizando como fuente la tabla 3 se graficaron las discrepancias de las elevaciones ortométricas obtenidas en los levantamientos de 1977 y 1978, manteniendo como base (Línea Horizontal) el levantamiento de 1977.

Después de inspeccionar visualmente la gráfica resultante (anexo 1) se observaron cinco tramos de discrepancias (Fig. 1) con comportamientos diferentes.

*Tramo I.* En este tramo, comprendido del BN Y1224 al BN 10029, se observa que los desplazamientos

varían en forma irregular; es decir, sin presentar una tendencia uniforme de levantamiento o hundimiento de la corteza terrestre.

*Tramo II.* En este tramo, que comprende del BN 10029 al BN 10046, se observa una pequeña tendencia al hundimiento.

El fuerte hundimiento que se observa en el BN 10042 quizá se deba a que se localiza en las inmediaciones de una zona de cultivo.

*Tramo III.* En este tramo, comprendido del BN 10048 al BN 10120, se considera importante señalar que se presentan dos casos notables comentados a continuación:

*1er. caso.* Se localiza entre el BN 10058 y el BN 10062. Se observa un marcado hundimiento de la corteza terrestre, la posible causa del mismo quizá se deba a la cercanía con la zona de explotación del campo geotérmico.

*2do. caso.* Localizado entre el BN 10063 al BN 10120. Esta zona presenta una tendencia general al levantamiento.

El BN 10098 denota un fuerte hundimiento. Este BN se encuentra ubicado en los límites de una zona de cultivo. Similar es el caso del BN 10042.

NOTA: El análisis del tramo III se inició en el BN 10048 debido a la destrucción del BN 10047 (señalado con \* en la Fig. 1), por esta causa la gráfica (anexo 1) carece de información en ese punto.

Se construyó otro BN 10047 en una zona cercana al anterior.

*Tramo IV.* Este tramo, ubicado entre el BN 10029 y el BN 10067, muestra tendencias de levantamiento y hundimiento en forma irregular.

*Tramo V.* Este tramo, comprendido del BN 10109 al BN 10153, presenta una marcada tendencia al levantamiento.

Respecto a los BNs 10038-A y 10040-A (ramales), localizados en la Sierra de Cucapás, podemos decir que tienen una mínima tendencia al levantamiento, lo que indica que estos bancos se encuentran en una zona de buena estabilidad.

A manera de conclusión del estudio se observa que la magnitud de los hundimientos es significativamente menor que la correspondiente a los levantamientos.

Las causas de estos comportamientos están más allá del alcance de este reporte.

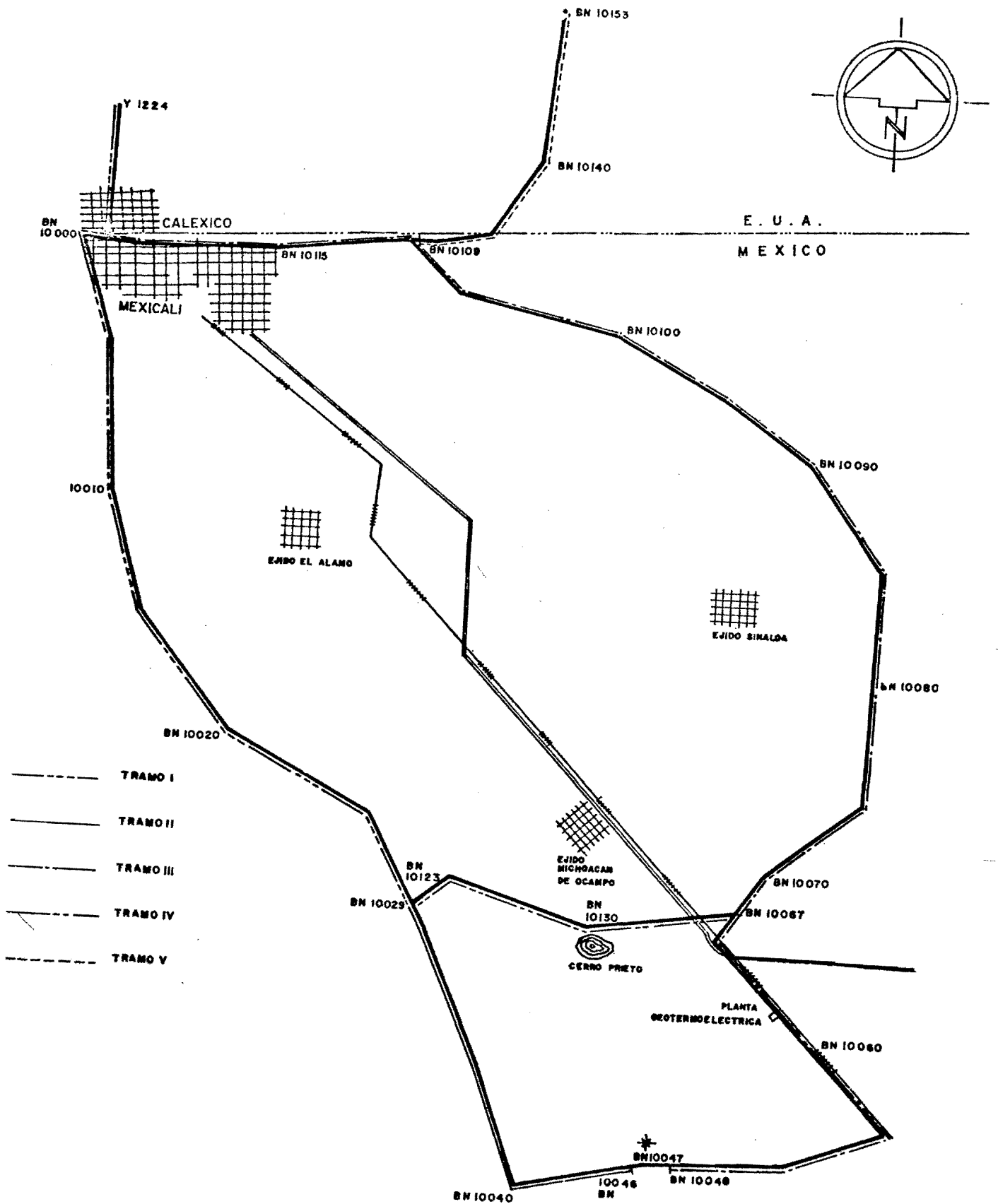


Figura 1. Red de control vertical en el Valle de Mexicali.

TABLA 1. DESNIVELES DE CAMPO

| SECCION        | DESNIVEL<br>(en m) | DISCRE-<br>PANCIA<br>(en mm) | TOLE-<br>RANCIA<br>(en mm) | LONGITUD<br>(en km) |
|----------------|--------------------|------------------------------|----------------------------|---------------------|
| Y1224 - A1225  | -5.3459            | -1.0                         | 3.2                        | 0.8560              |
| A1225 - Z1224  | -0.1536            | -0.7                         | 2.2                        | 0.4134              |
| Z1224 - B1225  | 0.6675             | 1.8                          | 3.5                        | 1.0493              |
| B1225 - F1223  | 0.3324             | 1.5                          | 2.5                        | 0.5205              |
| F1223 - R1225  | -0.3015            | 0.2                          | 2.5                        | 0.1180              |
| R1225 - 1 0121 | -0.4200            | 0.4                          | 2.5                        | 0.1520              |
| 10121 - 10122  | 0.1291             | 0.0                          | 2.5                        | 0.4795              |
| 10122 - 10000  | -1.5656            | -0.6                         | 3.5                        | 0.9956              |
| 10000 - 10001  | 1.9916             | 1.3                          | 3.2                        | 0.8854              |
| 10001 - 10002  | 1.3386             | 2.2                          | 3.5                        | 0.9973              |
| 10002 - 10003  | -0.4772            | -0.6                         | 3.8                        | 1.1777              |
| 10003 - 10004  | 0.2100             | -1.0                         | 3.4                        | 0.9697              |
| 10004 - 10005  | 0.7903             | -0.9                         | 3.6                        | 1.0896              |
| 10005 - 10006  | -0.3075            | -1.5                         | 4.1                        | 1.3465              |
| 10006 - 10007  | 1.8899             | -0.4                         | 4.0                        | 1.3103              |
| 10007 - 10008  | -0.8475            | 0.7                          | 3.8                        | 1.2152              |
| 10008 - 10009  | 0.6474             | 0.6                          | 3.5                        | 1.0251              |
| 10009 - 10010  | 0.3391             | 0.4                          | 3.9                        | 1.2295              |
| 10010 - 10011  | 0.1349             | -1.8                         | 3.4                        | 0.9255              |
| 10011 - 10012  | 0.4622             | -0.7                         | 4.1                        | 1.3885              |
| 10012 - 10013  | 0.7927             | -1.8                         | 4.0                        | 1.3101              |
| 10013 - 10014  | 0.0465             | 1.4                          | 3.1                        | 0.8138              |
| 10014 - 10015  | -0.3481            | -2.2                         | 3.5                        | 1.0147              |
| 10015 - 10016  | 0.4959             | 2.4                          | 4.0                        | 1.3420              |
| 10016 - 10017  | 0.4976             | -0.7                         | 3.4                        | 0.9770              |
| 10017 - 10018  | 0.6604             | -2.1                         | 3.9                        | 1.2500              |
| 10018 - 10019  | -0.1433            | -1.7                         | 4.4                        | 1.5988              |
| 10019 - 10020  | 0.6203             | -1.4                         | 3.3                        | 0.9170              |
| 10020 - 10021  | -0.0514            | -2.2                         | 4.2                        | 1.4151              |
| 10021 - 10022  | 0.1420             | -2.7                         | 4.1                        | 1.4100              |
| 10022 - 10023  | 0.9861             | 0.4                          | 3.7                        | 1.1084              |
| 10023 - 10024  | -0.5058            | 0.9                          | 3.7                        | 1.1162              |
| 10024 - 10025  | 0.0964             | -0.1                         | 3.9                        | 1.2271              |
| 10025 - 10026  | 0.3910             | -0.6                         | 3.0                        | 0.7297              |
| 10026 - 10027  | -0.4113            | 0.0                          | 3.7                        | 1.1144              |
| 10027 - 10028  | -0.4318            | 0.5                          | 3.8                        | 1.1607              |
| 10028 - 10029  | 1.9989             | 2.5                          | 4.0                        | 1.3299              |
| 10029 - DDF65  | 0.8913             | 1.1                          | 3.0                        | 0.7519              |
| DDF65 - 10030  | 1.3858             | 0.8                          | 1.8                        | 0.2735              |
| 10030 - 10031  | 14.4418            | 0.0                          | 3.6                        | 1.0819              |
| 10031 - 10032  | 2.0515             | 1.2                          | 3.6                        | 1.0724              |
| 10032 - DDF64  | 6.3364             | 0.5                          | 2.8                        | 0.6424              |
| DDF64 - 10033  | 1.6087             | -1.6                         | 2.5                        | 0.5163              |
| 10033 - 10034  | 7.3069             | 2.4                          | 3.7                        | 1.1032              |
| 10034 - 10035  | 1.6992             | 0.2                          | 3.6                        | 1.0903              |
| 10035 - DDF63  | 0.2880             | -0.2                         | 3.5                        | 0.4928              |
| DDF63 - 10036  | -6.2460            | -0.4                         | 2.9                        | 0.6709              |
| 10036 - 10037  | -11.3888           | 2.0                          | 3.9                        | 1.2290              |
| 10037 - 10038  | -5.3713            | 1.5                          | 3.9                        | 1.2343              |
| 10038 - DDF62  | -3.4813            | 0.9                          | 2.6                        | 0.5532              |
| DDF62 - 10039  | -1.2079            | -0.6                         | 2.4                        | 0.4793              |
| 10039 - 10040  | 1.1518             | 1.1                          | 3.0                        | 0.7297              |
| 10040 - 10041  | -9.9491            | -2.5                         | 3.7                        | 1.1324              |
| 10041 - 10042  | 0.8849             | -1.7                         | 3.5                        | 1.0350              |
| 10042 - 10043  | -0.9990            | -0.9                         | 3.7                        | 1.1574              |

