COMPUTER GENERATED MOSAIC OF UNDERWATER PHOTOGRAPHS OF ANCIENT AMPHORAE, OFFSHORE THE SYRIA

Shunji Murai, Hiroaki Kakiuchi, Kenji Hano
Institute of Industrial Science, University of Tokyo
7-22, Roppongi, Minatoku, Tokyo, Japan

Kiyotari Tsuboi
Osaka Cultural Center
Osaka, Japan

Shozo Tanabe
Kyoto Cultural Property Research Center
Kyoto, Japan

Commission V/4

ABSTRACT

Ancient amphorae in a sinked ship were discovered 50 meters underwater, offshore the Syria, which were used as drinking water bases on ships in 12 and 13 centuries. Underwater photographs were taken to produce a computer generated mosaic, a planimetric map and color coded images.

Although the underwater survey was so hard to set up good control points and targets, an analytical phtogrammetry was applied to determine the orietation parameters. A computer controlled mosaic was generated from 14 digitized underwater photographs.

Local filter and special coloe enhancement were applied to produce a high quality mosaic image from the original photographs of low contrast. The computer generated mosaic in digital form was used for advanced archeorological studies.

INTRODUCTION

The depth of 50 meters is almost the limit where the divers can dive and work for surveying underwater objects. In order to map a number of amphorae

discovered in a sinked ship offshore the Syria, underwater photographs were taken with control targets. As the control survey was so hard to obtain the precise coordinates of the targets, it was rather difficult to get the good results by the conventional photogrammetric orientation. However because the distance survey between the targets was rather reliable, a bundle adjustment with use of constraints for distance was used to determine the exterior orientation parameters.

The image quality of underwater phtographs was poor because of ill illumination , low contrast, sedimented mud over the amphorae etc., the underwater photgraphs were digitized to improve the image quality by a computer. As an overall planimetric map is more important than a topographis map for archeorological study, a computer controlled orthophoto was generated in consideration of digital smoothing for discontinuous tones at boundaries between the neighbor photographs in a mosaic.

UNDERWATER PHOGRAPHY

Underwater photographs were taken two times by the Hsselbrad MK-70 with focal length of 60 mm, offshore the Syria.

1) October, 1985

Altitude from the bottom; 4 meters; 6 courses; 82 photographs

The image quality was not too bad but control grid of steel wire as shown in Fig.1 was not accurate for phtogammetric analysis. The total number of phtographs were also too many for mapping. The phtographs were used to survey the detail of individual amphora.

2) September, 1986

Altitude from the bottom; 6 meters; 2 courses; 14 photgraphs

The control targets were newly located as shown in Fig.2 but the image quality was not good. However the number of photographs is not too many for the phtogrammetric analysis. Therfore the phtographs were used for computer generated mosaic.

ORIENTATION

28 control points were located as shown in Fig.3. Distance measurement was done by using a tape with rather good acccuracy. Height measurement was done by

a hand level which will provide rather low accuracy, that is about 5cm error. Therefore the bundle adjustment with constraint for distance which has been developed by Murai Laboratory was applied. The standard deviation of residuals on the films was 270 micrometers, equivalent to 2.7 cmm error on the ground. Considering the 50 meters depth underwater and the difficulty of surveying, the result was not too bad for archeorological study.

COMPUTER GENERATED DIGITAL MOSAIC

The flow of producing a computer mosaic is as follows.

1) A/D convertion

Three time enlarged photographs were digitized by a drum scanner with a pixel size of 0.1mm, that is equivalent to 4mm at the bottom of the sea.

2) Exterior orientation

The exterior orientation parameters were determined with the bundle adjustment as mentioned above.

3) Digital orthophoto projection

The digital photographic data of 14 photographs were projected digitally onto an ortho-reference plane for the subsequent mosaic generation.

4) Digital mosaic generation

Deletion of discontinuous tones between the neighbor photographs and contrast enhancement were carried out. A mosaic was generated by computer at the scale of 1/20 on a film.

Fig. 4 shows the size of digital mosaic consisted of 3984 pixels and 2324 lines.

Because the sea bottom was very flat, each photograph was projected onto a datum under the assumption that a local area with respect to a photograph should be flat. The datum was taken constant except photo no. 109.

