APPLICATIONS OF SKYLAB EREP PHOTOGRAPHS TO MAPPING OF LANDFORMS AND ENVIRONMENTAL GEOLOGY IN THE GREAT PLAINS AND MIDWEST

(EREP NO. 491; NASA Contract No. T-4647-B)

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Federal Center

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(E75-10055) APPLICATIONS OF SKYLAB EREP PHOTOGRAPHS TO MAPPING OF LANDFORMS AND ENVIRONMENTAL GEOLOGY IN THE GREAT PLAINS AND MIDWEST Progress Report, (Geological Survey) 32 p HC $3.75 CSCL 08B G3/43 N75-13355 Unclas 00055

1 July 1974

Progress report for period January 1 - June 30, 1974

NASA Technical Monitors: Martin Miller and David Amsbury

EREP Investigations Office, Code TE

NASA L. B. Johnson Space Center

Houston, Texas 77058

STANDARD TITLE PAGE FOR TECHNICAL REPORTS

1. Report No.

2. Gov't Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle

Applications of Skylab EREP photographs to mapping of landforms and environmental geology in the Great Plains and Midwest

5. Report Date

1 July 1974

6. Performing Organization Code

7. Author(s)

Roger B. Morrison

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

U. S. Geological Survey
Federal Center
Denver, Colorado 80225

10. Project/Task Work Unit No.

EPN 491 Task 303

11. Contract/Grant No.

T-4647-B

12. Sponsoring Agency Name and Address

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EREP Investigation Office, Code TE
NASA L. B. Johnson Space Center
Houston, Texas 77058

13. Type of Report & Period Covered

Progress report
Jan. 1 - June 30 1974

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstracts

Coverage with less than 30% clouds by Skylab 2 and 3 S-190A multispectral photos in the project area--the states of Illinois, Iowa, Kansas, Missouri, Nebraska, and South Dakota--totals about 568,000 sq km. The utility of these photos for environmental-geologic/geomorphic applications is being tested by using them to prepare 1:250,000-scale maps of geomorphic features, surficial geology, geologic linear features, and soil associations of large, representative parts of the Great Plains and Midwest. Parts of Nebraska, Iowa, Missouri, and South Dakota were mapped during the reporting period. The maps are prepared primarily by interpretation of the S-190A photos, supplemented by information from topographic, geologic, and soil maps and reports. The color band provides the greatest information on geology, soils, and geomorphology; its resolution also is the best of all the multispectral bands and permits maximum detail of mapping. The color-IR band shows well the differences in soil drainage and moisture, and vegetative types, but has only moderate resolution. The B/W-red band is superior for topographic detail and stream alinements. The B/W-infrared bands best show differences in soil moisture and drainage but have poor resolution, especially those from SL 2. The B/W-green band generally is so low contrast and degraded by haze as to be nearly useless. Where the photos provide stereoscopic coverage, interpretation and mapping are done most efficiently in a single operation using a Kern PG-2 stereoplotter.

17. Key Words and Document Analysis. (a). Descriptors

Quaternary geology and geomorphology; environmental geology; landform analysis; glacial geology; soil survey; regional land-use planning

18. Distribution Statement

19. Security Class (This Report) UNCLASSIFIED

21. No. of Pages

20. Security Class. (This Page) UNCLASSIFIED

22. Price

FORM NBS-667(1-70)

Status summary

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Accomplishments

This project received severe setbacks because of two successive resignations of the PI's (principal investigator) associate; the first resigned in February, and the second in May. Twice it was necessary to find and train replacements. Nevertheless, the following accomplishments can be reported:

(1) We received the following SL (Skylab) 2 and 3 photographs, mostly in duplicate, of the six-state project area:

a. Transparency copies of the six bands from the S-190A multispectral camera array, in 70-mm format.
b. Transparency copies of the S-190B earth-terrain camera 5-inch color photographs.
c. Transparency 4X enlargements of all bands of the S-190A photos.
d. Transparency 2X enlargements of the S-190B photos from SL 2, but none from SL 3.
e. Color print 2X enlargements of SL 2 S-190B photographs from Track 19.

No SL 4 photographs were received during the reporting period. However, we received our first SL 4 photographs July 8. They are from S-190A, in 70-mm format.

In addition, we received color and color-infrared transparency copies of 9-inch format airphotos taken November 28, 1973, on Missions 260 and 261 by a Wild RC-8 metric camera aboard a WB-57 aircraft. Mission 260 consisted of three east-west flight lines and provided complete coverage of the northern half of the Omaha and northwestern ½/ of the Des Moines 1° x 2° quadrangles, Iowa-Nebraska. Mission 261 consisted also of three east-west flight lines that provided partial coverage (about 60%) of the Moberly, Kansas City, and east half of the Manhattan 1° x 2° quadrangles, Missouri-Kansas.

(2) We indexed all the Skylab S-190A and S-190B photographs and WB57F airphotos received both on State base maps (scale 1:1,000,000) and 1° x 2° quadrangle maps (scale 1:250,000).

(3) We distributed duplicate copies of the S-190A (70 mm and 4X enlargements), S-190B (5-inch and 2X enlargements), and WB57F airphotos to the respective State Geologists for analysis and comment.

(4) We evaluated the S-190A and S-190B skylab photos of the project area in terms of (a) cloud cover, (b) photographic quality, and (c) coverage, especially noting coverage with less than 30% clouds. Results of this evaluation are given in Table 1 and Figure 1. Coverage with less than 30% clouds totals about 568,000 sq km.

