Large-scale UAV magnetometry on a former World War II airfield at Ganacker (Lower Bavaria, Germany)

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BAYERISCHES LANDESAMT FÜR DENKMAL PFLEGE

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SENSYS® Magnetometers & Survey Solutions

Instrument, data processing and interpretation

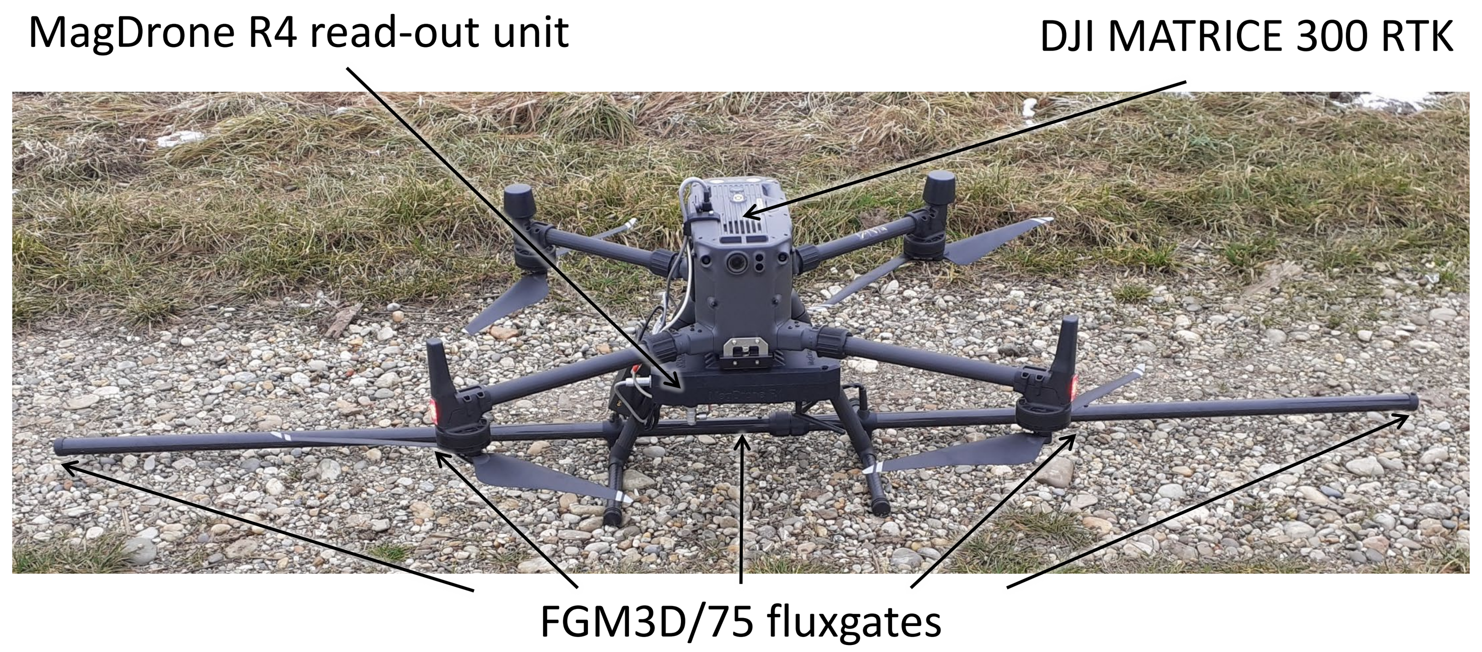

Fig. 1. The compact setup of the Sensys MagDrone R4 magnetometer system

The aim of the study was to test the capabilities of Sensys MagDrone R4 for Archaeological Prospection. It is equipped with five three-axis FGM3D/75 fluxgate sensors at 0.5 m spacing, which allows the coverage of a 2.5 m wide swath within one flight pass (Fig. 1). Due to the quite flat terrain of the test site, the R4 could be operated at a fixed flight height of just one metre above the surface. A radar sensor controlled the constant flight height of the UAV. The 200 Hz sampling rate of the FGM3D/75 sensors allows easy filtering of interference generated by the UAV and external disturbances like power lines or infrastructure. Magnetograms with a spatial resolution of up to 0.20 m per pixel were produced using the R4 data (Fig. 3 and 4). To calculate the intensity of the anomalies, a 25 m running median was applied to the total intensity raw data. Since three-axis fluxgates are based on the same physical principles as widely used fluxgate gradiometers (Gavazzi et al., 2021), this simplifies the interpretation of the R4 borne magnetograms. For the archaeological interpretation, multitemporary historical aerial photographs and several recent digital orthophotos were used.