Fig. 5 shows a part of original image and digitally enhanced image after local filtering. Fig. 6 shows the computer generated mosaic from 14 underwater photographs and Fig. 7 shows a line draw plan of amphorae.

THREE DIMENSIONAL MEASUREMENT OF AMPHORAE

An overall distribution of amphorae can be studied with a computer generated mosaic, which was very useful for archeorological study. However, the exact size and three dimensional shape are also very important. Th larger scale of

underwater photographs taken in 1985 with altitude of 4 meters from the bottom were used for the detail measurement. A part of the sea bottom with several amphorae was measured its digital elevation using an analytical plotter.

Fig. 8 shows a bird eye view of amphorae.

CONCLUSION

Digital image processing in connection with phtogrammetry was very useful to generate a computer enhanced mosaic. The computer generated mosaic and the line draw plan could provide archeorologists with very useful information. Even though the control survey was not good, the method developed in this study could show practically available results.

ACKNOWLEDGEMENT

The authors express their heartful thanks to the cooperation given by the Executive Committee for Excavation of Syrian Antiquities off the Syrian Coast. The authors also thank NHK for her support to the study.

##########

Presented paper to the 16th International Congress of the International Society for Phtotgrammetry and Remote Sensing, July1-10, Kyto, Japan

Fig. 1 Underwater Photograph with Control Grid
(taken in October, 1985)

