

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

E7.5-10328

CR 143065

"Made available under NASA sponsorship
in the interest of early and wide dis-
semination of Earth Resources Survey
Program information and without liability
for any use made thereof."

Quarterly Progress Report, December 1974 - February 1975

SKYLAB EREP Investigation 475, Contract Number NAS 9-13406

INTERDISCIPLINARY APPLICATION AND INTERPRETATION OF
EREP DATA WITHIN THE SUSQUEHANNA RIVER BASIN*

Office for Remote Sensing of Earth Resources (ORSER)
Space Science and Engineering Laboratory (SSEL)
Room 219 Electrical Engineering West
The Pennsylvania State University
University Park, Pa. 16802

Principal Investigators: Dr. George J. McMurtry
Dr. Gary W. Petersen

NASA Technical Monitor: Mr. Martin Miller

(E75-10328) INTERDISCIPLINARY APPLICATION
AND INTERPRETATION OF EREP DATA WITHIN THE
SUSQUEHANNA RIVER BASIN Quarterly Progress
Report, Dec. 1974 - Feb. 1975 (Pennsylvania
State Univ.) 16 p HC \$3.25

N75-27516

CSSL 08H G3/43

Unclas
00328

March 1975

*USER IDENTIFIED SIGNIFICANT RESULTS

Quarterly Progress Report

December 1974 - February 1975

SKYLAB EREP Investigation 475
Contract Number NAS 9-13406

RESEARCH ACTIVITIES

Photointerpretation

Lineament Interpretation Analysis:

It has become evident that lineaments seen on SKYLAB and ERTS images are not equally well defined, and that the clarity of definition of a particular lineament is recorded somewhat differently by different interpreters. In an effort to determine the extent of these variations, a semi-quantitative classification scheme has been devised. This scheme involves three interpreters (Gold, Nowalik, and Krohn) and three confidence categories of lineaments (obvious, less obvious, and vague).

The method can be summarized as follows: Each of the three interpreters scans the whole area of the image and records with the symbol "3" the largest and most obvious lineament (there may be one or two others, equally obvious, and these are recorded also). Then respectively smaller areas of the image are scanned and the less obvious lineaments ("2") and finally the vague ("1") lineaments are recorded. (The nature of the lineament is also recorded, as follows: A - major stream alignment, B - minor stream alignment, C - tonal variation.) Lineaments are drawn on the image according to the scheme shown in the table below. This scheme is based on three interpreters observing lineaments in three categories. A lineament observed by all three interpreters carries three numbers. A zero means that the lineament was not observed by that interpreter.

<u>Class</u>	<u>Symbols</u>			<u>Sum of Symbols</u>	<u>Map Symbol</u>
I	333			9	Solid Line
	332			8	
	322	331		7	
II	222	321	330	6	Dashed Line
	221	311	320	5	
	2.1	310	220	4	
III	111	210	300	3	Dotted Line
	110	200		2	
	100			1	

C-2

Lineament Comparisons -- SKYLAB and ERTS:

Lineament detections on SKYLAB and ERTS scenes are also being compared, with the objective of determining if the same features are seen on both sets of data and to what extent the precision of determination differs for the two data sets. An area over north central Pennsylvania has been chosen (SL4, S190B, roll 91, frame 324; and ERTS 1459-15221-7, 25 Oct 73) and the lineaments have been plotted on both scenes. The lineament end points have been digitized, the information stored in computer compatible format, and their orientations compared by use of summarization programs. It has been found that the major peaks in the distributions are the same, and that well expressed lineaments are much more likely to be detected on both the SKYLAB and ERTS scene than are lineaments which are poorly defined on one or the other. This analysis will be expanded to include an evaluation of various SKYLAB sensors and image formats with respect to lineament detection in north central Pennsylvania.