TABLA 1. (Continuación)

|               |         |      |     |        |
|---------------|---------|------|-----|--------|
| 10043 - 10044 | 0.3994  | 1.9  | 3.1 | 0.7651 |
| 10044 - 10045 | -0.3221 | 0.8  | 3.2 | 0.8556 |
| 10045 - 10046 | 0.9616  | 2.1  | 3.2 | 0.8608 |
| 10046 - 10047 | 2.2298  | -1.3 | 3.7 | 1.1115 |
| 10047 - 10048 | -1.6524 | -1.1 | 4.6 | 1.7436 |
| 10048 - 10049 | 0.5364  | -0.5 | 2.9 | 0.6943 |
| 10049 - 10050 | 0.2570  | -1.5 | 3.7 | 1.1093 |
| 10050 - 10051 | 0.1094  | -0.8 | 3.6 | 1.0682 |
| 10051 - 10052 | -0.5288 | -1.4 | 3.1 | 0.7996 |
| 10052 - 10053 | 0.7041  | -0.9 | 3.8 | 1.1939 |
| 10053 - 10054 | -1.2525 | 0.6  | 3.5 | 0.9890 |
| 10054 - 10055 | -0.6151 | -2.0 | 3.9 | 1.2538 |
| 10055 - 10056 | -0.3458 | -1.7 | 3.3 | 0.8953 |
| 10056 - 10057 | 0.7845  | -1.3 | 2.9 | 0.6771 |
| 10057 - 10058 | 1.6372  | -0.4 | 3.2 | 0.8524 |
| 10058 - 10059 | -0.4066 | -0.0 | 3.7 | 1.1037 |
| 10059 - 10060 | -0.9258 | -1.6 | 3.5 | 0.9984 |
| 10060 - 10061 | -1.3292 | -1.5 | 3.7 | 1.1116 |
| 10061 - 10062 | -0.3573 | 0.1  | 3.5 | 0.9577 |
| 10062 - 10063 | 0.8784  | -1.4 | 3.2 | 0.8525 |
| 10063 - 10064 | 0.8041  | -0.5 | 3.7 | 1.1535 |
| 10064 - 10065 | 0.5187  | -0.8 | 3.6 | 1.0517 |
| 10065 - 10066 | -0.5076 | 2.1  | 3.3 | 0.8865 |
| 10066 - 10067 | 0.4324  | 1.5  | 2.5 | 0.5328 |
| 10067 - 10068 | 1.8606  | -2.0 | 3.5 | 0.9570 |
| 10068 - 10069 | -1.1123 | -2.5 | 3.7 | 1.1080 |
| 10069 - 10070 | 1.1420  | -2.2 | 3.6 | 1.0490 |
| 10070 - 10071 | 0.1935  | -2.2 | 3.3 | 0.9150 |
| 10071 - 10072 | 0.2537  | 1.4  | 3.3 | 0.8878 |
| 10072 - 10073 | -0.3521 | 0.9  | 3.8 | 1.1850 |
| 10073 - 10074 | 0.4701  | -1.5 | 3.9 | 1.2620 |
| 10074 - 10075 | -3.5450 | 1.4  | 3.5 | 0.9587 |
| 10075 - 10076 | 2.4375  | 0.8  | 3.3 | 0.8821 |
| 10076 - 10077 | -1.6884 | 0.4  | 3.4 | 0.9508 |
| 10077 - 10078 | 1.0591  | -1.7 | 3.5 | 1.0039 |
| 10078 - 10079 | -0.2875 | -1.8 | 3.6 | 1.0508 |
| 10079 - 10080 | -0.7777 | 1.1  | 3.5 | 1.0143 |
| 10080 - 10081 | 1.9770  | -0.5 | 3.7 | 1.1210 |
| 10081 - 10082 | 0.4135  | -0.0 | 3.6 | 1.0760 |
| 10082 - 10083 | 0.5914  | 1.2  | 3.5 | 1.0063 |
| 10083 - 10084 | -0.1861 | -0.2 | 2.6 | 0.5649 |
| 10084 - 10085 | 0.7689  | -0.3 | 3.4 | 0.9440 |
| 10085 - 10086 | 0.6470  | -1.9 | 3.7 | 1.1146 |
| 10086 - 10087 | -1.1804 | -1.6 | 3.7 | 1.1190 |
| 10087 - 10088 | 0.4528  | -0.7 | 3.4 | 0.9325 |
| 10088 - 10089 | -0.2844 | 1.7  | 3.3 | 0.8990 |
| 10089 - 10090 | -0.1176 | 1.9  | 3.3 | 0.8827 |
| 10090 - 10091 | -0.2039 | 1.9  | 3.6 | 1.0580 |
| 10091 - 10092 | -0.5594 | -1.4 | 3.9 | 1.2681 |
| 10092 - 10093 | 0.1133  | 0.9  | 3.4 | 0.9260 |
| 10093 - 10094 | 1.5639  | -1.2 | 3.0 | 0.7280 |
| 10094 - 10095 | -0.2996 | 1.5  | 3.4 | 0.9635 |
| 10095 - 10096 | 0.5962  | 0.5  | 3.4 | 0.9485 |
| 10096 - 10097 | -0.8204 | -1.7 | 3.3 | 0.8922 |
| 10097 - 10098 | -1.2724 | 0.0  | 3.6 | 1.0396 |
| 10098 - 10099 | 0.8233  | -2.0 | 3.8 | 1.2147 |
| 10099 - 10100 | -1.6429 | 1.6  | 3.2 | 0.8469 |
| 10100 - 10101 | -0.8983 | 1.0  | 3.8 | 1.1907 |
| 10101 - 10102 | -0.9546 | -1.5 | 3.5 | 1.0034 |
| 10102 - 10103 | 1.1543  | 2.3  | 3.4 | 0.9745 |

TABLA 1. (Continuación)

|               |         |      |     |        |
|---------------|---------|------|-----|--------|
| 10103 - 10104 | 1.5130  | -0.2 | 3.2 | 0.8231 |
| 10104 - 10105 | -0.8378 | 1.3  | 4.1 | 1.3467 |
| 10105 - 10106 | -3.9906 | 1.6  | 3.6 | 1.0641 |
| 10106 - 10107 | 1.8213  | 0.0  | 3.5 | 1.0010 |
| 10107 - 10108 | 0.1952  | 1.4  | 3.6 | 1.0330 |
| 10108 - 10109 | 0.2976  | -0.4 | 2.6 | 0.5769 |
|               |         |      |     |        |
| 10109 - 10110 | 1.2571  | -0.3 | 3.2 | 0.8401 |
| 10110 - 10111 | 0.6660  | -1.3 | 2.7 | 0.5996 |
| 10111 - 10112 | -6.4786 | 0.5  | 3.8 | 1.2145 |
| 10112 - 10113 | -0.7726 | -0.2 | 3.2 | 0.8538 |
| 10113 - 10114 | -0.6470 | -2.3 | 3.5 | 1.0195 |
| 10114 - 10115 | -0.3504 | 0.3  | 3.3 | 0.9032 |
| 10115 - 10116 | -1.1674 | 2.4  | 3.6 | 1.0926 |
| 10116 - 10117 | -0.7407 | -1.6 | 3.4 | 0.9528 |
| 10117 - 10118 | -0.4507 | -0.1 | 3.4 | 0.9420 |
| 10118 - 10119 | -0.8878 | -1.0 | 3.4 | 0.9446 |
| 10119 - 10120 | -0.3819 | -0.5 | 3.2 | 0.8638 |
| 10120 - 10121 | -0.3533 | -1.2 | 3.6 | 1.0552 |
|               |         |      |     |        |
| 10029 - 10123 | -1.7515 | 0.9  | 3.3 | 0.9180 |
| 10123 - 10124 | 0.1754  | 1.7  | 2.9 | 0.7179 |
| 10124 - 10125 | 0.4445  | 0.0  | 3.4 | 0.9458 |
| 10125 - 10126 | 0.1819  | -1.2 | 3.3 | 0.8996 |
| 10126 - 10127 | 1.6011  | 0.1  | 3.6 | 1.0610 |
| 10127 - 10128 | 0.4768  | 0.3  | 4.0 | 1.3083 |
| 10128 - 10129 | 0.9287  | 1.4  | 3.5 | 0.9923 |
| 10129 - 10130 | -1.6842 | -0.1 | 3.0 | 0.7610 |
| 10130 - 10131 | 0.4319  | -0.3 | 3.9 | 1.2812 |
| 10131 - 10132 | -0.3572 | -0.7 | 3.8 | 1.1754 |
| 10132 - 10133 | 0.8102  | 0.1  | 3.1 | 0.7874 |
| 10133 - 10067 | 0.1450  | 1.2  | 3.6 | 1.0917 |
|               |         |      |     |        |
| 10109 - 10134 | -1.2134 | 0.3  | 3.0 | 0.7530 |
| 10134 - 10135 | 0.5744  | -2.2 | 3.4 | 0.9600 |
| 10135 - 10136 | 3.2511  | -1.9 | 3.9 | 1.2565 |
| 10136 - 10137 | -2.1828 | 0.9  | 3.6 | 1.0800 |
| 10137 - 10138 | -1.4825 | 0.6  | 3.3 | 0.9181 |
| 10138 - 10139 | -1.0783 | -0.1 | 2.3 | 0.4420 |
| 10139 - 10140 | -1.5431 | 1.0  | 3.2 | 0.8254 |
| 10140 - 10141 | -0.0254 | 0.3  | 3.1 | 0.7750 |
| 10141 - 10142 | 0.4237  | 0.7  | 3.1 | 0.8168 |
| 10142 - 10143 | -0.6462 | -0.1 | 3.2 | 0.8406 |
| 10143 - 10144 | -0.1071 | -1.1 | 3.2 | 0.8330 |
| 10144 - 10145 | -0.7283 | 1.0  | 3.1 | 0.7840 |
| 10145 - 10146 | 0.3553  | 0.7  | 3.2 | 0.8275 |
| 10146 - 10147 | -1.1067 | 2.2  | 3.1 | 0.8040 |
| 10147 - 10148 | -2.3587 | 0.8  | 3.8 | 1.2072 |
| 10148 - 10149 | 5.8853  | 2.0  | 3.8 | 1.2186 |
| 10149 - 10150 | -6.7139 | 0.3  | 3.3 | 0.9336 |
| 10150 - 10151 | -1.7823 | 0.7  | 3.1 | 0.8000 |
| 10151 - 10152 | -0.3621 | -0.2 | 3.3 | 0.9043 |
| 10152 - 10153 | -1.3099 | -0.2 | 3.4 | 0.9820 |

