APPLICATION OF SKYLAB EREP PHOTOGRAPHS TO STUDY OF THE MODERN EPISODE OF ACCELERATED EROSION IN SOUTHERN ARIZONA

(EREP NO. 489; NASA Contract No. T-4113-B)

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Progress Report for period January 1 - June 30, 1974

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16. Abstracts

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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 photographs of Arizona, taken from Skylab 2 and 3, in duplicate:
   - a. Transparency 70-mm-format copies of the six bands from the S-190A multispectral camera array, SL (Skylab) 2 Track 6 and SL 3 Tracks 6 and 30.
   - b. Copies of the 5-inch format color transparencies from the S-190B earth-terrain camera, SL 3 Tracks 6 and 30.
   - c. Four-times transparency enlargements of all bands of the S-190A photos from SL 2 and 3.

No SL 4 photos were received during the reporting period. However, transparency copies of 70-mm-format S-190A photos of SL 4 Tracks 6 and 63 were received July 5.

(2) We indexed all the S-190A and S-190B photos on both the Arizona state 1:1,000,000-scale base map and on 1° x 2° quadrangle 1:250,000-scale maps.

(3) We evaluated the S-190A and S-190B photos 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.

(4) We selected certain areas within the total area covered by Skylab photos for intensive testing of the applicability of these photos to study of the accelerated erosion problem. 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. The instruments available at the U.S. Geological Survey in Denver for stereoscopic viewing cannot use 70-mm transparencies effectively; therefore, good-quality 4X enlargements are essential.
(b) Stereoscopic coverage (about 60% endlap).
(c) Duplicate coverage, by either approximately coincident or crossing Skylab passes.
(d) Congruence with or partial overlap upon the irregular 44,000-sq km area studied during our ERTS-1 investigation of the erosion problem in southern Arizona.
(e) Terrain conspicuously affected by accelerated erosion.
(f) Terrain where accelerated erosion is seriously affecting urban or agricultural lands.
(g) The apportionment of the test areas to represent the full range of the diverse climatic, soil, and vegetative conditions within the project area.

Limitations in (a), especially the lack of good-quality enlargements of SL 2 Track 6 photos and (b) at present severely restrict the areas that can be given first priority. Several potential first-priority areas in southeastern Arizona that rate high in items (d), (e), (f), and (g) cannot be considered now because of the lack of good-quality 4X enlargements or stereoscopic coverage. They will be scheduled as soon as suitable 4X enlargements of SL 2 and/or SL 4 Track 6 photos become available.

Areas selected for first-priority study and mapping total about 24,000 sq km, and those for second-priority mapping about 26,000 sq km. They are of various sizes and shapes and range from very warm, arid desert to semiarid intermontane plains to semiarid and subhumid plateaus and mountains.

(5) We compiled several hundred measurements of depths and widths of stream channels cut since 1890 on the following 1° x 2° 1:250,000-scale quadrangles: Ajo, Phoenix, Mesa, Tucson, Holbrook, Prescott, and the Arizona parts of the Saint Johns, Clifton, Silver City, Douglas, and Nogales quadrangles. Most of these measurements were made between 1964 and 1973 by Maurice E. Cooley of the U.S. Geological Survey, although some were made by R. B. Morrison between 1955 and 1973; additional measurements made during field work in 1974 also will be entered.

(6) We experimented with several techniques and instruments to determine those most efficient and accurate for detecting and mapping modern arroyos and gullies and sheet-eroded areas from both S-190A and S-190B photos, as follows:

(a) Viewing the S-190A 70-mm and S-190B 5-inch unenlarged photos under a B&L zoom stereoscope, at 5 to 20X magnification. This method is useful for rapid evaluation of photo quality and detection of specific features, but is unsatisfactory for comprehensive mapping because the stereoscope we used lacks a scanning capability.