Prospecting for Ore Deposits:

Research has been continuing in the identification of ground evidence for lineaments and their usefulness in prospecting for lead-zinc deposits. In the field, along the crest of Bald Eagle Mountain in central Pennsylvania, statistical techniques borrowed from sedimentary petrography (point counting) were used to determine the existence and location of intensely fractured float rock -- zones of brecciation must likely to be the field manifestation of lineaments. (Such fractured rock zones are highly preferential sites for localization of lead-zinc deposits.) Verification of SKYLAB and ERTS detected lineaments on aerial photography at different scales indicated that the brecciated zones appear to occur at one margin of the 1 km zone of brecciation defined as a lineament. This suggests that lineaments should be regarded as indirect, rather than direct, tools for the location of lead-zinc ore deposits. The imagery and photography used in this analysis are listed below.

SL4: S190A, Roll 55, Frame 317

ERTS-1: 1045-15247-7, 6 Sep 1972
1243-15253-7, 23 Mar 1973

U2: 73-009, 25 Jan 1973, Sensor 14, Frames 82257-83300
74-016, 5 Feb 1974, Sensor 23, Frames 252-253
74-060, 25 Apr 1974, Sensor 17, Frames 8108, 8128, 8135

RB57: Mission 248, 30 Aug 1973, Roll 103, Frames 243-247

C130: Mission 226, 12 Jan 1973, Roll 2, Frames 124-143
Roll 12, Frames 142-193

Mission 230, 15 Apr 1973, Roll 91, Frames 100-165
Roll 74, Frames 224-244

Mission 258, 12 Feb 1974, Roll 145, Frames 1-18
Roll 156, Frames 90-143

C54: Mission 183-2 10 Jan 1973, Roll 202-1, Frames 19-88

Groundwater Prospecting and Engineering Problems:

In the study of the applications of lineaments to groundwater and geologic engineering problems, an additional area is being considered for analysis. The U.S. Geological Survey has available a considerable body of well data in southeastern Pennsylvania. The advantage of this locality is its density of population, with a resulting concentration of wells in a small area. This presents the possibility of narrowing field variables, as statistically sufficient numbers of wells may be located within a single lithologic, stratigraphic, or structural unit.

Thermal Anomalies:

Thermal anomalies from SKYLAB and ERTS scenes are being studied using both photo-interpretative and digital processing techniques. The study concentration is in the Shermansdale Warm Springs area of Pennsylvania. Various geophysical and hydrogeological techniques will be used to correlate the remote sensing analyses with ground truth observations. A graduate assistant, Barry Weinman, has been appointed to work on this project.

SKYLAB Photography Quality:

The SKYLAB data quality comparison study, being conducted by Dr. Weeden and three students (see previous report) is progressing rapidly. In the Lock Haven area, for instance, comparison of the film types from the SL4 S190A sensor revealed the black and white Pan X photography to be superior in quality for general interpretation to the black and white IR film. Also, the color positive film is better for interpretation than the color IR film. These determinations were based on the interpreter's judgment of clearness and sharpness of the image, using a variety of viewing techniques (described earlier). A significant factor was the graininess of the film.

Geologic features identified on C130 aircraft photography (Mission 258, Roll 144, Frame 24) were sought on the SL4 S190B color positive photography (Roll 91, Frame 324 -- Orbit 73). An attempt was made to delineate on the SKYLAB photography the features identified on the aircraft photography. Unfortunately, three inches of snow on the ground and some cloud cover, present at the time of the SKYLAB data collection, somewhat limited this effort (in one instance, however, the snow proved to be an advantage). It was found that lithologic groups (such as sandstones, shales, and limestones) could be identified on the SKYLAB photography on the basis of topographic high and low points and drainage texture. It was not possible to determine

categories of rocks within lithologic groups, or to identify slope breaks in finer detail. The approximate location of first and second order drainage was identifiable from the shadows in the associated gullies -- an advantage of the low sun angle in January. However, accurate delineation of these small streams was not possible. Open fields were easily identified by their light covering of highly reflective snow. These stood in sharp contrast to the heavily forested areas.

It was possible to identify some street patterns in Lock Haven, Bellefonte, and State College. However, separation of roads from railroads was not possible on SKYLAB photography without assistance from the underflight photography.

Results similar to those indicated above are being obtained from the Harrisburg and Reading areas. Each of the three students, under the supervision of Dr. Weeden, will submit a detailed report on the results from his area and these reports will be combined and edited to obtain a technical report for this phase of the SKYLAB project.