Conclusion and outlook

The R4 offers an outstanding survey progress that cannot even be reached by common vehicle-moved multi-sensor arrays. Thus, efficient UAV magnetometry provides the possibility of mapping the subsurface of huge areas during short time. It is therefore of high importance for the landscape archaeology. The R4 is well suited for the detection of large archaeological structures with high magnetisations, and also shows great potential in terms of accuracy for the detection of small archaeological features. In the future, we want to test, whether the system is suitable for detecting older, e.g. prehistorical archaeological features that have lower magnetic susceptibility and remanence contrasts with the surrounding soil.

Preliminary results

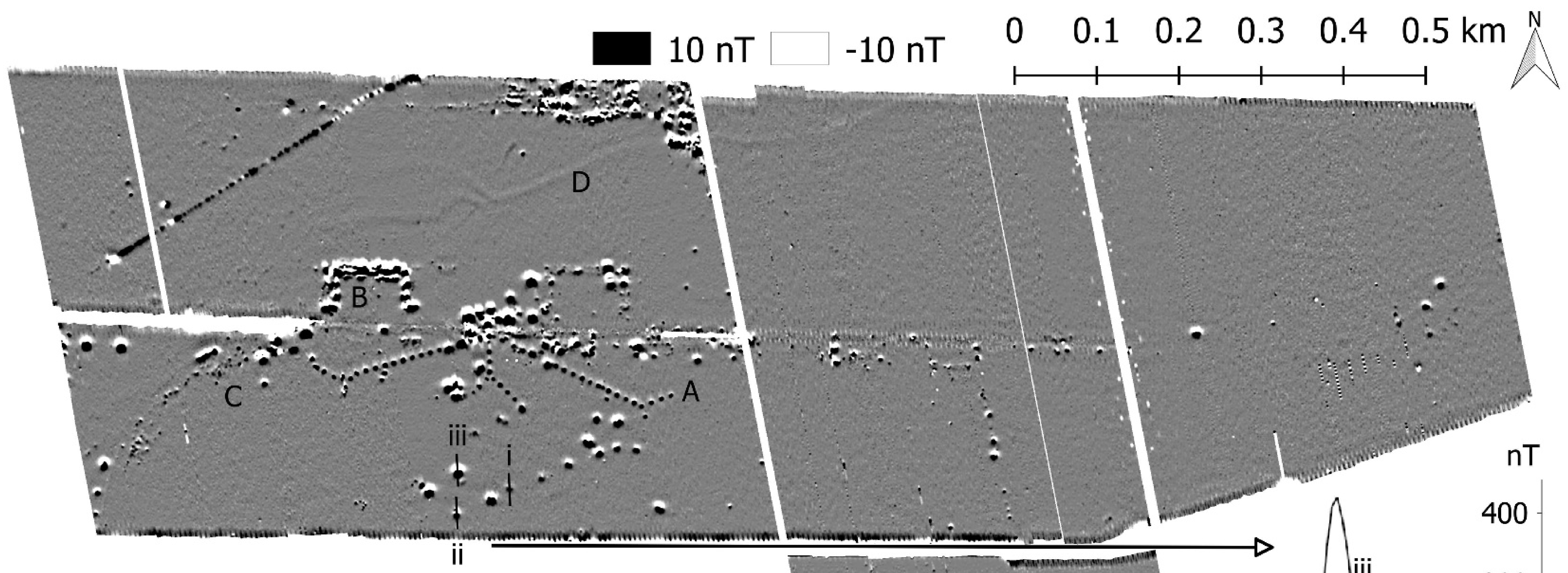

Fig. 3. Results of the UAV magnetometry in Ganacker with marked detail sections and individual anomalies discussed below. Magnetogram: dynamic +/- 10 nT; black = positive; white = negative; spatial resolution 0.2 m

