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ESTABLISHMENT OF A GEODETIC NETWORK ACROSS THE CENTRAL GULF OF CALIFORNIA

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## RESUMEN

Una red geodésica, constituida por 11 estaciones y determinada por medio de 24 mediciones de distancias, ha sido establecida en febrero-marzo de 1982, en la parte central del Golfo de California, entre la costa de Sonora y la de la península de Baja California. Esta zona, en donde pasa el límite entre las placas de América del Norte y del Pacífico, está caracterizada por un régimen tectónico extensivo y transforme.

En el futuro, repeticiones de las mediciones de distancias permitirán precisar la geometría de las deformaciones en curso, y evaluar la tasa de desplazamiento relativo actual entre las dos riberas del golfo.

## RESUME

Un réseau géodésique constitué de 11 stations, et déterminé à l'aide de 24 mesures de distances, a été installé en février-mars 1982 dans la partie centrale du Golfe de Californie, entre la côte de Sonora et celle de Basse Californie. Cette zone, dans laquelle passe la frontière entre les plaques Américaine du Nord et Pacifique, est caractérisée par un régime tectonique à la fois distensif et transformant.

Ce réseau permettra, lors de remesurages ultérieurs, de préciser la géométrie des déformations en cours et d'évaluer le taux de déplacement relatif actuel entre les deux rives du golfe.

## INTRODUCTION

The Gulf of California has been described as a transform and extensive zone, linking the northeastern extremity of the East Pacific Rise and the San Andreas Fault system (fig.1) (Carey, 1958; Hamilton, 1961; Moore & Buffington, 1968; Atwater, 1970; Garfunkel, 1973; Moore, 1973; Bischoff & Henyey, 1974; Colletta, 1981; Colletta *et al.*, 1981; Angelier *et al.*, 1981; etc.). In the Andreas Fault system, numerous measurements of present-day lateral motion have been completed through various

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medium or long ranges was selected Kasser *et al.*, 1979; Ruegg *et al.*, (1979). These laser EDM instruments are relatively easy to operate and to carry on site.

Thanks to the extraordinary visibility (at night) found at the end of the winter in this region, measurements of distances up to 93 km were possible. To our knowledge this is one of the longest distances ever surveyed with a Aga 8 "Geodimeter" laser E D M.

## DESCRIPTION OF THE GEODETIC MEASUREMENTS

The field operations to establish the network were realized in February-March 1982, and lasted about 10 days. The geodetic network is formed by 11 stations: 3 in Baja California, 3 in Sonora and 5 on the islands Angel de la Guarda, Tiburon, San Esteban, San Lorenzo and San Pedro Martir. All the stations have been located on topographical summits. Every station is materialized by a brass benchmark fixed in the rock with molten sulphur.

Twenty-four distance measurements were made with a model 8 AGA laser "Geodimeter". Measurements were performed at night to take advantage of the greater homogeneity of air refraction index, and were accompanied by meteorological observations at both ends. Minimum and maximum measured distances were 18 and 93 km (fig. 2,3).

Unfortunately the altimetry of the trigonometric points is rather poor for a global adjustment of the observations. In order to compute the ellipsoidal reductions, a barometric compensation was calculated from the meteorological data. With a barometric pressure accuracy around 0,1 mm Hg, and a temperature accuracy of 0,1°C, the root mean square of the altimetric determination is 4 m. This is insufficient and when the difference of elevation between the points is too large, the horizontal reductions cannot be calculated with enough acceptable precision. Anyway, the only purpose of this adjustment is to assess the validity of the measurements.

