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A HYPOTHESIS FOR IDENTIFYING AREAS FOR GEOTHERMAL EXPLORATION IN THE MEXICALI VALLEY OF BAJA CALIFORNIA

ABSTRACT

A hypothesis is presented for identifying possible areas for geothermal exploration in a zone with hydrothermal manifestations. The paper is based on magnetometric and gravity survey studies in the Mexicali Valley and its results indicate that several areas, independent of one another, present potential for geothermal exploration.

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The area in which the Cerro Prieto geothermal field is located is recognized as a zone in which the earth's crust has been weakened by tensile stress exerted by the two large tectonic plates that tend to shift in this zone.

Some surface manifestations of this week zone in the earth's crust may be found in Cerro Prieto, both as volcanic and hydrothermal activity, which led to the exploration and development of the Cerro Prieto geothermal field.

Since the weak zone referred to above is quite extensive, geological and geophysical conditions that exist in Cerro Prieto are expected to be found in other parts of the same geological area, even though the surface manifestations in Cerro Prieto, such as the volcanic cone and outlets of hot water or steam, may not be present.

The problem, then, should be approached through an attempt to identify, first of all, the areas where magma heat penetrates (windows) and, secondly, the areas where such heat may be accumulated in zones where the earth's crust is known to be weak.

(Fig. 1) We know that heat transmission through rocks is generally quite low and could therefore state that heat over a given period of time will be transmitted more easily through thin rock than through thick rock. Thus, magma heat should be transmitted better, for a given time, where the basal rock is thinnest or does not exist.

We also know that faults without significant breaks, indiscriminately known as strike, transform or transcurrent faults, have been observed in the Cerro Prieto area, which indicates the presence of block shifting. If we accept the existence of shifting in the area, we can then apply the conclusions of researchers M.Gzovsky and J.C.Crowell (1974), who arrived at compatible results independently.

(Fig. 2) Working with practically homogeneous rock material, the first researcher concluded that "S" shaped weak areas are produced in zones subject to shifting and that such weak areas are aligned in relation to each other according to the direction of the pair of forces that cause shifting and lie at approximately a 45° angle from the axis of the pair of forces.

(Fig. 3) The second researcher maintains that such weak areas are created in a rhomboid or lens-shaped form, which he calls "traction basins" and that the ends tend to rise or sink depending on whether the fault lines that border them are convergent or divergent. He also maintains that igneous rock should be found at the bottom of such basins.

If we assume that basal rock is affected by the pair of forces that cause shifting, we may conclude that the basement should have rhomboid, lens or "S" shaped weak zones, which would be aligned according to the direction of shifting and would serve as windows through which igneous rocks intrude into the sediments lying above them. We could also conclude that such windows would lie at an angle of approximately 45°from the axis of shifting.

In order to determine the position of these windows through which magma heat passes, this project used a combination of the magnetic and gravity studies available.

(Fig. 4) A study of continous gravity measurement anomalies 1 km deep conducted by a government agency in 1981 was used. This depth may be expected to coincide approximately with the level of the basal rock, because of the significant contrast in densities between the granite (1.7 gr/cm^3) and the sedimentary layers that lie above it (1.2 gr/cm^3). It should be pointed out, however, that lutites in the high temperature areas of Cerro Prieto have proven to be of high density (1.5 to 1.6 gr/cm^3), which has been attributed to the effect of prolonged exposure to heat that has altered their structure. In high temperature areas, the density contrast will thus be less and the depth of the basement indicated in the map interpretation will also be less than it actually is. The gravity study also shows the position of faults with vertical shifting and consequently the zones in which basal rock thickness has been reduced. The minumum gravity measurements indicate the areas where the greatest thickness of sediments has accumulated while the maximum gravity measurements indicate the areas where the sediment is thinner.

(Fig. 5) A residual aeromagnetic study conducted by M. de la Fuente and J. Summer of the University of Arizona in 1973 was used. The maximum values indicate the presence of intruding magnetic rocks, which may have reduced the thickness of basal rock or crossed through it as they approached the surface, or such values may simply indicate the presence of large masses of deep magnetic rocks.

