DEPARTMENT OF
MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1974/50

GEOLOGICAL INVESTIGATION OF EARTH RESOURCES SATELLITE IMAGERY OF THE MOUNT ISA, ALICE SPRINGS AND CANBERRA AREAS

Final report to the US National Aeronautics and Space Administration on BMR investigation of ERTS-1 imagery, February 1974

by

C. Maffi, C.J. Simpson, P.W. Crohn, O.G. Fruzzetti and W.J. Perry

Note: The original Record contains overlays for figure/s 2, 3, 4 and 6. If you wish to view the original, please contact the N.H. (Doc) Fisher Geoscience Library.

Mail

N.H. (Doc) Fisher Geoscience Library
GPO Box 378
Canberra ACT 2601
Australia

Email

library@ga.gov.au

Telephone

Within Australia: 02 6249 9567

International: +61 2 6249 9567

Fax

Within Australia: 02 6249 9989

International: +61 2 6249 9989

Record 1974/50

GEOLOGICAL INVESTIGATION OF EARTH RESOURCES SATELLITE IMAGERY OF THE MOUNT ISA, ALICE SPRINGS AND CANBERRA AREAS

Final report to the US National Aeronautics and Space Administration on BMR investigation of ERTS-1 imagery, February 1974

by

C. Maffi, C.J. Simpson, P.W. Crohn, O.G. Fruzzetti and W.J. Perry

CONTENTS

1 - SUMMARY

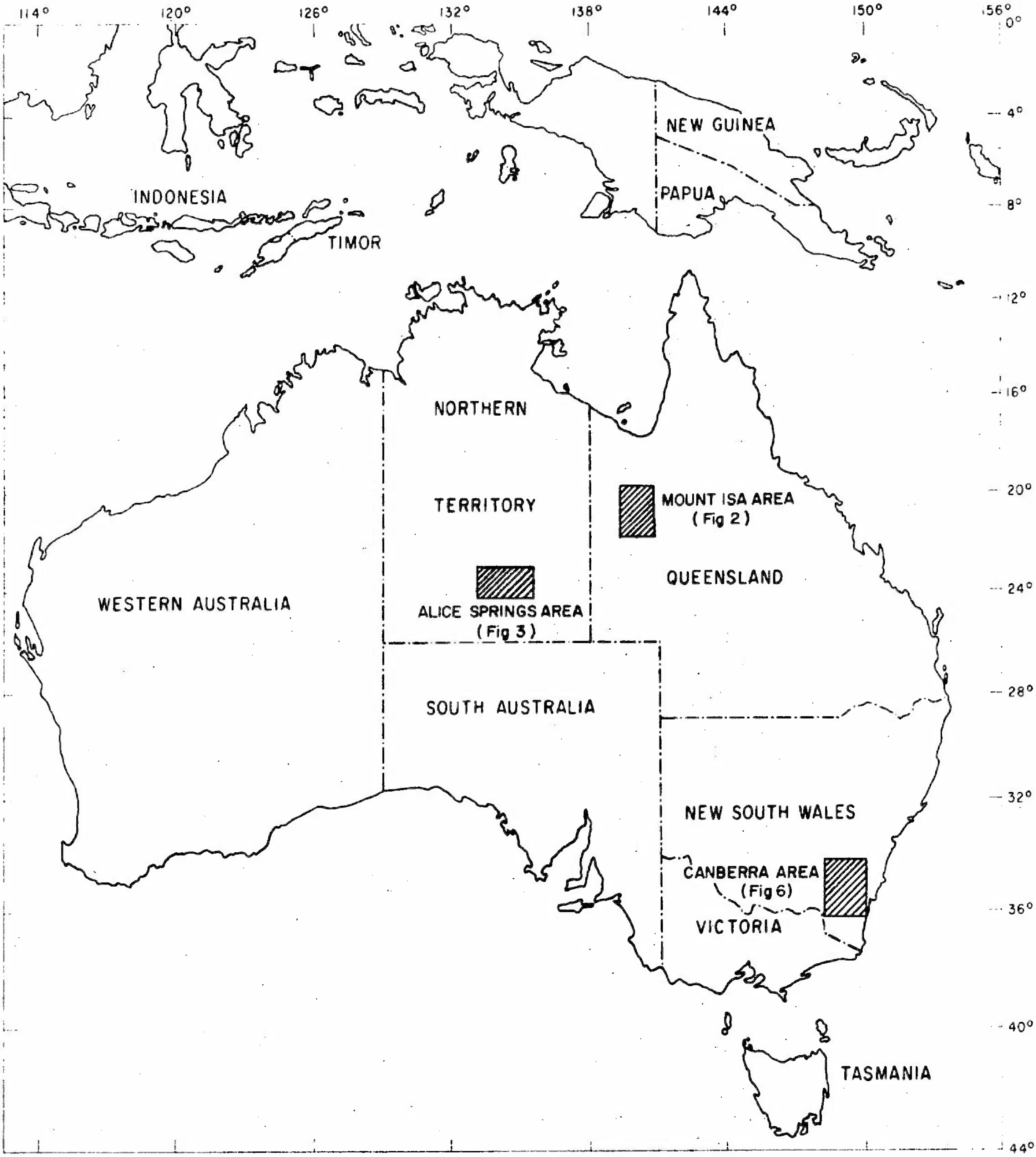
ERTS-1 imagery of areas at Mt Isa (arid tropical climate), Alice Springs (arid climate), and Canberra (temperate sub-humid to humid climate) has been examined by conventional photogeological interpretation techniques to assess its potential for small-scale geological mapping. Interpretations were compared with existing geological maps at scales of 1:250 000 or larger.

The best results were obtained by comparing, under a mirror stereoscope, pairs of positive transparencies at 1:1 000 000 scale.

Bands 5 and 7 provided more geological information than bands 4 and 6. Most information was obtained from stereoscopic viewing of images from adjacent orbits, and from images taken with low sun angle.

Some existing geological information was confirmed, and some new information obtained. ERTS-1 imagery is considered a useful aid to small-scale regional geological mapping.

It is recommended that NASA investigate the possibility of providing higher quality early generation 1:1 000 000 scale products for investigators, and more extensive stereoscopic and low sun angle imagery coverage with future satellites.



LOCALITY MAP

Areas investigated by the Bureau of Mineral Resources, Geology and Geophysics
during the geological evaluation of ERTS-1 imagery

5

2 - INTRODUCTION

ERTS-1 images of areas at Mt Isa, Alice Springs and Canberra have been examined to assess the potential of such imagery for small-scale geological mapping. The three areas differ from each other in geology, geomorphology, climate, vegetation and land use.

A fourth area (Kalgoorlie) listed in the original Australian proposal to NASA as a 'Possible Test Area' for joint investigation by the Bureau of Mineral Resources and the Geological Survey of Western Australia was studied and reported on by the latter.

The images studied during the investigation are those received until August 1973, plus the high radiance linear density images of Mt Isa, received in January 1974.

Details of identification number, sun elevation angle, and percentage cloud cover are given in the Appendix.

Detailed interpretation was carried out, then compared with information from publications and air photographs. The interpretation was not checked in the field, therefore the results presented in this report are preliminary. It is possible that, in some places, the interpretation will have to be reviewed after field work.

Images received after August 1973 will be studied in the near future. A multispectral viewer will be used for the eventual revision of the interpretation, and for further investigations.

3 - EQUIPMENT AND TECHNIQUES

3.1 Materials

NASA-produced 70 mm ERTS positive (3rd generation) and negative (4th generation) products were shipped to the Division of National Mapping (DNM) the Australian distribution body for ERTS investigator material.

For each test area BMR received from DNM either 70 mm negatives (if multiple copies were available) or the notification that a negative had been received from NASA. In the first instance BMR obtained 5th generation positive copies of the NASA product either through a commercial firm, or from its own Photographic Section. In the second instance, BMR ordered copies (5th generation) through DNM from the Australian Government photographic contractor, Air Photographs Pty Ltd.

After preliminary examination of the 1:3 369 000 and 1:1 000 000 scale positive and negative products it was decided to obtain each band of all available ERTS images of the three test areas as 1:1 000 000 scale black and white positive transparencies (5th generation). One selected image in each area was prepared as a 1:1 000 000 scale false colour infrared positive transparency by the Australian Government contractor.

Selected images were enlarged to 1:500 000 and/or 1:250 000 scale prints for comparison with maps.

A mosaic was prepared from band 7 images of the Canberra area at 1:500 000 scale. Scenes with the least cloud cover and the highest contrast were selected. Band 7 images were used because they display more structural information than any other band, and good discrimination between vegetation types. Figure 5a is a photographic reproduction of part of this mozaic.

The usefulness of some original imagery was affected by various defects such as: distortion (e.g. 1011-00250), 'Newton ring' effects (e.g. 1011-00250), reticulation (e.g. 1139-00371-4), excessive signal noise along scan lines (e.g. 1030-00303-5) and spotting (e.g. 1152-00073-4).

Some original negative products were of such high density that only poor contrast low density positives could be obtained from them.

3.2 Annotation

The 1:1 000 000 scale images were systematically examined and compared on a light table (fixed intensity) and data were annotated onto a transparent film overlay. Normally band 7 was annotated first and additional data from the other three bands were then compiled onto the one overlay.

When compiling data from different scenes it was necessary to use geographic information (mainly streams) from maps of the 1:1 000 000 scale International Map of the World (IMW) series - Lambert Conformal Conic Projection - to control compilation at a uniform scale and correctly position parallels and meridians. In some places the ground position of co-ordinate markings on the image surrounds was up to 5 km in error.

For the purpose of this report figures have been prepared at scales of 1:1 000 000 or 1:500 000. Because of the small scale of presentation, drafting techniques, and image distortion, some discrepancies occur in the plotted positions of similar features from different sources.