Digital Processing

Preliminary SKYLAB Digital Data Tape Processing:

The SUBTRAN and TPINFO programs have been revised to process tapes in the SKYLAB S192 line-straightened and conical formats. The control card "SKYLAB" is used as input to both programs to notify them that a SKYLAB tape is to be read. The corresponding program manuals have also been updated.

Processing was done on a SKYLAB tape received from the Jet Propulsion Laboratory (JPL) in Pasadena, California. The SKYLAB tape header record contains the following information: The data tape was made on 5/15/74 at 19:25; there are twenty channels on the tape, as shown in the table below.

Channel Numbers and Spectral Bands			
Channel Number	Spectral Band (microns)	Channel Number	Spectral Band (microns)
1	0.52 - 0.56	11	1.55 - 1.75
2	0.52 - 0.56	12	1.55 - 1.75
3	0.56 - 0.61	13	2.10 - 2.35
4	0.56 - 0.61	14	2.10 - 2.35
5	0.62 - 0.67	15	12.00 - 13.00
6	0.62 - 0.67	16	0.46 - 0.51
7	0.68 - 0.76	17	0.98 - 1.03
8	0.68 - 0.76	18	1.09 - 1.19
9	0.78 - 0.88	19	10.20 - 12.50
10	0.78 - 0.88	20	0.41 - 0.46

No latitude and longitude were given to locate the data; there are ten records per video data set and two channels per record, which is in agreement with the twenty channels. There are 1240 pixels across a scan line; and there are 18 calibration bytes per channel. In addition, it was determined that there are 59 scan lines on the tape, and that there is only one data file.

The header record indicates that the data are in conical format, since there are 1240 pixels per scan line and calibration bytes present for each channel. However, the format description sent by JPL, accompanying the tape, describes the tape as being in the line-straightened format, where there are 1033 pixels and no calibration bytes. The conical and line-straightened formats are given in the "Earth Resources Data Format Control Book," pages 6.1.3-1 through 6.1.3-23.

A block of data containing 13 of the 20 channels (channel numbers 1, 3, 5, 7, 9, 11, 13, 17, 18, 19, 20, 21, and 22) was subset as if the original data were in conical format. A gray level map of the first 240 elements and 59 scan lines was output by the NMAP program. No distinctive patterns emerged.

The same 13 channels were subset as if the SKYLAB data were in the line-straightened data format. The rationale behind this was that perhaps the video data were in the line-straightened format as specified in the description from JPL. Again, no patterns emerged, and an 18 element wide band on the left-hand margin of the map indicated that calibration bytes are present.

A third block, containing only channel one, was subset. This time definite patterns could be identified in the grey level map, indicating that the lack of success with more than one channel may be caused by bad channels in the data or poor channel registration.

The preliminary SKYLAB digital data processing reports described above were submitted to Martin Miller on February 20, 1975. It was concluded that ORSER would have no problem working with SKYLAB tapes and that it would not be difficult to resolve the difficulties causing the lack of definite patterns on the preliminary tape supplied by JPL.

Program Refinements:

The programs SUBSET, SUBAIR, and SUBTRAN have been altered to output the number of scan lines present on the tape. Without this correction, it was necessary to specify a large number of records when subsetting SKYLAB and aircraft data, as the header records on these tapes do not indicate the number of scan lines present on the tape.

The TPINFO program has been updated to print information relevant to SKYLAB tapes, such as the longitude and latitude of the spacecraft nadir, orbit number, etc. Thus, the TPINFO program is now suitable for processing SKYLAB, ERTS, and aircraft data tapes.

Processing of SKYLAB Digital Data Tapes for Pennsylvania Areas:

Graduate student David Barr, under the supervision of Dr. Yates Borden, has begun processing the newly received SKYLAB data tapes for three Pennsylvania areas. One of the data tapes has been subset, and work has begun in the evaluation of the utility of the various channels and channel combinations for the classification of specific targets. The ultimate objective is to determine the utility of SKYLAB digital data for classification of targets significant to land use mapping.