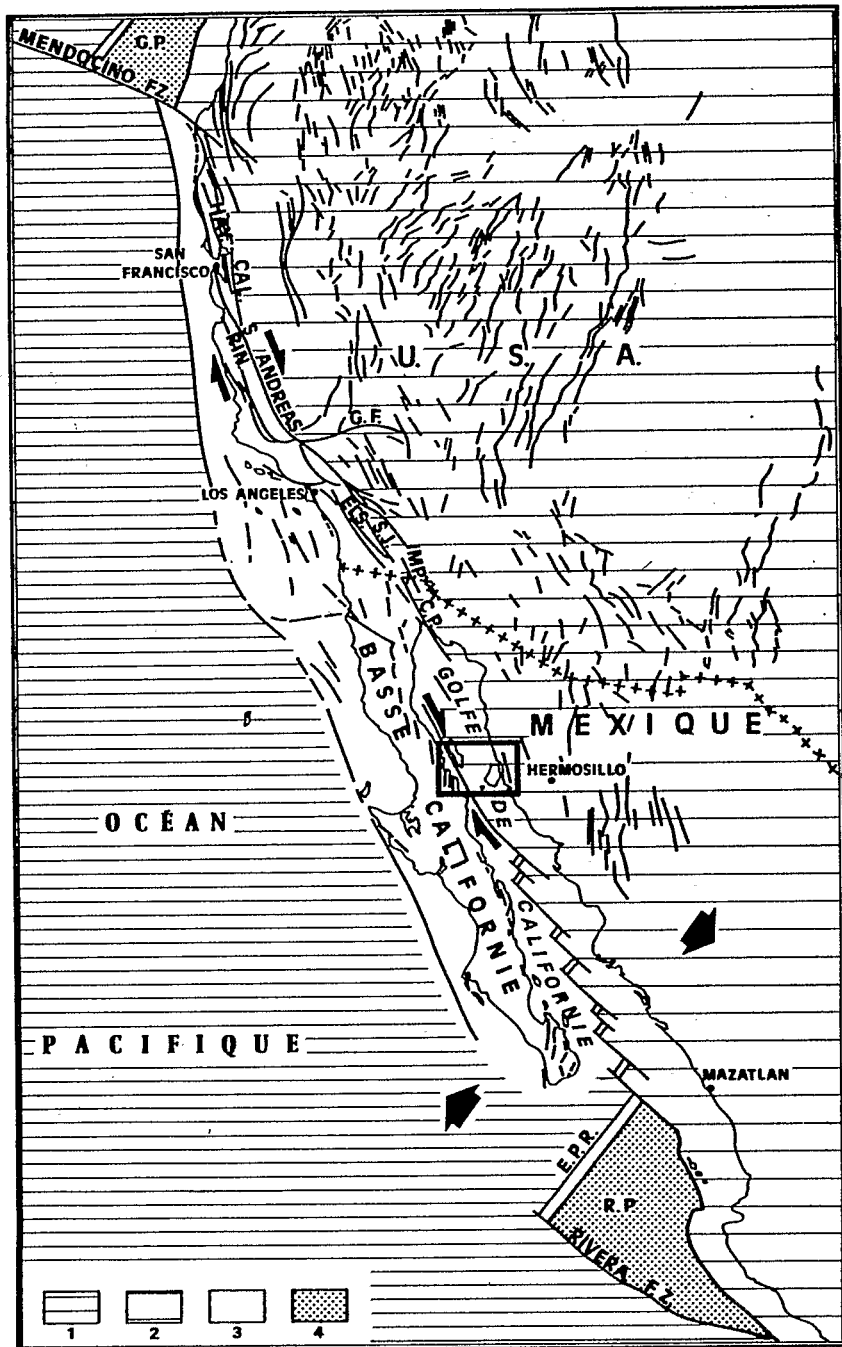


Figure 1.- Structural sketch of the western boundary of the north-american continent, with the main fractures along the Pacific and North America plates boundary. Localization of the surveyed area.

1.- Pacific plate; 2.- North-America plate; 3.- Baja California peninsular crustal block; 4.- Remains of Farallon plate.