TABLA 2. ELEVACIONES

| BNP    | TOPOGRA<br>FICAS<br>(en m) | ORTOME<br>TRICAS<br>(en m) | DEFINITI<br>VAS,<br>(en m) |
|--------|----------------------------|----------------------------|----------------------------|
| Y-1224 | 6.1330                     | 6.1330                     | 6.1330                     |
| A-1225 | 0.7871                     | 0.7871                     | 0.7861                     |
| Z-1224 | 0.6335                     | 0.6335                     | 0.6321                     |
| B-1225 | 1.3010                     | 1.3010                     | 1.2985                     |
| F-1223 | 1.6334                     | 1.6334                     | 1.6304                     |
| R-1225 | 1.3319                     | 1.3319                     | 1.3287                     |
| 10121  | 0.9119                     | 0.9119                     | 0.9086                     |
| 10122  | 1.0410                     | 1.0410                     | 1.0376                     |
| 10000  | -0.5246                    | -0.5246                    | -0.5281                    |
| 10001  | 1.4670                     | 1.4670                     | 1.4633                     |
| 10002  | 2.8056                     | 2.8056                     | 2.8018                     |
| 10003  | 2.3284                     | 2.3284                     | 2.3244                     |
| 10004  | 2.5384                     | 2.5384                     | 2.5343                     |
| 10005  | 3.3287                     | 3.3287                     | 3.3244                     |
| 10006  | 3.0212                     | 3.0212                     | 3.0167                     |
| 10007  | 4.9111                     | 4.9111                     | 4.9064                     |
| 10008  | 4.0636                     | 4.0636                     | 4.0587                     |
| 10009  | 4.7110                     | 4.7110                     | 4.7059                     |
| 10010  | 5.0501                     | 5.0501                     | 5.0449                     |
| 10011  | 5.1850                     | 5.1850                     | 5.1796                     |
| 10012  | 5.6472                     | 5.6472                     | 5.6416                     |
| 10013  | 6.4399                     | 6.4399                     | 6.4341                     |
| 10014  | 6.4864                     | 6.4864                     | 6.4805                     |
| 10015  | 6.1383                     | 6.1383                     | 6.1322                     |
| 10016  | 6.6342                     | 6.6342                     | 6.6279                     |
| 10017  | 7.1318                     | 7.1318                     | 7.1254                     |
| 10018  | 7.7922                     | 7.7922                     | 7.7856                     |
| 10019  | 7.6489                     | 7.6489                     | 7.6420                     |
| 10020  | 8.2692                     | 8.2692                     | 8.2622                     |
| 10021  | 8.2178                     | 8.2178                     | 8.2106                     |
| 10022  | 8.3598                     | 8.3598                     | 8.3524                     |
| 10023  | 9.3459                     | 9.3459                     | 9.3383                     |
| 10024  | 8.8401                     | 8.8401                     | 8.8323                     |
| 10025  | 8.9365                     | 8.9365                     | 8.9285                     |
| 10026  | 9.3275                     | 9.3275                     | 9.3194                     |
| 10027  | 8.9162                     | 8.9162                     | 8.9079                     |
| 10028  | 8.4844                     | 8.4844                     | 8.4760                     |
| 10029  | 10.4833                    | 10.4833                    | 10.4747                    |
| 10030  | 12.7604                    | 12.7604                    | 12.7516                    |
| 10031  | 27.2022                    | 27.2023                    | 27.1933                    |
| 10032  | 29.2537                    | 29.2538                    | 29.2445                    |
| DDF64  | 35.5901                    | 35.5903                    | 35.5808                    |
| 10033  | 37.1988                    | 37.1990                    | 37.1894                    |
| 10034  | 44.5057                    | 44.5061                    | 44.4962                    |
| 10035  | 46.2049                    | 46.2054                    | 46.1953                    |
| DDF63  | 46.4929                    | 46.4934                    | 46.4831                    |
| 10036  | 40.2469                    | 40.2475                    | 40.2371                    |
| 10037  | 28.8581                    | 28.8588                    | 28.8480                    |
| 10038  | 23.4868                    | 23.4875                    | 23.4763                    |
| DDF62  | 20.0055                    | 20.0062                    | 19.9949                    |
| 10039  | 18.7976                    | 18.7983                    | 18.7869                    |
| 10040  | 19.9494                    | 19.9501                    | 19.9385                    |
| 10041  | 10.0003                    | 10.0011                    | 9.9892                     |
| 10042  | 10.8852                    | 10.8860                    | 10.8739                    |
| 10043  | 9.8862                     | 9.8870                     | 9.8746                     |
| 10044  | 10.2856                    | 10.2864                    | 10.2738                    |
| 10045  | 9.9635                     | 9.9643                     | 9.9515                     |
| 10046  | 10.9251                    | 10.9259                    | 10.9129                    |
| 10047  | *                          | *                          | *                          |
| 10048  | 11.5025                    | 11.5033                    | 11.4895                    |
| 10049  | 12.0389                    | 12.0397                    | 12.0258                    |
| 10050  | 12.2959                    | 12.2967                    | 12.2825                    |
| 10051  | 12.4053                    | 12.4061                    | 12.3916                    |
| 10052  | 11.8765                    | 11.8773                    | 11.8626                    |
| 10053  | 12.5806                    | 12.5814                    | 12.5664                    |
| 10054  | 11.3281                    | 11.3289                    | 11.3137                    |
| 10055  | 10.7130                    | 10.7138                    | 10.6983                    |
| 10056  | 10.3672                    | 10.3680                    | 10.3522                    |
| 10057  | 11.1517                    | 11.1525                    | 11.1366                    |
| 10058  | 12.7889                    | 12.7897                    | 12.7736                    |
| 10059  | 12.3823                    | 12.3831                    | 12.3667                    |
| 10060  | 11.4565                    | 11.4573                    | 11.4406                    |

TABLA 2. (Continuación)

|       |         |         |         |
|-------|---------|---------|---------|
| 10061 | 10.1273 | 10.1281 | 10.1111 |
| 10062 | 9.7700  | 9.7708  | 9.7536  |
| 10063 | 10.6484 | 10.6492 | 10.6318 |
| 10064 | 11.4525 | 11.4533 | 11.4356 |
| 10065 | 11.9712 | 11.9720 | 11.9540 |
| 10066 | 11.4636 | 11.4644 | 11.4462 |
| 10067 | 11.8960 | 11.8968 | 11.8785 |
| 10068 | 13.7566 | 13.7574 | 13.7388 |
| 10069 | 12.6443 | 12.6451 | 12.6264 |
| 10070 | 13.7863 | 13.7871 | 13.7682 |
| 10071 | 13.9798 | 13.9806 | 13.9616 |
| 10072 | 14.2335 | 14.2343 | 14.2151 |
| 10073 | 13.8814 | 13.8822 | 13.8629 |
| 10074 | 14.3515 | 14.3523 | 14.3328 |
| 10075 | 10.8065 | 10.8073 | 10.7876 |
| 10076 | 13.2440 | 13.2448 | 13.2250 |
| 10077 | 11.5556 | 11.5564 | 11.5365 |
| 10078 | 12.6147 | 12.6155 | 12.5954 |
| 10079 | 12.3272 | 12.3280 | 12.3077 |
| 10080 | 11.5495 | 11.5503 | 11.5299 |
| 10081 | 13.5265 | 13.5273 | 13.5067 |
| 10082 | 13.9400 | 13.9408 | 13.9201 |
| 10083 | 14.5314 | 14.5322 | 14.5113 |
| 10084 | 14.3453 | 14.3461 | 14.3251 |
| 10085 | 15.1142 | 15.1150 | 15.0939 |
| 10086 | 15.7612 | 15.7620 | 15.7407 |
| 10087 | 14.5808 | 14.5816 | 14.5601 |
| 10088 | 15.0336 | 15.0344 | 15.0128 |
| 10089 | 14.7492 | 14.7500 | 14.7283 |
| 10090 | 14.6316 | 14.6324 | 14.6105 |
| 10091 | 14.4277 | 14.4285 | 14.4065 |
| 10092 | 13.8683 | 13.8691 | 13.8469 |
| 10093 | 13.9816 | 13.9824 | 13.9600 |
| 10094 | 15.5455 | 15.5463 | 15.5238 |
| 10095 | 15.2459 | 15.2466 | 15.2241 |
| 10096 | 15.8421 | 15.8428 | 15.8202 |
| 10097 | 15.0117 | 15.0224 | 14.9996 |
| 10098 | 13.7493 | 13.7500 | 13.7271 |
| 10099 | 14.5726 | 14.5733 | 14.5502 |
| 10100 | 12.9297 | 12.9304 | 12.9071 |
| 10101 | 12.0314 | 12.0321 | 12.0087 |
| 10102 | 11.0768 | 11.0775 | 11.0539 |
| 10103 | 12.2311 | 12.2318 | 12.2081 |
| 10104 | 13.7441 | 13.7448 | 13.7209 |
| 10105 | 12.9063 | 12.9070 | 12.8829 |
| 10106 | 8.9157  | 8.9164  | 8.8922  |
| 10107 | 10.7370 | 10.7377 | 10.7133 |
| 10108 | 10.9322 | 10.9329 | 10.9084 |
| 10109 | 11.2298 | 11.2305 | 11.2059 |
| 10110 | 12.4869 | 12.4876 | 12.4637 |
| 10111 | 13.1529 | 13.1536 | 13.1303 |
| 10112 | 6.6743  | 6.6750  | 6.6527  |
| 10113 | 5.9017  | 5.9024  | 5.8809  |
| 10114 | 5.2547  | 5.2554  | 5.2348  |
| 10115 | 4.9043  | 4.9050  | 4.8852  |
| 10116 | 3.7369  | 3.7376  | 3.7188  |
| 10117 | 2.9962  | 2.9969  | 2.9789  |
| 10118 | 2.5455  | 2.5462  | 2.5291  |
| 10119 | 1.6577  | 1.6584  | 1.6421  |
| 10120 | 1.2758  | 1.2765  | 1.2610  |
| 10123 | 8.7318  | 8.7318  | 8.7233  |
| 10124 | 8.9072  | 8.9072  | 8.8988  |
| 10125 | 9.3517  | 9.3517  | 9.3433  |
| 10126 | 9.5336  | 9.5336  | 9.5253  |
| 10127 | 11.1347 | 11.1347 | 11.1265 |
| 10128 | 11.6115 | 11.6115 | 11.6035 |
| 10129 | 12.5402 | 12.5402 | 12.5323 |
| 10130 | 10.8560 | 10.8560 | 10.8482 |
| 10131 | 11.2879 | 11.2879 | 11.2802 |
| 10132 | 10.9307 | 10.9307 | 10.9231 |
| 10133 | 11.7409 | 11.7409 | 11.7334 |
| 10134 | 10.0164 | 10.0171 | 9.9917  |

