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SKYLAB-4 VISUAL OBSERVATIONS PROJECT - GEOLOGICAL FEATURES OF SOUTHWESTERN NORTH AMERICA†

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SUMMARY

The Skylab-4 crewmen conducted visual observations on seven designated geological target areas and other targets of opportunity in parts of southwestern United States and northwestern Mexico. The experiments were designed to learn how effectively geologic features could be observed from orbit and what research information could be obtained from the observations when supported by ground studies. For the limited preparation they received, the crewmen demonstrated exceptional observational ability and produced outstanding photographic studies. They also formulated cogent opinions on how to improve future observational and photo-documentation techniques.

From the photographs and other observations, it was possible to obtain significant research contributions to on-going field investigations. These contributions were integrated into other aspects of the ground investigations to: (1) identify and evaluate zones of major faulting in southeastern California, Baja California and northwestern Sonora; (2) develop a new key to the regional stratigraphy of the pre-batholithic rocks of northern Baja California; (3) discover the most southwesterly known occurrence of Precambrian crystalline rocks in North America; (4) discover a previously unmapped section of Mesozoic (?) volcanic rocks in southeastern California; and (5) contribute important overview perspectives to many regional geologic problems.

The experimental data and the demonstrated crew capabilities justify planning future geology visual observation experiments for manned earth-orbiting programs such as the Shuttle. Both professional scientist-observers and astronaut-observers can make contributions if properly prepared and equipped. The experiments should be closely coordinated with active surface research investigations. The emphasis would be on selecting important problems and objectives and integrating orbital observations and ground studies. It should not be on prospecting for isolated "spectacular" discoveries.

INTRODUCTION

Man's role as a direct and discriminating observer of geologic features on the earth's surface as he sees them from the peculiar vantage point of an orbiting platform was tested formally for the first time in the third visit (SL-4) to Skylab. Prior to the Skylab missions, unmanned orbital photographic and other remote-sensing techniques had established clearly their great value in earth sciences. The potential of man in real-time, dedicated terrestrial geological observation activities had not been previously investigated. With the obvious future requirements for a better geological understanding of the earth, man's capability to meet these needs in various space flight applications deserves thorough consideration and evaluation.

To provide relevance there are two general conceptual areas in which the objectives and implementation of the Skylab geology observation experiments should be considered. They are represented in the following questions:

(1) What are man's inherent capabilities as a geological observer from a satellite? What orbital conditions, equipment and techniques, and what ground-based follow-on can provide the most effective use of these capabilities?

(2) What are the types of geologic problems and scientific questions to which man in orbit can make superior or unique observational contributions? Are the problems and his contributions of sufficient

scientific value to justify the use of man in this space activity as compared to other functions he can perform? As compared to other approaches to the same problems?

The Skylab visual observations experiments provided useful data and experience bearing on these questions. In addition they have provided a variety of data valuable to geological research in a number of areas in southwestern North America.

Pre-Mission Activities

Approximately a month before the third visit (SL-4) to the Skylab orbiting laboratory was launched, the principal investigator (Leon T. Silver) was invited to participate in the preparation of a visual observations program in which the SL-4 crew would examine and photograph selected geological target areas in southwestern North America. A series of eleven operational exercises and study areas in the southwestern United States and northwestern Mexico were prepared by Silver, his colleagues and students, each exercise utilizing a base satellite photograph from earlier Apollo and Skylab missions. These exercises were reorganized into seven study problems by the Johnson Space Center Visual Observations Group, and were incorporated in the Flight Visual Observations Book as HH-108, 111, 112, 113, 114, 125 and 126 (see Figs. 1, 2, 3 and Appendix A). Analogous geological problems for other areas in the world were prepared by W. R. Muehlberger of the University of Texas.

Preflight crew preparation for these observational experiments consisted of two parts: (1) a three-hour lecture period by Prof. Muehlberger, Prof. Silver and Prof. R. H. Jahns of Stanford University; and (2) a pre-flight briefing of the SL-4 crew as part of an afternoon session covering all categories of visual observation experiments.

When the SL-4 Visual Observations Experiment became a continuing part of the flight activities the principal investigator, on invitation, submitted an informal proposal to evaluate the crew effectiveness and science yield for the geological observations in southwestern North America. This proposal was accepted. A preliminary report — "Skylab-4 Visual Observations Project - Geologic Investigations of Southwestern North America" — was submitted to NASA on March 28, 1974.

Post-Mission Activities

The crew completed its nominal mission stay-time, made extensive observations in almost all of the geological study areas of southwestern North America, and compiled an extraordinarily comprehensive photographic record of their observational opportunities. The systematic tabulation of the results of these efforts are contained in Figs. B1 - B17 and in Tables 1 and 2 in Appendix B.

On March 12, 1974 Silver and Muehlberger conducted a four-hour geology debriefing session with the SL-4 crew. This included a brief review of the handheld photography available at the time as well as a discussion of observing opportunities,

conditions, equipment and construction of the exercises. All members of the crew showed great interest and enthusiasm for the geology experiments. Their perceptive comments were taped and transcribed at JSC. We have corrected and slightly edited this transcript because of its significance, and it is included as Appendix C. D. K. Slayton and V. Brand, of the ASTP crew, F. El-Baz, V. R. Wilmarth, W. Lenoir and R. B. Parker were among other observers and participants during the debriefing. A number of observations by the SL-4 crew provided useful inputs to the ASTP Visual Observations Experiment led by Dr. Farouk El-Baz.

Photographic transparencies and a limited number of 8" x 10" prints were received irregularly over an interval between March and August 1974. Field studies to provide ground verification for our photo-geologic interpretations were carried out from April 1974 to December 1974, as the availability of the photographs and the climatic conditions in the target areas permitted.

Field work and photo interpretation dedicated directly to this project was carried out in Arizona by Mr. Clay Conway and L. T. Silver; in southern California by Mr. R. Powell and L. T. Silver; in Baja California by Mr. Jay Murray and L. T. Silver; and in Sonora, Mexico by Dr. T. H. Anderson and L. T. Silver. Miss Dayna Salter assisted with the correction of the debriefing transcript and a study of structural lineaments in southern California.

Objectives of this Report

This report is organized to present in a simple format the following information:

I Planned geology visual observation experiments.

II Data produced by the experiments — Comprehensive tabulations and indices of the flight commentary and handheld photography.

III Evaluation of SL-4 crew effectiveness in visual observations.

IV Description and summary of results of a selected number of research topics to which the SL-4 geology observations have contributed.

V Evaluation of the usefulness of SL-4 visual observation efforts for research purposes.

VI Recommendations for conducting future visual observations programs from manned satellites.

Much of the mission data product has been organized on the basis of the geographic distribution of the original geological exercises and placed in appendices.

Appendix A - Visual Observation Experiments as described in Flight Book.

Appendix B - Tabulation of verbal commentary on geology.

- Tabulation of photography of geologic targets.

- Maps showing location and field orientation of photographs.

Appendix C - Transcript of SL-4 Crew Debriefing.

- Letter to L. T. Silver from E. Gibson, dated 10 June, 1975.

Sources of Information

The principal sources of information used for preparing this report are the following:

(1) SL-4 Visual Observations Flight Book

(2) Transcript of SL-4 Crew Comments

(3) SL-4 Handheld Photography Logs

(4) SL-4 Summary of Completed Visual Observations and Handheld Photographs

(5) SL-4 Orbital Track Map, starting Nov. 10, 1973

(6) SL-4 Indices of Handheld Photography by Geographic Location (R. Underwood, as available)

(7) Earth-Looking Videotapes SL-4-165, 175, 186

(8) SL-4 Crew Debriefing March 12, 1974

(9) SL-4 Handheld Photography - HDC Magazines 136 - 143
- NK Magazines 156, 191-194, 197, 199, 202-204, 206-209

(10) Apollo 6, 7, 9 and SL-2, SL-3 Handheld and EREP Photography

(11) Field Investigations by L. T. Silver, T. H. Anderson, J. Murray, R. Powell, and C. Conway

(12) Informal discussions with Dr. E. Gibson, G. Carr and W. Pogue, and with numerous other astronauts on problems of earth observation

PLANNED GEOLOGY VISUAL OBSERVATION EXPERIMENTS

The geology experiments were designed with dual objectives: (1) to learn how effective an orbiting observer could be in the context of the Skylab flight path, flight-time and facilities; and (2) to determine what type of science yield could be obtained from the crew's observations and photographic products when supported by ground studies and analysis.

The seven assigned exercises are given in Appendix A, in the same form which the crew encountered them. Since preflight briefing was minimal, the crew's understanding of the objectives was obtained from, and limited by, these brief statements and the base photography by which each exercise obtained local geographic reference. The general geographic location was given by index maps similar to those in Figures 1 - 3. In Figure 1, the general orbital tracks show the types of northeast and southeast passes during which the crew made their observations.

Each exercise was designed about a geological problem or group of problems with which the experimenter and his colleagues were concerned. In each case, extended field work had been carried out prior to the flight and a considerable familiarity with "ground-truth" had been established. Therefore, some questions were designed to test the crew's observations of known phenomena. Nevertheless, substantial scientific questions remained in each area for which it was hoped that SL-4 crew efforts might make significant contributions. It was intended that further ground verification activities would be a part of these studies. (See Figs. 2 and 3 for study area locations.)

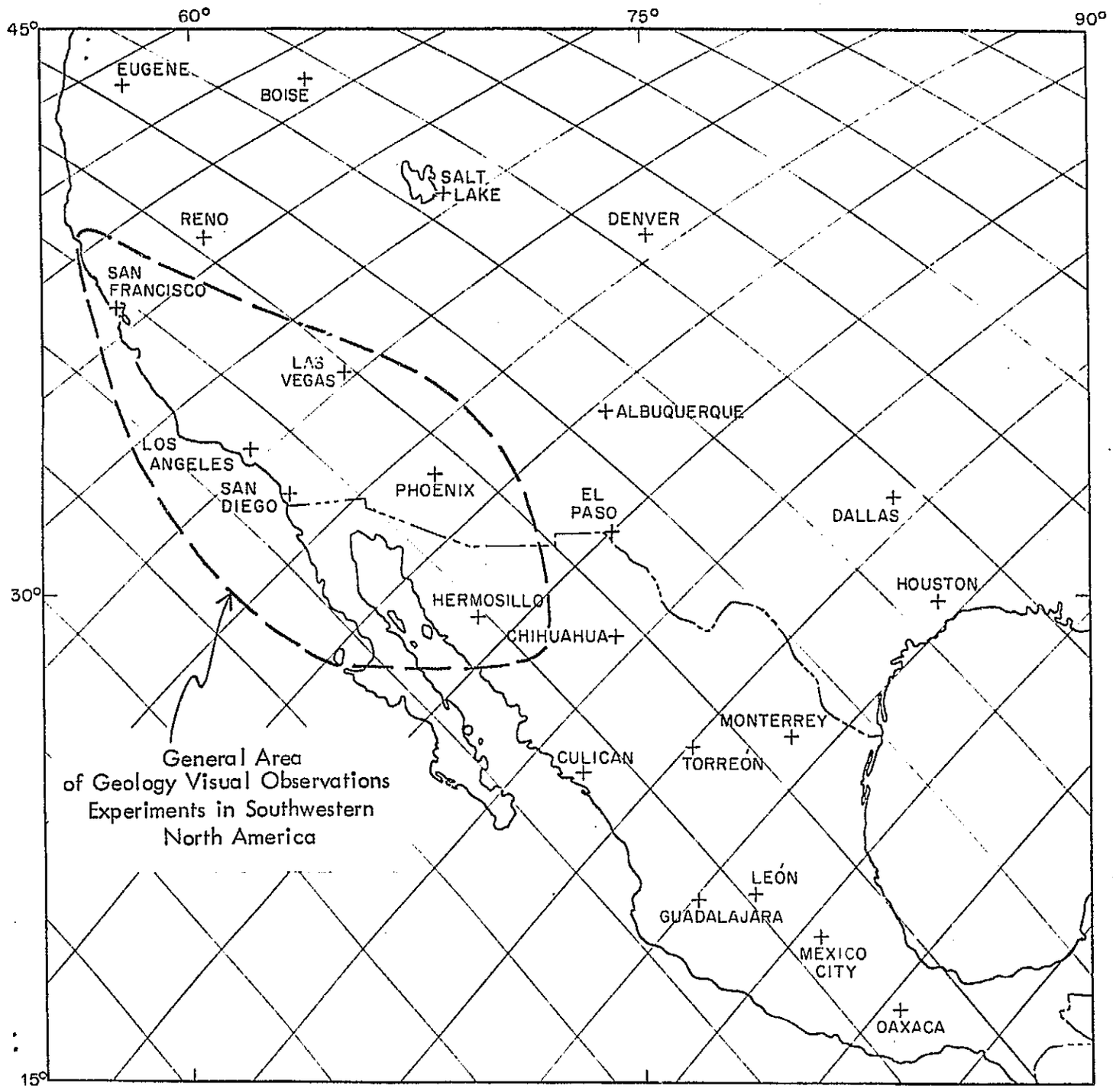

Figure 1: Skylab 4 orbital track map

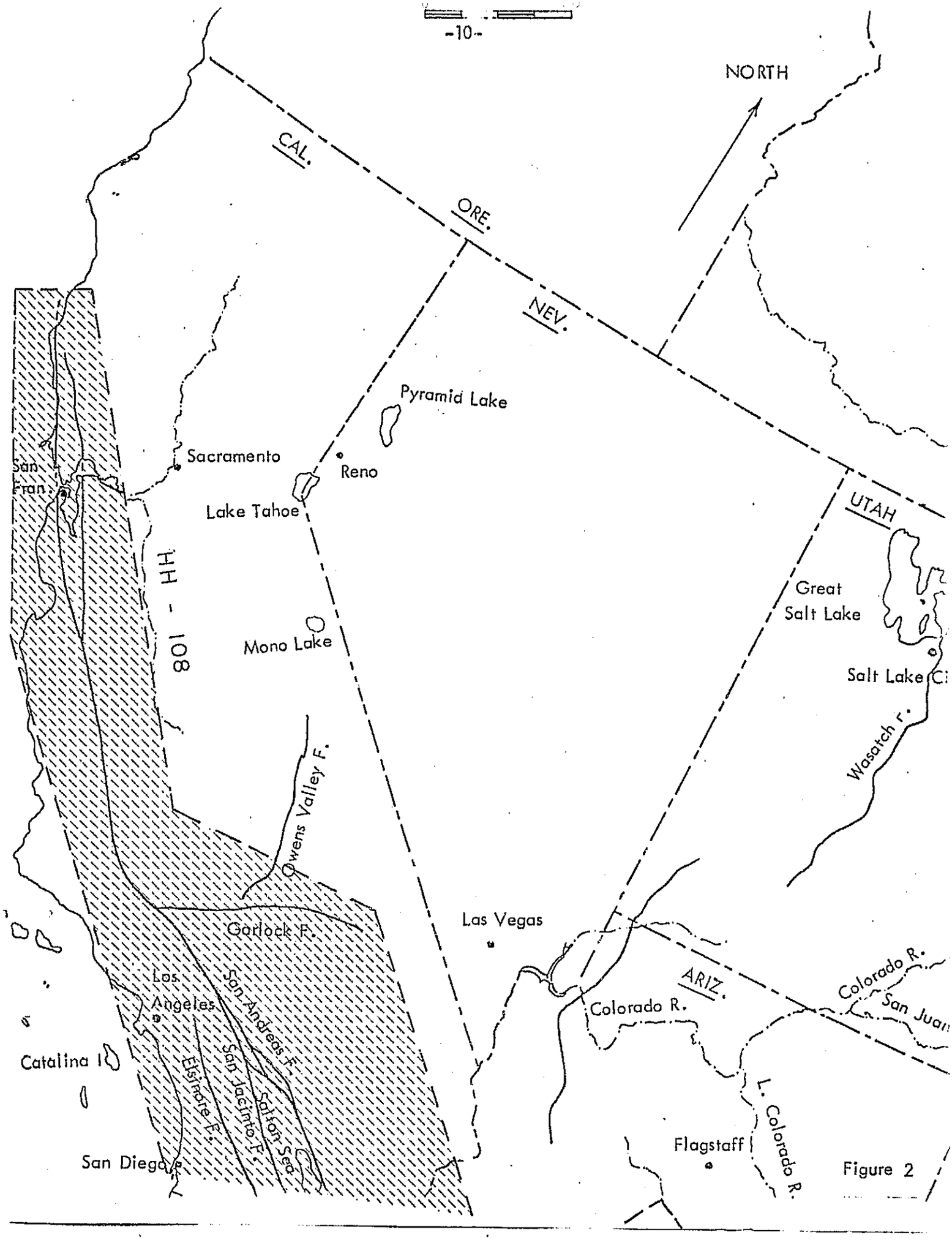
NORTH
CAL.
ORE.
NEV.
UTAH
ARIZ.
Pyramid Lake
Sacramento
Reno
San Fran.
Lake Tahoe
HH - 108
Mono Lake
Great Salt Lake
Salt Lake Ci
Wasatch r.
Owens Valley F.
Garlock F.
Las Vegas
Los Angeles
San Andreas F.
Colorado R.
Colorado R.
San Juan
Catalina I
Elsinore F.
San Jacinto F.
Salton Sea
L. Colorado R.
Flagstaff
San Diego

Figure 2

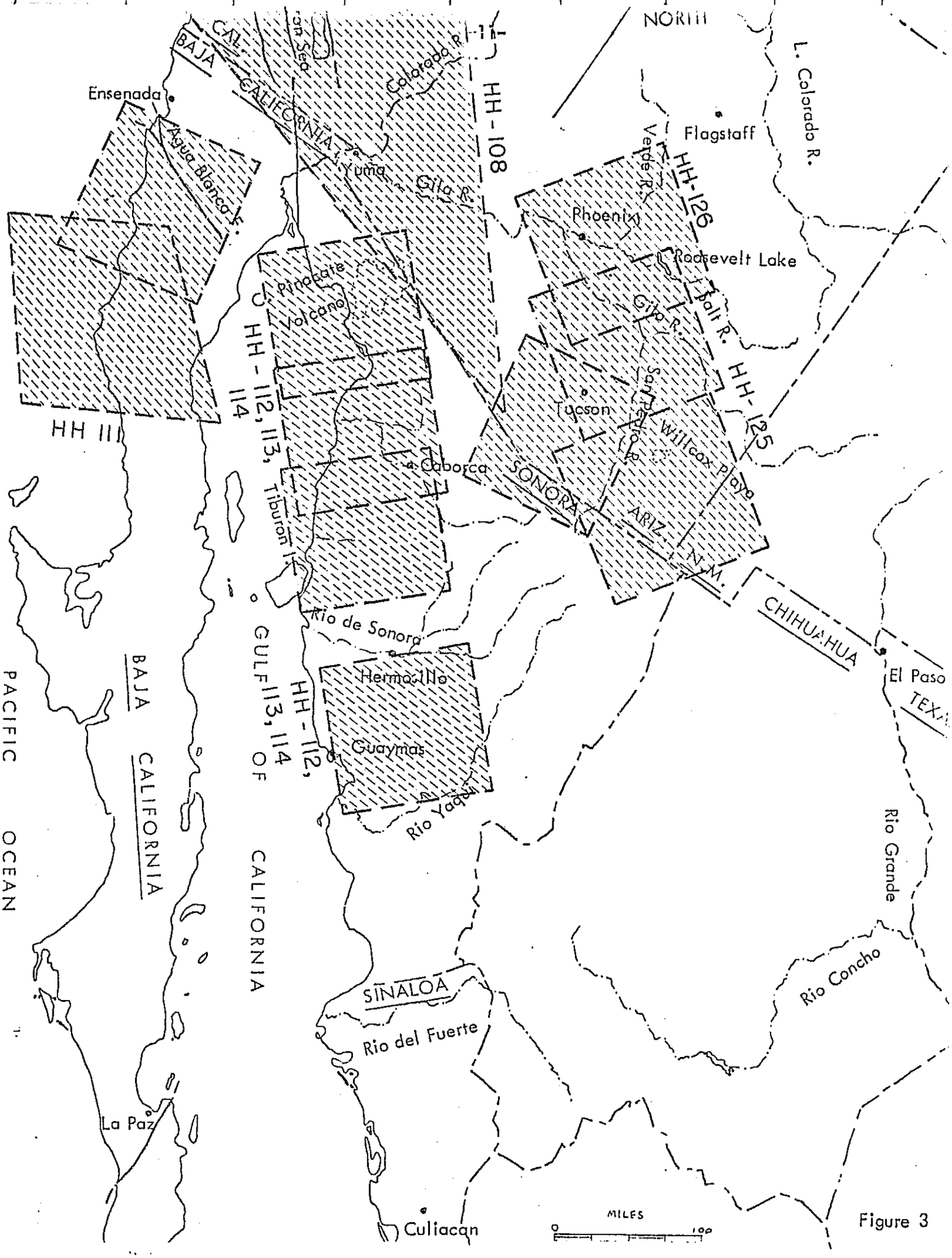
NORTH
L. Colorado R.
Flagstaff
Verde R.
HH-126
Phoenix
Roosevelt Lake
Salt R.
Gila R.
HH-125
Tucson
Sonoyta R.
Willcox Playa
ARIZ.
N.M.
CHIHUAHUA
El Paso
TEXAS
Rio Grande
Rio Concho
SONORA
Caborca
Pinacate Volcano
HH-108
Colorado R.
Yuma
Gila R.
Salton Sea
CAL.
BAJA
CALIFORNIA
Ensenada
Agua Blanca F.
HH 111
HH-112, 113, 114
Tiburon I.
Rio de Sonora
Hermosillo
Guaymas
Rio Yaqui
HH-112, 113, 114
GULF OF CALIFORNIA
SINALOA
Rio del Fuerte
Culiacan
La Paz
BAJA CALIFORNIA
PACIFIC OCEAN
MILES
0
100

Figure 3

DATA PRODUCED BY THE EXPERIMENTS

The direct products of the observational experiments take three forms:

(1) In-flight verbal commentary by crew members as they conducted their observations was recorded and transcribed. The transcripts have been searched and excerpted for these comments. They are contained in Table 1 of Appendix B where they are organized by the geographic location and experiments as well as by chronological sequence.

(2) Crew members utilized a handheld Hasselblad 70 mm camera with a 100 mm lens (HDC) and a Nikon 35 mm camera with 55 and 300 mm lenses. They utilized both cameras on all targets, under a variety of observing positions and lighting conditions. They also made numerous photographs of "targets of opportunity", i.e. geological features which they believed to be noteworthy but which had not been included in the assigned exercises. A total of more than 400 photographs were taken during the course of these experiments. A tabulation of the photography, organized by geography problem and then by chronological sequence is given in Table 2 of Appendix B. A series of geographical map indices showing photographic coverage and photographic orientation are presented in Figures B1 to B17 of Appendix B. The comprehensive

coverage required a number of separate maps to minimize confusion. The maps are separated according to type of camera and each represents a limited number of magazines.

(3) Post-mission crew debriefing and individual crew communications provided opportunities for the crew to synthesize and summarize their impressions on the actual observing conditions, on the art of observation and on the scientific subjects explored by them and to offer their recommendations for future improvements. Two documents are contained in Appendix C: the transcript of the March 12 Crew Debriefing, and a very thoughtful letter sent to L. T. Silver by astronaut E. G. Gibson, whose consent to its incorporation in this report is sincerely appreciated.

Other discussions with crew members have been stimulating and useful. Their content has been utilized by the P.I. in the course of completing this study.

SL-4 CREW EFFECTIVENESS IN GEOLOGY OBSERVATIONS

Our preliminary assessment (Silver, et al., 1974) of crew effectiveness has been reinforced during the completion of the project. This section is developed from our earlier statement.

The effectiveness of a visual observations program depends on the personnel involved; their interest, scientific training, observational powers, and preflight preparation are key aspects. The SL-4 crew demonstrated a high degree of interest both in the general visual observation program and in the specific geologic questions that concerned their targeted sites. Both during and after the mission this interest and an obvious enjoyment of earth observation were manifested.

The scientific background of the crewmen varied from sound for the Commander and Pilot to outstanding for the Science Pilot. They clearly understood the nature of observational techniques and the associated inductive logic. For geological sciences, the crewmen lacked a basic familiarization with geologic phenomena. This could have been remedied by a longer geological training program.

The preparation of the crew for the Visual Observations Project was minimal. The crew members recognized this and stated it explicitly in the debriefing of March 12, 1974. The extensive and detailed flight book for visual observations served to keep them task-oriented. More preflight discussion of basic scientific objectives would have been desirable.

The observational powers of the crew were exceptional. Combined with their interest and enthusiasm, these capabilities have produced some outstanding photographic studies. The contribution of the verbal commentary is subordinate to these photographs because of a general crew tendency to depend on their photographic documentation. We suspect this may reflect a lack of crew confidence in their command of the diverse scientific subject matter. The fact that the crew members quickly recognized and identified the geological features in their target areas reinforces the belief that more extensive preflight preparation would have enhanced the total science yield of the visual observations.

The crew developed many new and significant impressions of visual observation and photography techniques. For example, they have stressed one important factor which we suspected. No photography can match the effectiveness of the human eye in perception of color, texture and form of surface phenomena. To quote Cdr. Carr in our debriefing of March 12, 1974. (Appendix C)

"Let me say just one thing to you. I think there is one fallacy we fell to, and that was the tendency to depend on the photographs. We've gotten back and we've looked at this photography now. It doesn't capture everything that's there and I think you guys understand that. I don't think we understood it as well as we should have before we left. Some of the stuff we have looked at just does not hold a candle to what you can really see with the old MK-VIII eyeball. And this is something we are going to have

to do in future programs, and that is either to get better photography or start training a little bit more towards being able to get verbal descriptions of what you're looking at, because these pictures just don't have all of it at all". (End of quote.)

Science Pilot E. G. Gibson has summarized many of the crewmen's major points and made recommendations for enhancing future Visual Observations efforts in an excellent letter, presented in Appendix C. We endorse most of these comments and suggestions and urge consideration of all of them. The letter should be made a part of the permanent record along with the many thoughtful and incisive comments voiced by the crewmen during the geology debriefing.

We would summarize by saying that the crew's observational performance was outstanding, despite the paucity of verbal comment. On the basis of their photographic documentation and our discussions with them, and recognizing the state of their initial preparation for visual observations, we believe that they have made a strong case for future geological visual observations experiments from orbit. Such experiments should continue to test and compare the effectiveness of manned visual observations against other approaches. They should be designed, however, around genuine on-going research efforts with the orbiting observer, astronaut or scientist, as a full-fledged participant in the research. The criteria for effectiveness should include measures of steady research contribution as well as the opportunities for unexpected discovery.

DESCRIPTION AND SUMMARY OF RESEARCH RESULTS

The visual observations of the astronauts, particularly in their photographic record, were deliberately directed to areas where regional research investigations were being actively pursued by various members of this team. We have found this selective photography to be a rich reservoir of new information and insights.

We have rarely found totally new, unsuspected, major geologic features, although there are innumerable new data points. We have invariably found that each research problem has been given a new perspective in which the geography and geometry of the diverse geologic elements of a region hundreds of kilometers in dimension fall into obvious spatial relation. This is not simply a result of having a new horizontal map base. It reflects the ability of the photography to help establish entities of color, texture, structure, and form, on a scale and with an orientation that was not previously available.

From our previous work and our post-mission ground checks we have learned to be cautious against oversimplification of the significance of many apparent photographic relations. At the same time we have confirmed a number of large-scale relations we suspected but had previously been unable to integrate properly for lack of a documented overview.

For a region as geologically well known as southern California, the visual observations photography appears to make its greatest research contribution when it is treated as an important tool to be utilized in conjunction with other diverse approaches in developing a more complete grasp of large scale features. In this role its usefulness will be more steady and pervasive if less spectacular.

In more unfamiliar regions such as northwest Mexico, there is a greater potential for exciting discoveries, and indeed we believe that some of this Skylab effort will help us achieve this type of product. But it is in precisely this type of situation that premature generalization without adequate ground-studies for confirmation can cloud the potential. The scale of our efforts has not been such as to provide rigorous testing of most of the important possibilities inferred from our studies of the photography and the crew's appropriate commentary.

With these circumstances in mind we present a selection of some of the many stimulating, sometimes enigmatic, research results we have derived and continue to derive from the visual observation efforts of the SL-4 crew. A summary statement which concludes this section will indicate where we believe the greater significance should be placed.

HH-108 San Andreas Fault System and the Architecture of Southern California -

R. Powell and L. T. Silver

The remarkable control exerted on its topographic character by the complex network of active faults in southern California was explicitly documented by the SL-4 astronauts. From a striking series of oblique handheld photographs we have constructed a photo-mosaic (Fig. 4) which captures their continuity and their relation to the great rift of the Gulf of California. The principal elements of this fault system are identified in Fig. 4a .

Most of these structures are well known and intensively studied, of course. The crew's attention was directed to them as perhaps the best examples of fault-line features from which they could establish their own observational criteria for fault recognition. Their photographic record has provided, in turn, an unparalleled overview of the fault system which can be as informative to the public as it is to scientists and students.

From a significant number of relevant applications to southern California geology which we hope to develop, we have selected three diverse examples. We believe they illustrate the great potential of the SL-4 handheld photography.