(Fig. 6) Areas of geothermal interest should therefore be associated with windows where heat passes, which are found in the vecinity of magnetic maximums and of faults with vertical shifting, and also with the sides of places with minimum gravity measurements, which is where paleobars and paleocanals develop and become structural or stratigraphic traps in a deltaic environment.

(Fig. 7) As mentioned before, the procedure used to identify areas similar to Cerro Prieto was to superimpose the maps of gravity anomalies and of magnetic anomalies so that the points at which the curves of both Cerro Prieto values intersect would indicate areas with potential for geothermal exploration and the map in Fig. 7 was prepared in this manner.

The areas marked on the map in Fig. 7 should, of course, be considered those most likely to contain hydrothermal reservoirs, but the boundaries only represent approximations, since the method, apart from its validity, depends to a great extent on the quality of the geophysical work on which it is based.

The reasoning presented here led to the formulation of a hypothesis for identifying, though only in a rough or approximate manner, the location of areas that are likely to contain hydrothermal reservoirs:

(Fig. 8) Within a geological area associated with volcanic activity and hydrothermal manifestations, the source of heat is considered to be intruding bodies in the form of complexes or swarms of tree-shaped dikes. These basic, non-plutonic, volcanic intruding bodies may be arranged in different forms, so that their grouping, taken as a whole, appears to indicate the presence of a fairly deep great magnetic mass. In the process of cooling, these swarms of young tree-shaped dikes transmit their thermal energy to the water that saturates the neighboring porous rocks and it either accumulates in stratigraphic or structural traps, dissipates or is released at the surface.

It may thus be concluded that areas of interest for exploration in the Mexicali Valley should have the characteristics described above, that is:

1. They should be near the magnetic maximums that define the location of concentrated swarms of tree-shaped dikes, and

2. They should lie within the corridors formed by minimum gravity lines where deltaic deposits could have developed and, consequently, paleocanals and paleobars, which serve as storage structures.

FIGURES

Fig. 1. Transmission of magma heat to the sediments through thin areas in the basal rock.

Fig.2. Creation of weak zones aligned according to the direction of the pair of forces and lying at an angle of 45° from the axis of the pair of forces.

Fig.3. Traction basins formed by shifting or transform faults, the ends of which sink or rise depending on whether the faults that border them are convergent or divergent.

Fig.4. Map of continuous gravity anomalies at a depth of 1 km.

Fig.5. Map of residual magnetic anomalies (Gammas) U. of Arizona.

Fig.6. Main elements for the existence of hydrothermal reservoirs.

Fig.7. Areas with possibilities for geothermal exploration.

Fig.8. Weak zones in the basement that allow for the intrusion of complexes of volcanic dike swarms (basic and non-plutonic) and constitute sources of heat the accumulates in the porous rocks.