TABLA 2. (Continuación).

|       |         |         |         |        |         |         |         |
|-------|---------|---------|---------|--------|---------|---------|---------|
| 10135 | 10.5908 | 10.5915 | 10.5651 | 10149  | 9.2471  | 9.2478  | 9.2082  |
| 10136 | 13.8419 | 13.8426 | 13.8149 | 10150  | 2.5332  | 2.5339  | 2.4934  |
| 10137 | 11.6591 | 11.6598 | 11.6310 | 10151  | 0.7509  | 0.7516  | 0.7102  |
| 10138 | 10.1766 | 10.1773 | 10.1475 | 10152  | 0.3888  | 0.3895  | 0.3472  |
| 10139 | 9.0983  | 9.0990  | 9.0688  | 10153  | -0.9211 | -0.9204 | -0.9637 |
| 10140 | 7.5552  | 7.5559  | 7.5248  | DDL42  |         |         | 3.5293  |
| 10141 | 7.5298  | 7.5305  | 7.4986  | DDF65  | 11.3746 | 11.3746 | 11.3659 |
| 10142 | 7.9535  | 7.9542  | 7.9214  | 10038A | 41.0815 | 41.0820 | 41.0710 |
| 10143 | 7.3073  | 7.3080  | 7.2744  | 10040A | 49.9390 | 49.8395 | 49.8281 |
| 10144 | 7.2002  | 7.2009  | 7.1664  |        |         |         |         |
| 10145 | 6.4719  | 6.4726  | 6.4373  |        |         |         |         |
| 10146 | 6.8272  | 6.8279  | 6.7917  |        |         |         |         |
| 10147 | 5.7205  | 5.7212  | 5.6842  |        |         |         |         |
| 10148 | 3.3618  | 3.3625  | 3.3242  |        |         |         |         |

\* El BN 10047 se encontró destruido, por tal motivo no se determinaron sus elevaciones.

TABLA 3. COMPARACION DE RESULTADOS ENTRE LOS LEVANTAMIENTOS  
DE 1977 y 1978.

Las discrepancias se expresan en mm en los elementos comparados.

| E L E V A C I O N E S . |             |               |               |                                      |                      |  |
|-------------------------|-------------|---------------|---------------|--------------------------------------|----------------------|--|
| Tramo                   | Desniveles. | Topográficas. | Ortométricas. | Definitivas.<br>Sol.Red.<br>Circuito | Solución<br>Cholesky |  |
| Y-1224                  | A-1225      | 1.0           | 1.0           | + 0.5                                | + 1.0                |  |
| A-1225                  | Z-1224      | 0.8           | 1.8           | + 1.1                                | + 1.8                |  |
| Z-1224                  | B-1225      | -15.2         | -13.4         | -14.5                                | -13.4                |  |
| B-1225                  | F-1223      | 15.5          | 2.1           | +10.8                                | + 2.1                |  |
| F-1223                  | R-1225      | - 4.4         | - 2.3         | - 3.7                                | - 2.3                |  |
| R-1225                  | 10121       | - 0.7         | - 3.0         | - 4.4                                | - 3.0                |  |
| 10121                   | 10122       | 7.1           | 4.1           | + 2.6                                | + 4.1                |  |
| 10122                   | 10000       | -19.7         | -15.6         | -17.1                                | -15.6                |  |
| 10000                   | 10001       | 2.7           | -12.9         | -14.5                                | -13.0                |  |
| 10001                   | 10002       | 25.4          | 12.5          | +10.8                                | +12.4                |  |
| 10002                   | 10003       | -12.3         | 0.2           | 1.6                                  | + 0.1                |  |
| 10003                   | 10004       | - 1.6         | - 1.4         | - 3.2                                | - 1.6                |  |
| 10004                   | 10005       | -11.3         | -12.7         | -14.6                                | -12.9                |  |
| 10005                   | 10006       | 17.1          | 4.4           | + 2.4                                | + 4.1                |  |
| 10006                   | 10007       | - 1.0         | 3.4           | + 1.3                                | + 3.1                |  |
| 10007                   | 10008       | 3.7           | 7.1           | + 4.6                                | + 6.8                |  |
| 10008                   | 10009       | 0.1           | 7.2           | + 4.8                                | + 6.8                |  |
| 10009                   | 10010       | - 3.1         | 4.1           | + 1.7                                | + 3.7                |  |
| 10010                   | 10011       | -54.2         | -50.1         | -52.6                                | -50.5                |  |
| 10011                   | 10012       | 61.9          | 11.8          | + 9.2                                | +11.3                |  |
| 10012                   | 10013       | 0.9           | 12.7          | + 9.9                                | +12.2                |  |
| 10013                   | 10014       | -26.7         | -14.0         | -17.8                                | -14.6                |  |
| 10014                   | 10015       | 26.0          | 12.0          | + 9.1                                | +11.4                |  |
| 10015                   | 10016       | 0.8           | 12.8          | + 9.8                                | +12.2                |  |
| 10016                   | 10017       | 15.2          | 28.0          | +24.9                                | +27.3                |  |
| 10017                   | 10018       | -19.7         | 8.3           | + 5.1                                | + 7.6                |  |
| 10018                   | 10019       | 1.9           | 10.2          | + 6.8                                | + 9.5                |  |
| 10019                   | 10020       | 0.8           | 11.0          | + 7.6                                | +10.1                |  |
| 10020                   | 10021       | - 0.4         | 10.6          | + 7.1                                | + 9.7                |  |
| 10021                   | 10022       | -18.6         | - 8.0         | -11.6                                | - 8.9                |  |
| 10022                   | 10023       | 18.1          | 10.1          | + 6.3                                | + 9.1                |  |
| 10023                   | 10024       | - 6.1         | 4.0           | + 0.1                                | + 3.0                |  |
| 10024                   | 10025       | 3.5           | 7.5           | + 3.5                                | + 6.4                |  |
| 10025                   | 10026       | - 1.2         | 6.3           | + 2.3                                | + 5.2                |  |
| 10026                   | 10027       | -12.5         | - 6.2         | -10.4                                | - 7.3                |  |

TABLA 3. (Continuación)

|       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|
| 10027 | 10028 | 8.8   | 2.6   | 2.6   | - 1.6 | + 1.4 |
| 10028 | 10029 | 1.0   | 3.6   | 3.6   | - 0.7 | + 2.4 |
| 10029 | 10030 | - 0.2 | 3.4   | 3.4   | - 1.3 | + 1.9 |
| 10030 | 10031 | - 0.2 | 3.2   | 3.2   | - 1.8 | + 1.2 |
| 10031 | 10032 | 1.1   | 4.3   | 4.3   | - 1.2 | + 1.9 |
| 10032 | DDF64 | - 1.4 | 2.9   | 3.0   | - 2.8 | + 0.3 |
| DDF64 | 10033 | - 1.1 | 1.8   | 1.9   | - 4.0 | - 1.0 |
| 10033 | 10034 | - 0.5 | 1.3   | 1.4   | - 5.0 | - 1.9 |
| 10034 | 10035 | - 3.9 | - 2.6 | - 2.5 | - 9.3 | - 6.3 |
| 10035 | DDF63 | - 0.1 | - 2.7 | - 2.6 | - 9.7 | - 6.6 |
| DDF63 | 10036 | 0.1   | - 2.6 | - 2.5 | - 9.8 | - 6.7 |
| 10036 | 10037 | - 1.5 | - 4.1 | - 3.9 | -11.7 | - 8.6 |
| 10037 | 10038 | 1.7   | - 2.4 | - 2.2 | -10.6 | - 7.4 |
| 10038 | DDF62 | 1.4   | - 1.0 | - 0.8 | - 9.4 | - 6.2 |
| DDF62 | 10039 | - 1.8 | - 2.8 | - 2.6 | -11.4 | - 8.2 |
| 10039 | 10040 | 2.9   | 0.1   | 0.3   | - 9.8 | - 5.6 |
| 10040 | 10041 | 1.3   | 1.4   | 1.7   | - 7.9 | - 4.6 |
| 10041 | 10042 | -49.0 | -47.6 | -47.3 | -57.2 | -54.0 |
| 10042 | 10043 | 47.8  | 0.2   | 0.5   | - 9.9 | - 6.6 |
| 10043 | 10044 | - 1.1 | - 0.9 | - 0.6 | -11.3 | - 8.1 |
| 10044 | 10045 | 1.7   | 0.8   | 1.1   | -10.0 | - 6.7 |
| 10045 | 10046 | - 2.4 | - 1.6 | - 1.3 | -12.7 | - 9.4 |
| 10046 | 10047 | *     | *     | *     | *     | *     |
| 10047 | 10048 | *     | 16.9  | 17.2  | + 4.6 | + 8.0 |
| 10048 | 10049 | - 1.8 | 15.1  | 15.4  | + 2.6 | + 5.9 |
| 10049 | 10050 | 0.5   | 15.6  | 15.9  | + 2.6 | + 6.0 |
| 10050 | 10051 | - 2.8 | 12.8  | 13.1  | - 0.7 | + 2.8 |
| 10051 | 10052 | - 0.8 | 12.0  | 12.3  | - 1.8 | + 1.6 |
| 10052 | 10053 | 3.6   | 15.6  | 15.9  | + 1.3 | + 4.7 |
| 10053 | 10054 | - 5.7 | 9.9   | 10.2  | - 4.7 | - 1.3 |
| 10054 | 10055 | - 2.5 | 7.4   | 7.7   | - 7.7 | - 4.2 |
| 10055 | 10056 | - 1.0 | 6.4   | 6.7   | - 9.2 | - 5.7 |
| 10056 | 10057 | - 1.3 | 5.1   | 5.4   | -10.7 | - 7.2 |
| 10057 | 10058 | - 0.6 | 4.5   | 4.8   | -11.6 | - 8.2 |
| 10058 | 10059 | - 4.8 | - 0.3 | 0.0   | -16.9 | -13.3 |
| 10059 | 10060 | - 5.3 | - 5.6 | - 5.3 | -22.6 | -19.1 |
| 10060 | 10061 | - 2.7 | - 8.3 | - 8.0 | -25.8 | -22.2 |
| 10061 | 10062 | 7.1   | - 1.2 | - 0.9 | -19.0 | -15.5 |
| 10062 | 10063 | 16.7  | 15.5  | 15.8  | - 2.7 | + 0.9 |
| 10063 | 10064 | - 9.1 | 6.4   | 6.7   | -12.2 | - 8.7 |
| 10064 | 10065 | 5.6   | 12.0  | 12.3  | - 7.1 | - 3.4 |
| 10065 | 10066 | 8.1   | 20.1  | 20.4  | + 0.7 | + 4.3 |
| 10066 | 10067 | 0.2   | 20.3  | 20.6  | + 0.7 | + 4.3 |
| 10067 | 10068 | - 8.0 | 12.7  | 13.0  | - 7.1 | - 3.3 |
| 10068 | 10069 | 7.6   | 20.3  | 20.6  | + 0.5 | + 4.2 |
| 10069 | 10070 | 0.2   | 20.5  | 20.8  | + 0.5 | + 4.4 |
| 10070 | 10071 | - 0.5 | 20.0  | 20.3  | 0.0   | + 3.9 |
| 10071 | 10072 | 3.0   | 23.0  | 23.3  | + 2.8 | + 6.8 |
| 10072 | 10073 | - 2.5 | 20.5  | 20.8  | + 0.3 | + 4.3 |
| 10073 | 10074 | - 4.8 | 15.7  | 16.0  | - 4.6 | - 0.5 |
| 10074 | 10075 | 13.9  | 29.6  | 29.9  | + 9.2 | +13.3 |
| 10075 | 10076 | - 6.0 | 23.6  | 23.9  | + 3.1 | + 7.3 |
| 10076 | 10077 | 1.5   | 25.1  | 25.4  | + 4.6 | + 8.8 |
| 10077 | 10078 | 0.2   | 25.3  | 25.6  | + 4.7 | + 8.9 |
| 10078 | 10079 | 0.5   | 25.8  | 26.1  | + 5.0 | + 9.4 |
| 10079 | 10080 | 3.0   | 28.8  | 29.1  | + 8.0 | +12.4 |
| 10080 | 10081 | - 0.8 | 28.0  | 28.3  | + 7.1 | +11.5 |
| 10081 | 10082 | 2.6   | 30.6  | 30.9  | + 9.7 | +14.1 |
| 10082 | 10083 | - 1.6 | 29.0  | 29.3  | + 7.9 | +12.5 |
| 10083 | 10084 | - 3.4 | 25.6  | 25.9  | + 4.5 | + 9.1 |
| 10084 | 10085 | 3.4   | 29.0  | 29.3  | + 7.8 | +12.4 |

