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## ► To cite this version:

Pierre Grussenmeyer, J. Yasmine. Photogrammetry for the preparation of archaeological excavation. A 3D restitution according to modern and archive images of Beaufort Castle landscape (Lebanon). XXth Congress of the International Society for Photogrammetry and Remote Sensing (ISPRS), Jul 2004, Istanbul, Turkey. pp.809-814. halshs-00264014

**HAL Id: halshs-00264014**

**<https://shs.hal.science/halshs-00264014>**

Submitted on 20 May 2008

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# PHOTOGRAMMETRY FOR THE PREPARATION OF ARCHAEOLOGICAL EXCAVATION. A 3D RESTITUTION ACCORDING TO MODERN AND ARCHIVE IMAGES OF BEAUFORT CASTLE LANDSCAPE (LEBANON)

Pierre Grussenmeyer <sup>a</sup>, Jean Yasmine <sup>b</sup>

<sup>a</sup> MAP-PAGE UMR 694, National Institute of Applied Sciences, 24 Bd de la victoire, 67084 Strasbourg, France  
[pierre.grussenmeyer@insa-strasbourg.fr](mailto:pierre.grussenmeyer@insa-strasbourg.fr)

<sup>b</sup> Republic of Lebanon, Ministry of Culture, Directorate General of Antiquities  
Po. Box 1019 Jounieh, Lebanon - [jyasmine@beirut.com](mailto:jyasmine@beirut.com)

**CIPA Special Session**  
**Low Cost Systems in Recording and Managing the Cultural Heritage**

**KEY WORDS:** Photogrammetry, archaeology, comparison, restitution, orthorectification, decision support, landscape.

## ABSTRACT:

This paper presents the contribution of photogrammetry within the framework of the documentation of the Beaufort castle (South Lebanon), also called *Qalaat el-Chaqif* (12-17<sup>th</sup> century). After the withdrawal of the Israeli army of southern Lebanon, the Lebanese government asked for a consulting firm (J. Yasmine, DGA consultant) to establish general tender documents for the restoration of the Beaufort castle. Many parts of the site were destroyed or buried because of the war.

In 2002, the castle has been surveyed by geodetic methods (GPS and total station techniques) to establish reference points and a revised map of the area. In 2003, J. Yasmine has completed the survey by aerial oblique images taken by helicopter and terrestrial images, following the recommendations of CIPA 3x3 rules. After the calibration of the different cameras, the block of images has been computed within the PhotoModeler<sup>TM</sup> package, in order to document and draw the parts difficult to reach by traditional topographic techniques and to check the homogeneity of this important historic building (approx. surface of 150m x 75m, height of 30m).

Several archive images of the castle were taken by the French army between the years 1935 and 1937 (vertical and oblique overall views on glass plates). The aim of the project is to use this archive documentation in order to make a 3D restitution of the destroyed and buried historical structures of the castle within a photogrammetric project including both modern and archive images. A comparative restitution makes it possible to locate in a precise way the visible archaeological structures on the archive photographs. The contractor who will be in charge of the restoration will then have all information to release the great quantity of fill around the castle, in order to preserve intact the historical and archaeological structures which would be still *in-situ* below the embankment. The restitution will help the consultant to establish the framework of the excavation and restoration tasks, by showing the destroyed historical structures.



**1930-1936:** Archive images of the French Air Force of the Levant (aerial large format images)



**2003:** Modern digital images (aerial and terrestrial small format images)

## 1. INTRODUCTION

The Fort of Beaufort is a medieval castle constructed by the crusaders, the Ayyubids and the Mamluks. The castle is located in the southern part of Lebanon, a few kilometers far of the Israeli border. It is one of the emblematic monuments attesting the successive occupations of the site. After the Israeli

withdrawal of southern Lebanon, the Lebanese government commissions a multidisciplinary team to establish a preliminary study for the restoration of the castle. This team is composed of many specialists and is headed by Jean Yasmine, a consultant at the Directorate General of Antiquities (DGA). This team is responsible of the establishment of tender documents for contractors. There are many works on this important monument

(dimensions of the castle: 75m x 150m; height. 30m; dimensions of the surroundings: 200m x 500m). There is archaeological excavation. There is consolidation and restoration of structures and surfaces. There are also cultural and touristic equipment in the scope of works. The present paper deals with the preparation of archaeological excavation and restoration tasks, by showing the destroyed historical structures.