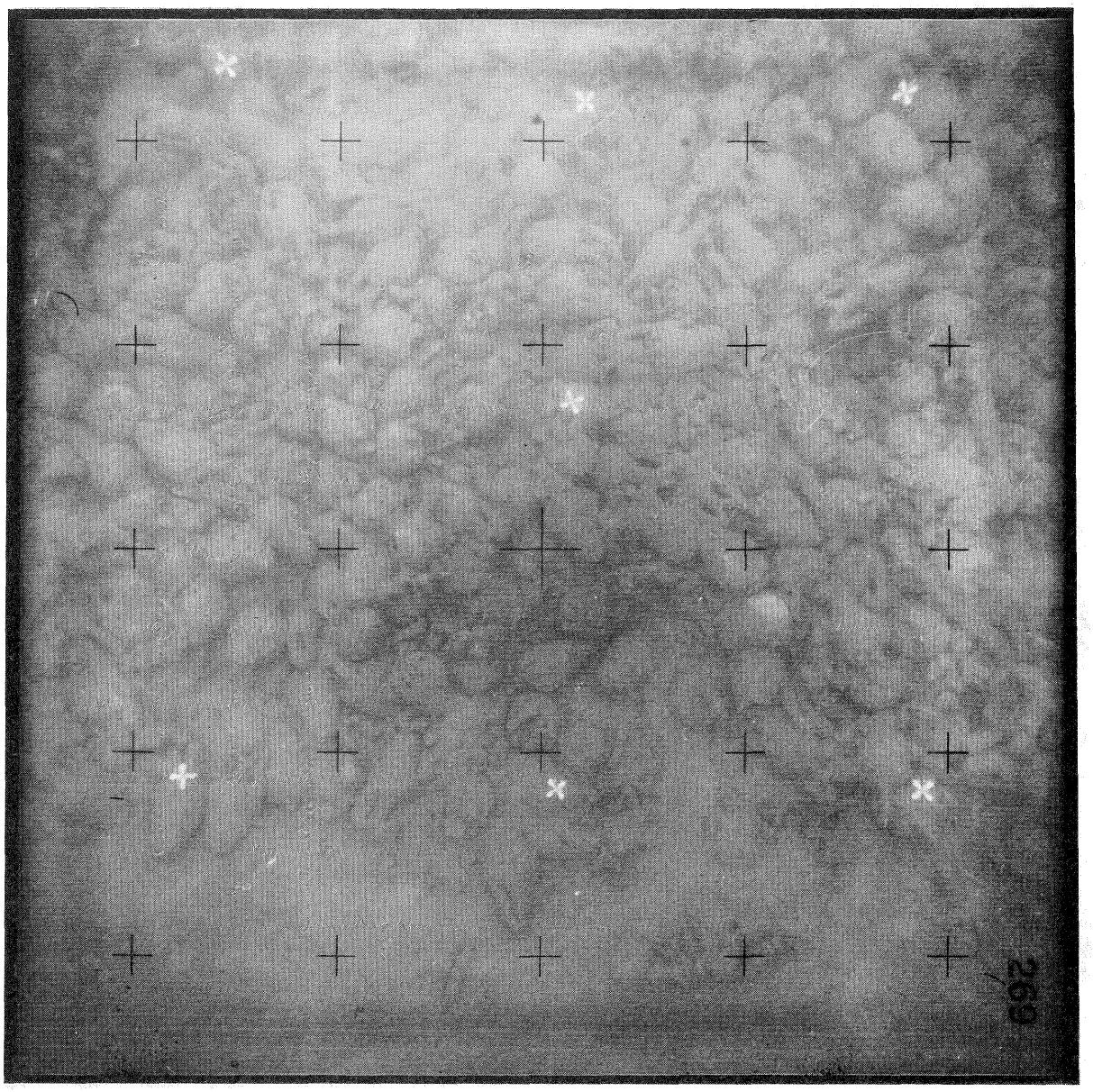


Fig. 2 Underwater Photograph with Control Targets
(taken in September, 1986)

