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Subsoil and Structure Imaging
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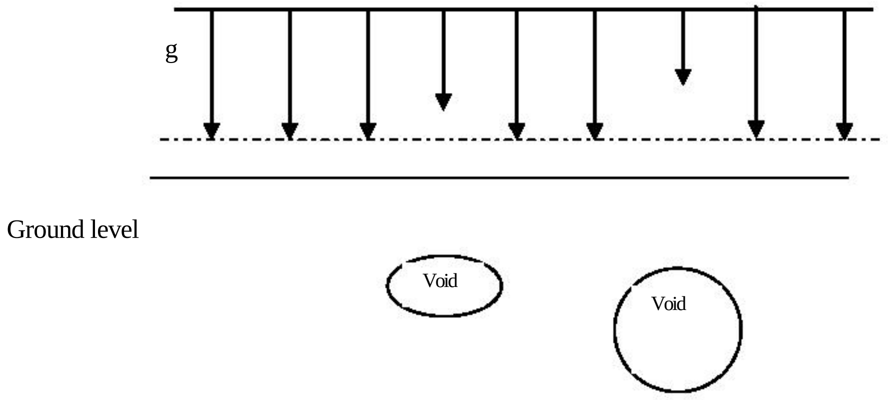
MICROGRAVIMETRY TO SEARCH FOR UNDERGROUND CAVITIES, SUBSIDENCE, GALLERIES, DECOMPRESSED ZONES

Microgravimetry is one of the most adapted methods for density anomaly research in the underground (cavity, cave-in, decompression, gallery…). It is based on the application of Newton's law which establishes that the intensity f of the gravitational force exerted between two masses m and m', distant of d, is $f=G.m.m'/d^2$, where G is the universal gravitational constant. To gravitational forces of Earth and Universe (virtually only the effects of the Moon and the Sun are noticeable), inertia forces caused by the rotation of the Earth, and, also, reliefs, altitude and latitude effects have to be added.

Gravitational effects, also called gravimetric effects, are expressed in the well-known relation: p = m.g, where p is the weight intensity and g the gravitational acceleration. Variations of g at the surface of Earth are linked to effects previously defined and to masses repartition in the underground. This leads up to use microgravimetry, the study of g variations, to detect density anomalies in the underground. This is illustrated on the figure below, on which the decreasing of g over cavities is schematically represented.



Measures, expressed in microgal ($1\mu gal=10^{-9}g$), are taken with a microgravimeter. **INNOGEO** owns and uses **two microgravimeters SCINTREX CG5M**. These very sensitive instruments offer a resolution about a microgal. A density anomaly, like a cavity, can be detected only if the gravimetrical anomaly produced (owing to its size, depth and density) is higher than a threshold called significance level. The latter depends on the measurement conditions and corresponds to the measurement noise. In excellent measuring conditions, the significance level can be as low as 15 or even 10 µgals. It should be made clear that a negative anomaly of 10 µgals corresponds approximately to the effect of a 2m diameter spherical void, at 1m depth, in a ground of 2000 kg/m density. In extreme conditions (vibrations, rain, wind, earthquake…), the significance level can increase notably, limiting method efficiency.

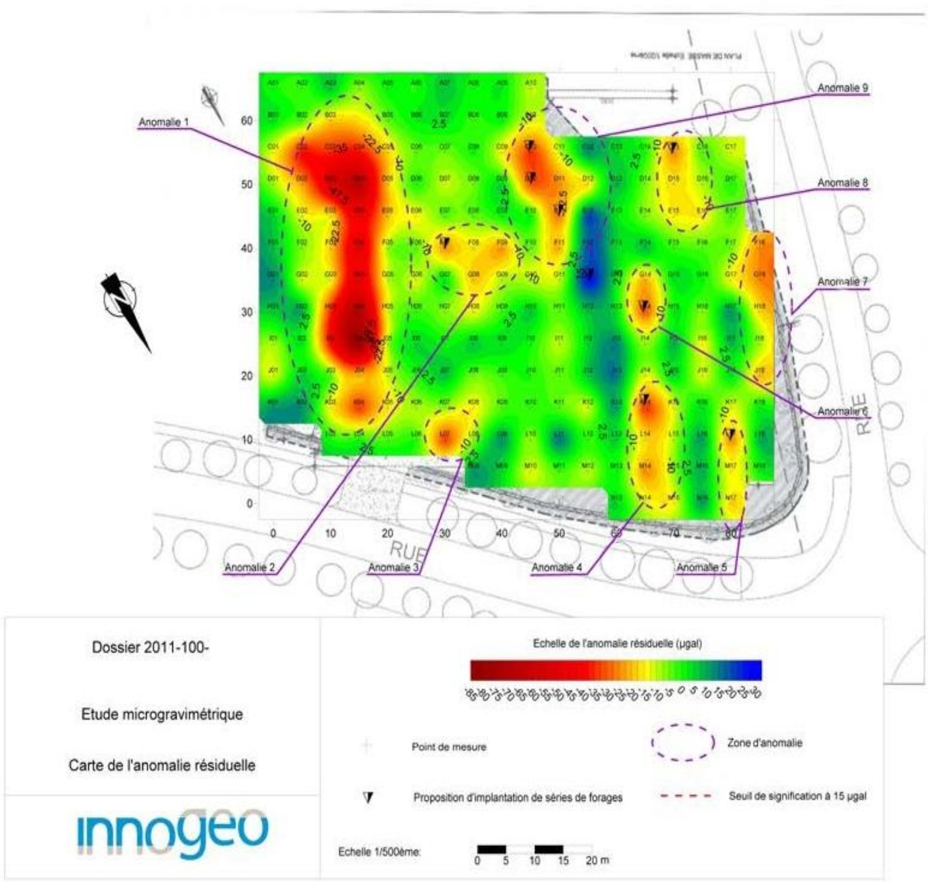
To determine the significance level, we repeat measurements on stations picked at random. At least 20% of the stations are remeasured, sometimes more. We then trace the statistic curve of the cumulated frequency of differences observed during remeasuring. This enables us to determine the threshold. Each measure station is levelled with precision of about a centimetre.

The mesh width depends on the size and depth of the anomalies searched. For instance, we frequently use a 5m x5m mesh that allows us to take 400 measures on a 1 ha field. Rate of measures varies between about 80 and 100 stations per day and per team, depending on the type of microgravimeter used and on work conditions.

Processing and interpretation of measures are done by the engineering office. Processing consists in correcting measures of all disruptive gravimetrical effects, i.e. not linked to geology. It thus results in the Bouguer anomaly, which represents variations of g strictly due to geology effects. Interpretation consists in determining, based on the Bouguer anomaly, the residual anomaly, of which variations correspond to density variations in the near subsoil. Indeed, in general we look for negative anomalies corresponding to voids or decompressed zones in the first tens of meters below the ground. However, we can also search for positive anomalies in some cases. These correspond to particular geological structures (fauts, volcanic intrusions…).

The residual anomaly is represented on profiles and maps (SURFER™ software) which permit to locate underground density anomalies.. These microgravimetrical anomalies have to be the object of mechanical boreholes to check the nature and size of the density anomalies to which they correspond. We sometimes combine the soundings to video-endoscopic examinations to visualise the cavities.

The example below is a residual anomaly map of a site in the North of France. Microgravimetric anomalies are shown is red. (Information about the location have been purposely hidden.)



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