THE OTRANTO MOSAIC FLOOR: TEN YEARS OF PHOTOGRAMMETRIC SURVEYS

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ABSTRACT

This paper described the photogrammetric analyses of the ancient mosaic floor in the Otranto Cathedral carried out in ten years from 1981 until 1991. Given the development of instrumental methodologies in this decade it seems opportune to illustrate the different experiences with cameras, platforms and stereoplotters. Camera performances in architectural and archeological applications are also documented.

1. INTRODUCTION

In the last ten years, the Laboratory of Photogrammetry (Department of Architecture and Urban Planning, Bari, Italy) has been actively involved in the restoration project for the mosaic floor of Otranto Cathedral (near Lecce in the south of Italy). During the long time required initially for the difficult decisions involving the restoration plans and then for disassembling and reassembling the mosaic tesserae some interesting changes in instrumental and operative methodologies come about. Otranto Cathedral, built in the XI Century, has a wide mosaic on the floor of the nave (10 x 30 m2). This work was executed by a monk from the East between 1163 and 1166.It represents the "life tree" with Biblical scenes, and others illustrating northern tales from classical and Breton cycles as well as figures and signs of the zodiac related to working activities for each of the twelve months. The cited representations probably inspired Dante Alighieri while writing some parts of his major work "La Divina Commedia". In the 80's, since the floor's progressive degradation, it was decided to plan the overall consolidation of the base which showed unhomogeneous static stability. The plan proposed lifting the 300 m2 mosaic all at one time using a technique never tried before. Given the risks for the mosaic, our Laboratory set up the first stage of a metric documentation of the mosaic floor entailing an analysis integrating photogrammetry, micro-geodesy and CAD (M.Minchilli, 1982). Since the Ministry of Cultural Assets was to only partially finance the plan it was impossible to undertake the restoration of the entire mosaic. Thus it was decided to begin work in the fore part of the nave, near the presbytery, using traditional techniques consisting in pulling up the mosaic divided into parts. During this operation and the subsequent archeological excavations, many column foundations, graves, ancient findings and part of another wide mosaic floor were found. From the portion of this mosaic

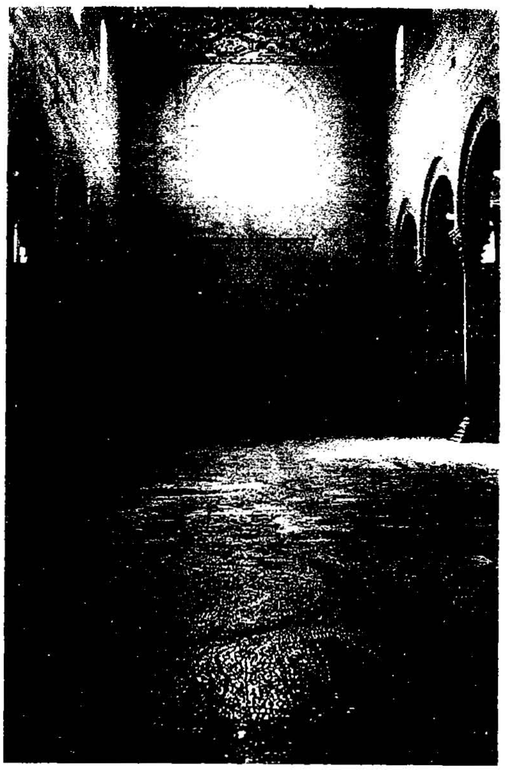


Fig. 1 - The floor in the original situation.