Figure 1. Recent aerial view of the Beaufort castle (Nikon F3, 2003)

## 2. HISTORIC OVERVIEW OF THE CASTLE

There is no text related to the castle before the arrival of the crusaders. This rock crest overlooks the passage towards the Syrian hinterland. It is difficult to imagine that there was not a fortified point controlling this passage before the arrival of the crusaders.

The texts say that Beaufort was deserted and taken by the crusaders in 1139. A few years later, Beaufort was ruled by the Lord of Saïda (Sagette). In the year 1179, a battle between Baudoin IV and Saladin took place while Renaud de Sagette was the master of the castle. Saladin took Beaufort in 1190, after a one year siege. A few years later, before the arrival of the Mamluks, *Al Salih Ismaïl* made a deal with the crusaders and gave them the castle back in 1240. In 1260, Julien de Sagette sold the castle of Beaufort to the Order of the Temple. This order kept the castle until 1268. On that date, the Mamluk Sultan *Baibars* besieged Beaufort and took it. Restoration works and new constructions are attested in Arab texts.

The 14<sup>th</sup>, 15<sup>th</sup> and 16<sup>th</sup> centuries were calm.

In the 17<sup>th</sup> century, during the reign of *Fakhreddine*, a prince of Lebanon, the castle became part of his fortified net. After the defeat of *Fakhreddine*, the ottomans destroyed the upper structures of the castle. Between 1616 and 1769, the area was ruled by feudal families. In 1782 *Al jazzar* governor of <sup>c</sup>Akka (Saint Jean d'Acre) besieged the castle, took it and destroyed its fortifications.

In 1837, an important earthquake destroyed many parts of the castle. After this date, it became a quarry for the neighborhood and a sheep-fold.

During the same period, in the late 19<sup>th</sup> century, the Orientalists came and described the castle (successively Rey, Guérin, Conder & Kitchener). The castle was quiet in that period.

After 1920, there was the French mandate on Syria and Lebanon. The French emphasized on the crusader period sites. The authorities began to consolidate and to restore these castles. A first survey and documentation of the site was done in 1936

by the architect Pierre Coupel showing the means of access to upper courtyard of the castle (figure 2). After the independence of Lebanon in 1943, extensive works began.

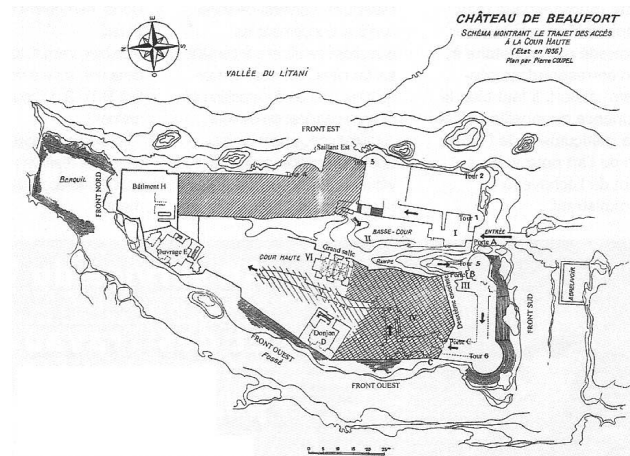


Figure 2. Map of Pierre Coupel (Architect) drawn up during the Deschamps survey (1936)

Lately, the castle became again a strategic stake in the war of Lebanon. Between 1976 and 1982 it was occupied by the Palestinians who attacked from this fortified point the North of Israel. Between 1976 and 1980, dozens of raids were made on the castle. On June 6<sup>th</sup>, 1982, it was heavily shelled before it fell in the hands of Israelis on June 8 of that year. The destructions we see nowadays date from that period. The Israeli army stayed there and fortified the surroundings with bunkers and reinforced concrete blocks.

Finally, in the year 2000, the Israeli army withdrew from the castle after the attacks of the Lebanese resistance.

## 3. THE THREE-DIMENSIONAL RESTITUTION AND THE AIM OF THE RESEARCH

The problem raised for the restitution of the historic surroundings is the preservation of the archaeological remains while excavating the spoil heap dating of the war. Many of these archaeological remains can be seen on historical documentation.