TABLA 3. (Continuación)

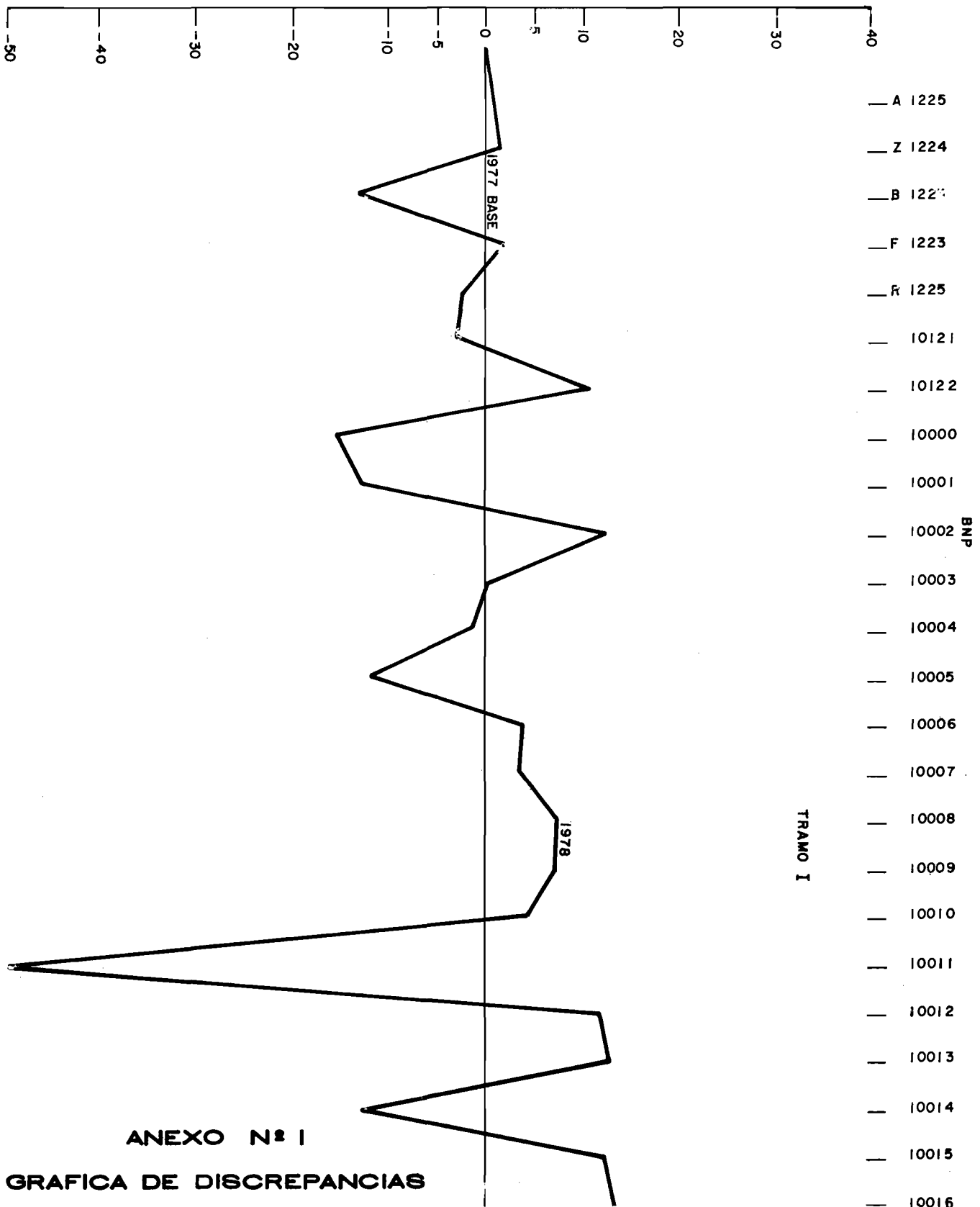
|       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|
| 10085 | 10086 | 1.7   | 30.7  | 31.0  | + 9.4 | +14.1 |
| 10086 | 10087 | - 2.4 | 28.3  | 28.6  | + 6.9 | +11.7 |
| 10087 | 10088 | - 1.2 | 27.1  | 27.4  | + 5.7 | +10.4 |
| 10088 | 10089 | 4.1   | 31.2  | 31.5  | + 9.7 | +14.5 |
| 10089 | 10090 | 1.5   | 32.7  | 33.0  | +11.1 | +16.0 |
| 10090 | 10091 | - 0.6 | 32.1  | 32.4  | +10.5 | +15.3 |
| 10091 | 10092 | - 0.9 | 31.2  | 31.5  | + 9.5 | +14.3 |
| 10092 | 10093 | - 1.1 | 30.1  | 30.4  | + 8.2 | +13.2 |
| 10093 | 10094 | 2.1   | 32.2  | 32.5  | +10.3 | +15.3 |
| 10094 | 10095 | 0.7   | 32.9  | 33.1  | +10.9 | +15.8 |
| 10095 | 10096 | - 5.1 | 27.8  | 28.0  | + 6.8 | +10.7 |
| 10096 | 10097 | -10.3 | 17.5  | 17.7  | - 4.6 | + 0.4 |
| 10097 | 10098 | -32.8 | -15.3 | -15.1 | -37.5 | -32.5 |
| 10098 | 10099 | 46.1  | 30.8  | 31.0  | + 8.5 | +13.7 |
| 10099 | 10100 | 0.4   | 31.2  | 31.4  | + 8.8 | +14.0 |
| 10100 | 10101 | - 1.9 | 29.3  | 29.5  | + 6.9 | +12.0 |
| 10101 | 10102 | - 2.0 | 27.3  | 27.5  | + 4.7 | +10.0 |
| 10102 | 10103 | - 0.1 | 27.2  | 27.4  | + 4.6 | + 9.0 |
| 10103 | 10104 | - 3.5 | 23.7  | 23.9  | + 1.0 | + 6.3 |
| 10104 | 10105 | 3.2   | 26.9  | 27.1  | + 4.0 | + 9.6 |
| 10105 | 10106 | 1.1   | 28.0  | 28.2  | + 5.1 | +10.6 |
| 10106 | 10107 | 0.2   | 28.2  | 28.4  | + 5.2 | +10.8 |
| 10107 | 10108 | - 0.4 | 27.8  | 28.0  | + 4.8 | +10.3 |
| 10108 | 10109 | 2.0   | 29.8  | 30.0  | + 6.7 | +12.3 |
| 10109 | 10110 | - 1.3 | 28.5  | 28.7  | + 5.6 | +11.0 |
| 10110 | 10111 | - 2.7 | 25.8  | 26.0  | + 3.2 | + 8.3 |
| 10111 | 10112 | 4.3   | 30.1  | 30.3  | + 7.9 | +12.5 |
| 10112 | 10113 | - 0.9 | 29.2  | 29.4  | + 7.3 | +11.6 |
| 10113 | 10114 | - 5.1 | 24.1  | 24.3  | + 2.5 | + 6.5 |
| 10114 | 10115 | 0.7   | 24.8  | 25.0  | + 3.5 | + 7.1 |
| 10115 | 10116 | - 6.3 | 18.5  | 18.7  | + 2.4 | + 0.8 |
| 10116 | 10117 | 7.7   | 26.2  | 26.4  | + 5.6 | + 8.5 |
| 10117 | 10118 | - 2.6 | 23.6  | 23.8  | + 3.4 | + 5.9 |
| 10118 | 10119 | - 1.0 | 22.6  | 22.8  | + 2.6 | + 4.8 |
| 10119 | 10120 | - 5.5 | 17.1  | 17.3  | - 2.5 | - 0.7 |
| 10120 | 10121 | - 2.2 | - 3.0 | - 3.0 | - 4.4 | - 3.0 |
| 10029 | 10123 | - 0.1 | 3.5   | 3.5   | - 0.5 | + 2.7 |
| 10123 | 10124 | - 6.2 | - 2.7 | - 2.7 | - 6.4 | - 3.3 |
| 10124 | 10125 | 9.0   | 6.3   | 6.3   | + 2.8 | + 6.0 |
| 10125 | 10126 | 2.0   | 8.3   | 8.3   | + 5.1 | + 8.4 |
| 10126 | 10127 | -36.3 | -28.0 | -28.0 | -30.9 | -27.5 |
| 10127 | 10128 | 24.1  | - 3.9 | - 3.9 | - 6.3 | - 3.0 |
| 10128 | 10129 | 6.5   | 2.6   | 2.6   | + 0.5 | + 3.8 |
| 10129 | 10130 | - 0.4 | 2.2   | 2.2   | + 0.4 | + 3.8 |
| 10130 | 10131 | - 7.3 | - 5.1 | - 5.1 | - 6.6 | - 3.1 |
| 10131 | 10132 | 4.4   | - 0.7 | - 0.7 | - 1.8 | + 1.7 |
| 10132 | 10133 | - 1.2 | - 1.9 | - 1.9 | - 2.7 | + 0.8 |
| 10133 | 10067 | 3.1   | **    | **    | **    | **    |
| 10109 | 10134 | 0.6   | 30.4  | 30.6  | + 7.0 | +12.9 |
| 10134 | 10135 | 0.6   | 31.0  | 31.2  | + 7.2 | +13.5 |
| 10135 | 10136 | 2.7   | 33.7  | 33.9  | + 9.3 | +16.2 |
| 10136 | 10137 | 2.6   | 36.3  | 36.5  | +11.5 | +18.8 |
| 10137 | 10138 | 2.2   | 38.5  | 38.7  | +13.3 | +21.0 |
| 10138 | 10139 | - 2.4 | 36.1  | 36.3  | +10.7 | +18.6 |
| 10139 | 10140 | - 1.0 | 35.1  | 35.3  | + 9.3 | +17.6 |
| 10140 | 10141 | - 1.0 | 34.1  | 34.3  | + 8.0 | +16.6 |
| 10141 | 10142 | - 1.3 | 32.8  | 33.0  | + 6.3 | +15.3 |
| 10142 | 10143 | 1.1   | 33.9  | 34.1  | + 7.1 | +16.4 |
| 10143 | 10144 | - 6.3 | 27.6  | 27.8  | + 0.4 | +10.1 |
| 10144 | 10145 | 3.8   | 31.4  | 31.6  | + 3.9 | +13.9 |
| 10145 | 10146 | 0.9   | 32.3  | 32.5  | + 4.4 | +14.8 |