7

3.3 Viewing

Three techniques were used for examining the images:

1. Transparencies were examined using various magnifying lenses of powers between 2x and 6x.

2. Two different bands of the same scene were viewed simultaneously under a mirror stereoscope with 1x, 1.8x, and 3x magnifying capability. This technique proved to be useful for rapid comparison of the differences between separate bands.

3. Where sidelap of two scenes existed, pairs of images of the same band were studied stereoscopically at different magnifications.

3.4 Interpretation

To keep the geological evaluation of ERTS as objective as possible, examination and interpretation of the imagery was carried out without reference to available ground data. However, each interpreter already had some familiarity with the general geology of the area he was studying.

Conventional principles of photogeological interpretation were applied in the examination of the imagery. In most cases this had to be undertaken monoscopically, and the absence of stereoscopy combined with the low resolution meant that interpretation was restricted to the use of tonal/textural criteria.

During interpretation attempts were made to differentiate, delineate and correlate rock units and identify rock structures. Emphasis was placed on detecting lineaments (as defined in the AGI "Glossary of Geology" 1972), in attempting to identify them as faults, joints, dykes, or trends, and in separating geological from man-made features.

After completion of the interpretation the results were compared with available data, generally in the form of published geological maps at 1:250 000 scale or larger. All geological maps used in the comparison were originally prepared with the aid of air photographs. Major differences between the ERTS interpretation and map data were further checked against other available ground data and vertical air photography at 1:83 000 scale or larger.

4 - MT ISA AREA, QUEENSLAND

by

C. Maffi and C.J. Simpson

4.1 Area Studied

Although an area of about 90 000 km^2 was examined on ERTS imagery only about 40 000 km^2 was examined in detail. The corner co-ordinates of the latter area, which is discussed in this report, are:

$19^{\circ}33'$S	$139^{\circ}15'$E
$19^{\circ}33'$S	$140^{\circ}50'$E
$21^{\circ}46'$S	$140^{\circ}50'$E
$21^{\circ}46'$S	$139^{\circ}15'$E

The interpretation of ERTS images was checked by comparison with information from the following sources: Geological Series Sheets - Camooweal, Dobbyn, Mt Isa, Cloncurry, Urandangi and Duchess at 1:250 000 scale and Mt Isa, Mary Kathleen, Marraba and Cloncurry sheets at 1:100 000 scale. Carter et al. (1961), Perry et al. (1964), Derrick et al. (1971) and Maffi (1973).

No field check of the interpretation was carried out. Detailed mapping at 1:25 000 scale for preparation of 1:100 000 scale geological maps was regarded as providing adequate ground information for comparison with the image interpretation.

4.2 Imagery studied

The first ERTS 70 mm products of the Mt Isa study area received from NASA produced positives of low density and low contrast. A request for certain scenes to be reprocessed was approved by NASA. High radiance linear density products were received on 2 January 1974, and used for a revision of the interpretation of the original imagery.

One scene of RBV imagery (1009-00120) which covers part of the study area was also examined.

4.3 Climate

The climate of the area is arid tropical: the average annual rainfall (which ranges from 380-500 mm) is mostly limited to the four summer months of December to March. The mean monthly temperature at Cloncurry ranges from 31°C in January to 18°C in July.

9

4.4 Topography and Physiography

The continental divide ranging from 250 to 650 m a.s.l. crosses the area in a general northwest-southeast direction just south of Mt Isa. South and west of the divide the streams drain inland into the Georgina-Diamantina Rivers system. North and east of the divide, streams drain into the Gulf of Carpentaria.

The northeastern corner of the area is fairly flat with altitudes ranging from 120 to 200 m a.s.l. It belongs to the broad belt of plains which stretch from the Great Artesian Basin to the Gulf of Carpentaria.

The remainder of the area is highly dissected. The greatest local relief is about 300 m. Land forms are largely determined by rock type and structure. The major valleys are developed in shale and slate, quartzite forms the areas of greatest relief, and granite generally forms areas of subdued relief. In places quartz-filled faults form sharp ridges, the most prominent of which reaches a maximum altitude of 180 m above the surrounding ground level.

4.5 Vegetation

The plains are generally grassy and sparsely timbered. Stony hill country supports light grasses, scrub and low trees. Large eucalypts thrive along the main watercourses.

In many places a close relationship between vegetation type and geological features can be observed on air photographs.

4.6 General Geology

Most of the area is occupied by the Lower Proterozoic Cloncurry Complex, which is part of the Australian Precambrian Shield. Cambrian rocks crop out in the centre of the southern part of the area. Scattered outliers of Mesozoic rocks are present throughout most of the area.

The Cloncurry Complex forms part of an orogenic belt. The older rocks are largely metamorphosed acid lavas and metabasalts, which were uplifted and intruded by granite during a major orogenic phase. These volcanics and granites form the basement to two distinct geosynclinal basins which were separated by a narrow tectonic welt located across the centre of the area in a north-south direction. Sandstone-shale sequences interbedded with calcareous and volcanic rocks were deposited in the geosynclines.

During a second orogenic phase followed by uplift, the whole region was deformed, and lower Proterozoic sedimentation ceased.

The Cambrian rocks, which unconformably overlie the Cloncurry Complex, are sandstone-shale and carbonate sequences. During the Cambrian and early Ordovician these rocks were moderately folded and strongly faulted. As a result of these movements, horst-and-graben structures, predominantly trending northeast, were formed.

The Mesozoic sequence of clastic rocks was deposited on the eroded surface of the Precambrian and Cambrian rocks during a marine transgression. After uplift and strong erosion, only scattered residuals remain of the Mesozoic sequence.

Cainozoic unconsolidated clastics floor the major valleys and the coastal plain to the northeast of the area.

4.7 Results of Investigation

4.7.1 Rock type discrimination

Boundaries between rock bodies can be identified on ERTS imagery by means of contrasting tone e.g. light toned quartzite (Mitakoodi Quartzite) against dark toned volcanics (Marraba Volcanics); however, gradational tonal changes along the strike of rock bodies severely limit accurate delineation. Ground data suggest that tonal changes within a rock type may be significantly influenced by changes in the surface nature of rock outcrop and do not necessarily indicate any compositional change. Since the nature of rock outcrops can vary to the vertical view depending on size, state of weathering, vegetation type and density, and superficial cover, attempted differentation and correlation of rock types on tonal/textural criteria is not reliable. This problem affects the interpretation of both individual black and white ERTS bands and false colour composites.

From ERTS imagery it was possible to distinguish general rock type distributions and trends, but it was not possible to discriminate between the 21 different rock subdivisions shown on the available 1:250 000 scale geological map. The 1:100 000 scale geological maps covering the southern half of the area show approximately 70 rock type subdivisions.

4.7.2 Geological Structure

Attempts were made to detect and identify trends, folds, faults, joints and dykes and differentiate them from man-made features. More data could be interpreted from bands 7 and 5 than from bands 4 and 6. Regional trends can

11

be interpreted by recognition of numerous discontinuous segments of bedding or rock-type boundaries. In some instances bedding traces can be annotated continuously for distances of more than 20 km.

In some areas of gently dipping sediment, dip directions can be determined by morphology. However, steep dips (greater than 60°) are the norm, and it is generally not possible to determine the attitude of steeply dipping beds. Thus folds can be recognized, but generally cannot be further identified as synform or antiform.

4.7.3 Lineaments

Numerous lineaments (Fig. 2a) have been interpreted from ERTS imagery by vertical viewing. To determine their significance they have been compared with fault data reduced to 1:1 000 000 scale from published geological maps originally at 1:250 000 scale (Fig. 2b) and 1:100 000 scale (Fig. 2c), and with interpretations from Side Looking Airborne Radar (SLAR) (Fig. 2d).

Where they could be identified, man-made features and rock trends were excluded from the lineament annotation. Two lineaments between AA (Fig. 2a) do correlate with segments of railway line.

Lineaments BB, CC, DD, EE, FF, GG, HH, II, JJ were interpreted as major faults on ERTS imagery because rock bodies and geological trends appear to terminate against linear features. With the exception of HH, JJ, and KK all these lineaments coincide in part with known major faults from published geology (Fig. 2b). ERTS data suggest that the faults may extend further than shown by 1:250 000 scale mapping. The 1:100 000 scale data (Fig. 2c), confirm that this is correct for the northern end of FF, although a fault extension beyond the southern end of FF has yet to be detected.

Lineaments GG and HH are distinct on the ERTS imagery but coincide only with short segments of faults or inferred faults on Figure 2b. The 1:100 000 scale data on Figure 2c confirm that the northern parts of GG and HH are faults which are subparallel to, and approximately 1 km apart from, one another. There is insufficient detail on the ERTS imagery to identify the two separate fault traces.

A set of northwesterly trending faults between and including LL and MM were interpreted from ERTS with reasonable accuracy (compare Figs. 2b, 2c); this was possible because fault displacements of dark toned volcanics (Eastern Creek Volcanics) could be observed against lighter toned quartzites and shales.

Major north-trending strike and near-strike faults immediately west of Mt Isa town were not detected on ERTS

12

because they could not be distinguished from bedding trends. These faults have local significance in the geology of the major copper-lead-zinc mine at Mt Isa.

Faults such as NN (Fig. 2b) were not detected because they could not be differentiated from normal rock contacts.

Some significant lineaments such as those that are present between O and O (Fig. 2a) suggest that known faults extend further than has been previously mapped.

Two sets of lineaments, the origin of which cannot be explained by existing maps have been detected on ERTS. A northeasterly trending set - subparallel to PP in figure 2a - is present throughout the whole area but coincides with a known fault only between Q and Q (Fig. 2b). The other less extensive set has a northwesterly direction subparallel to RR (Fig. 2a). Segments of lineaments in this direction rarely coincide with known faults.

