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Ultra High Resolution Caesium Magnetometry at Monte da Ponte, Concelho Evora, Portugal 1994–1996

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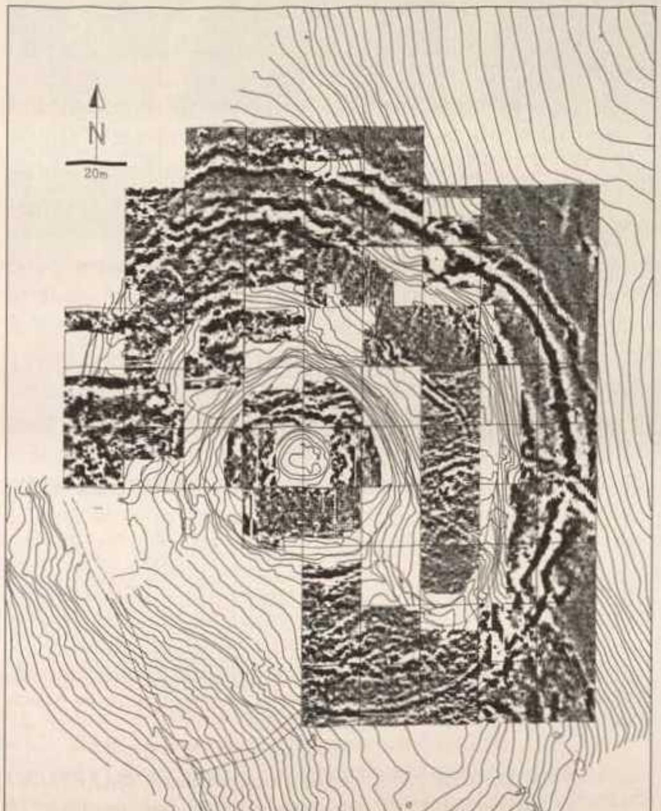
During a prospection flight with O. Braasch in May 1989 the archaeologists team of the project Vale de Rodrigo (Ph. Kalb and M. Höck) realized that the site of Monte da Ponte must be something special. The place was used for centuries as canada for locking the sheep during night when driving them over long distances. But only for keeping sheep this building would be overconstructed consisting of several rings of high stone ramparts with a central tower and radial divisions. But until 1996 no characteristic ceramics could be found, when some Copper Age pottery came to light by the activity of rabbits. With the beginning of the topographical survey of this complex site by Martin Höck in 1994 a 20 m grid was layed out for geophysical prospection. The site became a test area for the prototypes of the Picotesla-caesium magnetometer-system CS2/MEP720 and the duo-sensor configuration with SM4G-Special. It became evident that a very important archaeological site had been discovered. A test excavation started in 1996.

Fig. 1. Monte da Ponte 1994/1995. Magnetogram as dot density plot on the base of the topographical map by M. Höck. Caesium magnetometer CS2/MEP720, sensitivity 1 Picotesla (0.001 nT), variometer mode, raster after resampling 0.5/0.25 m, highpass filtering 5 x 5 pixel, dynamics -2.5/+2.5 nT in 17 grayscales (white/black), 20 m grid, north upwards



Based on the experience from the prospection of Megalithic sites in the Vale de Rodrigo project (Becker 1994) for prospecting the stone structures at Monte da Ponte resistivity survey was applied first. This became also a test for the new resistance meter RM15-Advanced (Geoscan, Bradford) with twin electrode. But it was clear from the beginning of the prospection project, that it would take to long time to undertake a resistivity survey alone. For magnetic prospection the prototype of the ultra high sensitive CS2/MEP720 caesium magnetometer (Scintrex/Picodas, Canada) was used the first time. This instrument being still the most sensitive magnetometer used on the ground marks the step from Nanotesla- to Picotesla-systems (Becker 1995). The measurement was done in variometer mode (one sensor fixed as base station for cancelling the geomagnetic time variations). The instrument was switched to 10 measurements per second, which gave a spacial resolution of about 10 cm on the line. Traverse inverval was choosen with 0.5 m. Distance triggering was made manually every meter using a switch. The whole process was controled by the subnotebook computer Olivetti Quaderno, which was used for data logging too. A 12 V car battery was sufficient for running the system one day. Also a sun collector was added to the power supply, so there were no problems with energy in the field. However at this first test many problems mainly concerning the distance trigger and data logging had to be solved. The main problem under difficult surface conditions remained due to the separation of the sensor-unit and the (magnetometer, power supply, computer)-unit connected by a long cable which got stuck very often and had to be handled by a third person. The ideal magnetometer for rough surface conditions became the Scintrex SMARTMAG SM4G-Special, which can be operated by one person carrying the whole system, and which was used the first time in March 1996 at Monte da Ponte.

