

# In which direction is the earth's crust moving?

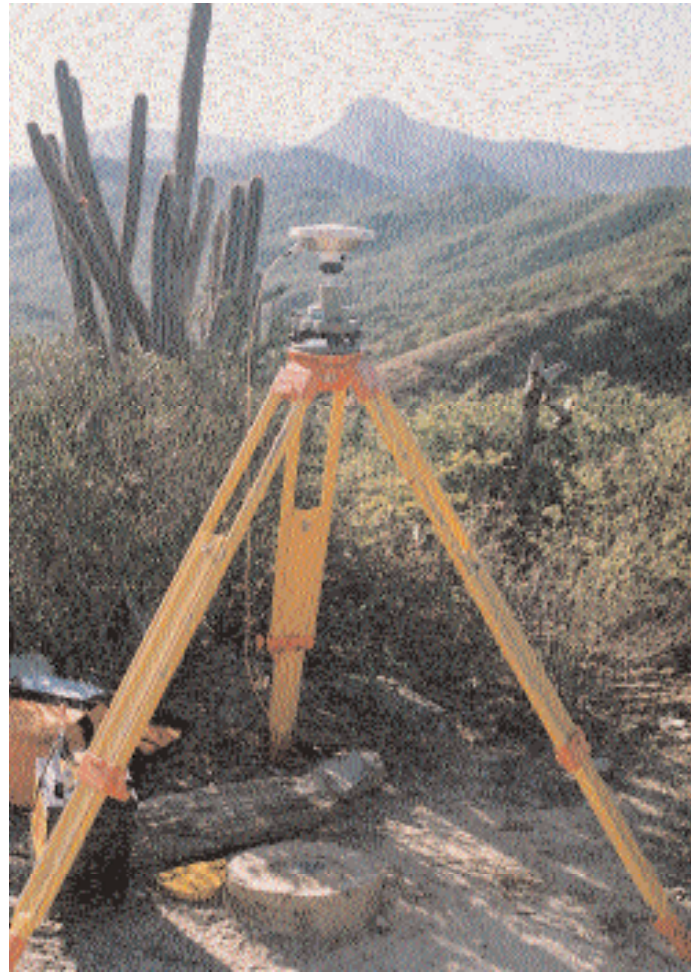
**Tectonically, Central and South America are extremely active zones. The Nazca, Cocos, Caribbean and South American plates all influence each other with their movements. This area has for a long time been the target of geological research into the complicated patterns of change. The Leica GPS System 300 has contributed considerably to the results which have been attained.**

Within the research area an attempt was made in many small areas to prove movements with geodetic measurements including measurements of gravity. It is only since the completion of the NAVSTAR Global Positioning System (GPS) that a satellite-based procedure has become available. It enables quick and highly accurate position fixing to be carried out in regional, continental and even in global networks.

## Co-operation across continents

As long ago as 1988 various North and South American as well as European institutes started the GPS project known as CASA (Central And South America). The object of the project is to determine deformations in the earth's crust between the different tectonic plates, in critical areas of collision. Together with the Venezuelan land survey authority, Servicio Autonomo de Geografia y Cartografia Nacional (SAGECAN) and the University of Maracaibo, the German Geodetic Research Institute (DGFI) Department 1 in Munich has taken over responsibility for the part of the area which is covered by Venezuela.

The area includes the most varied of landscapes, climates and topography, ranging from maritime to mountainous. On studying deformations in the earth's crust, this diversity had to be taken into account. Both sides of the Bocono - El Pilar Fault were thus provided with a network of 22 points (Fig. 1). Starting in the west from the Columbian border via an observatory in the Andes at 3600 m east of Merida (Fig. 2) it reaches in the east to a point east of Isla Margarita. The start of



*LEICA GPS System 300 operating over a control mark.*

measuring was somewhat modest, five points being fixed in the Andes region in 1988. Five years later in February 1993 the Leica GPS System 200 became available, and with this, the first complete survey took place. A repeated survey of the complete network followed in February and March 1996 using the Leica GPS System 300. Additionally, the project team integrated in CASA the GPS measurements which were carried out at some points within the framework of other projects.

## Compensating for fluctuations in the reference system

The derivation of point movements from coordinate solutions at various epochs pre-supposes that the superior reference system has not altered. This presumption is not simple to guarantee. The DFGI had therefore already defined in the observation equations,

speed parameters as a linear function of time. This strategy is implemented in the Bernese GPS processing software.





Fig. 2



Fig. 4



Fig. 3



Figure 3 shows the annual movements along the border between the Caribbean and the South American Plate, derived

from all the GPS measurements taken to date. This regional field of movement was included in the global terrestrial reference system ITRF (International Terrestrial Reference Frame). The movement made by the South American plate can be seen on the map. The South American Plate moves generally in the direction north-north-west. On the other hand, the shift vectors on the Caribbean side turn to the east. Also, directly on the Bocono - El Pilar fault, the change in the movement is not abrupt but a sliding movement.

In this critical area a severe earthquake of the magnitude of 6.9 occurred on the 9th July 1997. Its epicentre lay near Casany. It caused massive destruction to buildings (Fig. 4). In the direct vicinity of a measuring point, a crack opened up in the earth's surface of about 25 cm (Fig. 5). In order to record the results of this earthquake on the geodynamic network, further GPS measurements were carried out in the second half of September 1997 after the expected post-seismic activities subsided. Results are yet to be published.

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Fig. 5

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