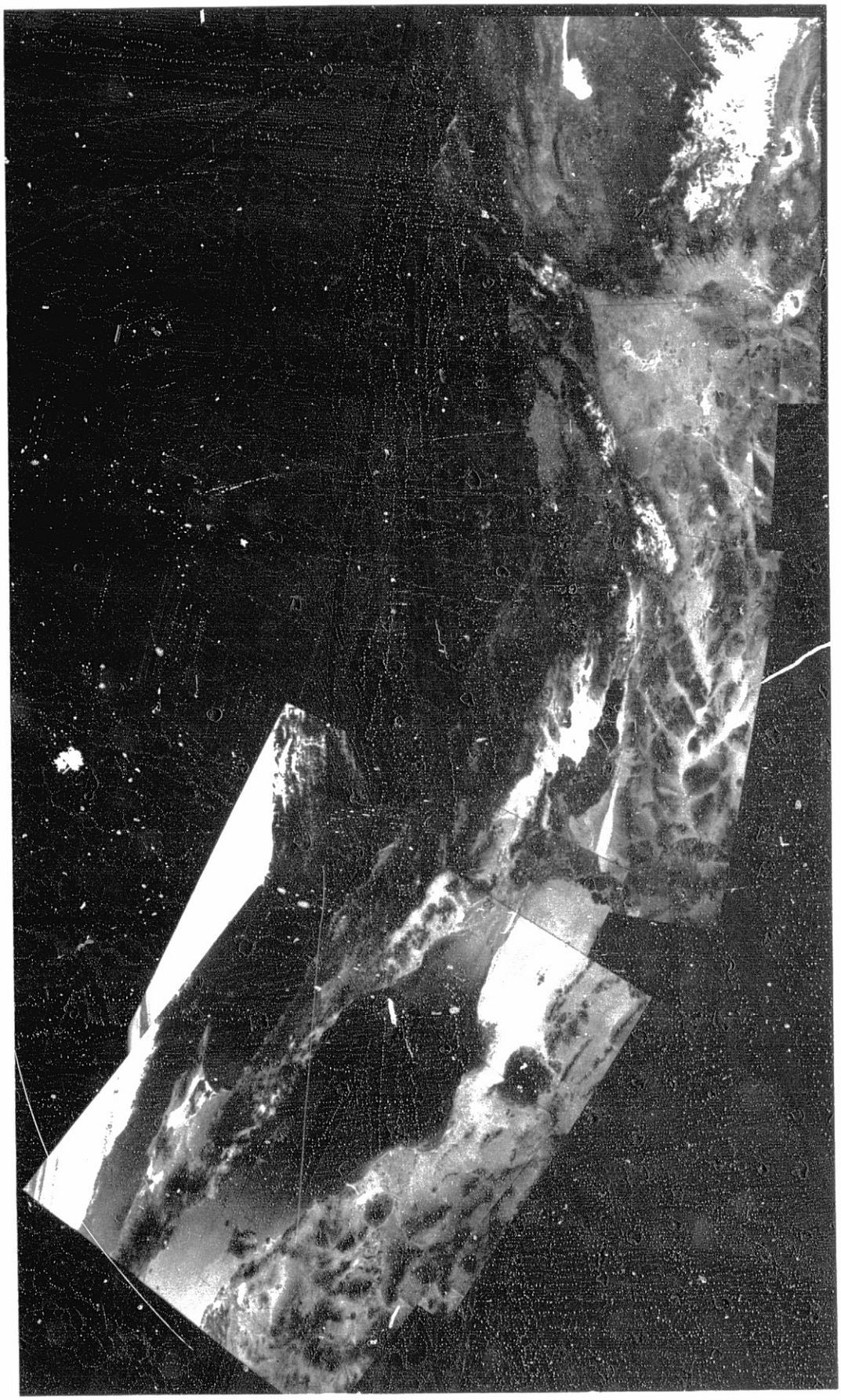

Figure 4

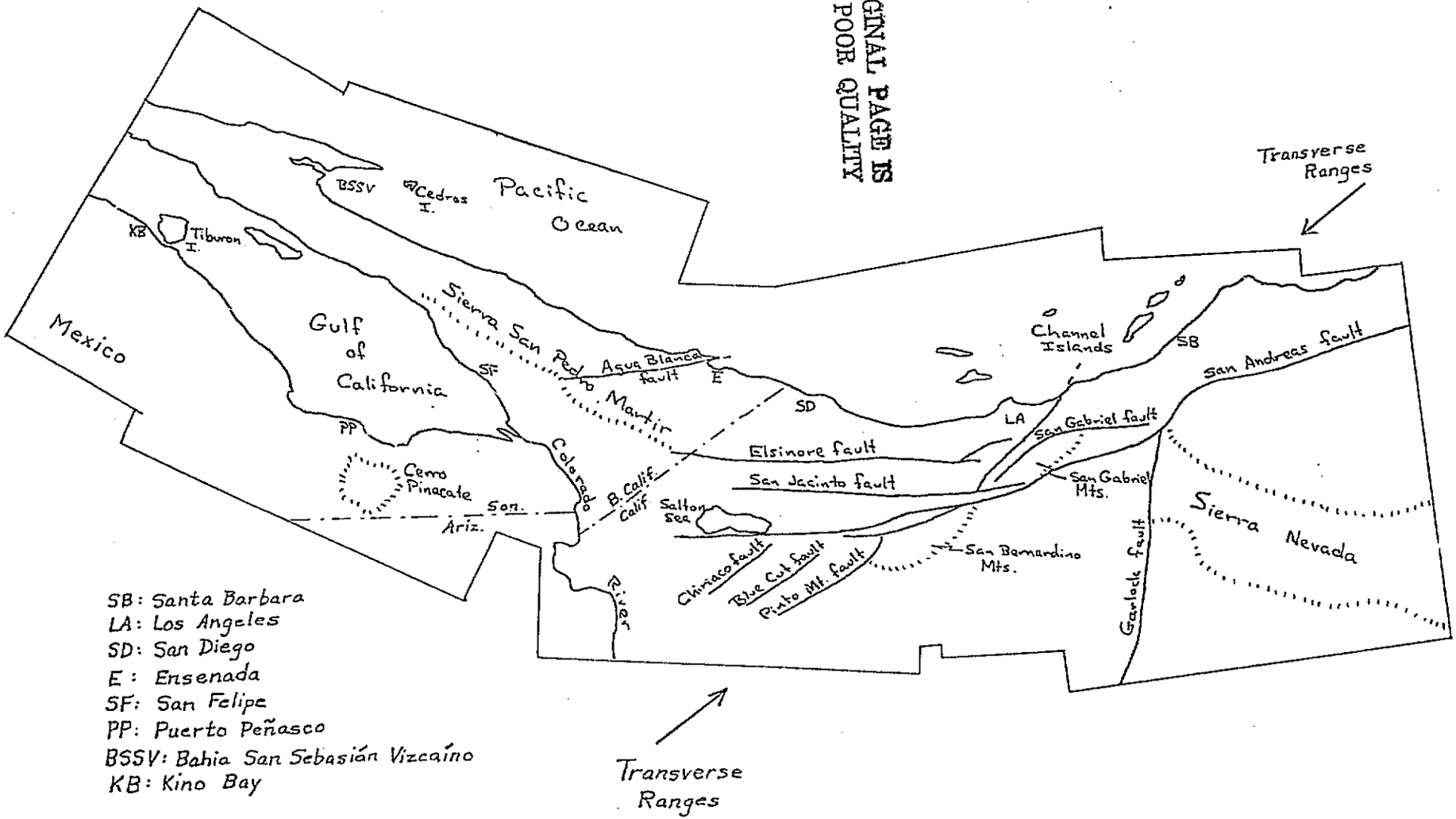

Figure 4a: Overview of major fault systems in southern California and northwestern Mexico.

East - West Lineaments

The east-west structural grain of the Transverse Ranges forms a profound geologic and physiographic break in the general northwest-southeast trends of California and Baja California. The tectonic significance of this unique transverse province in western North America is not yet fully understood in terms of timing of structural events or even definition of structural elements. Skylab-4 handheld photography has provided an excellent overview of the Transverse Ranges province (Figure 4) and an opportunity to further delineate some of its structures.

The eastern Transverse Ranges are distinguished by several east-west faults along which left-lateral displacement has been documented (Dibblee, 1967; Hope, 1969). These faults, including the Pinto Mountain, Blue Cut, and Chiriaco faults (Figs. 5, 5a), define prominent linears on Skylab 4 handheld photographs. The Pinto Mountain, Blue Cut, and a few smaller faults were known to have left-lateral displacement prior to the Skylab-4 mission.

Displacement along the Chiriaco fault has been demonstrated during ground-check of in-flight observations of the Skylab-4 crew. Seven miles of left-lateral movement can now be demonstrated along the eastern half of the Chiriaco fault (Figure 6, and Powell, 1975); the offset lithologic units cannot be resolved on HDC photographs but target areas for comparison and possible correlation were suggested and are detectable on NK 300 mm photograph SL-4-203-7804 (Figure 6).

SL4-142-4545

Figure 5

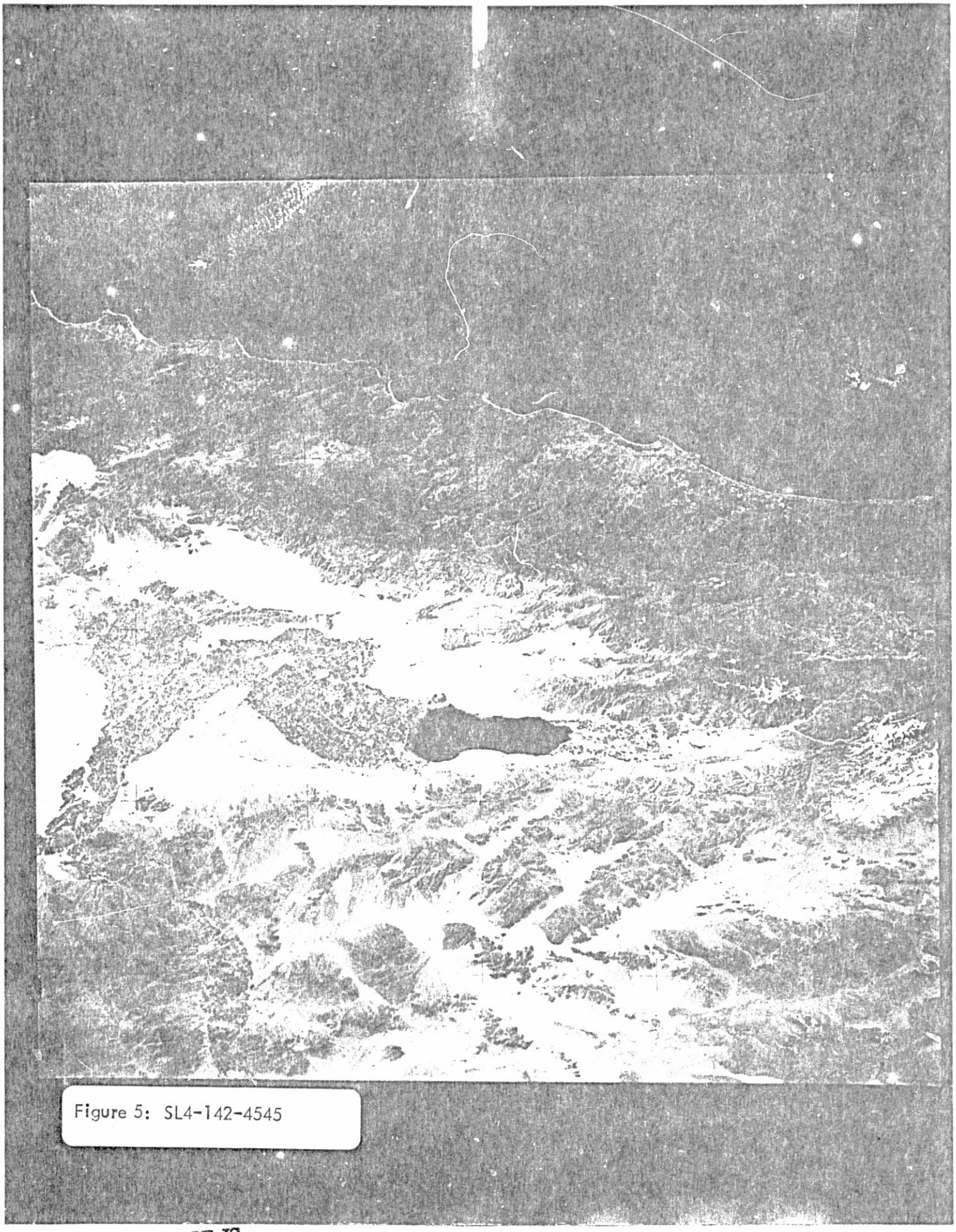

Figure 5: SL4-142-4545

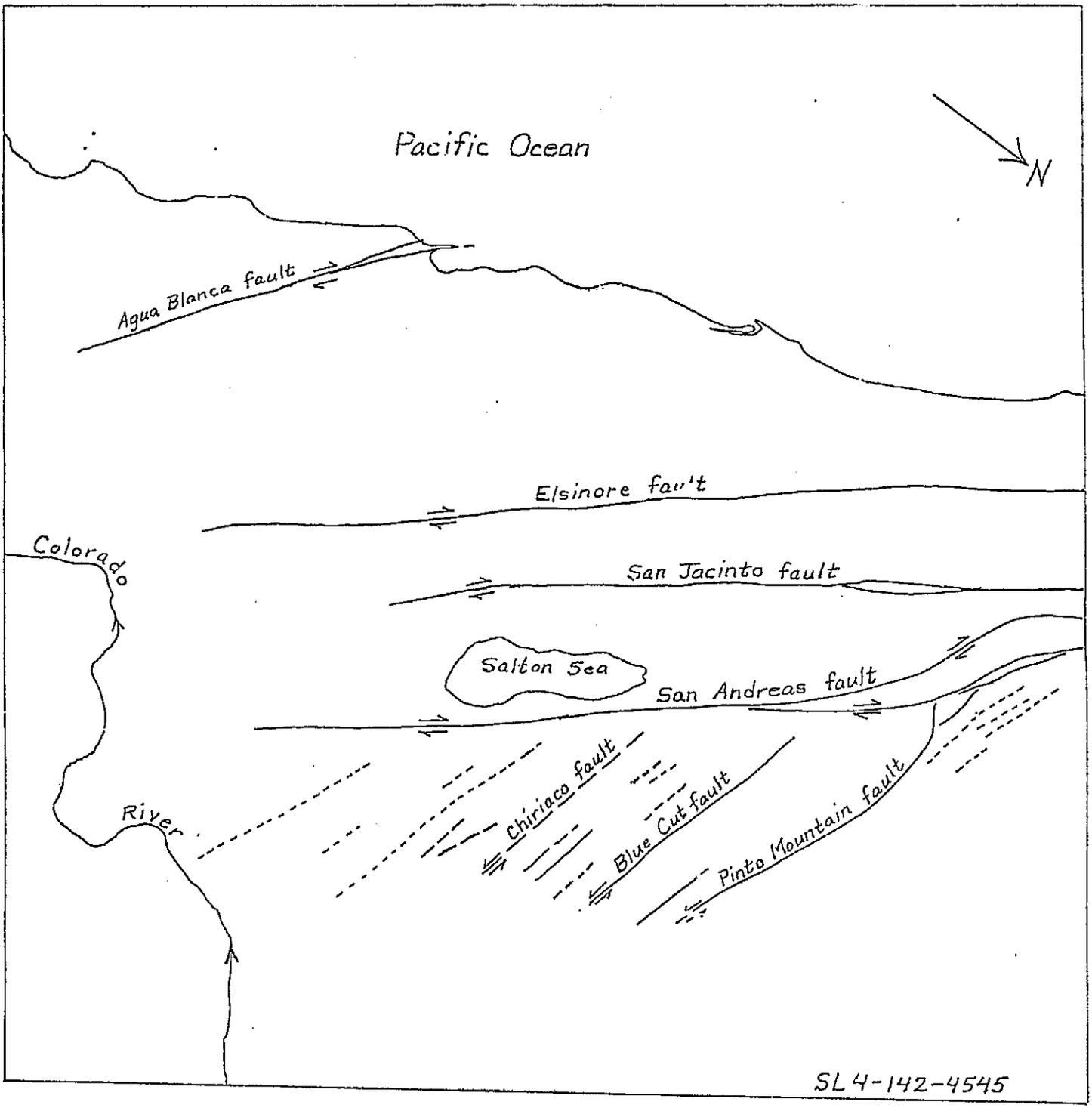

Figure 5a: Major east-west and northwest-southeast linear features in southern California. Arrows indicate the direction of relative motion on opposite sides of faults. For the area east of (below) the San Andreas fault:

Solid lines = faults of previously known left-lateral displacement

Long-dashed lines = faults with left-lateral displacement demonstrated during the course of Skylab-4 ground-check

Short-dashed lines = linears with possible left-lateral displacement

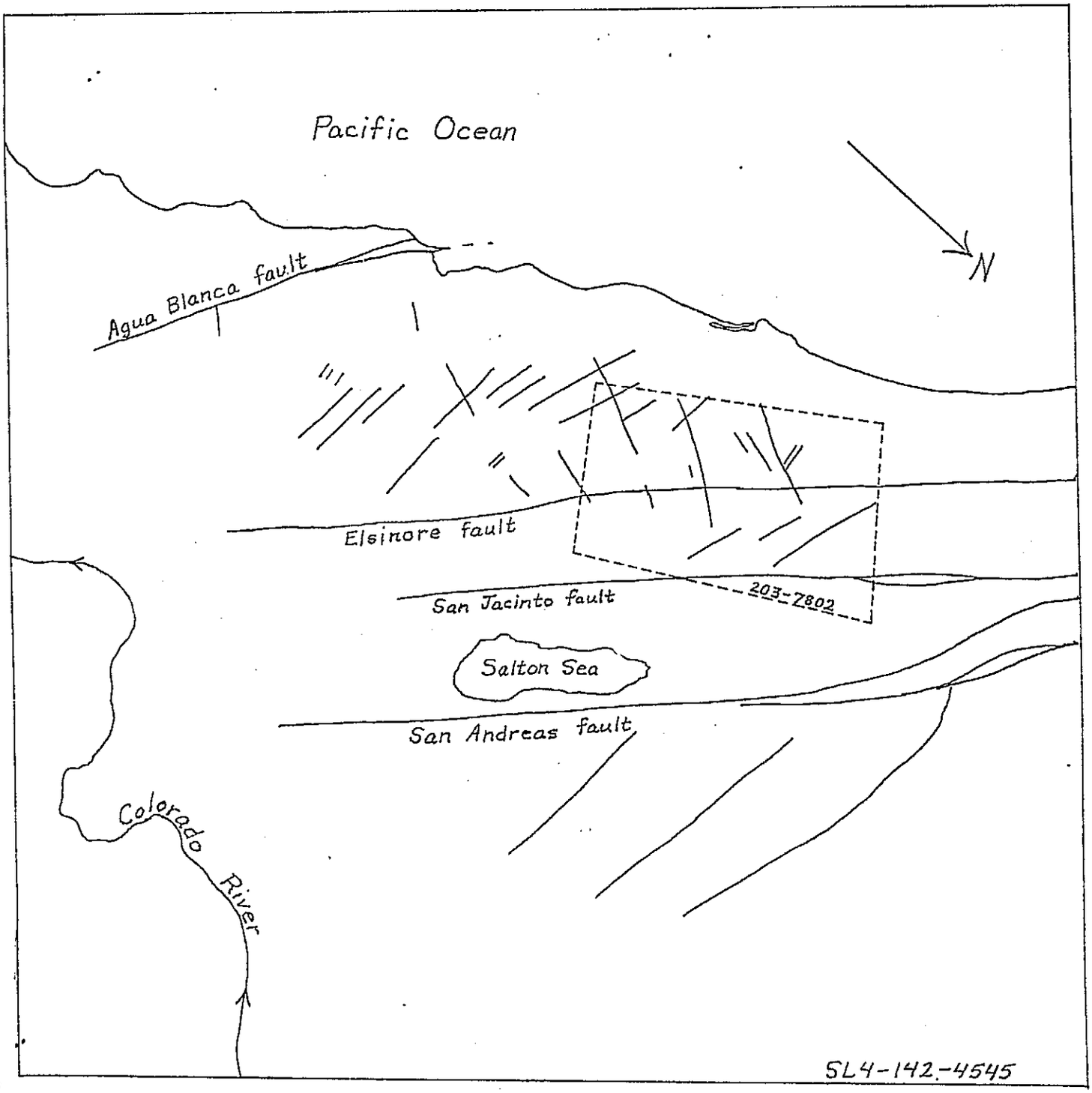

Figure 5b: Prominent conjugate linears in the northern Peninsular Ranges. Location of SL-4-203-7802 (Figure 7, 7a) is outlined.

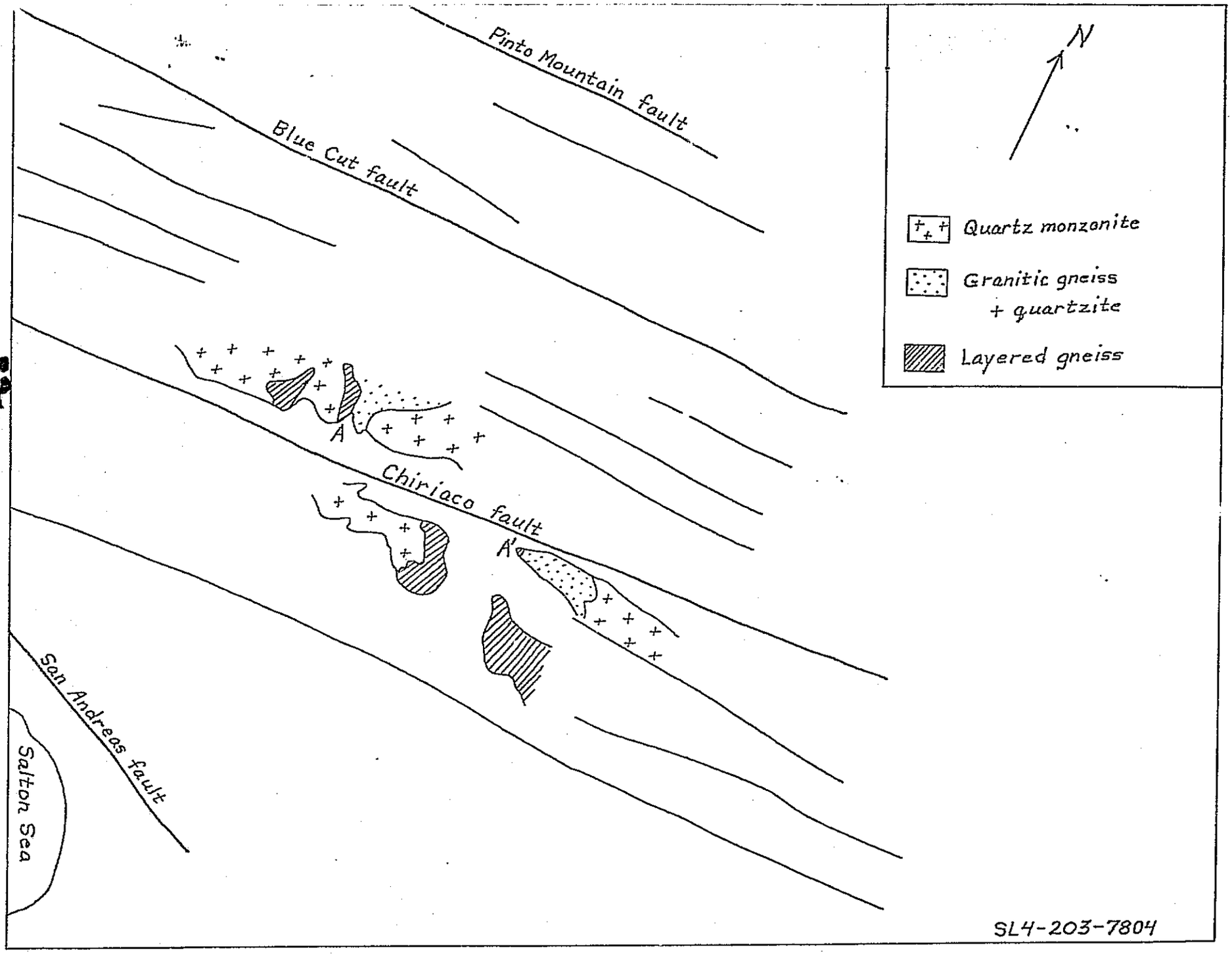

Figure 6: Prominent east-west linears northeast of the Salton Sea. Distance from A to A' indicates 7 miles left-lateral displacement on the Chiriaco fault.

Further study of Skylab 4 handheld photographs resulted in recognition of additional east-west linears south of the Chiriaco fault. Left-lateral displacement has since been established on two of these linears. An important goal for continued research is to determine whether or not the rest of these linears are controlled by left-lateral faults. Recognition of the distribution of east-west linears on SL-4 photographs, followed by documentation of fault-control and timing of fault motion, will increase understanding of the mechanical evolution of the Transverse Ranges structural province.

Conjugate Fracture Systems in the Peninsular Ranges

Two prominent sets of linears are recognizable in the Peninsular Ranges of southern California and Baja California on Skylab-4 handheld photographs. Southwest of the Elsinore fault these sets trend N 15°-35° E and N 70°-80° W (Figs. 5, 5b, 7, 7a). Northeast of the Elsinore fault, the linear sets trend N 20°-30° E and N 60°-70° E. The geometric pattern of the linears suggests that they may be conjugate fracture sets which have been superimposed on the batholithic terrane, trangressing but not confined to individual plutons. The fracturing occurs throughout the length of the Peninsular Ranges covered by Skylab-4 photography available to us (see discussion of HH-111 in Baja California). Other structural linears are present but are considered as separate phenomena.

SL4-203-7802

Figure 7

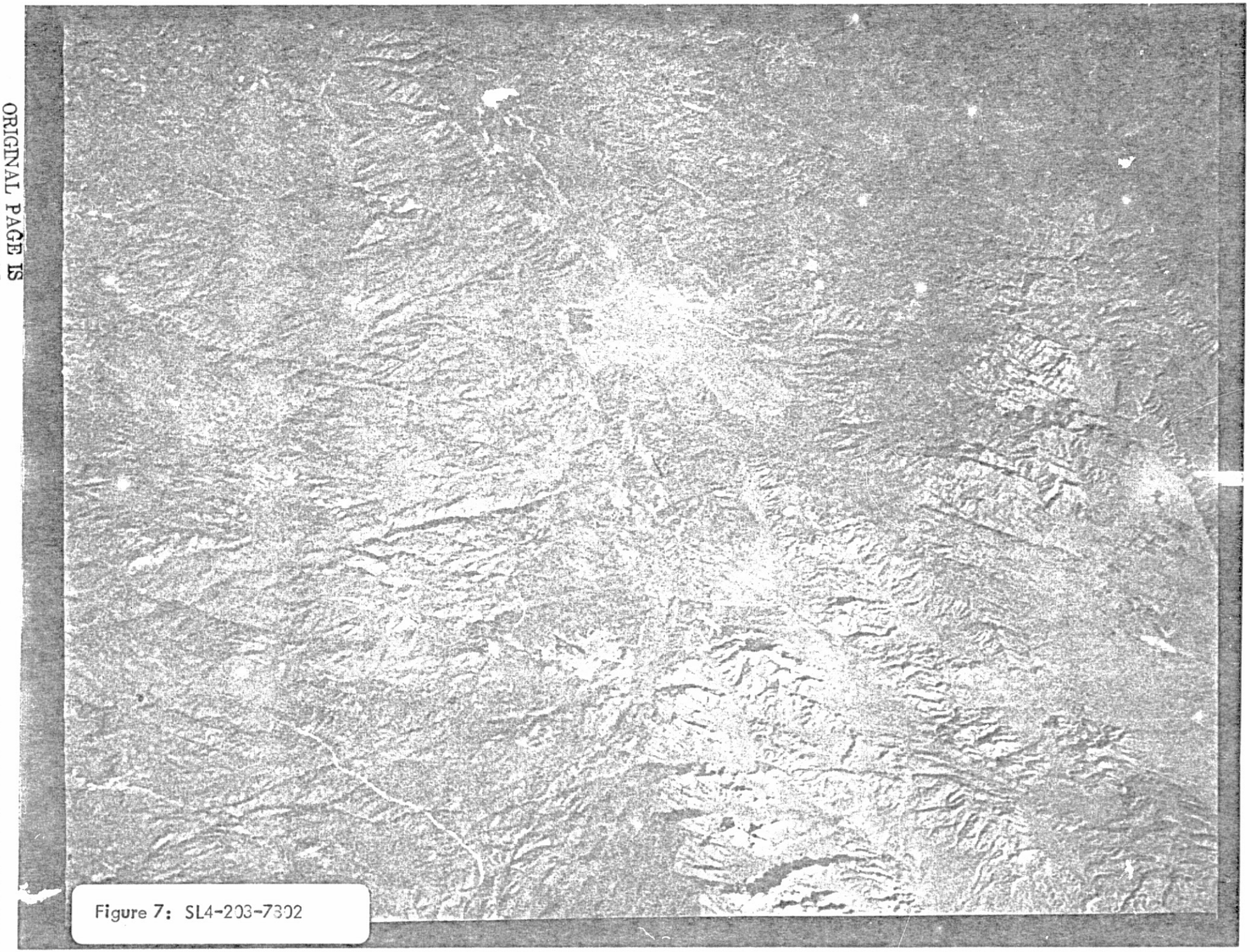

Figure 7: SL4-203-7302

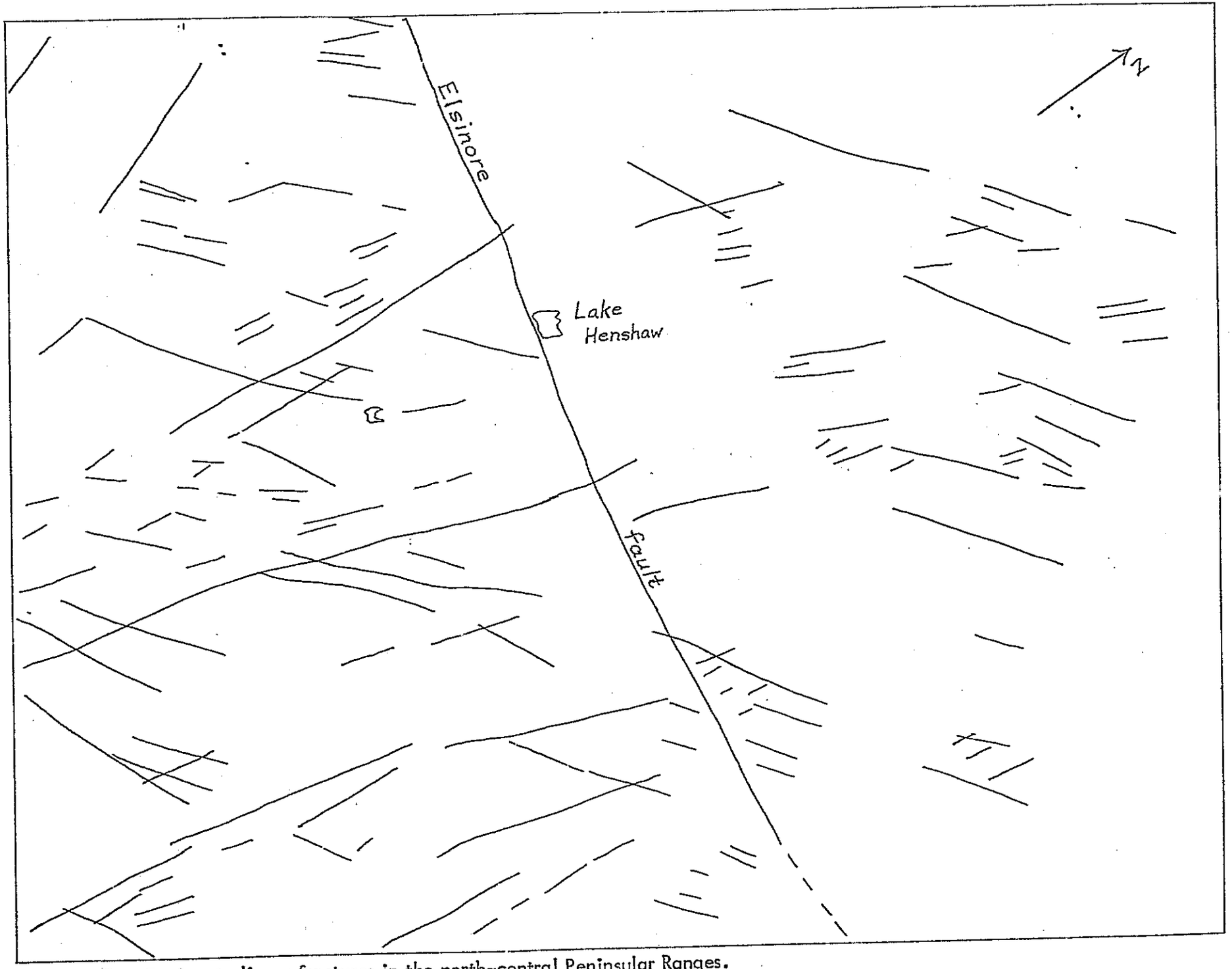

Figure 7a: Conjugate linear fractures in the north-central Peninsular Ranges.

If the conjugate fracture system is interpreted as a conjugate shear system, then the axis of maximum principal (compressional) stress is oriented ~ N 65° E or roughly perpendicular to the main structural, petrologic, geochemical, and geophysical trends of southern California and Baja California. The slightly different orientation of the fracture pattern northeast of the Elsinore fault may reflect a variation in local stress field across one of the major faults of the Peninsular Ranges, or a superimposed rotational effect produced by later movements on the Elsinore and San Jacinto faults. The conjugate fracture pattern may represent a response of the Peninsula to compressional stresses imposed on the Peninsular block during the opening of the Gulf of California or to regional stresses developed on a more extensive area of southwestern North America shortly before the rifting of the Gulf. It does not appear to be related directly to the San Andreas stress system. A similar pattern of fracturing appears to be present in the southern Sierra Nevada, as shown faintly on SL-4-142-4540 and very distinctly on SL-4-203-7787, centered on Lake Isabella.

The overview of these regional fracture patterns provided by the Skylab photography suggests the possibility of an integrated crustal response to tectonic strain on a scale that has not been observed and appreciated previously. It appears to us that within the inventory of Skylab mapping and handheld photography, much of which was not available to us at this time, are the resources for an extended investigation of these phenomena and their broad implications.

A Test of Color Values for Lithologic Correlations

The value of Skylab handheld color photography for identifying and correlating lithologic units on a regional scale is potentially great, although reliable use requires a thorough understanding of color values and the factors which influence them. Color differences between rock types of varying lithologic composition are modified by sun angle, desert varnish, surface texture of bedrock and debris, and vegetation. Ambiguity in photo-interpretation arises when some or all of these factors combine to give different lithologies similar color values. Resolution of the ambiguity requires an interplay of photo-interpretation and field work.