(b) Projecting S-190A 70-mm transparencies onto a screen or, preferably, onto either a transparent-film overlay on paper 1° x 2°-quadrangle maps or directly onto 1:250,000-scale green-line prints of these maps on drafting film, using a 2 1/4-inch slide projector. This method is the most practicable for Skylab photos that do not provide stereoscopic coverage, like SL 3 Track 6. The quality of the mapping, however, is inferior to that produced by methods (c) and (d).

(c) Examining 4X transparency enlargements of various S-190A bands under an Old Delft magnifying scanning steroscope at 4.5X magnification. In the project area, only SL 2 Track 6, SL 3 Track 30, and SL 4 Tracks 6 and 63 provide the necessary stereoscopic coverage. Also, the quality of the enlargements determines the detail and accuracy of the photointerpretive mapping. The 4X enlargements of all bands of the SL 2 Track 6 photos are so fuzzy that only intermediate- to large-sized arroyos (no narrower than about 15-20 m, even where contrast with adjacent terrain is high) can be distinguished. These enlargements have only slightly better resolution than the best ERTS-1 images of the project area.

Fortunately, the 4X enlargements of SL 3 Track 30 are much sharper. We tried mapping the modern arroyos on transparent-film overlays of color 4X enlargements of frames 241 - 243, viewed under an Old Delft stereoscope at 4.5 magnification. We had very little ground control in this area, but it appeared that arroyos as narrow as about 10 m could be distinguished clearly where they contrasted well with adjacent terrain. This method is relatively rapid but transfer of data from the overlays to 1:250,000-scale base maps takes considerable time and is likely to result in loss of accuracy because of the nearly 3X enlargement required. Technique (d) is much more efficient and accurate.

(d) Using a Kern PG-2 steroplotter both for interpretation and for plotting data directly onto the 1:250,000-scale base maps. The superior optics and illumination of this precision instrument, plus the one-step operation, make this the most accurate and efficient method we have tried for photointerpretive mapping. The steroimage can be scanned as readily as with the Old Delft stereoscope and it is sharper and better illuminated. Both mega- and micro-features and relationships can be seen, because each steromodel covers about 15,500 sq km and can be viewed under various magnifications up to 10X. The stereomodel from the 4X color S-190A transparencies from SL Track 30 is sharp at 5X magnification; it begins to lose detail at 10X but still is useful at this magnification. The model from the 5-inch color S-190B transparencies is exceptionally sharp at 5X magnification and barely fuzzy at 10X. Although adequate ground control is lacking in the test area mapped, it appears that arroyos as narrow as 5-8 m can be distinguished on the S-190A model, and gullies only several meters wide on the S-190B model.

(7) Completed mapping at 1:30,000 scale of the modern erosion features and Holocene geomorphology of the flood plains and Holocene terraces of a 40-mile reach along the Santa Cruz River, from Marana to Saharita, and of a 22-mile reach along the San Pedro River near Benson. This mapping is partly from interpretation of U-2 color-infrared airphotos and partly from field examination; it will serve as a valuable reference datum for evaluating the accuracy of mapping from the Skylab photos.

Significant results

(1) Indexing and analysis of the SL 2, SL 3, and SL 4 photos of the project area has shown that S-190A coverage with less than 30% clouds totals about 123,000 sq km. The 70-mm unenlarged color, color-infrared, B/W red, and B/W green bands from S-190A are of good to excellent quality; the B/W IR bands from SL 2 are excessively grainy and have very low resolution; those from SL 3 are better but nevertheless have low resolution. The 5-inch unenlarged color transparencies from S-190B are generally of excellent photographic quality. However, where cloud cover is extensive, commonly the S-190A and S-190B color and color-IR photos are correctly exposed for the clouds but considerably underexposed for the ground. The 4X enlargements of all bands of S-190A photos taken by SL 2 are much fuzzier than they should be; evidently the enlarger was not focused properly. The 4X enlargements from SL 3 are much superior. No 2X S-190B enlargements have been received. Details of our analysis of coverage and photo quality are given in Figure 1 and Table 1.