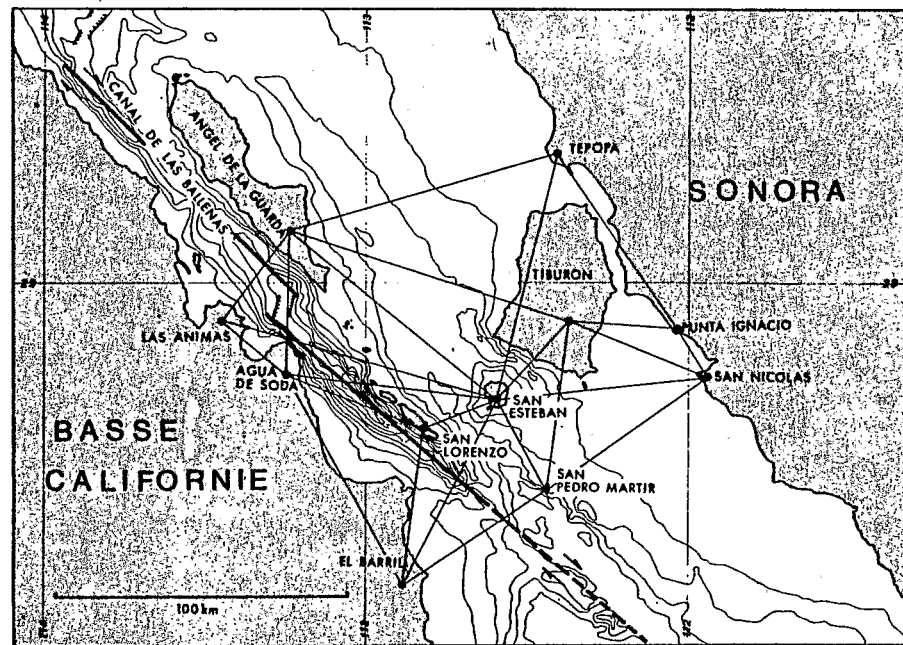


Figure 2.- Localization of the geodetic network in the Gulf of California, with its 11 stations and 24 measured distances. Solid lines indicate the main strike slip faults. Bathymetry (from Rusnak et al., 1964) with isolines every 100 fathoms.

geodetic, geologic and geophysical methods (Grantz & Dickinson, 1968; Tocher, 1969; Whitten, 1969; Jahns, 1969; Keller *et al.*, 1978; Savage *et al.*, 1979; Thatcher, 1979; Smith *et al.*, 1979; Sieh, 1980; Burford & Harsh, 1980, etc.). In the whole San Andreas system, the total motion between the Pacific (southwestern California) and North-America plates is evaluated to a mean 5 cm/year (on a 10 to 10<sup>6</sup>y. time range). At the southern extremity of the Gulf of California, the magnetic anomalies pattern suggested that during the last 3.5 M.y., the peninsula of Baja California moved north-westwards, at a mean 6 cm/year velocity, with respect to the continent (Larson *et al.*, 1968). Global cinematic considerations yielded similar motion velocities across this plate boundary (Le Pichon, 1968; Minster, & Jordan, 1978).

In the Gulf of California, only one attempt of direct measurement of lateral motion has been made. In this experiment, Vacquier & Whitman (1973) unsuccessfully tried to measure the relative displacement, during a two years period, between Angel de la Guarda Island and the Baja California coast at Bahia de los Angeles. A more precise device than the optical parallax system that they used, a longer period of observation, and a large network set across the entire gulf would be more promising.

The problem of the distance between the Sonora and Baja California coasts (around 150 km) can be partly solved by taking advantage of the existence of the islands of the central part of the gulf. Nevertheless distances over 90 km would to be measured, to get a satisfactorily constructed network (distances between Tiburon island and Baja California coast, or between Angel de la Guarda island and the Sonoran coast).

To survey a network across the central Gulf of California, satellite geodetic methods (Laser Ranging and VLBI= Very Long Baseline Interferometry, systems) would not be appropriate because of their cost, and because of the required density of such a network. The two available wavelength laser EDM (Electronic Distance Measurement) instruments, which provide a 10<sup>-7</sup> precision, cannot yet be used on such long distances. Thus the classic laser EDM instruments which have proved to reach a 5.10<sup>-7</sup> precision level, in well-chosen circumstances and on