In an area northeast of the Salton Sea (Figs. 8, 8a), we have carried out such a cross-check. Existing field and photo-interpretive mapping represent the eastern Eagle and Pinto Mountains as granitic intrusive rocks, and the southern Coxcomb and Palen Mountains as volcanic-derived metasedimentary rocks. However, the color values of the eastern Pintos and southern Coxcombs and Palens on SL 4-203-7804 are very nearly the same, which suggested the possibilities that existing maps are inaccurate and that the dark color values are reflected from equivalent lithologies. On the basis of these color values, we postulated a possible right-lateral offset of approximately 20 miles along the queried line shown in Figure 8a. This line represents the eastern physiographic limit of the Transverse Ranges as well as a consistent local geologic discontinuity. In our attempt to use Skylab 4 handheld photographs for photo-geologic

SL4-203-7804

Figure 8

Figure 8: SL4-203-7304

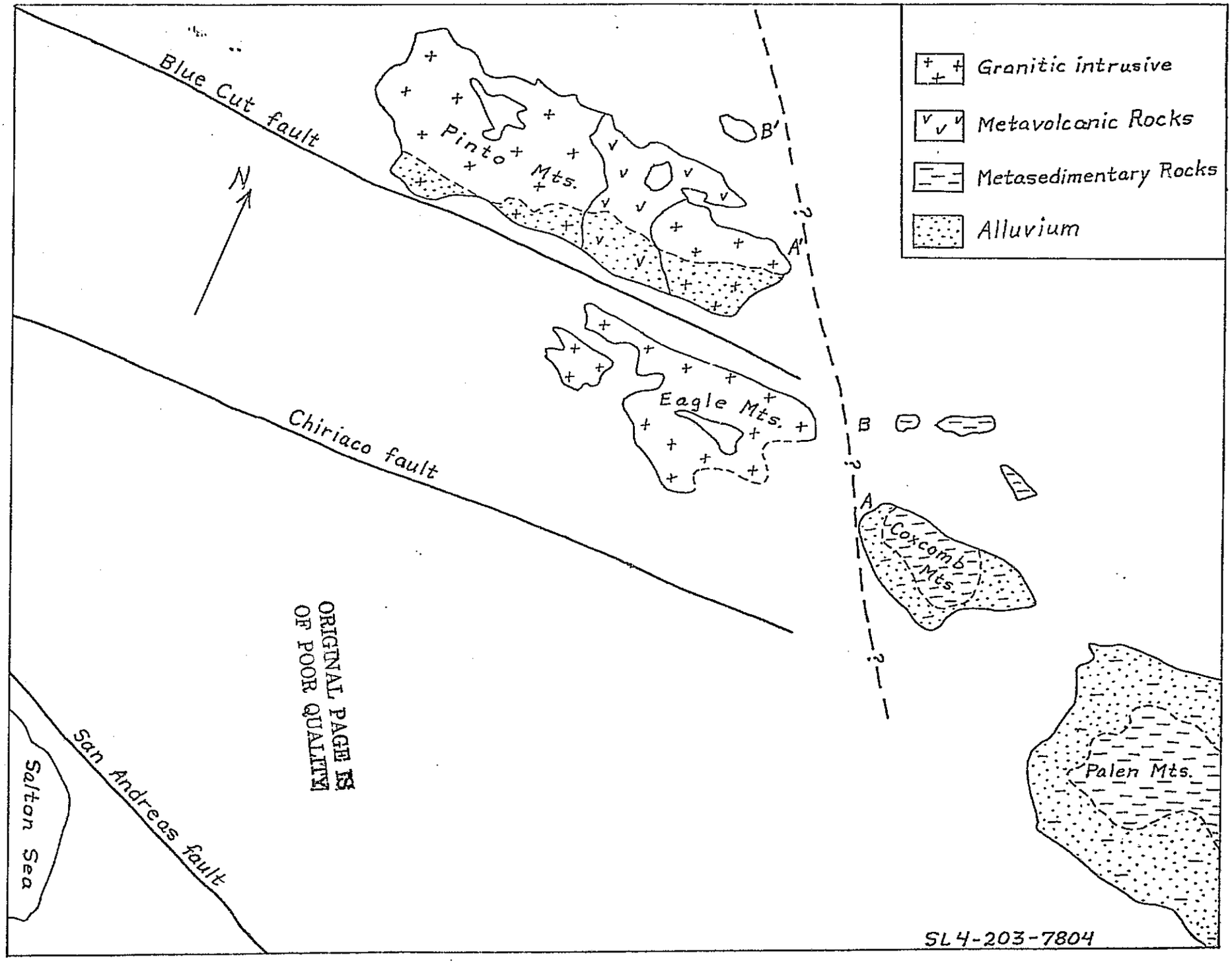

Figure 8a: Geologic map of an area northeast of the Salton Sea. Based on combined photo-interpretation and field reconnaissance.

interpretation, we proposed correlation of dark color-valued units intersecting the queried line at A and B with those at A' and B'.

Field reconnaissance has indicated that there is in fact a significant area of unmapped volcanic rocks in the eastern Pintos, although subordinate to the granitic intrusives (Figure 8a). However, the dark color values do not represent equivalent lithologic units, so that the suspected fault displacement was not confirmed. The dark units in the eastern Pintos are metavolcanics and granitic intrusives, whereas volcanic-derived metasediments comprise the southern Coxcombs and Palens.

There are several points to note on Fig. 8 (7804) with respect to photo-interpretation of the dark color values. First, this particular granitic lithology is deeply colored by desert varnish so that its color value in the eastern Pintos is difficult to distinguish from that of the lithologically darker metasedimentary and metavolcanic rocks. Second, the texture and color of the alluvial material derived from the granitic unit are distinct from those derived from the sedimentary and volcanic units. In particular, it should be noted that the freshly broken stream :naterial is lighter-colored in granitic-derived fans than it is in metavolcanic- or metasedimentary-derived fans. This contrast probably reflects primary lithologic color differences unbiased by desert varnish. Third, metasedimentary and metavolcanic lithologies here are indistinguishable on the basis of color value. Fourth, the texture and color of alluvium derived from metasedimentary and metavolcanic sources are indistinguishable.

The geologic usefulness of Skylab photography in southeastern California is constrained by the overlap between the component of color value contributed by lithology and that contributed by desert varnish. Usefulness may, however, be enhanced by coordinating photo-interpretation and field study. Comparison of photographs taken of a single area in visible and infrared light and at different sun angles might further help to distinguish lithologic units.

HH-111 Northern Baja California - J. Murray and L. T. Silver

General Statement

Target HH-111, northern Baja California, was divided into five specific sites and objectives (see Appendix A), and the detail of photography, visual observations, and commentary varied greatly among these sites. The crew focussed particularly on the Agua Blanca fault zone (specific site #3), but also addressed themselves directly to several of the other sites. The entire HH-111 area was covered by 58 Hasselblad (HDC) and 44 Nikon (NK) 55 mm or 300 mm photographs.

The geology of Baja California has not been studied in nearly as great detail as that of most areas in the United States, and the potential yield from satellite-based observations and photography in terms of geologic reconnaissance is correspondingly high. The objective of the project was the identification of major patterns in the folded strata, granite plutons, possible major faults, and other conspicuous recent geological features. The photographs provide an overview of large areas of the peninsula in a way not possible by conventional aerial photography and are therefore especially useful for observation and integration of large-scale structural patterns.

The results of the HH-111 project will be discussed under four major topics: (1) observation and interpretation of the significance of the lightly colored stripe (specific site #1; see Appendix A) and associated linear features; (2) recognition and mapping of igneous intrusive bodies (plutons); (3) observations concerning the Agua Blanca

fault zone and related features; and (4) photogeologic mapping of major fracture patterns in the northern part of the peninsula. The crew also photographed and discussed the young volcanic features at San Quintín and farther south as directed in specific site #5 (see Appendix A). Apparently the cinder cones were more clearly visible to the naked eye than they are in the photographs. Little detail of the volcanic constructs is visible in the photographs, despite the fact that the photographs are of as good quality as any of the others.

The Lightly Colored Stripe and Associated Linear Features

Specific sites #1 and #4 in the original HH-111 project description (Appendix A) involved photographing and tracing the extension of two major linear features (#1 and #5) shown on Fig. 9a traced from Figure 9 (197-7428). The goal was to map these features, to look for any patterns or differences in the rocks or vegetation on either side of these features, and to look for any other evidence relating to their geologic nature.

Numerous photographs show both features clearly, especially the lightly colored stripe (#1). The crew were able to recognize the light stripe for a distance of about 45 km southward from just south of the San José pluton. On photograph 197-7428 (Figs. 9 and 9a) the stripe can be traced much farther, for a distance of nearly 100 km southeastward from Arroyo Calentura. North of the San José pluton the stripe is less well-defined than it is farther south and may, in fact, consist of two subparallel stripes which merge (?) near the northern end of the pluton. At its southern end, the light stripe gives way to a region

SL4-197-7428

Figure 9

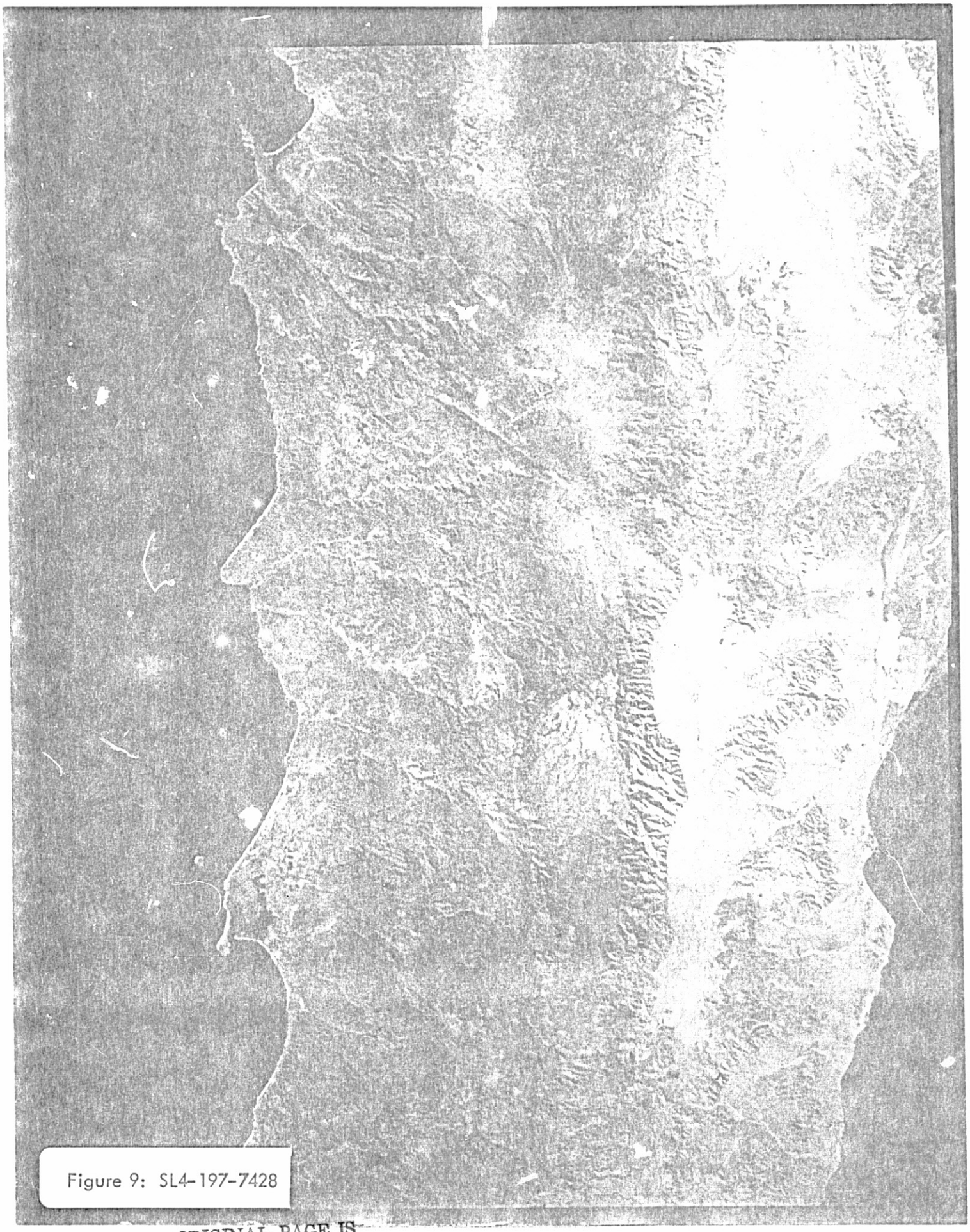

Figure 9: SL4-197-7428

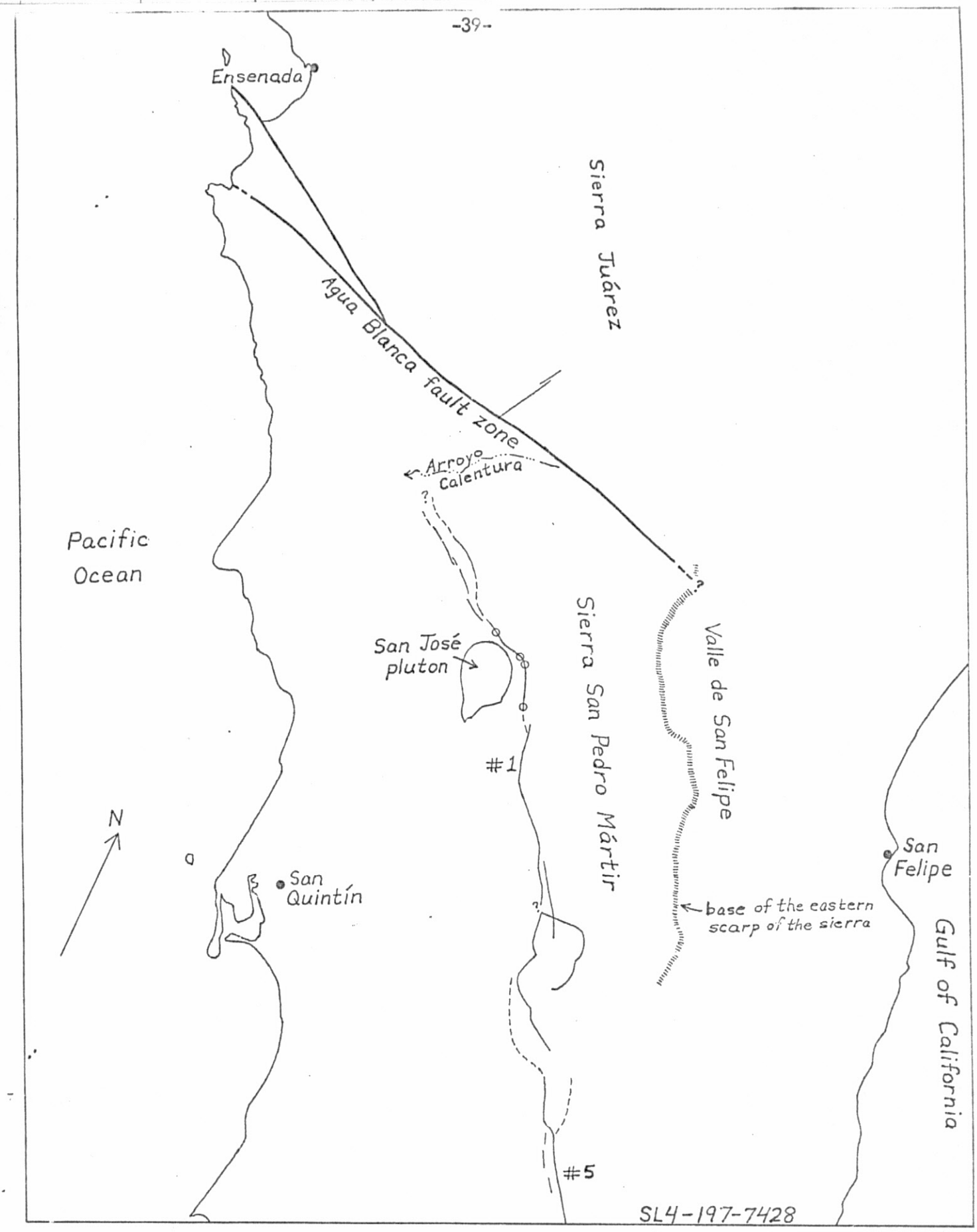

Figure 9a: Trace of linear features #1 (lightly colored stripe) and #5 and the intervening region of arcuate patterns. Small circles denote locations of ground study.

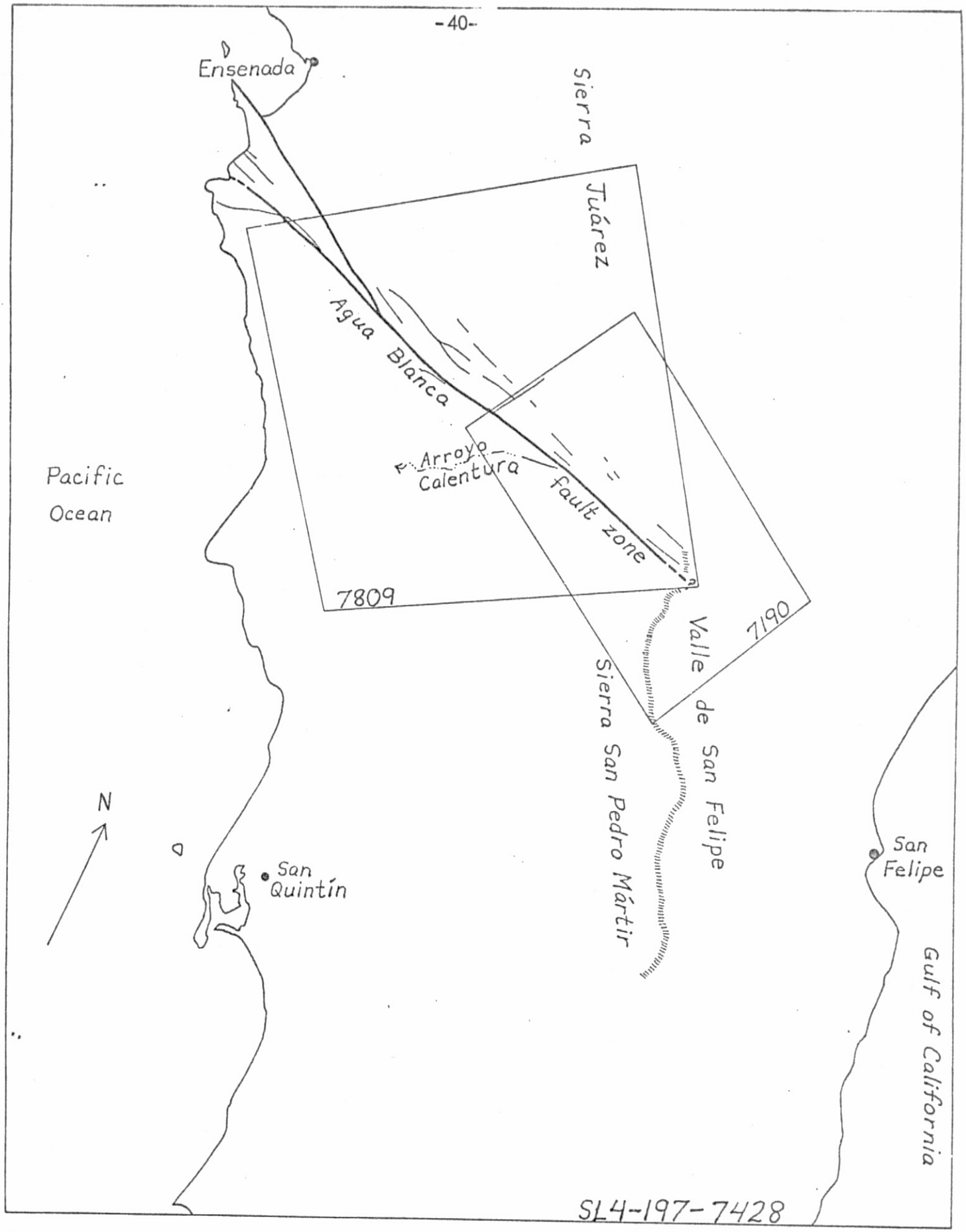

Figure 9b: Overview of the Agua Blanca fault zone and associated fractures. Locations of photographs 193-7190 (Figure 11, 11a) and 203-7809 (Figure 12, 12a) are outlined.

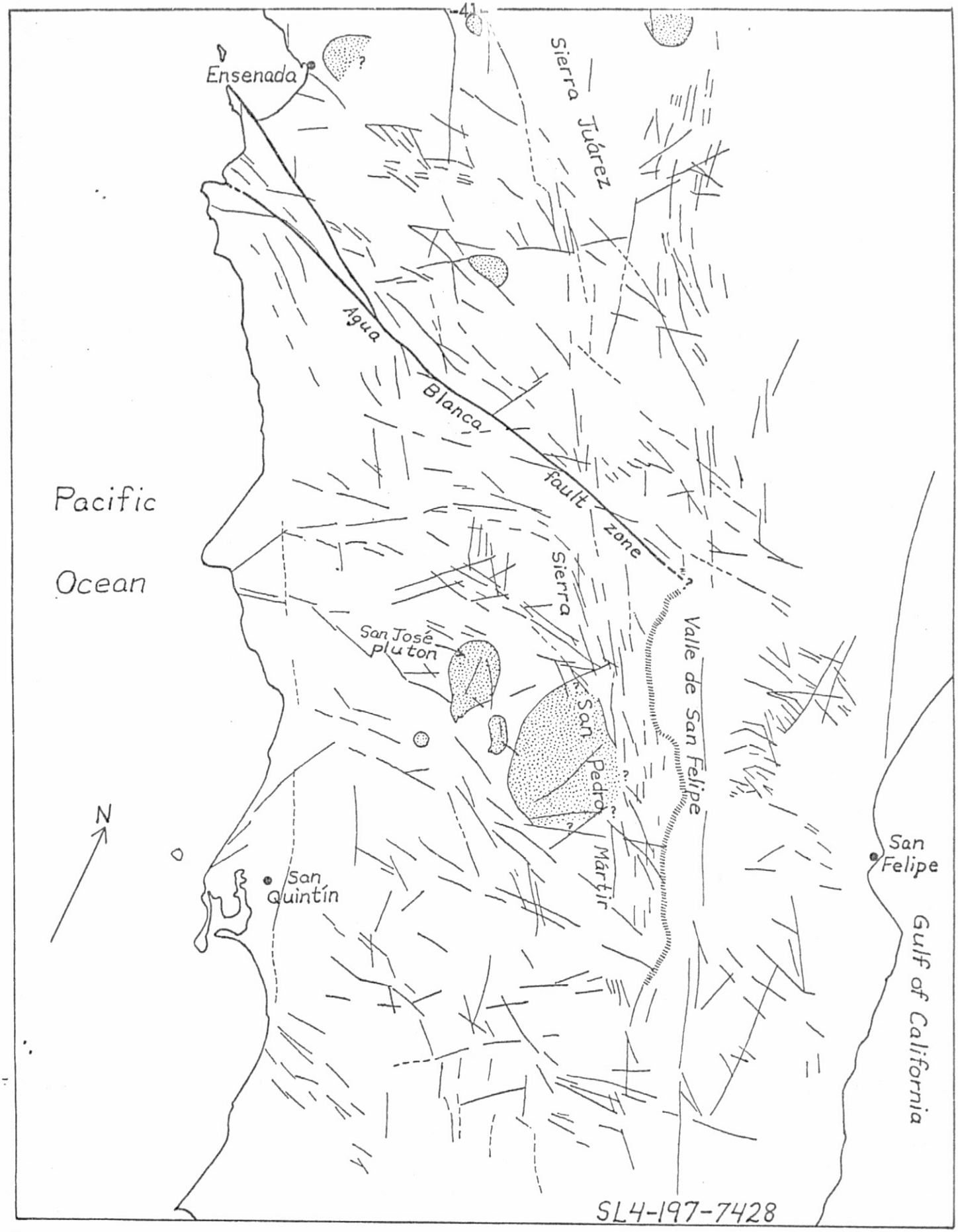

Figure 9c: Principal sharp linear features and several prominent plutons (stippled) in northern Baja California. Lines are dashed where defined only by vague color change or where continuity is probable, but uncertain.

of arcuate patterns. Because it is generally exposed on westward- or southward-facing slopes, the stripe is most clearly visible when illuminated by midday or afternoon sun.

Ground-truth checks at four localities (circled on Figure 9a) indicate that the lightly colored stripe is principally the expression of a specific stratigraphic zone in the pre-batholithic section, at least along a 15-km-long segment north and east of the San José pluton. The light color is due to: (1) the paucity of brush and the smoothness of the ground surface underlain by this unit; (2) the light color (tan) of the rock and its derivative soil; and (3) the fissile (platy and chippy) nature of the rock, which partially covers the slope with small reflective platy chips lying parallel to the ground surface. However, for a 2-km distance between the two northernmost ground-truth sites, the stripe coincides with a steep southward-facing reflective slope in ne southern margin of a light colored granitic (tonalite) pluton. Farther south, a 15-km portion of the stripe (near symbol #1 on Figure 9a) appears on the photographs to coincide with the western escarpment of the Sierra San Pedro Mártir. In the latter area the light stripe may still be a manifestation of the same stratigraphic zone, or it may be due to reflection off a steep westward-facing slope, possibly coinciding with the western margin of a large mass of granitic rock underlying much of the sierra (the largest stippled area in Figure 9c). Thus, while evidence to date suggests that the lightly colored stripe probably defines the distribution of a single stratigraphic zone, we still do not know that it coincides with this zone along its entire length. If not, portions of the stripe may be the manifestation of an important structural feature as yet unrecognized. Ground-truth checks at additional

localities along the stripe should resolve this question.

Recognition of this stripe, its trace, and its stratigraphic nature, provides new and extremely valuable information on the regional stratigraphy and structure in the pre-batholithic rocks. For the first time we can trace what appears to be a single stratigraphic zone from a region west and northwest of the San José pluton, where the age and general structural characteristics are fairly well known, into a little-explored area southeast of the pluton. Northwest of the pluton the lightly colored stripe is part of a section known from the work of Silver et al. (1963) to be part of the Alisitos formation of upper Lower Cretaceous age. Silver et al. showed that this section can be traced from the Pacific coast just south of the Agua Blanca fault zone southeastward (about S 60° E) for 110 km to the San José pluton. Beyond there, little information existed. The trace of the lightly colored stripe now suggests that east and southeast of the pluton the Alisitos formation swings abruptly to a more southerly trend (about S 30° E) and can be projected with reasonable confidence for another 55-60 km parallel to the trend of the Sierra San Pedro Mártir. Of course, this projection needs to be tested by more extensive ground observations, particularly as to the validity of the identification of the lightly colored stripe as the trace of a single stratigraphic zone.

Around the San José pluton and in much of the area to the west and northwest, the Alisitos strata are known to be tightly folded, but none of the folds has yet been mapped. The suggested duplication of the northwestern end of the light stripe is probably

a manifestation of this folding. Folding may also account for the apparent discontinuity of the stripe east of the San José pluton. Recognition of the stripe has thus provided us with a zone which can be mapped in the field and used to help decipher the complex structures.

Only the northernmost, least-well-defined end of linear feature #5 is shown on Figs. 9 and 9a. Although its trend is parallel to and along the projected extension of the lightly colored stripe, it is separated from that stripe by a 25-km long area dominated by complex arcuate rather than linear patterns. Photographic coverage of this linear feature is limited. No new information has been obtained on its nature or on its structural or stratigraphic relationship, if any, to the lightly colored stripe, but it is clearly a very important feature which needs to be carefully examined.

Recognition and Mapping of Igneous Intrusive Bodies

In specific site #2 (Appendix A), the crew were asked to observe and photograph igneous intrusive masses (plutons), with particular emphasis on their sizes and distribution and their relationships to layering in the surrounding rocks. As hoped, the San José pluton (see Figs. 9, 9a, and 9c) served as a readily visible and identifiable reference. Other plutons are also visible on many photographs; yet, comparatively few of the plutons known to exist are actually recognizable. However, the crew members have emphasized that the plutons, especially the San José pluton, were much more clearly visible to the naked eye than they are in the photographs.

The visibility of plutons on the Skylab photographs appears to be dependent upon several factors: (1) sun angle; (2) density of vegetative cover; and (3) atmospheric clarity. Obliquity of view also becomes a problem in shots taken far off the vertical. In Figure 10a, arcuate patterns associated with known or possible plutons have been traced from Figure 10 (203-7808), which is a 300 mm oblique taken in the early morning. The plutons are revealed principally by their topographic expression enhanced by low sun angle. Color and albedo contrast between the plutons and their surrounding rocks is practically nil in the photograph, in part because of the non-uniform illumination at low sun angle, but probably in part because, in the oblique view and oblique lighting, vegetation is especially effective in masking color variations.

Contrast Figure 10 with Figure 9, which is a near-vertical Nikon 55 mm shot taken at high sun angle (about 11:30 a.m.). Color and albedo contrast are greater in the latter photograph, but topographic expression is less pronounced. Several prominent plutons, recognized in Figure 9 (7428) in part by topographic expression, but also in part by color and albedo contrast, have been outlined in Figure 9c . The San José pluton and a smaller pluton several kilometers to the southeast show up strikingly well on this photograph, principally because of their high albedo. Unlike the plutons visible in Figure 10, these two bodies become less visible (although still distinct) at lower sun angles. Thus the ideal sun angle for satellite observation and photography of plutonic bodies (and other rock types as well) varies depending upon whether the bodies are best distinguished by their topographic expression or by their color and albedo contrasts with

SL4-203-7808

Figure 10

Figure 10: SL4-203-7808

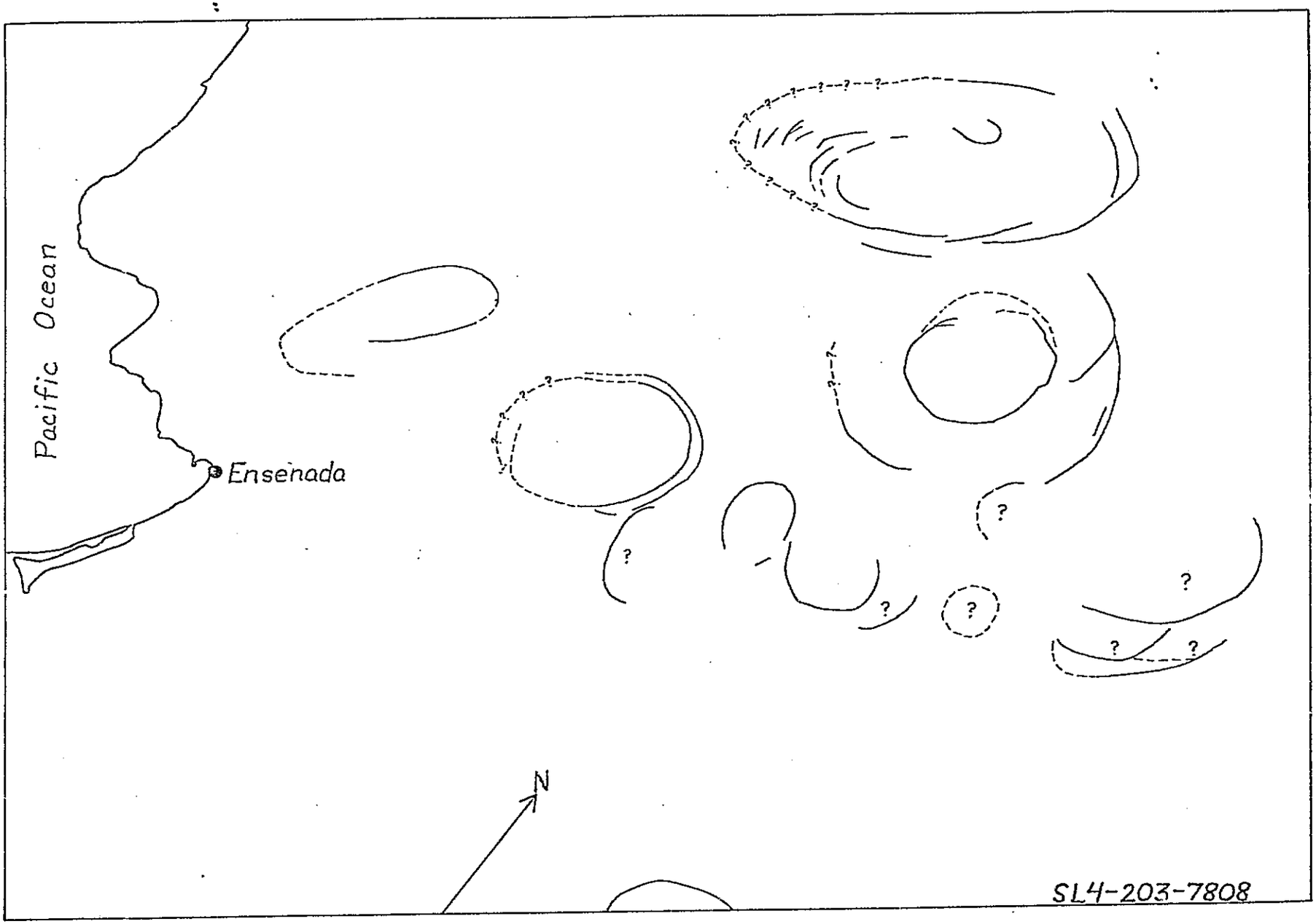

Figure 10a: Arcuate features associated with known or possible granitic intrusive bodies in northern Baja California.

adjacent rocks. (See crew members' comments in Appendix C.)