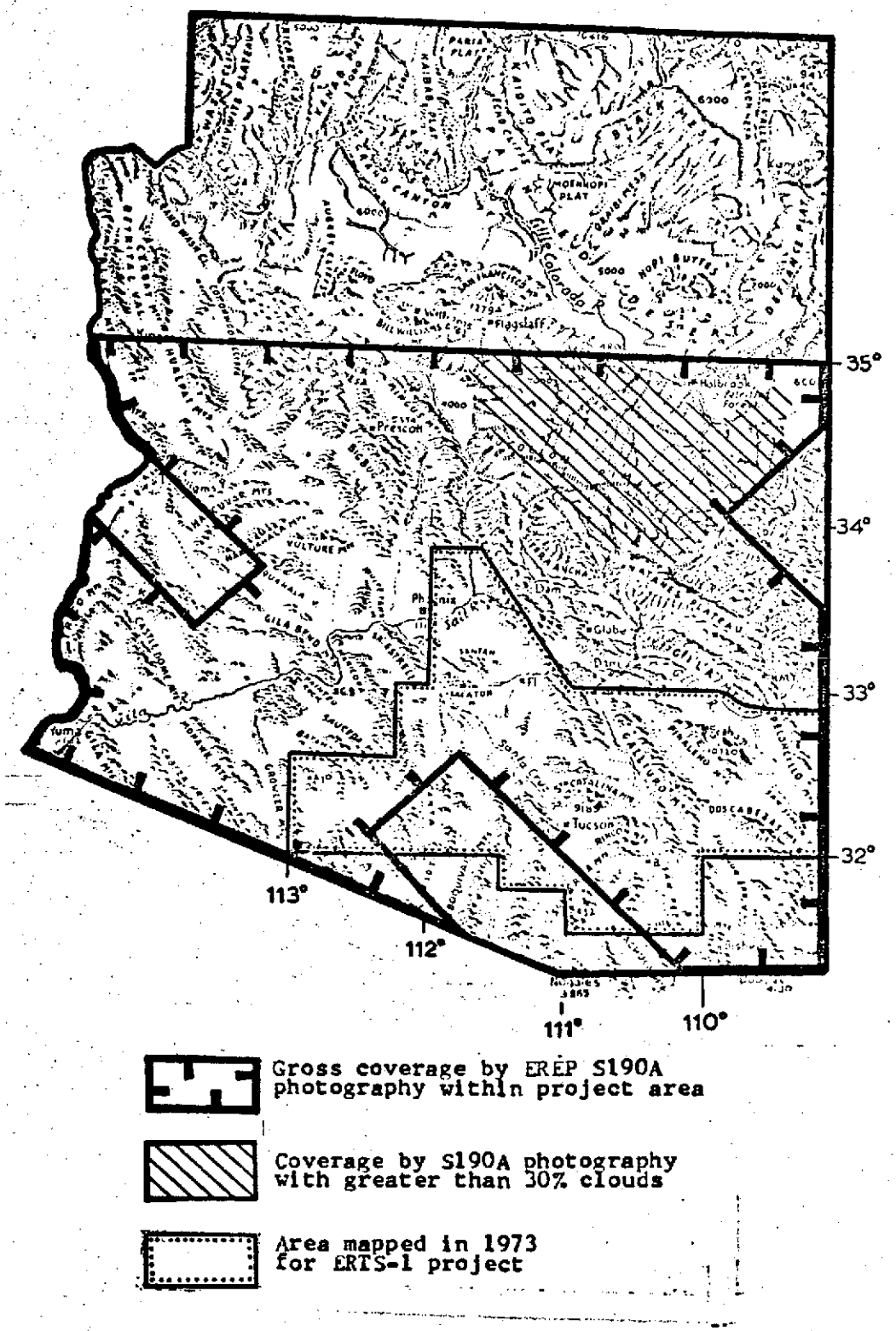

Figure 1. Coverage of project area by Skylab EREP S190A photography

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

SYSTEM Track/Date	ROLL NO.	FRAME NOS.*	CLOUD COVER 0-5%	CLOUD COVER 5-30%	CLOUD COVER >30%	USABLE FRAMES Total number in project area: Fully	USABLE FRAMES Total number in project area: Partly	ENDLAP (%)	PHOTOGRAPHIC QUALITY		REMARKS
						SKYLAB 2					
S190A									70mm	4X Enl.	
4 6/3/73	4 color	195-209 (195-206)	195-202 206	203-205			12	60	Excellent, good color, best resolution.	Poor resolution, good color.	Scattered small clouds (<3 to 15%) generally not detrimental. Stereoscopic coverage is highly advantageous. Photographic quality of 70mm material excellent (roll 4, color) to poor (rolls 1 and 2, IR); of 4X enlargements, poor to very poor
	3 color IR	do.	do.	do.					Good color and resolution.	Poor resolution, good color.	
	5 B/W red	171-185 (171-182)	171-178 185	179-184					Good resolution and contrast.	Poor resolution.	
	6 B/W green	do.	do.	do.					Fair resolution and contrast.	Poor resolution, fair contrast.	
	1&2 B/W IR	do.	do.	do.					Very poor resolution (very grainy), good contrast.	Very poor resolution (very grainy).	
S190B - Not available											

SYSTEM / Track/Date	ROLL NO.	FRAME NOS.*	CLOUD COVER 0-5%	CLOUD COVER 5-30%	CLOUD COVER >30%	USABLE FRAMES Total number in project area: Fully	USABLE FRAMES Total number in project area: Partly	ENDLAP (%)	PHOTOGRAPHIC QUALITY		REMARKS
SKYLAB 3											
S190A									70mm	4X Enl.	
6 8/11/73	28 color	059-066 (060-064)	059-066			2	3.	10-15	Excellent resolution and color, frames 61-63 somewhat dark.	Very good resolution; somewhat too blue.	Essentially cloud-free and excellent to good photographic quality; however, non-stereoscopic coverage is a serious detriment for objectives of project. Enhancement of reddish hues by SO 356 color film is very beneficial for interpreting soils and geomorphology.