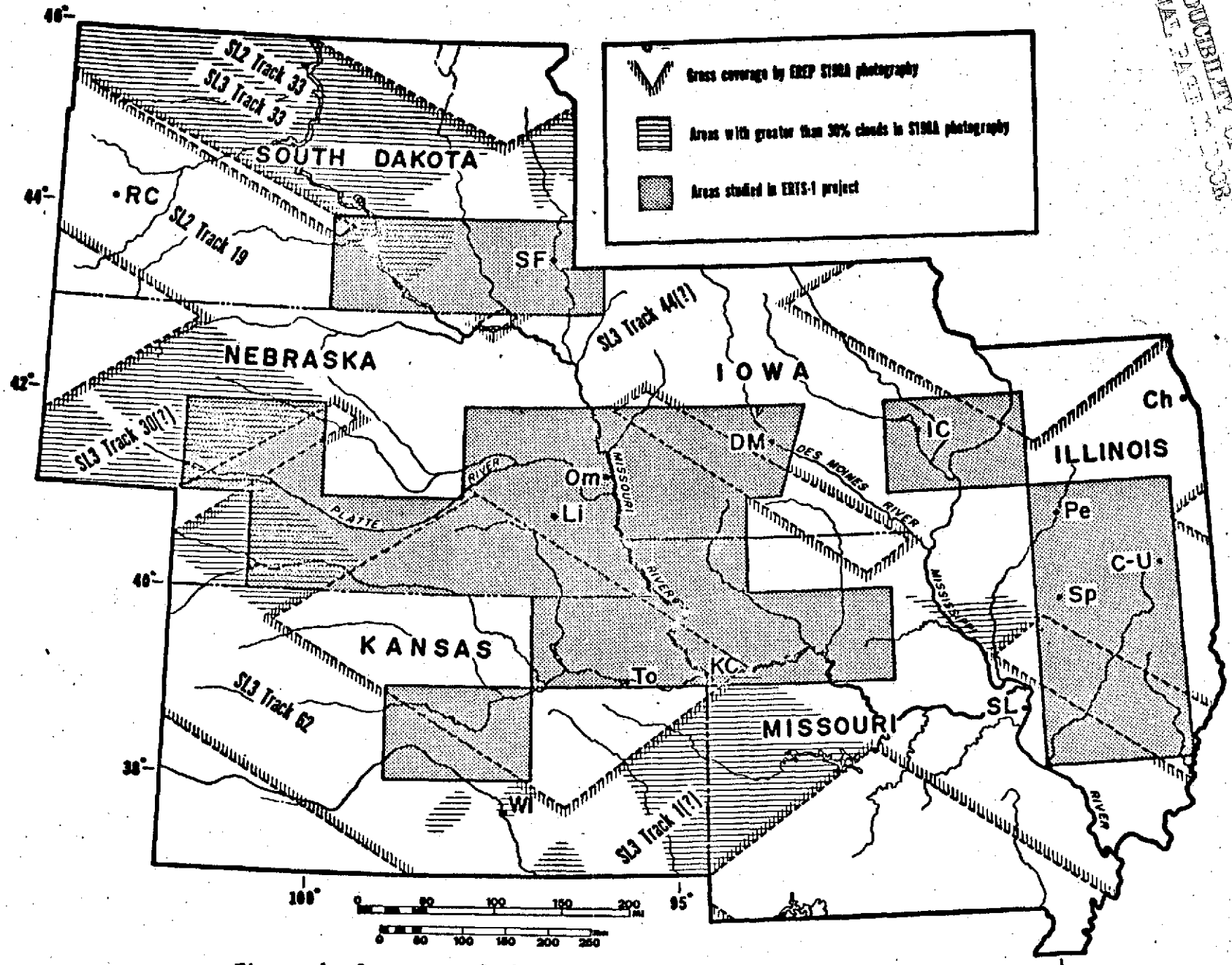

Figure 1. Coverage of the project area by Skylab S190A photography.

Table 1. Evaluation chart for Skylab photography of the project area.

SYSTEM / Track/Date	ROLL NO. (color)	FRAME NOS. (color) (color IR)	CLOUD COVER 0-5%	CLOUD COVER 5-30%	CLOUD COVER >30%	ENDLAP (%)	PHOTOGRAPHIC QUALITY*		REMARKS
							70mm.	4X Enlrg.	
SKYLAB 2									
S190A									
19 (6/10/73)	10	120-156	120-156			60	Excellent	Good	State coverage: S.D. (120-127) Neb. (128-134) Ia. (135-136) Mo. (137-144) Ill. (145-151)
33 (6/10/73)	10	232-260	240-260	239-241	232-238	60	Excellent	Fair	State coverage: S.D. (232-240) Ia. (241-250) Ill. (251-259)
							5 inch	2X Enlrg.	
S190B									
19 (6/10/73)	81	157-201	157-178 181-194 196-201	179-180 195		60	Excellent	Excellent	State coverage: S.D. (157-165) Neb. (166-174) Ia. (175-178) Mo. (179-189) Ill. (190-195)
33 (6/10/73)	81	407-342	317-362	316-315	307-314	60	Good	Good	State coverage: S.D. (313-316) Ia. (317-329) Ill. (330-338)
SKYLAB 3									
S190A							70mm.	4X Enlrg.	
1† (9/18/73)	46	186-198	196-198	195	186-194	15 60	Excellent	Excellent	Most frames have 60% endlap. State coverage: Kan. (189-191) Mo. (192-194) Ill. (195-198)
30† (9/10/73)	40	053-060		060	053-059	15	Excellent	Good	State Coverage: Neb. (053-056) S.D. (057-060)
33 (9/20/73)	46	251-267		262	251-261 263-267	15 60	Excellent	Good	Endlap varies. State coverage: Ia. (259-262) Ill. (263-264)
44 (9/7/73)	33	276-303			276-303	60	Excellent	Excellent	100% clouds over study area.
44† (9/6/73)	34	232-264	256-259	260	252-255 261-264	15	Excellent	Excellent	State coverage: Neb. (254-257) Ia. (258-261)
62 (8/5/73)	22	228-233		228-230	231-233	60	Excellent	Excellent	State coverage: Kan. (228-229)
S190B							5 inch	2X Enlrg.	
1† (9/18/73)	88	210-227	219-222	223-224	210-218 225-227	0 60	Excellent	Not available	Endlap varies.
30† (9/10/73)	85 (B/W)	389-403			389-403	60	Excellent	"	State coverage: Neb. (389-395) S.D. (396-402)
33 (9/20/73)	88	310-342	326-327	325	310-324 328-342	15 60	Excellent	"	Endlap varies. State coverage: Ia. (317-328) Ill. (329-336)
44 (9/7/73)	86	069-107			069-107	60	Excellent	"	100% clouds over study area.
44† (9/6/73)	86	024-036	030-034	029	024-028 033-038	0 5	Excellent	"	One gap. State coverage: Neb. (027-232) Ia. (033)
62 (8/5/73)	83	197-207	197-199 206-207	200-205		60	Excellent	"	State coverage: Kan. (197-203)

*Based on color band (has highest resolution); both B/W IR bands from SL 2 are excessively grainy, causing very poor resolution.

(5) We selected, after communication with the State Geological Surveys, certain areas in each state in which the applicability of Skylab photographs to geomorphic and environmental-geologic mapping will be tested intensively. The selection was based on meeting as many as possible of the following criteria:

a. Coverage by good-quality S-190A and S-190B photos having not more than 30% clouds.
b. Stereoscopic coverage (about 60% endlap).
c. Duplicate coverage, by either approximately coincident or crossing Skylab passes.
d. Late-spring coverage, at the start of the growing season after plowing of croplands is completed. For this project area, space photos taken at this time of year provide maximum information on geology and soils--consequently, SL 2 coverage is preferred over SL 3.
e. Congruence with or partial overlap upon any of the 17 areas (mostly 1° x 2° quadrangles) studied during our ERTS-1 investigation of this region.
f. Terrain of special environmental-geologic interest to the respective State Geological Surveys.
g. Terrain of special geomorphic and geologic interest as determined from our own preliminary evaluation of the Skylab photos and/or from our ERTS-1 studies.

