VERTICAL AERIAL PHOTOGRAPHY

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1. DESCRIPTION

Aerial photographs (sometimes called airphotos) are often the first choice of imagery datasets available to help interpret regolith landform characteristics especially for mineral exploration. Aerial photographs are easy to use, especially for lesser-experienced interpreters. Photographs are often more widely applicable because they are based on the visible portion of the spectrum and can provide more easily identifiable ground features with which to work. The use of ordinary photographs, mostly as contact prints either black and white or often colour, is a widely practiced and well known technique for obtaining geological information otherwise not readily available. Regolith is part of that geological information, and can be interpreted from photographs. Regolith characteristics are closely related to landform characteristics and landform evolution. Regolith and landform attributes are more easily recognised by interpreters with training in geomorphology.

Vertical aerial photographs are taken with the camera pointing vertically towards the ground surface. Other orientations are possible such as high angle oblique where the tilt of the camera includes the horizon or low angle oblique where the tilt of the camera is insufficient to include the horizon. The major advantage in the use of vertical aerial photographs comes from their ability to show the landscape and its features in three dimensions as a stereomodel. Stereomodels are usually seen with the aid of a stereoscopic viewer to view two photographs simultaneously. The photographs are taken usually in the visible light spectrum in an overlapping arrangement that permits scene duplication on at least two successive frames. This duplication is known as stereoscopic overlap. Often the overlap between photographs is optimised at 60% in the forward direction forward-lap and 30% as sidelap. With this arrangement, every second photo is sufficient to provide a satisfactory stereomodel. The complete suite therefore can be divided into an alternate set, a conjugate set, and either set can be used for interpretation.

Regardless of whether sequential photos or alternate photos are used to establish and view a stereomodel there is an element of vertical exaggeration introduced into the vertical scale of the model. This is due to the vertical scale being greater than the horizontal scale. The degree of exaggeration present in the model is related to the separation of the photo centres (ie. principal points) and the geometry of the viewing apparatus. The exaggeration that stereoscopic viewing of photos in alternate number sets induces is double the vertical exaggeration of photos viewed in sequential number order. (As a rough rule of thumb the vertical exaggeration seen in the 3D model from stereoscopic viewing of normal sequential 60% overlap photography, is between 3-4 times the horizontal scale).

Contained on each aerial photographic print is a strip of information known as the title strip. The title strip is usually located on one edge of each individual photograph and contains details relevant to that photograph. The title strip typically includes: the name of the geographic sheet, or of the local area on the ground, over which the photograph was taken, a number specific to that photo (identifying the order of acquisition within the flight line), flying altitude (above sea level) at time of photography, the identity number of the negative on which the photo occurs, the focal length of the lens on the camera used (the nominal photo scale is derived by determining the ratio of the focal length of the camera lens divided by the flying altitude – all in common units), a designator of the camera type (eg. RC 9), and an arrow indicating the general direction of North.

In Papp, É. (Editor), 2002, *Geophysical and Remote Sensing Methods for Regolith Exploration*, CRCLEME Open File Report 144, pp 1-5.

There are possible errors introduced at the time of acquiring aerial photography. It is best to be aware of these errors because they can make using aerial photos more awkward. The error caused by plane drift during photo acquisition is characterised by the photo edges being parallel but not collinear within one flight line (also known as a run). Between successive flight lines, drift can cause the sidelap to be highly variable or sometimes non-existent. Crab error on the other hand results in twisting of the photo orientation so that the photo edges are not parallel with the flight line. Usually, crab results from an effort to correct drift without the necessary correction to aircraft heading. Aircraft induced pitch, yaw and roll errors can also be incorporated into vertical aerial photographs and may need to be removed in particular circumstances. These errors will not be discussed here.

Runs of airphotographs may be arranged to form a complete coverage of a designated area. They can be assembled in ways to reduce feature mismatch, further manipulated to reduce tonal differences or just assemble without modification. Print laydowns are assemblages of sequences of aerial photos, usually every second print in their correct relative positions to provide an approximate unrectified map. This may be rephotographed and form a photoindex. The prints may be cut to eliminate the distorted portions and then these parts fitted together along fencelines, roads, rivers and ridge crests for example to form a jigsaw puzzle like map. It is still not geographically correct and is said to be an uncontrolled photomosaic. If careful correction of differences in scale, tone, tilt of each print is carried out, a controlled photomosaic can be produced. These may be sold by the various agencies. They may cost many tens of dollars, depending on the area required and scales involved. Digital photogrammetry is now more readily available through contractors and is increasingly used to produce such products. The cost is sometimes a little less and may be already produced in areas of significant exploration activity. Sometimes digital elevation models are a by-product of this work and may be available at affordable prices. They can be important additional datasets to help with interpretations.

