Considerations in the Interpretation of Aerial Views in Archaeology *

RALPH S. SOLECKI,
U. S. National Museum,
Smithsonian Institution, Washington, D. C.

THE interpretation of aerial views is playing an ever-increasing role in archaeological work. Under certain conditions, terrain study from aerial photographs will reveal to the archaeologist tell-tale evidences of sub-surface conditions. If correctly interpreted, these will enable him to direct his energies to best advantage.

The uses of aerial photography for purposes of archaeological work may be divided into four parts. These are (1) documentary, (2) location, (3) evaluatory and appraisal, and (4) progress report. A single aerial photograph may exemplify one of these categories, or several. The first, documentary value, pertains to a picture of a site for descriptive purposes, as part of a landscape. The second, the location of an archaeological site, is an obvious use for aerial views. The third, the photographs serve as aids in estimating the site's worth for investigation, and necessary planning attendant to making budgetary estimations, etc. In the fourth category, the aerial photograph is an excellent device to show how much of the site has been excavated. Included here are determinations of how the site is standing up under natural agencies, such as erosion, etc. Regrettably, unnatural agencies must be included here also, since aerial views may be used to detect unauthorized excavations.

The history of air photography in archaeology has been summarized well in Daniel (1950) and Crawford (1954). Stonehenge was fittingly the first archaeological subject to be photographed from the air, when in 1906 Lt. P. H. Sharpe, R.E., ascended over it in a balloon. However, the two photographs he took were exhibited primarily as curiosities, and not for their archaeological worth. The scene shifted next to the Anglo-Egyptian Sudan on the Upper Nile. There, Sir Henry Wellcome, just before the first World War, successfully used large box kites with automatically controlled cameras to take aerial photographs of his archaeological excavations.

The aerial photographs taken during World War I on the Western front were not of particular use to archaeological work. However, air operations during the conflict in the Near East yielded astounding results to archaeological knowledge. The Germans in Palestine, and the English in Mesopotamia produced views of important archaeological sites known heretofore only from ground plans and eye-level ground photographs.

Following the war, with the perfection of heavier-than-air machines and improved cameras, aerial photography had reached a point where its obvious potentialities had begun to outstrip the imagination of its supporters. Up to this time, the photography of archaeological works was only incidental to military operations. The study took on serious purpose and impetus with the interest of the British archaeologist, O. G. S. Crawford in 1922. As Archaeology Officer of the Ordnance Survey, Mr. Crawford became interested in some R.A.F. photographs showing prehistoric and Romano-British fields, and determined to investigate the possibilities of aerial photography and archaeology to its fullest. It was largely due to his efforts that the study was raised to its present plane. Mr. Crawford's founding and editorship of the English archaeological journal, *Antiquity*, his personal charge for 30 years, gave him much opportunity to include many items concerning his pet interest.

In the years between World War I and World War II, aerial photography in archaeology owed its development largely to the efforts of three people. These were

* Presented at the Society's 24th Annual Meeting, Hotel Shoreham, Washington, D. C., March 28, 1958. This paper is a part of the Photo Interpretation Panel. For other papers in the Panel see Sept. 1958 issue (Vol. XXIV, No. 4).—*Editor*

O. G. S. Crawford, mentioned above, Major G. Allen, and Father A. Poidebard. Stimulated by one of Crawford's publications (Crawford, O. G. S. and Alexander Keiller, *Wessex from the Air*, 1928) the late Major Allen flew many solo missions taking near-vertical photographs while holding the joy-stick of his airplane between his knees (Bradford, 1957, p. 54). Father Poidebard pioneered in Near Eastern aerial photography, obtaining excellent views of archaeological sites.

Before 1939, large-scale, low-flown single-verticals were the working photographs in archaeological photography. Following World War II, using stereoscopic examination, the smaller scale overlapping mosaics taken in high-flown photography were found to give good archaeological details. Today, three dimensional viewing has taken its place alongside single-vertical and oblique views. More recently, infra-red and color photography have proven their worth as another refinement in the interpretation of archaeological photographs (Ediene, 1956; Bradford, 1957, pp. 43, 55–56, 124).

The question of what can be seen from the air above archaeological sites which are not visible from eye-level on the ground is pertinent here. We are concerned exclusively with ancient man-made disturbances which show up in one way or another on the earth's surface. Some sites which are covered by heavy mantles of soil, such as Early Man sites, leave no surface traces for detection. The same principles of interpretation apply whether the problem is the identification of a Roman villa in England, a tell in Mesopotamia, or a Mandan Indian earth lodge on the bank of the Missouri.