uncovered, probably dated V-VI century, it seems likely that it was as large as the nave itself! At the end of excavations we executed another photogrammetric covering and control survey (2nd stage, 1986) tightly connected to the first as regards the homogeneity of the coordinate system. It was strictly necessary to keep the reference system unchanged in order to obtain a superimposed graphical representation of the two mosaics. At the beginning of 1989, thanks to other funds assigned to the work, the whole upper mosaic was deassembled so that the lower one was entirely visible. Then the 3rd stage of the photogrammetric records was extended to the 300 m2 of the nave in order to document the earlier mosaic and the archeological excavations. After this operation the archeologists continued their work documenting it solely by traditional methodology. The fact that techniques like archeology, wich destroy existing situations as they progress, are not always documented by photogrammetry is open to severe criticism. Before reassembling the upper mosaic we completed the 4th stage of the survey taking vertical and low-oblique photographs of the bottom of the excavations. The oblique records were necessary to document the archeological stratigraphy and the lateral views of the nave. During the first months of 1991 the medieval mosaic was completely reassembled and we have planned the 5th and last stage of the survey finalizing it to the comparison with the existing situation before the restoration. The long time interval between the first stage up to today has made it possible to experiment with different camera performances, different height platforms and changed stereorestitution methodologies. We started in 1981 using a small-format stereometric camera and a plotting instrument that provided analogical solutions to reach the present using medium and large format cameras, Total-Stations, analyitical stereoplotters and numerical on-line data-collection. Besides instrumental progress, that radically changed the close-range photogrammetry during the last years, we incurred typical difficulties always present in this kind of application. Among these I should mention how the continually modified situation in a

Fig.2 - Part of the mosaic restored in the '50.

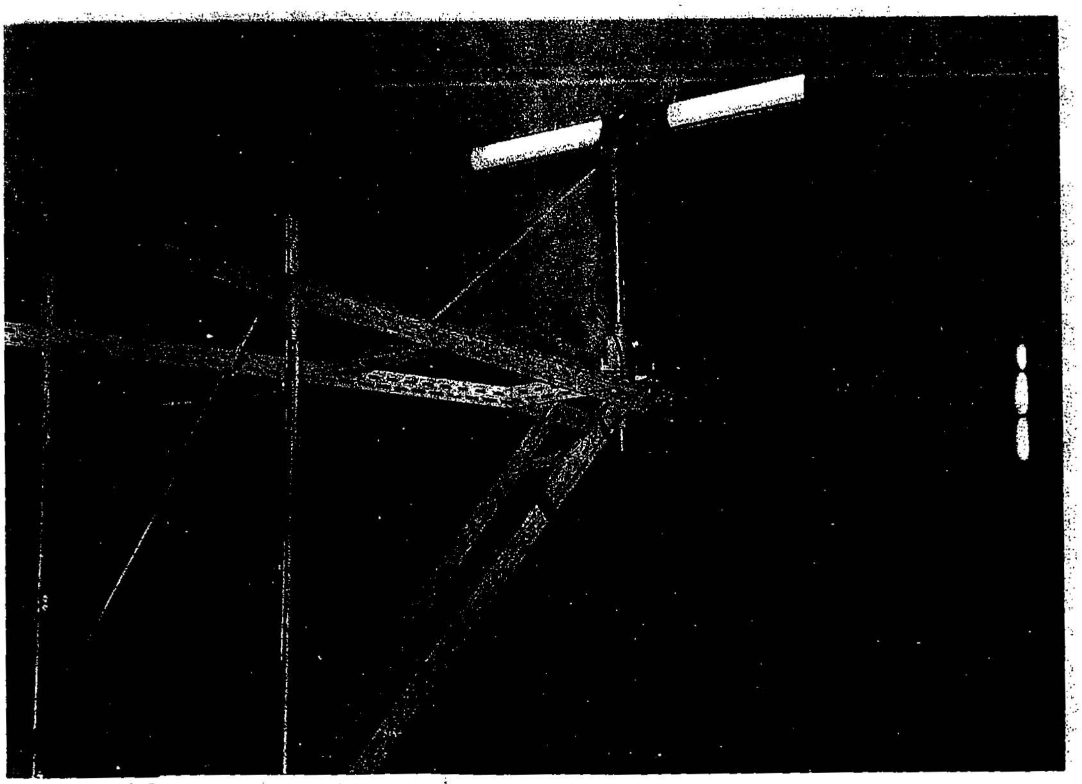


Fig.3 - Special stereocamera bracket used in the 1st stage.

restoration working area frequently involves different taking heights, focal lengths of the camera, scale ratio and, as in our case, changes concerning the control points survey. In the conclusion of this paper I draw some conclusions as to the optimum of terrestrial camera performances and stereoplotting compilation resulting from this field experience.