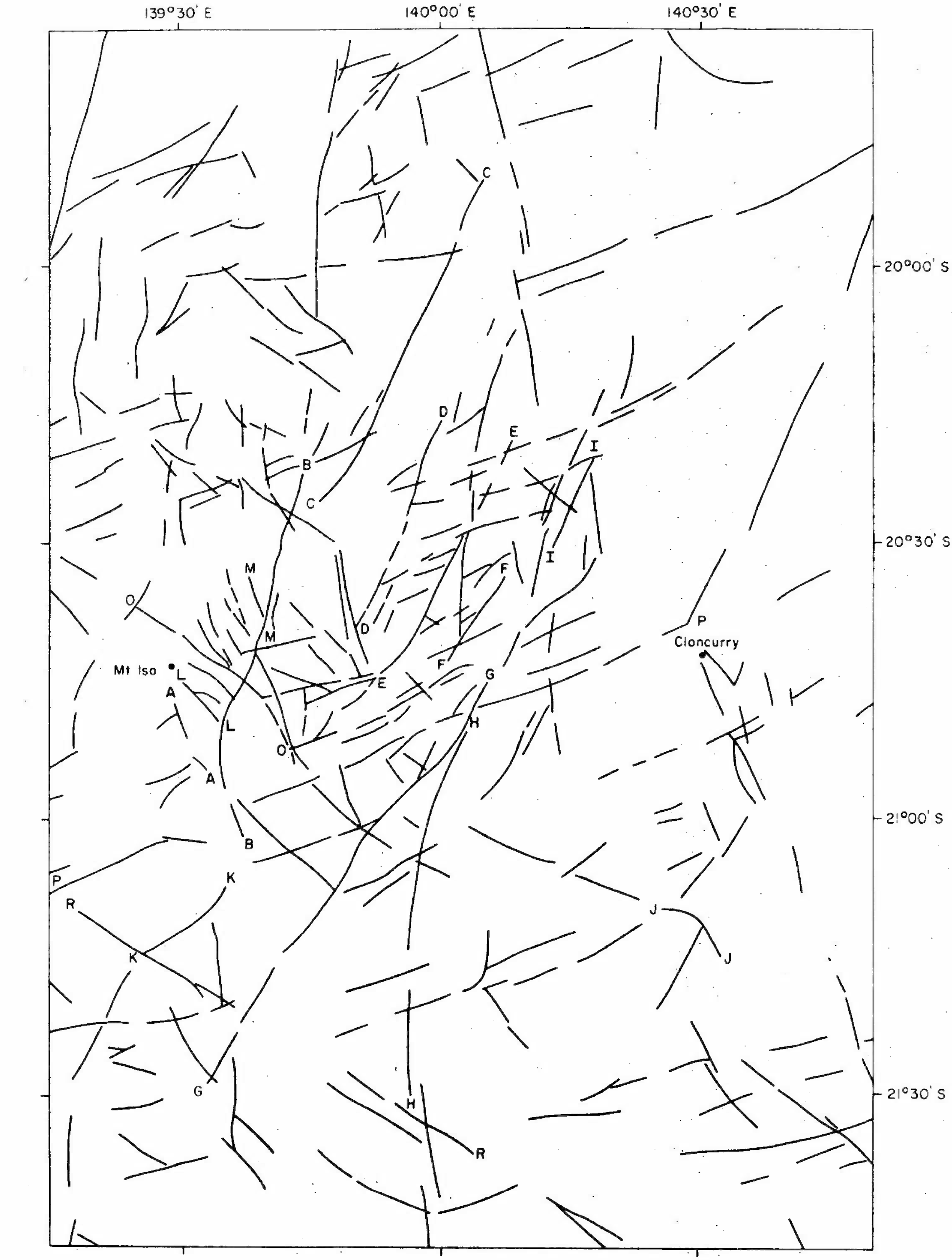
Lineaments from ERTS were compared with faults and inferred faults from SLAR (Fig. 2d). The comparatively limited area of SLAR coverage was flown on east-west flight lines with a look direction to the south, and image interpretation was carried out at 1:100 000 scale (Maffi, 1973). Over the area imaged more linear features were interpreted from SLAR than from ERTS, and approximately 30% of the ERTS lineaments coincide with SLAR lineaments. One notable difference is that the SLAR interpretation does show the major north-trending faults west of Mt Isa.

Three ERTS lineaments that coincide with SLAR lineaments SS, TT, UU (Fig. 2d) are not shown on published maps. A dolerite dyke is coincident in part with UU.

4.7.4 Discussion on lineaments

To compare data from published geology with those from ERTS, the zone on Figure 2a between 20°30'S and 21°00'S was selected. Lineaments on ERTS normally exceed 4 km in length (possibly because of the image scale examined and the terrain type). For this reason faults or inferred faults which are less than 4 km in length on figures 2b and 2c have been excluded from the comparison, except where they can be interpreted to be part of a single feature which exceeds 4 km in length.

In the zone considered the number of faults or inferred faults shown on 1:250 000 scale maps approximately equals the number of ERTS lineaments detected. However, less than 30% of the ERTS lineaments coincide in part with faults or inferred faults. Similarly approximately 30% of ERTS lineaments coincide with known faults or inferred faults from the detailed 1:100 000 scale mapping.



MOUNT ISA AREA

Data from:

ERTS-1 interpretation

17

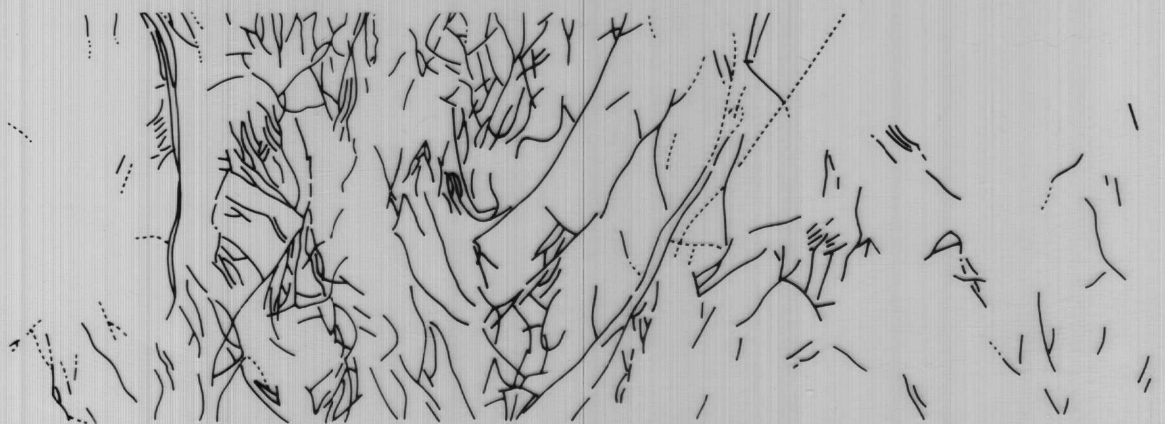
To accompany Record 1974/50

Q/A/518

Fig 2a

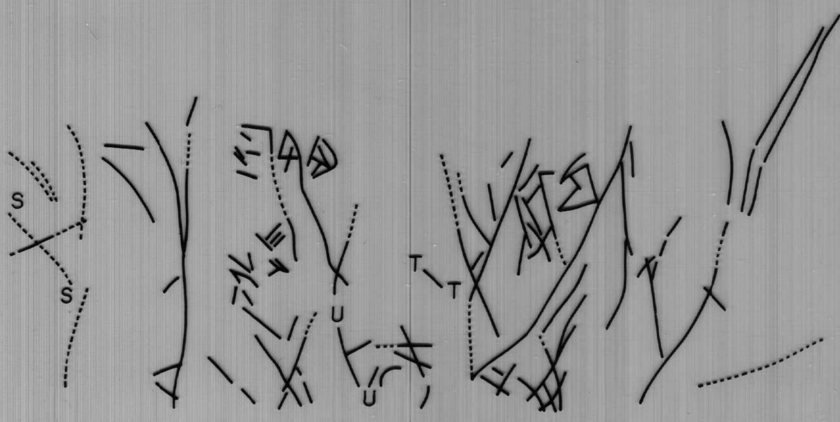
Published geology (1:250,000 scale) ——— Fault .... Inferred fault

16



Published geology (1:100,000 scale) —— Fault - - - - - - - - - Inferred fault

15



SLAR interpretation ——— Fault --------- Possible fault

Both sources of published geological data indicate that approximately 30% of the ERTS lineaments coincide with faults or inferred faults. However, there are approximately 2½ times more faults or inferred faults shown on the 1:100 000 scale maps than there are lineaments detected from ERTS. Thus only about 10% of the known or inferred faults in the area have been detected on ERTS. This figure is probably underestimated because the detailed 1:100 000 mapping shows that what appear as single-linear features on ERTS are composed of numerous close faults or fault segments which have been counted as individual features in the calculation.

The 10% of faults detected on ERTS include the major transgressive faults (or rather fault zones), but major strike or near strike faults could not be detected. Some lineaments not detected on 1:250 000 scale maps are confirmed as faults by data from 1:100 000 detailed mapping.

The origin of the unidentified lineaments (approximately 70% of all ERTS lineaments) is uncertain. Their location and trend in many instances suggest that some represent previously unidentified faults. Some lineaments are parallel to directions of dykes which are prevalent in the area.

4.8 Conclusions

In the area studied the evaluation of ERTS imagery has shown that:

High radiance linear density products are superior to the first products supplied by NASA.

Only a very general interpretation of rock type distribution and trends can be made, and the interpreted information is inferior to that on published 1:250 000 scale geological maps.

Correlation and differentiation of rock types on tonal textural criteria is not reliable.

Bands 5 and 7 provide more geological data than bands 4 and 6.

Dip directions of sediments generally cannot be determined.

About 30% of lineaments interpreted appear to be faults but these represent only about 10% of known faults greater than 4 km long.

The major transgressive faults of the area were detected, but strike or near strike faults could not be identified.