### 3.1 The historical documentation

Many series of historical photos of the castle exist.

**a- Serie 1:** These are the photos of the publication of Paul Deschamps (*Les châteaux croisés en terre sainte, t. II, La défense du royaume de Jérusalem*, Ed. Geutner, Paris, 1939). A little part of these photos were taken by the French air force of the *Levant* between the years 1930-36. These photos are only available in the publication. The original negatives were never found. The use of this documentation is difficult within the scope of this project; they can only be indicative photos.

**b- Serie 2:** These are photos still existing in the *Institut Français du Proche-Orient* (IFPO) archives (figure 3). All these photos were taken by the French air force of the *Levant* between the years 1930 and 1936. We were able to get duplicates (contact prints) of negatives at a size of 13cm x 18cm, scanned on a desktop scanner.





Figure 3. Example of archive photo of 1936 (IFPO), showing in the foreground the archeological hidden remains

**c- Serie 3:** These are photos existing in the archives of the DGA. All these photos were taken by the French air force of the *Levant* between the years 1931 and 1936. They are vertical views (figure 4). Only contact prints at a size of 13cm x 18cm are available; the original negatives were not found. Those contact prints were scanned.



Figure 4. Example of archive photo of 1935 (DGA, area of Beaufort's castle), showing the castle (in the middle) and the landscape (focal length 26cm, flying height 1300m above ground, 2000m above sea level)

### 3.2 The modern documentation

After the end of the war, access to the castle became secure. There was a need to manage to realize a complete documentation of the unreachable parts of the castle (basically the eastern elevation over the valley). That's why a helicopter flight was scheduled in 2003. Aerial oblique views were taken (figure 1) in that flight. They were composed of digital images (Nikon Coolpix 5000, 2560x1920 pixels) and film-based small format color slides (Nikon F3, Nikkor lenses, 55 mm, scanned at a resolution of 3000x2000 pixels). Last but not least, a complete documentation requested terrestrial views of the castle; digital images and again film-based small format color slides were taken (figure 5). Thanks to this exhaustive documentation, three-dimensional restitution was possible. All the modern documentation was produced in one day.



Figure 5. Recent terrestrial digital image (modern documentation, Nikon Coolpix 5000, 2003)

### 3.3 The topographic survey

On that same day, while photos were being taken, a team of geodetic surveyors installed reference points on the ground and elevations of the castle. These points (figure 6) were easy to identify on the photos. A total-station was used by the surveyors to measure the reference points. This generated three-dimensional coordinates for these points.



Figure 6. Examples of targets used for the control points

### 3.4 The AutoCAD documentation

The first topographic surveys conducted during the preliminary study were not very accurate due to the difficulties encountered in trying to access some of the areas of the castle. These first surveys were performed using GPS and tacheometric techniques. The AutoCAD maps (figures 7 and 8) used to establish the tender documents for the restoration of the castle were based on these surveys. The inaccuracies of these surveys did not represent a major problem for the restoration of the visible areas of the castle. However, these inaccuracies prevented us from computing the exact position of the archaeological hidden remains. We plan to generate a new AutoCAD documentation showing the surroundings of the castle and the archaeological hidden remains that should be dug out (§5).

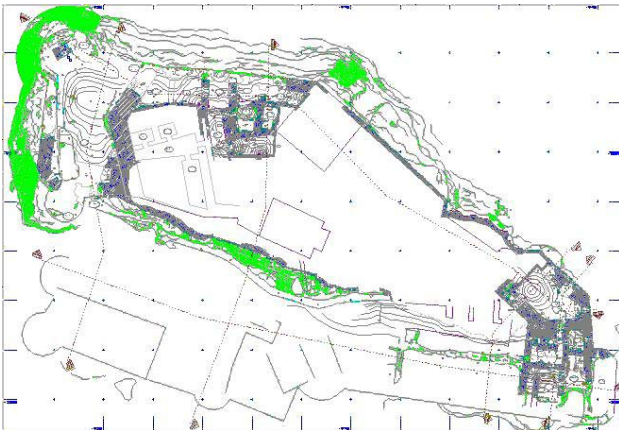


Figure 7. Example of 2D AutoCAD map from the tacheometric survey of 2002 (level 4 of the castle).