TABLA 3. (Continuación)

|       |        |       |       |      |       |       |
|-------|--------|-------|-------|------|-------|-------|
| 10146 | 10147  | - 1.2 | 31.1  | 31.3 | + 2.9 | +13.6 |
| 10147 | 10148  | - 0.8 | 30.3  | 30.5 | + 1.6 | +12.8 |
| 10148 | 10149  | 0.0   | 30.3  | 30.5 | + 1.0 | +12.8 |
| 10149 | 10150  | 0.9   | 31.2  | 31.4 | + 1.6 | +13.7 |
| 10150 | 10151  | 1.6   | 32.8  | 33.0 | + 2.8 | +14.4 |
| 10151 | 10152  | - 0.9 | 31.9  | 32.1 | + 1.5 | +13.6 |
| 10152 | 10153  | - 0.8 | 31.1  | 31.3 | + 0.4 | + 5.8 |
| 10030 | DDF65  | 0.3   | 3.7   | 3.7  | 0.9   | + 2.2 |
| 10038 | 10038A | 2.3   | - 0.1 | 0.1  | - 8.1 | - 5.1 |
| 10040 | 10040A | 1.1   | 1.2   | 1.4  | - 7.5 | - 4.5 |

NOTA: \* El BN 10047 se encontró destruido, por tal motivo no se determinó su comparación. La comparación del desnivel para el tramo BN 10047-BN 10048 no se terminó por las razones expuestas.

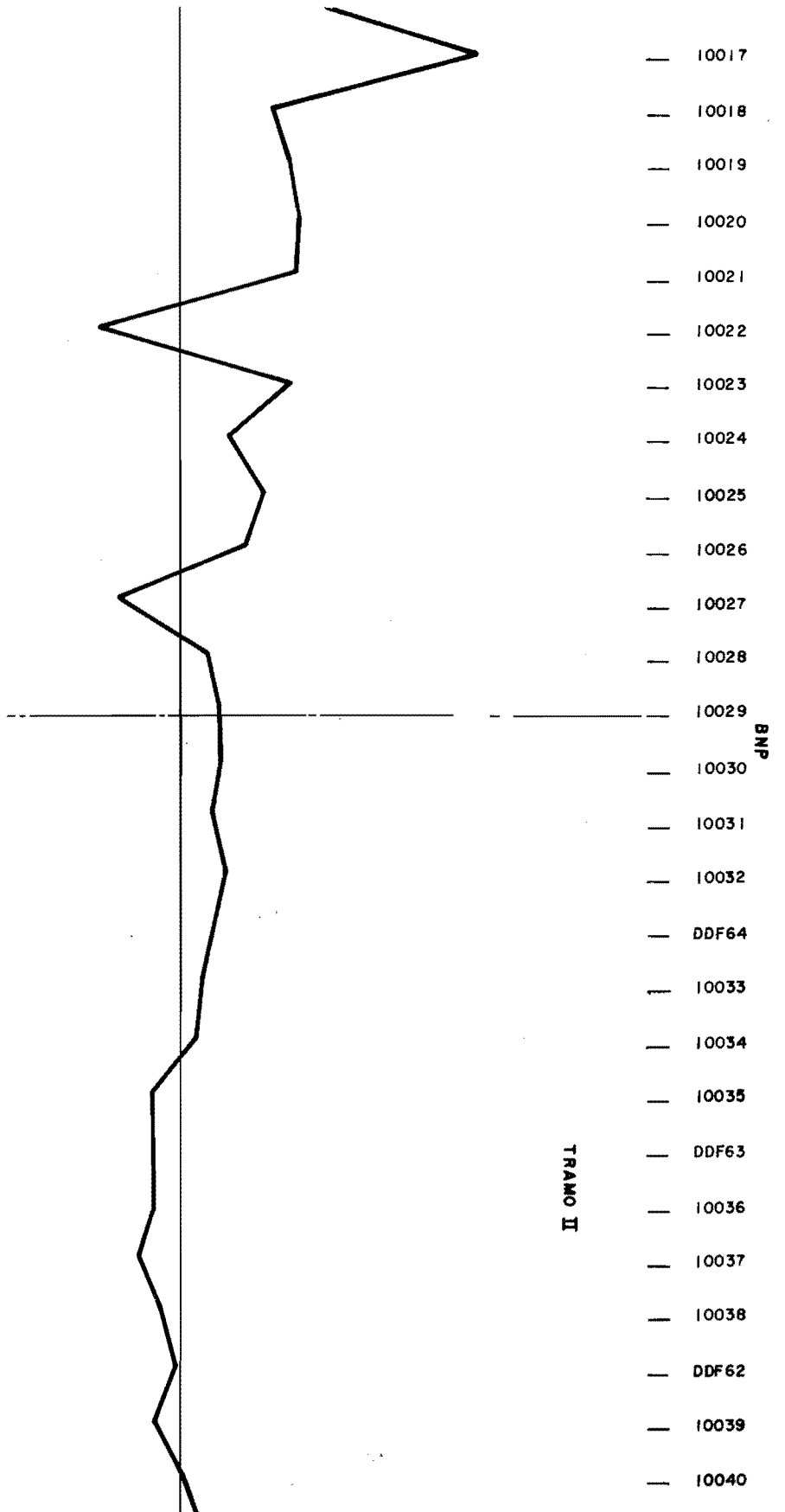
\*\* La comparación para el BN 10067 se encuentra en el tramo BN 10066-BN 10067.

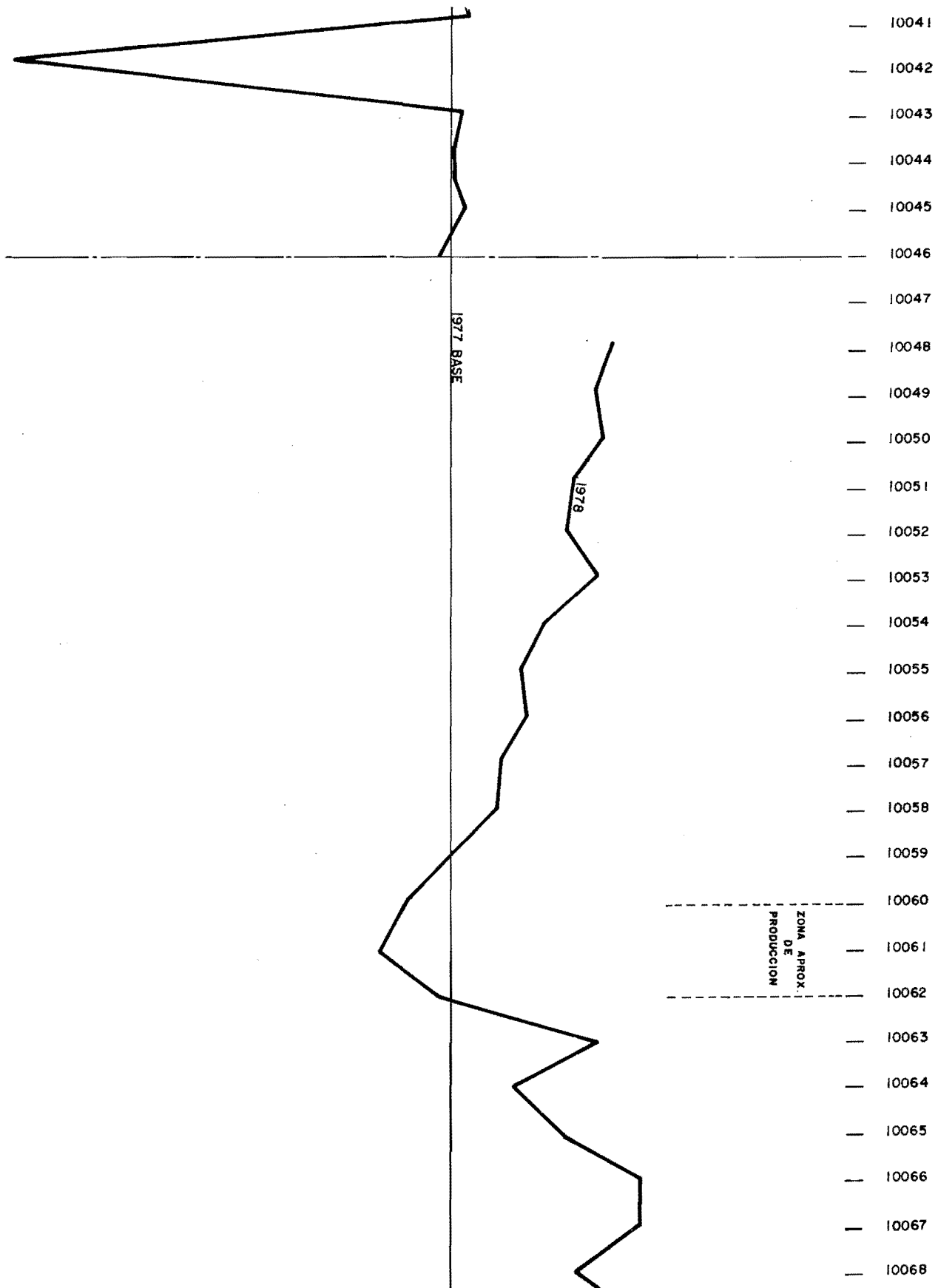
CAMBIOS DE ELEVACION  
(MILIMETROS)