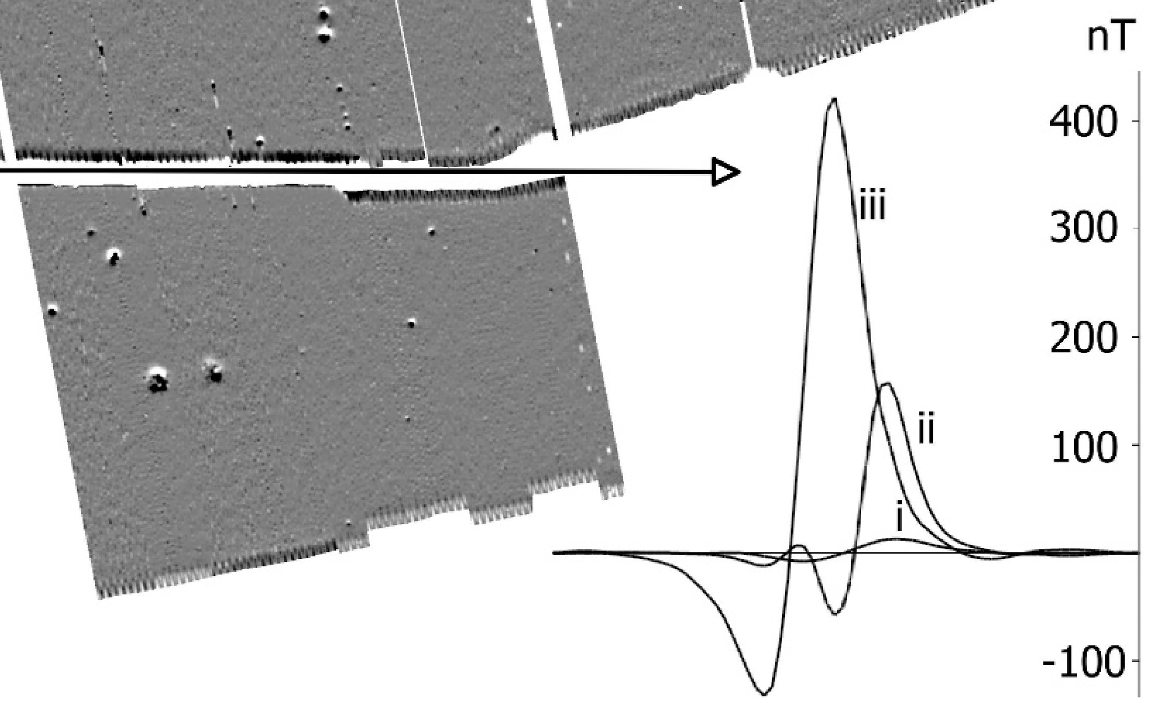

Fig. 3i-iii: Magnetogram profiles through selected bomb crater anomalies

Approximately 110 hectares could be prospected within only four days using the R4. Most of the expected archaeological features and several unknown ones were detected by the UAV magnetometer system (Fig. 3/4). The unknown linear structures A (Fig. 3) depict possible fuel lines connected by iron sleeves (circular, dipolar anomalies) (Immekus, 2011). The anomalies B trace the remains and backfill of a former rifle shooting range (Fig. 3/4 B). Smaller structures, such as outlines of aircraft shelters and backfills of anti-splinter trenches (Fig. 3/4 C), were also recorded. This was not to be expected. A geological structure extending over several hundred meters was detected by the R4 system as a very weak negative anomaly (Fig. 3 D). The former, backfilled bomb crater anomalies show different intensities (Fig. 3 i-iii). We attribute these differences to the heat influence on the soil during the explosion and the accompanying transformation of pedogenic iron minerals to ferrimagnetic compounds, resulting in weaker anomalies (Fig. 3 i). The intense (Fig. 3 ii) and very intense anomalies (Fig. 3 iii) are produced by metallic iron, whose Curie points was exceeded during the explosion. The newly acquired, main-field-parallel dipolar remanence superimposes the ferrimagnetic thermo-