2. FIRST STAGE (1981)

In this paper I briefly describe the starting stage of the survey, referring to: M.Minchilli, 1982 for more detailed descriptions. The initial request, in 1981, was for a complete metric analysis of the whole mosaic floor with special regard to the height variations of the surface. Both graphical and numerical data were to constitute a basis for the operative restoration design and the permanent documentation of the existing planimetry and altimetry of the ancient mosaic. At that time the state of the floor was still practicable, but great care was needed because of its seriously damaged mosaic, so we planned to take 30 vertical stereometric pairs using a camera with a special bracket mounted on wheels. The light weight of this platform allowed us to perform our work without damaging or detaching the tesserae of the mosaic. The values obtained for scale factor (about 1:60) and base-height ratio (about 1:3.5) resulted in a data collection, by analogical stereoplotting, of less than 5 mm mean accuracy . This upper limit was intentionally fixed because the deep cracks on the surface and a large number of slanting tesserae made a higher degree of accuracy useless, both from the technical and the economical point of view. The restitution of the stereopairs was carried out by a mechanical-projection terrestrial stereoplotter and by assembling a wide photo-mosaic at the scale of 1:20. The 30 rectified photographs had only a slight image displacement because the floor height variations were only a small percentage of the taking distance (less then 2%). The geodetic control included about 350 points, arranged on a regular grid of 1x1 m, materialized by numbered targets on the mosaic surface. The spatial coordinates survey was carried out by classical solution: a network of distances for planimetry and a levelling for altimetry. The global digitizing of the graphic restitution was carried out off-line by a Digital PDP-11 based CAD system; the computed D.T.M. became the base for some graphic processing and automatic contour compiling.

Fig.4 - Restitution of the original situation.

3. SECOND STAGE (1986)

As already mentioned, in 1986 at the beginning of the excavation, only 60 m2 of the mosaic were deassembled. A classic technique was used consisting in gluing small parts of the mosaic surface, about 3 m2, and then pulling them up. The backs of the tesserae were completely cleaned and then they were put together on a light-weight concrete layer. Under the floor the archeologists carried on excavations bringing to light many interesting findings: among them the fore part of another very well preserved mosaic. The photogrammetric coverage was executed in very good conditions because it was economically possible to build a light metallic scaffolding on the excavated area. Using a platform, assembled above c.a. 5 m on the ground, we took photographs with a metric medium-format terrestrial camera with a principal distance of 100 mm suitable for 1:50 photo scale. The control survey was

Fig.5 - Excavations during the 2nd stage.

