MEMOIRS
1969

Waltham, A.C., 1969
"The Study of Underground Features from Aerial Photographs"
Memoirs, NCMRS, pp.93-98

Published by the

THE NORTHERN CAVERN & MINE RESEARCH SOCIETY
SKIPTON U.K.

NB
This publication was originally issued in the 10 by 8 inch format then used by the society. It has now been digitised and reformatted at A5. This has changed the original pagination of articles, which is given in square brackets.

THE STUDY OF UNDERGROUND FEATURES FROM AERIAL PHOTOGRAPHS

by

A.C. WALTHAM, Ph .D.

Paper read at N.C.M.R.S. Conference, Skipton, 4th Oct. 1969.

Aerial photographs may be taken either obliquely or vertically, but it is the vertical ones which are most useful and only these are considered in this paper. The original use of such photographs was for the compilation of a mosaic and then the rapid construction of topographical maps.

Air photographs have the advantage of giving a broad view of an area, and with the use of a stereoscopic viewer a greatly exaggerated relief can be studied. For stereoscopic viewing, which is always preferable, photographs are needed with at least a 50% overlap. However, for reconnaissance field work alternate cover is adequate and economically more satisfactory. Their principal use, other than cartography, is the correlation of topographical features, in particular the drainage patterns, and the interpretation of the significance of any features of these.

To maintain adequate detail on the photographs, and at the same time to cover an area large enough for useful correlation, is most important. Most available photographs have a scale close to 1:10,000, which is optimum for general geological work, but for detailed studies of karst features and smaller mining areas a scale of 1:5,000 is probably more useful.

Monochrome prints are most commonly available and are adequate for most fields of study (further details in Norman, 1968a). Colour photography has been experimented with, but is excessively expensive, and inferior to monochrome as superficial colour effects may often mask subtle tonal changes which are of greater significance to the geologist. Infra-red photography is being increasingly used and has the advantage of very clearly showing water or wet ground (further details in Marshall, 1968). This my be extremely valuable to the karst hydrologist or geomorphologist, but at present infra-red air photographs are not freely and cheaply available. Recent developments, mainly in connection with photographs taken from satellites, include the use of extreme infra-red wavelengths and radar (Pardoe, 1969).

Finally it should be noted that there are a number of other factors which may influence the value of a set of air photographs. The time of year

year, and consequently the state of the vegetation, is a most important factor, and, in karst studies in particular, the state of the weather just previous to the taking of the photographs may greatly vary the amount of detail which can be observed. It is therefore best, in the study of such an area, to obtain as many sets of photographs as possible, as each new set will very likely reveal some added information.

Interpretation criteria of photogeology.

Photo geological interpretation requires from the observer a broad geological knowledge, preferably including some knowledge of the local conditions, together with the ability to carefully examine all elements of the air photograph pattern, and a deductive evaluation of these elements.

Aspects of structural geology are most easily studied on the photographs, and of prime significance is the recognition, correlation and interpretation of linear features. These are visible on the photograph as a sharp or gentle break in the relief, a tonal change or change of vegetation type, or a break in the drainage pattern. The feature may then be interpreted as a lithological boundary or a fault line, and its relationship to other features should determine which is the case. Such linear features my commonly be visible through a layer of drift or soil, using the same criteria but present in a subdued form; however, some transported soils can completely obscure even a major fault below a very thin cover.

The lithology of the solid rocks may also be determined from the photographs, the principal criteria being topography, texture, vegetation, angularity of outcrops, and drainage and joint patterns. Further details of this complex subject may be found in standard texts such as Allum (1966), Lueder (195Y) and Miller (1961). Soil types may also be indicative of the geology, and photographs may show, by means of weak tonal changes, details of the soil drainage; limestone or some highly porous drifts, with their non-integrated drainage patterns, are therefore very distinctive.