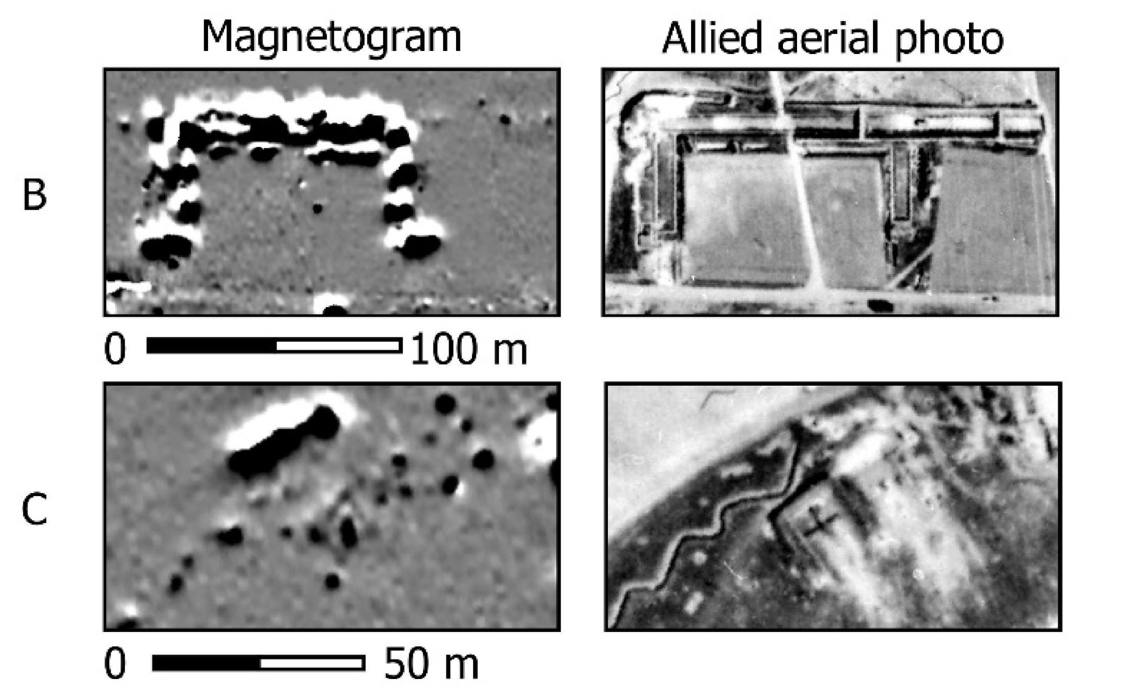

Fig 4. Detailed comparison of the magnetogram with the Allied aerial photograph of 20.04.1945

remanence acquired by the soil. Therefore, we interpret those bomb craters as infilled with wartime dipolar material (e. g. shrapnel and Unexploded Ordnance/UXO).