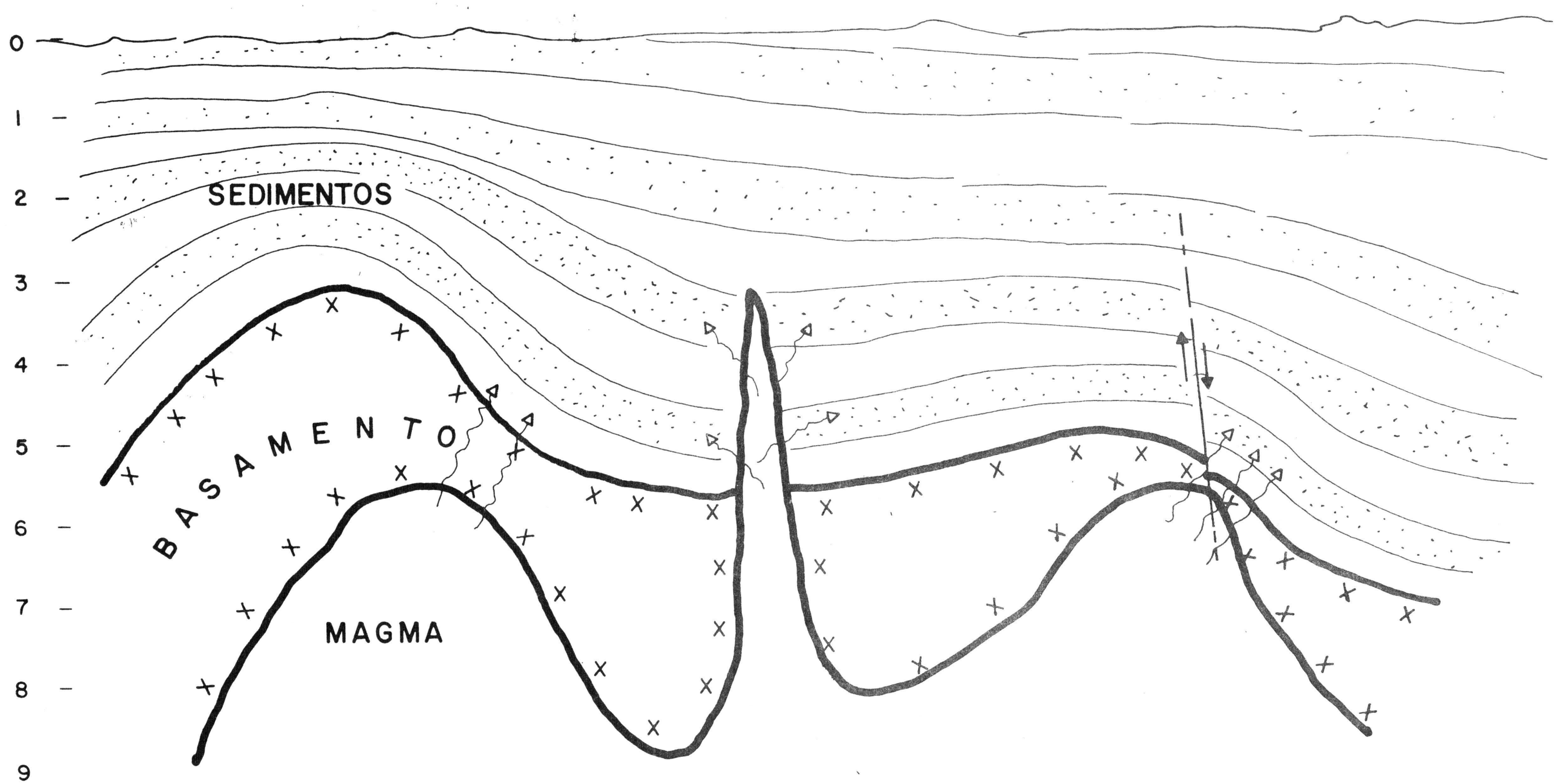

FIG.-1 TRANSMISION DEL CALOR DEL MAGMA A LOS SEDIMENTOS A TRAVES DE LOS ADELGAZAMIENTOS DE LA ROCA BASAL

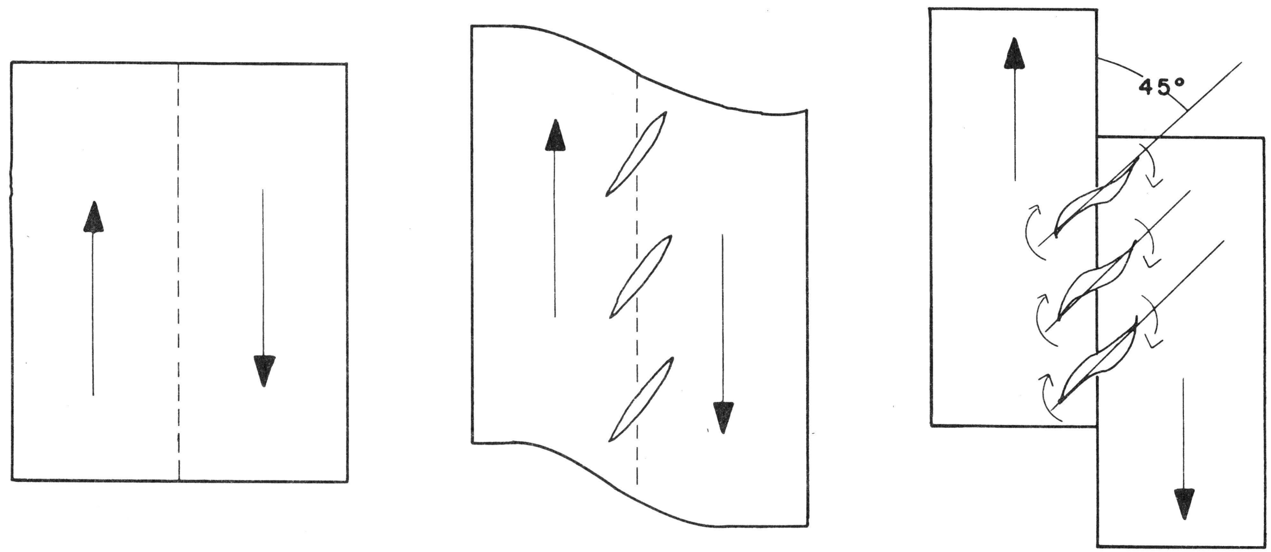

FIG.- 2 CREACION DE ZONAS DEBILES ALINEADAS SEGUN EL SENTIDO DEL PAR Y ORIENTADAS A 45° DEL EJE PAR (SEGUN M. GZOVSKI).

