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Archaeological Sites—Soils and Climate

Vertical photos and low-level obliques should be coordinated with soil and moisture conditions in searching for new sites.

ABSTRACT: *The importance of soil types and climate in registering archaeological sites on aerial photographs is investigated in more than 400 instances in a portion of the Rhineland in Germany. These influences should be considered in scheduling aerial flights in search of new sites. A porous soil may show more sites in a wet year because these soils dry quickly. The evidence of many sites on loess may be attributed to a period of rain followed by sunshine and wind. Sites frequently do not show on conventional vertical mapping photographs but can be detected by sight from low-level flights and registered on oblique views.*

INTRODUCTION

IN AIR-ARCHAEOLOGY it has long been appreciated that the factors of soil and climate play a large role in the discovery of the remains of buried ancient monuments, which are visible as *crop-* and *soil-marks* on aerial photographs. In the course of time, certain conditions relating to the occurrence-pattern of crop- and soil-marks in temperate zones have been ascertained; and the consideration of these conditions has led to success in discovering archaeological sites by means of low-level aerial photography and/or photo-interpretation of existing vertical coverage[1,2]. One such condition is that *more sites will be found in a dry year*, another is that *soils such as chalk and gravel will produce crop- and soil-marks in almost any year*, and that such types as loess or loam are not particularly suitable for air-archaeological research[3]. These conditions have their converses which are also true. One outstanding example of converse conditions is the work carried out in the Somme Basin by Roger Agache who photographed the area during low-level flights over a period of some ten years. Agache discovered that many soil-sites may become visible only after rain-storms, and that heavier soils such as loess and loam will produce large numbers of markings when photographed at specific times[4,5].

SOIL TYPES

Work done by means of planned low-level flights in the Rhineland during 1963 and 1964, and succeeding photointerpretion of available vertical coverage for the researched area, indicates that the interplay of factors leading to the visibility of archaeological sites is more complex than presently appreciated. Although it is true that on the sand and gravel plains of the lower Rhine more positive crop-marks will appear in a dry year than a wet one, the visibility of many of these sites in a dry year is often marginal. It is often possible to register such sites photographically only during low-level flights, and a corresponding search of verticals will reveal very few of the same sites for the same area. A porous soil, such as schist or tuff, will show more sites in a wet year than a dry one because these soils dry out quickly during long periods of sunny, low-humidity weather and then do not show any sites at all. Markings on these lighter soils also tend to be in higher color contrast in wet years and to give marginal visibility in dry years, thus making it difficult to record sites on vertical photographs.

Table 1 shows the variation in frequency-occurrence of marks for various soil-types in the Rhineland; both for sites registered by low-level aerial photography and those determined by photointerpretation of verticals.

TABLE 1. FREQUENCY WITH SOIL TYPES OF DETECTING ARCHAEOLOGICAL SITES

Soil-types	*1963*			*1964*			*Photointerpretation*		
	Shadow-sites	*Soil-sites*	*Crop-sites*	*Shadow-sites*	*Soil-sites*	*Crop-sites*	*Shadow-sites*	*Soil - sites*	*Crop sites*
River loam	—	—	5	—	—	14	4	1	3
Loess	—	—	46	—	23	38	2	6	9
Sand	1	1	6	—	1	23	1	4	8
Macadam gravels	—	—	21	—	—	33	2	9	5
Schist	—	—	80	2	—	56	Not investigated		
Tuff	—	—	26	—	—	22	Not investigated		

The first two columns show the number of markings discovered during two years of low-level flying. 1963 was a very wet year and only one soil-site was registered. 1964 was a very dry year and the total number of sites discovered rose to 226 versus 171 in 1963. Twenty-four soil-sites were discovered during three flying days in the spring: the 9th, 10th and 14th of April 1964. The occurrence of so many soil-marks on loess was probably caused by a period of soaking rains followed by a few days of very warm sun and high winds. This rapid change in climatic conditions slowed the ordinarily excellent moisture-exchange in the soil-layers and within the space of only four days produced many clear dry-marks and moisture-traces.