Lineament data suggest that some faults continue further than their previously mapped extent. No extensive comparison of Return Beam Vidicon (RBV) with Multi-Spectral Scanner (MSS) imagery was undertaken although the general impression obtained was that the MSS imagery was clearer and contained more detail than the RBV. The RBV contained more distortion than the MSS, based on comparison of both with IMW maps.

4.9 References

CARTER, E.K., BROOKS, J.H., & WALKER, K.R., 1961 - The Precambrian mineral belt of northwestern Queensland. Bur. Miner. Resour. Aust. Bull. 51.

DERRICK, G.M., WILSON, I.H., HILL, R.M., & MITCHELL, J.E., 1971 - Geology of the Marraba 1:100 000 Sheet area Qld. Bur. Miner. Resour. Aust. Rec. 1971/56 (unpubl.).

PERRY, R.A., SLEEMAN, J.R., TWIDALE, C.R., PRICHARD, C.E., SLATYER, R.O., LAZARIDES, M., & COLLINS, F.H., 1964 - General report on the lands of the Leichhardt - Gilbert area, Queensland, 1953-54. CSIRO Land Res. Ser. 11.

MAFFI, C., 1973 - SLAR interpretation in the Mount Isa area. Bur. Miner. Resour. Aust. Rec. 1973/59 (Abstract only - unpubl.).

5 - ALICE SPRINGS AREA, NORTHERN TERRITORY

by

C.J. Simpson (Bureau of Mineral Resources)
P.W. Crohn and O.G. Fruzzetti (Geological Section, Mines Branch, Department of the Northern Territory)

The main publications used in the evaluation of the ERTS interpretation were Joklik (1955), Forman et al. (1967), Wells (1969), and Wells et al. (1970).

5.1 Area Studied

The region studied in detail was the Alice Springs 1:250 000 scale sheet which has the following corner co-ordinates:

23°00'S	133°30'E
23°00'S	135°00'E
24°00'S	135°00'E
24°00'S	133°30'E

The sheet area covers approximately 16 760 km^2. However, more than 60 000 km^2 of the sheet and surrounds were examined on ERTS imagery (see Appendix) during the evaluation.

5.2 Techniques

Techniques of evaluation have been discussed earlier in this report. Stereoscopic viewing of overlapping images from adjacent orbits was used where possible. Images studied stereoscopically and the percentages of sidelap were: 1030-00303 with 1155-00253 (24%), 1030-00303 with 1119-00254 (28%), 1210-00313 with 1119-00254 (23%).

The number of lineaments detected by vertical viewing was compared with that detected by oblique viewing of images.

5.3 Climate

The whole of the area is arid, with an average annual rainfall ranging from 200 mm to 260 mm. Because of the sporadic nature of the rainfall there is no definite growing season.

5.4 Vegetation

The vegetation includes grassland, shrubland, and low woodland. Eucalypts are rare and acacias are the most common trees and shrubs. Spiny plants and succulents, common in overseas arid areas, are not important here. More comprehensive data on vegetation are reported in Perry et al. (1962).

5.5 Topography

The central part of the area consists of an east-west trending zone of ranges and hills. The ranges of greatest relief are formed of folded quartzite with crests 500 to 700 m above plain level. Most of the crystalline and metamorphic rocks of the ranges have subdued relief. Drainage throughout the area consists dominantly of consequent streams.

To the north and south of the central ranges and hills are extensive sand and alluvial plains, 550 to 700 m a.s.l. Sand dune development increases to the southeast.

5.6 General Geology

The investigation area covers part of the Amadeus Basin, originally an intracratonic depression which has a total length of 800 km within the relatively stable Australian Precambrian Shield. The crystalline basement comprises orogenically deformed igneous and metamorphic rocks known as the Arunta Complex. The basement rocks are unconformably overlain by the Amadeus Basin sequence of Adelaidean (Late Proterozoic) and Palaeozoic (Cambrian, Ordovician) sediments, which have been deformed by epeirogenic and orogenic movements. (The general distribution of the main rock types is shown on Figure 4a). The 1:250 000 scale mapping (Wells, 1969) was concerned primarily with the sedimentary basin, and lithological subdivision of the Arunta Complex was not attempted.

Within the zone of ranges and hills arid erosion processes have developed excellent rock exposures. Folded Palaeozoic sediments are well displayed by cuesta, hogback, and strike valley morphology.

5.7 Results

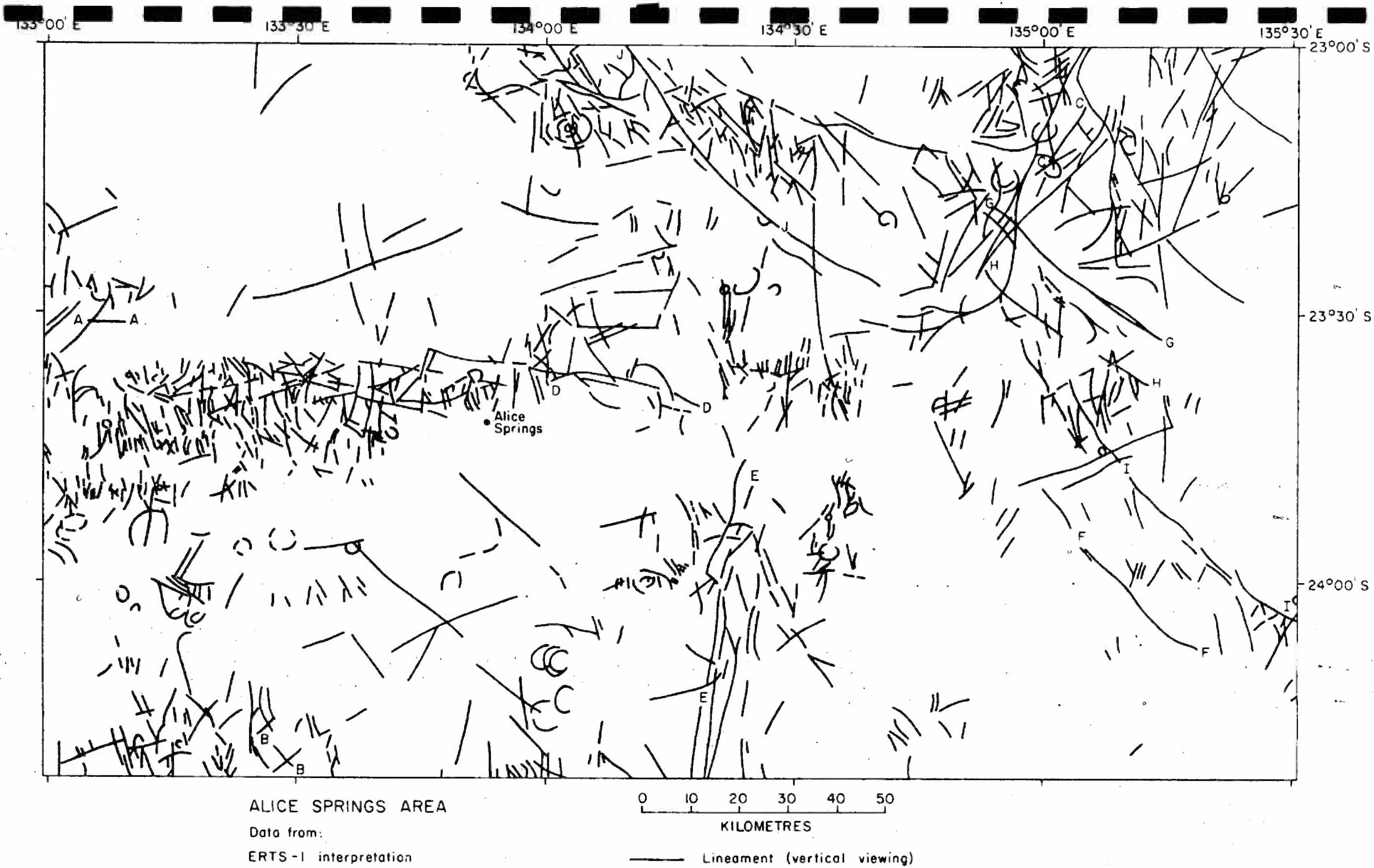
5.7.1 Rock type discrimination

In general the delineation of outcrop of medium to dark toned rocks is satisfactory. Only about 50% of light toned rocks, particularly those forming low outcrops in sandy terrain, were detected on ERTS, and some outcrop up to 30 km^2 in area could not be detected.

The metamorphic rocks of the Arunta Complex are dominantly of medium to dark tone, and different rock types can be distinguished. Basic rocks (e.g. amphibolites) are characterized by dark tones and are readily distinguishable. However, since gradational tonal changes are common particular rock types generally cannot be totally delineated. An exception is a dark toned area near Mt Ruby (23°21'S, 135°03'E), where the Riddock Amphibolite (Joklik, 1955) occurrence can be accurately delineated on all bands of image 1155-00253 because the basic rock is surrounded by light toned gneiss.

Almost the entire length of the contact between Arunta Complex metamorphics and overlying Proterozoic sediments was detected on ERTS imagery. This is attributed to the presence, along most of the contact, of a massive quartzite which is both tonally and topographically different from the metamorphics. Those places where the contact could not be detected on ERTS generally corresponded to a locality where the quartzite is absent.

Metamorphics could not be differentiated reliably from sediments using tonal/textural criteria, either on individual ERTS bands or on false colour composites. More success was achieved in differentiating and correlating rock types within the Upper Proterozoic and Palaeozoic sedimentary sequences because of well developed strike ridge and valley morphology.