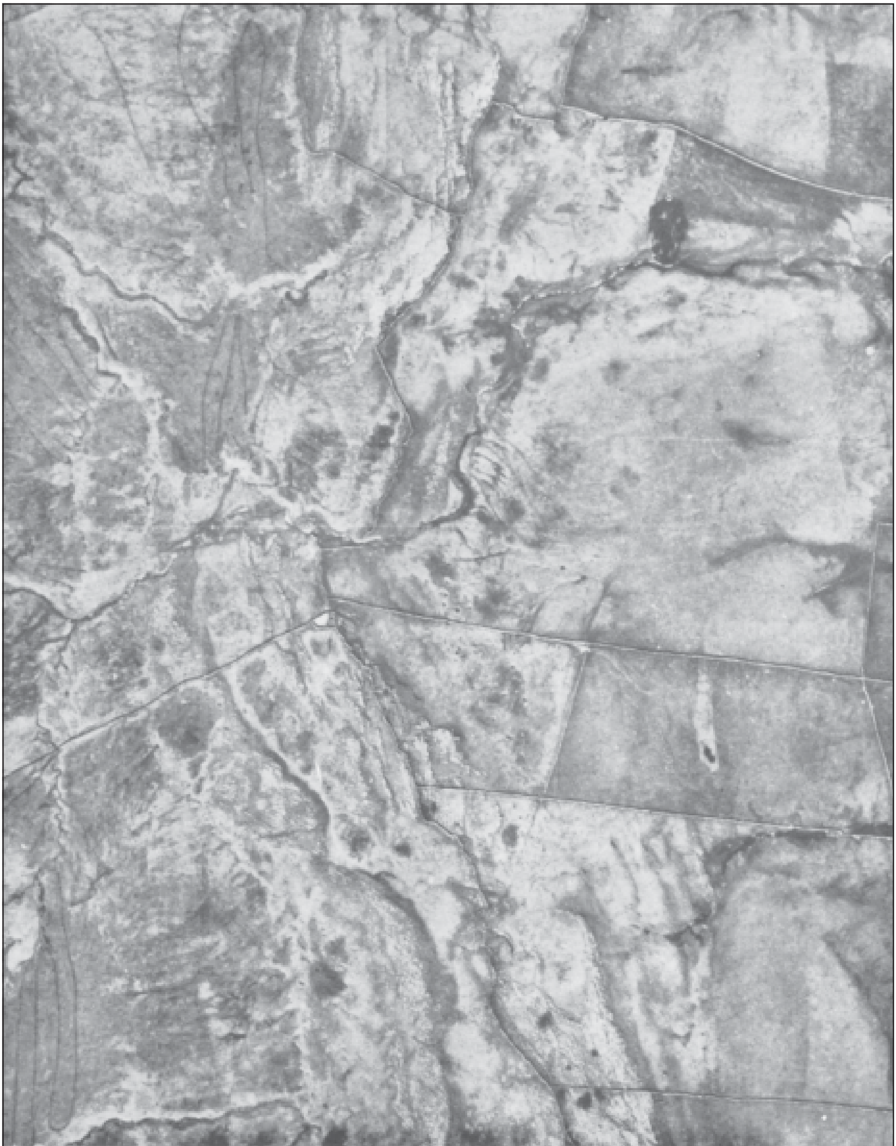
Limestone is very easily recognised by its light colour, lack of surface drainage, areas of clearly jointed limestone pavement and numerous closed surface depressions. (For further details of the appearance of these features on air photographs, see Norman and Waltham, 1969). Tropical karst areas with their cockpit or tower topography are also highly distinctive.

Limestone caves on aerial photographs.