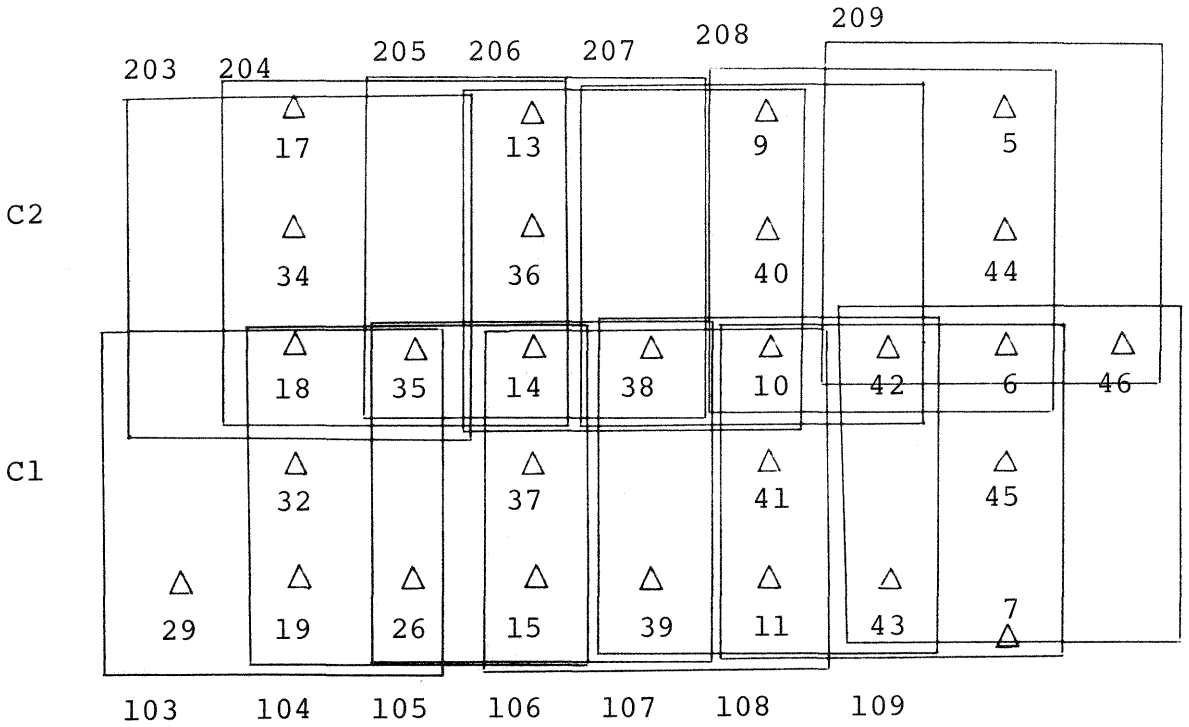


Fig. 3 Flight Course and Location of Control Points

