Magnetic Gradiometer surveying in areas of high ambient noise.

Surveying with a magnetometer in urban environments can be difficult due to high ambient noise. In the following example, we show that it is possible to make high resolution magnetic surveys in areas where there is high cultural noise from fixed sources such as buildings, but also from sources that vary rapidly in time.

The area surveyed was approximately 35 metres by 20 metres and was a flat area of grass and with a single large tree in the middle of it. A steel man hole cover was noted 4 metres off from the bottom right corner of the grid. A large hotel and conference centre bounded the site to the West, and roads, both surface and overpass bounded the site to the North and East

Lines were surveyed at a 2 metre interval with a G-858 Cs vapour vertical gradiometer running from South to North, with the bottom sensor 50 cm above the ground and the top sensor at a height of 1 metre above the ground and a system sample rate of 5 readings per second with the instrument set in continuous mode. In this mode the recording instrument has a sensitivity, or base noise level, of 0.075 nT/m
Whilst conducting the survey, variations on the gradiometer display of the magnetometer were seen with a total amplitude in the 100 to 200 nT/m range.

Data was exported from the magnetometer to a PC using MagMap 2000 where the data was corrected for positional errors only, and prepared for final display using WinSurf. Figure 1 shows the recorded total field for the top sensor, huge anomalies of the range of 4000 nT can be seen here.

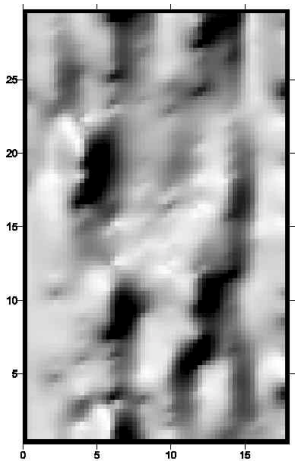

Figure 1

However, when the data was plotted in vertical gradient from using WinSurf several vertical gradient anomalies can be seen which have a maximum amplitude of 150 nT. It was supposed that the vertical gradient anomalies area due to previous excavations and constructions on the site, which used to form part of a graveyard. On closer examination, these vertical gradient anomalies as shown in figure 2, were seen to be spacially independent of the extremely large total field anomalies as shown in Figure 1 and recorded by both the top and bottom sensors, How could such large total field anomalies, producing huge horizontal gradients, not have a vertical gradient component as well ?

We noted when overlaying the data measurement positions on the data maps that these large total field anomalies did not in many areas spread laterally across more than one line. Thus it was concluded that the strong total field anomalies were varying with time and were probably caused an external cultural noise.

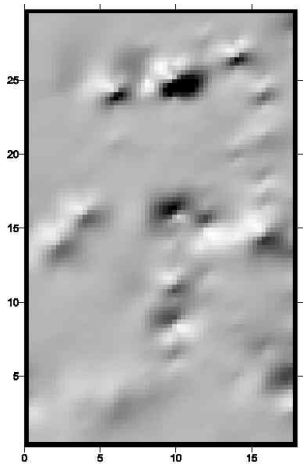

Figure 2

To test this theory, we conducted two experiments, first we ran a base station using two sensors in a vertical gradiometer mode, the results of which are shown in figure 3. This plot shows how the total field varies with time, with a total peak to peak amplitude of some 4000 nT, and with a period in some extreme cases of just a few seconds. Note, as we conducted the survey using a gradiometer, the use of a base station would not normally be considered as necessary to correct the data for diurnal or other time varying magnetic "noise". The results of the short base station trial as expected, show tiny variations in the vertical gradient with respect to time, but as expected huge variations in the total field with respect to time.

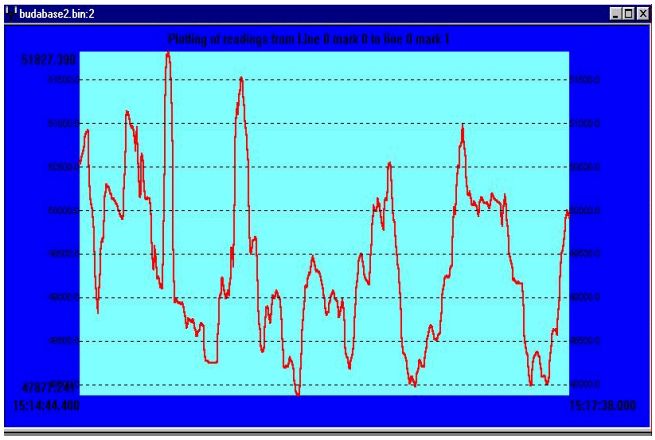

Figure 3 Base Station data.

Next as the site was small and readily accessible we conducted the whole survey again. As we predicted the results of this second survey showed great variation with the first survey in respect of the total field measurements, as is shown in figure 4, but the gradiometer data as shown in figure 5, shows excellent correlation with the first survey. Note that due to survey points disappearing in between the first and second surveys, there are some slight differences in the area surveyed on the two surveys.

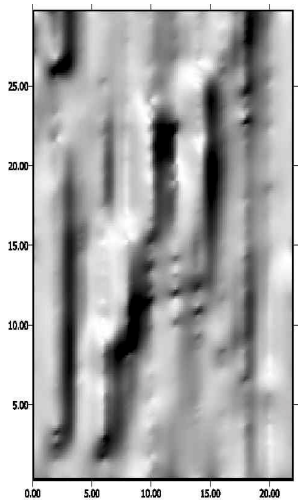

Figure 4

We re-examined the area around the site for possible sources of this time varying noise and observed an electric tram way beyond the road to the North and about 60-70 metres away from the site On enquiring, this was found to be powered by DC, and our conclusion was that the time varying magnetic anomalies were due to differences in load on the power lines caused by trams stopping, starting, accelerating etc.

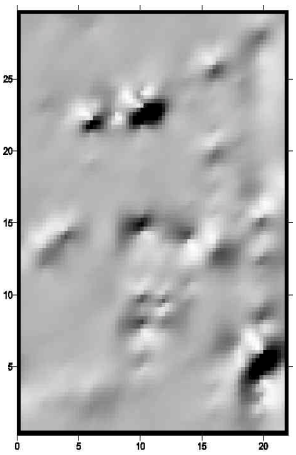

Figure 5

Examination of the total field signals from the survey data show time based variations of the magnitude of 4000 nT, in the time taken to survey one line, however gradient anomalies as small as 20-30 nT/m can be seen through this noise.

In conclusion, this survey is an excellent example of how, in a high noise urban environment with very high sources of cultural noise, both static and dynamic, a true simultaneous gradiometer, Ie one that reads both sensors at exactly the same time, can yield excellent results in resolving small magnetic gradient anomalies and filter out totally the cultural noise.