A project has been initiated using SKYLAB MSS digital data to study lineaments that have been seen on SKYLAB photography and ERTS images. Cluster analysis programs will be run on SKYLAB and ERTS data in an attempt to classify lineaments into unique signatures. Digital filter techniques will be applied in the spatial domain to pick out lineament features from the image background. The method will be to assume that the intensities along a scan line form a power series. Recursive IIR (indirect impulse response) filters will be applied in order to filter out periodic features, such as ridges, on the images. It is anticipated that lineament features will remain after this process.

The study of acid mine drainage effects in Western Pennsylvania will be continued, using SKYLAB digital data. The increased resolution of and larger number of SKYLAB MSS data channels should aid in discriminating vegetation, stressed by acid mine drainage, from unstressed vegetation. As in the case of ERTS data analysis for such discrimination, cluster analysis programs will be used in this study.

RELATED ACTIVITIES

Abstracts for three SKYLAB-related papers were submitted for the Earth Resources Survey Symposium in Houston, to be held June 8-13, 1975. These papers were:

FIELD EXPRESSION OF LINEAMENTS AND THEIR RELATION TO PB-ZN OCCURRENCES ALONG BALD EAGLE MOUNTAIN IN CENTRE, BLAIR, AND HUNTINGDON COUNTIES, PENNSYLVANIA

M. D. Krohn and D. P. Gold

USE OF SKYLAB/EREP PHOTOGRAPHY AS GROUND TRUTH FOR LAND USE MAPPING USING ERTS MSS DIGITAL DATA

G. J. McHenry

APPLICATION OF SKYLAB PHOTOGRAPHIC AND MSS DATA TO SELECTED GEOLOGIC AND NATURAL RESOURCE PROBLEMS IN PENNSYLVANIA

S. S. Alexander, D. P. Gold, and R. R. Parizek

Abstracts for these papers are appended.

The color display system equipment has been received and is being installed in room 217 -- a new laboratory recently allotted to ORSER by the University. This system will be capable of displaying the results of ORSER software installed on the main computer system at the University. The system permits effective high speed man-machine interaction and direct digitization, display, and enhancement of SKYLAB, ERTS, and aircraft imagery and photography. Limited operation is expected in April.

A table top Diazo machine has been purchased from Diazo Specialty Company, Beltsville, Md. This machine had been on approval at ORSER for two months, and proved very effective in reproducing both SKYLAB and ERTS images in transparent and paper print form. The machine was recently used to make seven ERTS color composites for a section of western Pennsylvania for Moody and Associates, Inc., of Meadville, Pa. -- a firm interested in strip mine inventories.

Dr. Petersen visited the Tennessee Valley Authority installations at Norris and at Chattanooga, Tennessee. During these visits he discussed land analysis systems and toured TVA's remote sensing and cartographic facilities. He also gave a presentation, "Remote Sensing as an Input to Land Analysis," to TVA personnel in Norris. Dr. Petersen, who is on sabbatical leave to the University of Wisconsin, has been presenting lectures on remote sensing to classes at that University and to local groups. One such talk, on "Remote Sensing," was given to the Rotary Club in Oconomowoc, Wisconsin.

Larry Rowan, Geophysicist with the USGS, and W. Douglas Carter, with the EROS program, both from Reston, Va., visited in January to learn of our capabilities and to determine our interest in participating in remote sensing research programs in South America. Particular interest was expressed in lineament studies and a comparison of methods of digital processing. Dennis Krohn, soon to graduate with an MS in geology, is seeking a permanent position with the EROS center in Reston, and Bill Kowalik is seeking a summer job there. During this period, both students visited Reston to further explore these possibilities. Mr. Kowalik is also seeking PhD thesis funding from Larry Rowan to work on lineaments in Nevada.

Dr. McMurtry, accompanied by representatives from the department of Landscape Architecture (at Penn State), gave a presentation on remote sensing to members of the Office of State Planning and Development (OSPD) in Harrisburg. ORSER, along with several academic departments at Penn State, was asked by OSPD to review preliminary drafts of a land use policy plan for Pennsylvania.