Many more plutons are known to exist in the area of Figure 9 than are shown on Figure 9c. Some can be distinguished vaguely on the photo, but many cannot. Although the effect of vegetation is minimized by the high sun angle and the near-vertical view, vegetation still is an important factor in masking color and albedo contrasts between the plutons and their adjacent rocks. In addition, atmospheric haze has probably reduced both spatial resolution and color and albedo contrasts. In the absence of clouds, the effects of haze are not obvious, but they must be even greater in highly oblique photographs such as Fig. 10, because of the greater interval of atmosphere through which the picture is taken. Possibly the ability of the crew members to see plutons more clearly than they appear on the photographs is due to an observer's ability to mentally compensate to some degree for the obscuring effects of haze, shadows, etc. Limited color range and color contrast of the film used also appears to be a factor.

Despite the difficulties in recognizing many plutons, it is clear from Figs. 9, 9c, 10, and 10a and from many additional photographs, that a combination of low and high sun-angle photography and observation could contribute significantly to reconnaissance geological mapping in unexplored areas, particularly where conventional aerial photographic coverage is not available. For problems requiring maximum color and albedo contrast, high sun-angle, vertical-view photography is essential.

Agua Blanca Fault Zone and Associated Fractures

The greatest part of the crew's effort in HH-111 was directed toward specific site #3, the Agua Blanca fault zone. In addition to general observation and photography of the fault zone, the site involved two principal questions. How far east can the fault be traced? Can offset streams or other features indicative of the relative motion on opposite sides of the fault be recognized by the crew or on photographs? The crew's verbal commentary concentrated on: (1) the striking physiographic expression of the fault — especially the appearance of a "k" shape defined by the intersection of Arroyo Calentura and of a canyon from the north with a canyon along the fault trace (photographs 7428 and 7809; Figures 9, 12, and 12a); (2) the eastern limit of the fault zone — whether or not it crosses Valle de San Felipe and reaches the Gulf; and (3) suggestions of offset along the fault zone. They took at least 20 photographs with the fault as the principal target.

In Figures 9b, 11a, and 12a, the known trace of the fault breaks as mapped by Allen et al. (1960) have been drawn, along with some of the more prominent subparallel lineaments. The correspondence between the fault trace and topography is obvious.

The astronauts looked repeatedly, but saw no evidence that the fault zone crosses the Valle de San Felipe to the Gulf. Likewise, several excellent photographs (e.g. 193-7190; Figures 11, 11a) reveal only faint lineaments east of the end of the mapped trace of the fault zone, and most of these lineaments stop at the western edge of the valley. Physiographic

SL4-193-7190

Figure 11

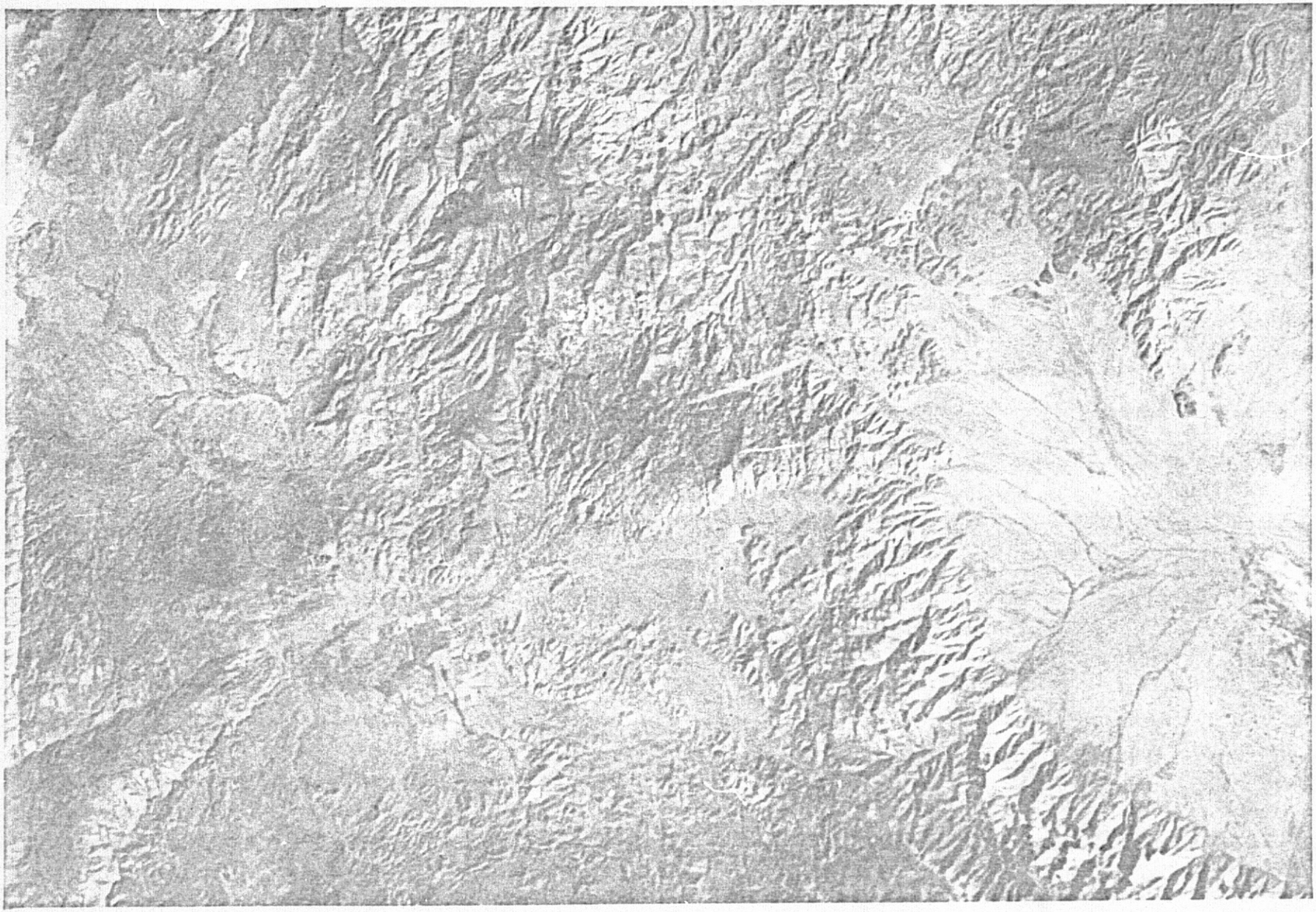

Figure 11: SL4-193-7190

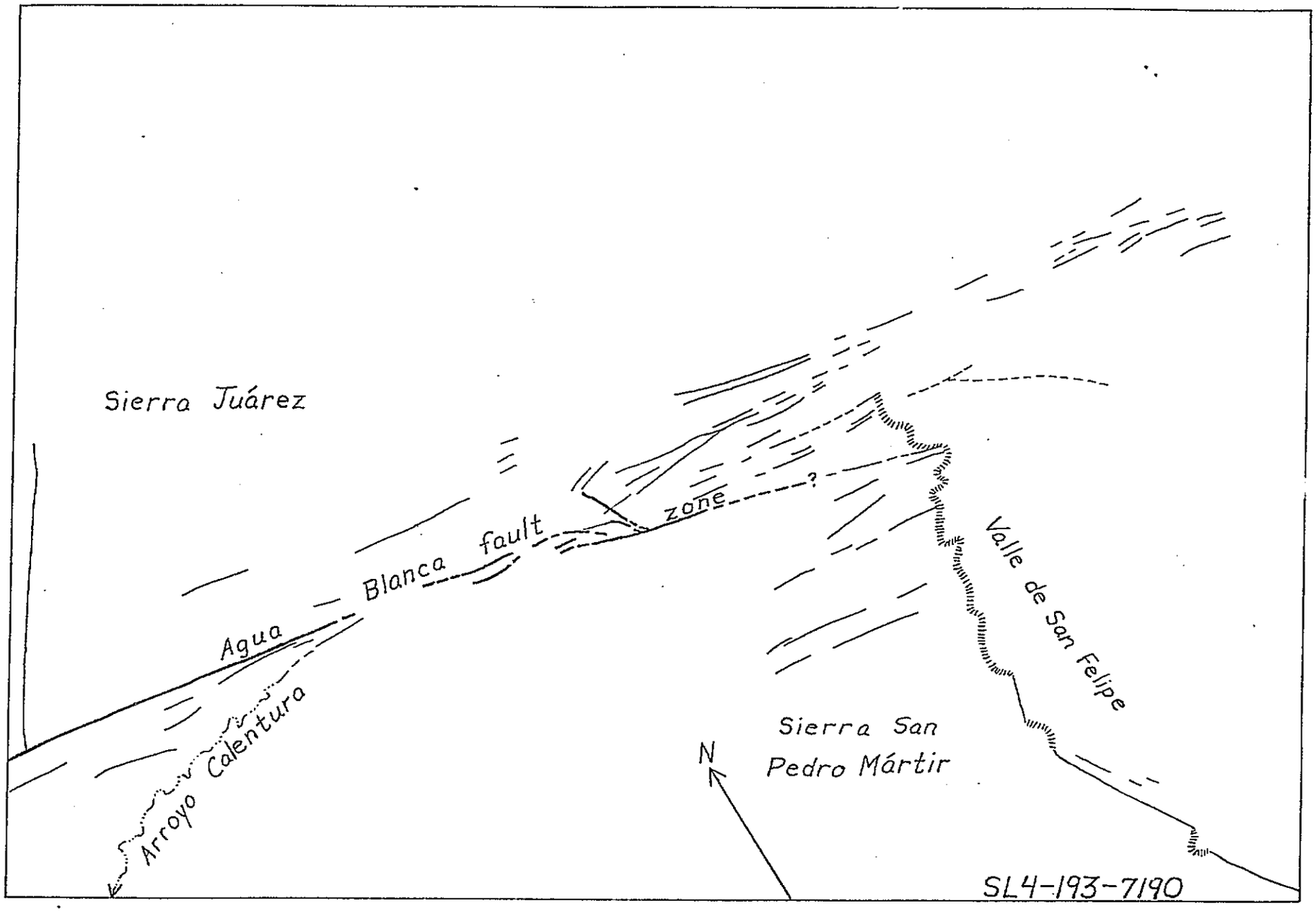

Figure 11a: Known fault breaks (heavy lines) and parallel lineaments at the eastern end of the Agua Blanca fault zone.

SL4-203-7809

Figure 12

Figure 12: SL4-203-7309

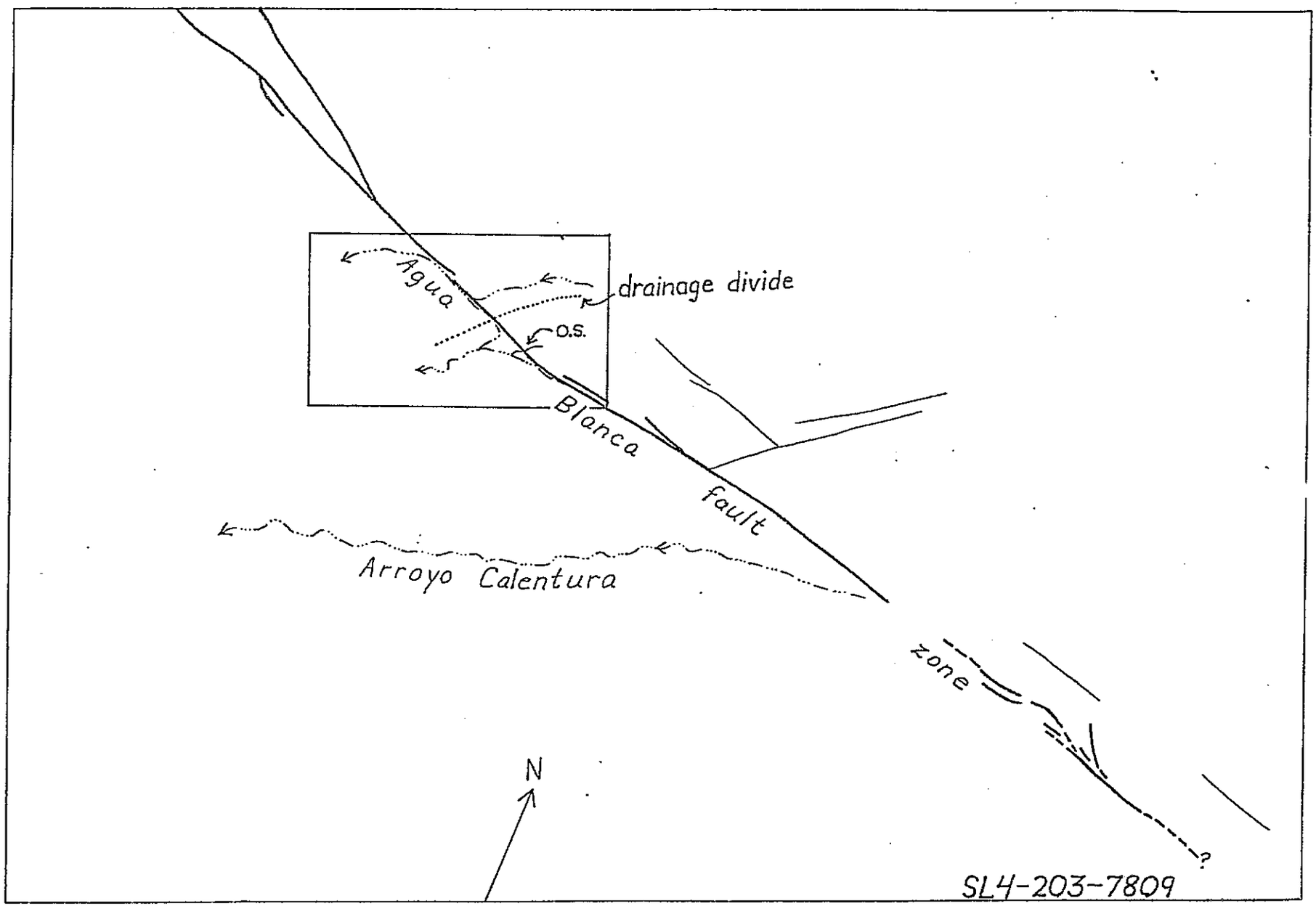

Figure 12a: Central and eastern portions of the Agua Blanca fault zone. Known breaks are shown by heavy lines.

evidence of a major break appears to stop where the mapped trace of the fault zone stops. Thus the photographs and crew observations strongly support the ground-based interpretation that the fault zone ends west of the Valle de San Felipe; and the objectives of this aspect of specific site #3 were very successfully met.

An important goal of specific site #3 was to determine whether or not small-scale fault features such as offset streams could be recognized from orbit. Commander Carr (DOY 341; GMT 18:46:07) interpreted the "k" pattern as a "cross-fault" offset in a left-lateral sense by movement on the Agua Blanca fault zone (see photograph 7809; Figures 12, 12a). He also felt that he could definitely see a left-lateral offset of a stream crossing the fault zone just west of the "k" (DOY 020; GMT 02:31:24). However, the detailed ground studies by Allen et al. clearly showed that the direction of relative motion on the fault zone is right-lateral. The second suggested left-lateral stream offset to which Commander Carr was referring is probably within the rectangular area outlined in Figure 12a. On photograph 7809 from which Figure 12a was traced, and on several other photographs, a drainage entering the fault zone from the northeast does indeed give the impression of being possibly diverted about 4 km southeastward along the fault zone and then turning abruptly southwestward away from the fault. In fact, the drainage is actually diverted about 6 km northwestward along the fault zone as shown on Figure 12a, and there is a low drainage divide, not distinguishable on the photograph, which separates the drainage northeast of the fault from its apparent extension southwest of the fault.

Two points should be emphasized concerning the use of offset streams as evidence of fault motion. First, such offsets are generally small-scale features. Second, reliable interpretation of relative motion from such offsets requires observation of numerous offsets with consistent direction. Sharp jogs in drainage traces can form in ways other than by actual fault motion and can even be in the direction opposite that of the true relative motion; only a pattern of many consistent offsets is reliable. In fact, Allen et al. observed numerous right-lateral stream offsets along much of the length of the fault zone, but they are generally on the order of tens to hundreds of meters. One of the offsets which they identified can be seen, albeit in a distorted and unconvincing view, in 7809 and is traced onto Figure 12a (the feature labeled "O.S."). In a less oblique view, this offset would probably be identifiable, even without prior knowledge of its existence, despite the limited resolution of the photograph. Thus, such features can be observed from satellites or from satellite-based photography. In fact, the crew members have emphasized that the details along this fault zone were much clearer to the naked eye than they are in the photographs. The HDC 100 mm and NK 55 mm photographs do not give sufficient magnification, and the NK 300 mm shots are limited somewhat by lower resolution of the 35 mm photography. Higher resolution telephoto photography might give excellent results. Vertical shots or slightly oblique views perpendicular to the length of a fault zone are potentially most effective, particularly at low sun angles.

In summary, it is clear, from both the crew commentary and the photographs, that satellite-based observations and photography have definite potential for discovery and reconnaissance mapping of faults of the magnitude of the Agua Blanca fault zone, and indeed of much smaller structures.

Fracture Patterns in Northern Baja California

The HH photography was particularly useful in providing the basis for an integrated analysis of the fracture system in northern Baja California.

Figure 9c is a map of the principal sharp linear features visible on Fig. 9 (197-7428; vertical view, high sun-angle, Nikon 55 mm shot), which covers most of the HH-111 area. Several prominent plutons are also traced from the photo, but linear features #1 and #5 have been omitted, as have features believed to reflect bedding trends in the stratified rocks. The resulting map therefore reveals the principal fault and fracture patterns in the area. Given similar photography of the entire peninsula, a photo-lineament map could be constructed for the peninsula which would be extremely useful.

Nearly all of the linear features in Figure 9c fall into one of three rather well-defined sets: (1) a set subparallel to the Agua Blanca fault zone, generally in the range N 70°-90° W, but reaching N 80°-90° E; (2) a set trending N 25°-35° W, parallel to the high mountain ranges and to the axis of the peninsula; and (3) a less well-developed set trending N 30°-55° E. All but a few of the remaining lineaments

trend in the range N 60°-80° E. Thus almost all of the linear features strike within a very restricted range of angles totalling only 85° out of a possible 180°.

The first linear set tends to be concentrated in fairly discrete zones separated by areas in which features parallel to this direction are sparse. North of the Agua Blanca fault zone some of the linears have been previously identified as faults, while others are probably major fractures or fracture zones without significant offset. South of the Agua Blanca fault zone, major faults have not been recognized parallel to this direction.

The N 25°-35° W set is very strongly developed along and parallel to the eastern escarpments of the Sierra Júarez and Sierra San Pedro Mártir. East and west of this zone of maximum development, parallel lineaments are sparse. Certainly, at least some of these linears reflect major faulting parallel to the escarpments of the sierras.

A series of aligned short features suggests the possibility of a major throughgoing linear feature extending N 30°-35° W from just east of the "San" of "San Pedro Mártir", crossing the Agua Blanca fault zone at the "t" of "fault", and continuing to the northern end of the map. If this apparent continuity, which is especially striking on the photograph (7428), is real, it suggests that no major offset has occurred along the eastern part of the Agua Blanca fault zone since the development of this N 30° W structure.

The N 30°-55° E lineament set, sparsely developed throughout the area, is the least consistent in trend of the three main sets. Neither it nor the N 60°-80° E set is

parallel to any other obvious geographic or geologic features in the area. At present, we have no evidence of major faulting parallel to these directions.

HH-112 Sierra Mazatan, Sonora, Mexico - T. H. Anderson and L. T. Silver

Our earlier investigations in Sonora identified the topographically distinctive Sierra Mazatan as an important geological subject. The small mountain range is comprised almost entirely of intensely deformed granite which can be distinguished in terms of chemistry and deformational history from nearby rocks. The geologic information about its vicinity is extremely meager. No detailed topographic maps or aerial photography were available. The crew was asked to consider the possibility that the entire mountain range may have been brought to its present site by profound faulting. They were requested to observe and photograph any linear features which might represent such fault systems and to look for topographic characteristics similar to those of S. Mazatan in the mountainous region surrounding the range.

The Sierra Mazatan region was thoroughly photographed, without commentary. Inspection of the photographs (e.g. Fig. 13, 141-4388) has not revealed any features similar to Sierra Mazatan within a radius of 50 km. Linear features observed on earlier Skylab photographs are visible but provide no additional information. From the new photography and our ground studies, we have now focussed on an approximately N-trending linear feature which passes only a few km east of S. Mazatan (Figs. 13, 13a). It can be traced for more than 100 km south toward Ciudad Obregon and about the same distance to the north. Further field studies are necessary to confirm whether this is a significant structural feature to which the enigma of S. Mazatan can be related.

SL4-141-4398

Figure 13

Figure 13: SL4-141-4398

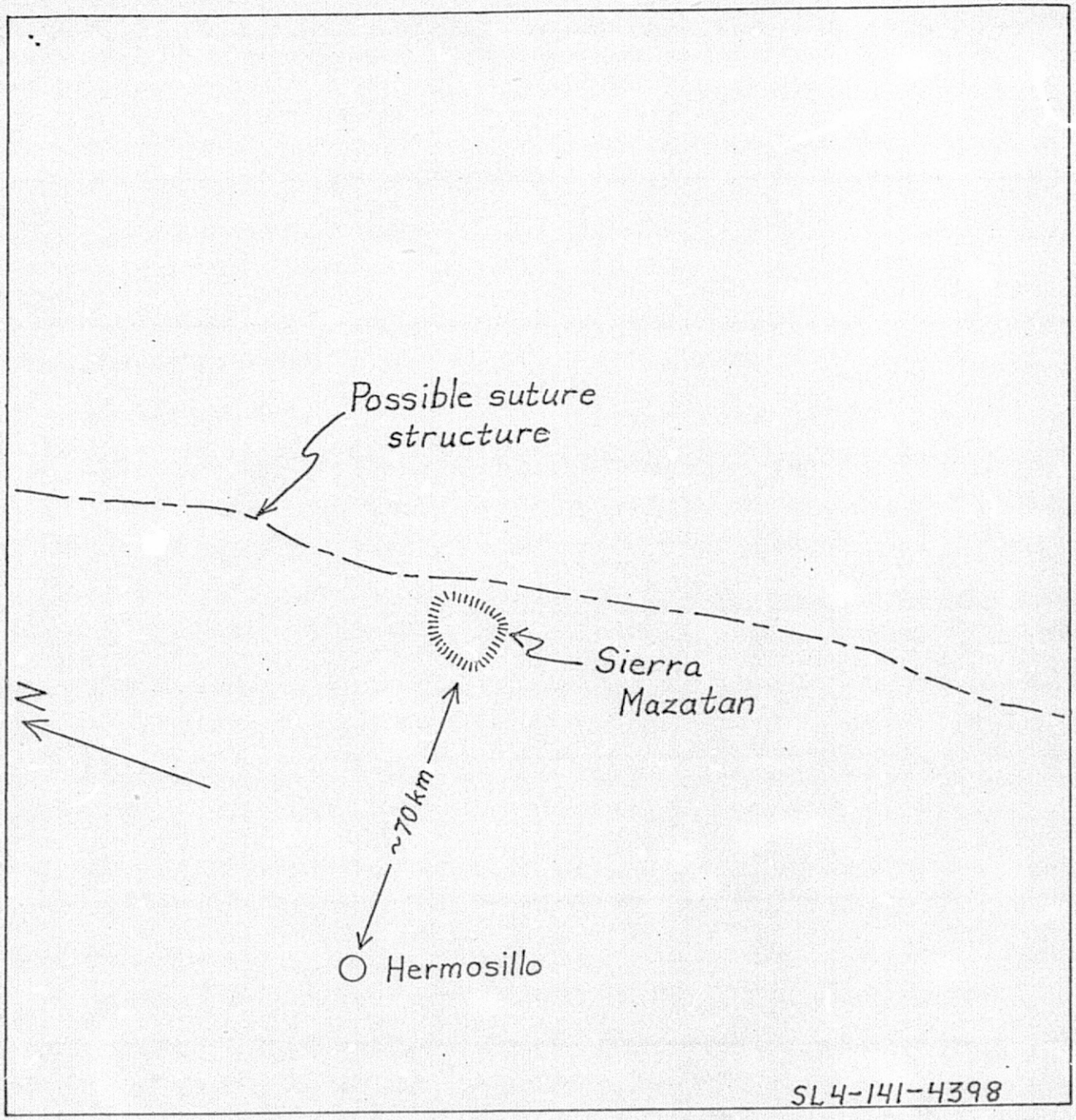

Figure 13a: Sierra Mazatan in northwestern Sonora, Mexico is an anomalous mountain range of deformed granite whose structural position may be related to a possible north-trending fault suture to the east of it.

HH-113 Northwestern Sonoran Coast Fault Zones - T. H. Anderson and L. T. Silver

For a number of years we have investigated the evolution of the continental margin in northwestern Sonora. Along the coast between Puerto Libertad and Kino Bay (Fig. 14, 140-4155) we encountered intermittent indications of NW-trending faults paralleling the coast. Associated with the region of faulting is the termination of the older crust (Precambrian and Paleozoic rocks) against younger crust (middle and late Mesozoic volcanic and granitic rocks). The SL-4 crew was asked to observe and evaluate linear trends in the coastal desert for their possible expressions of major fault zones, both active and inactive, which may have modified the continental margin.

The crew obtained a superb folio of photography along the Sonoran coast. The suspected fault zones were established on a through-going basis and documented both with HDC and NK photography. In Fig. 15 (194-7236), a Nikon telephoto shot clearly reveals the presence of numerous linear discontinuities in the bedrock along the coast in the Sierra Seri and Sierra Bacha. In Fig. 14a, the general dimensions of the fault zone from north of Pto. Libertad to south of Kino Bay are visible.

The photographs and ground studies reveal that in general there is little evidence of recent ground breakage. Only on a point just north of Pto. Libertad and east of the tied-island of Pta. Tepopa were there possible suggestions of active fault scarps. Several significant and many minor drainages cross the fault zone without indication of fault offset. The principal fracture systems do offset middle (?) to late (?) Tertiary volcanics and

SL4-140-4155

Figure 14

Figure 14: SL4-140-4155

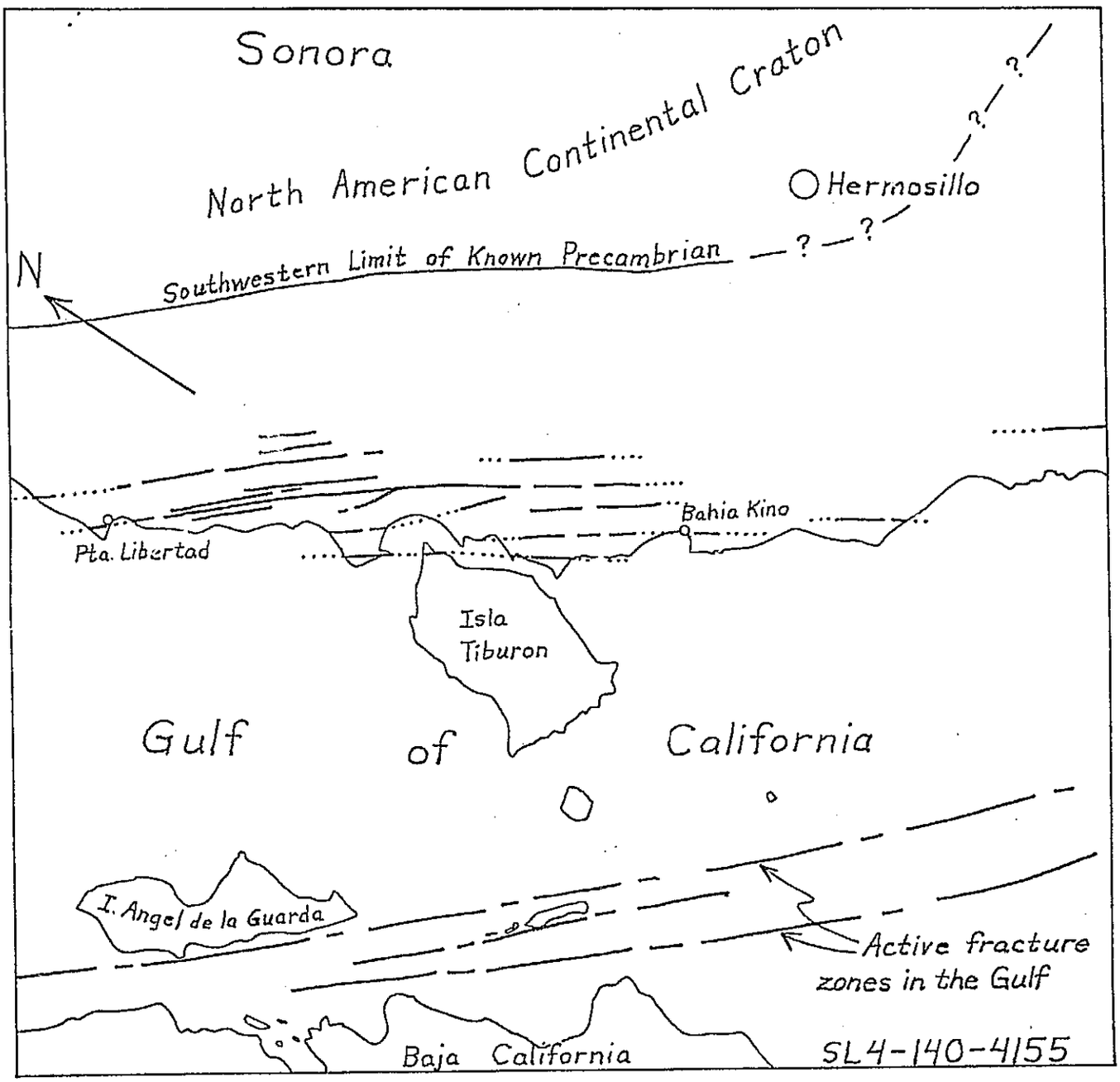

Figure 14 a: The coastal fracture system of northwest Sonora revealed in this photograph appears to be related to, but older than, the active transform fractures within the present Gulf of California.