Test site

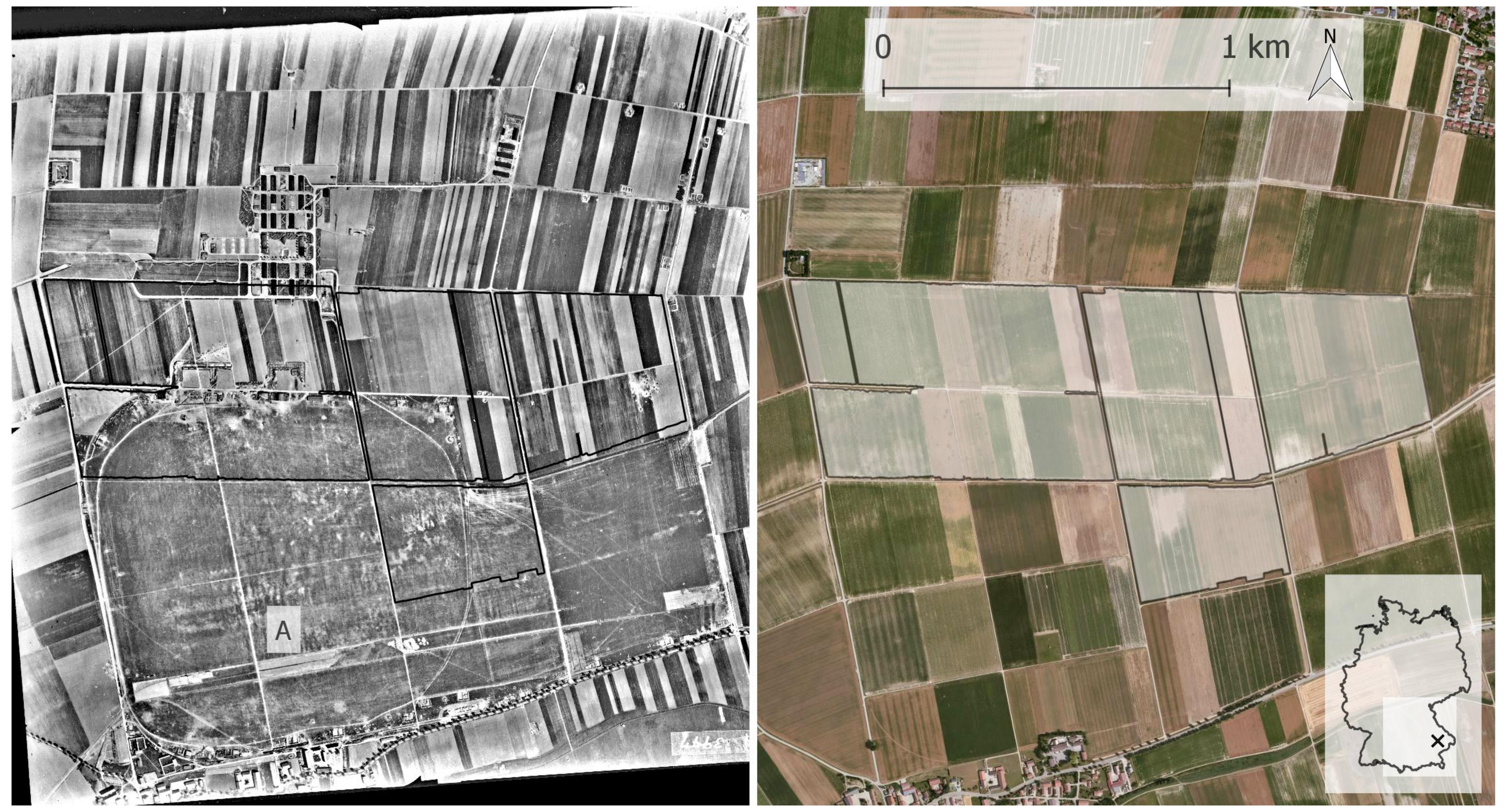

Fig. 2. Georeferenced aerial photograph taken on 20.04.1945 within the R4 survey area (black edged polygons). Labelled area: A = runway under construction (left). The former airfield in 2013 with the R4 Survey area. (right) (© Geobasis data: Bayerische Vermessungsverwaltung).

The test site Ganacker is a former "Luftwaffe" operational airfield. Since February 1945 and under inhumane conditions, forced labourers were used to build a runway for the Messerschmitt Me-262 jet-powered fighter aircraft (Fig. 2 A left). Towards the end of the war, the airfield was attacked several times by Allied air forces (low-level attacs and bombardements) (Zapf, 2013). The present landscape of the test site is characterised by open, mostly flat croplands on loess soils. To the northwest, the terrain rises slightly and the relief becomes more uneven. While the older maps from the early 1950s still show the remains of the barracks camp and the splinter protection walls, nothing can be seen of the airfield today (Fig. 2 right). We chose the former infrastructure core of the airfield for the R4 test survey. A wide range of archaeological features with high magnetisation contrast to the surrounding soil was expected in this area (Fig. 2 left).

References

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