Mr. Richard Wells, from the Pennsylvania Geologic Survey, visited ORSER in December to update some topographic maps from SKYLAB-related underflight photographs, using the Bausch and Lomb Zoom Transferscope. ORSER was also visited by Mr. Samuel Root and Dr. Donald Hoskins, also from the Pennsylvania Survey, who reviewed our work on lineament analysis.

Possible joint efforts between HRB Singer and ORSER are under discussion in relation to a proposal by HRB to the U. S. Bureau of Mines. The project, involving the use of color positive and color IR photography to monitor strip

mining operations, would involve ORSER in multiband analysis, ground truth collection, and color additive viewing work. It is expected that SKYLAB data will be partially involved in the initial stages of this work.

SKYLAB and ERTS images are being studied by Mr. Kowalik and Mr. Krohn in connection with repeated water main breaks in the South Lebanon and Indiantown Gap area of Pennsylvania. It is thought that these breaks are associated with possible movement along faults and lineaments.

Charles Kleeman, Graduate Student in Civil Engineering, has proposed to do an MS thesis concerning the evaluation of SKYLAB data for environmental pollution considerations. SKYLAB and aircraft photography have been consulted by students in Landscape Architecture in a study of the historic Pennsylvania canal system, and by Regional Planning students as source material in studies of the building distribution in local towns.

ORSER has been active in education during this period. A list of courses on campus directly or indirectly involved with remote sensing techniques has been compiled -- this list is appended. Remote sensing seminars have been conducted almost weekly (see appended schedule), and several graduate students have presented talks in seminars and colloquia on campus. Dr. McMurtry presented two talks on campus: "Thematic Mapping by Remote Sensing," to the Annual Surveyor's Conference; and "Processing Procedures, Requirements, and Examples for Satellite and Aircraft Remote Sensing Data," at the Applied Computing Seminar. Dr. Gold discussed "Satellite Surveillance and Ore Deposits" at a meeting of the Delaware Valley Chapter of the American Society for Metals.

ORSER activities with SKYLAB, ERTS, and aircraft data are being described in the latest issue of INTERCOLLEGE RESEARCH, a Penn State publication with wide distribution throughout the State and Nation. This publication is distributed to State and Federal governmental offices, colleges and universities throughout the Nation and high schools throughout the State; State newsmedia, industries, libraries, research organizations, and scientific societies; and to the offices of doctors and barbers throughout the State. In all, 4800 issues were distributed last year.

ORSER also recently completed an Energy Inventory questionnaire for the Subcommittee on Energy of the House Committee on Science and Astronautics, summarizing our contribution to energy research. Work with strip mines and similar activities, involving SKYLAB data, was described.

Interest in ORSER activities has been expressed by Dr. Fred A. Schmer, Assistant Director of the Remote Sensing Institute of South Dakota State University. A copy of ORSER-SSEL Technical Report 9-74, THE PENN STATE ORSER SYSTEM FOR PROCESSING AND ANALYZING ERTS AND OTHER MSS DATA, was sent to Dr. Schmer.

DATA FLIGHTS AND RECEIPTS

16 Dec	SL 3	S190B	2X photography
20 Dec	SL 3	S190A	4X photography
9 Jan	SL 4	S190B	2X photography
6 Feb	SL 4	S190B	2X photography
10 Feb	SL 3	S192	Straight scan tapes
26 Feb	SL 3	S190A	Pos and Neg photography
27 Feb	SL 3	S192	MSS imagery

COURSES AT PENN STATE CONTAINING MATERIAL ON REMOTE SENSING AND/OR PHOTOINTERPRETATION:

Agronomy 415	Soil Morphology, Mapping and Land Use
Architecture 490.1	Computer Cartography
Civil Engineering 112	Photogrammetry and Photo Interpretation
Civil Engineering 316	Photogrammetry and Photo Interpretation
Civil Engineering 512	Applied Soil Mechanics
Electrical Eng. 530	Adaptive Systems and Pattern Recognition
Forestry 455	Aerial Photos in Forestry
Forestry 597	Remote Sensing of Earth Resources
Geography 410	Cartography - Map Design and Construction
Geography 451	Map Interpretation
Geography 452	Interpretation of Aerial Photographs
Geography 457	Geographic Data Systems
Geology 546	Principles of Photogeology
Geology 596	Introduction to Remote Sensing and Air Photo Techniques