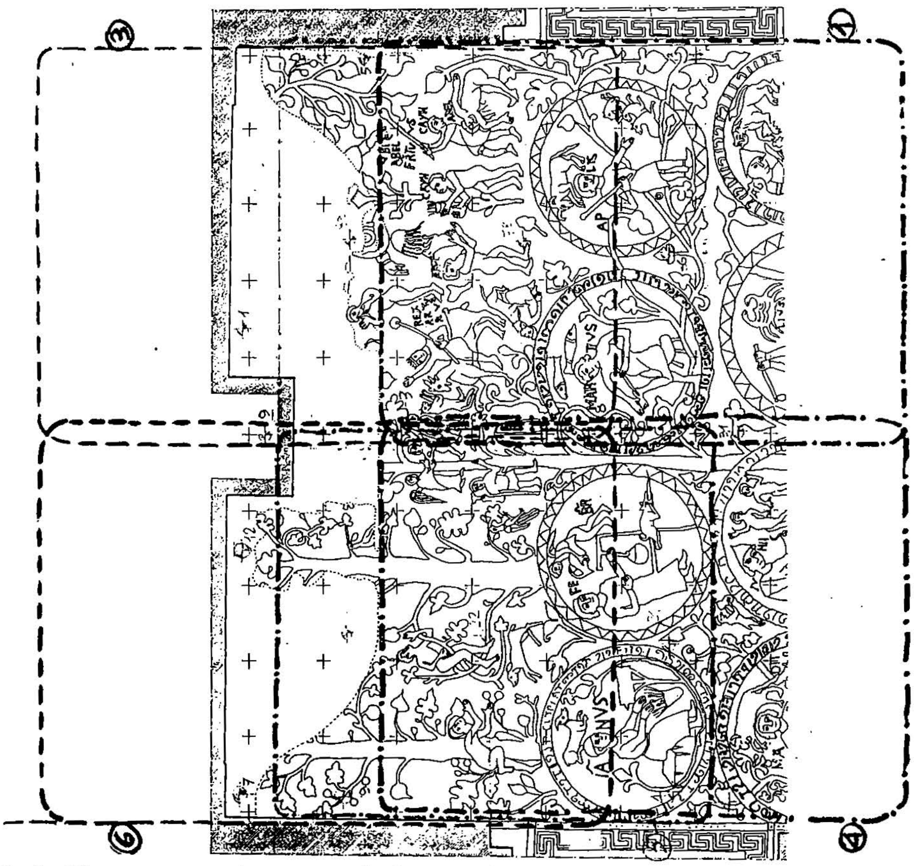
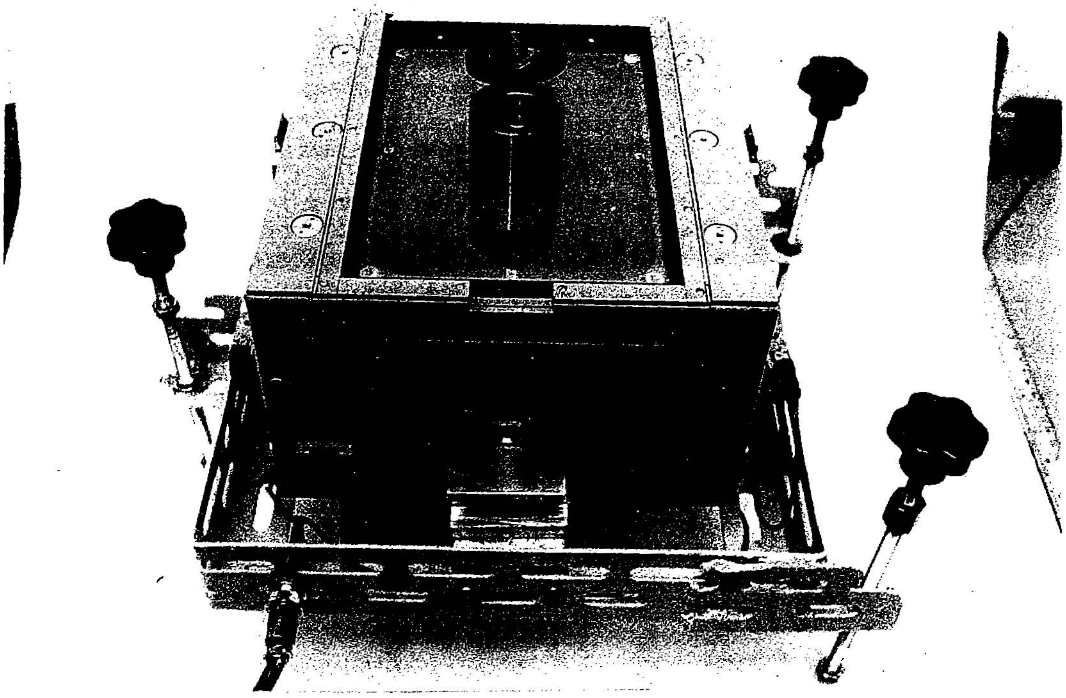


Fig.6 - Photogrammetric coverage in the 2nd stage.