2. FIELD PROCEDURES

Preliminary interpretation may be made prior to visiting the field. Ultimately though the interpreter reaches a point where experience fails to resolve uncertainties in interpretation. Field calibration of photographic images is usually required by the interpreter to resolve uncertainties. Once the relief patterns, tones, textures, and perhaps colours in the photopatterns are understood a more reliable interpretation can result. Calibration may sometimes be possible and be based only on the interpreters prior experience. There are no hard and fast rules; each case is different. Photopatterns are calibrated by collecting attributes describing the regolith materials and landform characteristics. All attribute descriptions are usually linked to the observation point marked on the photographs. These represent the calibration points and form part of the more general site descriptions recorded during fieldwork. The points should be spatially located by way of some form of geographic coordinate for later more accurate construction of maps whether hard copy or digital.

3. DATA PROCESSING

Mostly processing of aerial photographs, because they are from the visible spectrum, is done through the eyes (with the aid of optical instruments) of trained experienced interpreters. Aerial photographs can be reprocessed by computer manipulation using specialised software packages. This should only be undertaken by experienced interpreters with the required computing skills. The "black-box" approach can be a trap for the inexperienced.

4. DATA INTERPRETATION

Interpretation is mostly experience-based because of the complexity of photopatterns and the variability of problems encountered. Many of the regolith landform features outlined in RTMAP (Pain, et al., 1991) can be recognised to varying degrees. Training in geomorphology makes the task of interpretation of regolith landform features from aerial photographs and in the field much easier.

Potential mappers and interpreters should at least read the RTMAP guidelines if they lack basic training in geomorphology or have little field experience.

Some more basic interpretative techniques eventually may be available in the future through automated computer analysis using knowledge-based rule systems; but this is not yet routinely used. Interpreters using aerial photographs will usually have to rely on their knowledge of relief, patterns, tones, textures, and colours present in the photopatterns. Ideally, interpreter experience and reliability will be improved by repeated comparisons with numerous stereomodel characteristics and actual ground surface features.

5. APPLICATIONS

Geology, regolith, land-use, soils, forestry, engineering, urban planning, natural hazards are a few examples of studies where aerial photographs may be used to help provide interpretations.

6. PROBLEMS AND LIMITATIONS

Photographs may not necessarily show all the features you may hope to identify or distinguish and therefore other forms of remotely sensed imagery may be needed eg. satellite thematic mapper; radar; magnetics; EM; radiometric; to name a few. The lack of tonal contrast can be a problem with photographic prints from time to time. This can sometimes be overcome by reprocessing scanned images by computer image-manipulation software. Care must be taken to scan them at sufficiently high resolution so that their usefulness is not severely reduced. Resolution is usually not a problem with reasonable quality commercial aerial photographic prints. Sometimes the scale may not suit your purpose but you may have to adapt if other scales are not available and you cannot afford to have custom photographs generated commercially. There is often an exaggeration factor (2x to 3x) using aerial photographs and stereoscopic viewers.

7. SURVEY ORGANISATIONS

Suppliers of aerial photography range from government departments to private contractors. Private contractors are sometimes used by the government departments as well. The national survey organisation is probably the best place to start inquiries for obtaining aerial photographs. In Australia, this Department is currently known as AUSLIG. AUSLIG staff can tell you who is its current outsourced supplier for aerial photographs are for much of Australia. These photos may not be at the scale you require. They may not cover the specific area of your interest and therefore you may need to direct your inquiries to the State Government Survey responsible for Lands or Mapping -they may have an outsourced supplier as well. Commonwealth Government generated photography goes back many years - as early as the 1920's but more significantly in the late 1940's.

The first aerial photography from which a map (photomap) was made in Australia was carried out in 1922 and scattered localised coverages were acquired in the following years. In 1924, the first systematic aerial photography of a mining field was at Mt Isa. However, it was not until after World War 2 that a concerted program of systematic regional coverage was implemented utilising the RAAF aerial photographic squadron's capability. This program was subsequently expanded using commercial operators and State agencies to produce the "K17" regional coverage over most of Australia. This comprised panchromatic photography at a nominal scale of 1:50,000 with a forward overlap between photographs of 60%. The photography name ie. K17 is derived from the designation of the camera used.

In 1960, a program of photography at a nominal scale of 1:84,000 was developed using the RC9 super wide-angle camera that produced a flight-line coverage with an 80% forward overlap. The K17 and RC9 photography represent the only near complete nationally consistent coverages flown in Australia. Many other coverages of local and regional areas are available at different scales and photo types (panchromatic, colour, high altitude etc.) through government and commercial agencies (Lines, 1992). Photographs at 1:50,000 scale are often obtainable from State Lands Survey Offices or their outsourced agents. Currently, no simple accurate guidelines for suppliers can be provided. The circumstances now change over time. You can currently view the flight line diagrams for Commonwealth generated photography at: http://www.ga.gov.au/products/photos. From that site, you may be able to follow links to other outsourced suppliers and State Government agencies.