SL4-194-7236

Figure 15

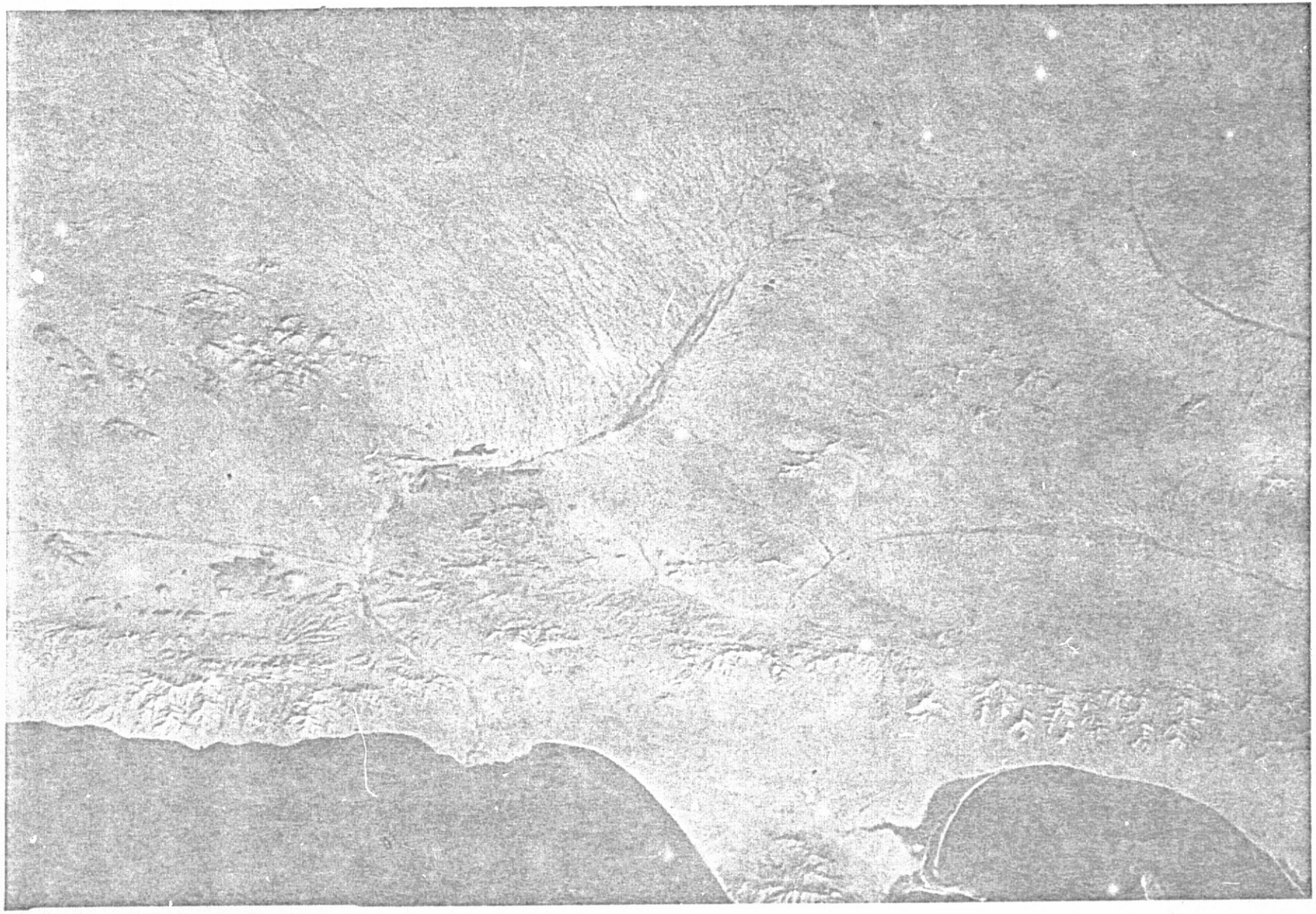

Figure 15: SL4-194-7236

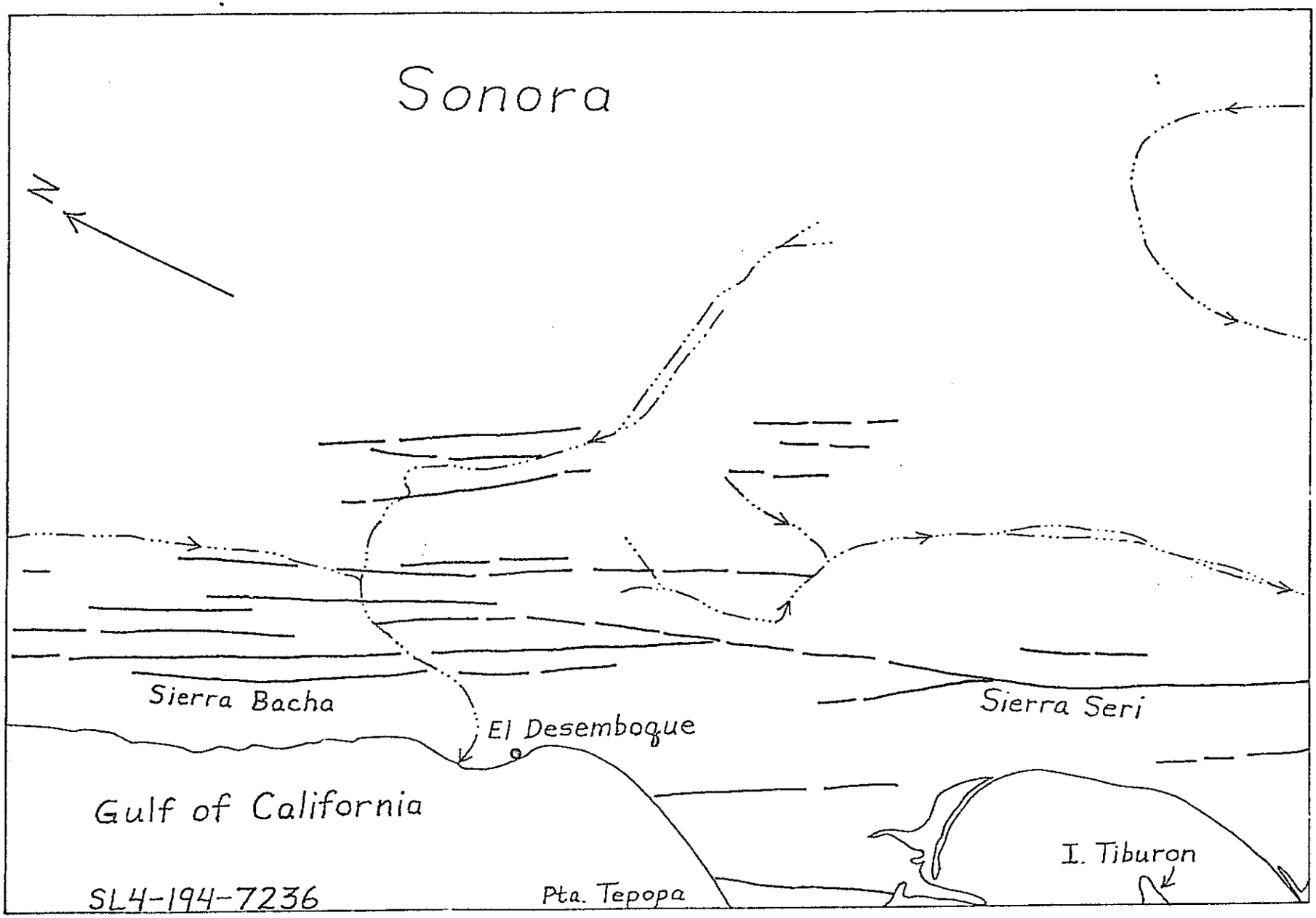

Figure 15a: A Nikon 300 mm telephoto detail of the coastal fracture zones of Sonora seen in Fig. 14a.

non-marine sedimentary rocks. We infer possible Miocene or Pliocene activity along the major fractures of the zone with perhaps some more recent reactivation, locally.

It is clear that this structural zone developed prior to the establishment of the presently configured Gulf of California which is only 4 - 5 million years old. We tentatively relate it to the development of a proto-gulf, a series of elongate marine basins which preceded the through-going Gulf of California rift system (Moore, 1973). It may have developed in the early stages of the present Gulf.

We have not established yet the sense and magnitude of displacement on this fracture system. As indicated in Fig. 14a, the fractures parallel the presently known southwestern limit of older continental crust and are located only about 30 km from the nearest Precambrian exposures. One important possibility is that the fractures we have identified with the Skylab photos constitute part of a significant late Tertiary strike slip fault zone along which two dissimilar crustal blocks have been juxtaposed. This would imply a possible correlation with early movements on the larger San Andreas - Gulf of California transform fault system. In our future work we shall pursue this possibility.

In summary, the Visual Observations photography has provided an integrated view of the Sonoran coastal fault system which emphasizes its regional significance and will guide future research efforts.

HH-114 Sierra Del Alamo - T. H. Anderson and L. T. Silver

The color contrasts in the Sonoran desert strikingly reflect the diversity of geologic formations and rock types exposed in the region, despite the homogenizing effects of desert varnish. In this exercise the crew was asked to observe and photograph distinct color and textural units in the Sierra del Alamo and adjacent ranges to the south. They selected several excellent perspective and lighting conditions for telephoto documentation.

An important photograph (Figs. 16, 16a, 203-7821) of the set revealed some previously unrecognized Precambrian "basement" exposures, south of S. del Alamo in the north and central region of Sierra Viejo. In a ground check, the dark zone adjacent to the granitic terrain was found to contain a variety of metamorphic rocks including granitic gneisses and metasedimentary schists. South of these crystalline rocks, a complex structural belt of late Precambrian and early Paleozoic sedimentary rocks extend to the south tip of the range.

The combination of Precambrian and Paleozoic formations in the Sierra Viejo represent the most southwesterly extension of the North American craton (older crust) identified thus far (Fig. 3). We are now planning a detailed investigation of the ages and character of these formations to learn more about the early evolution of this margin of the continent.

SL4-203-7821

Figure 16

Figure 16: SL4-203-7821

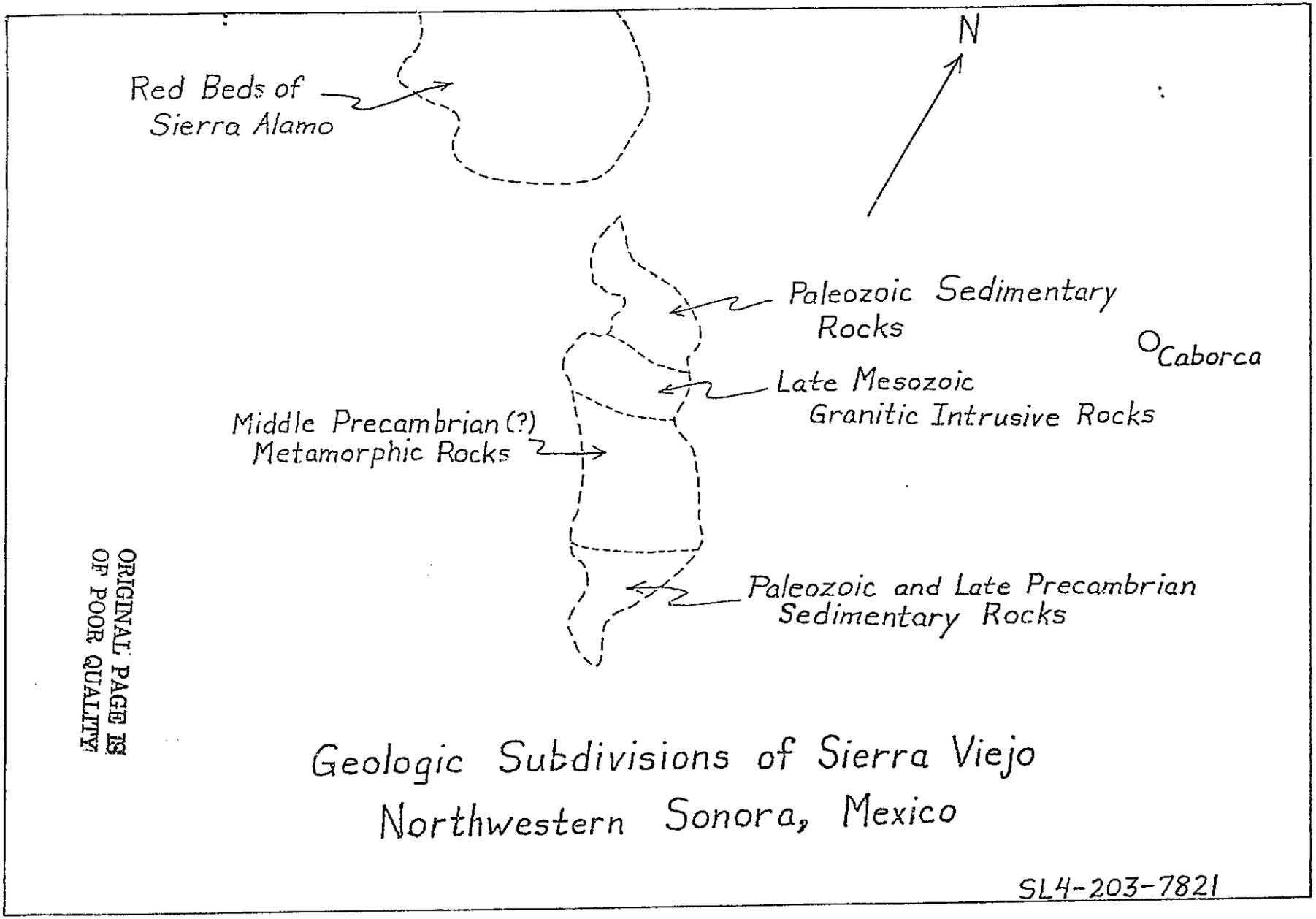

Figure 16a

HH-125, 126 Arizona - Clay Conway and L. T. Silver

The yield of observational data for these experiments was generally less extensive than for the other study areas, apparently for operational reasons. Nevertheless, a number of excellent photographs were obtained, including some of the best surface photos of the Colorado River drainage in Arizona we have seen. The erosional features and the principal structures of the Grand Canyon and the adjacent plateaus were captured by the astronaut photographers in a remarkable demonstration of man's ability to utilize a unique unprogrammed opportunity.

We briefly summarize two areas in Arizona to which the handheld SL-4 photography has brought some new insights.

Central Arizona

A number of linear or arcuate features, all or nearly all due to faulting, were noted in the photos of the HH-126 study area. Some of these features had been already mapped, some are clearly extensions or connections of features previously mapped, and some were previously unrecognized.

Of specific interest are arcuate features. Conway (1976) has mapped a system of NE-SW faults in northern Gila County, some of which swing around to the north to trend N-S. A very similar arcuate feature is one of the salient features of the northern Mazatzal Mounrains (142-4438). A part of this feature was earlier mapped (Wilson, 1939) as an almost straight fault, the Deadman fault. This whole arcuate feature is almost certainly a fault and probably of the same origin as the arcuate faults first identified

only 20 miles to the east by Conway. There are much weaker suggestions of other such arcuate features. Recognition in the photos of arcuate faults, and possible arcuate faults, in a much broader area than that in which similar features were first mapped is very exciting. Further search for and confirmation of these features, utilizing Skylab EREP photography is important; understanding such a distinctive regional fault system will have significant implications for the nature of the tectonic regime in which this old portion of the earth's crust was both formed and subsequently modified. Work has been and is proceeding on this project.

With regard to Precambrian structures, the NE-SW grain was noted throughout the Sierra Ancha-Mazatzal Mountain area thus confirming and clarifying what has been noted by many geologists over the years. The usefulness of the photos in this regard is the identification of lineations in areas where detailed mapping has not yet been done. This will aid in future investigations to determine nature and extent of faulting. There are suggestions of continuation of faults only partially mapped in earlier studies.

Tertiary faulting in the Mazatzal Mountains/Sierra Ancha area has extensively modified the Precambrian terrain. These faults are more difficult to see in the photos than are the Precambrian structures but are nevertheless decipherable. One probable Tertiary fault is newly identified from HDC-142-4438. This is a prominent linear feature which runs NW-SE for more than 15 miles in the northern Sierra Ancha Mountains and is on trend with the central Verde Valley to the northeast. There are numerous other

lineations of similar trend and probably of related Tertiary origin.

The understanding of Tertiary structure in this area is exceedingly important for this would provide clues to the nature of the profound transition from the thick, relatively undeformed Colorado Plateau crustal block to the much thinner, structurally complex basin and range crustal block. The understanding of the nature of this transition is particularly important in understanding geologically recent crustal activities which have (and still may be) modifying the southwestern North American crust and which have played an important role in the origin of some metallogenic processes.

Northern Arizona Linear Features: A Product of Spontaneous Crew Photographic Effort

Skylab-4 photos 142-4435, -4436, -4438 of the Grand Canyon area of northern Arizona are remarkable for clarity, resolution and color contrast. Conditions prevailing during photography — early to mid-afternoon for winter sun, excellent visibility, perfectly cloudless skies, light snow cover at higher elevations (greater than 5000-6000') — combine to make these photos unusually valuable to the geologist. Though the Grand Canyon was extensively photographed by the Skylab-4 astronauts, no other photos of the Canyon area compare in quality.

The light snow cover is particularly helpful in enhancing some linear features and providing contrasts both in elevation and in vegetation cover. For example, high unforested areas and drainage bottoms are sharply defined in white. Abundant lineations,

which reflect faulting, jointing and monoclinal flexing, all only partially mapped, are spectacularly highlighted on the photos. No doubt some such structural features are not visible with the conditions under which these photographs were taken. Indeed, in the summer time or in morning lighting or without snow, other lineations might appear and some seen clearly in these photos would disappear.

All lineations suggestive of jointing, folding, or faulting were traced from these three photos. Photo 142-4435 and traced lineations (Figures 17, 17a) are shown to illustrate the technique and the detail in which the regular through-going lineation systems can be seen. Only a few of these features correlate with structures shown on the geologic map of Arizona (Wilson, et al., 1969). These are some half dozen major, north-south faults, irregular in trend, which appear only discontinuously in Figure 17a. In a recent structural study of a central portion of this area (Shivwits Plateau and vicinity) Lucchitta (1974) has mapped numerous faults predominantly in the north-south grain. There is good correspondence between faults shown by him and lineaments traced from the Skylab photo. Lucchitta's tectonic map was constructed from field mapping and analysis of ERTS imagery.

Lucchitta hypothesized that the grossly straight portion of the Grand Canyon from the mouth of Kanab Creek to the southwest to the first major southward bend of the river is a structurally controlled segment. This is based on a very few fault features of this trend in his map area, none in the immediate vicinity of, or on trend with, this straight

SL4-142-4435

Figure 17

Figure 17: SL4-142-4435

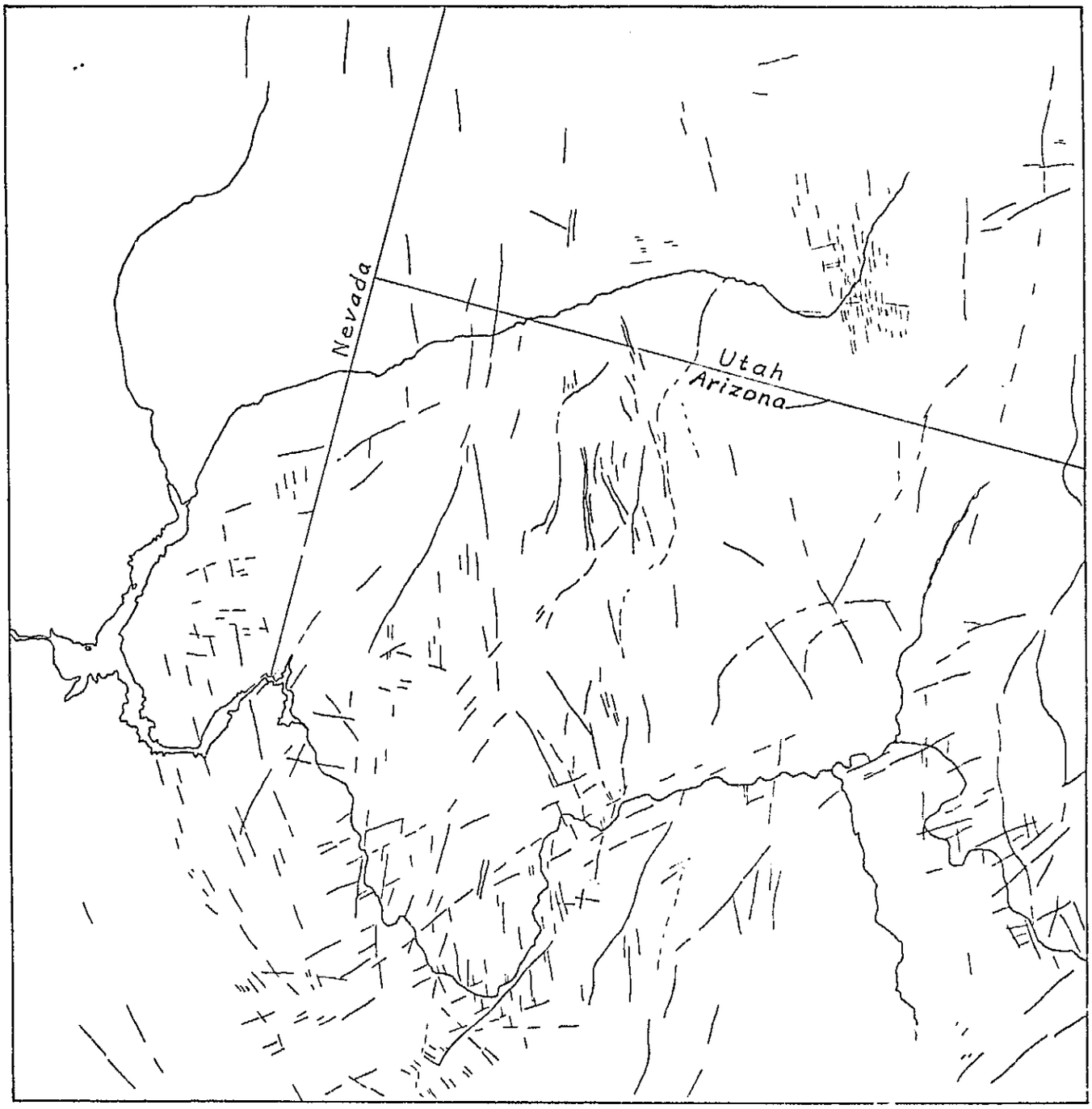

Figure 17a: Linear fractures developed in the surface strata of the Colorado Plateau in the vicinity of the Grand Canyon as revealed in 142-4435.

river segment, and on segments of the major irregular N-S faults which are of this trend. He also noted a zone of lineaments of this orientation on ERTS photography. A major discovery from the Skylab photo (142-4435) is a pronounced set of lineaments along, and particularly on trend to the southwest of, the "straight segment" of the Canyon. This documentation supports Lucchitta's suggestion of structural control for this segment of the river, although it is seen that abundant northeast lineaments heretofore unrecognized, are by no means restricted to such a zone.

Shoemaker et al. (1974) compiled structural data from many published sources, including Lucchitta's work discussed above and from ERTS imagery, to construct a map of faults in northern Arizona, here reproduced as Figure 18 . A mosaic of photo lineaments from the three Skylab photos was prepared of this same area. Generally the two maps were found to be in good agreement. As would be expected, many faults on the compilation map were not detected in the Skylab photos. On the other hand, a surprising number of Skylab photo lineaments were found to be without analogs on the compilation map. Skylab photo lineaments not corresponding to faults on the map by Shoemaker et al. are shown in Figure 19 . Most pronounced are the northeast-southwest lineations which are best shown in the western part of the Grand Canyon as discussed above. Numerous faults of this trend are shown by Shoemaker et al. in the far eastern part of the Grand Canyon in and near the Bright Angel fault system and further south and east in the Mesa Butte fault system, but the lineation system seen so clearly in the Skylab photos to the west has essentially no fault representation on their map.

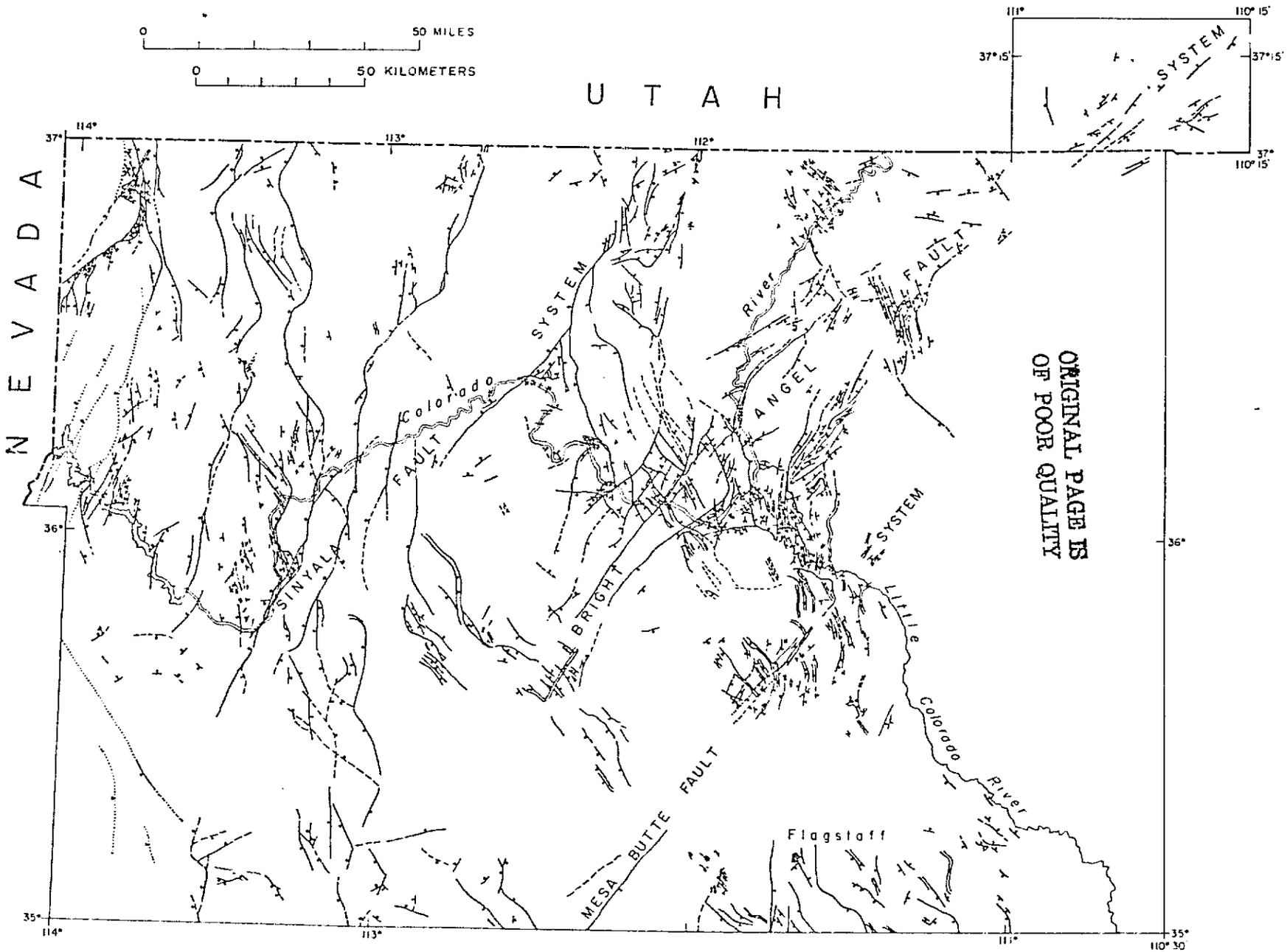

Figure 18

Map of faults in northwestern Arizona. Most faults shown are normal faults; bar and dot on downthrown side.

(From Shoemaker et al., 1974)

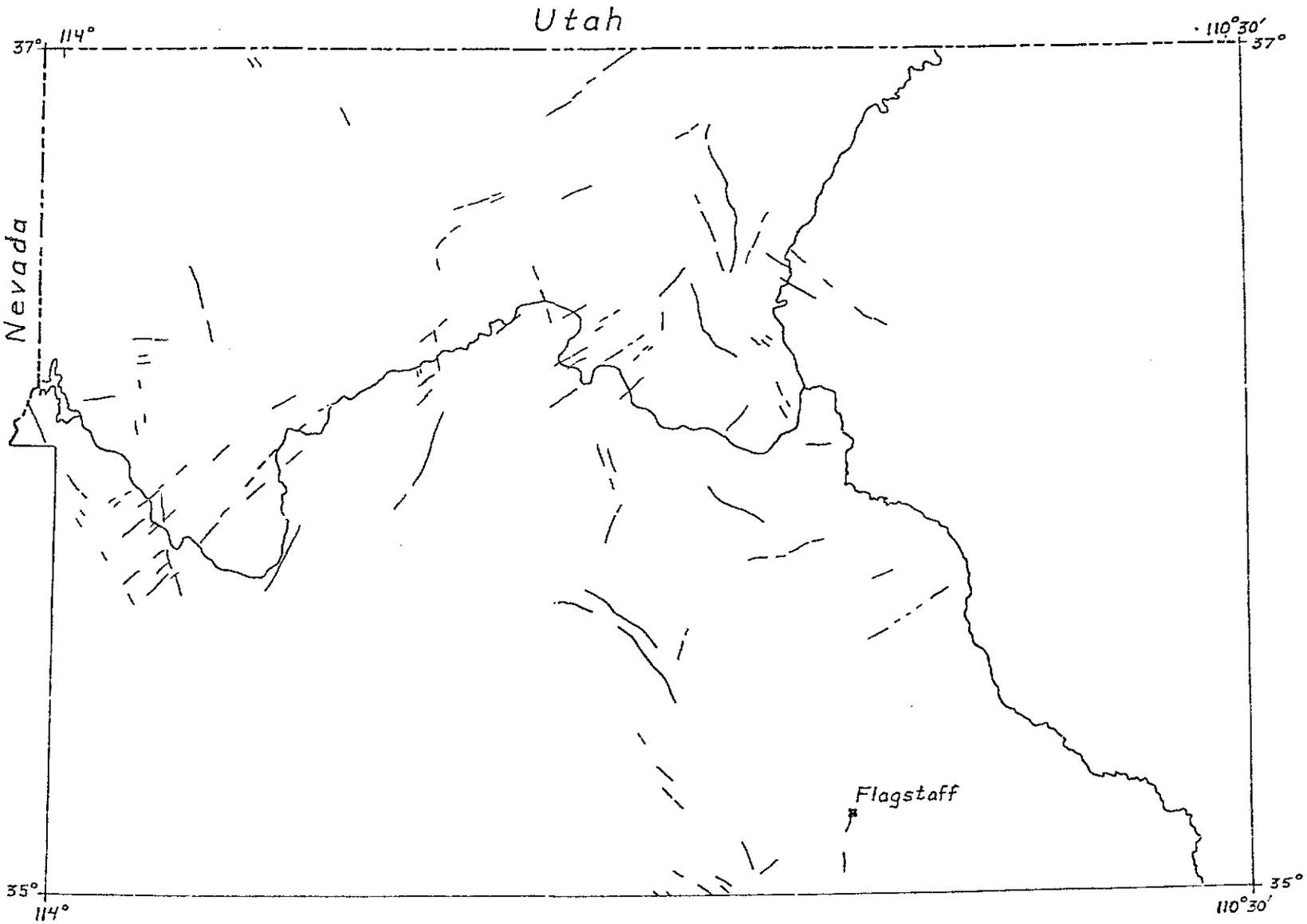

Figure 19: Previously unrecognized fracture systems in northern Arizona revealed by SI-4 handheld photography.

It is interesting that prior to the present photo analysis the senior author had discussions with Shoemaker in which he questioned the existence of a trend implied in Figure 18 for the Sinyala fault system. Now the Skylab data quite clearly shows a strong structural trend in near coincidence with, though perhaps displaced to the north of, Shoemaker's originally inferred zone.

Fault offset has not been demonstrated yet on these newly-discovered lineaments of course, and if present may be very minor. Fault offset on the Sinyala fault is only about 5 m on the bend of the river (attenuating upward to less than 1.5 m in the highest strata of cuts) but the fault is continuous for 48 km and profoundly influences topography (Huntoon, 1974, p. 331).

Rejuvenation of motion along old Precambrian fault lines is well-documented (Shoemaker et al., 1974; Huntoon, 1974) for faults cutting Paleozoic strata of the Grand Canyon area. This is particularly true for those trending NE-SW, and Shoemaker et al. suggest that the Mesa Butte, Bright Angel and Sinyala sysiems are developed on great Precambrian fault zones.

It is well known that the Precambrian basement of Arizona has a strong NE-SW structural grain. Skylab photo lineaments strongly support the suggestion of a Sinyala system and add significantly to the overall NE-SW fault pattern. Apparent concentration of these lineaments in the deeper portions of the Canyon area may further support the idea of reactivation on Precambrian faults.

Summary of Significant Research Results

Products of this research which already have substantial significance include:

(1) Demonstration of a 7 mile left-lateral displacement on the Chiriaco fault zone and of the presence of other previously unidentified faults of similar orientation and sense in the Colorado desert of southern California.

(2) Evidence for a previously unrecognized major northwest-trending shear zone on the northwest coast of Sonora.

(3) Confirmation of the abrupt eastern termination of the Agua Blanca Fault Zone in northern Baja California.

(4) Recognition of the extensive nature of conjugate linear fracture systems in the crystalline rocks of Peninsular California over a distance of more than 400 miles.

(5) Establishment of a continuous stratigraphic reference zone in the pre-batholithic rocks of northern Baja California.

(6) Discovery of the most southwesterly known occurrence of Precambrian crystalline rocks in the North American continent.

(7) Discovery of a previously unmapped section of Mesozoic(?) volcanic rocks in the Pinto Mountains of southeastern California.

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EVALUATION OF SL-4 GEOLOGY VISUAL OBSERVATION EFFORTS FOR RESEARCH USE

The research which we have reported in the preceding section represents the integration of the orbital observation data with well-coordinated and extensive ground studies. These studies were supplements to long-term research programs, initiated independently of the Skylab program, which provided us with a background of problem awareness for the recognition of research potential in the SL-4 observations. It is desirable to establish as clearly as possible the direct research value of these observations.