Areas selected on the basis of these criteria were rated according to first, second, and third priorities. First-priority areas obviously will be studied and mapped initially, second and third-priority areas only if sufficient time is available. Our goal is to apportion the test areas as evenly as possible among the six states. This objective cannot be realized fully, however, because of limitations in meeting various of the criteria, especially items (a), (f), and (g). Some states, especially Nebraska, have extensive cloud-free coverage in areas of interest, whereas others, notably Kansas, have little such coverage. Consequently, the areas rated as first priority range from a minimum of 15,000 sq km in Kansas to a maximum of 30,000 sq km in Nebraska.

(6) Commenced detailed photointerpretive analysis of S-190A multispectral photos (SL 2, Track 19, and SL 3, Track 44) of eastern Nebraska and adjoining parts of Iowa, Missouri, and South Dakota, using Old Delft magnifying stereoscopes, a Kern PG-2 stereoplotter, and a projector for 2 1/4-inch slides. A fundamental part of this analysis is comprehensive mapping of the geomorphic features, surficial geology, and soil associations at 1:250,000 scale in the first and second priority test areas in these states. This mapping is being done by interpretation of the S-190A photos, supplemented by information from available topographic, geologic, and soil maps and reports. At this scale, landform (geomorphic) associations must be emphasized, rather than individual landforms; however, special attention is given to detection and mapping indications of such features as moraines of the last glaciation, relicts of moraines of earlier glaciations, river terraces, and ancient filled river valleys. Several different matrix models of descriptive and analytic map-unit factors were tried out, and a final matrix has been adopted that appears to be the best for this type and scale of mapping throughout the project area. It is discussed in the next section.

(7) Analyzed the screening films for the S-192 multispectral scanner for the project area. Selected two areas, one in northeastern Missouri and western and central Illinois, the other in northeastern Kansas and northwestern Missouri, for precision processing.

Significant results

(1) Indexing and analysis of Skylab photographs of the 6-state project area have shown that coverage by S-190A photographs from SL 2 and SL 3 that have less than 30% clouds totals about 568,000 sq km. The color, color-infrared, and B/W-red bands from S-190A in 70-mm format are of good to excellent photographic quality; the B/W-infrared bands from SL 2 are very grainy and low in resolution but nevertheless useable. The color S-190B photographs in 5-inch format generally are of excellent photographic quality. Where cloud cover is extensive, however, commonly the S-190A and S-190B color and color-IR photos are correctly exposed for clouds but underexposed for the ground. The 4X enlargements of the S-190A bands are of fair to good quality for SL 2, and good to excellent quality for SL 3. The 2X enlargements of the S-190B color photos from SL 2 are good to excellent (no 2X enlargements from SL 3 have been received).

(2) Evaluation of SL 2 and SL 3 photographs for their utility for photointerpretive mapping of geomorphic (landform) features, surficial geology, and soils at 1:250,000 scale is in progress in parts of Nebraska, Iowa, Missouri, and South Dakota. A matrix has been adopted of possible map-unit factors that can be identified and mapped from the S-190A photos, supplemented by information from topographic, geologic, and soil maps and reports. This matrix is modified from that used by E. H. Hammond for the Land-Surface Form maps in the National Atlas of the United States. The modifications were made to better distinguish landforms peculiar to the Great Plains and Midwest, and also to differentiate the principal associations of surficial deposits and soils, on as detailed a descriptive and quantitative basis as possible at the scale of mapping. Seven principal factors are analyzed and categorized: slope, local relief, profile, drainage pattern, soil color, soil drainage, and geomorphic/geologic genetic type. Ours probably is the first attempt at comprehensive 1:250,000-scale geomorphic and surficial-geologic mapping of large representative parts of the Great Plains and Midwest. From these maps we plan to make environmental geomorphic/geologic maps that will stress applications useful for regional land-use planning.

For this type of mapping, the SL 2 photos were taken at a much better time of year (late spring) than the SL 3 photos. The SL 2 photos were taken at the start of the growing season, after plowing of croplands was completed, while croplands, pastures, and woodlands were relatively bare of foliage; thus these photos provide maximum information on soils and surficial geology. Also, the SL 2 coverage is much more free of clouds and is stereoscopic; however, its B/W-IR bands are poorer quality, because of excessive graininess, and some of the 4X enlargements are fuzzier.

Preliminary evaluation of the utility of the various multispectral bands of the S-190A photos for geomorphic, geologic, and soil mapping shows that the most useful bands are the color and color-infrared bands--in some cases the color band is the best, in other cases, the color-IR. The color band gives the best resolution, hence maximum detail; however, it presents much distracting detail ("noise") not related to geomorphology, geology, and soils, and it also has poor haze penetration. The color-IR band has good haze penetration and shows the differences in relief and soil moisture (soil drainage) fairly well, but it has fairly low spatial resolution. The red-hued vegetated areas,

although helpful in places, commonly are distracting "noise," especially in the late-summer SL 3 photos. Next most useful is the B/W-red band. It has good resolution and fair haze penetration; it shows topographic and stream-alignment details especially well, with the least distracting "noise"; also, some soil-moisture differences are shown in SL 2 (spring) photos that supplement those shown on the B/W-IR bands. The two B/W-infrared bands have the poorest resolution, particularly in the excessively grainy SL 2 photos; however, they have very good haze penetration and show the various water bodies and the differences in soil moisture especially well. The B/W-IR photos from SL 2 were taken at the best time of year for distinguishing differences in soil moisture and drainage. The B/W "far" IR band shows these differences somewhat better than the B/W "near" IR band. Both B/W-IR bands are relatively poor for distinguishing woodlands from croplands, topographic detail, and outlines of urbanized areas. The B/W green band, although of potentially good resolution, invariably is poor because of widespread haze and low contrast; it is the least useful band for geologic-terrain mapping in this region.

After trying several methods and types of instruments for the photo-interpretive mapping, it appears that the most efficient methods are as follows: (1) For Skylab passes that provide stereoscopic coverage, first a preliminary inspection and mapping under a magnifying stereoscope (e.g., an Old Delft stereoscope at 4.5X magnification) on transparent-film overlays to the S-190A 4X transparencies of the color, color-IR, B/W-red, and B/W "far" IR bands, then careful mapping with a Kern PG-2 stereoplotter (using the color, B/W-red, and sometimes the color-IR bands) for refinement of the preliminary mapping. (2) For passes that do not provide stereoscopic coverage, the stereoscopes and stereoplotter cannot be used and the quality of the photo-interpretation suffers accordingly. First, the 4X transparencies are inspected on a light table under 2.5 to 7X magnification, and various types of significant boundaries are mapped on the color, color-IR, B/W-red, and B/W "far" IR bands. Next, the 70-mm transparencies of these bands of a given frame are projected successively (using a 2 1/4-inch slide projector) onto a 1:250,000-scale "green-line" print on drafting film of the 1° x 2° quadrangle base map, and the map-unit boundaries are drawn on the image on the film.