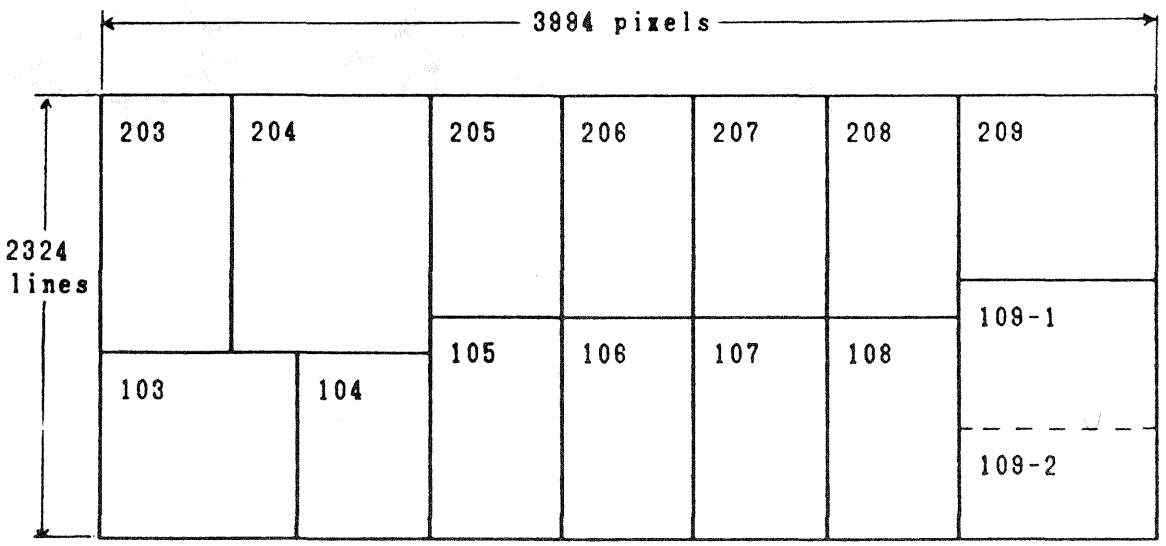


Fig. 4 Size of Digital Mosaic

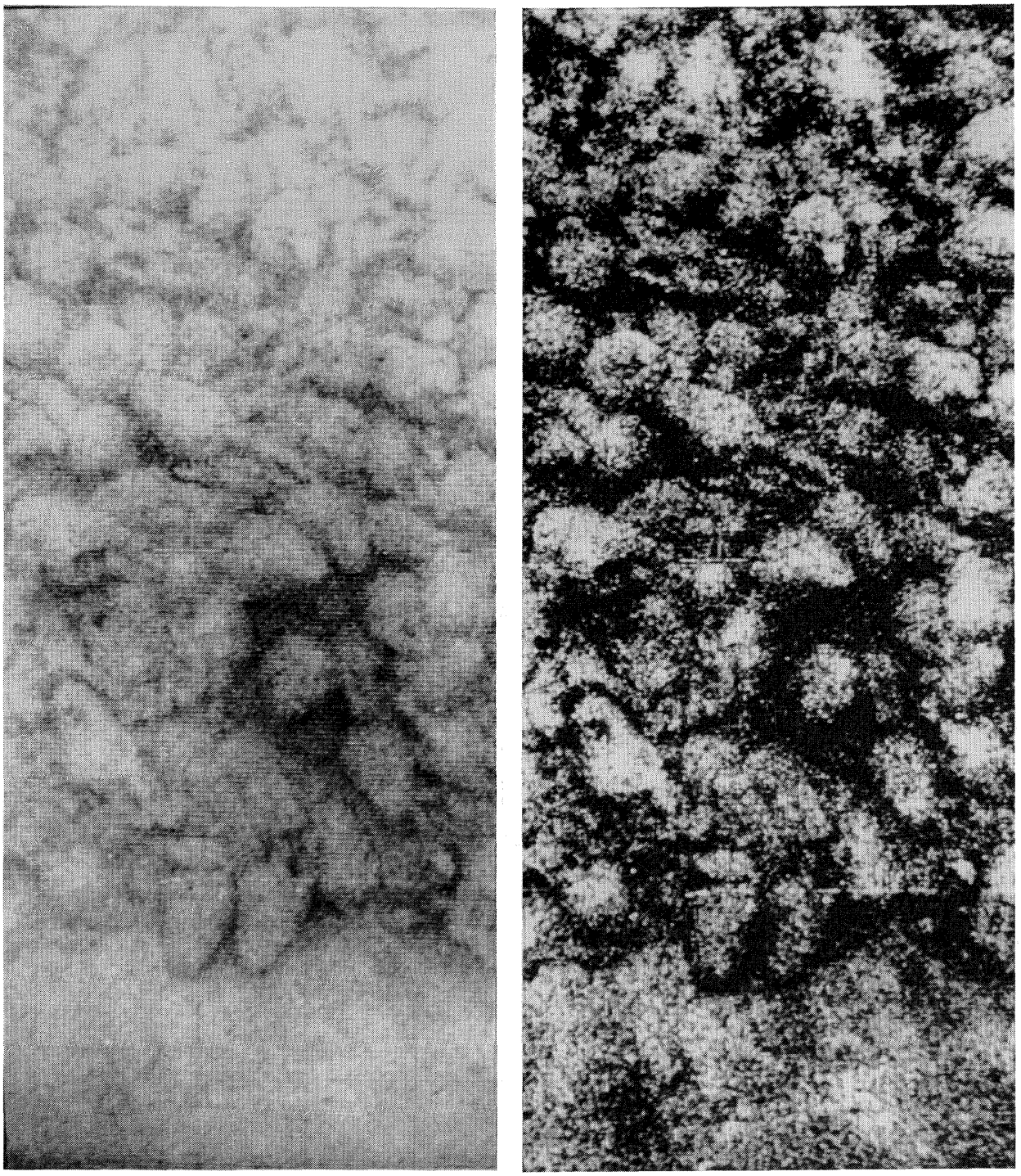


Fig. 5 Original Image