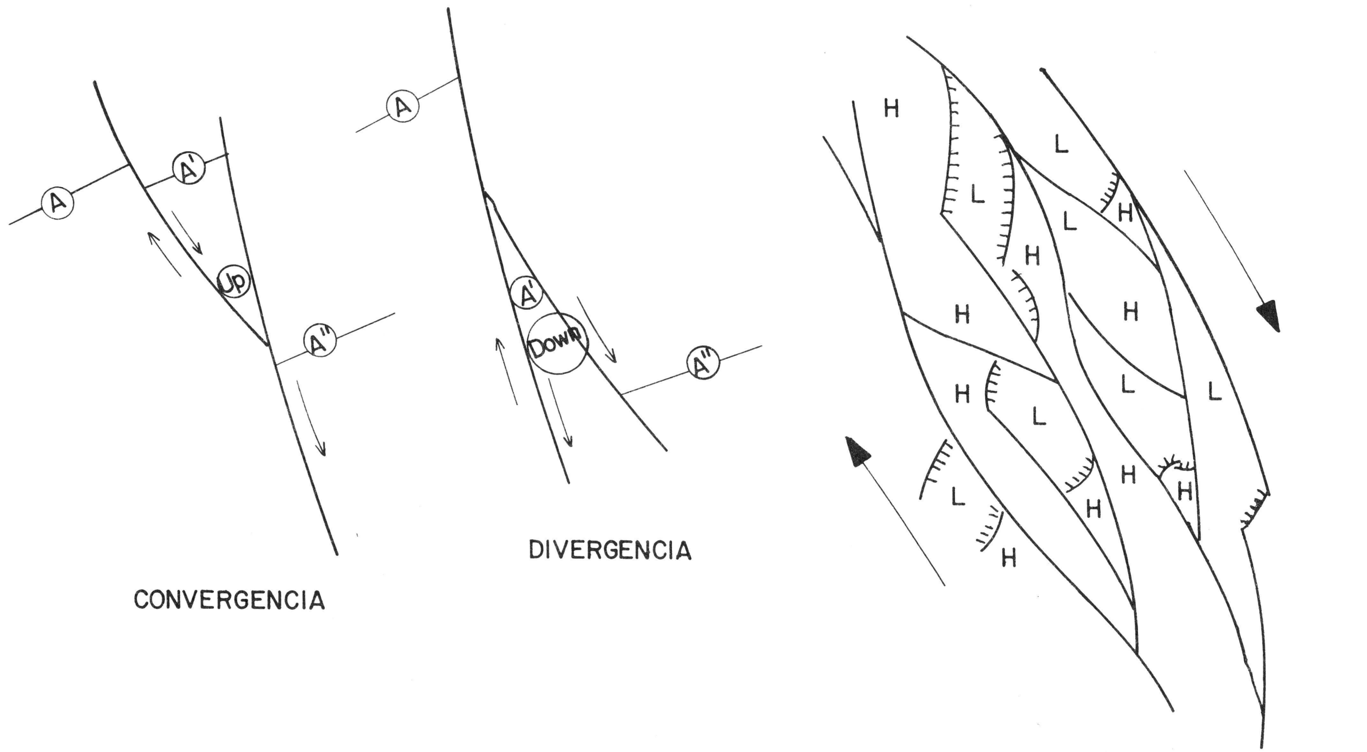

FIG.-3 CUENCAS DE TRACCION FORMADAS POR FALLAS DE DESPLAZAMIENTO O TRANSFORMACION, CUYOS EXTREMO SE HUNDEN O LEVANTAN SEGUN SEAN DIVERGENTES O CONVERGENTES LAS FALLAS QUE LAS LIMITAN (J. C. CROWELL, 1974)