ALICE SPRINGS AREA

Data from:

ERTS-1 interpretation

24

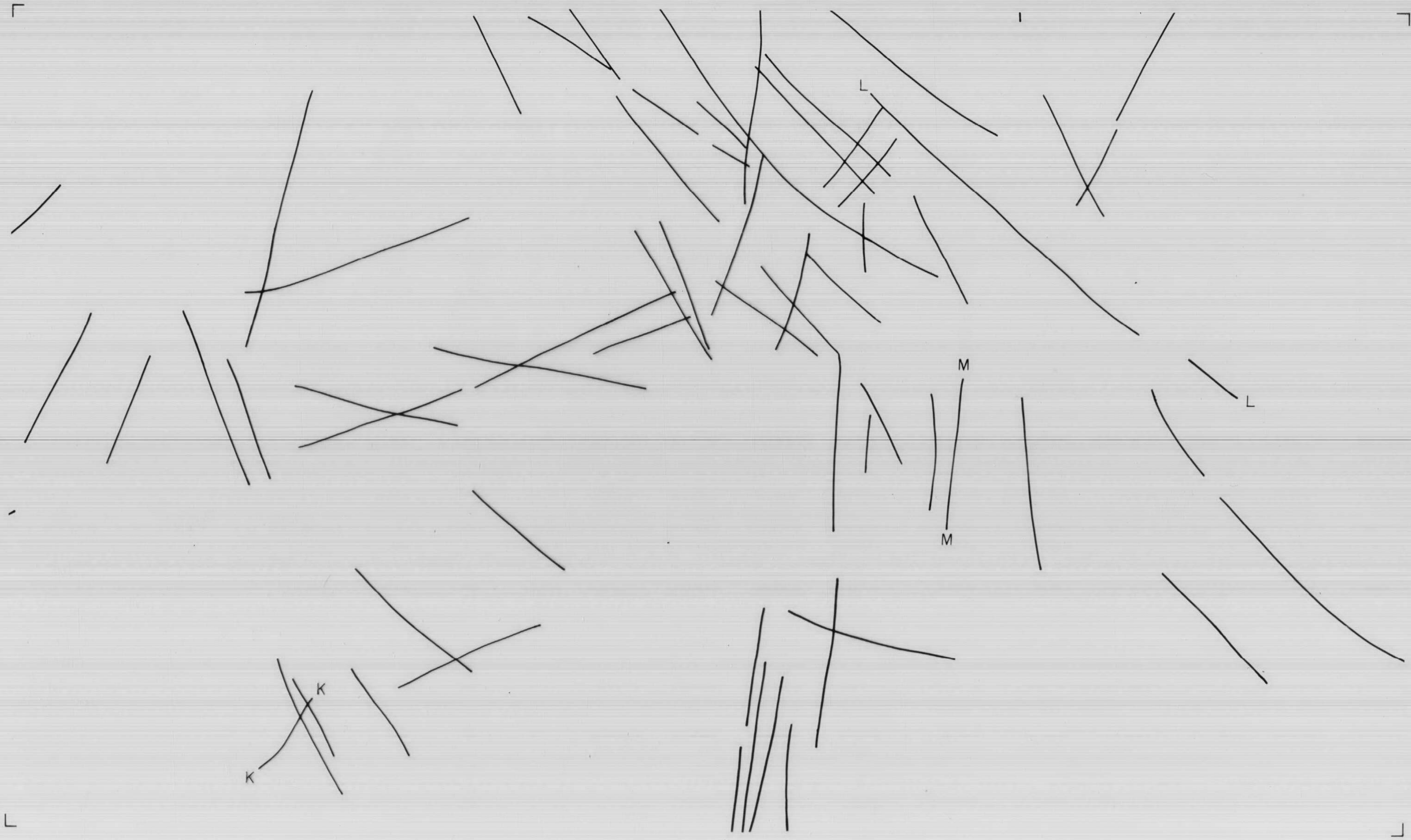
Fig. 3a

To accompany Record 1974/50

NT/A/399

Published geology (1: 500,000 scale) ——— Fault, ------ Inferred fault, -•-•- Dyke

3 b



22

ERTS-I interpretation

— Lineament (oblique viewing)

The reliability of both correlation and differentiation of sedimentary rocks was further improved where stereoscopic viewing was available. The impression of stereoscopic height was apparent where relief exceeds approximately 60 m.

5.7.2 Geological Structure

Attempts were made to detect and identify structures such as trends (foliation in metamorphics, bedding in sediments), folds, faults, joints, and dykes.

Within the metamorphics trends of different rock types could be identified by tone, but attitude could not be interpreted. In the sediments bedding could be identified and in most instances attitude could be determined. Dips could be broadly categorized into high or low because of the well developed cuesta morphology. Dip faces on cuestas are more easily identified on low sun angle imagery. This is demonstrated by comparison of 1011-00250 (SUN EL 32) with 1101-00255 (SUN EL 56). The recognition of dip faces allowed the main fold structures to be identified and the positions of fold axes to be reliably interpreted. Some folds as small as 10 km long and 3 km across formed by cuestas in sand plain could be identified.

5.7.3 Lineaments

Lineaments interpreted from ERTS are shown on Figure 3a. They represent those linear features which could be annotated at 1:1 000 000 scale and exclude any bedding and rock trends, and man-made features that could be identified. The high density of lineaments in various areas reflects the occurrence of outcrop compared to non outcrop. Evaluation of false colour composites did not provide as much lineament data as did the individual bands and of these bands 7 and 5 proved more useful than 4 and 6.

Lineaments AA, BB, CC on Figure 3a correspond to sections of roads. Lineaments DD, EE, FF can be interpreted as faults because of displacement of geological units, and they do coincide in part with inferred faults from published geology (Fig. 3b) after Wells et al. (1970).

Lineaments GG, HH, II, JJ were suspected faults because they are distinct and well defined. Of these GG and HH have been mapped in part as faults (Fig. 3b), and recent mapping (Shaw & Longworthy, 1972) has confirmed that a major fault coincides with ERTS lineament JJ.

Comparison of Figures 3a and 3b shows that in the metamorphics (approximately the northern half of the figure) about 50% of the faults or inferred faults from published geology coincide either wholly or partly with lineaments detected on ERTS. In the sediments (approximating to the southern half of the figure) only about 10% of the published faults coincide with ERTS lineaments. This is attributed to the fact that many published faults within the sediments are strike or near strike thrusts and their surface traces cannot be distinguished from bedding trends.

To the west of Alice Springs (Fig. 3a) there are many short northerly trending lineaments. There are no known faults of similar trend in that region, but there are numerous dolerite dykes and approximately 30% of those mapped coincide with ERTS lineaments. Some lineaments also parallel known joint directions.

The number of ERTS lineaments detected by vertical viewing (Fig. 3a) was compared with the number detected by oblique viewing (Fig. 3c). The latter technique favours detection of the longer lineaments or lineament segments. Of the lineaments detected by oblique viewing approximately 30% coincide wholly or partly with lineaments detected by vertical viewing, but less than 7% coincide with known geological structures. Lineament KK on Figure 3c coincides with a road and others such as LL appear to represent previously unmapped extensions of known faults.

Some lineaments such as MM can be detected on 1:80 000 scale air photography (Alice Springs CAG 7002 Run 7/048) by oblique viewing but are extremely difficult to detect by conventional vertical viewing. Lineament MM crosses several well developed easterly trending strike ridges but there is no photo evidence to suggest that movement has taken place.

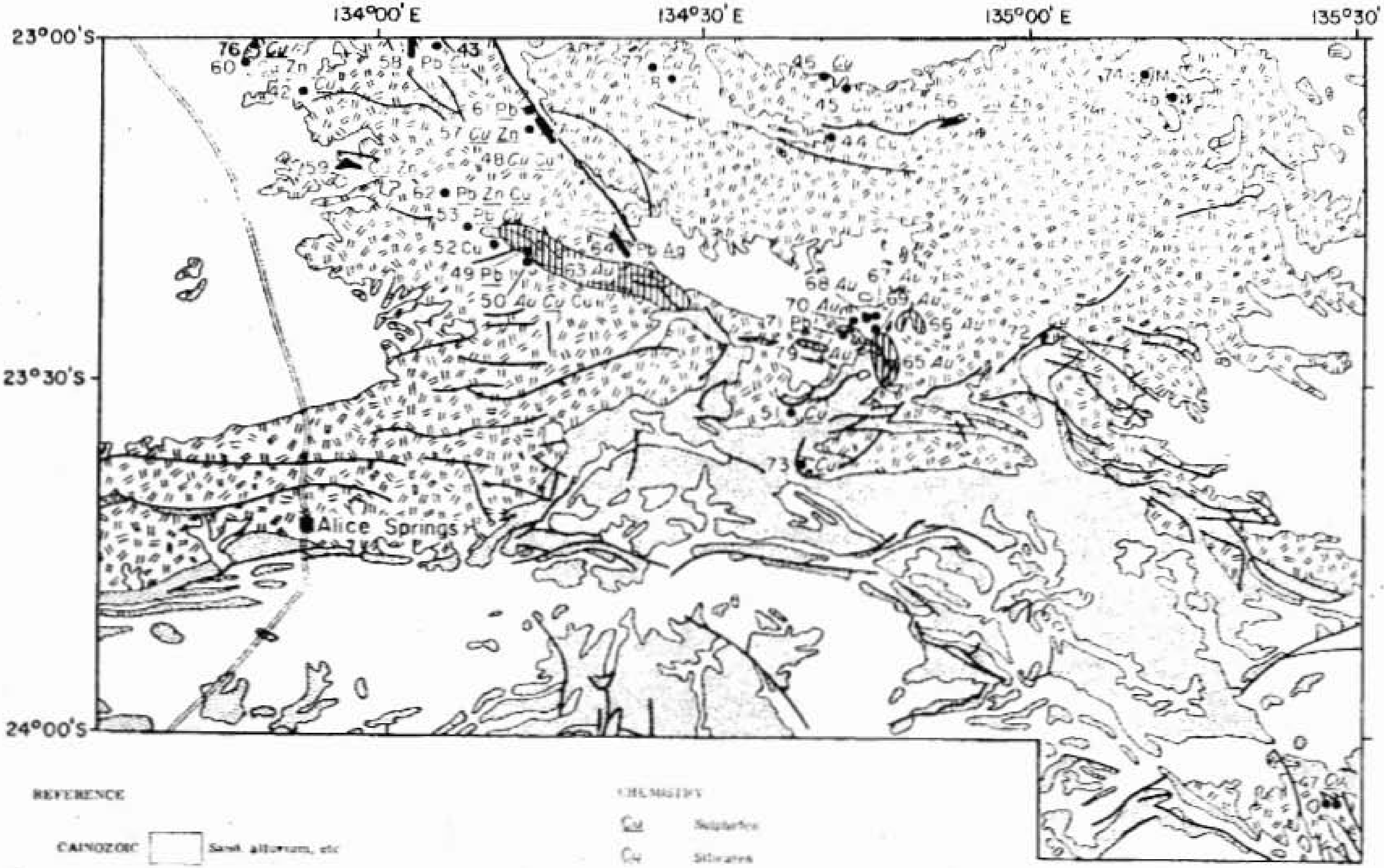
Some preferential erosion is associated with lineament MM indicating a zone of weakness; however, the erosion has not been superimposed onto the strike ridges, suggesting that the zone of weakness is a relatively young structural feature.