An impressive amount of information is recorded in the Skylab photographs. Under the Kern PG-2 stereoplotter, the 4X color S-190A transparencies from SL 3 are sharp at 5X magnification (of the stereomodel) and begin to lose detail at 10X but are still useful at this magnification. The poorer 4X color S-190A transparencies from SL 2 are somewhat fuzzy at 5X magnification and nearly useless at 10X. The unenlarged 5-inch color S-190B transparenices are extraordinarily sharp at 5X magnification and barely fuzzy at 10X. With both the S-190A and S-190B color transparencies, any geomorphic, geologic, and soil boundaries that can be clearly identified on conventional and ultrahigh airphotos can be mapped accurately at 1:250,000 scale. The Skylab photos are especially suited to identifying and mapping geologic linear elements.

Problems and recommendations

The only problems are

(1) The delay in receipt of SL 4 photographs. (The first SL 4 photographs were received July 8, after the end of this reporting period.) It was necessary to complete the selection of first-priority test areas before any SL 4 photographs

were received. Any supplementary coverage of these areas by SL 4 will be used, and coverage of additional parts of the project area might influence reevaluation of the priorities of the test areas.

(2) Because the SL 2 photographs, taken in late spring, are generally the most useful for the mapping objectives of this project, better quality color and color-IR 4X enlargements of the S-190A photos would be helpful. (The 4X enlargements of the B/W-red band are satisfactory and the quality of 4X enlargements of the B/W-infrared bands probably cannot be improved.)

(3) The 2X color enlargements of SL 2 S-190B photos also are fuzzier than they ought to be. Better quality enlargements would be helpful, but are not as important as the enlargements of S-190A color photos because the unenlarged 5-inch S-190B color photos can be used directly in the Kern PG-2 stereoplotter.

(4) No 2X enlargements of SL 3 S-190B color photos have been received; these enlargements would be very useful.

Summary outlook for remaining effort

During the next several months, analytic photointerpretive mapping of mainly first-priority and some second-priority test areas will be done at Denver, using S-190A photos supplemented by S-190B photos. After the preliminary "office" mapping has been completed for a State, a visit will be made to the State Geological Survey for conferences as outlined in the next section.

Travel summary and plans

No travel was performed during the reporting period. Beginning in July or August, after preliminary "office" photointerpretive maps of all the first-priority and some second-priority test areas in a State have been completed, short trips will be made to various parts of the project area. The purposes of a trip will be (1) to confer with the staff of the State Geological Survey to (a) evaluate the accuracy and utility of the preliminary maps, (b) obtain suggestions on other kinds of maps and map units, and how accuracy of the interpretive mapping might be improved, (c) compare the results obtained from Skylab photos with those from ERTS-1 images and from airphotos, and (d) obtain additional surface and subsurface data on file at the State survey; and (2) to make short visits to representative parts of the test areas for additional ground-control data needed to refine the interpretations made from the Skylab photographs.

Publications

None.

APPENDIX

COMMENTS ON SKYLAB EREP PHOTOGRAPHS FROM MEMBERS OF THE STATE GEOLOGICAL SURVEYS IN THE PROJECT AREA

STATE OF ILLINOIS
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ILLINOIS STATE GEOLOGICAL SURVEY

NATURAL RESOURCES BUILDING, URBANA, ILLINOIS 61801 TELEPHONE 217 344-1481

JOHN C. FRYE, Chief

February 7, 1974

Dr. Roger B. Morrison
U.S. Geological Survey
Federal Center
Denver, CO 80225

Dear Roger:

Your letter of 30 January 1974 has been referred to me by Dr. Frye for answer. Thank you very much for the Skylab 2 9 x 9 color transparencies. They make a welcome addition to our growing collection of space photographs and imagery. We would like to take you up on your offer of a loan of the black and white transparencies for the Skylab frames that cover southern Illinois. We will have our photographer make copies for our files and return the originals to you. Do you have copies of the photographs from the 18 inch Earth Terrain Camera for southern Illinois also? We would be interested in having copies or in making copies of these also. As more Skylab data from Illinois comes into your possession we would greatly appreciate receiving copies or getting loans of your originals so we can make copies.

We will be happy to review your final report on ERTS. I also enclose a statement regarding our evaluation of Skylab photography.

Thank you again for your consideration.

Sincerely yours,

Jerry A. Lineback

Jerry A. Lineback
Associate Geologist
Stratigraphy and Areal
Geology Section

Enclosure

cc: John C. Frye

USEFULNESS OF SKYLAB PHOTOGRAPHS IN GEOLOGIC MAPPING IN ILLINOIS

by Jerry A. Lineback

After a preliminary evaluation of Skylab photography in the Remote Sensing Files of the Illinois Geological Survey we can make the following observations:

1. Skylab multispectral photographs are greatly superior to ERTS images in resolution and in ease of use for geologic purposes.

2. Many geologic features that are visible on Skylab photographs cannot be seen on ERTS images.

3. Frames from the 18 inch long focal length Earth Terrain Camera are suitable for use in mapping in the same manner as regular aerial photographs.

4. Results from the multispectral cameras in the EREP package on Skylab indicate that color IR and the red band have more information on them than the others. The two black and white IR bands are also valuable. The color and blue-green band black and white are less useful.

5. Season and soil moisture conditions are important in determining what can be seen in any particular image or photograph. Spring season photographs when the soils are somewhat moist appears to best enhance features of the glacial drift in Illinois.

The following geologic features can be distinguished on Skylab photographs of Illinois:

1. Disturbed areas due to highway construction, mining, and drainage ditching.

2. Outcrops of bedrock units marked by vegetation or steep topography.

3. A few major faults in the unglaciated regions.

4. Glacial lake beds including some small ones not previously mapped.

5. Glacial ridges and moraines.

6. Textural differences in surface expression between different surficial drift units.

7. Abandoned glacial and post glacial drainage ways.

8. Drainage patterns related both to major and minor geologic features such as joint patterns, stagnant glacial ice, moraine topography, and others.