In our discussion of photo interpretation in archaeology, we are not concerned with the technique of photography, the piloting of the aircraft, etc.; these problems are dealt with elsewhere (Miller, 1957; Solecki, 1957). The factors involved in the detection and interpretation of archaeological air views are perhaps more varied than any other kind of aerial detection. Particularly sensitive to the elements,—the wind, the sun, rain, snow; presence or absence of growth of verdure, differences in soil color and texture, shadows, time of day as well as season, all of these enter into the complex set of equations of taking the aerial photograph as well as its interpretation. And as one cannot believe everything one sees in print, for a true appraisal the site must be checked on the ground by the investigator. Indeed, the work should be a combination of air- and ground-survey. In short, the interpretation must be done by a flying archaeologist for optimum results.

The problem of obtaining photographs of archaeological sites during the most advantageous time is a real one, and upon it may hinge success or failure of the interpretations. D. N. Riley in his article, *The Technique of Air-Archaeology* (1946) happily combined his aerial investigations with ground observations, succinctly describing the particular circumstances and features governing the probability of the maximum amount of information yielded in aerial observation of archaeological sites. Manifestly the same subject photographed at different times of the year under different conditions, will vary somewhat in appearance.

Archaeological sites may be detected from the air by means of four distinguishing criteria either singly or in combination. These are "*crop marks*," "*soil marks*," "*shadow marks*," and more rarely what may be called "*climatological marks*." The latter phenomena include "damp marks," "frost marks," and "snow marks." Climatological marks is a category of relatively minor importance in comparison to the other three. These phenomena are dependent upon botany or agriculture, surface geology and meteorology.

Crop marks means the difference in plant growth and color-contrast of plants, whether agricultural or non-agricultural in origin. The presence of ancient remains such as ditches, pits or wall foundations and pavings buried beneath a relatively shallow soil cover may affect the growth of the plants above them. These differences may be marked by contrast in color and density with normal growing plants in the vicinity. Climate and rainfall, season, soil, the type of plants, the cultivation methods, etc., introduce variables, although the signs will as a rule reappear annually.

Crops marks are divided into two classes, negative and positive marks. *Negative marks* occur when there is an adverse effect on the plant growth. The plants look pale and stunted because of poor nutrition and/or hindrance to root growth. This may be due to some inhibitor in the soil chemistry, or to the presence of some physical obstacle such as buried wall foundations. *Positive crop marks* conversely are caused by plants whose growth is favored by the soil chemistry; e.g. such factors as the fertilizing ef-

RALPH S. SOLECKI

fect of certain buried features, or the presence of moisture retaining pits or ditches. This enhancement in growth causes the plants to grow taller and greener than the surrounding plants. The types of soils make a difference in the growth of crop marks. Compact gravels and chalk are best. Sand and loose gravels are generally not favorable. Clay soils are not good producers of vegetational differences. Soil conditions, such as soft alluviums, in which plant roots can reach deep in dry conditions, appear to limit the probability of crop marks (Bradford, 1957, p. 15).

Crop marks are important in country that has been intensively cultivated, where remains which once may have existed above ground have been leveled. The best season for photographing crop marks is during the hot summer months of the growing period, or during a drought. In fact, a prolonged drought is excellent for the flying archaeologist. Bradford (1957, p. 23) uses a very apt term, "parched marks," for crop marks produced by drought.

The cereal crops, such as wheat, barley and oats, are the best medium for yielding buried-remains to discovery. These plants grow relatively close together, and any enhancement or hindrance of growth is readily seen. Sugar beets, clover, and grass are also good indicators. Wider-spaced plants, such as maize, are exceedingly difficult to use as indicators. Wet weather generally causes the crop marks to disappear. Provided visibility is good, crop marks may be photographed at any time of the day. D. N. Riley (1946) has very carefully noted the best time for observing various crops in England.

Soil marks are indications on bare earth of the differences in coloration or texture of the soil, as between top soil and subsoil, or between ditch or pit filling and normal soil. In England, the sharpest distinctions are visible on chalk and limestone subsoils. Included in this category are stone clearings and heaps. In fact, any upturned soil may reveal a color contrast, the most common example being the freshly plowed row in the farmer's field. Archaeological remains show up especially well after a good rain and drying.

Certain types of agricultural work, such as deep plowing, tend to blur the outlines of soil marks. Although an archaeological earthwork or similar feature may have been reduced by plowing, its presence may be detected long after surface relief has been destroyed. A common example in the eastern United States is the Indian refuse midden, which will show as a great stain on the farmer's field. Familiar soil marks are the cuts made by the archaeologists themselves. Soil marks disappear eventually with continued turnover.