5.7.4 ERTS lineaments and mineral occurrences

From published geology the metalliferous mineral occurrences of the Alice Springs area do not appear to have any well defined association with major faults. The locations of metalliferous mineral deposits shown on Figure 4a (after Warren & Stewart, in prep.) have been compared with lineaments interpreted from ERTS (Fig. 4b). On the latter, lineament AA may be related to mineral deposits numbered 61, 48, 64 and 79 on Figure 4a. Apart from this, the many remaining lineaments detected from ERTS do not appear to have any obvious relationship to the locations of metalliferous mineral deposits.

NUMBERED KEY TO MINERAL DEPOSITS

42. Tom Fraser's Prospect
43. Moller Creek Copper Prospect
44. Copper Queen
45. Selin's Deposit
46. Virginia Prospect
47. Arthur Pope's Prospect
48. Pinnacles Lodes
49. Sliding Rock Copper Prospect
50. Turner's Prospect
51. Paddy's Jump-Up Copper Show
52. Ghecko Prospect
53. Rankin's Copper Prospect
56. Oonagalabi Prospect
57. Johnnie's Reward
58. Edwards Creek Prospect
59. Harrys Bore Prospect
60. Red Rock (Coles Hill) Prospect
61. Woolanger Bore Prospect
62. Johannsen's Phlogopite Mine
63. Winnecke District
64. Glankroil (Gander) Mine
65. White Range Field
66. Wheal Fortune Group
67. Wipe Out Group
68. Minor workings west of Wipe Out Mine
69. Round Hill Area
70. Claraville Mine
71. Arltunga Lead Show
72. Hale River Prospect
73. Tommy's Gap Copper Prospect
74. Inkamulla Dome
76. Copper prospect 7 km W of Mount Strangways
77. Copper prospect 10 km W of Blackfellows Bones Bore
78. Copper prospect 5 km W of Blackfellows Bones Bore
79. Arltunga Goldfield



REFERENCE

CAINOZOIC — Sand, alluvium, etc

PROTEROZOIC-PALAEOZOIC — Sandstone, shale, dolomite, limestone, tillite

PRECAMBRIAN ARUNTA BLOCK — Granite; Younger metamorphic rocks; Older metamorphic rocks

Geological boundary

Fault

0 10 20 30 40 50

KILCMETRES

CHEMISTRY

Cu Sulphides

Cu Silicates

Cu Oxides, native metals, arsenates

Cu Carbonates, sulphates

Cu Unknown

GENESIS OF DEPOSITS

Sedimentary (chemical)

Hypogene

Hypothermal

Magmatic

Pegmatitic

METALLOGENIC DATA

FORM OF DEPOSITS

Vein; trend shown by symbol orientation

Pipe

Stratiform

Irregular

Unknown or minor

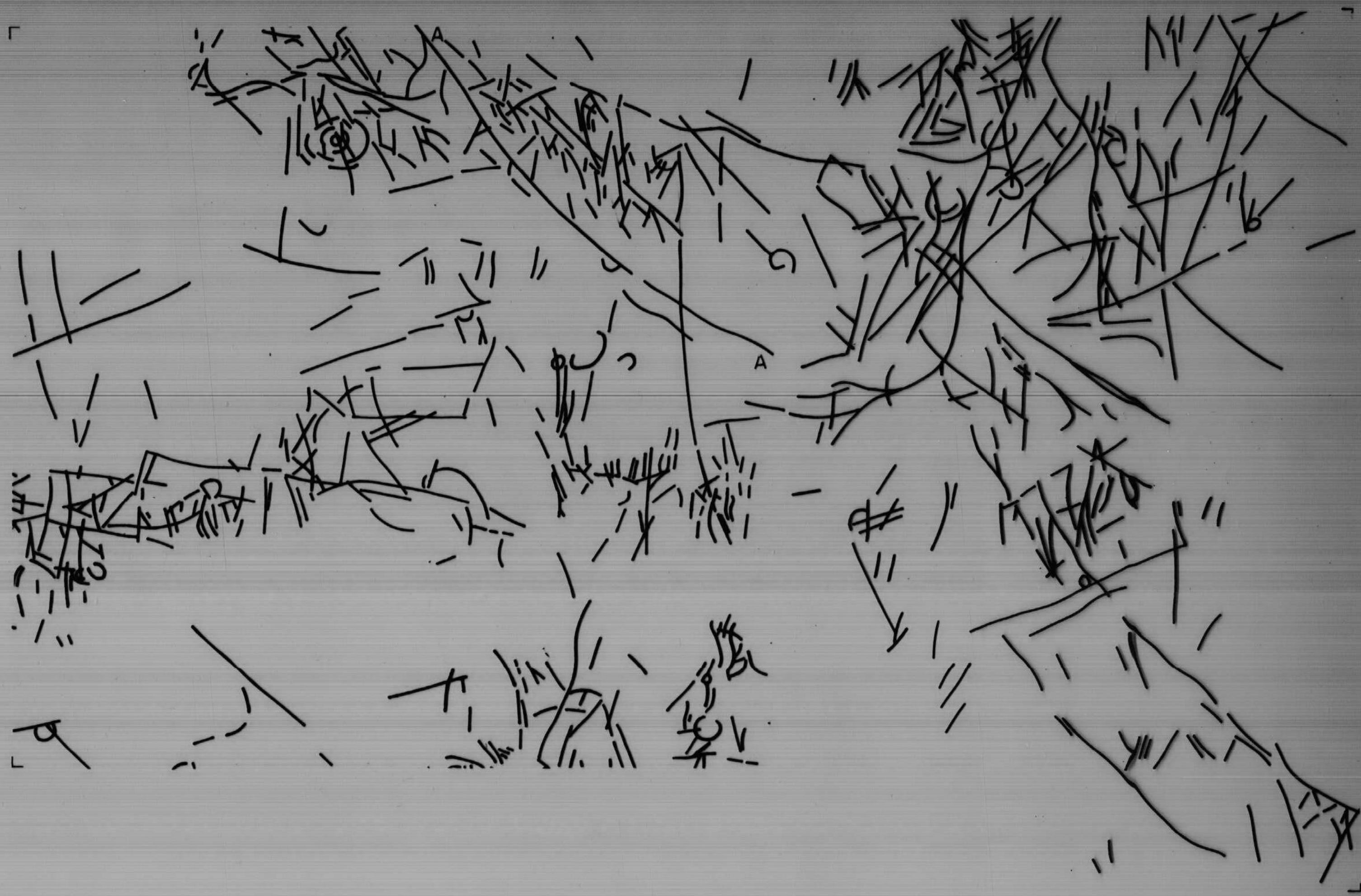
Area of numerous deposits

ALICE SPRINGS AREA

Location of main metalliferous mineral occurences (AFTER WARREN & STEWART, in prep)

To accompany Record 1974/50

Fig 4a



Lineament interpretation from ERTS I

5.7.5 Discussion

Although some ERTS lineaments can be explained by known geological features, many remain unidentified. Approximately 2½ times more linear features have been detected on ERTS than are shown by joints, faults, dykes, etc. on published 1:250 000 scale geological maps. Recent detailed mapping has shown that some ERTS lineaments coincide with faults not detected during 1:250 000 scale mapping.

This reflects the reconnaissance nature of the 1:250 000 map data used for evaluating ERTS.

Examination of good quality 1:80 000 scale vertical air photographs by conventional photogeological techniques shows that a high proportion of 'new' lineaments detected on ERTS can be seen on the photographs.

The photogeological map of the Alice Springs area (Scanvic, 1961), which was prepared in advance of 1:250 000 scale field mapping, shows some lineaments which have not been included in the first edition map but which have been detected on the independent ERTS interpretation. This suggests that the significance of such lineaments cannot be readily determined in the field.

The main problem relating to the majority of ERTS lineaments is to determine what features cause particular lineaments. There is no evidence to suggest that this can be done by conventional photogeological techniques applied to existing ERTS imagery.

5.8 Conclusions

In the area studied the evaluation has demonstrated that on ERTS imagery:

Attempted differentiation and correlation of rock types on tonal/textural criteria is not reliable.

Only very general rock distribution data can be interpreted and these are inferior to the data in those areas shown on the published 1:250 000 scale geological map where differentiation was attempted.

Stereoscopic examination of overlapping images from adjacent orbits assists geological interpretation.

In sediments, dipping beds and folds could be identified because of their topographic expression.

29

Low sun-angle illumination allows a better appreciation of topography to be made and this assists geological interpretation.

Lineaments may be an expression of faults, joints, dykes, rock trends, or man-made features and in the absence of obvious indicators (e.g. fault displacements) no definite criteria could be established to determine what features cause particular lineaments.

Not all major faults can be detected.