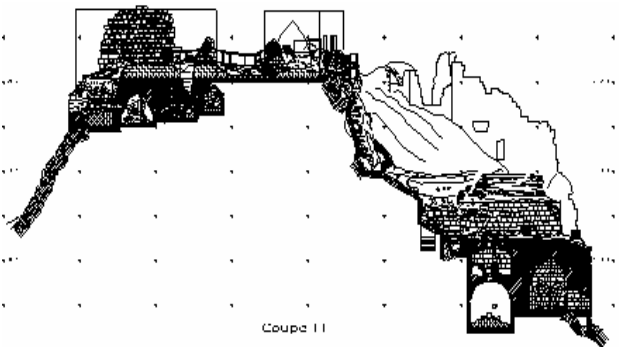


Figure 8. Example of 2D AutoCAD section.

#### 4. PHOTOGRAMMETRIC DATA PROCESSING

##### 4.1 Multi-image photogrammetry

Photogrammetric solutions (Grussenmeyer et al., 2002) are either based on the processing of single images (e.g. image rectification of plane objects), stereoplottings (for stereopairs of photos), or multi-image restitutions when a set of convergent photos of an object is available. The last solution has been chosen for our project in order to process in one block the sets of photos taken from the different types of cameras. We used the PhotoModeler software package from EOS System (Canada), well known for its applications in close range photogrammetry, architecture and archaeology.

The preparation steps in order to process the images were the following:

- definition of the "camera" file for each type of camera: the « camera calibrator » module of PhotoModeler has been used for the calibration of the digital cameras;
- for the archive images, an approximate camera file has been edited (camera with four fiducial marks) for further "on the job calibration";
- edition of the control point table (from the geodetic survey);
- scan of the film or paper-based images (for the set of archive images and the color slides from the Nikon F3 camera).

The basic steps in this type of project performed with PhotoModeler are :

- choice two or more overlapping photographs from different angles of the object ;

- use the point and line tools to mark on the photographs control and tie points;
- reference the points by indicating which points on different photographs represent the same location on the object (homologous points);
- process referenced data to produce 3D model;
- check the adjustment and view the resulting 3D model in the 3D viewer ;
- extract coordinates, distances, curves, surfaces, textures etc. within PhotoModeler ;
- export the 3D model to rendering, animation or CAD program.

##### 4.2 Calibration of the cameras

Four types of images are used for this project:

- images from a Nikon Coolpix 5000 camera used in the extreme positions of the zoom (7mm and 21mm). This camera was calibrated in the two positions using the calibration grid proposed in the PhotoModeler software (module "camera calibration");
- images taken with a traditional reflex camera Nikon F3, equipped with a Nikkor 55mm objective. The calibration was carried out like previously after scanning the slides of the calibration grid;
- images (prints or copies of film, see paragraph 3.1) of 1930-1936 scanned with a resolution of 900dpi: unfortunately no photogrammetric information on the characteristics of the cameras used has been found. Several types of glass-plates-based cameras with focal distances of 20 to 30cm were used at that time for the acquisition of aerial and terrestrial views (Roussilhe, 1936). The focal length of the camera used for this archive images is written on the border of the image (26 cm) and the original size of the images (glass plates in the 1930's) was supposed to be 24 cm x 18 cm.

##### 4.3 Adjustment of the block of the images of 2003

More than 130 images were realized in spring 2003 with the Nikon F3 and Nikon Coolpix cameras (a hundred images on the ground and about thirty in the helicopter). A first block of 18 oblique views of the castle was oriented in June 2003 using the control points materialized on the ground by targets (figure 6). Standard deviations of about 10 cm on the co-ordinates of the points measured on the images have been obtained. We then selected in this project a set of points simultaneously visible on the images of 1931-1936, in order to define approximations of the photogrammetric parameters, and to calculate a block based on a selection of these archive images.

##### 4.4 Adjustment of a block of archive images

Initially we selected 5 oblique photographs (approx. scales of 1/1000 to 1/2000) in order to document archaeological vestiges of the North and West parts (Grussenmeyer & Yasmine, 2003). The approximate values of the internal and external orientations of the archive images have been computed within the module "process & autocalibration" of PhotoModeler with the help of control points defined in §4.3.