	27 color IR	do.	do.						Good resolution and color.	Fair resolution (grainy); somewhat too blue.	
	29 B/W red	do.	do.						Excellent resolution and contrast.	Good resolution and contrast.	
	30 B/W green	do.	do.						Good resolution and contrast.	Fair resolution and contrast.	
	25&26 B/W IR	do.	do.						Fair resolution, good contrast.	Poor resolution, good contrast.	
S190B									5-inch	2 X enl.	
6 8/11/73	84 color	014-022 (015-020)	014-022			4	3	10	Excellent resolution, somewhat under-exposed in frames 15-18; color slightly too blue.	Not available.	
S190A									70 mm	4 X enl.	
30 11/6/73	34 color	241-250 (241-246)	241-243	244; 249-250	245-248	2	3	60	Very good resolution, somewhat under-exposed, esp. frames 244-247.	Very good resolution, somewhat too blue and under-exposed (dark).	Cloud-free except in mountains NE of Tonto Basin; excellent to good photographic quality; stereoscopic coverage is very helpful.
	33 color IR	do.	do.	do.	do.				Good resolution; slightly under-exposed, esp. frames 244-247.	Fair resolution (grainy); somewhat too blue.	
	35 B/W red	do.	do.	do.	do.				Excellent resolution and contrast; frames 244-247 are too dark.	Good resolution and contrast.	
	36 B/W green	do.	do.	do.	do.				Fair resolution and contrast.	Fair resolution and contrast.	
	31&32 B/W IR	do.	do.	do.	do.				Poor resolution, fair contrast.	Poor resolution, fair contrast.	
S190B									5-inch	2 X enl.	
30 11/6/73	86 color	007-022* (007-014)	007-012	013; 020-022	014-019	5	3	60	Excellent resolution and color.	Not available.	Excellent photographic quality; cloud-free except in mountains NE of Tonto Basin; stereoscopic.