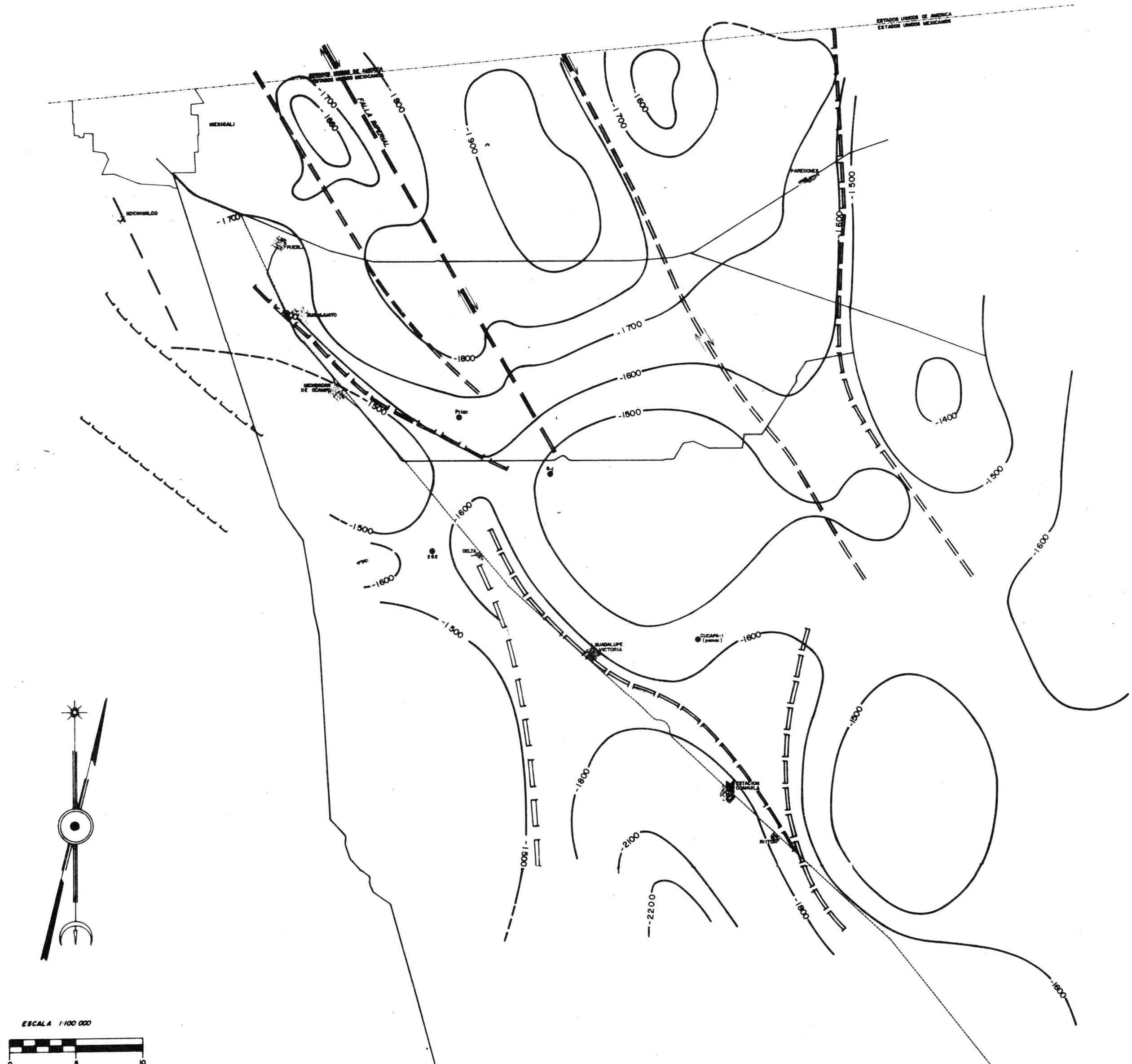

Fig.-4 MAPA DE ANOMALIAS GRAVIMETRICAS DE CONTINUACION 1 KM. HACIA ABAJO (U. G.)