It is also interesting to note that the number of crop-marks on loess actually diminished during the dry year of 1964 as against the rainy, changeable weather-periods of 1963. This was true even though the distribution of marks on loess was wider in 1964. This result would fit the observations made by Agache for the loess areas of the Somme Basin where changeable weather produces markings on loess, whereas during continuous periods of dry weather this soil shows no markings at all. The crop-marks on loess in 1964 were usually only visible for a week or ten days, and the color difference was not as distinct as for crop-marks on loess in 1963.

Attention should be called to the fact that a decrease in frequency of markings occurred in the dry year of 1964 for tuff and schist soils.

A later comparative examination of available vertical photographs for the same areas, dating from 1945 up to 1961, gives the frequency of occurrence by soil-types as shown in the last column. Photography scales ranged from 1:7,000 to 1:14,000[6]. Of the 54 sites registered on the vertical photographs, only *two* were known sites previously discovered in the course of low-level flying. Some of the sites visible on vertical photographs were single-mound graves, which could easily be discerned as positive crop-sites or dry-marks at scales up to 1:12,000.

The question is, is it possible to predict which soil-types will show crop- and soil-marks with predictable regularity? Taking into account that other factors (such as topography, exposition, and type of land-use) also play a role in the occurrence of crop- and soil-markings, the answer is a qualified "Yes" as shown in Figure 1. This map gives an overview of the area flown over in the Rhineland in the years 1963 and 1964. The area is bordered on the north by the Netherlands and comprises parts of the States of North-rhine-Wesphalia and the Rhine-Palatinate. Compilation and soil-types are based on the official geological maps, published at a scale of 1:500,000[7].

During April to August in each of the years 1963–1964 this area was flown over regularly, each section being examined approximately once every two weeks. The flight-pattern is due to the fact that landing-fields with a permit for controlllng photographic flights are available for the various sections. The sections were flown only because all of them were more or less interesting in terms of known archaeological finds. As can be seen, markings tend to cluster in certain areas and on particular soils, regardless of yearly variations in climatic conditions.

