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Geodesic variations induced by hydrology on the karstic plateau of Calern (Alpes-Maritimes, France)

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On the karstic plateau of Calern, (Caussols, France) the astronomical observatory of the OCA measures geodetic variations since several years. In order to explore possible relationships with hydrology, two long baseline inclinometers were installed in a shaft and several hydrogeological sites have been instrumented since 2007. Dye tests have shown that, except for its Western third, the plateau is drained towards the East, to the spring of Bramafan. The instrument made it possible to characterize different reservoirs: the deep karst aquifer of Bramafam with high amplitude oscillations of its water table, up to 100 m, the perched aquifer of Moustiques shaft whose response is attenuated, and several slope aquifers with reduced oscillations (Fontaniers, Castel Bon Pré). The correlation with rainfall recorded at the observatory Calern is excellent.

The inclinometric observations show a load in the direction N100 ° E which starts one month after the beginning of the rainy period, then an unload in the direction N90 ° E during the dry period. The maximum inclinometric gradient reaches 8 µrad.

The best correlation between hydrology and inclinometry is observed for the deep aquifers. The first autumn rainfall is ineffective, then there is a good correlation water table / inclinometers, from November, when heavy rains are associated to inclinometry with a charge towards N100 ° E. The plateau then stabilizes but it starts again to tilt at the end of the dry season. The long term inclinometric variations could therefore be linked to the variations of the water table. In autumn, the first rainfall recharges the epikarst and refills the reserves, that were emptied during the low water. This does not affect the inclinometers. The winter rains cause the water to flush towards the eastern deep aquifer and this provokes a quick tilt of the plateau. Then occasional variations are measured by the N320 inclinometer.

A simple model of flexure, based on the principle of Boussinesq can calculate the inclinometric effect of a charge of water in a given location, according to a direction of maximum inclination between 90 and 100 ° E. We choose an area of 4 km by 2 km, located between the spring of Bramafam and the inclinometers. Then we estimate the quantity of water that can be found in the aquifer of Bramafam following the rainfall (25 million m3) and it is assumed that all the water accumulates on this area. The flexure corresponding to the inclinometric station is 4 µrad, which is consistent with our observations.

The variations are correlated with the hydrology of the plateau but the relationship with the tectonics must also be analyzed. Are the movements observed in Calern purely elastic or is there a remanence? The observation of broken and shifted speleothems in the shafts indicates a general shift of the plateau towards the south. Samples have been collected for dating to estimate the age of the damage.