The comparison of resistivity and magnetic prospection at the main east plateau of Monte da Ponte showed, that the magnetometer survey is the most suitable method for prospecting this site, because magnetics is about 5 times faster than resistivity. Also the archaeological structures are better shown in the magnetograms, because at Monte da Ponte a high magnetic contrast was found due to a huge conflagration of the site. The ramparts and walls of the monument were identified in the magnetogram both as positive and negative magnetic anomalies, depending on their magnetic contrast (Fig. 1 and 5). There must have been a wooden construction with sun dried mudbricks on the stone foundations of the fortification wall, which have been burnt down. The walls of the fortification and also the filling of the bastions in the forth wall must have gained a strong positive

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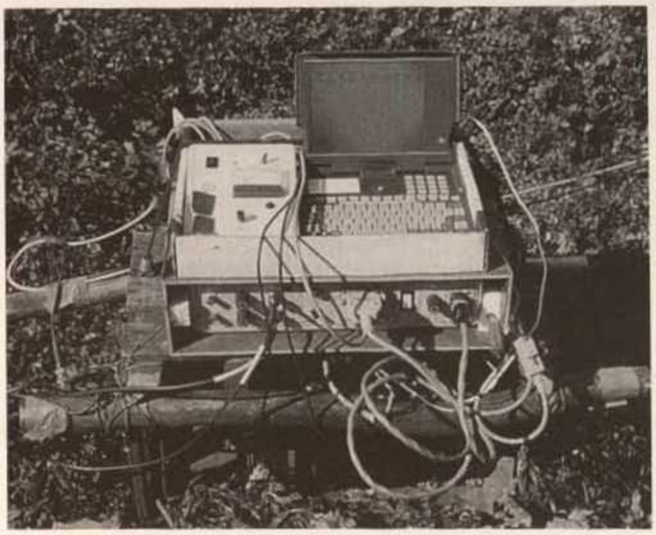

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magnetization, which certainly is due to the burnt mudbrick materials. The magnetic anomaly pattern seems to be rather complicated, because these positive anomalies have their magnetic "shadow" as a negative anomaly in the north. The structures with negative magnetization contrast (stone foundations in burnt surroundings) show as negative anomalies with a positive "shadow". Sometimes it's difficult to decide which anomaly is due to the structure itself and which is only the "magnetic shadow" phenomenon.

The site of Monte da Ponte shows a geometric construction of a huge oval fortification with 5 ring walls including the central tower, which measures 190 to 170 m. The plateau area between the second and the forth wall, which may have been the main habitation area, is divided into several sectors by radial walls with negative magnetization contrast, which indicates stone walls. The well preserved forth wall shows at their northern front a series of bastions, which are no more visible at the surface. But they could be also be seen in the drying vegetation during some days in late spring 1996. The main gate may be identified on the east side in the fifth wall and the earth rampart extended in front of it, with the trace of the gateway leading to the interior plateau between tower and the second wall. Only the tower could not be surveyed, because is was impossible walking over it due to a big

Fig. 2 and 3. Monte da Ponte 1994. Caesium magnetometer Picotesla-system CS2/MEP720 (Scintrex/Picodas) at first application in March 1994

Fig. 4. Monte da Ponte 1996. Caesium magnetometer SMARTMAG SM4G-Special (Scintrex) with duo-sensor configuration, sensitivity 10 pT (0.01 nT) at 0.1 sec cycle (10 measurements per second)