9. Terraces and flood plain flow patterns.

10. Linaments related to faulting.

11. Sediment dispersal patterns in lakes.

Our preliminary evaluation indicates that Skylab data can be directly applied to geologic mapping programs in Illinois. The boundaries of some geologic features, such as moraines and glacial lakes, can be traced on Skylab photographs as well as they can be on topographic maps or on conventional aerial photographs. The Skylab photographs, like ERTS images, provide a synoptic overview to moraine patterns and surficial soil patterns that is obtainable in no other way. This can greatly aid the geologist in evaluating the area he is mapping in terms of regional trends. This can be true even if no new information is obtained from the synoptic photographs. Rough, small scale, geologic maps can be drawn directly from the photographs. In a unknown area these can be very valuable. In the case of a well mapped area, they provide keys to regional trends that may have been missed in detailed mapping.

In conclusion, we feel that the drift cover and vegetative cover of Illinois limits the geologic use of ERTS images and Skylab photographs when compared to arid or mountainous areas. Still, much valuable geologic information can be gleaned from the data to enhance a geologic mapping program, even in well mapped regions.

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ILLINOIS STATE GEOLOGICAL SURVEY

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JOHN C. FRYE, CHIEF

February 20, 1974

Dr. Roger B. Morrison
U.S. Geological Survey
Denver Federal Center
Denver, CO 80225

Dear Roger:

Thank you very much for the Skylab S190B photographs of parts of Illinois. We appreciate receiving these and they have been placed in our Remote Sensing Files. I have given each photograph a preliminary evaluation and below are some general comments regarding their usefulness.

Comments on the usefulness of Skylab 2 S190B, frames 81-190 to 195 taken over southern Illinois 9 June 1973:

1. These photographs are not quite as high quality as those taken in central Illinois because of higher atmospheric haze levels which affect the resolution.

2. The following features can be seen; fault traces in the unglaciated region, outcrops marked by vegetation and cliff forming units, floodplain flow and meander patterns, disturbed ground, reclaimed and unreclaimed strip mines, minor stream patterns, sink holes, and general structural patterns.

3. Hicks dome, a major structural feature in Hardin County, is visible because of vegetation and land use patterns dependent on the type of outcropping rocks.

4. Artifacts, such as city street patterns, railroads, major and minor roads, and levees, can all be seen.

5. Stereo is very valuable in making maps in this region and good stereo vision can be obtained with these photographs.

6. These photographs can be used for making general geologic maps, locating mined areas and degree of reclamation, and for mapping flooded areas. They have limited use in well mapped areas, but may be very valuable in poorly known areas.

Comments on value of Skylab 3 S190B, frames 88-329 to 342 taken over central Illinois:

1. Extensive cloud cover renders these photographs useless for geological purposes. Even where the ground can be seen, the high haze level results in poor resolution.

Comments on Skylab 3 S190B photographs, frames 88-218 to 225 taken over northern Illinois 18 September 1973:

1. These are high quality photographs, but the crop vegetation covers soil patterns that define geologic units in this glacial drift-covered area.

2. Turbidity patterns in Lake Michigan can be seen very easily. The dispersal of sediment and dirty water show the position and direction of long-shore lake currents.

3. Gross details of land use in the urban areas can be determined and mapped.

4. Areas of swamp vegetation along the Illinois River can be delineated.

5. Terraces along the Illinois River can be mapped.

6. On the whole, these photographs are good for studies of Lake Michigan, sediment transportation, and for use in the urban areas. Surficial geology is largely hidden. Once again, stream patterns and disturbed areas can be delineated. This series has its greatest use in studying Lake Michigan, and lesser use for geologic purposes. They were taken in the wrong season for studying the glacial drift.

I hope the above comments will be helpful to you. Again, we thank you for the photographs.

Sincerely yours,

Jerry A. Lineback

Jerry A. Lineback
Associate Geologist
Stratigraphy and Areal
Geology Section

MISSOURI GEOLOGICAL SURVEY AND WATER RESOURCES
BUEHLER PARK ROLLA MISSOURI 65401 314-364-1752

WALLACE B. HOWE STATE GEOLOGIST AND DIRECTOR

LARRY D. FELLOWS ASSISTANT STATE GEOLOGIST

February 26, 1974

Dr. Roger B. Morrison, Geologist
U.S. Geological Survey
Bldg. 25, Federal Center
Denver, Colorado 80225

Dear Roger:

The receipt of the RB-57 data and the Skylab imagery is here and acknowledged. We have made some preliminary evaluation of the photography and find some problems in relating directly back data generated from the ERTS images. However, I must confess that we have not spent the time on the Skylab photography that we did on ERTS. Also, we are not looking at comparable band widths either. Enlargement of Skylab photography does not give us the clarity achieved with ERTS; however, this may be due to processing problems on our part. The ET camera data appears to be excellent. Have you seen or had access to any of the other data channels from Skylab such as the thermal IR or Microwave information?

The RB-57 coverage is excellent, and I feel that it may prove to be most useful. If it is reflown as you suggested that it might be (and I agree that it should from the standpoint of obtaining better true color data) I would strongly suggest that the three flight lines be moved to the south to create the sidelap that was missed in the original data. This would provide more comprehensive coverage and allow better correlation within the area covered by two separate flights.

We will continue to evaluate the data, as time permits. One area that may receive rather comprehensive appraisal is the Thomas Hill Reservoir and Chariton River complex that you and I visited this past year.

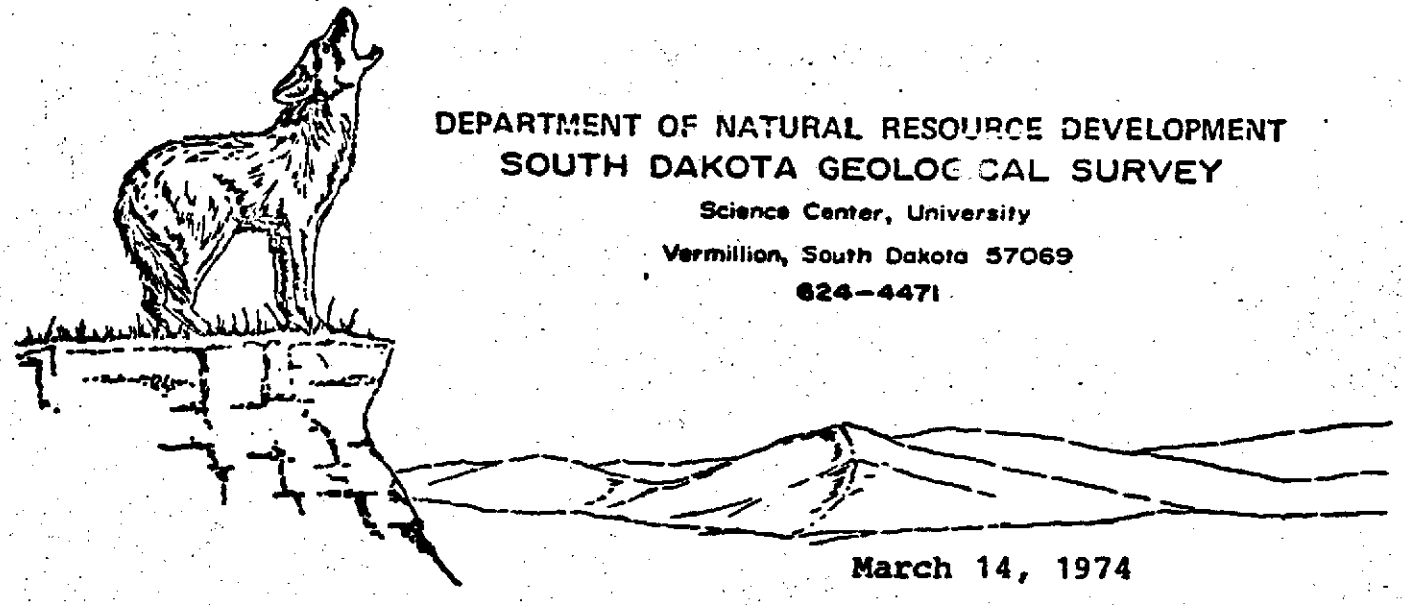
Let me express my sincere gratitude to you for the continued receipt of this information. It is very helpful to us, and I anticipate that we will derive a significant amount of information from it in the near future.