The most prominent evidence of caves in a karst region are the

PLATE 18
AERIAL PHOTOGRAPH OF ALUM POT AREA, INGLEBOROUGH
SCALE APPROX. 1:5000

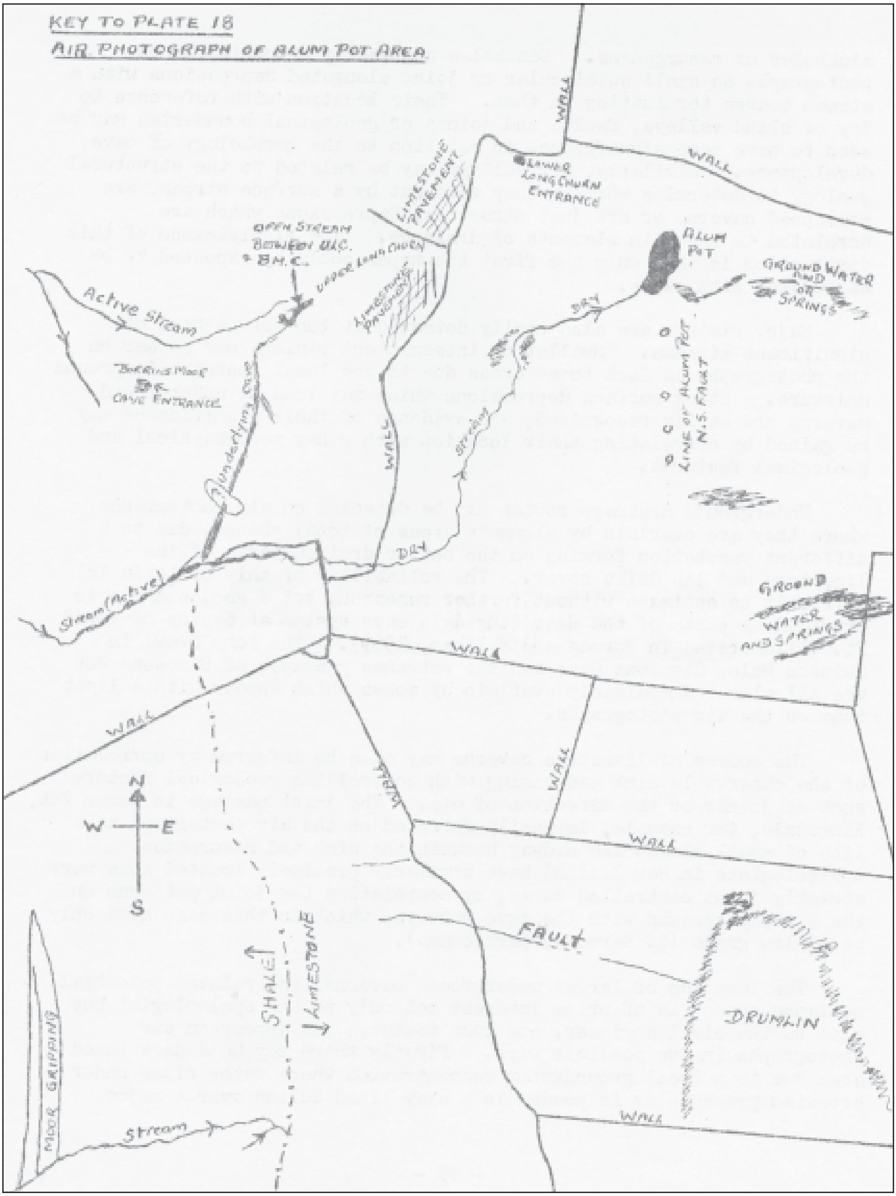
Alum Pot itself is conspicuous in the northeast quarter of the photograph, as is the short streamway, between Borrins Moor Cave and Upper Long Churn Cave, to the west of it. The almost straight lines on the photograph are dry stone walls and moor gripping, while the meandering lines are stream courses, dark when active, or light when dry and rocky (as just above Alum Pot). In the southwest corner a stream flows eastwards over the shale and sinks on reaching the limestone. The shale-limestone boundary can clearly be traced northwards from the sink by the line of small shakeholes, delimiting the darker toned shale to the east from the lighter, better drained, limestone topography to the east. Patches of very light toned limestone pavements are also prominent and show at least two principle joint directions. In the southeast part of the photograph a drumlin is easily recognisable by its elliptical plan. It effectively masks a fault which can clearly be traced across the limestone, westwards from the drumlin, until its course is lost in the shale outcrop. In contrast, the north-south fault through Alum Pot is barely discernable, being only marked by a few small shakeholes. South of Alum Pot, a number of dark toned areas indicate seepages of groundwater and intermittent springs. Also, a weak lineation of tonal variety, between Upper and Lower Long Churn Cave entrances (west of Alum Pot) may represent the surface expression of the underlying cave.