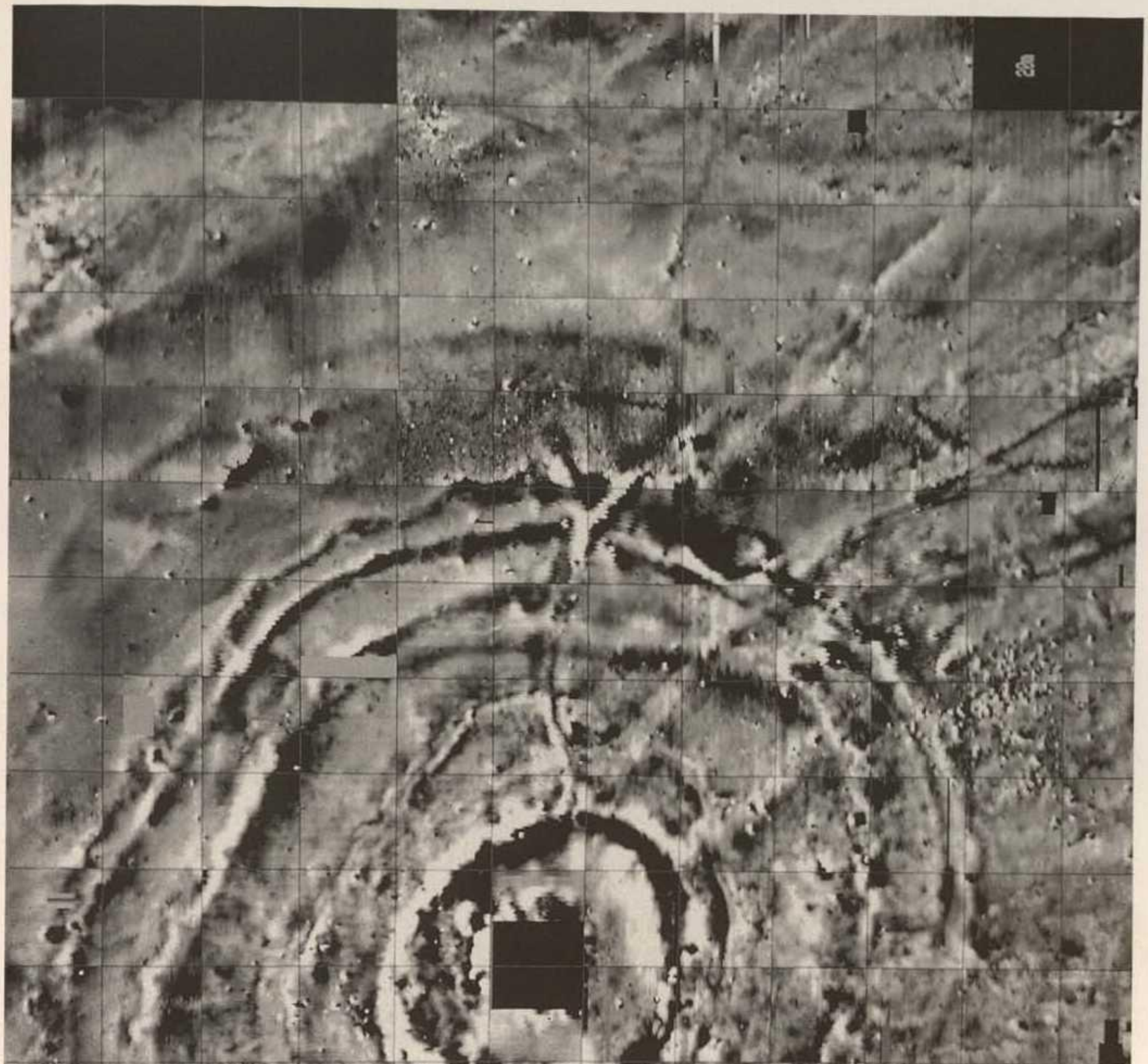

Fig. 5. Monte da Ponte 1994–1997. Magnetogram as digital image. Caesium magnetometer CS2/MEP720 (technical details see above) and SMARTMAG SM4G-Special with duo-sensor configuration, sensitivity 10 pT, raster after resampling 0.5/0.25 m, dynamics -6.4/+6.4 nT to -3.2/+3.2 nT (outer area) in 256 greyscales (white/black), 20 m grid

Fig. 6. Monte da Ponte 1997. Aerial view of the Copper Age fortified settlement with signaled control points (20 m grid) on the ground by Rupprecht and Michaela Steinman as base for an photogrametric evaluation for a plan of all stones

heap of stones and many bushes. In front of the fifth wall there is another curved structure, which could be an earth-work. Another 20 and 30 m outside of this structure there can be partly identified the trace of a palisade and an outmost ditch mainly on the northeast quarter of the fortification (Fig. 5). The third ring wall is only preserved in the northern part, but has vanished from the surface in the remaining area. The fifth wall can not be seen above surface any more, but is clearly visible in the magnetogram.

Early in 1996, when the SMARTMAG magnetometer was to be tested, all stone ramparts (walls) were cleaned from their blackberry bushes, which resulted in an almost complete plan of the whole fortification (Fig. 5), but still missing the central tower. With the use of the duo-sensor configuration the SMARTMAG magnetometer allowed also the prospection of huge areas in the surroundings, where the above mentioned palisade and ditch system was found. The idea of finding more external seperate fortifications far outside the site was not confirmed by the prospection.

Besides the terrestrial topographic work by M. Höck, 1997 also some flights for aerial photos were undertaken by Ruprecht and Michaela Steinman, which also show the 20 m grid as ground control for photogrametric work. The 20 m stacks of the grid were signaled for this purpose by white plastic dishes. The photogrametric evaluation of these oblique aerial photographs by digital image processing will result in a scaled plan of all stones visible on the photos. There will be also a chance for an stereoscopic analysis of the aerial photos with sufficient overlap.

The combination of several prospection und survey methods like aerial photography, field walking, topographic surveying, digital terrain modeling and geophysical prospecting resulted in an idea and plan of the important archaeological monument of a Copper Age fortified settlement at Monte da Ponte. In addition to these nondestructive methods archaeological test excavation can be concentrated on specific areas for answering questions, which should give optimal additional information about this site. Thanks the open and extremely helpful cooperation between many scientists named above, the development of new instruments and techniques for geophysical prospection in archaeology became a real progress.

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