REMOTE SENSING SEMINARS, WINTER TERM 1975:

January 13	SATELLITE DETECTION OF VEGETATIVE DAMAGE AND ALTERATION CAUSED BY POLLUTANTS E. L. Fritz, Research Aid in Plant Pathology Dr. S. P. Pennypacker, Asst. Prof. in Plant Pathology
January 20	RELATION OF LINEAMENTS TO GEOCHEMICAL ANOMALIES AND LEAD-ZINC OCCURRENCES ALONG BALD EAGLE MOUNTAIN M. Dennis Krohn, Graduate Asst. in Geology
January 27	DIFFERENTIATION OF FOREST COVER TYPES USING ERTS-1 MSS DATA, ORSER PROGRAMS, AND GE IMAGE 100 TECHNIQUES James Anderson, Instructor in Forest Resources
February 3	MACHINE MERGING OF GROUND TRUTH DATA WITH REMOTE SENSING DATA Hugh A. Devine, Res. Asst. in Forest Resources Dr. F. Yates Borden, Assoc. Prof. of Forestry
February 17	THE APPLICATION OF MULTISPECTRAL SCANNER DATA TO FOREST SOIL MAPPING Thomas W. Simpson, Grad. Asst. in Agronomy

ABSTRACTS

Field Expression of Lineaments and Their Relation to Pb-Zn Occurrences Along Bald Eagle Mountain in Centre, Blair, and Huntingdon Counties, Pennsylvania

M. D. Krohn and D. P. Gold

The alignment of 5 lead-zinc occurrences along the ERTS-identified Tyrone - Mount Union lineament in central Pennsylvania makes other lineaments located on ERTS-1 scenes potential targets for further mineral exploration. However, the discontinuity of scale between megascopic lineaments detected on ERTS and SKYLAB/EREP scenes and mesoscopic features observed on the ground handicaps direct aerial-photographic correlation and suggests using statistical techniques to characterize the ground observations. Point-counting, a technique of sedimentary petrography which compares observations between the mesoscopic and microscopic scales, is well-suited to the data-gathering requirements of a remote-sensing experiment.

To test this methodology, 60 kilometers along the ridge of Bald Eagle Mountain were sampled at 0.4 km intervals by making counts of brecciated quartzite float. Frequency distributions for the breccia approximated the negative binomial affirming a zonation of the breccia into a non-homogeneous population. The mean width of these zones is approximately 1 km, although large variations in width were observed. The concept of lineaments as wide zones of fracturing helps explain the offset of potential mineralized gossans from the physiographic features defining the lineaments.

Support for the work reported here was provided by NASA contracts NAS 5-23133 and NAS 9-13406, as part of the ERTS-1 and the SKYLAB/EREP programs, respectively (Principal investigators: G. J. McMurtry, G. W. Petersen).

Use of SKYLAB/EREP Photography as Ground Truth for Land Use Mapping Using ERTS MSS Digital Data

G. J. McMurtry*

Land use mapping from ERTS MSS digital data was accomplished with major verification information provided by SKYLAB/EREP S190B photography. The objective of the study was to compare classifier performance on a relatively simple data site, i.e., where relatively large areas of homogeneity exist. An area along the Allegheny River, just west of Oil City, Pa., was chosen primarily because of the presence of large visually uniform areas and the availability of unbanded and cloud-free ERTS and SKYLAB/EREP data for the scene. The area is very heavily forested.

*Office for Remote Sensing of Earth Resources, 219 Electrical Engineering West, The Pennsylvania State University, University Park, Pa. 16802

It was decided to do a five class land use analysis on the area, restricting the classes to water, city (urban and suburban), agricultural land (of all types), forest (all kinds), and abused land (strip mines, etc.). This necessitated making each of the latter classes broad enough so that they include all of the various subclasses which conceivably could be formed in other analyses with these data. Making these classes broad involved the definition of classes with several different training areas for each class, as well as breaking down some classes into two or three subclasses. For example, the three types of forest present in the scene each had its own training area, but in the resultant map were given the same "forest" mapping symbol. It was found in the analysis that there were three types of forest (deciduous, coniferous, and shaded trees). Shaded trees are those located in valleys (where there is a different intensity of ambient light). Only one water class (for the Allegheny River) was needed.