Shadow marks are of course useful only

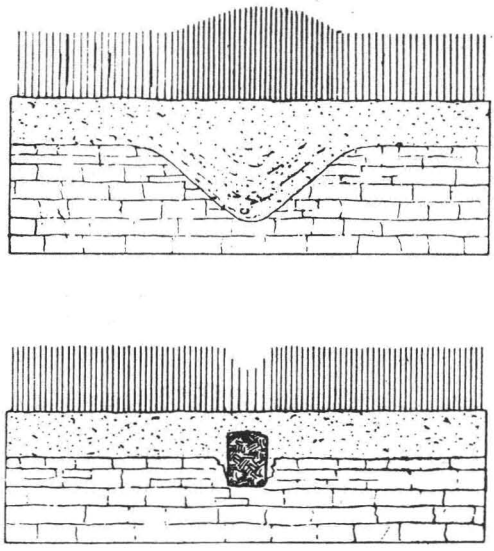

FIG. 1. Crop marks. Top—positive crop mark. Showing how subsurface depression, acting as a moisture reservoir, permits taller and denser growth of plants above it. Bottom—negative crop mark. Showing how subsurface obstruction, in this case a foundation wall, hinders the growth of plants above it. Illustration from D. N. Riley, 1946, *The Archaeological Journal.*

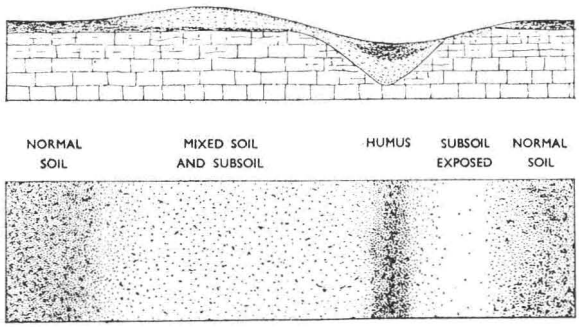

FIG. 2. Soil marks. Cross section and plan showing the formation of a soil mark in a field bare of vegetation. Illustration from D. N. Riley, 1946, *The Archaeological Journal.*

in archaeological sites which have features in some relief; these are thrown into prominence by light cutting across them. Actually we are dealing with a set of contrasts, including the normal lighting of the surroundings, the highlights which may be reflected back to the camera from the features, and the shadows themselves. The dark areas of the shadows are most important of the three.

Early morning or late afternoon lighting is better than noon lighting for bringing out contrasts. We are familiar with the way automobile headlights pick out stones in the road which in broad daylight are scarcely noticed. Light, as from a very low sun, thrown across at 90 degrees to the line of the relief is best. Air photographs taken during the middle of the day may reveal little to the investigator, since this is the poorest time for shadows. Winter lighting in the northern latitudes will help since the noon-sun will be lower in the sky than the noon summer sun. Grass grown earthworks give sharper shadows because they afford more relief than bare features.

Pairs of photographs for stereoscopic examination can make study of shadow marks an easy matter. In England, stereoscopic research has been carried to such popularity in locating ancient dead villages that a "Deserted Medieval Village Research Group" has been formed (Bradford, 1957, p. 36).

In the *climatological marks* category, damp marks occur as a phenomenon on buried features following winter and spring rains. These absorb and retain moisture, showing up the feature in outline against the normal soil after a period of dry weather. Damp marks tend to disappear as the season of drier weather wears on. A heavy soaking rain will wipe the marks out.

Frost and snow marks are more rare and evanescent. Light snow followed by wind on open fields tends to give the same impression as shadow marks, bringing out surfacial detail and depressions. Melting snow tends also to linger most in hollows and protected places, which may reveal archaeological features. Frost cracks of nat-

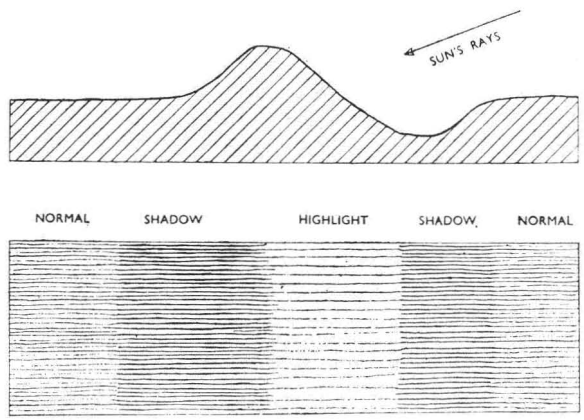

FIG. 3. Shadow marks. Cross section and plan showing formation of a shadow mark on an earthwork. For best effect, the sun should be low in the horizon and directed at right-angles to the line of the relief (earthwork). Illustration from D. N. Riley, 1946, *The Archaeological Journal.*