*Frames listed in parenthesis are wholly or partly within the project area.

(2) Preliminary evaluation was made of the utility of the various multispectral bands of the S-190A photos and of the color S-190B unenlarged transparencies for identifying and mapping modern erosion features and for mapping other characteristics germane to the accelerated erosion problem, such as soil associations, potential erodibility, and vegetative cover. The results of this evaluation are given in Table 2. In general, the color band is the most useful. It has the best resolution and therefore enables maximum identification of detail, such as the smaller arroyos and gullies. Its excellent registry of colors, especially yellow and red hues, is a great help for identification of soils and potential erodibility of earth materials. The color-IR band is fairly good overall, and the B/W red band is almost as good; the B/W green band rates fair to poor. The B/W IR bands are generally poor because of their low resolution, especially those from SL 2, and are most useful for certain soil discriminations.

Problems and recommendations

As stated above, an important problem has been the poor quality (fuzziness) of the 4X enlargements of SL 2 Track 6 S-190A photos, particularly of the color, color-IR, and B/W red bands. These photos are especially valuable for the objectives of this project because they provide steroscopic coverage, whereas the SL 3 Track 6 photos do not. Better-quality enlargements of the SL 2 Track 6 S-190A photos have been requested via the Technical Monitors. Fortunately, SL 4 Track 6 S-190A photos also provide steroscopic coverage; however, only 70-mm unenlarged transparencies of these photos had been received by mid-July.

Summary outlook for the remaining effort

During the next several months, analytic photointerpretive mapping of modern erosion features and potential erodibility will be done in Denver of first-priority and some second-priority test areas, using mainly the Kern PG-2 stereoplotter with S-190A 4X color transparencies, supplemented with S-190B unenlarged 5-inch color transparencies. Probably in September the PI will spend a week or two at the USGS offices at Flagstaff, Arizona, experimenting with an advanced-design stereoplotter for the photointerpretive mapping. This stereoplotter was designed for lunar and martian studies and has super-precision optics. It can use directly the unenlarged 70 mm transparencies from S-190A and 5-inch transparencies from S-190B; it can be adjusted to the exact focal length of the camera that took the photographs, and it can enlarge the stereoimage as much as 18X.

From this work, the modern erosion features and potential erodibility of several large areas in southern Arizona will be mapped accurately at 1:250,000 scale, providing information needed to assess the magnitude of the accelerated erosion problem.

Travel summary and plans

Short trips were made to Tucson, Arizona, in January, March, and May, for conferences with Maurice E. Cooley and personnel at the Arizona District Office, Water Resources Division, U.S. Geological Survey, and with members of the Department of Geosciences, University of Arizona. One day was spent on

Table 2. Evaluation of utility of S-190A photographs from Skylab missions 2 and 3 for mapping modern erosion features and data relevant to the problem of accelerated erosion in southern Arizona.

[E = excellent, VG = very good, G = good, F = fair, P = poor.]

S-190A multispectral band	Features to be mapped					
	Present stream channels	Modern arroyos and gullies	Soils	Potential erodibility	Bedrock-basin fill contacts	Vegetative ground cover
Color	E-VG	E-VG	VG	E-VG	VG-G	F-P
Color-IR	E-VG	VG-G	G-F	G-F	G-F	G
B/W red	VG-E	VG	F-P	F-P	F-G	P
B/W green	G	G	P	F-P	F-P	P
B/W "near" IR	P	P	G-F	P	P	F-P
B/W "far" IR	P	P	G-F	P	P	F-P

field observations during the May trip. Additional travel to Arizona will be deferred until fall, 1974 and will be mainly for experiments with the USGS stereoplotter at Flagstaff, and secondarily for field work to obtain ground control for the photointerpretive maps.

Publications

None.