The visual ground truth employed (SKYLAB photographs, in this case) in the analysis provided assurance of training area homogeneity. SKYLAB photographs were used as photographic ground truth because they were the only photographic source available. It was decided that lower altitude (more detailed) photos would not be necessary anyway since a relatively non-detailed classification was sought. Another source of ground truth was the set of USGS topographic maps for the area.

The SKYLAB data used was frame number 342 of roll number 85 (S190B). The data was taken on September 10, 1973 (orbit 30). The film was five inch by five inch black and white, and the wavelengths measured were .5 to .7 μm .

The ERTS data used in this phase of the research was taken from scene 1028-15295, obtained on August 20, 1972. All four MSS channels were used.

A very detailed process of "eyeball" point-by-point comparison of the EREP photography and the computer processed classification map was used to determine classifier accuracy. The care with which this was done, however, made this procedure almost as accurate as the zoom transfer scope (ZTS) superposition technique. An attempt to use the ZTS with the SKYLAB photo was made, but it was found that the difference in scale between the photograph and the computer-produced map necessitated reducing the computer map to such a scale as to make individual mapping symbols indistinguishable. Magnifying the SKYLAB photo an equal amount made class boundaries unobservable.

During analysis of the data it was realized that, due to the similarity of some land areas (primarily abused land) and roads, railroad tracks and large oil bins, a large number of the city signatures were being misclassified as abused land. This lowered the accuracy of classification below an acceptable level. Upon reference to the topographical maps, which detail such information as large buildings, oil storage drums, railroad tracks, and roads, it was found that most of the area originally classified as abused land actually fell into the above categories. Since these categories could not properly be put into any of the other four categories, they were lumped into an "other" category. By this process, percentage classification of all classes was

acceptable without penalizing the classification of any one of the original five classes. The presence and locations of the various "other" categories were determined by means of the ZTS, superimposing the topographical map onto the computer map.

Several preprocessing and classification algorithms in the ORSER system of programs were compared. The numerical classification results are discussed and the resulting classification maps are shown.

The data used for the work reported here was provided in part by NASA contract NAS 5-23133 of the ERTS-1 program (Principal Investigators: G. J. McMurtry and G. W. Petersen) and NASA contract NAS 9-13406 of the SKYLAB/EREP (Principal Investigators: G. J. McMurtry and G. W. Petersen).



Application of SKYLAB Photographic and MSS Data to Selected Geologic and Natural Resource Problems in Pennsylvania

S. S. Alexander, D. P. Gold and R. R. Parizek*

SKYLAB S190A, S190B, and MSC digital data have been utilized in studies of several specific geologic and resource problems in Pennsylvania.

These include:

1. Scale and Resolution of Geologic Features: In several areas we have compared the resolvability of structural geologic features such as faults, lineaments, and folds as well as specific rock types exposed at the surface by examining the data for each region of interest provided by ERTS-1, SKYLAB, Aircraft underflights (including U-2), and ground-based surveys. SKYLAB data provides an important intermediate link between the ERTS-1 synoptic view and aircraft coverage.
2. Lineaments Associated with Mineral Deposits: SKYLAB data has been used to advantage in verification of lineaments and lineament intersections associated with known mineral deposits in SE Pennsylvania and the Tyrone - Mt. Union areas. SKYLAB also provides more precise locations of these lineaments than is possible with ERTS-1 imagery.

*Office for Remote Sensing of Earth Resources, (ORSER), The Pennsylvania State University, 219 Electrical Engineering West, University Park, Pennsylvania 16802.