Sincerely,

William Allen, Jr.

William H. Allen, Jr., Geologist
Areal Geology and Stratigraphy

WHA:sm



DEPARTMENT OF NATURAL RESOURCE DEVELOPMENT
SOUTH DAKOTA GEOLOGICAL SURVEY
Science Center, University
Vermillion, South Dakota 57069
624-4471

March 14, 1974

Dr. Roger B. Morrison, Geologist
United States Geological Survey
Denver Federal Center
Denver, Colorado 80225

Dear Roger:

We are certainly glad that you caught the inaccuracies on the new Geological Map of the United States on your trip to Reston. I am returning the revised copy with the latest information we have.

I do not believe there will be any problems in correlating with Nebraska; however, Iowa is another kettle of fish. No one has done any work in northwestern Iowa for quite some time; therefore, it may be a little difficult to bring that line across the southwest tip of Minnesota down into Iowa. My only suggestion would be to follow the old Ihlen Moraine of Ruhe until it intersects the present Pre-Wisconsin line as drawn on the map that you sent us. This would follow Ruhe's break between the Tazewell and Iowan. In field consultations with Ruhe, he agrees that his old "Iowan" is Pre-Wisconsin. I think he would probably lean toward calling it Kansan in the Plymouth-Sioux County area, while we would call it Illinoian.

The Sky Lab imagery that you sent us is absolutely out of this world--at least the part in western South Dakota. I am sure you know the set of prints of eastern South Dakota are almost worthless due to the cloud cover. The one Sky Lab photograph in eastern South Dakota that is fairly free of clouds is in the Sioux Falls area, and our Illinoian-Early Wisconsin contact shows up beautifully. I believe it is probably due to the change in loess thickness. Other than that, the Sky Lab imagery in the glacial areas are almost useless.

By contrast, the Sky Lab imagery in western South Dakota is totally free of cloud cover, and is some of the nicest

areal photography we have ever seen. We have not had much of a chance to evaluate it as yet, but a few people think they have spotted a previously unknown structure some 25 miles long northeast of the Black Hills. This is not for publication in any way as this has not been checked in the field in any manner, and until it is, calling it a structure is really putting yourself out on a limb.

There is no question the Sky Lab imagery is going to be much more useful than the ERTS imagery to us, and we would certainly appreciate copies of any other imagery that you have available of South Dakota.

Again, thanks for the opportunity of putting the line of revision on the glacial map. Certainly are glad you caught that.

Sincerely,

Merlin J. Tipton
Associate State Geologist

MJT:co
Enclosure

KANSAS GEOLOGICAL SURVEY
Office of the Director

1930 Avenue "A", Campus West
The University of Kansas
Lawrence, Kansas 66044
913-864-3965

March 8, 1974

Mr. Roger B. Morrison
U. S. Geological Survey
Denver Federal Center
Denver Colorado 80225

Dear Koger:

I have put off writing you until several of our people could look at the photos you sent to us. The RB 57 photos are really something and we are happy to receive any of this and skylab photography we can get.

You asked for suggestions for future photography (U2 or RB 57) in Kansas. We would like full coverage of the glaciated area of Kansas. The three fights of RB 57 you sent give us partial coverage however full coverage would be quite useful in our work in this area. Another area in which we have an interest is coverage of the Namaha Anticline across Kansas. Part of this area would be covered in the glaciated area but full coverage might be useful in some structural studies we are doing over the Nemaha.

Thanks again for the photos and if we can be of any assistance in your studies let us know.

Sincerely,

Chuck B

Charles K. Bayne
Associate Director

P.S. The Midwest Friends trip to Meade County has been cancelled due to the gasoline shortage. We will try again next year.

et

Phone call 3/15/74: Bayne says "glacial limit shown on latest Geol. Map of Kansas is OK – no important revisions".

THE UNIVERSITY OF NEBRASKA-LINCOLN
CONSERVATION AND SURVEY DIVISION
NEBRASKA HALL
LINCOLN, NEBRASKA 68508
(402) 472-3471

ASSOCIATED SURVEYS
GEOLOGICAL CONSERVATION
WATER RESOURCES
SOIL INFORMATION

June 17, 1974

Mr. R. B. Morrison
U.S. Geological Survey
Federal Center
Denver, Colorado 80225

Dear Roger:

I would like first to express our appreciation for the several shipments of Skylab imagery. I have delayed responding until our projects were more stable for the coming year.

A preprint is enclosed which should bring you up to date on our activities. We intend to utilize the Skylab data, where available, its supplement both ERTS and low level data.

If any of these activities should be more closely correlated with your current projects, please contact either me or Rex Peterson.

Sincerely,

Marvin P. Carlson
Asst. Director

MPC/les

Enclosure

APPLICATIONS OF REMOTE SENSING BY THE STATE OF NEBRASKA* **

Marvin Carlson, Rex Peterson, Richard Hoffman, James Drew, Donald Edwards, Gary Hergenrader, Norman Rosenberg and Leslie Sheffield, The University of Nebraska; Marion Ball, Nebraska State Department of Water Resources; James Barr, Nebraska State Office of Planning and Programming; Gerald Chaffin, Nebraska Game and Parks Commission; Gerald Grauer, Nebraska State Department of Roads; Raymond Hartung, Nebraska State Department of Environmental Control; and Gerald Wallin, Nebraska Resources Commission, Lincoln, Nebraska

ABSTRACT

Remote sensing in Nebraska has a broad-base orientation aimed at the general public, educators and decision makers in government and industry. Several objectives have been achieved and others have been defined.