8. COSTS

Each organisation has its own costing arrangements. Therefore it would not be instructive to quote current costs but suffice to say that the unit cost for small numbers of prints is usually much higher than for large numbers of prints. Prices in the past have been around twenty dollars for low number individual prints. There is often an access or retrieval cost if films are archived and that fee may be around thirty dollars. This access fee is usually built into the overall cost structure for large orders. Costs also vary depending on if you require positive prints or transparencies ie. diapositives. Other cost factors would depend on whether colour or black and white photos were required, the number of duplicates or even single prints you require from the same roll of film. Single prints from many different films are often a costly purchase.

9. EXAMPLE INTERPRETATION

Figure 1 shows an example of an area near Higginsville, south of Kambalda, in the Eastern Goldfields of Western Australia where aerial photography has been used to assist in the generation of a regolith landform map. The regolith polygon interpretations can be seen on the black and white aerial photographic basemap. An extract of the final map now replaces the corresponding area on the basemap. This example shows the progression from aerial photographic polygon interpretation through to selected portion of the final map.

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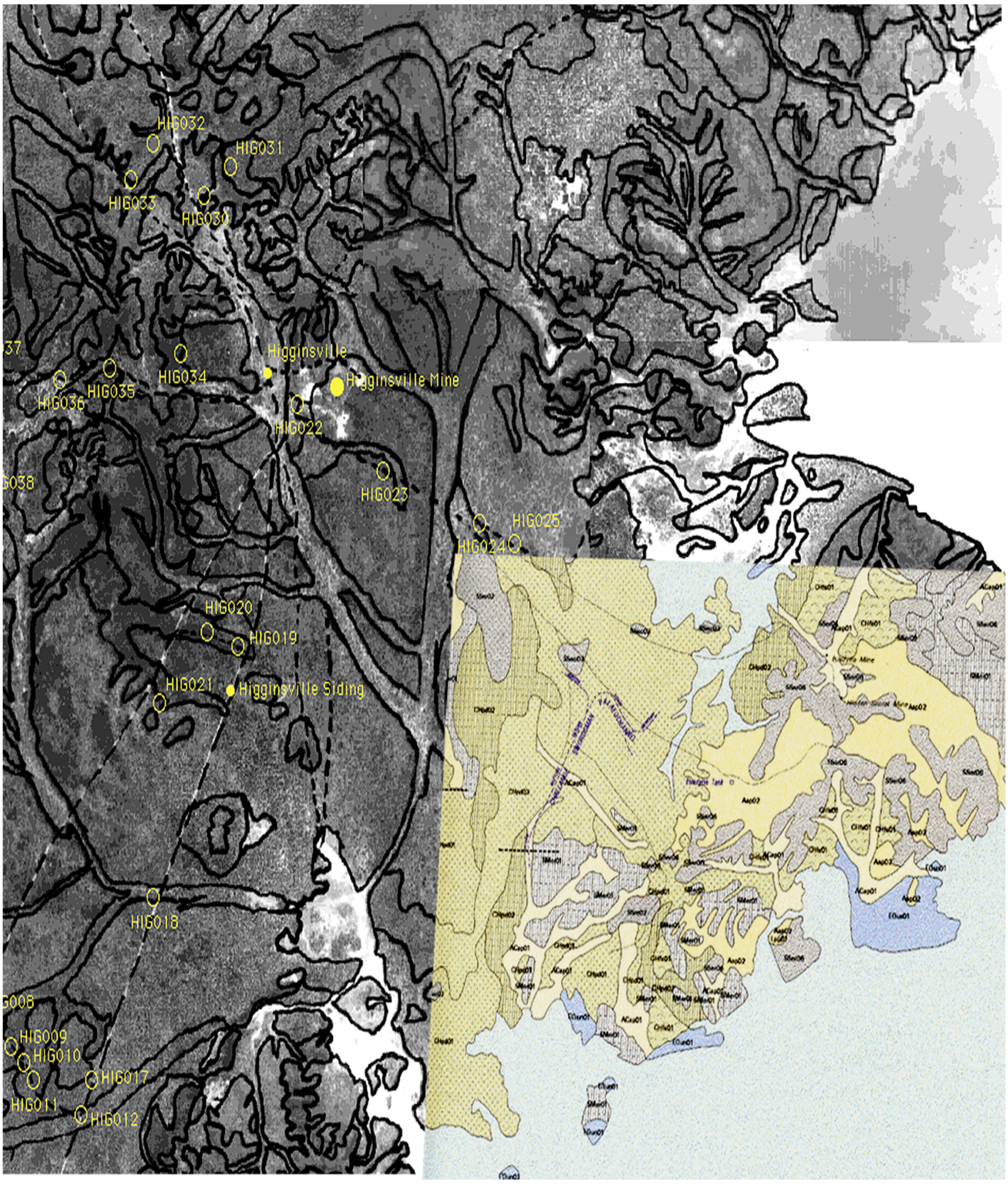

Figure 1. Higginsville regolith base map (Lintern, et al., 1996), compiled by Mike Craig on RC9 aerial photographs. The map shows regolith polygons, side localities and place names. A final regolith map extract is shown at the bottom right to indicate the relationships between the airphoto interpretation and the final map. From AMIRA Project P409