Site-distribution on the lower Rhine, where

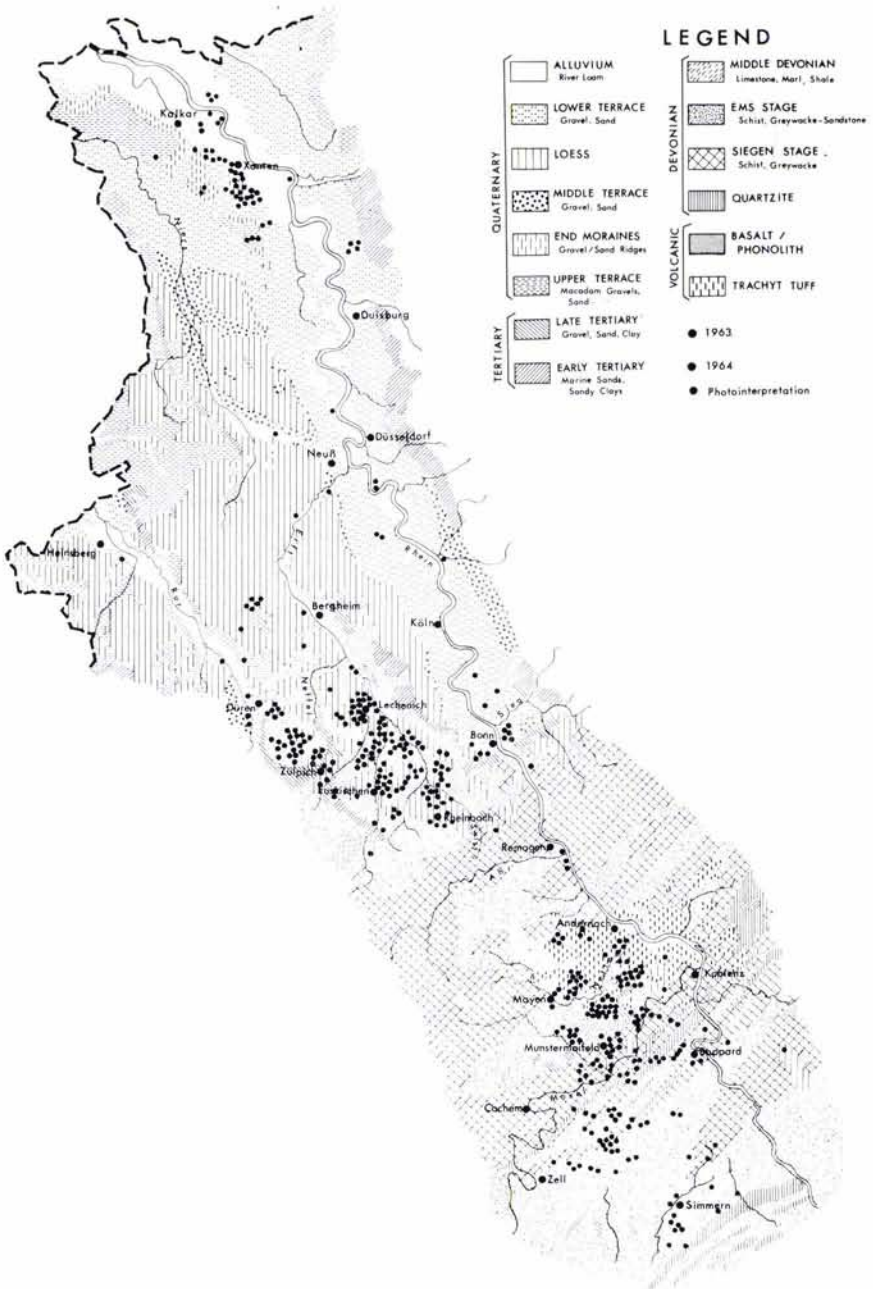

FIG. 1. Map of a portion of the Rhineland showing the archaeological sites studied.

sand and fine-gravel soils predominate, is concentrated around Xanten and Birten, which are Roman settlements. Sites on alluvial loam in this section, discovered by photo-interpretation, are mostly shadow-markings of existing monuments. In the middle Rhine area, one sees the spread of site-distribution onto the more deeply-layered loess soil in the dry year of 1964. In the lower Rhine valley and the heights above the Moselle, there is a heavy concentration of markings on tuff and schist in both wet and dry years although, as previously stated, the number of markings visible on these porous

soils will actually decrease in a very dry year. For this area only verticals at a scale of 1:24,000 were available so that no comparative photointerpretation was made.

A final explanation for the site distribution shown on the map is not possible at present, especially as other features not shown on the map for purposes of cartographic readability, such as topographical relief, forested areas, or types of land-use, are also important in the registration of crop- and soil-marks on aerial photographs. For example, a possible explanation for the heavy site concentration in the area Lechenich-Zülpich-Euskirchen-Rheinbach on macadam-gravels (partially decked with loess) must include such factors as topographic relief (the terrain slopes gently from higher ground in the South to lower in the North) and hydrology (the area is drained by several rivers, so that the ground-water level remains constantly low). These factors, together with soil-type and climate, could then build a favorable condition for the development of soil-and crop-marks in the area.

Climate

One important aspect of the influence of climate is not only the fact as to whether a soil will show more or fewer crop- or soil-marks according to the weather conditions prevailing in any year, but that the *times* when the soil- and crop-marks appear will show wide variations from year to year. This is important both for the aerial photographer and the photointerpreter. The work of Agache in France and of J. K. S. St Joseph in England illustrates how important climate can be in influencing the registration of archaeological sites on aerial photographs. Figure 2 shows the extreme range of times when sites may appear on various soils due to climatic factors.

Comparison is made between the wet year of 1963 when no sites were discovered in April despite intensive coverage, and the dry year of 1964 when soil-sites appeared at the beginning of April. On the curves showing the number of sites per flight, the peaks are almost a month apart for the highest number of sites discovered in each year. Crop-marks will occur for a longer period in a wet year because the grain ripens more slowly and is reaped later. The frequency-occurrence of markings may drop in July of a dry year, as the grain ripens earlier and is harvested earlier. Moreover porous soils dry out rapidly and produce no more markings at all.