A Remote Sensing Center has been established within the University of Nebraska's Conservation and Survey Division, which also includes the function of the State Geological Survey. The Center serves as an interface between state and local agencies and units of the University. It supports several interdisciplinary projects in natural resource applications funded by NASA grants. A photomosaic and a Level I land use map of Nebraska, both derived from ERTS-1 imagery, have been published at a scale of 1:1,000,000. A Level II land use map of Lancaster County is ready to be printed at a scale of 1:62,500 and the inventory is complete for a Level II map of the Lower Platte South Natural Resources District. Land Use maps, based on dominant land use in each ten acre cell, are being prepared for Lancaster County for 1940, 1949, 1955, 1959, and 1965 to compare with the 1973 map now being printed and to show changes in land use during the last 33 years. Land use data for a 640 acre section is placed on a 8-1/2 x 11 inch checklist and is then keypunched for computer manipulation and computer mapping.

The application of remote sensing to irrigation has shown the following: center pivot irrigation systems, which increased 115 per cent in one Nebraska county in one year, can be inventoried from ERTS-1 imagery. In two Nebraska counties over 7,000 fields were outlined from ERTS-1 imagery and classified as alfalfa, wheat, wetland pasture, range and pasture, nonirrigated row crops, and irrigated corn.

An evapotranspiration project is determining the feasibility of using thermal imagery to obtain temperatures for use in evapotranspiration models. Results from these models can be used in hydrologic

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* Preprint of a paper to be published in The Proceedings of the Ninth International Symposium on Remote Sensing of Environment, April 15-19, 1974, Ann Arbor, Michigan.

** This research was supported in part by the National Aeronautics and Space Administration under Grant NGL 28-004-020.

studies, to improve irrigation scheduling, and to indicate areas of moisture stress. In the Nebraska Reservoir Water Quality Project an attempt is being made to use remotely sensed data to quantify concentrations of chlorophyll and the degree of inorganic turbidity in Nebraska's thousands of water bodies.

The geologic applications project involves the mapping of both conventional lineaments and curvilinears. Curvilinears in the form of circles, ellipses, and other curved features appear to be controlled by a combination of structure and geomorphology. In Nebraska many features visible on the landscape appear to relate to structures in the Precambrian basement.

Remote Sensing in Nebraska has advanced rapidly on four fronts: (1) establishment of a Center within a broad-based basic data agency; (2) publication of a Level I land use map of Nebraska from ERTS 1 data; (3) publication of a more detailed Level II land use map of selected areas; and (4) pilot projects pertaining to agriculture, irrigation and natural resources. A high priority is placed on published products since it is difficult to design remote sensing applications into projects without some initial products for context evaluation. Much of the current "applications" activity appears to be directed toward restricted problem solving at the technical level. However, it is just as important to generate widespread general interest in remote sensing by easily understandable published products.

The Nebraska Remote Sensing Center, coordinated by Dr. Rex Peterson, is located within the Conservation and Survey Division, University of Nebraska-Lincoln. This enables the Center to utilize the established interface of the Division with both the University and the numerous state and local agencies. The Center also serves as a base for interdisciplinary projects and has been supported by grants from the Office of University Affairs, National Aeronautics and Space Administration. It is anticipated that facilities and expertise will be developed for both user agencies and the general public. The center will also serve as a teaching and research area for the academic programs.

During the summer of 1973, a land use study of Nebraska was initiated, using ERTS imagery. The result of the project was the publication of a seven color, 1:1,000,000 scale, Level I general land use map of Nebraska. This project was supported by the Nebraska State Office of Planning and Programming and the Nebraska Natural

Resource Commission. This map is needed by the State Office of Planning and Programming in preparing recommendations for developing land use planning legislation. The Nebraska Natural Resources Commission has included the map as part of the Land Inventory of the Nebraska State Water Plan.

The land use map categories for Level I mapping were obtained from the U. S. Geological Survey Circular 671 which lists nine categories of which seven were applicable to Nebraska. ERTS imagery from April-June 1973 was utilized as a data source. A Spectral Data color additive viewer was used to project MSS bands 5-7 onto a smooth surface at a scale of 1:250,000. The various MSS bands were color filtered and combined to emphasize the seven major land use categories. Band 5 was utilized as the basic source for pattern delineation, but the following special combinations of filter and MSS images were found effective: band 4 (no filter) and band 7 (green filter) for forests; band 7 (red filter) and band 4 (blue filter) for water; band 7 (blue filter) and band 4 (no filter) for wetlands.

Land use boundaries determined from ERTS imagery were outlined and hand-colored on mylar copies of the U. S. Geological Survey 1:250,000 topographic base maps. These work maps were overlaid on enlarged prints of band 5 for review and further verification. The patterns were then transferred to a 1:500,000 base map to prepare color separations. The maps were printed at a scale of 1:1,000,000. This map is considered to be a tool for orientation and for visual impact of both the land use data and remote sensing applications.

A Level II land use pilot study was supported by the Nebraska State Office of Planning and Programming, the Nebraska Natural

Resources Commission, and the Lancaster-Lincoln Planning Department Lancaster County, with Lincoln as the state capitol and principal city, was chosen as the first test area because it combines an expanding urban area and shrinking agriculture area. This is representative of southeastern Nebraska. The Lancaster County project area was expanded to include the remainder of the Lower Platte South Natural Resources District which includes parts of adjacent counties. This land use inventory is needed by the Board of Directors of the Resources District and by the Nebraska Resources Commission for developing action programs. State and local planning offices need the inventory for urban and rural planning. The Nebraska Game and Parks Commission is interested in the number of acres in pasture, small grain and corn, and changes that might result under the new farm program. The above acreage supports the pheasant and small game crop, so any major changes will have significant effects on the game harvest and the setting of hunting seasons. The Lincoln Lancaster Planning Commission has a difficult time keeping a current land use map of Lancaster County. They are comparing our Level II results with their map from both a technical and cost point of view.

The Level II map was developed from photographs taken during June, 1973, from 40,000 feet AGL using Aerochrome Infrared Film (2443) in a KS-72 cameras with a 6-inch lens. The same area was reflown in August and September, 1973, at the same altitude using the same film, but with a KA-55 panoramic camera with CC10 magenta filter. The Level II categories of U.S. Geological Survey Circular 671 were used with a subdivision of cropland into row crop and small grain. This subdivision was possible because of the seasonal

acquisition of photography. The photography was inventoried by ten-acre legal subdivisions using visual comparison of the two sets of seasonal photography and classification into 25 categories of land use. The data product was a 8-1/2 by 11-inch checklist for each 640-acre legal section. This data was keypunched for tape storage and was available for data manipulating and processing. The data was recombined into convenient categories for publication at scales of 1:62,500 and 1:125,000.