Lineaments should be regarded as a potential source of significant geological information.

Lineament detection should employ both vertical and oblique viewing techniques.

Reliability of lineament detection is influenced by the rock type present.

There is no significant relationship between metalliferous mineral occurrences and possible structural control as indicated by lineaments.

5.9 References

FORMAN, D.J., MILLIGAN, E.N., & McCARTHY, W.R., 1967 - Regional geology and structure of the northeastern margin of the Amadeus Basin, Northern Territory. Bur. Miner. Resour. Aust. Rep. 103.

JOKLIK, G.F., 1955 - The geology and mica-fields of the Harts Range, central Australia. Bur. Miner. Resour. Aust. Bull. 26.

PERRY, R.A., MABBUTT, J.A., LITCHFIELD, W.D., QUINLAN, T., LAZARIDES, M., JONES, N.O., SLATYER, R.O., STEWART, G.A., BATEMEN, W., & RYAN, G.R., 1962 - General report on lands of the Alice Springs area, Northern Territory, 1956-57. CSIRO Land Res. Ser. 6.

SCANVIC, J.Y., 1961 - Report on photo-interpretation of the Amadeus Basin. IFP Rep. AUS/31A (unpubl.).

SHAW, R.D., & LANGWORTHY, A.P., 1972 - 1:100 000 scale mapping Laughlen Sheet area in Geological Branch summary of activities 1972. Bur. Miner. Resour. Aust. Rec. 1972/103, pp. 70-72 (unpubl.).

WARREN, R.G., & STEWART, A.S., (in prep.) - Mineral deposits of the Arunta Complex. Bur. Miner. Resour. Aust. Rec.

WELLS, A.T., 1969 - Alice Springs, Northern Territory - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SF/53-14.

WELLS, A.T., FORMAN, D.J., RANFORD, L.C., & COOK, P.J., 1970 - Geology of the Amadeus Basin, central Australia. Bur. Miner. Resour. Aust. Bull. 100.

6 - CANBERRA AREA

AUSTRALIAN CAPITAL TERRITORY AND NEW SOUTH WALES

by

C. Maffi

6.1 Area studied

The area being reported is that of the Canberra 1:250 000 scale sheet, whose corner co-ordinates are:

35°00'S	148°30'E
35°00'S	150°00'E
36°00'S	150°00'E
36°00'S	148°30'E

A larger area is presented in Figure 6a, to include features which may be related to those of the Canberra sheet.

The MSS images used in the study are listed in the Appendix.

The interpretation was not checked in the field, but it was compared with geological maps at 1:100 000, 1:250 000 and 1:1 000 000 scales, and with information from Best et al. (1964), Gunn et al. (1969), Pogson (1972), and Strusz (1971).

6.2 Climate

The area has a temperate subhumid to humid climate influenced by proximity to the coast, elevation, and the seasonal north to south movement of the sub-tropical belt of high pressure. Rainfall is fairly evenly distributed throughout the year. The recorded mean annual rainfall over most of the area varies between 500 mm in the west and 962 mm in the east, but the ranges receive a higher rainfall. Mean monthly temperatures in Canberra range from 21°C in January to 60°C in July. Prevailing winds are from the west and northwest.

6.3 Topography and Physiography

The western part of the area, from latitude 148°30' to the Murrumbidgee River, is mountainous, moderately rugged country (Fig. 5a). The Snowy Mountains reach 1780 m a.s.l., the Fiery Range reaches 1630 m, and the Brindabella Range 1910 m. Most slopes do not exceed 10 percent, but locally steep incisions are present. The altitude of the Murrumbidgee valley floor ranges from 716 m a.s.l. in the south to 365 m a.s.l. in the north.

The centre of the area, from the Murrumbidgee River to the Great Dividing Range, is rolling hills country, with maximum altitudes about 1600 m. To the north, Lake George and its tributaries form an internal drainage system. The Great Dividing Range has a maximum altitude of 1475 m a.s.l.

Eastwards the country slopes down towards the coastal lowlands. The southeastern corner of the area is deeply dissected and slopes of about 50 percent are fairly common. The lowest point is 75 m a.s.l., along the Moruya River.

The Murrumbidgee River and its tributaries form the major drainage system. East of the Divide is the coastal system, whose major rivers are the Shoalhaven and the Moruya.

The streams are mostly subsequent, either following or cutting sharply across the generally north-south tectonic trend.

6.4 Vegetation

The natural vegetation appears to be closely linked with climate and topography, and much less with rock type and soil. Areas with mean annual rainfall of 1000 mm or more and without extremes of cold and heat, such as the south and east-facing slopes of the Great Dividing Range (Fig. 5a), support wet sclerophyll forest. Mountainous or hilly country with a lower rainfall supports intermediate and dry sclerophyll forest. The Shoalhaven and Moruya catchments support tallwood forest. The undulating country on the tableland is savannah-woodland. The flat areas, where cold air drainage causes intense winter frosts, are pure natural grasslands.

In many places the natural vegetation has been altered by human action. In some places these alterations appear to be related to rock type and soil: improved pastures tend to be established on the granites because of relatively good soil, whereas vegetation on sedimentary and volcanic rocks tends to be left unaltered.

32

CANBERRA AREA

Mosaic prepared from Band 7 imagery

Fig 5a

Fig 5 b

Geological sketch, prepared from the Canberra 1:250,000 scale Geological Sheet

I55/A16/1130

6.5 General geology

Ordovician and possibly some Silurian sandstone-shale sequences (Os and Ss in Fig. 5b) are the oldest rocks exposed. Their deformation is due to several compressive episodes which started at the end of the Ordovician and continued intermittently until the Carboniferous.

Thick sequences of Middle to Upper Silurian acid volcanics (Sv) with lesser interbedded sediments are distributed in north-south belts across the area. These belts are bounded by granite batholiths of Late Silurian to Early Devonian age (g).

West of the Great Dividing Range, these intrusive rocks are present in the horsts of a horst-and-graben structure. Horsts and grabens are separated by faults whose predominantly northerly orientation was probably controlled by east-west compressive forces during the Silurian-Devonian, culminating in the mid-Devonian Tabberabberan Orogeny.

East of the Great Dividing Range, the structural style consists of fold belts separated by north-south faults.

Devonian volcanics (Dv), possibly extruded along the major longitudinal faults, partly fill the grabens. In the northwest corner of the area, early Devonian limestone overlies Dv.

Devonian molasse-like sandstones (Ds) are preserved in long narrow meridional synclines formed during the Kanimblan Orogeny of Early Carboniferous age.

The Siluro-Devonian horst-and-graben style is still expressed in the landscape, as a result of the Late Tertiary uplift of the Kosciusko Massive, which rejuvenated many of the faults. Remnants may still be seen of the high-level Tertiary gravels, stream and lake deposits, and basalts disrupted by the Kosciusko uplift.

Cainozoic deposits (Cz) cover the floors of some of the present valleys.

6.6 Results of investigation

6.6.1 Lithology

In some places, rock units can be differentiated and correlated on ERTS imagery by using conventional photogeological techniques as described in Chapter 3.

For example, in the northwestern corner of the area (Fig. 5), the large outcrop of Devonian volcanics can be differentiated from Devonian sedimentary rocks by following a sharp change in vegetation, relief, and texture. In the centre and east, a light tone and a smooth appearance are associated with some of the granite outcrops. South of Lake George, the Cainozoic is imaged in a lighter tone than the rock units around it.

However, when the ERTS band 7 mosaic (Fig. 5a) is compared with information from the Canberra 1:250 000 scale geological sheet (Fig. 5b), it can be seen that:

(a) Many outcrops of the same rock unit are differently displayed in the imagery.

(b) Some outcrops of different rock units are similarly displayed in the imagery.

(c) Many lithological boundaries do not follow tone, vegetation, landform, or texture boundaries in the imagery.

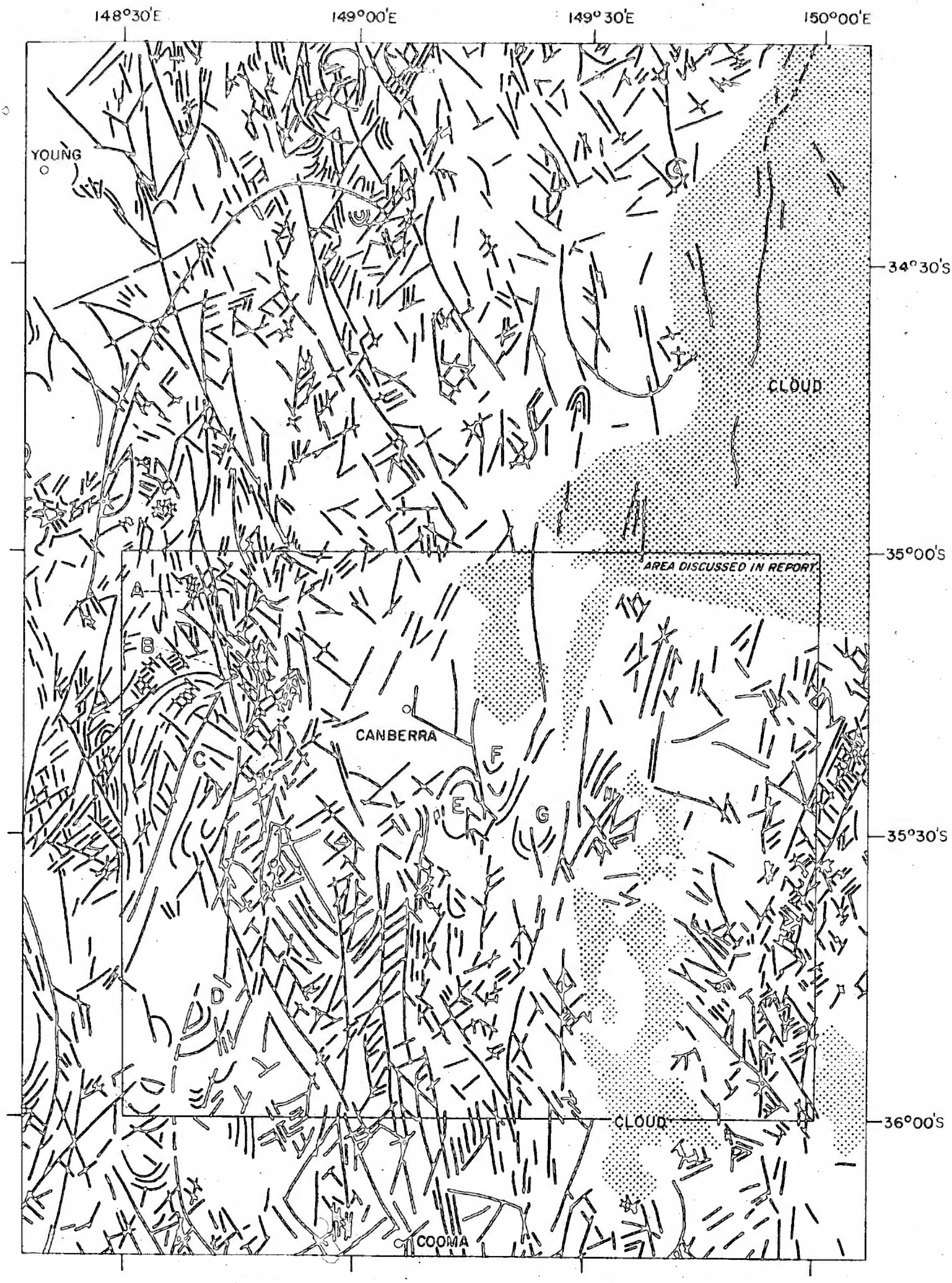
The same problems are encountered when individual copies of bands 4, 5, and 6, or false colour composites of the imagery, are used.