and Digitally Enhanced Image

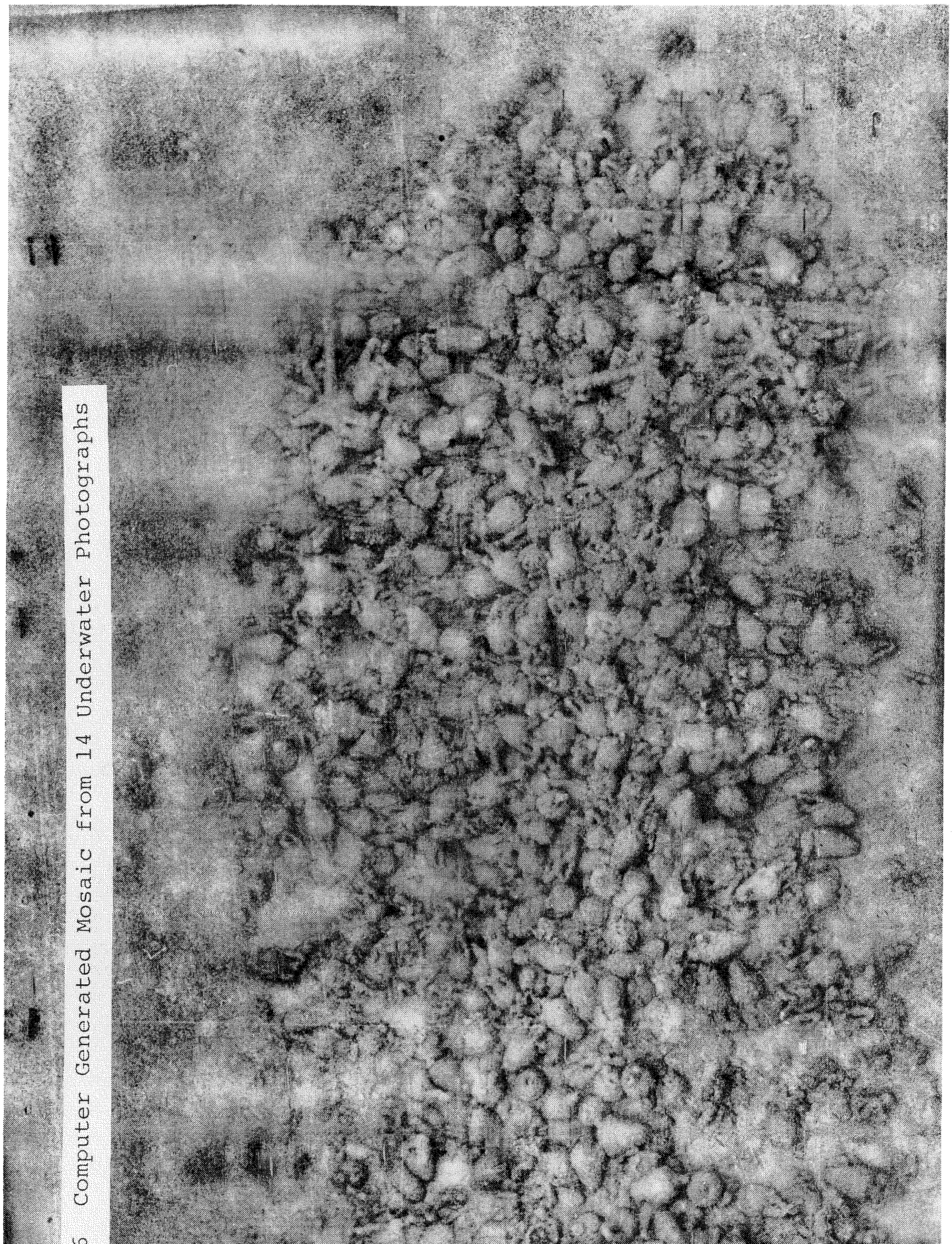
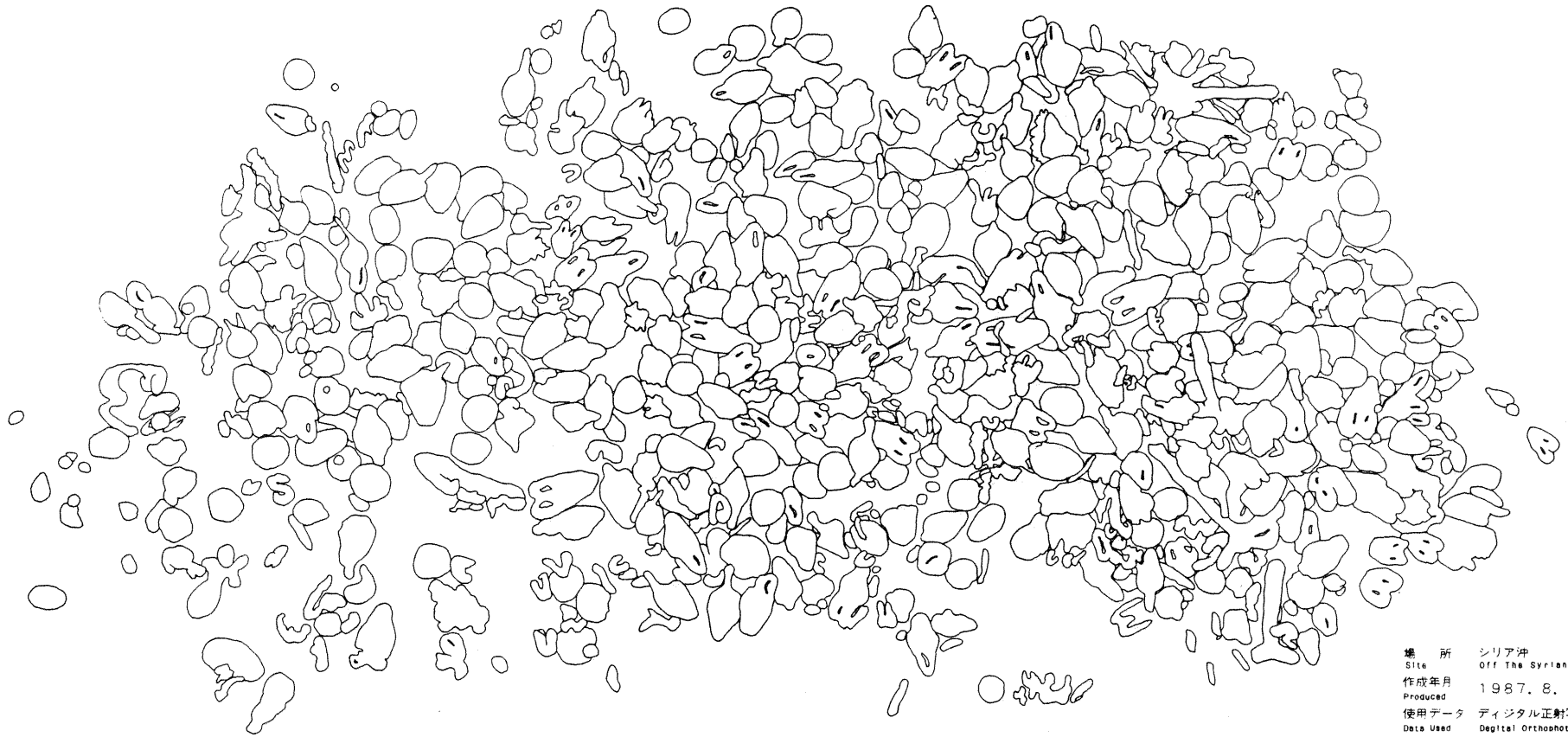