The working inventory map was hand colored to facilitate verification. After field checking, which showed the map to be 90% accurate, changes were made and color separations prepared. The map of Lancaster County will be printed at a scale of 1:62,500. The Level II map of the entire Lower Platte South Natural Resource District will be published at a scale of 1:150,000 in the summer of 1974.

After seeing the preliminary Level II land use map of Lancaster County, based on 1973 data, planners and tax officials showed immediate interest in similar maps of the county for past years to see changes in land use. Aerial photos in 9" x 9" stereo pairs were available from the U. S. Department of Agriculture for 1940, 1949, 1955, 1959, and 1965. Air photo index mosaics for the county were purchased for each year when coverage was flown. Close-up 35 mm. slides were made of each 2-1/2 inch square on a mosaic. When these small portions of index mosaics were projected, there was sufficient detail for mapping. Mapping land use in selected areas (for example, nine sections of land) for five different periods, (1940, 1949, 1955, 1959, and 1965) was much more rapid than it would have been to map the entire county one year at a time. Efficiency was increased by

using several 35 mm. projectors to show the same area at different times.

For each of five years dominant land use of each ten acre legal subdivisions was entered on the 8-1/2 by 11 inch data sheet that codified one 640-acre section of land. The photos are being inventoried and the data keypunched from the inventory sheets for computer processing. The land use data will be available in different formats, including computer maps.

Remote sensing techniques have been used to detect and estimate the acreage of irrigated land in Nebraska. In order to develop procedures for inventory by remote sensing, one hundred and twenty-four test sites were established in Dawson and Phelps Counties. At this point in the ERTS inventory, all irrigated alfalfa has been identified and limited success has been achieved in identifying irrigated cornfields. Over 7,000 fields have been mapped at a scale of 1:125,000 and five categories of crops identified. Research is continuing in adding more detail to these crop categories and in the delineation of noncenter pivot irrigation through photographic and electronic enhancement of ERTS-1 imagery, and through the use of density ratios.

In the center pivot inventory five counties were selected as a test site. Once each center pivot irrigation system was identified from ERTS-1 imagery the number of acres irrigated was calculated and the type of crop identified. Preliminary analysis indicated that there were about 5,500 center pivot irrigation systems in Nebraska in 1973. Estimates for new systems to be installed for 1974 range as high as 2,000.

The irrigation project is of value to Nebraska because so much of the state's agriculture depends on irrigation. There are at least five million irrigated acres out of a total of 16 million acres of crops and pasture in Nebraska. In western Nebraska irrigation can increase yields of corn per acre by a factor of five. Information on the amount of irrigated land is important for estimating crop yields, river levels, water table levels, wind erosion, beef production yields, and energy needs. It is estimated that an irrigation system using gated pipes or siphon tubes requires 30.9 gallons of diesel fuel, or its equivalent, for each acre per season. A center pivot irrigation system requires 53.4 gallons of diesel, or its equivalent, per acre per year. In Box Butte County, Nebraska, the number of center pivot irrigation systems identified on ERTS-1 imagery increased from 54 to 116 in one year--an increase of 115 per cent. Obviously knowing the number of center pivots and their location is critical information for management of water and energy.

Because of world-wide food shortages, Nebraska's agricultural production must be increased. The procedures and results developed in the evapotranspiration project will be used by the Nebraska Natural Resources Commission, the county agencies and the farmer. Specifically, the objectives are: (1) to develop and test evapotranspiration (ET) models based upon surface temperatures for estimating water consumed by various crops. Results from these models can be used in hydrologic studies, can improve the scheduling of irrigation, and may also indicate areas of reduced crop yields due to moisture stress; (2) to determine the feasibility of using remotely sensed thermal imagery to obtain surface temperature for use in the ET models and for other applications such as detecting

Note: Miss Soils/geologic section of this paper 7.

stressed crops due to inadequate moisture and disease.

Another project has been directed toward mapping soil associations and forage densities in the Sand Hills, which cover more than one-quarter of Nebraska. Preliminary data show a good relationship between optical density of ERTS band 5 and density of forage in the Sand Hills. To map soil associations, models were established for two counties where newly published soil maps showed vegetational and topographic associations with soils. By using various combinations of seasonal imagery to delineate topography and vegetation the soil associations were extended to other areas.

Nebraska has thousands of small natural and man-made bodies of water. To measure the water quality of these bodies of water individually is economically impossible. The Nebraska Department of Environmental Control is required to conduct quality measurement. The purpose of the Nebraska Reservoir Water Quality Project is to determine the feasibility of measuring selected aspects of water quality in Nebraska reservoirs by remote sensing. Specifically, the concentrations of chlorophyll and the degree of inorganic turbidity will be quantified by remote sensing. In addition, the various filter-film combinations and spectral signatures for the rooted macrophytes and major classes of phytoplankton that occur in our reservoirs will be determined. If it is possible to measure these parameters of water quality remotely, then remote sensing will provide a powerful new tool for monitoring eutrophication in Nebraska waters.

The Nebraska Geological Survey, located within the Conservation and Survey Division, is involved with geologic applications of ERTS imagery. Major tectonic lineaments in Nebraska have been

delineated and research is being conducted on the numerous curvilinear elements that appear on small scale imagery. The best results come from superimposing ERTS bands 5 and 7 to prepare overlays. Streams and other features are drawn on the overlay for orientation so that images taken at different times may be interchanged. The images are studied with a reducing lens to see patterns that are otherwise overlooked.

This technique indicates that in many landscapes there are as many curved lines as straight lines. Curved lines are expressed on the landscape by topography, drainage, vegetation patterns, soils, or other phenomena. They usually show as a continuous gray tone interrupting other tonal patterns. There does appear to be some structural control of the curvilinears. Important in the interpretation of curvilinear elements is the pattern made by intersecting circles, ellipses, arcs, and straight lines. Although this investigation is still in the preliminary stages, certain arcuate patterns have been correlated with specific geologic features. The interpretations of straight and curved lines will assist groups, interested in ground water, gas storage, oil exploration, construction, and the location of power plants.

The initial programs for remote-sensing in Nebraska are not complex. It was felt that sufficient research was underway elsewhere to determine specific technical procedures. As these techniques become available, they will be utilized to serve the technical and management audience. Our concern has been to establish a broad-base orientation toward the potential of remote sensing, especially in land use inventory. Our products are aimed below the typically defined technical "user-audience" toward the general

public, the political decision-maker, the elected officials, and the educators. With our citizens thus informed, it is hoped that the Nebraska Remote Sensing Center will evolve as an integral part of our expanding planning processes.