- 3. Thermal Hot Spot: SKYLAB photography has been used in conjunction with coverage from ERTS-1, U-2, C130 and ground based geophysical surveys to investigate the origin of a thermal hot springs area near Shermansdale, Pennsylvania. The hot spring is readily discernible using thermal IR, and subtle tonal variations in the high altitude images indicate that the hot spot is on the periphery of a large (30 km diameter) circular feature that appears to coincide with a major (500 gamma) magnetic anomaly believed associated with a deep pluton not previously recognized in Pennsylvania. Alternative associations can be made with lineaments that pass through the hot spot area, and possibly with diabase dikes that crop out in the vicinity.
- 4. Ground Water Problems: SKYLAB S190A and S190B photographs have been used to verify suspected associations of geologic features (e.g. lineaments) to ground water movements. Increased yields have been associated with water wells located on lineaments as compared with adjacent sites. A recent problem of nearly simultaneous rupturing of water mains in the Lebanon, and Indian Town Gap areas, approximately 12 miles apart, appears to be related to two lineaments and a fault discernible on the SKYLAB and ERTS-1 photographs.
- 5. Digital Analysis: We have applied various classification processing (e.g. cluster analysis) to SKYLAB and ERTS-1 MSS data to determine spectral signatures in various surface features as viewed at the two altitudes. Specific targets of interest include areas of coal mining and specific rock-type signatures, as well as faults and lineaments in Southwestern Pennsylvania. In addition, pattern recognition algorithms have been applied in a preliminary attempt to isolate subtle features not discernible on the photography.

The data used for the work reported here was provided by NASA contract NAS 9-13406 of the SKYLAB/EREP (Principal Investigators: G. J. McMurtry and G. W. Petersen).



Photointerpretative Analysis of Skylab Photography for Engineering Purposes

H. A. Weeden, S. Daelhausen, C. Kleeman, and G. Hessler*

Skylab photography has been studied for its use in evaluating terrain for soils and bedrock characteristics as they affect engineering decisions. In Pennsylvania, engineering soil and geology maps have successfully been made from aerial photographs taken at scales varying from 1:4800 to 1:60,000. The procedure involves a detailed study of a stereoscopic model while evaluating land form, drainage, erosion, color or gray tones, tone-texture patterns, vegetation, and cultural or land use patterns. The purpose of this study has been to ascertain the level of achievement that can be attained in this type of analysis of Skylab photography.

*Office for Remote Sensing of Earth Resources, 219 Electrical Engineering West Building, The Pennsylvania State University, University Park, Pa. 16802

Scenes from three geographic areas in Pennsylvania, centered around State College, Harrisburg, and Reading, were studied. All available photographic forms from the S190A and S190B sensors over the study areas were evaluated. After evaluation, the results from the various formats were compared and the best selected for the purpose in mind. Seasonal comparisons were also made, using photographs from two different Skylab passes.

After studying the Skylab photography, the evaluators checked aircraft underflight photography for the greater detail available. Comparisons of selected features on Skylab photographs and underflight photographs were prepared. Then the analyst returned to the Skylab photographs to see if greater detail could have been read initially if the evaluator had been more alert or conditioned to expect a certain level of performance.

Certain trends were observed consistently across the variety of film types with respect to certain terrain features:

1. Major drainage, such as rivers and their tributary creeks were adequately visible in all of the photography.
2. The sandstone ridges of the Appalachian Ridge and Valley region were adequately and sharply visible in all of the photography.
3. Slope breaks between the sandstone ridges and the flatter lying shales were adequately visible, by changes in the vegetative cover, in all of the photographs.
4. With the aid of underflight photography for positive identification, limestone quarries in the Great Valley could be located in all of the photography.
5. Minor drainage was visible by its adjacent vegetation in all of the photography except that of S190A in the bandwidth ranges .7-.8 and .8-.9 micrometers (Stations 1 and 2).
6. The color/tonè variations in the Susquehanna River were visible in all of the photography except Stations 1 and 2.
7. The Triassic mountains were adequately visible in all of the photography except Stations 1 and 2.
8. Vegetation sensitivity was at least good in all of the photography except Stations 1 and 2.
9. Reservoirs and lakes were clearly visible in only the photography of Stations 1 and 2.
10. Cultural features were adequately visible in all of the photography except Stations 1 and 2.
11. The water/wind gaps in Little Mountain were adequately visible in only the photography of Stations 1 and 2.

This study provides a basis for analytical evaluation of the MSS data now available from Skylab.