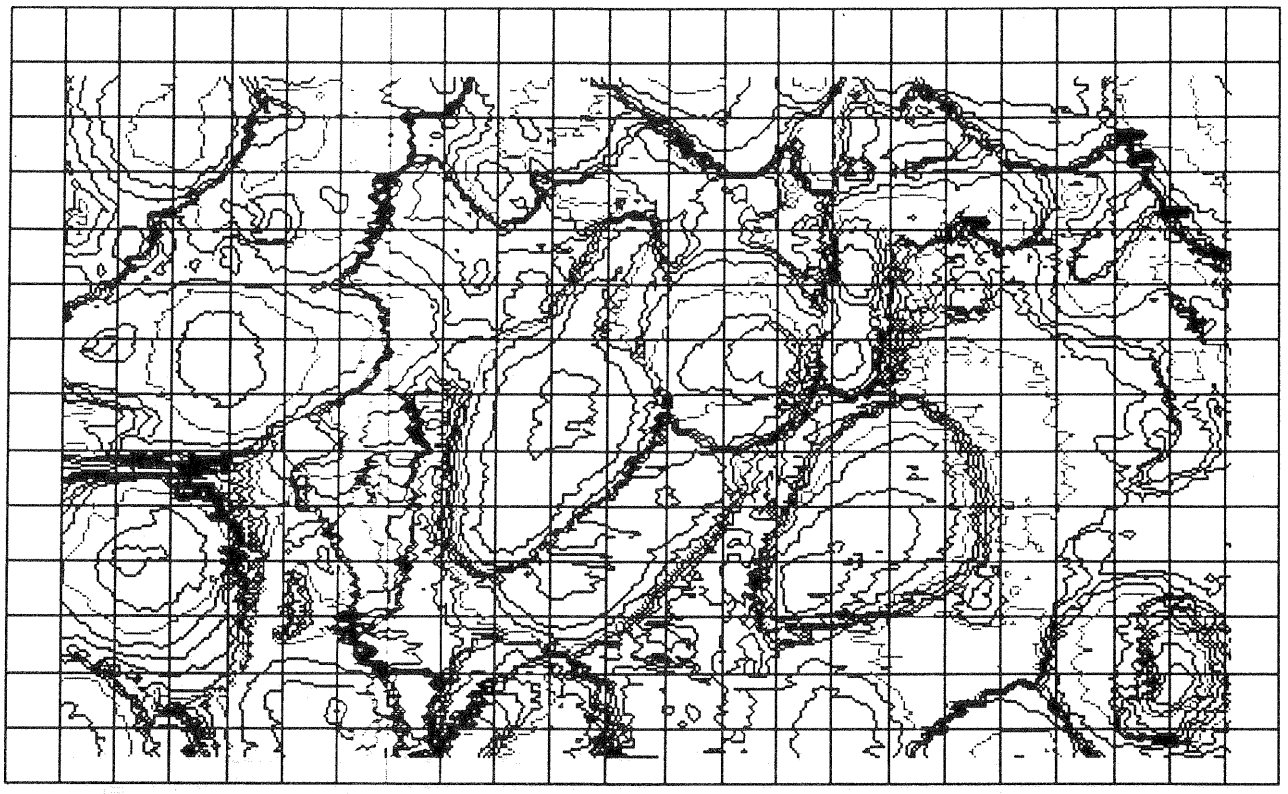
Fig. 6 Computer Generated Mosaic from 14 Underwater Photographs