The primary contribution is in the form of excellent photography which could be applied in photogeologic appraisals of the target terrains. As we noted previously, verbal commentary by the astronauts was largely limited to establishing subject, time and photographic conditions. Our debriefing indicated a much greater potential in terms of crew awareness and sensibilities than was recorded in real-time or than was translated and focussed in post-mission contacts. It was only in the inspection of the eastern terminus of the Agua Blanca fault zone that the crew positively verbalized their research conclusions. Our ground studies supported their validity and it is unfortunate that similar contributions were not obtained on many of the other targets.

L. 2

The great value of the photography is to be found in the effective selection of a view of the subject in which lighting and camera position, as well as other transient conditions, permit the capture of geologically significant aspects of the subject. This requires a value judgment on the part of the operator of the handheld camera which distinguishes his work from mapping camera photography. There is a tendency to view geological subject material as static and therefore automatically capturable. This is erroneous. Informative photography of geology features is derived from an educated photographer recognizing an effective opportunity.

We have been impressed that for the greater majority of the designated targets and for a number of opportunity targets, the astronaut photography was very effective. It communicated to us the "message" the astronaut received about the spatial and geometric relations under consideration. We noted, too, that the effectiveness of the photography increased as the mission progressed. Even without seeing their photographic product the astronauts seemed to learn to appreciate and document the better perspectives of their subjects. An outstanding example is the sequence of oblique photography (142-4530 to 4565) of the California fault systems from which the mosaic in Figure 4 was created.

There were a number of targets, e.g. the plutons of the Peninsular batholith, in which the camera failed to catch what the astronauts could clearly discriminate and appreciate. These discrepancies must reflect our lack of understanding of all the factors by which the human eye and brain exceeds the camera and film in perception. It is clear

our training of the astronauts for handheld photographic documentation was more or less perfunctory and that the equipment which they carried was good but not optimal.

The photographic product which we introduced into our research, then, was an astronaut-selected view of the earth from which we attempted to recognize the important geological patterns bearing on our research objectives. The scale of the features observed, the ability to interrelate large features in areas measuring $10^4 - 10^5$ sq. km and unexpected revelations about the organization in the surface patterns are contributions almost unique to this type of data. The color values, when the lighting and photo-processing were optimal, were also unprecedented in our experience.

Essentially, this visual information has provided a large scale framework on which we could organize the details derived from surface studies. In the best circumstances we could expand local investigations much more confidently to their proper regional significance.

An appropriate example can be drawn from a recent research report by two of us (Silver and Anderson, 1974). We concluded, tentatively, that an enormous fault zone, active about 150 - 200 million years ago, sliced NW-SE across southwestern North America from California to Mexico displacing the crust at least 800 km. This was an unsuspected structure whose existence explained many first order plate tectonics problems in continental evolution.

The research leading to this conclusion was of least 6 years in progress. In the spring and summer of 1974 the implications of our research grew apparent to us but the regional dimensions seemed too vast to obtain extensive confirmation easily. By the spring of 1974, the handheld photography of Skylab was available to us (unfortunately, the EREP photography was not!). While the coverage was not complete, we found it provided us with many clues to important surface sites for detailed inspection and study in California, Arizona and Sonora. We found the additional information supported our hypothesis, and, accordingly, reported it. The Mojave-Sonora Megashear has received much attention, some of it flattering. If it survives independent scrutiny, the excellent photography we received from Skylab must be recognized as a valuable source of perspective in refining the final hypothesis. In the studies in coastal Sonora which we have reported here we see the possibility for recognizing still other important features related to the growth and modification of the continental margin (e.g. the coastal shear zones described in HH-113).

We believe that numerous other observations made by the astronauts or developed from our studies of the photography also have the potential for significant research yield. We emphasize that the most effective use of the SL-4 data will be made in the course of its continued incorporation and application in on-going research at the ground level. Until such time as new programs of directed visual observations are initiated, it is only by means of additional surface investigations and by providing "ground-truth" tests to follow up the many interesting implications of existing photography that we can expect to harvest

more of this potential science. The great library of Skylab handheld and EREP photography now available for southwestern North America should be made readily accessible for these uses. Similarly the Skylab photography available for other parts of the world should be vigorously advertised to competent active geological investigators who can learn to incorporate the unique orbital perspectives into their studies.

RECOMMENDATIONS FOR FUTURE GEOLOGY VISUAL OBSERVATIONS PROGRAMS FROM MANNED SATELLITES

1. We have found that the SL-4 geology experiment has yielded data of significant scientific value and we believe the SL-4 crewmen have shown that there is still greater potential in this approach. Accordingly, we urge that future orbital missions include plans for manned visual observations of earth.

2. We believe that in order to achieve the potential yield a comprehensive planning, facility preparation and training program is necessary. We recommend that a basic design for such a program be considered sufficiently soon so that the experiences earned from Skylab will not be lost.

3. We recognize that a earth-orbiting observatory on Shuttle may be manned by a professional scientist. Nevertheless we recommend that Shuttle astronaut crews be given training in geology and other earth sciences so that their natural observational talents can be brought to bear on appropriate problems and on targets of opportunity.

4. We recommend that the distribution of the Skylab handheld photography and the EREP photography be facilitated to the working science community, at NASA's expense if necessary, to develop both the educational familiarity and the

research use which its content deserves. This broad market development is the best way to prepare earth resource programs to utilize orbital photogeology on a regular, effective basis.

APPENDIX A

SKYLAB-4 VISUAL OBSERVATIONS PROJECT - GEOLOGICAL FEATURES OF SOUTHWESTERN NORTH AMERICA

L. T. Silver and others

1. Flight Book Descriptions of Geology Visual Observation Exercises.

HH1[illegible] SAN ANDREAS FAULT IN CIRCUM PACIFIC FAULT ZONE

DESCRIPTION: Strike Slip (transform) type of fault shown in Ex. 10-1. Does not have a major ocean trench offshore. Has been studied extensively and can be used for detection of major trends when studying other faults.

P.1 LOCATION: California - San Francisco to Gulf of California (See Ex. 10-5 and Ex. 10-6). It possibly extends into Northwestern Sonoran Coast. Several other faults are located in this area and are shown in Ex. 10-5 and Ex. 10-6.

PROCEDURE:

1. Photograph & describe fault intersection area (San Andreas & Garlock).

2. Describe possible extensions of the Garlock fault.

3. Describe possible southward extension of San Andreas fault into NW Sonoran Coast.

   Note: Fault extensions may be noted by lineations and color contrasts (vegetation change or rock type discontinuities).

OBJECTIVE:

Identify major fault patterns in and along San Andreas fault and intersecting systems.

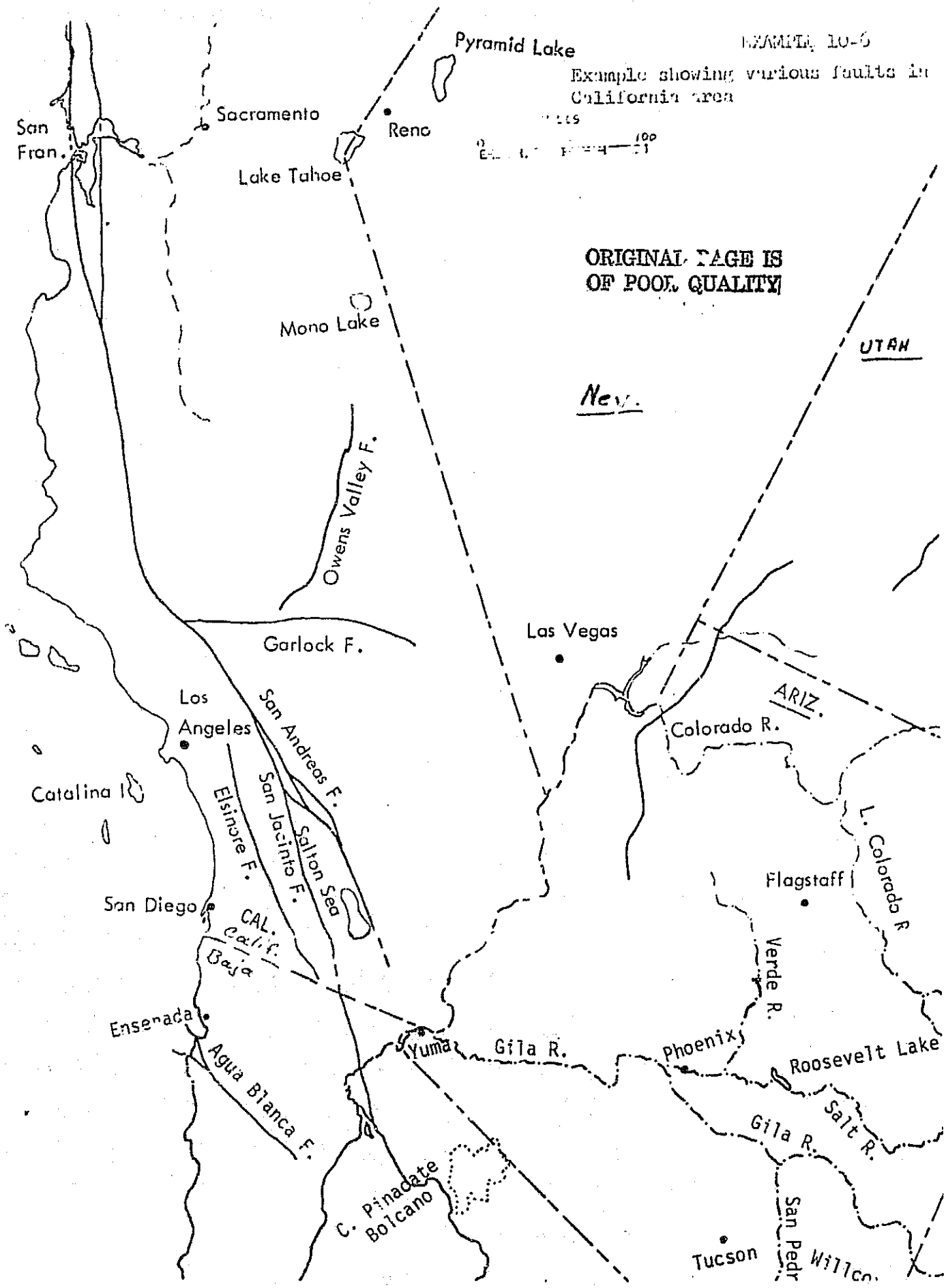
CAMERA DATA:

Use Hasselblad/100mm. Use aperture setting for GENERAL.

HH108/109

EXAMPLE 10-6

Example showing various faults in California area



(SL3 - 121 - 2337)

EXAMPLE 10-5

SL-3 Photo of San Andreas and Garlock Faults, California, San Joaquin Valley, Majave Desert (Looking South)

HH111 NORTHERN BAJA CALIFORNIA, MEXICO

DESCRIPTION: In the mountainous deserts of Baja, erosion has etched out the internal structure in the older rocks (steeply tilted and folded sedimentary and volcanic strata intruded by large masses of granite). The strata display intricate color stripe patterns reflecting : (1) their folding; (2) their displacement around ellipsoidal masses of granite; and (3) offsets by numerous fault zones. Sparse vegetation may accentuate this. The largest faults in the area (Agua Blanca fault zone) are believed to be related to the crustal movement in which the Baja peninsula is moving away from North America.

P.1 LOCATION: Northern Baja California between latitudes 29-32 deg. N and longitudes 114-117 deg W. Specific sites for observation and photography are:

(1) The 200km lightly colored stripe of folding (#1 in Ex. 10-13 and Ex. 10-14). Trace its extension as far northwest and southeast as possible. Observe the general trends of the outcrops of tilted strata in the region. Look for sequences of color stripes. Observe older structures and try to identify granite structures being unroofed by erosion.

(2) San Jose' pluton (#2 in Ex. 10-13 and 10-14)(intrusive granite mass 20X12 km in major dimensions). Using it as a reference, estimate the size of the largest and smallest identifiable plutons. Is there a direction (E or W) in which the size, abundance, and slope of the plutons change systematically? Do any plutons appear to cut through the color stripes described in specific site #1?

(3) Agua Blanca fault (#3 in Ex. 10-13). Not presently well defined. Does it reach the Gulf of California? Are there any offset streams which would indicate the relative motion of opposite sides of this fault?

(4) Linear feature (#5 in Ex. 10-14). Is there a color change in the rocks on opposite sides? Does folding style change in the strata? Describe any concentration or variation in the vegetation along the line. Are there changes in other features?

(5) Volcanic features are (#4 Ex. 10-14). Determine the relation of the volcanic cones to coastline features. Are these cones as well preserved as those farther south? relation of the volcanic cones to coastline features. Are these cones as well preserved as those farther south?

PROCEDURE:

Observe and photograph to illustrate all major interpretations.

OBJECTIVE:

Identification of major patterns in folded strata, granite plutons, possible major faults, and other conspicuous recent geological features.

CAMERA DATA:

Use Hasselblad/100mm. Take photos of faults at low sun angle, if possible, to enhance features. Use aperture setting for GENERAL.

AS7-7-1795

EXAMPLE 10-13

Photo was taken during Apollo 7 over Northern Baja. Folding(#1), the San Jose pluton(#2), and the Agua Blance Fault(#3) are shown.

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OF POOR QUALITY

AS7-5-1629

EXAMPLE 10-14

Photo was taken during Apollo 7 over Northern Baja. Folding(#1), linear features(#5), volcanic features(#4), and the San Jose pluton(#2) are shown.

(SL2-04-145)

EXAMPLE 10-15

Photo was taken during SL-2 over Sonora,Mexico. Sierra Mazatan (#1) and linear features (#2,#3,#4, and #5) are shown.

[illegible] SIERRA MAZATAN, SONORA, MEXICO

DESCRIPTION: Sierra Mazatan is an unusual mountain mass. An isolated block of granite gneiss lies athwart the regional north-trending pattern of linear mountain ranges and valleys. It resembles none of the surrounding lower elevation rocks. It may represent a remnant of a subhorizontal plate of rocks which has been moved on a near-horizontal fault-plane tens of kilometers from the east. Surface studies have not yet determined the possible source. Numerous other linear features nearby may be faults. Recognition and delineation of all possible major faults is needed.

P.1 LOCATION: In the foothills of the western Sierra Madre east of Hermosillo, Sonora, Mexico. Northeast of Guaymas (see Ex. 10-15). The following are the detailed sites:

(1). The boundaries of Sierra Mazatan (#1 of Ex. 10-15). Are there simillar isolated features to the north, east, or south within tens of kilometers? Is there any evidence to suggest an eastern source region?

(2). The linear feature shown in #2 of Ex 10-15. Observe its sharpness of definition as it crosses valleys and ridges and any color contrasts. How far to the east and west does it extend?

(3). The region surrounding #3 of Ex. 10-15. It may contain active fault lines which have broken the valley sediments in long, straight north-trending lines parallel to the ridges. (Man-made features may be confused with such lines.)

(4). The linear ridges surrounding #4 of Ex. 10-15. These appear to approach and perhaps extend unbroken across the linear feature shown at #2. Examine and confirm. and confirm.

(5) A very prenounced light-colored linear feature (#5 of Ex.10-15) just east of the Rio Yaqui may be another major fault-line. How far does it extend south? Does it cross #2? Are there similar features to the east?

PROCEDURE:

Observe and photograph.

OBJECTIVE:

Definition of possible fault lines which have been revealed by preferential erosion or recent faulting.

CAMERA DATA:

Use Hasselblad/100mm. Photograph at low sun angles for better definition of fault lines. Use aperture setting for GENERAL.

HH11/112

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OF POOR QUALITY

(SL2-04-141)

EXAMPLE 10-16

Photo was taken during SL-2 over the coast of Sonora, mexico.
Linear features are shown.

SIERRA DEL ALAMO

DESCRIPTION: Sierra del Alamo,(#1 in Ex. 10-17) a reddish-brown oval mountain mass rises above the surrounding desert valley because of an underlying thick and resistant Triassic sedimentary strata.To the south, the reddish sedimentary rocks have been intruded by a pale-gray mass of granite (#2 in Ex. 10-17),which has on its southern contact a darker gray complex (#3 in Ex. 10-17) of older metamorphic and igneous rocks. These three rock units have colors and erosional textures which make them readily distinguishable. The reddish sandstones of Sierra del Alamo have become the host rocks for some important mineral deposits, and further knowledge of the distribution of this distinctive red sandstone section is desireable. Since this entire section of the Sonoran coast has been extensively faulted with large crustal displacements, the Triassic formations appear intermittently and unpredictably. It would be particularly important to find other occurances of the red beds in contact with granite as observed on the south side of Sierra del Alamo. Inferences as to whether such contacts are fault or intrusive, based on linearity, would also be useful.

P.1 LOCATION: NORTHWESTERN SONORAN COAST, MEXICO, WEST OF CABORCA (See Ex. 10-17).

PROCEDURE:

Photograph and observe the following:

a. The Sierra del Alamo area (#1, 2, & 3 in Ex. 10-17). Take a close-up of the contacts between these rock types.

b. Is there a basis for further subdividing any of these three major units?

c. Are there any visible color variations at the north end of Sierra del Alamo which indicate the presence of the mining district El Antimonio?

d. Are there any other red outcrops? (In particular, look near Caborca.)

OBJECTIVE:

Characterization and identification of various distinct rock types in the desert environment utilizing color and erosional textures.

CAMERA DATA:

Use Hasselblad/100mm for overview. Use Nikon/300mm for close-up of Sierra del Alamo.. Use aperture setting for GENERAL.

HH113/114

(SL2-04-139)

EXAMPLE 10-17

Photo was taken during SL-2 over the Northwestern Sonoran Coast, Mexico. Sierra del Alamo (#1), a granite mass(#2), and a complex of older metamorphic and igneous rocks(#3) are shown.

HH113 NORTHWESTERN SONORAN COAST FAULT ZONES

DESCRIPTION: In this region there appear to be many different linear features which suggest major faults. Surface studies indicate that somewhere within this area there is a fundamental boundary, probably faulted, between an ancient continental crust south of Caborca, and newer crust in the Sierra Bacha and Sierra Seri. This boundary is possibly just east of these mountains. No detailed maps exist for this region, so all observations which help define faulting in the region are of great value.

P.1 LOCATION: Sonoran coast, Mexico, southwest of Caborca and northeast of Tiburon Island (Ex. 10-16).

PROCEDURE:

Observe and photograph the following:

a. Linear features between Caborca and the coastline.

b. The east flanks of the Sierra Bacha and Sierra Seri for recent fault disturbance of the gravels.

c. The broad valley floors for linear patterns in the natural vegetation which might suggest damming of ground water by fault lines.

OBJECTIVE:

Observation and evaluation of the major trends in the Sonoran coastal desert for their possible expressions of major fault zones related to the growth and modification of the western boundary of North America.

CAMERA DATA:

Use Hasselblad/100mm. Photograph at low sun angles for better definition of fault lines. Use aperture setting for GENERAL.

HH125 SOUTHEASTERN ARIZONA

DESCRIPTION: Several distirtly different visual observation features are present in this area. A granite intrusive is exposed in Texas Canyon (See #1 in Ex. 10-25). Part of the roof still remains. Ore deposits are found in the roof on the NE boundary and in NE-trending veins within the granite.

The 'Lavender Pit' (See #2) is the oldest and richest copper deposit in Arizona. A new open-pit operation has been developed in a deeply oxidized and billiantly colored rock terrain. There are many oxidation colors weathered over sulfide ore deposits. There are many other copper mines throughout the region.

A very young volcanic field (See #3) is found east of Douglas, Arizona, and south of the Chiricahua Mountains. This field has many individual vents. There has been no analysis as to whether the vents are controlled by fractures that are reflected in alignment of the vents or other linear features. The lavas are iron-rich basalts and show some reddening on weathering which makes a comparison with the 'Lavender Pit' coloration very interesting.

LOCATION AND FEATURES: The following features are of interest in Southeastern Arizona:

(1) Texas Canyon granite intrusion: Describe any red iron-oxide colors in the walls near the granite. Describe any internal structures in the granite that might be sets of veins. Can the roof of this granite be indentified. (See #1 in Ex. 10-25)

(2) 'Lavender Pit' copper mine: Compare the colors inside the pit with the colors on the natural slopes near the pit. Compare the coloration of this mine with the colors in other mining districts. (See #2 in Ex. 10-25)

(3) Young volcanoes east of Douglas: Describe the volcanic vents. Describe the direction of lava flow and any linear features. Compare the oxidation colors of this area with the 'Lavender Pit' area. (See #3 in Ex.10-25)

PROCEDURE:

1. Describe and photograph the above features.

2. Compare the colorations in the 'Lavender Pit' area with other mining areas such as the Pima copper mines south of Tucson, Arizona.

OBJECTIVE:

To compare the coloration of different mining areas to aid in mineral exporation studies.

CAMERA DATA:

Use Hasselblad/100mm. Take photos during different lighting conditions during the mission, if possible. Use aperture setting for GENERAL.

HH125/126

EXAMPLE 10-25

Photo was taken during Apollo 6 over southeastern Arizona. Texas Canyon (#1) contains a granite instrusion, the Lavender Pit (#2) is the oldest richest copper deposit in Arizona, and the young volcanic field (#3) contains iron-rich basalts. A typical smoke plume is shown at the bottom of the photo.

HH126 CENTRAL ARIZONA LINEAR FEATURES

DESCRIPTION: Very ancient strata and granite (1.6 billion years old) are exposed from the Sierra Ancha region southwest to the Phoenix area. A major search for ore deposits is in active progress in these rocks. Recognition of through-going strata and offsetting faults is essential to working out exploration plans. In the northern Sierra Ancha region (#1 in Ex. 10-26) a sequence of nearly vertical strata (white to brown at the base, gray-green in the midd'e, and red-brown at the top) may be traced to the northern Mazatzal Mountains (See #2) without major fault offset. There is some possibility that the sequence of strata may be traceable beyond the Verde River to the southwest (See #3).

A second vertical strata sequence may be present in the southern Mazatzal Mountains (See #4).

LOCATION AND FEATURE:

(1) Sierra Ancha region: Describe the color-striped strata. Trace the strata sequence southwestward to the Mazatzal Mountains and beyond. Describe any faulting which may complicate this pattern. (See #1,#2,#3 in Ex. 10-26)

(2) southern Mazatzal Mountains: Describe color-striped strata. Attempt to trace strata southwestward toward Phoenix.

PROCEDURE:

Photograph and describe the above features.

OBJECTIVE:

To identify and trace a color sequence of strata and to evaluate whether faulting is responsible for loss of continuity.

CAMERA DATA:

Use Hasselblad/100mm. Take photos at low sun angles to accent the linear features, if possible. Use aperture setting for GENERAL.

HH125/126

EXAMPLE 10-26

Photo was taken during SL-2 over the Phoenix, Arizona, area. The following areas are shown: (#1) vertical strata in Sierra Ancha region, (#2) possible vertical strata in northern Mazatzal Mountains, (#3) possible extension of strata, (#4) vertical strata in southern Mazatzal Mountains.

NASA-JSC

APPENDIX B

SKYLAB-4 VISUAL OBSERVATIONS PROJECT - GEOLOGICAL FEATURES OF SOUTHWESTERN NORTH AMERICA

L. T. Silver and others

1. Table 1. Verbal Commentary
2. Table 2. Photographic Summary
3. Photographic Map Indices: Figures B1 through B17

SKYLAB 4 — VISUAL OBSERVATIONS OF GEOLOGICAL FEATURES OF SOUTHWESTERN NORTH AMERICA

Table 1. VERBAL COMMENTARY

Numbers in brackets are final NASA frame numbers

I. Baja California and the Gulf of California
HH-111

DOY	GMT	Track	Rev	Subject matter, observations, photography
331	20:06	49	2847	Comment: good photos of Baja; refers to next entry below.
331	20:27:49	49	2847	Over San Diego and Baja, looking for faults. NK/55mm, CX-19, frames 34-35 [7426, 7428, 7429].
340	17:48:57	35	2975	Referred to GMT 17:05 to 17:06. Northern Baja and southern Calif. looking for faults. Low sun angle. View oblique to east. HDC, CX-47, frames 58-60 [3437-3439].
340	17:51:33	35	2975	Can't tell if Agua Blanca fault reaches Gulf. May end at San Felipe valley.
341	16:39:40	49	2989	Referred to GMT 16:20. Baja from California border south to Ensenada. Agua Blanca fault extremely well-defined. 3 HDC pictures [3479-3481].
341	16:40:49	49	2989	Agua Blanca fault looks like K in ground.
341	18:44:32	49	2989	Referred to GMT 16:23. California-Mexico border along coast south to Ensenada. 3 photos taken of Agua Blanca fault from just south of San Jose pluton looking north. HDC, CX-47, frames 99-101 [3479-3481].
341	18:46:07	49	2989	Suggested left-lateral offset on Agua Blanca fault.
364	23:41:32	30	3325	Referred to GMT 22:54. Some good photos of Baja from over Los Angeles basin.
365	00:17:13	30	3325	Could not see much in Baja.

Table 1. HH-111

DOY	GMT	Track	Rev	Subject matter, observations, photography
365	00:17:32 and 00:18:14	30	3325	Referred to DOY 364, GMT 22:54 - 22:55. Photos of northern Baja from over L.A. basin. Oblique; low sun angle. HDC, CX-52, frames 81-82 [3807-3810].
002	23:06:03	2	3368	Referred to GMT 22:20. From Pt. Mugu southward. Broken clouds south of San Clemente. HDC, CX-52, frame 134 [3861].
004	21:07:49	30	3396	Referred to GMT 20:54. Jet stream cirrus over northern Baja. Taken approx. 300 miles SW of L.A. HDC, CX-52, frames 154-155 [3880, 3881].
004	21:34:58	30	3396	Comments on last entry.
005	20:23:45	44	3410	Referred to slightly earlier GMT. Observations on cinder cones along coast. Volcanic features #4, example 10-14. Well-preserved; no relationship to coastline features.
010	23:02:32 through 23:04:28	44	3481	Referred to GMT 18:14. Comparison of volcanic cones at San Quintin and south of there. NK/300 mm, CX-39, frames 10-11 [7187, 7188]. Overlapping photos of Agua Blanca fault at the "K"— the cross fault. Question of how far east fault goes; no answer. NK/300 mm, CX-39, frames 8-9 [7189, 7190].
016	00:24	49	3557	TV picture of northern Baja.
016	15:45:55	58	3566	Referred to GMT 15:28 (approx.). Northern Baja and NW Mexico coast. HDC, CX-50, frames 82-84 [4154-4156].
020	2:26:47 through 2:33:35	35	3614	Referred to DOY 019, GMT 23:05. Northern Baja; NK/300 mm, CX-41, frames 26-30 [7036-7040]. No indication that Agua Blanca fault continues across San Felipe valley to Gulf. Area all covered with sand. Can see the cross-fault on the Agua Blanca very well. Agua Blanca starts curving towards Ensenada. Frames 26-30 also include southern volcanic area (#4 in example 10-14). Linear feature #5 appears to start just south of San Jose pluton and continues south. Suggested left-lateral offset of a stream crossing Agua Blanca fault just west of the traverse fault, where Agua Blanca jogs slightly more to NW. No stream offsets seen further east towards San Felipe valley.

Table 1. HH-111

DOY	GMT	Track	Rev	Subject matter, observations, photography
021	22:00:08	63	3642	Referred to slightly before GMT 21:52. West coast of U.S. and Mexico down to 300 miles south of border. HDC, CX-46, frames 124-154 [none applicable to Baja].
026	17:30	62	3712	CC briefing; Baja geology very interesting.
028	00:06:02	6	3727	Referred to DOY 027, GMT 18:55 to 19:04. Photos from north of San Francisco all the way south to tip of Baja. HDC, CX-18, frames 110-133 [4544-4550, 4552-4554].
028	00:06:58	6	3727	Couldn't carry Agua Blanca fault to Gulf. Sand or eroded material may cover faulting evidence. Morning lighting might show things better.
028	18:53:01	20	3741	Referred to GMT 18:15 (approx.). Coast of California south to Baja. Looking for faults. Oblique shots towards west. HDC, CX-18, frames 137-147 [4562-4565].
028	19:01:04	20	3741	Referred to GMT 18:16. Obliques shot towards west. NK/100 mm, CX-44, frames 51-52 (approx.) [7967, 7970].
029	18:28:35	34	3755	Referred to GMT 17:40 (approx.). SW U.S. and Baja; oblique shot from east. HDC, CX-18, frame 160 [4581].
030	19:40:20 through 19:43:33	49	3770	Referred to GMT 18:28 (approx.). Agua Blanca fault extremely conspicuous in vertical lighting. Hard to see linear features because of bad sun angle. Very strong northbound or NW, southbound (?) linear pattern, possibly linear feature #5. Cross-fault also visible.
033	13:18	19	3811	2 brief references about desire for more photos of dunes and other features in Baja.
034	17:04	35	3827	Agua Blanca fault very conspicuous. Can't see if it reaches Gulf. San Quintin volcanoes visible.
035	16:37:24	49	3841	Referred to slightly earlier GMT, 14:45 (approx.). Overview of northern Baja, Gulf, and western Mexico as far south as San Quintin (?). Mosaic Covering Fresno to Guadalajara. NK/300 mm, CX-57, frames 2-43 [7807-7813, 7816-7819].

Table 1. HH-111

DOY	GMT	Track	Rev	Subject matter, observations, photography
036	16:10:59	63	3855	Referred to slightly earlier GMT, 14:00 (approx.). Sierra Madre Occidental and west coast of U.S., Mexico, and South America. NK, magazine CX-61 [7552, 7553].
037	15:37:00	6	3869	Referred to GMT 13:10 to 13:25 (error?: 15:10 to 15:25). L.A. to Lima, Peru. Low sun angle. NK, CX-58, frames 57-33 [7718, 7725, 7732].

Table 1. Other Geology Features of Baja California and Gulf of California

Numbers in brackets are final NASA frame numbers.

DOY	GMT	Track	Rev	Subject matter, observations, photography
331	20:27:29	49	2847	Western Mexico and Gulf of Calif. NK/55 mm, CX-19, frames 36-37. Jet stream cirrus just south of border, frame 38 [7426, 7428, 7429].
334	19:55:08	21	2890	Jet stream over Baja and clouds over Isle Clarion (?). NK (?), IR08, frames 11-12 [5186].
339	17:19:59	20	2960	Referred to GMT 16:12. NW Mexico next to border in Baja; oblique. Looking for faults. NK/55 mm, CX-20, frames 24, 25 [7371, 7372].
017	14:58:44	1	3580	Referred to GMT 14:48. Gulf of Calif. and Sonora; oblique. Target HH-112. Low sun angle. HDC, CX-50, frames 125-126 [4197, 4198].
023	22:10:46	21	3671	Referred to GMT 21:55 (approx.). Oblique stereo pair of southern Baja from west. HDC, CX-18, frames 68-69 [4486-4489].
030	19:23:40 and 19:27:00 and 19:30:08	49	3770	Referred to GMT 18:28 (approx.). Confused description in transcript. Gulf of Calif.; sunglint at south tip of Baja; subtropical jets across middle of Baja. HDC, CX-45, frames 11-16 [4603-4607].

Table 1. VERBAL COMMENTARY

Skylab 4 — Visual Observations of Geological Features of Southwestern North America. Numbers in brackets are final NASA frame numbers.

II. Sonora, Mexico
HH-112, 113, 114

DOY	GMT	Track	Rev	Subject matter, observations, photography
339	17:19:59	20	2960	Referred to 16:12. NK/55 mm, CX-20, oblique 2 tracks away. Frame 25 [7354] - northwest Mexico and coastline - looking for faults. Frame 24 [?].
016	15:45:55	58	3566	Referred to about 15:28. HDC; CX-50 frames 82-84 [4154-4156].
017	14:58:44	1	3580	Referred to 14:48. HDC; CX-50 frames 125-126 [4197-4198]. Guaymas in foreground, Isla Tiburon in background; quite low sun angle; target was 112; unable to see requested features.
021	22:00:08	63	3642	Referred to 21:52. HDC/100; CX-46 frames 143-154 stereo [4390-4401].
022	20:25:29	63	3642	Referred to 21:44 to 21:47. NK/300, CX-42 frames 35-53 [8052-8034]. Mexico from Sonora desert to Guadalajara.
028	00:06:02	6	3727	Referred to 18:55 to 19:04. HDC/100, CX-18 ~ frames 110-133 [4530-4553]. No obs. on Sonora. San Francisco to tip of Baja, some stereo.
028	19:01:04	20	3741	Referred to 18:10 to 18:16. NK/55, CX-44 ~ frames 50-48 [7970], low angle obliques to east.
028	19:01:04	20	3741	Referred to 18:18. NK/100, CX-44 frame 47 [7971], smoke plume - SW U.S.A.
030	19:27:00	49	3770	HDC/100, CX-45 frames 10-14 [4603-4607]. Mouth of Colorado; also shots on Mexico side.