##### 4.5 Merger of the two projects and preparation of the restitution

At this stage, the two separately calculated projects are referred to the same reference system. The process of merging (of several projects) proposed in the PhotoModeler software allows



the restitution of three-dimensional elements simultaneously on the photographs of 1936 and 2003, and to superimpose and display these results within a unique project.

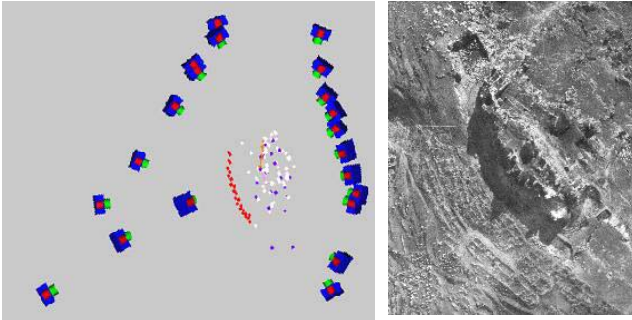


Figure 9. Overview of the camera stations and the block configuration after the exterior orientation. At the right: a vertical view of 1935 allowing the location of the camera stations.

#### 4.6 Addition of other images in the project

Depending on the parts of the castle to model, any other recent or archive image can be imported and oriented within the project by identification of homologous points.

### 5. PREPARATION OF ARCHAEOLOGICAL EXCAVATION

From the block of images previously oriented, the restitution initially carried out in 2D in Autocad (e.g. fig. 7 and 8) will be enriched by a 3D restitution corresponding to the objectives of the documentation. We are then able to calculate and draw the visible structures from the aerial and terrestrial photographs of 2003 by digitalizing on the images. One will proceed in an identical way on the archive photographs to measure the archaeological structures currently covered by the remains of the war currently embanked or destroyed (fig. 10), or to plot in 3D parts of the castle (see §6).

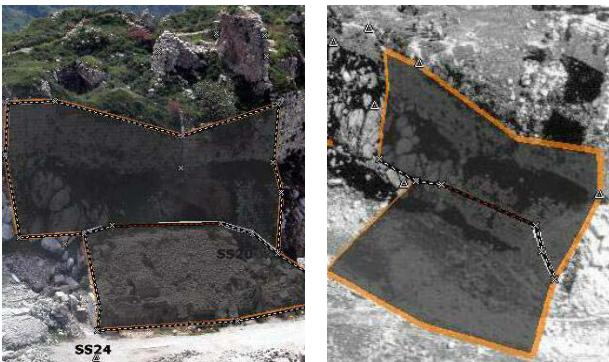


Figure 10. Restitution of the embankment areas: on the left, the boundary of the embankment is marked on a photo of 2003 and on the right, the corresponding surface is projected on an archive photo of 1936

The superposition of the two restitutions makes it possible to highlight the areas of interest (figures 10 and 11) for archaeological work and to estimate work of civil engineering (fill, cubature, rebuilding, etc).

Moreover, the restitution of the site in wire frame and surface model can be supplemented by the addition of textures coming

either from the images of 1936, or of those of 2003. From the resulting 3D photomodels, orthophotos can be calculated for the two periods, as e.g. for the frontages of the castle or the installations around the site covering the archaeological structures (fig. 11).

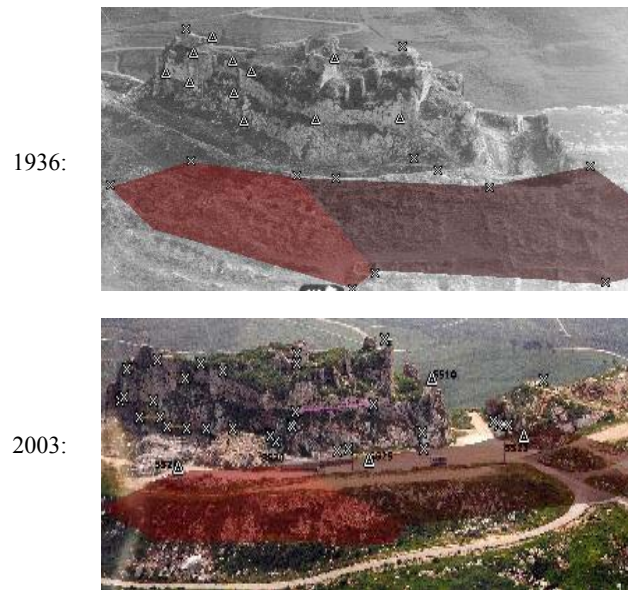


Figure 11. Archaeological structures are measured on the archive images of 1936 and the corresponding surface is shown on the photos of 2003



Figure 12. Example of orthophoto of the archaeological structure (computed from an archive image of 1936).