AERIAL PHOTOGRAPH OF ALUM POT AREA, INGLEBOROUGH, YORKSHIRE

0177. F21: 82/RAF/1153: 18 APR 55. Scale 1:5000 approx.

PLATE 18


KEY TO PLATE 18
AIR PHOTOGRAPH OF ALUM POT AREA
WALL
LIMESTONE PAVEMENT
LOWER LONG CHURN ENTRANCE
ALUM POT
GROUND WATER AND OR SPRINGS
OPEN STREAM
UPPER LONG CHURN
LIMESTONE PAVEMENT
Active Stream
DRY
CAVE ENTRANCE
Underlying Cave
LINE OF ALUM POT N.S. FAULT
WALL
DRY
Stream (Active)
GROUND WATER AND SPRINGS
WALL
WALL
WALL
WALL
N
W
E
S
SHALE
LIMESTONE
FAULT
DRUMLIN
MOOR GRIPPING
Stream
WALL

sinkholes or resurgence. Sinkholes are easily recognisable on photographs as small sub circular or joint elongated depressions with a stream course terminating in them. Their location with reference to dry or blind valleys, faults and joints or geological boundaries may be seen to have some significance in relation to the morphology of cave development. Similarly, dry valleys may be related to the structural geology to determine whether they were cut by a surface stream, are collapsed caverns or are just structural depressions which are unrelated to the main elements of drainage. The significance of this distinction is that only the first two types could be expected to be associated with caves.

Major risings are also easily detected at the abrupt head of significant streams. Smaller or intermittent risings may appear on the photographs as dark toned areas due to the local increase in ground moisture. Other surface depressions which may lead to underground caverns are easily recognised, and evidence of their significance may be gained by correlating their location with other topographical and geological features.

Underground drainage routes may be detected on air photographs, where they are overlain by elongate areas of tonal change, due to a different vegetation forming on the better drained parts of the limestone and its drift cover. The reliability of this criteria is difficult to estimate without further research, but a good example is provided by parts of the West Kingsdale cave system at depths of 10-40 ft. (illustrated in Norman and Waltham, 1969). The Long Crawl in Swinsto Hole, Simpsons Cave and the entrance passages of Simpsons Pot are all almost immediately overlain by zones which appear with a light tone on the air photographs.

The course of limestone caverns may also be inferred by correlation of the observable sink and rising with controlling geological factors such as joints or the direction of dip. The joint passage in Heron Pot, Kingsdale, for example, is easily detected on the air photograph as a line of small shakeholes midway between the sink and resurgence. Speleologists in New Zealand have similarly precisely located some very strictly joint controlled caves, by correlating the joint patterns on the air photographs with the cave surveys, which in this case need only be of low grade (L. Kermode, pers .comm.).

The location of larger underground caverns, and related potential collapse zones, is of prime interest not only to the spe1eologist but also to the civil engineer, and such features my appear on air photographs in two possible ways. Firstly there may be a dark toned area due to a local groundwater concentration where water rises under artesian pressure or is ponded in a clay lined doline over a major cavern. Alternatively a major cavern may appear as a light toned, well drained area due to locally more efficient drainage of the overlying limestone and soil cover. Further research is needed in this field, preferably in South Wales or somewhere such as Jugoslavia, as the only major cavern in Yorkshire at a shallow depth below an undisturbed soil cover is Mud Hall in Gaping Gill, which is, however, directly overlain by a light toned area.

Mine workings on aerial photographs.

Surface features of active mine workings are only too prominent on aerial photographs. Unfortunately little geological information is usually available from such photographs as the activities of man, and particularly his transport routes, will effectively mask the great majority of geological features in the immediate vicinity of the mine. In contrast, however, air photographs can be most useful in the search for geological data, and location of underground workings, in and around abandoned mining areas.

Old opencast workings, which have been partly filled in, landscaped or revegetated, show clearly due to tonal changes, and the pattern of mining progress and successive waste dumping may also express itself on the photographs. Such information will commonly be obtainable even though the land has been extensively farmed and ploughed since the mining era.