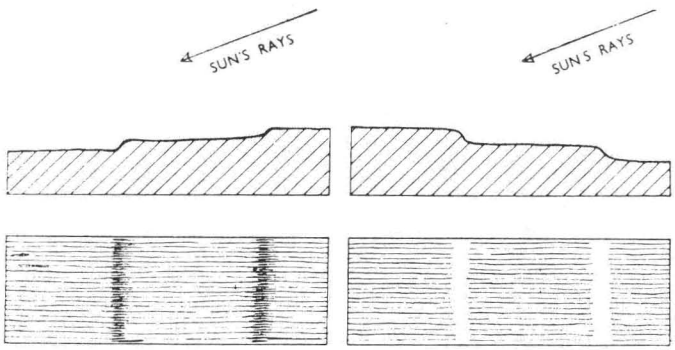

FIG. 4. Shadow marks. Left, cross section and plan showing effect of sun's rays on a series of shallow terraces oriented away from the sun. Right, cross section and plan showing effect of sun's rays on a series of shallow terraces oriented toward the sun. In the first, the terrace edges are thrown into shadow. In the second, the terrace edges are lit up by reflected light from the sun. Illustration from D. N. Riley, 1946, *The Archaeological Journal.*

ural origin and caused by the Ice Age may confuse the interpretation.

While archaeological details may be stereoscopically mapped from views taken with other reasons in mind, better results are achieved when flights are arranged specifically for archaeological purposes. Expense is one of the drawbacks in aerial photography for archaeology, but for large scale planning it is worth it. Stereoscopic viewing as a technique has been slowly building up since World War II, but full exploration of the possibilities has not been realized. Lamentably, archaeologists in the United States are far behind the British in all phases of air-photography and archaeology. However, the time will come when, "no archaeologist can consider himself completely trained who is not an expert in the interpretation and reading of air photographs as he is in map interpretation and reading" (Daniel, 1950, p. 301).

SELECTED BIBLIOGRAPHIC REFERENCES

Anonymous. 1940. *Manual on the Technique of Archaeological Excavations.* International Institute of Intellectual Co-operation [UNESCO], International Museums Office, Paris.

Bradford, John, 1957. *Ancient Landscapes, Studies in Field Archaeology.* G. Bell and Sons Ltd., London.

Crawford, O. G. S. 1928. "Air Survey and Archaeology." *Ordnance Survey Professional Papers,* n.s., No. 7. 2nd edition., London.

———. 1954. "A Century of Air Photography." *Antiquity,* Vol. 28, No. 112, pp. 206–210. Newbury.

Crawford, O. G. S. and Alexander Keiller. 1928. *Wessex from the Air.* Clarendon Press, Oxford.

Daniel, Glyn E. 1950. *A Hundred Years of Archaeology.* Duckworth and Co., London.

Ediene, Bernard. 1956. "Une méthode pratique pour la détection aérienne des sites archéologiques, en particulier par la photographie sur films en couleurs et sur films infra-rouges." *Bulletin de la Société Préhistorique Française,* Vol. 53, Part 9, pp. 540–546. Le Mans.

Kosok, Paul and Maria Reiche. 1947. "The Mysterious Markings of Nazca." *Natural History Magazine,* Vol. 56, No. 5, pp. 200–207, 237–238. New York.

Miller, William C. 1957. "Uses of Aerial Photographs in Archaeological Field Work." *American Antiquity,* Vol. 23, No. 1, pp. 46–62. Salt Lake City.

Poidebard, A. 1934. *La Trace de Rome dans le desert de Syrie, le limes de Trajan a la conquête arabe, recherches aeriennes (1925–1932).* 2 Vols. Libraire Orientaliste Paul Geuthner, Paris.

Reeves, D. M. 1936. "Aerial Photography and Archaeology." *American Antiquity,* Vol. 2, No. 2, pp. 102–107. Menasha.

Riley, D. N. 1946. "The Technique of Air-Archaeology." *Archaeological Journal,* Vol. 101 [1944], pp. 1–16. London.

St. Joseph, J. K. 1951. *A Survey of Pioneering in Air-Photography. In Aspects of Archaeology in Britain and Beyond,* Essays Presented to O. G. S. Crawford, edited by W. F. Grimes, pp. 303–315. H. W. Edwards, London.

Schmidt, E. F. 1940. *Flights over Ancient Cities of Iran.* University of Chicago Press.

Solecki, R. S. 1952a. "Photographing the Past. In Missouri River Basin Progress Report," September 1952. United States Department of the Interior, Interior Missouri Basin Field Committee, Billings.

———. 1957. "Practical Aerial Photography for Archaeologists." *American Antiquity,* Vol. 22, No. 4, pp. 337–351. Salt Lake City.

Wedel, W. R. 1953. "Prehistory and the Missouri Development Program. Summary Report on the Missouri River Basin Archaeological Survey in 1948." *River Basin Surveys Papers,* No. 1, Bureau of American Ethnology, Bulletin 154, pp. 1–59. Washington.