### 6. RESTITUTION OF THE HISTORICAL STRUCTURES NOWADAYS DISAPPEARED

The aim of the restitution is to help the consultant to establish the framework of the excavation and restoration tasks, by showing the destroyed historical structures.

The study is currently focused on different parts of the castle (figure 13). For some of them (as courses of bricks or stoneworks "label B"), a 3D restitution of both archive and recent images is possible.

Parts recovered by embankment are modelled from only archive images (watering place "label A", counterscarp "label C" and archaeological remains on the western part of the castle "label D").

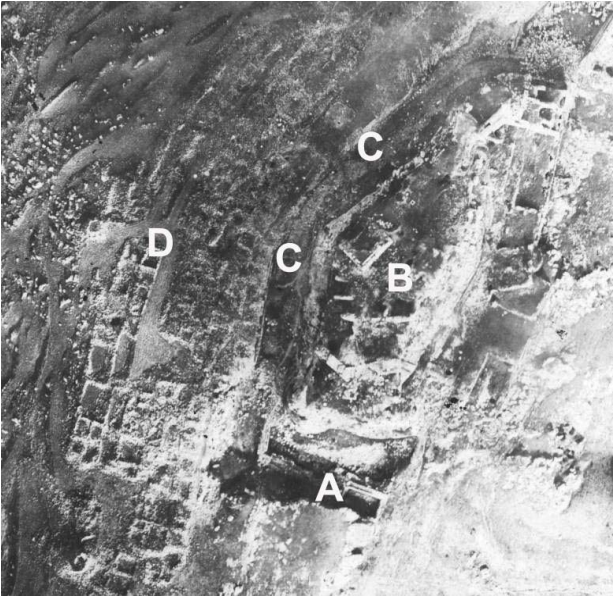


Figure 13. Vertical archive view showing some studied parts



Figure 14. Recent image showing the surroundings of the castle and the current constructions

## 7. CONCLUSION

This project shows the importance of photogrammetry within the framework of 3D documentation of the castle of Beaufort, for the development of the site and the landscape. By using the old aerial photographs taken by French air force of the *Levant* between 1931 and 1936, a comparative restitution makes it possible to locate in a precise way the visible archaeological structures on the archive photographs. This documentation helps the consultant to establish the framework of the excavation and restoration tasks by showing the destroyed historical structures. A photogrammetric restitution of the whole set of photographs carried out in April 2003 is planned in the future, as a preparation of the restoration of the castle and its surroundings. The contractor who will be in charge of this work will then have all information to release the great quantity of fill around the castle, in order to preserve intact the historical and archaeological structures which would be still *in-situ* below the embankment.

Such a project shows also the interest of a cooperation between the architect and the photogrammetry expert for both simple and complex tasks. On the one hand, the orientation process combining different kind of archive and digital images requires scientific tools and experience in the handling of images with different geometry. On the other hand, the photogrammetric

documentation (in this project one day only was enough for the aerial and terrestrial images) as well as the restitution work can easily be done by the architect.

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## 9. ACKNOWLEDGEMENTS

The authors would like to thank Ghassan Salame Minister of Culture of the Lebanese Republic and Frederic Husseini General Director of Antiquities for their help in organizing the helicopter flight in 2003.

The authors would like also to thank Jean-Louis Huot, Alma Kardous (IFPO) and Anne Marie Afeiche (DGA) for their help in providing the historical documentation.

The authors finally thank Mrs. Rawya Majzoub Barake, Director of the Center of restoration from the Lebanese University in Tripoli to have allowed and encouraged the organization of an introductory course in architectural photogrammetry in the diploma of specialized studies of restoration and conservation of monuments and historic sites in Tripoli, within the framework of the French-Lebanese cooperation. It was under these circumstances that the authors allowed to meet in 1998.