Air photography may assist in the study of old underground workings in a number of ways. Firstly, rapid mapping and correlation of scattered old mine workings is made very much easier, and the relationship of the features on the photographs may help determine the geography of the past mining activities. A correlation study of this nature should reveal prominent lineations, either along old transport routes, or along the outcrops of the orebodies; in relation to the latter, the distribution and extent of spoil heaps could be easily determined from the photographs. In some of the Pennine mining fields, ore bearing veins are now marked by long lines of old workings, many difficult to recognise on the ground but quite clear from the air. (An excellent example of this in Derbyshire is figured in the paper by Norman, 1969).

The structural geology of a mined area is invariably closely related to the distribution of economic orebodies, and particularly in the case of hydrothermal vein deposits. Faults, major joints and veins will all appear on photographs as strong linear features, and these will usually be visible through any superficial deposits (Norman, 1968b). This is not always the case, however, and in parts of West Yorkshire the drumlins very effectively mask the faults for short distances, and on Leck Fell only 20-feet of boulder clay completely obscures some quite important fault zones. Whether a fault is a single clean fracture, or a wide breccia zone, can also be estimated from the width of the feature on the air photographs. Stratigraphical and lithological boundaries, which may control bedded ore deposits, may be recognised by the classical criteria of photogeology. Also apparent on the photography may be variations in vegetation which bear a relationship to orebodies or old tip heaps. This is due to the fact that very strict control over the prominent species of flora may be exercised by soil concentrations or certain elements, for example copper. Such biogeological studies have already proved successful in ground programmes of mineral exploration, and their application to photogeology could prove useful.

Evidence of collapse over abandoned mine workings may also be obtained from air photographs, and may yield information unavailable by other methods where collapse has been adequately extensive to prohibit entry to the workings. Linear collapse features over disused near vertical stopes are easily detectable, particularly with the aid of stereoscope. Furthermore nearly horizontal workings subject to collapse into a network of passages may express themselves on the photograph as a regular pattern of tonal changes. This is provided, of course, that the depth of mining is not too great, and the hanging strata are sufficiently incompetent to transmit the effects of localised collapse to the surface.

In conclusion it may be noted how useful air photographs may be to the student of underground features. At the same time, however, there is ample scope for further research into the evaluation of various criteria used in this branch of photogeology.

References.

Allum, J.A..E., 1966. Photogeology and Regional Mapping. Pergamon Press.

Lueder, D.R., 1959. Aerial Photographic Interpretation. McGraw Hill.

Marshall, A., 1968. Infra-red Colour Photography. Science Journal, V.4, N.1, p.45.

Miller, V.C., 1961. Photogeology. McGraw Hill.

Norman, J.VI., 1968a The Air Photograph Requirements of Geologists Photogrammetric Record V.6, N .32, p.133.

Norman, J.W., 1968b Photogeology of Linear Features in Areas Covered with Superficial Deposits. Trans. Inst. Min. Met. V.77, p.B66.

Norman, J.W., 1969. The Role of Photogeology in Mineral Exploration. Trans. Inst. Min. Met. (in press).

Norman, J.W. & A.C. Waltham, 1969. The Use of Air Photographs in the Study of Karst Features. Trans. Cave Res. Gp. (in press).

Pardoe, G.K.C. 1969. Earth Resource Satellites. Science Journal V.5, N.6, p.28.

Appendix.

A number of companies in the United Kingdom sell air photographs, but two useful sources with complete coverage of the West Riding of Yorkshire at least are:

R.A.F. photographs, available from the Air Photograph Library, Ministry of Housing and Local Government, Whitehall, London, S.W.l. Photographs are on scale of 1:10,000 and each print covers about 1 x 1½ miles.. Delivery time is in excess of three months and prints are 8/6d. each.

Meridian Airmaps Ltd., Commerce Way, Lancing, Sussex. Photographs are scale of 1:10,000 and each print covers about 1½ x 1½ miles. Delivery time is less than three weeks and the prices are on a sliding scale roughly as. follows: Single print orders – 21/-d.; 5 prints - 14/-d. each; 10 prints – 11/6d. each or 100 prints - 6/4d. each.

Either source will supply prints if the purchaser sends a sketch map to overlay the O.S. 1” maps, marking the grid lines.

Meridian will loan key maps, but the Ministry of Housing will not.

---ooo0ooo---