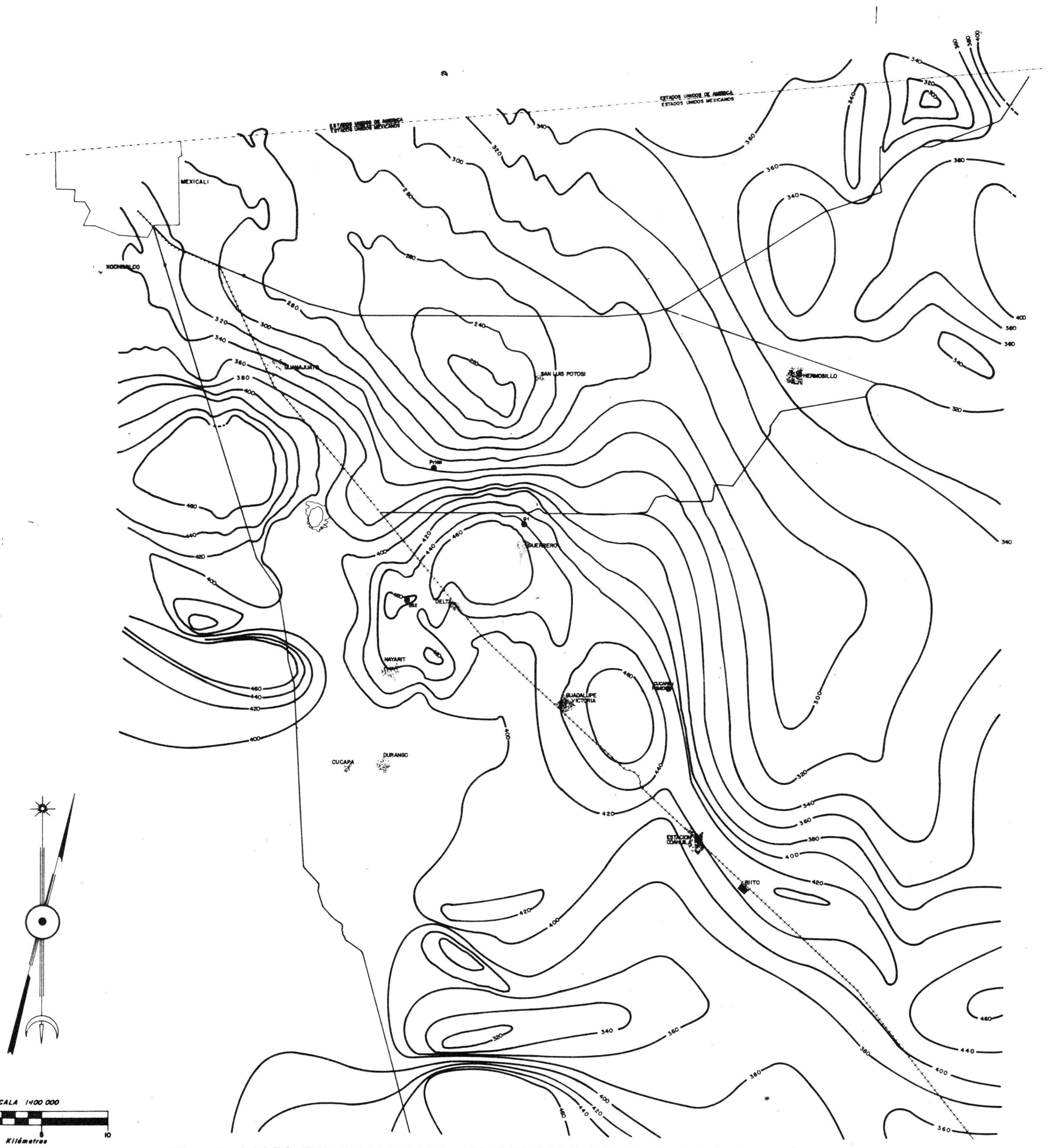

Fig.- 5 MAPA DE ANOMALIAS MAGNETICAS RESIDUALES (GAMAS) U. DE ARIZONA 1973

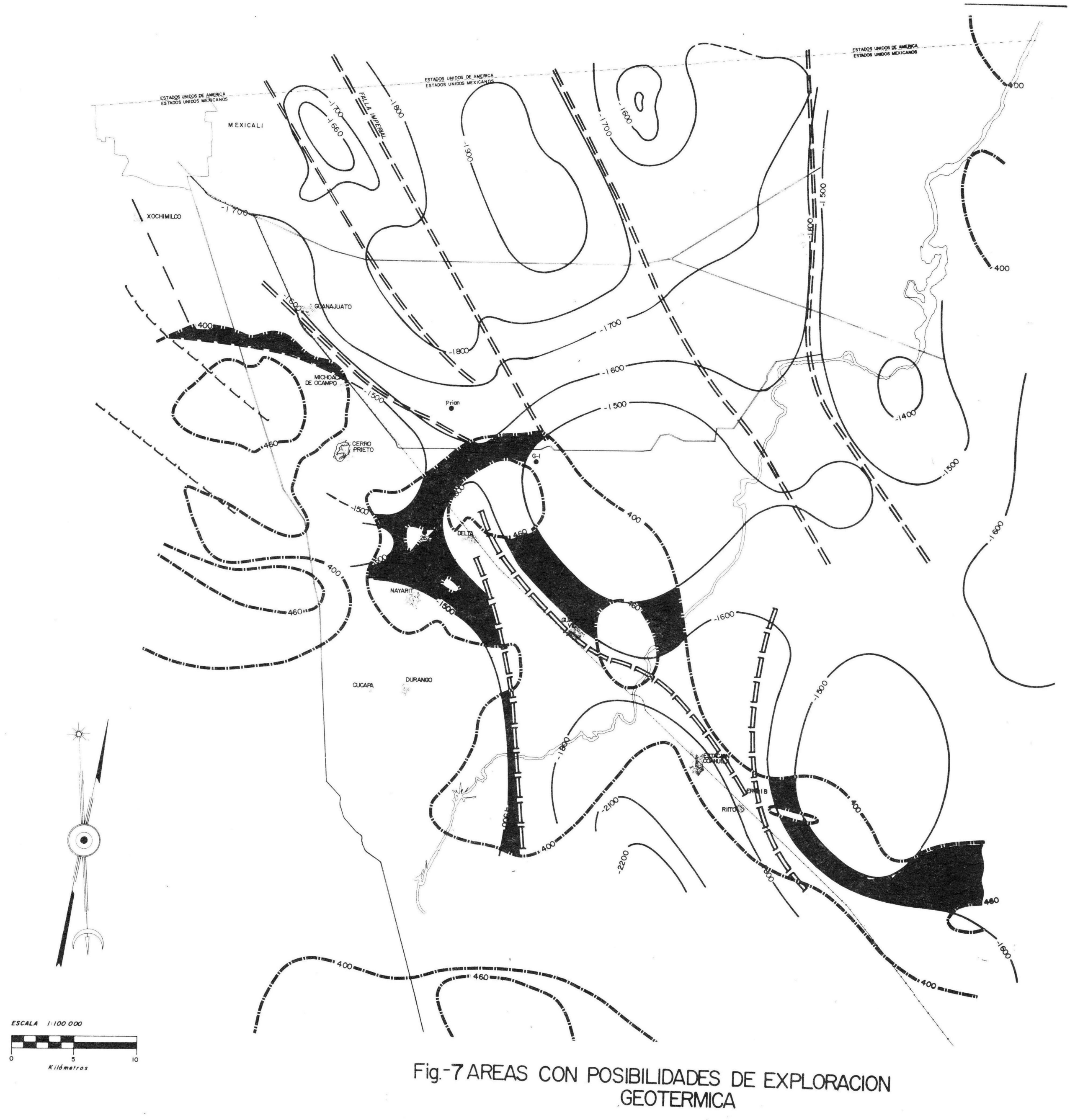