Therefore the interpretation of ERTS imagery by conventional techniques is not reliable in the differentiation and correlation of rock units in the Canberra area. This is probably due to the complexity of both the geological setting and the relationship between geology and morphology. The photogeological interpretation of large scale air photographs of the area is difficult.

6.6.2 Structure

Figure 6a shows lineaments interpreted from ERTS images. Most long lineaments (25 km or more) have a roughly north-south trend which is clearly related to the horst-and-graben structure of the region. In the western half of the sheet area, the long lineaments correspond fairly well with faults shown in the 1:1 000 000 geological map (Fig. 6b). The correspondence is not so good in the eastern half, where the geology is less well known, where widespread deforestation took place in flat country, and where scattered cloud cover was present when the ERTS images were taken.

In particular, the Long Plain Fault (A in Fig. 6b), the Cotter Fault (B), the Murrumbidgee Fault (C), the Queanbeyan Fault (D), and the Narongo Fault (E) are represented at least in part on ERTS images. On the images the Deakin Fault (F) is not well represented in the Sheet area, but outside the sheet area a strong ERTS lineament is



CANBERRA AREA

Data from:

ERTS I interpretation

0 10 20 30 40 50

KILOMETRES

Lineament

To accompany Record 1974/50

I 55/A16/1129

Fig 6a

Published geology (1:1,000,000 scale) —— Fault

Detailed mapping (1971–1973 unpublished)

—— Fault or inferred fault

------ Airphoto lineament

on trend with the fault for about 60 km in a north-northwest direction. The Lake George Fault (G) is parallel but not coincident with an ERTS lineament; when the geological map was compared with ERTS images, it was found that Lake George had been plotted about 2 km west of its correct position and that this displacement accounted for the discrepancy.

An example of new information obtained from ERTS interpretation is the extension to the south of the Tantangara Fault (H). Recent 1:100 000 scale mapping has indicated a fault that coincides with part of the lineament mapped from ERTS and is on trend with the Tantangara Fault.

Among faults which were not interpreted as lineaments on the images are the Whiskers Fault (I) and the Shoalhaven Fault (J), which are both in grassland country.

Many more short lineaments (shorter than 25 km) are shown in the ERTS interpretation (Fig. 6a) than in the 1:1 000 000 map (Fig. 6b). However, when the ERTS interpretation is compared with unpublished detailed mapping which was carried out during the 1971/73 period in the southwestern corner of the sheet area (Fig. 6c), several of those lineaments appear to match fairly well with mapped faults.

Some curved lineaments are visible in the imagery. The areas in which they appear are indicated in Figure 6a by letters A to G.

At A, B, and C these lineaments may correspond with fractures associated either with folding, or with the emplacement of granite bodies, or with volcanic activity. Since they cross the boundaries between different rock units (Fig. 5b) they cannot represent bedding traces.

The curved lineaments at D may correspond with either fractures or bedding traces, or both.

At E, the curved lineaments form part of a ring whose rim passes through two mapped outcrops of granite. This suggests that these lineaments are associated with the presence of a single intrusion. If this is so, then there is a possibility that the lineaments at F and G immediately to the east of E, are associated with the presence of either buried or un-mapped granite bodies.

6.7 Conclusions

In the Canberra area, little lithological information could be obtained from ERTS images, mainly because of complex geological structure and a poor lithology-to-morphology relationship.

Many lineaments traced from ERTS images correspond with mapped faults. It is probable that some lineaments coincide with the un-mapped extensions of known faults and with major joint patterns, but this has not yet been checked in the field.

The correspondence between ERTS lineaments and faults is poorest in areas of man-made alterations to natural vegetation.

Some curved lineaments may be linked with bedding traces or with fractures associated with folding, emplacement of intrusive bodies, or volcanic activity.

6.8 References

BEST, J.G., D'ADDARIO, G.W., WALPOLE, B.P., & ROSE G., 1964 - Canberra, A.C.T. and N.S.W. - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SI/55-16.

GUNN, R.H., STORY, R., GALLOWAY, R.W., DUFFY, P.J.B., YAPP, G.A., & McALPINE, J.R., 1969 - Lands of the Queanbeyan-Shoalhaven Area, A.C.T. and N.S.W. CSIRO Land Res. Ser. 24.

POGSON, D.J., 1972 - Geological Map of New South Wales, scale 1:1 000 000. Geol. Surv. N.S.W., Sydney.

STRUSZ, D.L., 1971 - Canberra, Australian Capital Territory and New South Wales - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SI/55-16 (2nd Edn).

STRUSZ, D.L., & HENDERSON, G.A.M., 1971 - Canberra City, A.C.T. - 1:50 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes.

7 - GENERAL CONCLUSIONS

From the investigation of ERTS imagery over three separate areas of Australia it is concluded that:

> Quality of original imagery varied considerably with respect to density and contrast. The high radiance linear density products were more uniform.
>
> Imagery of sparsely vegetated arid areas allows a better appreciation of general rock distribution and trends than imagery from well vegetated temperate regions.

Rock type differentiation or correlation on tonal/textural criteria is not reliable for the purposes of regional small-scale geological mapping, but may be useful in specific localized cases.

Stereoscopic examination of overlapping images from adjacent orbits assists geological interpretation particularly where land form reflects geology.

Landform, and thus geology, can be better interpreted from low sun-angle than from high sun-angle imagery.

Lineaments interpreted on ERTS imagery may correlate with man-made features, rock trends, faults, joints or dykes, and in the absence of indicators (e.g. fault displacements) no definite criteria could be established to determine what features cause particular lineaments.

Correlation of published geology with ERTS data shows that some known faults probably extend further than shown on published maps.

ERTS-1 imagery is a useful aid to conventional techniques of regional small-scale geological mapping but is not a substitute.

8 - RECOMMENDATIONS

To improve the quality of geological data that can be interpreted from ERTS type imagery it is recommended that:

The quality of normal photographic products should be improved to the standard of high radiance linear density products.

NASA should consider producing early generation 1:1 000 000 scale positive transparency products for shipment to investigators in addition to the normal 70 mm products.

A more extensive coverage of low sun-angle imagery should be obtained with future satellites.

The possibility of obtaining in future a more extensive coverage of stereoscopic imagery should be investigated.

42

APPENDIX

ERTS-1 Imagery Examined During Evaluation

IMAGE NUMBER	IMAGE DATE	SUN ELEVATION	% CLOUD COVER
	MOUNT ISA AREA		
1009 - 00120	1 August 72	36	12
1027 - 00121*	19 August 72	40	3
1027 - 00123*	19 August 72	39	0
1116 - 00073*	16 November 72	58	0
1116 - 00080*	16 November 72	57	0
1152 - 00073*	22 December 72	55	0
1152 - 00080*	22 December 72	55	0
1153 - 00134*	23 December 72	53	3
1189 - 00133*	28 January 73	51	3
1206 - 00081	14 February 73	49	20
1296 - 00081	15 May 73	35	0
	ALICE SPRINGS AREA		
1011 - 00250	3 August 72	32	0
1030 - 00303	22 August 72	38	22
1085 - 00363	16 October 72	54	0
1101 - 00255	1 November 72	56	0
1102 - 00311	2 November 72	56	0
1119 - 00254	19 November 72	57	0
1139 - 00371	9 December 72	56	0
1155 - 00253	25 December 72	55	1
1191 - 00255	30 January 73	50	0
1192 - 00314	31 January 73	50	6
1209 - 00261	17 February 73	48	5
1210 - 00313	18 February 73	48	5
1210 - 00315	18 February 73	48	4
1227 - 00255	7 March 73	46	0
1227 - 00262	7 March 73	46	0
	CANBERRA AREA		
1017 - 23245	9 August 72	26	16
1105 - 23144	6 November 72	51	8
1106 - 23202	6 November 72	51	50
1142 - 23201	12 December 72	54	32
1142 - 23203	12 December 72	53	7
1161 - 23254	31 December 72	52	0
1179 - 23253	18 January 73	49	0
1179 - 23255	18 January 73	49	0

* High radiance linear density product

43