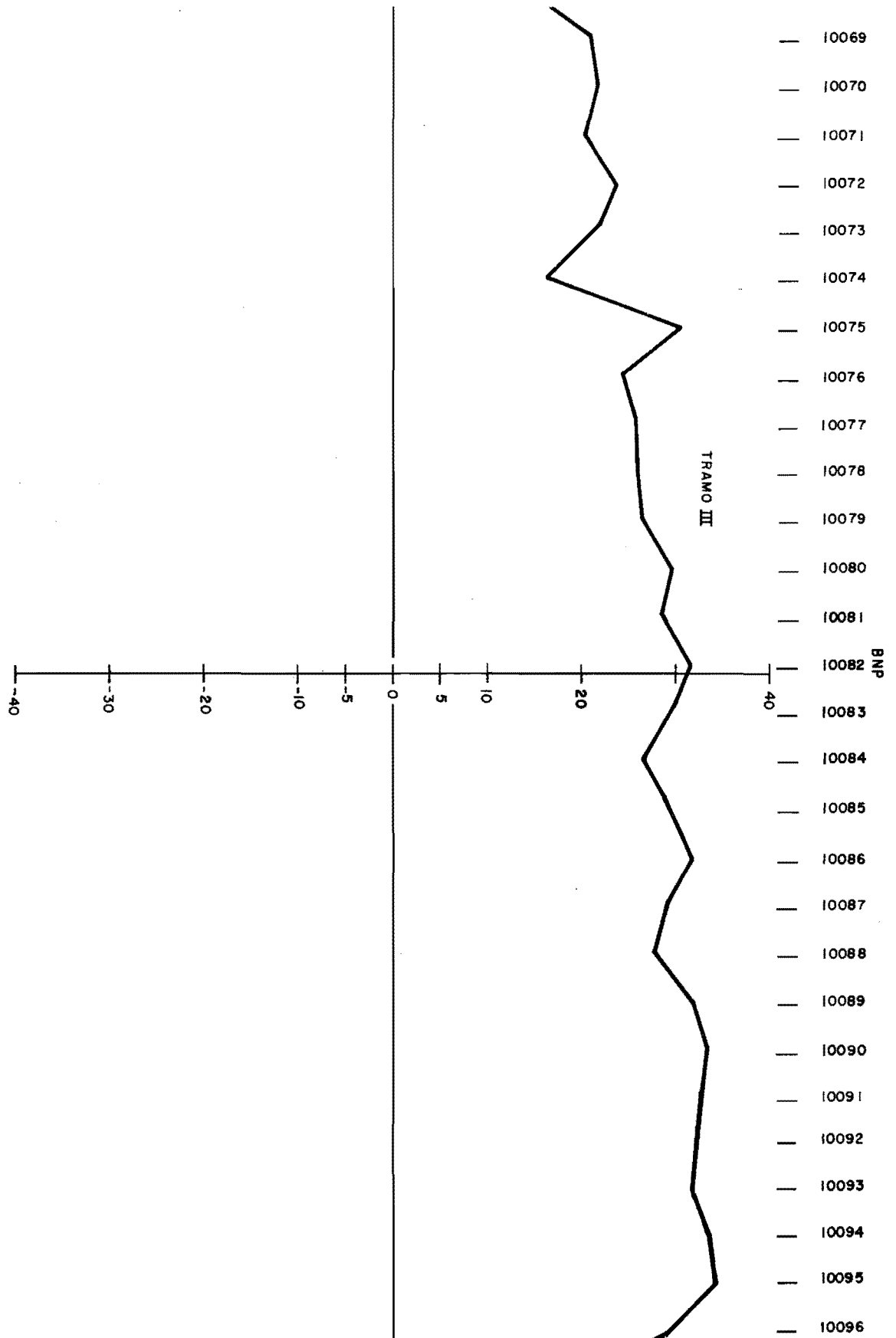
## ANEXO N° 1

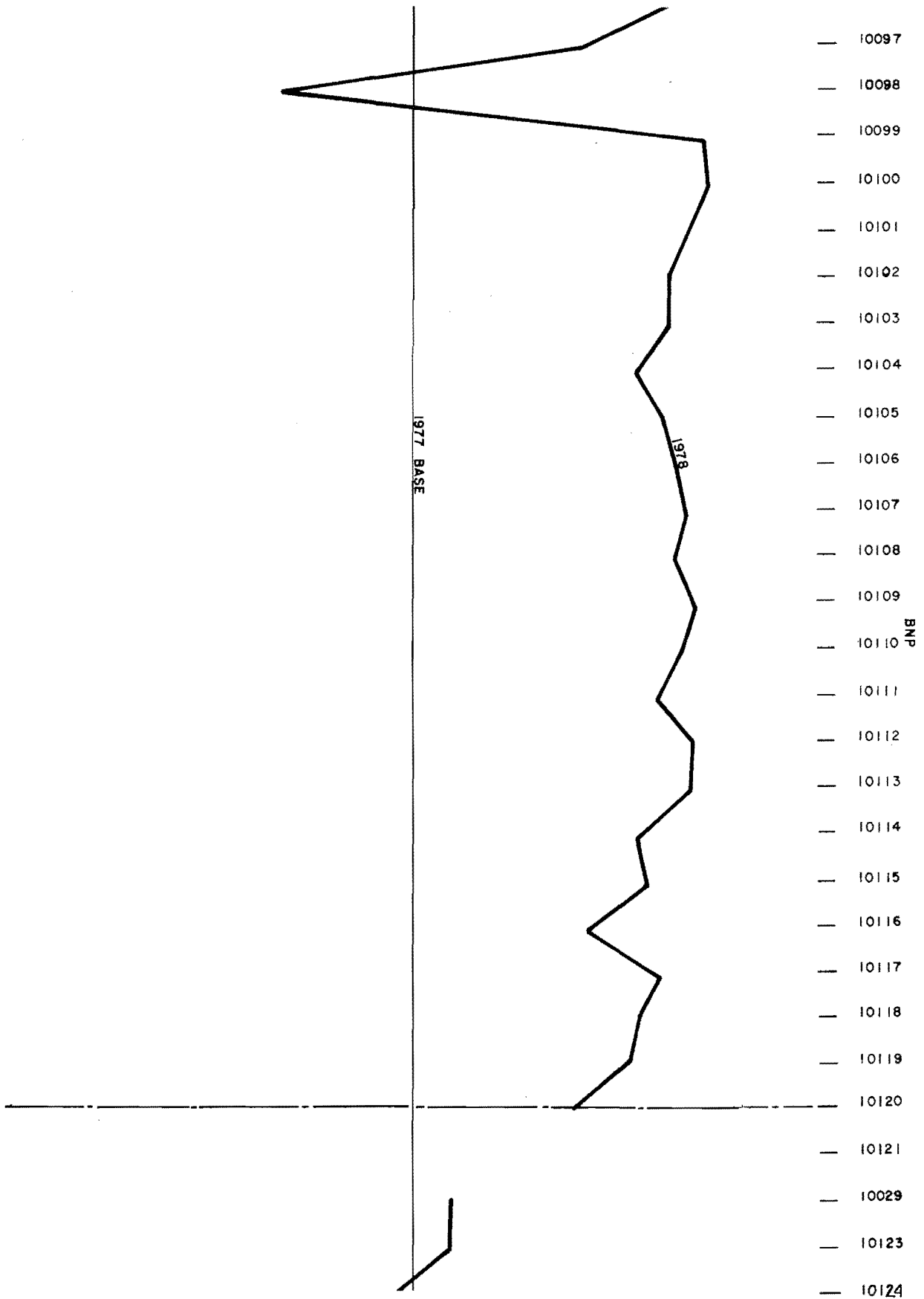
## GRAFICA DE DISCREPANCIAS

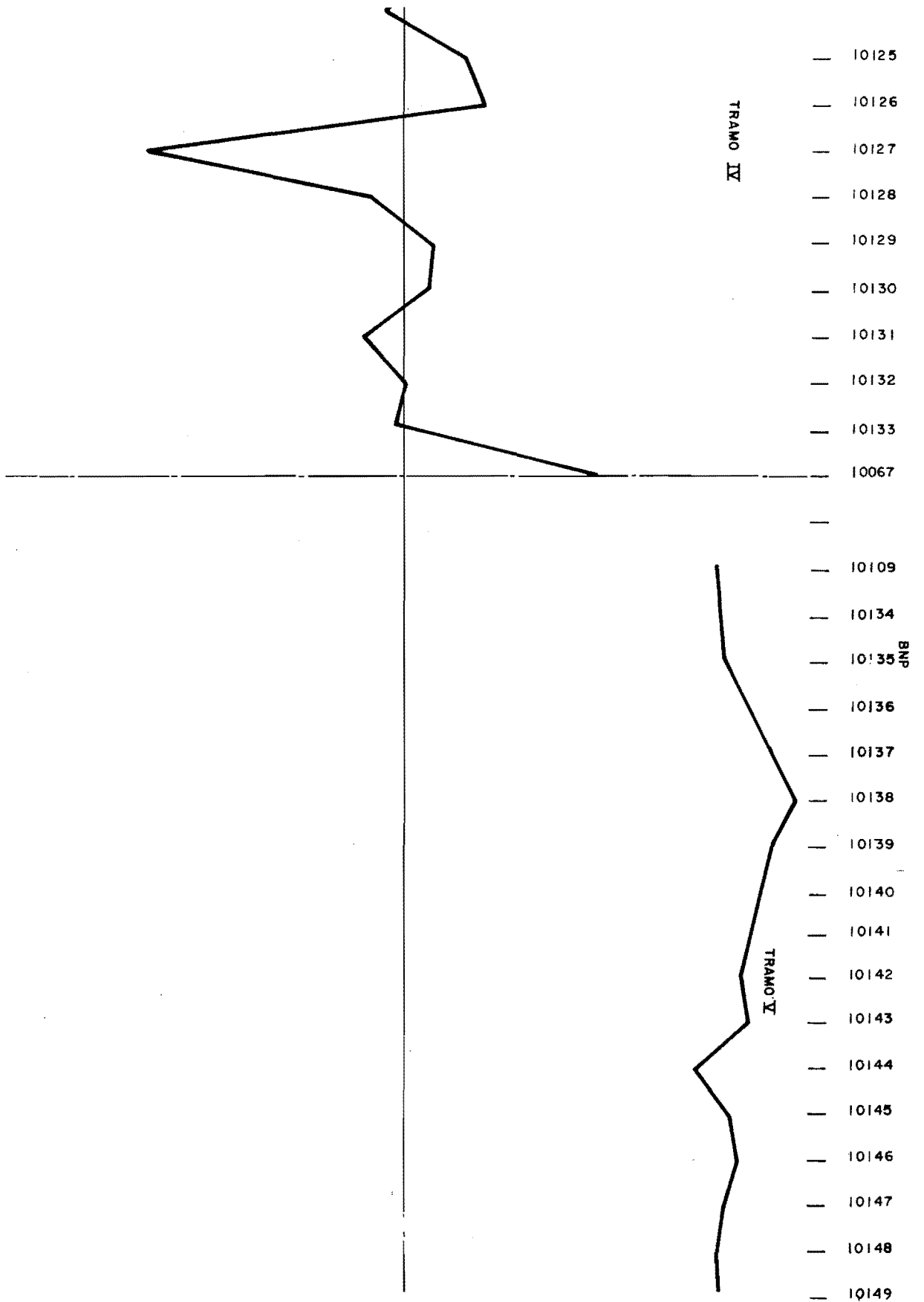
NOTA: LA GRAFICA SE ELABORO EN BASE A DISCREPANCIAS  
DE ELEVACIONES ORTOMETRICAS

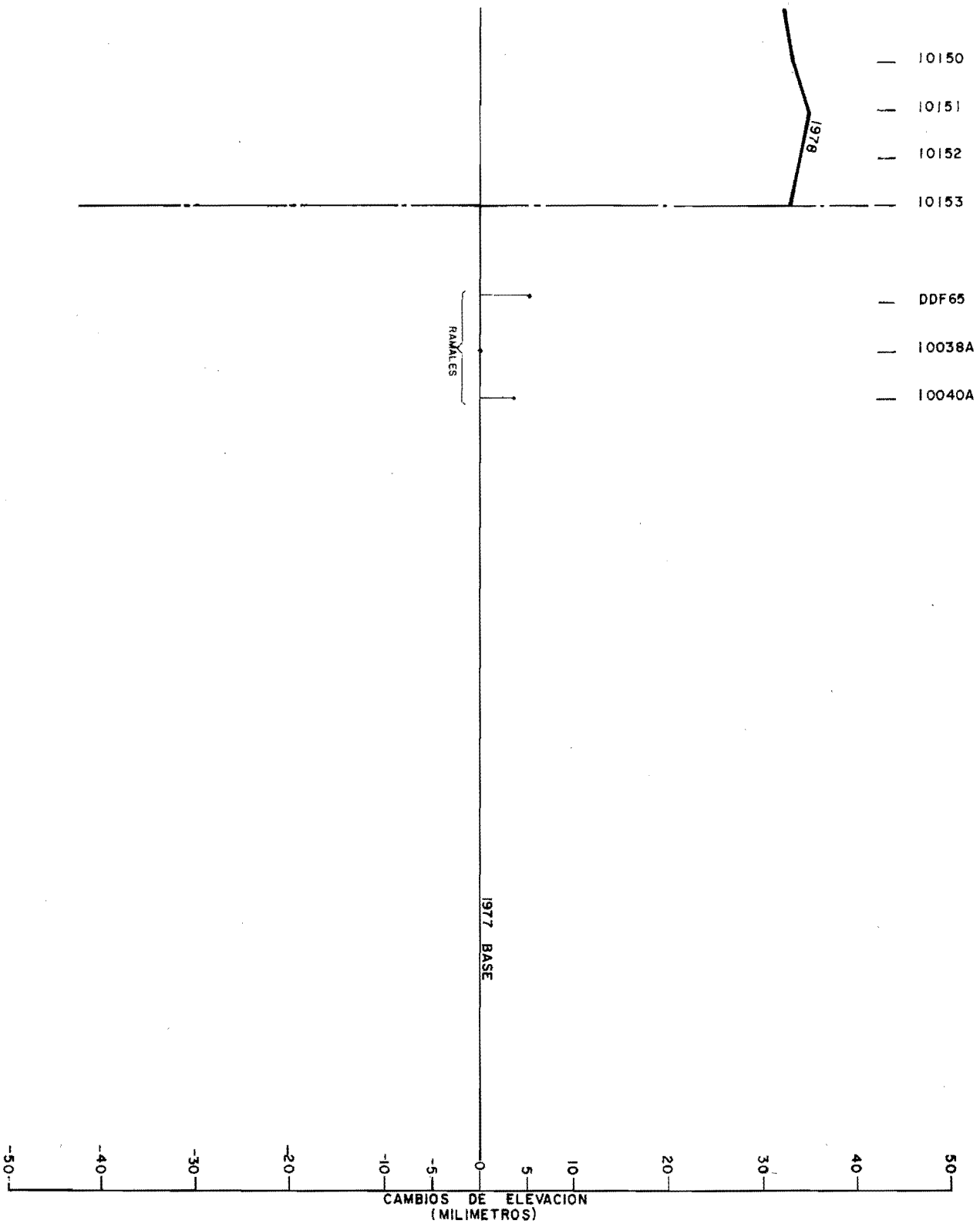












# GEODETIC CONTROL, FIRST ORDER LEVELING IN THE CERRO PRIETO GEOTHERMAL ZONE, MEXICALI, BAJA CALIFORNIA NORTE

## SUMMARY

Presented here are the results obtained by the second vertical control survey carried out during November and December of 1978.

Also presented are the results of calculations of the elevation differences across the field, as well as comparison of the 1977 and 1978 survey data.

## INTRODUCTION

The present document is the second in a total of three reports on the vertical control surveys carried out by DETENAL under Contract GEIP-CCP-014/78 signed by the Comisión Federal de Electricidad (CFE) and the Secretaría de Programación y Presupuesto (SPP). According to the above contract, DETENAL is in charge of carrying out the vertical control surveys of two networks located in the Mexicali Valley, B. C. N. (Figure 1) for a length of approximately 160 kilometers, following the specifications established in the Contract.

In the execution of this work, the same field methods, bench marks, and reporting format were used as in the first survey of 1977.

## PROJECT OBJECTIVE

The objective of the project is to determine the relative movement of the earth's crust in the study zone, whereby DETENAL will provide data on relative vertical movements.

## PRESENTATION OF RESULTS

TABLE 1:

Table 1 — "Differences in elevation measured in the field" shows the tolerances according to the specifications of the work and, comparatively, the differences obtained by the second survey with the purpose of verifying that the specifications established in the Contract had been fulfilled.

TABLE 2:

Table 2 — "Elevations" presents the elevation calculations based on the second survey, including the topographic, orthometric, and definitive elevations computed according to the methods detailed in the first report.

TABLE 3:

Table 3 — "Comparison of the results from the 1977 and 1978 surveys" indicates in its "differences in elevations", "topographic elevations", and "orthometric elevations" columns the differences between the surveys using as datum the survey conducted in 1977.

For the calculation of definitive elevations, two methods were used: the Circuit Reduction and Cholesky methods. Only the Circuit Reduction method was used in the 1977 survey since the Cholesky method had not yet been implemented. Nonetheless, this method was employed in the second survey with the purpose of testing its soundness. Given in the columns designated "Circuit Reduction Solution" and "Cholesky Solution" are the differences between definitive elevations of the first survey, used as datum, and the second survey, which used both the abovementioned methods.

