



## **Magnetic measurements with fluxgate 3-components magnetometers in archaeology. Multi-sensor device and associated potential field operators for large scale to centimetre investigations on the 1st millennium BC site of Qasr ʿAllam in the western desert of Egypt**

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Fluxgate 3-components magnetometers allow vector measurements of the magnetic field. Moreover, they are the magnetometers measuring the intensity of the magnetic field with the lightest weight and the lowest power consumption. Vector measurements make them the only kind of magnetometer allowing compensation of magnetic perturbations due to the equipment carried with the magnetometer. Fluxgate 3-components magnetometers are common in space magnetometry and in aero-geophysics but are never used in archaeology due to the difficulty to calibrate them. This problem is overcome by the use of a simple calibration and compensation procedure on the field developed initially for space research (after calibration and compensation, rms noise is less than 1 nT). It is therefore possible to build a multi-sensor (up to 8) and georeferenced device for investigations at different scales down to the centimetre: because the locus of magnetic measurements is less than a cubic centimetre, magnetic profiling or mapping can be performed a few centimetres outside magnetized bodies. Such an equipment is used in a context of heavy sediment coverage and uneven topography on the 1st millennium BC site of Qasr ʿAllam in the western desert of Egypt. Magnetic measurements with a line spacing of 0.5 m allow to compute a magnetic grid. Interpretation using potential field operators such as double reduction to the pole and fractional vertical derivatives reveals a widespread irrigation system and a vast cultic facility. In some areas, magnetic profiling with a 0.1 m line spacing and at 0.1 m above the ground is performed. Results of interpretations give enough proof to the local authorities to enlarge the protection of the site against the threatening progression of agricultural fields.