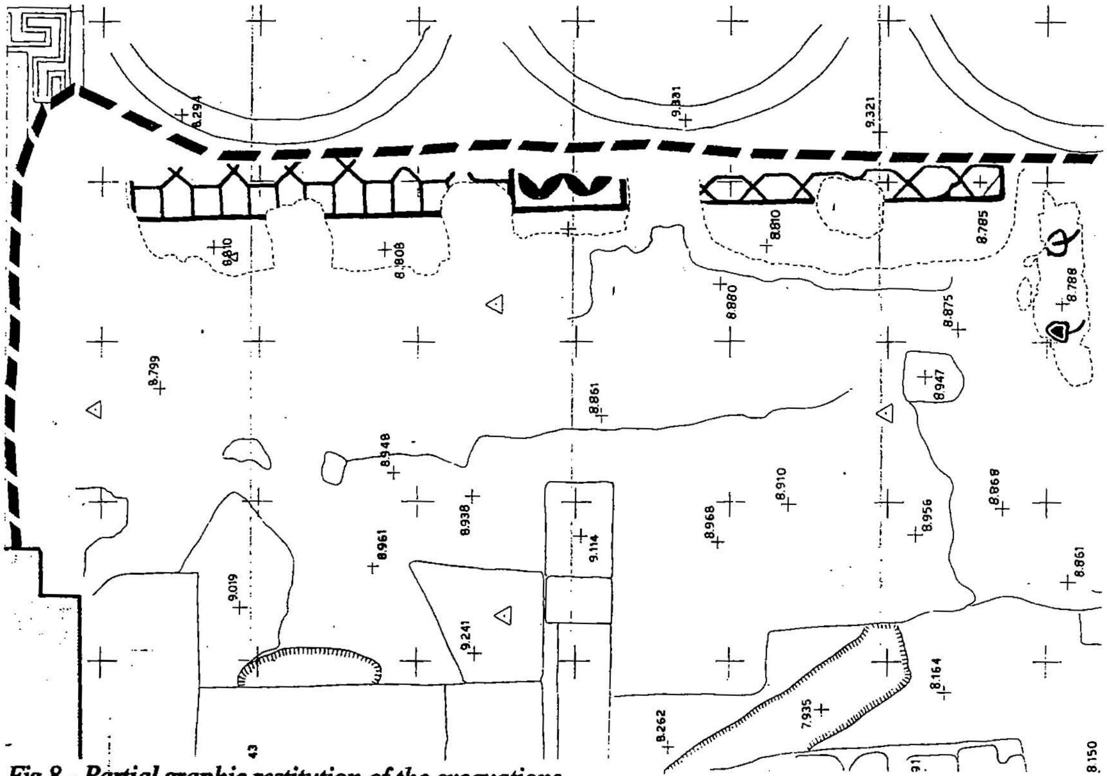


Fig.8 - Partial graphic restitution of the excavations.

executed with direct space resection using an electronic Total-Station interfaced to a data recorder. The target points were materialized by the conical head of milled steel nails. The heights were referred to the same datum mark of the previous control by a short trigonometric levelling. During the restitution, for the first time performed with an analytical stereoplotter compiling on-line, we noticed how the accuracy obtained by the chosen operative scheme exceeded the planned precision. I am fully persuased that it is really useless to push the accuracy of an archeological photogrammetric survey up to 1 mm because of the texture and shape characteristics of the findings.

4. THIRD AND FOURTH STAGES (1989, 1990)

During the subsequent third and fourth stages we made a photogrammetric analysis of the whole nave after the complete deassembling of the two mosaics. To overcome the expansive cost of a scaffolding, built so that it would be possible to take photographs very close to the object as in the previous stages, we decided to operate from the roof truss of the nave. Having deassembled some decorative elements of the wood ceiling we were able to locate 6 positions for a normal angle camera on a specially built vertical mount. The one strip obtained from the taking distance of 16 m had a photo scale of about 1:100, and the same 1:2.5 base/high ratio of the previous stages. This operative scheme allowed us to work quickly and at low cost but the large area covered by each photograph involved some difficulties in setting up uniform artificial lighting. The photographs, taken in B/W and invertible color films, were restituted both by direct plotting and by numerical data collection in an analytical stereoplotter. At the same time we also took color photographs of the internal lateral elevations of the entire nave in order to analyze the colonnade and the stratigraphy of archeological excavations. In this case we obtained a coverage of the entire surface in only 3 stereoscopic models with a super-wide-angle camera.

5. CONCLUSIONS

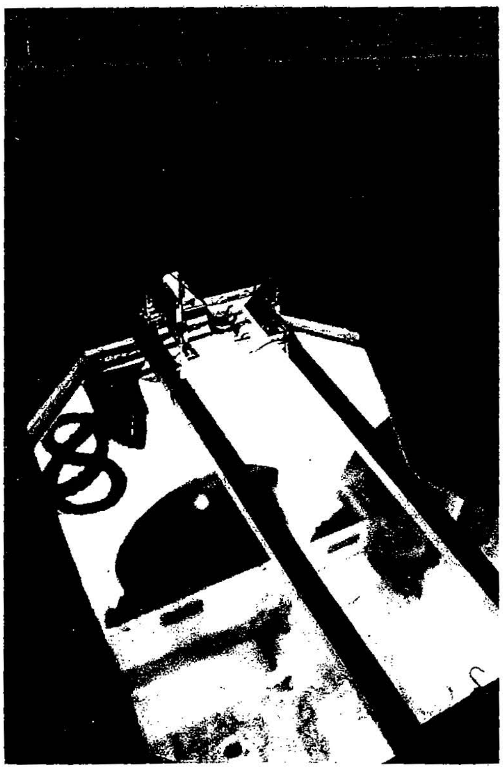


Fig.9 - Vertical mount in the wood ceiling.