Such variations often cause conflicting results if an archaeologically promising area is examined on vertical photographs and no sites are discovered although, according to rule, *the time is right*. The *right* time for showing soil- or crop-marks varies for the same soil as much as 1½ months from year to year, depending on the climate prevailing in the particular year. A very good example of the effect of climate on the occurrence of mark-

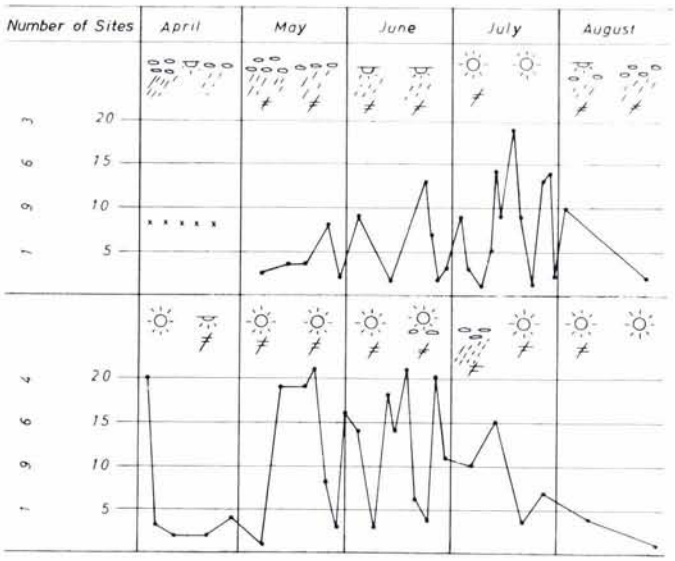

Fig. 2. Range of times when sites appeared on various soils due to climatic factors.

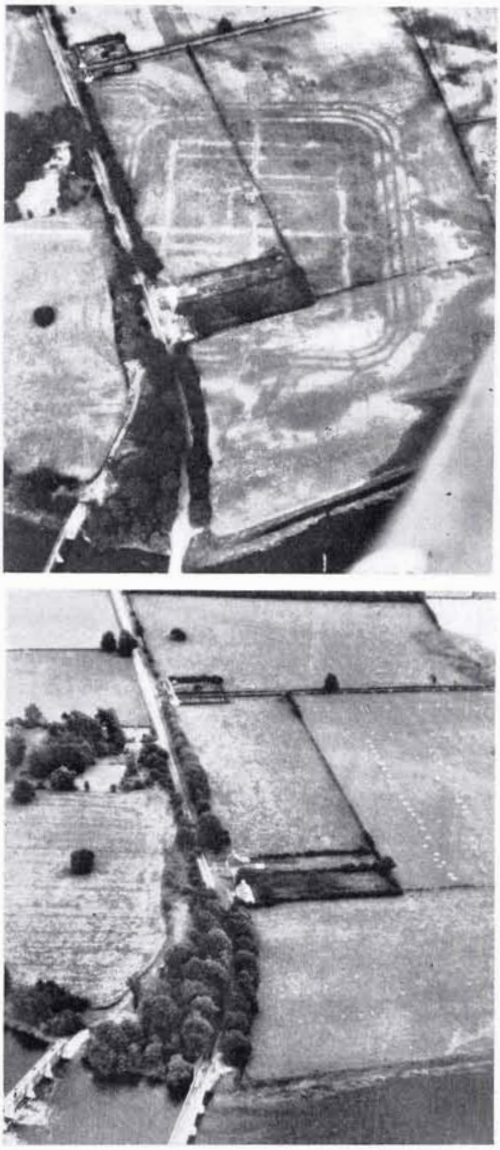

FIG. 3. Photographs of the site of the Roman fort Glenlochar Kirkcudbrightshire. The upper view was taken July 12, 1949, and the lower on July 25, 1953. (Taken by J. K. S. St Joseph. Copyright: Cambridge University Collection.)

ings on a particular soil-type is shown next. The upper view of Figure 3 shows the Roman fort of Glenlochar on the river gravel of the Dee, this photograph was taken by Dr. St Joseph on 12 July 1949, a year of exceptional drought. The lower view shows the same site, in a year with average precipitation, rephotographed by Dr. St Joseph on 25 July 1953[8]. There is no need to stress how the results of photointerpretation of verticals taken in the corresponding years would differ.

As far as the Rhinland is concerned it has been shown that the advantages of both low-level aerial photography[9,10] and the photointerpretation of verticals[11] should be utilized to ensure successful examination of an area. The influence of soil-types and climate must, however, be considered in conducting both types of research in order to avoid erroneous conclusions as to the efficiency of these methods.

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