Fig.-7 AREAS CON POSIBILIDADES DE EXPLORACION GEOTERMICA

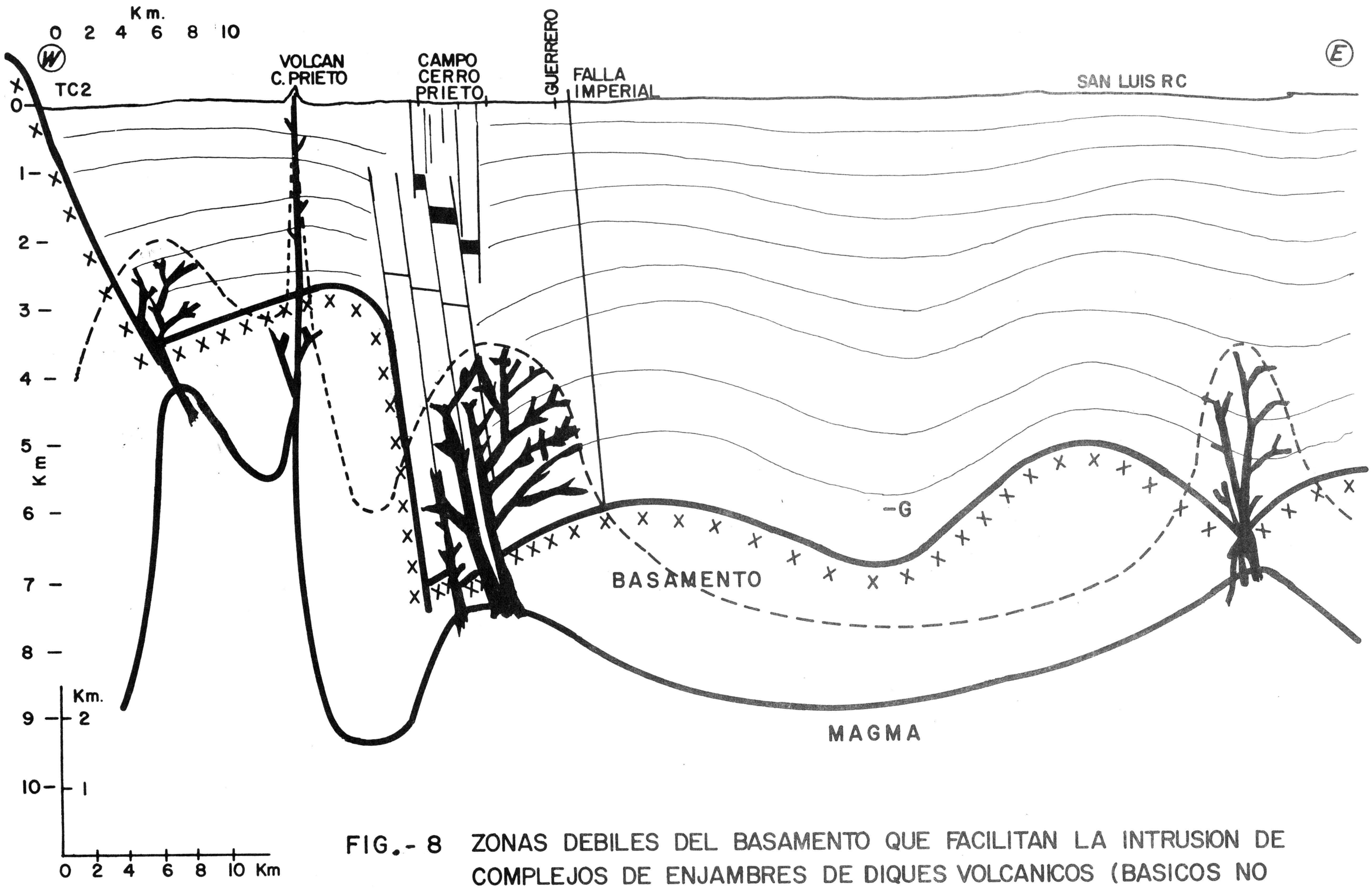

FIG.- 8 ZONAS DEBILES DEL BASAMENTO QUE FACILITAN LA INTRUSION DE COMPLEJOS DE ENJAMBRES DE DIQUES VOLCANICOS (BASICOS NO PLUTONICOS) Y QUE CONSTITUYEN LAS FUENTES DE CALOR QUE SE ACUMULA EN LAS ROCAS POROSAS.