## ANALYSIS AND REPRESENTATION OF THE DETECTED VERTICAL CHANGES

Using Table 3 as a source, the differences between the orthometric elevations obtained in the 1977 and 1978 surveys were plotted using the 1977 survey as datum (horizontal line).

After visually inspecting the resulting graphs, five inconsistent sections were observed which show different behaviors. (Figure 1)

*Section I.* In this section, between bench marks BN Y1224 and BN 10029, it was observed that the displacement was not uniform, that is to say, it did not display a uniform rising or sinking tendency of the earth's crust.

*Section II.* In this section, between BN 10029 and BN 10046, a slight sinking tendency is observed.

The strong sinking that is observed at BN 10042 is perhaps related to its being located near a cultivated zone.

*Section III.* In this section, between BN 10048 and BN 10120, it is important to note two remarkable cases:

*Case 1.* Between BN 10058 and BN 10062 a marked sinking of the earth's crust is observed. This is possibly

related to the proximity of this section to the production area of the geothermal field.

*Case 2.* The zone located between BN 10063 and BN 10120 displays a general rising tendency.

Bench mark BN 10098 denotes strong sinking. This station is located on the edge of a cultivated zone. This is similar to the case of BN 10042.

**NOTE:** The analysis of Section III was initiated at BN 10048 owing to the destruction of BN 10047 (indicated by an asterisk in Figure 1). As a result of this, the graph has no information on this point.

A new bench mark BN 10047 was built near the old one.

*Section IV.* This section between BN 10029 and the BN 10067 shows non-uniform sinking and rising tendencies.

*Section V.* This section between BN 10109 and BN 10153 presents a marked rising tendency.

With respect to BN 10038-A and 10040-A (branches) on the Sierra Cucapa, we can say that they have a minimal tendency towards rising, which indicates that these bench marks are located in a very stable zone.

To conclude, it should be observed that the magnitude of the subsidence is significantly less than the corresponding uplifts.

The causes of these behaviors is beyond the scope of this report.

#### FIGURE AND TABLE CAPTIONS

Figure 1. Network of vertical control in the Mexicali Valley

Table 1. Differences in elevation measured in the field.

Table 2. Elevations.

Table 3. Comparison of the results from the 1977 and 1978 surveys (differences are given in mm).

Attachment 1. Plots of elevation differences (based on orthometric elevations).