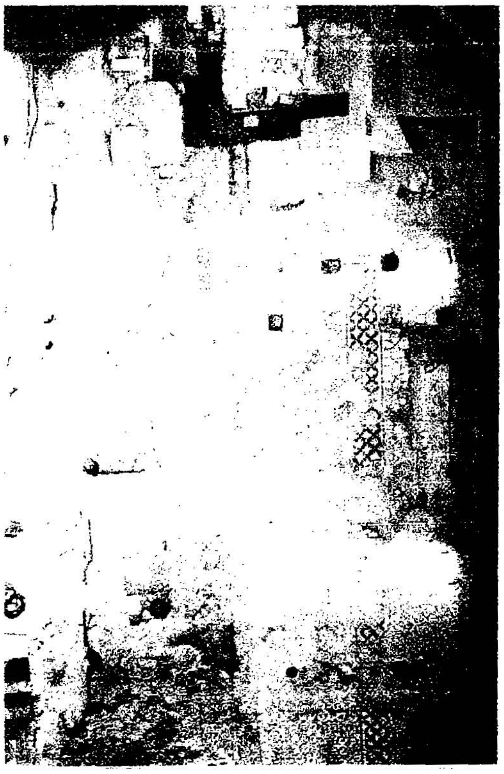


Fig.10 - Excavations in 1989.

Work on the Otranto project come just during the years of a change from the classic analogical to the analytical restitution. At present all the difficulties and the costs related to the off-line map digitizing are largely overcome working exclusively by on-line data collection during stereoplotting. It must be borne in mind that a digital graphic model can be processed very easily and it is a valid base for updating, checking, planning and also for interactions with termographic and ultrasonic analyses. This

TABLE OF PROCEDURES

PH. SURVEY										RESTITUTION			
St.	Date	Ster.mod. n.	Area m^2/mod	Base m.	Dist. m.	B/H	Emuls.	Ph.scale	Op.axis	Type	Scale	Numer.	Object
1st	10/81	30	16	1.20	4.2	1/3.5	B/W	1:65	vert.	analog.	1:20	Y(off-l.)	mosaic
2nd	10/86	4	54	2.00	5.2	1/2,6	B/W	1:52	vert.	analit.	"	N	excav.
3th	2/89	4	125	6.50	16.5	1/2.5	B/W	1:107	vert.	analit.	"	N	excav.
3th'	2/89	3+3	260	7.50	11.0	1/1.5	B/W	1:170	hor.	analit.	"	N	elevat.
4th	3/90	4	125	6.50	16.5	1/2.5	B/W color	1:107	vert.	analit.	"	Y(on-l.)	excav.
4th'	3/90	3+3	260	7.50	11.0	1/1.5	B/W color	1:170	-15	analit.	"	N	elevat.
5th	?	7	72	4.30	6.0	1/1.4	B/W	1:60	vert.	analit.	"	Y(on-l.)	mosaic