シリア沖発掘調査平面図 Plan of Excavation of Syrian Antiquities Off The Syrian Coast



場所 Site	シリア沖 Off The Syrian Coast	
作成年月 Produced	1987. 8. 10	
使用データ Data Used	ディジタル正射写真 Degital Orthophotograph	1986. 9. 13 撮影 photographed
縮尺 Scale	1/20	
作業機関 Plotted by	東京大学生産技術研究所 村井研究室 Mural Lab. Inst. of Industrial Science Univ. of Tokyo	
製作機関 Sponsored by	シリア沖古代遺跡発掘調査実行委員会 Executive Committee for Excavation of Syrian Antiquities Off The Syrian Coast	

Fig. 7 Plan of Excavation of Syrian Antiquities



Contour Interval: 5 cm Grid Interval: 10 cm

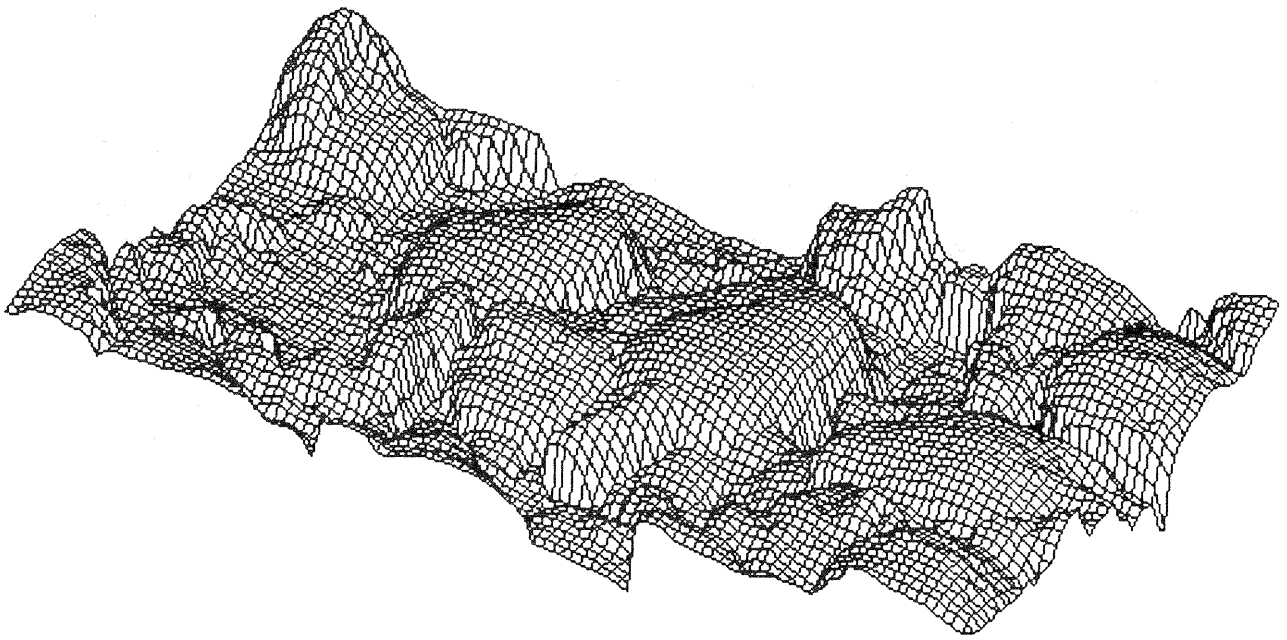


Fig. 8 Contour Lines at 5cm Interval and its Bird Eye View