Table 1. HH-112, 113, 114

DOY	GMT	Track	Rev	Subject matter, observations, photography
035	16:37:24	49	3841	Referred to 16:10. NK/300, CX-57: frames 2-43 [7807-7825]. Mexico side of Gulf from border to just south of Tiburon Island.
036	16:10:59	63	3855	Referred to 16:10. NK; CX-61. Sierra Madre Occidental; west coast Mexico [7558-7580].
037	15:37:00	6	3869	Referred to 13:10 to 13:25 (transcript error?: 15:10-15:25). NK; CX-58, frames 33-57 [7725-7745 (?)] includes Sierra Madre Occidental, Mexican coast.

Table 1. Other Geology Features in Mexico

Numbers in brackets are final NASA frame numbers

DOY	GMT	Track	Rev	Subject matter, observations, photography
331	20:06	49	2847	Coming down coast of Mexico. Good weather; NK-55 mm, CX-19 [7429-7431].
331	20:27:49	49	2847	Comments pertaining to above frames: frame 36 [7431] - slightly north of Guadalajara; " 37 [7430] - over Acapulco; " 38 [7429] - jet stream cirrus just south of border.
352	02:02			Over Mexico City - "looks like a star".
008	18:39:28	15	3452	Referred to 18:04. HDC; CX-51 - frame 83 [3983]. Chihuahua, Sierra Madre Oriental; haze going to E cut off abruptly at mountains.
010	16:33			Comments pertaining to big, circular, green structure near Mexico City.
010	16:54			Comments pertaining to big, circular, green structure near Mexico City.
011	16:09:25	43	3480	Referred to 16:10. HDC: CX-51 - "Two good shots fairly mountainous areas" - Mexico.
016	23:55:16	63	3571	HDC; CX-50, frames 114-116 [4186-4188] include smoke plume and mountain relief in north Mexico at low sun angle, "could see linear features lying down the mountain".
016	(21:48)	63	3642	NK/300, CX-42, frames 32-34 [8054-8052, probably includes 8055, 8056] Mexico City and Puebla; excellent mtn. description and discussion of circular feature, previously noted.
035	16:36:37	49	3841	HDC/100, CX-45, frames 23-29 Sierra Madre Occidental from north to south - emphasize western edge [4616-4622].

Table 1. VERBAL COMMENTARY

Skylab 4 — Visual Observations of Geological Features of Southwestern North America.

Numbers in brackets are final NASA frame numbers

III. Arizona
HH-125, 126

DOY	GMT	Track	Rev	Subject matter, observations, photography

HH-125. Southeastern Arizona

In several entries under Other Geology Features in Arizona there may be relevant photographic coverage of southeastern Arizona, although it is not stated positively in the transcript. DOY's 010, 022, 023, in particular.

HH-127. Central Arizona Linear Features

022	21:49:12	6	3656	Referred to a pass starting over San Francisco at 21:00. Photos taken of northern Arizona, Grand Canyon, Flagstaff, Meteor Crater. Should cover Salt-Verde watershed fairly well. No camera data given [probably 4438 through 4440].

Table 1. Other Geology Features in Arizona.

Numbers in brackets are final NASA frame numbers.

DOY	GMT	Track	Rev	Subject matter, observations, photography
365	00:20:16	30	3325	Referred to 22:57. Grand Canyon. Nikon, mag ?, frames 46, 47 [7216, 7217].
010	18:30:45	44	3481	Referred to 18:10 - 18:30 (a pass from Imperial Valley to Gulf of St. Lawrence). Phoenix, stereo pair. HDC, CX-51, frames 133, 134. Grand Canyon. HDC, CX-51, 135 [4034-4038].
010	23:04:28	44	1644	Referred to 18:16. Phoenix. NK, CX-39, frame 7 [7192].
016	15:45:55	58	3566	Referred to about 15:25. Grand Canyon and northern Arizona. HDC, CX-50, frame 86 [4157].
016	23:55:16	63	3571	Referred to 23:45. Grand Canyon. HDC, CX-50, frame 113 [4185].
022	21:49:12	6	3656	Referred to pass starting over San Francisco at 21:00. Phoenix, stereo pair. Northern Arizona, Grand Canyon, Flagstaff, Meteor Crater. These features photographed. No camera data given [probably 4435-4445].
023	20:44:18	20	3670	Referred to a pass starting over Cascades at 20:10. Northern Arizona, Salt River Valley. HDC, CX-18, frames 54-59 [4474, 4476, 4477].
034	15:27	34	3826	Grand Canyon. Noted location over Arizona. No photograpny.

Table 1. VERBAL COMMENTARY

Skylab 4 — Visual Observations of Geological Features of Southwestern North America.

Numbers in brackets are final NASA frame numbers.

IV. San Andreas Fault and Related Faults
HH-108

DOY	GMT	Track	Rev	Subject matter, observations, photography
331	20:27:36	49	2847	Referred to 20:27. L.A. to Baja California. NK, CX-19, frames 33-83 (38?) [7426-7431].
340	17:48:57	35	2975	Referred to 17:05-17:06. Southern California HDC, CX-47, frames 58, 59, 60 [3437-3439].
353	00:54:46			Referred to earlier time when pictures taken... "this morning...when cities...lighted". Northern California, down coastline, San Joaquin Valley. Camera ?, BV-43, frames 22-44[?].
365	00:16:51	30	3325	Referred to 22:54-22:55. Ascending over L.A. HDC, CX-52, frames 81-83 [3807-3809], frames 81 and 82 of Baja. NK, CX-37, frames 46-48 [7212-7214], all of L.A. basin.
001	23:10:29	59	3354	Referred to 23:10 (?). San Francisco HDC, CX-52, frame 117 [3843].
002	23:04:43	2	3368	Referred to 22:20. S. Calif. Clear from Pt. Mugu to San Clemente. Scattered and broken clouds elsewhere. Couldn't spot junction of San Andreas and San Jacinto faults. NK, CX-38, frames 26-29 [8116-8120]; HDC, CX-52 (?), frame 134 [3860, 3861].
010	18:30:45	44	3481	Referred to pass from 18:10 to 18:30 (Imperial Valley to Gulf of St. Lawrence). Photo - Imperial Valley. HDC, CX-51, frame 132 (?) [4033].
015	00:17	49	3557	TV camera pass over Los Angeles, Salton Sea, Imperial Valley, Sonoran Desert. Tapes MC 21-48/2, 21-49/1 [?].

Table 1. HH-108

DOY	GMT	Track	Rev	Subject matter, observations, photography
022	20:22:32	63	3642	Referring to DOY-021, 21:40, NK, CX-42, frames 61, 62. San Francisco [8026, 8027].
022	20:24:12	63	3642	NK, CX-42, frame 60 [8028] Monterey Bay. Frame 59 [8029], Mono Lake. Frame 58 [8030], small red lake in Sierras, south of Mono Lake.
022	20:24:21	63	3642	NK, CX-42, frames 54 to 57 [8031-8032]. Palm Springs to Imperial Valley.
023	22:09:58	21	3671	Southern California coast - three stereo pairs - oblique looking from west. Referred to 21:55. HDC, CX-18, frames 62-67 [4482-4487].
024	02:31:26	?	?	Monterey Bay, effluent from Santa Clara river NK 300 mm; CX-42; frame #2 [8086].
028	00:02:05	63	3713	Referring to DOY 026 (?) 19:42. San Francisco south to L.A. HDC, CX-18, frames 98-103 [4520-4523]. Very oblique photos.
028	00:05:22	6	3727	Earth terrain camera set up and apparently photographed Calif. coastline when craft had attitude error in roll of about 20° - oblique to west. Referred to following entry.
028	00:06:02	6	3727	Referred to 18:55-19:04, pass from northern California to tip of Baja. Clear as a bell so "I shot away". HDC, CX-18, frames 110-133 [4530-4547, 4551], photo overlapping.
028	18:53:01	20	3741	Referred to about 18:51. California coast; looking toward fault zones. HDC, CX-18, frames 137-145 [4558-4565].
028	19:01:04	20	3741	Referred to 18:10-18:16. California, Baja, S.West. U.S. NK 35, CX-44, frames 48-57 [7961-7972].
030	19:23:40	49	3770	Referred to 18:26. South end San Joaquin Valley. NK 300, CX-44, frames 1 to 8 [8009-8019].

Table 1. HH-108

DOY	GMT	Track	Rev	Subject matter, observations, photography
034	15:27			Looked for Garlock fault from over central Arizona. Couldn't see it.
035	16:37:24	49	3841	Sequence from Fresno, California to Guadalajara, Mexico. NK 300, CX-57, frames 2-43 [7784-7825].
036	16:10:59	63	3855	Just finished pass down west coast of U.S. toward S. America. NK, CX-61, apparently much of magazine used to shoot various targets along west coast of U.S. (and south) [7552-7557].

Table 1. Other Geology Features in Calif., Nevada, Utah, Colorado, New Mexico. Numbers in brackets are final NASA frame numbers.

DOY	GMT	Track	Rev	Subject matter, observations, photography
001	23:10:29	59	3354	Referred to 23:10 (?). Snow cover west of San Francisco to Salt Lake City. HDC, CX-52, 118-120 [3844, 3845].
004	21:07:49	30	3396	Referred to slightly after 20:54. Denver, Colo. NK 300, CX-39, frame 47 [7151].
007	23:43:19	2	3439	Referred to 20:15. Heavy snow cover northern Sierra Nevada, Calif. NK 300, CX-39, frame 19 [7179].
010	18:30:45	44	3481	Referred to pass from 18:10 to 18:30 (Imperial Valley to Gulf of St. Lawrence). Photos: Imperial Valley, Albuquerque, Colorado Springs - Denver (stereo pair). HDC, CX-51, frames 132-148 [4034-4040].
010	23:06:09	45	3482	Referred to 19:52. HDC, CX-51 (?), frames 148-149 [4047-4049] of southern Cascades. Great Salt Lake magenta and green (photo ?).
016	15:34:08	58	3566	Denver and Platte River area. SO 52 TV photography?
016	15:45:55	58 ?	3566 ?	HDC, CX-50. Frame 84 in southern Nevada, 85, 86 [4157, 4158] in northern Arizona - Grand Canyon, 87 [4159] in eastern Colorado. Time unspecified, but earlier.
016	17:18:06	58 ?	3566?	NK 300 mm, CX-41, frame 62 [7004], color contrast in Salt Lake.
018	14:18:24	15	3594	Referred to 14:05. Oblique, low sun angle, West Texas, New Mexico, northern Mexico. "Awful lot of geology..." CX-40, frame 140 [4211].
019	00:55:36	20	3599	Platte River drainage, CX-50, frame 159 [4231]; referred to 22:16 previous day, near vertical of White Sands, New Mexico, frame 160 [4232].

Table 1. Other Geology Features in Calif., Nevada, Utah, Colorado, New Mexico.

DOY	GMT	Track	Rev	Subject matter, observations, photography
020	02:12:21	30	3609	Denver, and Rockies, low sun angle. HDC, CX-46, frame 11 [4258, 4259]. Referred to 15:01, prev. day.
023	20:43:32	20	3670	N. California or Oregon coast, NK CX-42, frames 5-7 [8081-8082]. Flooding rivers.
023	20:44:18	20	3670	Lake Powell, Utah-Arizona HDC CX-18, frames 54-59 include these [4473-4477].
028	19:01:04	20	3741	Referred to 18:10-18:16. NK 35, CX-44, frames 51-57 [7961-7969] Calif. and southwestern U. S. NK 100, CX-44, frame 47 [7972], smoke plume in Ariz (?), Nevada (?).
029	18:28:35	34	3755	Referred to 17:31-17:38, a pass from over Crater Lake to Houston. Oblique of S. Western U.S. from over Great Plains. HDC, CX-18, frame 160 [4580, 4581].
030	19:23:40	49	3770	Referred to 18:26. Mojave block. NK 300, CX-44, frames 1 to 8 [8009-8019].
036	16:10:59	63	3855	Just finished pass down west coast of U.S. NK, CX-61, apparently much of magazine used to shoot various targets in western U.S. (and south) [7552-7557].
037	15:37:00	6	3869	Referred to 13:10-13:25 (sic, probably 15:10 to 15:25) Sierras to Lima, Peru. Low sun angle. NK, CX-58, frames 33-57 [7716-7726].

SKYLAB 4 — VISUAL OBSERVATIONS OF GEOLOGICAL FEATURES OF SOUTHWESTERN NORTH AMERICA

Table 2. PHOTOGRAPHIC SUMMARY

1. Baja California and the Gulf of California
HH-[illegible]1

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
331	20:27:49		NK	CX-19	34,35	34,36,37	197	7426,7428 7429
On or before 336 Not identified in crew transcript			HDC	CX-47		6,30,31	136	3385,3409, 3410
340	17:48:57	17:05	HDC	CX-47	58-60	58-60	136	3437-3439
341	18:44:32	16:23	HDC	CX-47	99-101	100-102	136	3479-3481
358,359 or 360 Not identified in transcript			HDC	CX-17		174	137	3727
365	00:[illegible]7:32	22:54 (DOY 364)	HDC	CX-52	81,82	80-83	138	3807-3810
365 or 001 Not identified in transcript			HDC	CX-52		100-102	138	3827-3829
002 Not identified in transcript			HDC	CX-52		133	138	3860
002	23:06:03	22:20	HDC	CX-52	134	134	138	3861
004	21:07:49	20:54	HDC	CX-52	154,155	153,154	138	3880,3881
010	{23:02:32 23:03:50	18:14	NK	CX-39	8-11	55-58	193	7187-7190
014 or 015 Not identified in transcript			HDC	CX-50		54-68	140	4126-4140
016	00:24		TV					
016	15:45:55	~15:28	HDC	CX-50	82-84	81-83	140	4154-4156
020	02:26:47	23:05 (DOY 019)	NK	CX-41	26-30	37-41	191	7036-7040
021	22:00:08	21:52	HDC	CX-46	124-154	none applicable		
028	00:06:02	18:55 to 19:04 (DOY 027)	HDC	CX-18	110-133	124-130, 132-134	142	4544-4550 4552-4554
028	18:53:01	~18:15	HDC	CX-18	137-147	142-145	142	4562-4565

Table 2. HH-111

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
028	19:01:04	18:16	NK	CX-44	51-52 (approx.)	14,17	206	7967,7970
029	18:28:35	~17:40	HDC	CX-18	160	161	142	4581
030	19:40:20	~18:28	HDC	CX-45	11	10	143	4603
035	16:37:24	~14:45	NK	CX-57	2-43	48-54 57-60	203	7807-7813 7816-7819
036	16:10:59	~14:00	NK	CX-61	Magazine	27,28	199	7552,7553
037	15:37:00	15:10 to 15:25	NK	CX-58	33-57	26,33,40	202	7718,7725, 7732

Table 2. Other Geology Features of Baja California and Gulf of California

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
331	20:27:29		NK	CX-19	36-38	34,36,37	197	7426,7428, 7429
334	19:55:08		NK	IR-08	11,12	36	152	5186
339	17:19:59	16:12	NK	CX-20	24,25	42,43	196	7371,7372
017	14:58:44	14:48	HDC	CX-50	125,126	125,126	140	4197,4198
023	22:10:46	~21:55	HDC	CX-18	68,69	68,69	142	4486-4489
030	19:30:08	~18:28	HDC	CX-45	11-16	10-14	143	4603-4607

Table 2. PHOTOGRAPHIC SUMMARY

Photographs Not Identified in Crew Transcript

I. Baja California and the Gulf of California
HH-111

DOY	Camera	Flight Mag. #	Correct Flight Frame #	Final Mag. #	Final Frame #
342	NK	CX-36	63	195	7325
365	NK	CX-37	37,38,41	194	7234,7235, 7238
031 ?	NK	IR-12	19,20	156	5294,5295
033, 034, or 035	NK	CX-54	44, 56-59	204	7870 7882-7885
336 or before	HDC	CX-47	6	136	3385
336	HDC	CX-47	30,31	136	3409,3410
358, 359, or 360	HDC	CX-17	174	137	3727
365 or 001	HDC	CX-52	100-102	138	3827-3829
002	HDC	CX-52	133	138	3860
014 or 015	HDC	CX-50	54-68	140	4126-4140

Table 2. PHOTOGRAPHIC SUMMARY

Skylab 4 — Visual Observations of Geological Features of Southwestern North America

II. Sonora, Mexico
HH-112, 113, 114

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
Before 340 Not identified in transcript			HDC	CX-47	30,31	30,31	136	3409,3410
339	17:19:59	16:12	NK	CX-20	25	26,27	196	7355,7356
340	17:48:57	17:05	HDC	CX-47	60	60	136	3439
Not identified in transcript			HDC	CX-50	58-69	58-69	140	4130-4141
016	15:45:55	~15:28	HDC	CX-50	82-84	82-84	140	4154-4156
017	14:58:44	14:48	HDC	CX-50	125-126	125-126	140	4197-4198
021	22:00:08	21:52	HDC	CX-46	143-154	143-154	141	4390-4401
022	20:25:29	21:44-21:48	NK	CX-42	32-53	14-36	207	8034-8056
028	00:06:02	18:15-19:04	HDC	CX-18	110-133	127-134	142	4547-4554
028	19:01:04	18:15-18:18	NK	CX-44	47-50	36(?)	206	7989
030	19:27:00	~18:28	HDC	CX-45	10-14	10-14	143	4603-4607
035	16:37:24	16:10	NK	CX-57	2-43	48-66(?)	203	7807-7825
036	16:10:59	16:10	NK	CX-61	?	33-55	199	7558-7580
037	15:37:00	15:10	NK	CX-58	33-57	33-53	202	7725-7745

Table 2. Other Geology Features in Mexico

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
331	20:06		NK	CX-19	36-38	37-39	197	7429-7431
008	18:39:28	18:04	HDC	CX-51	83	84	139	3983
011	16:10	16:09:25?	HDC	CX-51		163-165	139	4062-4064
016	23:55:16		HDC	CX-50	114-116	114-116	140	4186-4188
035	16:36:37		HDC	CX-45	23-29	23-29	143	4616-4622

Table 2. PHOTOGRAPHIC SUMMARY

Photographs Not Identified in Crew Transcript

II. Sonora, Mexico
HH-112, 113, 114

DOY	Camera	Flight Mag. #	Correct Flight Frame #	Final Mag. #	Final Frame #
336	NK	CX-20	42,43	196	7371,7372
365	NK	CX-37	39,40	194	7236,7237
365	NK	CX-37	42,43	194	7239,7240
010	NK	CX-39	22,23	193	7154,7155
031 (?)	NK	IR-12	19,20	156	5294,5295
033, 034, or 035	NK	CX-54	44	204	7870
036	NK	CX-61	33,35	199	7558,7560
336	HDC	CX-47	30-31	136	3409-3410
014 or 015	HDC	CX-50	58-69	140	4130-4141

Table 2. PHOTOGRAPHIC SUMMARY

Photographs Not Identified in Crew Transcript

Other Geology Features in Mexico

DOY	Camera	Flight Mag. #	Correct Flight Frame #	Final Mag. #	Final Frame #
336	NK	CX-20	34	196	7363
On or near 025	NK	CX-43	48-50	209	8199-8201
028	NK	CX-44	17	206	7970
036	NK	CX-61	36-54	199	7561-7579
?	NK	CX-60	27-30	200	7619-7622

Table 2. PHOTOGRAPHIC SUMMARY

Skylab 4 — Visual Observations of Geological Features of Southwestern North America

III. Arizona
HH-125, 126

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
				HH-125. S.E. Arizona				
In several entries under Other Geology Features in Arizona there may be relevant photographic coverage of southeastern Arizona, although it is not stated positively in the transcript. DOY's 010, 022, 023 in particular.								
				HH-126. Central Arizona Linear Features				
022	21:49:12	~ 21:04	HDC	CX-18		18-20	142	4438-4440

Table 2. Other Geology Features in Arizona

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
364		22:55(?)	HDC	CX-52		81-85	138	3808-3812
Not identified in transcript								
365	00:20:16	22:57	NK	CX-37	47,46	19,20	194	7216,7217
010	18:30:45	~18:10	HDC	CX-51	133-135	135-138	139	4034-4037
010	23:04:28	18:16	NK	CX-39	7	60	193	7192
016	15:45:55	~15:26	HDC	CX-50	86	85	140	4157
016	23:55:16	23:45	HDC	CX-50	113	113	140	4185
022	21:49:12	~21:04	HDC	CX-18		15-20	142	4435-4440
023	20:44:18	~20:13	HDC	CX-18	54-59	54,56,57	142	4474,4476, 4477
029	18:28:35	~17:35	HDC	CX-18	160	160,161	142	4580,4581

Table 2. PHOTOGRAPHIC SUMMARY

Photographs Not Identified in Crew Transcript

III. Arizona
HH-125, 126

DOY	Camera	Flight Mag. #	Correct Flight Frame #	Final Mag. #	Final Frame #
HH-125. S.E. Arizona					
036	NK	CX-61	29-32	199	7554-7557
HH-126. Central Arizona Linear Features					
039	NK	CX-58	30-32,34	202	7722-7724, 7726
014 or 015	HDC	CX-50	66,68,69	140	4138,4140, 4141
029	HDC	CX-18	161	142	4581

Table 2. PHOTOGRAPHIC SUMMARY

Photographs Not Identified in Crew Transcript

Other Geology Features in Arizona

DOY	Camera	Flight Mag. #	Correct Flight Frame #	Final Mag. #	Final Frame #
331	NK	CX-19	37	197	7429
336	NK	CX-20	42	196	7371
020	NK	CX-41	9,10,20	191	7008,7009, 7019
031 (?)	NK	IR-12	19-22	156	5294-5297
035	NK	CX-57	41,47 53-56,61	203	7800,7806 7812-7815 7820
036	NK	CX-61	27-32	199	7552-7557
037	NK	CX-58	27-32 34,38	202	7719-7724 7726,7730
364	HDC	CX-52	81-85	138	3808-3812
002	HDC	CX-52	133,134		3860,3861
004	HDC	CX-52	154		3881
014-015	HDC	CX-50	60,62,63 65-69	140	4132,4134, 4135, 4137-4141
021	HDC	CX-46	138,139 143,144	141	4385,4386 4390,4391
028-029	HDC	CX-18	144,145	142	4564,4565

Table 2. PHOTOGRAPHIC SUMMARY

Skylab 4 — Visual Observations of Geological Features of Southwestern North America

IV. San Andreas Fault and Related Faults
HH-108

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
331	20:27:36	20:27	NK	CX-19	33-38 (?)	34-39	197	7426-7431
340	17:48:57	17:05	HDC	CX-47	58-60	58-60	136	3437-3439
353	00:54:46	early a.m.	?	BV-43	22-44	?	?	?
365	00:16:51	22:54	NK	CX-37	46-48	15-17	194	7212-7214
001	23:10:29	23:10(?)	HDC	CX-52	117	116	138	3843
002	23:04:43	22:20	HDC	CX-52	134	133,134	138	3860,3861
002	23:04:43	22:20	NK	CX-38	26-29	30-32	208	8116-8120
010	18.30:45	18:10-18:30	HDC	CX-51	132(?)	134	139	4033
015	00:17		TV					
022	20:22:32-20:24:21	21:40	NK	CX-42	54-62	6-13	207	8026-8033
023	22:09:58	21:55	HDC	CX-18	62-67	62-67	142	4482-4487
024	02:31:26		NK	CX-42	2	66	207	8086
028	00:02:05	19:42 (DOY 026?)	HDC	CX-18	98-103	100-103	142	4520-4523
028	00:05:22	18:55-19:04	Earth Terrain Camera					
028	00:05:22	18:55-19:04	HDC	CX-18	110-133	110-127, 131	142	4530-4547, 4551
028	18:53:01	18:15	HDC	CX-18	137-145	138-145	142	4558-4565
028	19:01:04	18:10-18:16	NK	CX-44	48-57	8-19	206	7961-7972
030	19:23:40	18:26	NK	CX-44	1-8	56-66	206	8009-8019
035	16:37:24	pass ending ~16:37	NK	CX-57	2-43	25-66	203	7784-7825
036	16:10:59	pass ending ~16:10	NK	CX-61	much of magazine	27-32	199	7552-7557

Table 2. Other Geology Features in California, Nevada, Utah, Colorado, New Mexico

DOY	Transcript GMT	Photo GMT	Camera	Flight Mag. #	Transcript Flight Frame #	Correct Flight Frame #	Final Mag. #	Final Frame #
001	23:10:29	23:10?	HDC	CX-52	118-120	118,119	138	3844,3845
004	21:07:49	~20:54	NK	CX-39	47	19	193	7151
007	23:43:19	20:15	NK	CX-39	19	47	193	7179
010	18:30:45	18:10-18:30	HDC	CX-51	132-148	135-141	139	4034-4040
010	23:06:19	19:52	HDC	CX-51(?)	148-149	148-150	139	4047-4049
016	15:34:08		TV					
016	16:45:55		HDC	CX-50	84-87	85-87	140	4157-4159
016	17:18:06		NK	CX-41	62	5	191	7004
018	14:18:24	14:05	HDC	CX-50	140	139	140	4211
019	00:55:36	22:16	HDC	CX-50	159,160	159,160	140	4231,4232
020	02:12:21	15:01 (DOY 019?)	HDC	CX-46	11	11,12	141	4258,4259
023	20:43:32		NK	CX-42	5-7	61-62	207	8081-8082
023	20:44:18		HDC	CX-18	54-59	53-57	142	4473-4477
028	19:01:04	18:10-18:16	NK	CX-44	47,51-57	8-16,48	206	7961-7969, 7972
029	18:28:35	17:31-17:38	HDC	CX-18	160	160,161	142	4580,4581
030	19:23:40	18:26	NK	CX-44	1-8	56-66	206	8009-8019
036	16:10:59	pass ending ~16:10	NK	CX-61	much of magazine	27-32	199	7552-7557
037	15:37:00	15:10-15:25	NK	CX-58	33-57	24-34	202	7716-7726

Table 2. PHOTOGRAPHIC SUMMARY

Photographs Not Identified in Crew Transcript

IV. San Andreas and Related Faults
HH-108

DOY	Camera	Flight Mag. #	Correct Flight Frame #	Final Mag. #	Final Frame #
339 (?)	NK	CX-20	25,32,33	196	7354,7361, 7362
002 (?)	NK	CX-38	37-40	208	8123-8126
010	NK	CX-39	59	193	7191
025	NK	CX-43	41-45	209	8192-8196
031 (?)	NK	IR-12	19-20	156	5294,5295
033, 034, or 035	NK	CX-54	53-59	204	7879-7885
336	HDC	CX-47	27-29	136	3406-3408
364	HDC	CX-52	80-83	138	3807-3810
365	HDC	CX-52	101,102	138	3828,3829
014 or 015	HDC	CX-50	58-69	140	4130-4141
021	HDC	CX-46	130-131 134-137 140-142	141	4377-4378 4381-4384 4387-4389
030 (?)	HDC	CX-45	22	143	4615

Table 2. PHOTOGRAPHIC SUMMARY

Photographs Not Identified in Crew Transcript

Other Geology Features in California, Nevada, Utah, Colorado, New Mexico

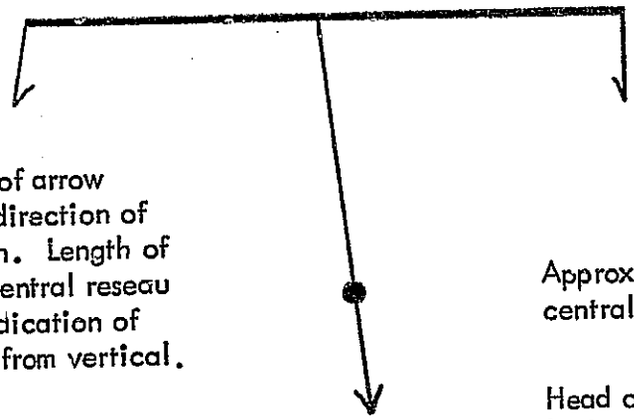
DOY	Camera	Flight Mag. #	Correct Flight Frame #	Final Mag. #	Final Frame #
012	NK	CX-40	24	192	7091
020	NK	CX-41	20	191	7019
031 (?)	NK	IR-12	21-22	156	5296,5297
033, 034, or 035	NK	CX-54	44	204	7870
364, 365	HDC	CX-52	84,85	138	3811,3812
003	HDC	CX-52	148	138	3875
004	HDC	CX-52	154	138	3881
011	HDC	CX-50	14	140	4086
016	HDC	CX-50	95,96,113	140	4167,4168, 4185
021	HDC	CX-46	124-129 132-139	141	4371-4376 4379-4386
022	HDC	CX-18	10-17	142	4430-4437

HDC PHOTOGRAPH GEOGRAPHIC INDEX

FOR MAGAZINES 136, 137, 138, 139, 140, 141, 142, 143 (HDC)

156, 191, 192, 193, 194, 197, 199, 202, 203, 204, 206, 207, 208 (NK)

Photograph edge of field of view nearest observer.

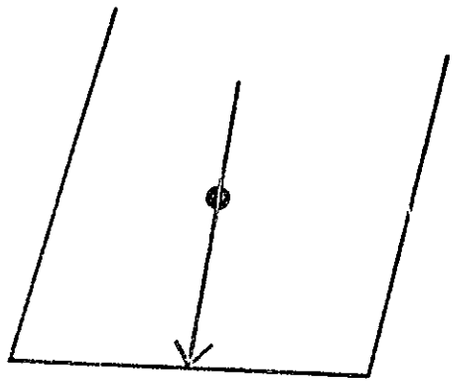


Direction of side limits of the field of the photograph.

Direction of arrow indicates direction of inclination. Length of arrow to central reseau mark is indication of the angle from vertical.

Approximate geographic location of central reseau mark.

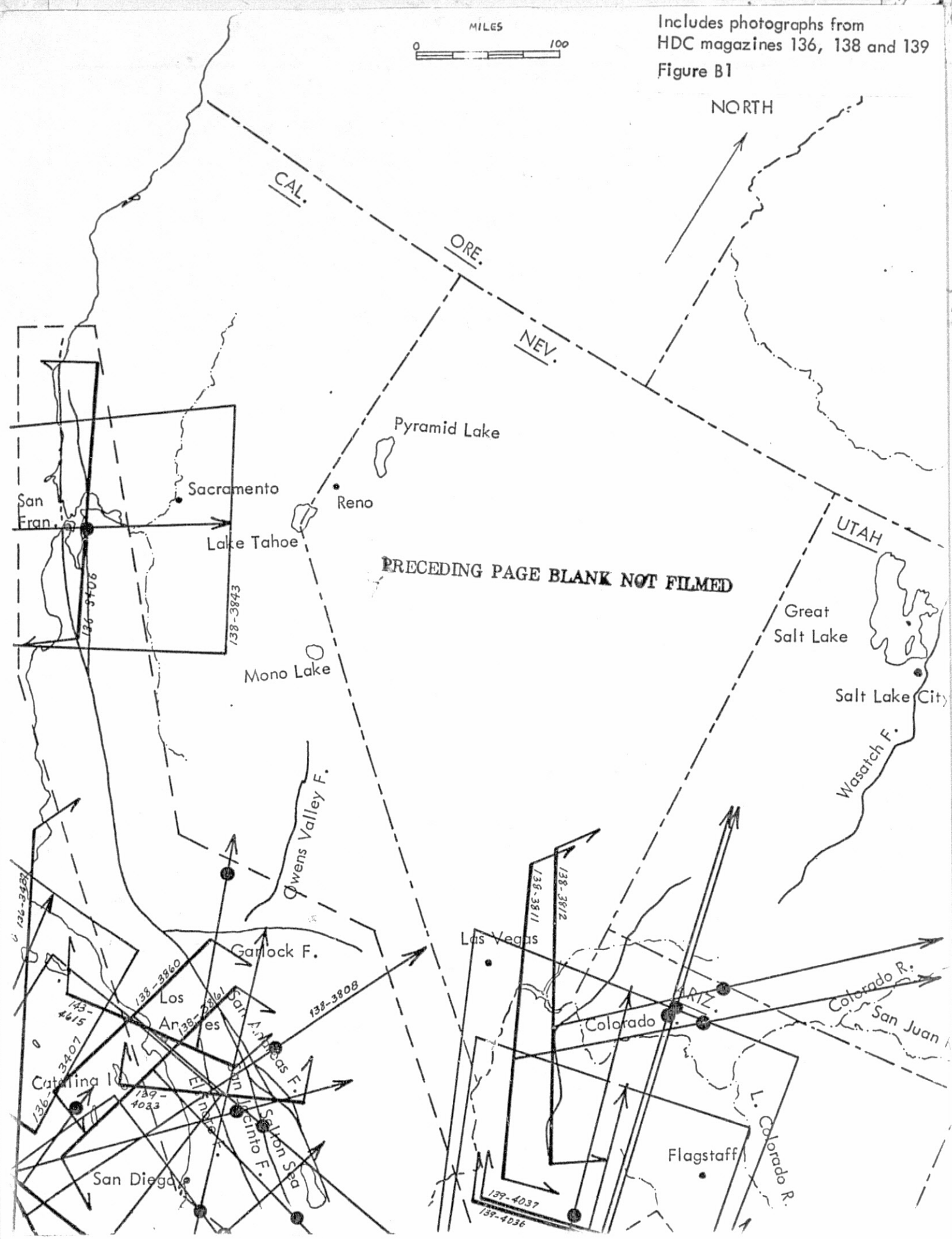
Head of arrow indicates approximate limit of useful photographic definition.