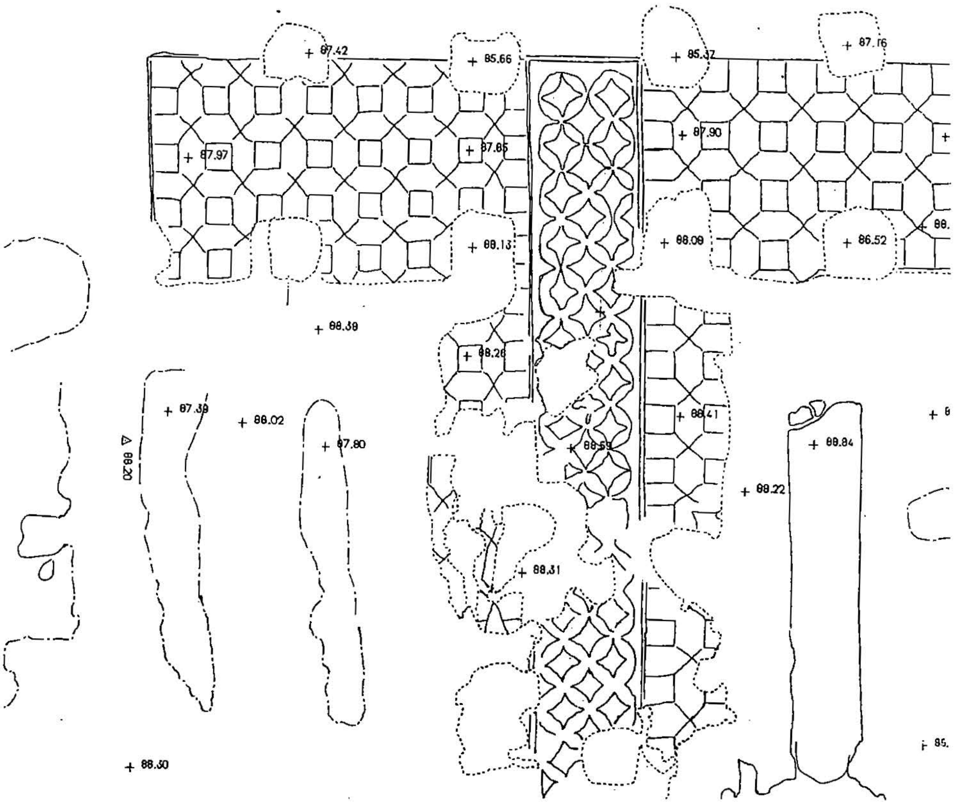


Fig.11 - Partial graphic restitution of the earlier mosaic.

TABLE OF INSTRUMENTS

PH. SURVEY						CONTROL			RESTITUTION
St.	Camera	Im.for. mm	F.L. mm	Focus m	Ang.field deg	Equipm.	Methods	Control pts.	Equipm.
1st	Wild C120	60x 80	65	fix	17+32x 64	Wild T2+ Distomat	distanc.+. trig.level.	glued targets	photo-rectif. + Wild A40
2nd	Jena UMK 10	120x166	100	6.0	62x 80	Nikon DTM-1	space resection	nails + "	Galileo Digicart
3rd	Galileo Veroplast	112x160	154	14.2	40x 55	"	"	targets	Galileo DS 302
3rd'	Jena UMK 6.5	120x166	65	fix	85x105	"	"	glued targets	"
4th	Galileo Veroplast	112x160	154	14.2	40x 55	"	"	targets	"
4th'	Jena UMK 6.5	120x166	65	fix	85x105	"	"	glued targets	"
5th	Jena UMK 10	120x166	100	6.0	62x 80	" DTM A5 Wild NA2	" sp.resec. dif.level.	" " " "	" Digicart 40

can be held true for aerial mapping but it is not completely right for architectural photogrammetry. I am sure that many research laboratories, and also private companies, today still operate with on-line drawing outputs particularly when highly detailed plans or elevations are required in architectural and archeological applications. This methodology comes from our habits when "reading" architecture and also from the difficulty in schematizing some decorative details. This way of planning and producing the final output of a survey will certainly be put aside when new faster and cheaper computers are able to compute models with a very high number of graphical entities much more quickly than today. So I think that in the near future we will not have to produce simplified drawings, as in aerial mapping, in order to save in managing internal and external computer memory. My last remark concerns current terrestrial metric camera performances. We see an increasing drop in the industrial production of these instruments; at the same time some companies are commercializing semi-metric small-format cameras at a very convenient prices offering good optic performances and light in weight. Is this a real improvement? In the last century Meydenbauer too designed and built "small" format cameras for use on his long travels in Europe and Asia, but only from his very-large format cameras could he obtain that wealth of detail that all of us know and appreciate (G.Weimann, 1988). Except for the industrial applications of photogrammetry, the best arrangement is probably a light weight 4" x 5" camera equipped with a lens wich having a high correction of optical aberrations, will inevitably have residual radial distortion.

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