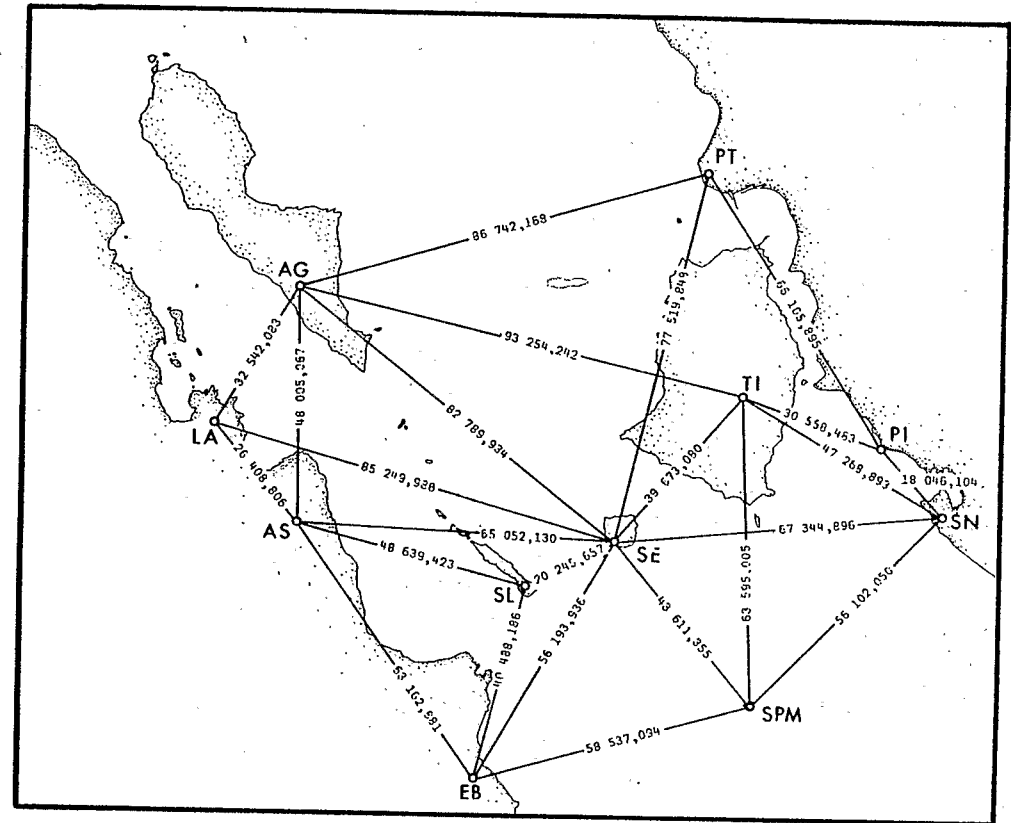


Figure 3.- Measured distances (in metres) between benchmarks of the stations.

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If two measured distances are discarded, the remaining 22 observations appear quite compatible and match within a few centimetres. The precision of the measurements is of the order of 5 cm for a 100 km distance. This precision is such that, with a presumed 5 cm/year lateral motion between both sides of the gulf, a reiteration of the network would be worth in a 3 year time.

## CONCLUSION

The geodetic network set up in march 1982 in the central Gulf of California is defined by 11 stations and 24 distance measurements, determined with a mean precision of  $0,5.10^{-6}$ . The next surveys of the network should provide useful informations on:

- the precise location of the motions (is the plate boundary restricted to the Canal de Ballenas, or is Angel de la Guarda island a crustal sliver limited by two main crustal faults ?);
- the kind of motion (creeping or seismic).
- the geometry of the deformation (distribution of the lateral slip and extensive motions).
- the relationships between the different motions observed along the plate boundary, from the East Pacific Rise to the San Andreas Fault system.

The next reiteration of the net is scheduled for march 1985.

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# NEOTECTONICS AND SEA LEVEL VARIATIONS IN THE GULF OF CALIFORNIA AREA, A SYMPOSIUM

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Contribuciones para el Symposium sobre Neotectónica y variaciones del nivel del mar en el área del Golfo de California, llevado a cabo en Hermosillo, Sonora, México, 21-23 de abril de 1984.



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