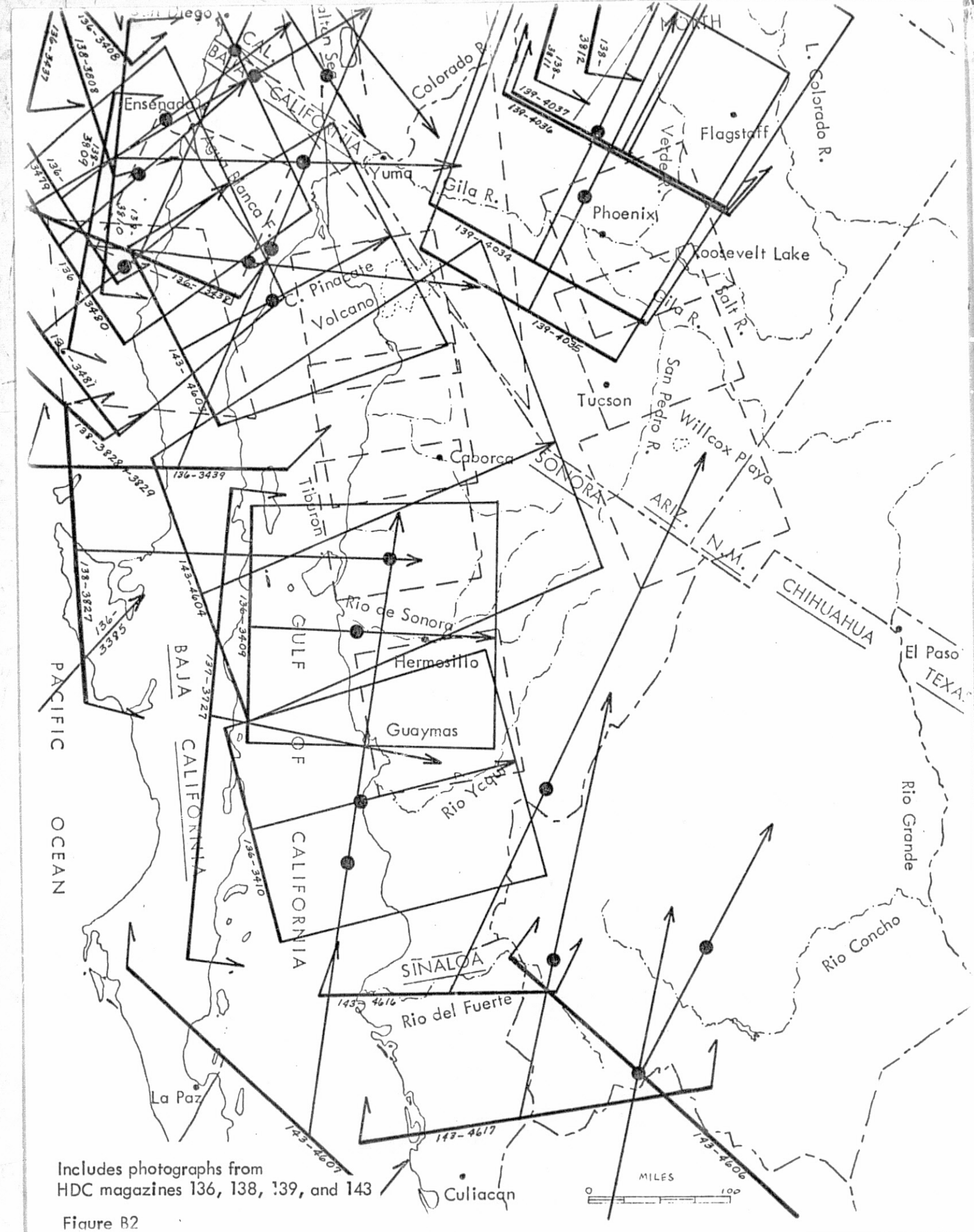
Limits of field of view on near vertical photograph. Arrow indicates direction of inclination from vertical. Dot represents central reseau mark.

Includes photographs from
HDC magazines 136, 138 and 139

Figure B1



PRECEDING PAGE BLANK NOT FILMED

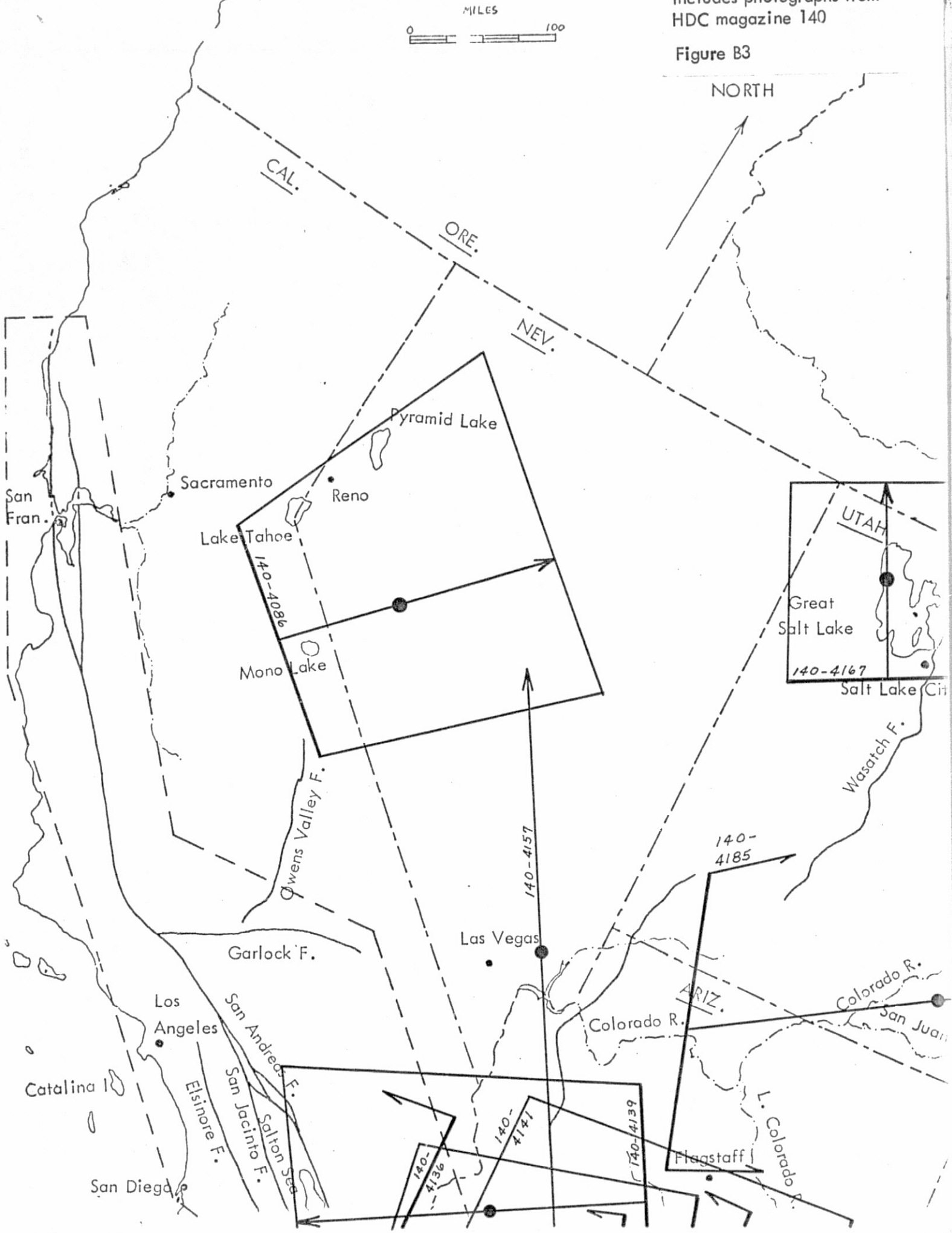


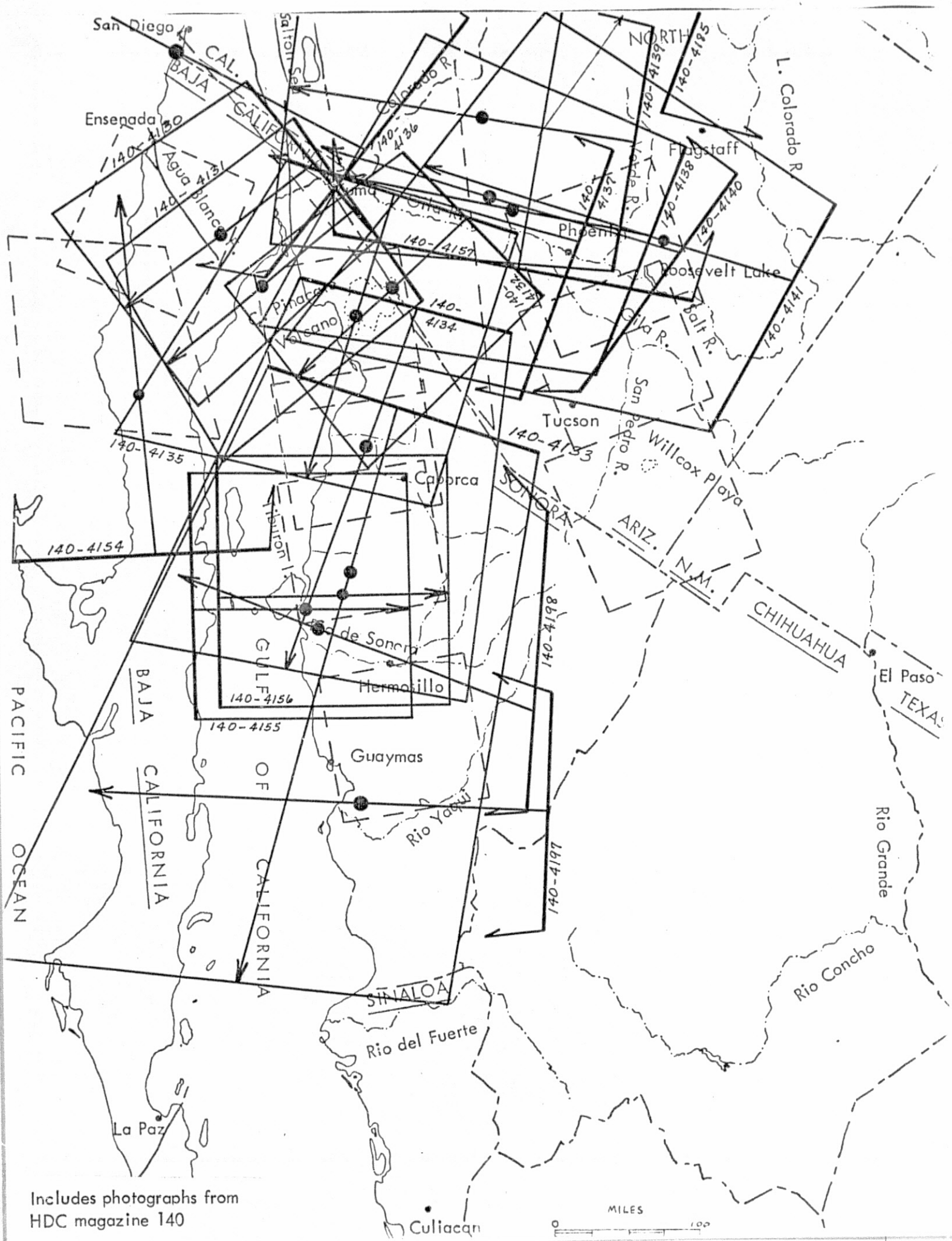
Includes photographs from
HDC magazines 136, 138, 139, and 143

Figure B2

Includes photographs from HDC magazine 140

Figure B3

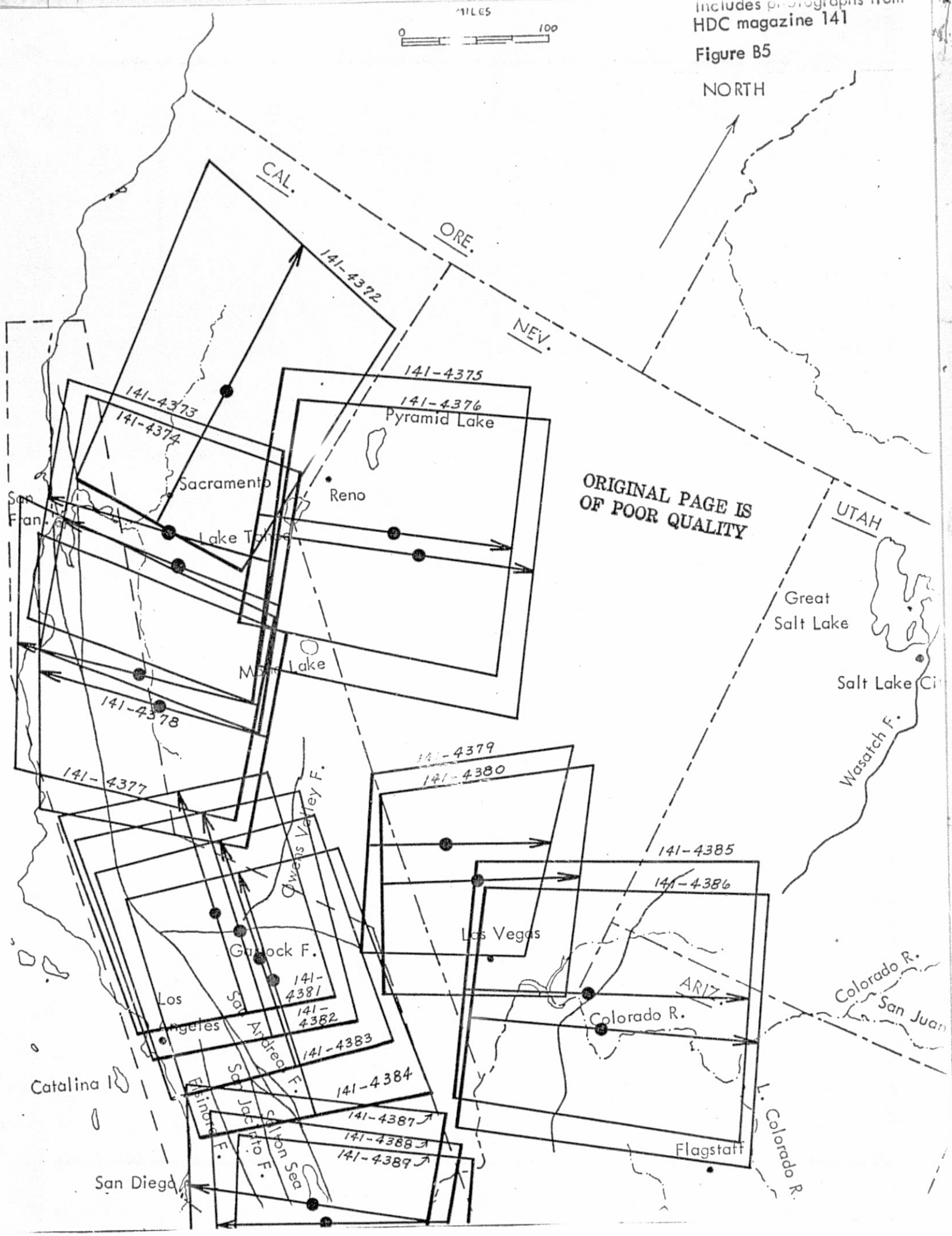




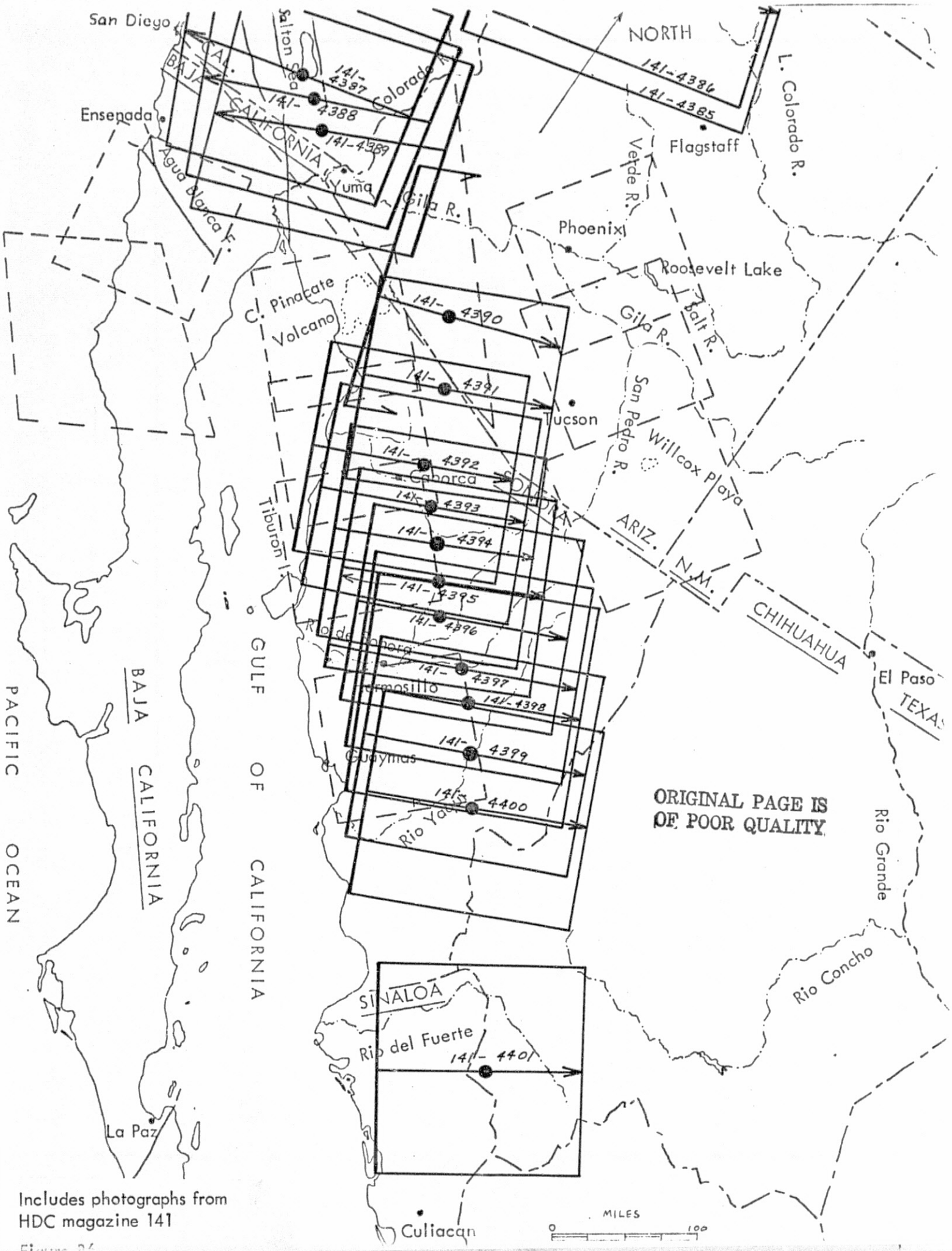
Includes photographs from HDC magazine 140

Includes photographs from HDC magazine 141

Figure B5

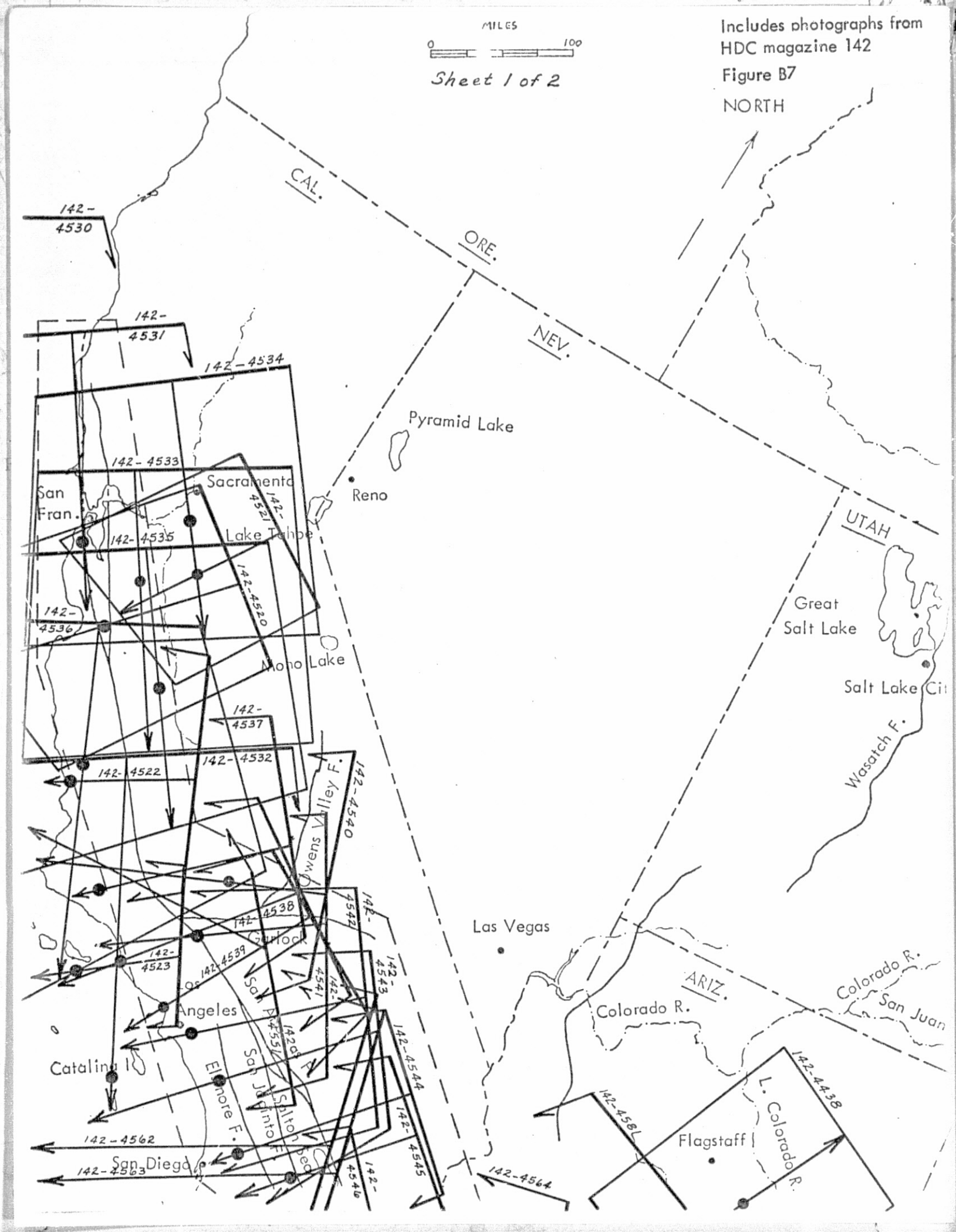


ORIGINAL PAGE IS OF POOR QUALITY



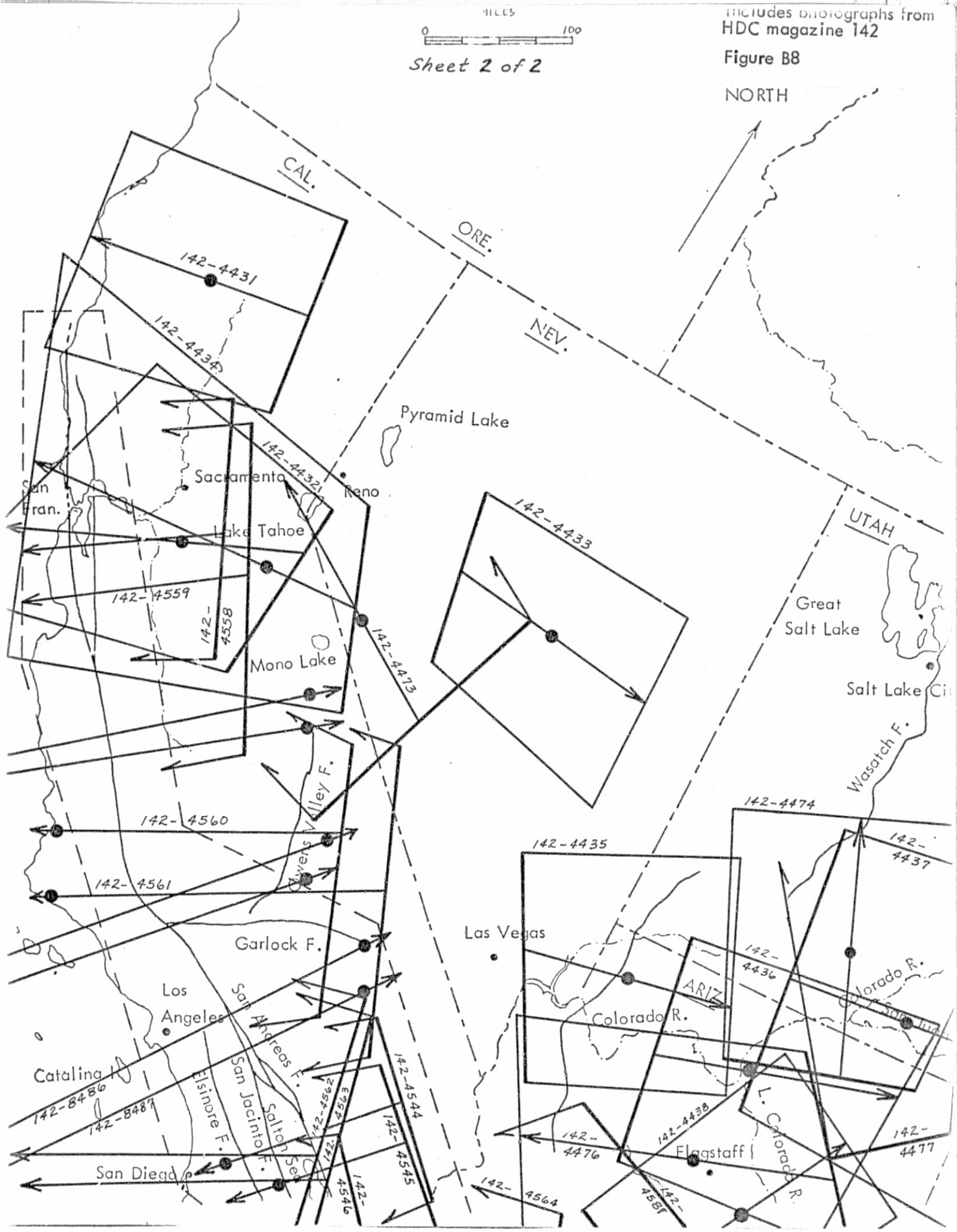
Includes photographs from
HDC magazine 141

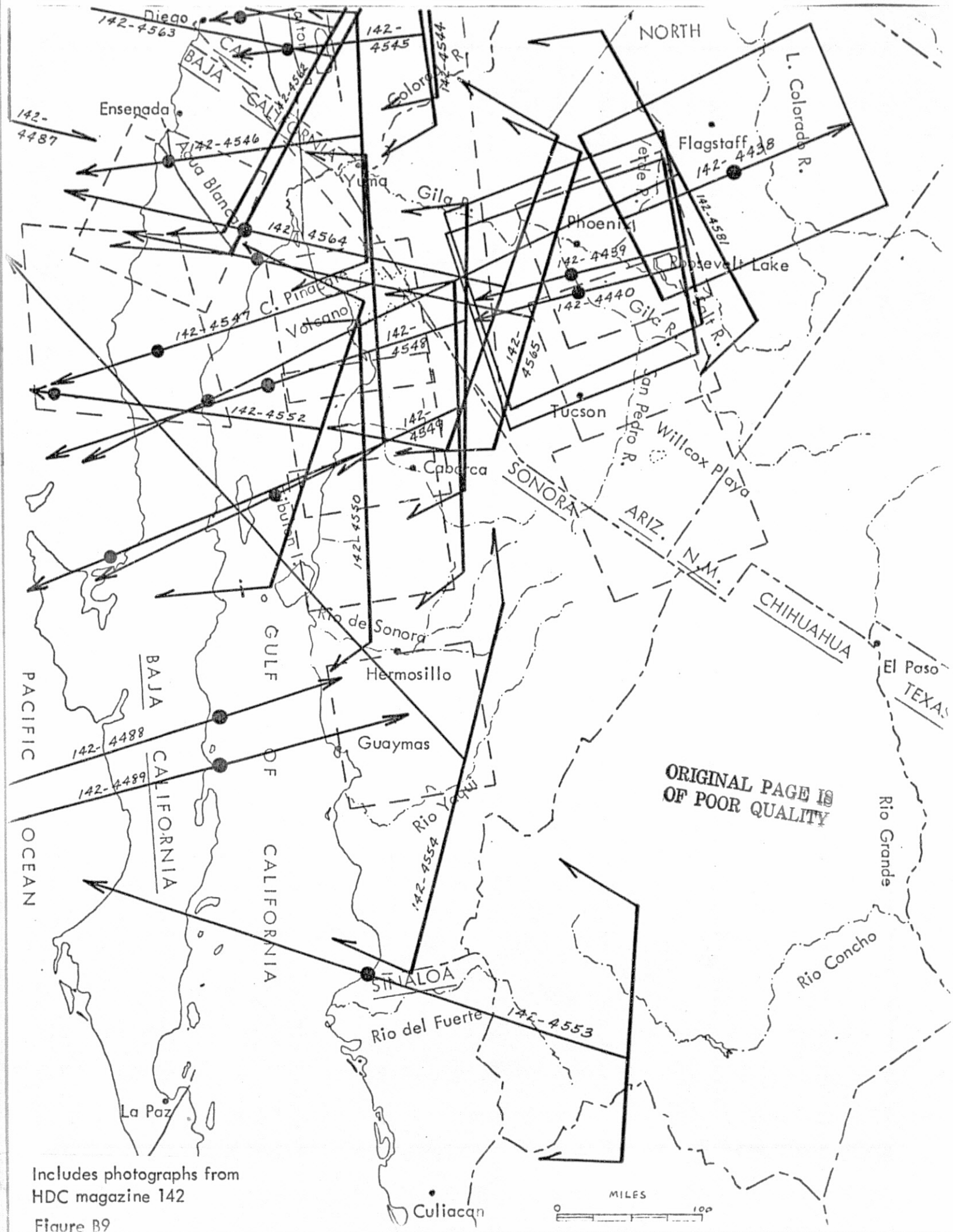
Figure 26


MILES
0
100
Sheet 1 of 2
Includes photographs from HDC magazine 142
Figure B7
NORTH
CAL.
ORE.
NEV.
UTAH
ARIZ.
142-4530
142-4531
142-4534
142-4533
142-4535
142-4536
142-4537
142-4532
142-4522
142-4521
142-4520
142-4540
142-4542
142-4538
142-4539
142-4523
142-4541
142-4543
142-4544
142-4545
142-4546
142-4562
142-4563
142-4564
142-4581
142-4438
Pyramid Lake
Reno
San Fran.
Sacramento
Lake Tahoe
Mono Lake
Owens Valley F.
Garlock
San Andreas
San Jacinto F.
Salton Sea
Elsinore F.
Angeles
Catalina I
San Diego
Las Vegas
Colorado R.
Flagstaff
L. Colorado R.
Great Salt Lake
Salt Lake Cit
Wasatch F.
San Juan

Includes photographs from HDC magazine 142

Figure B8



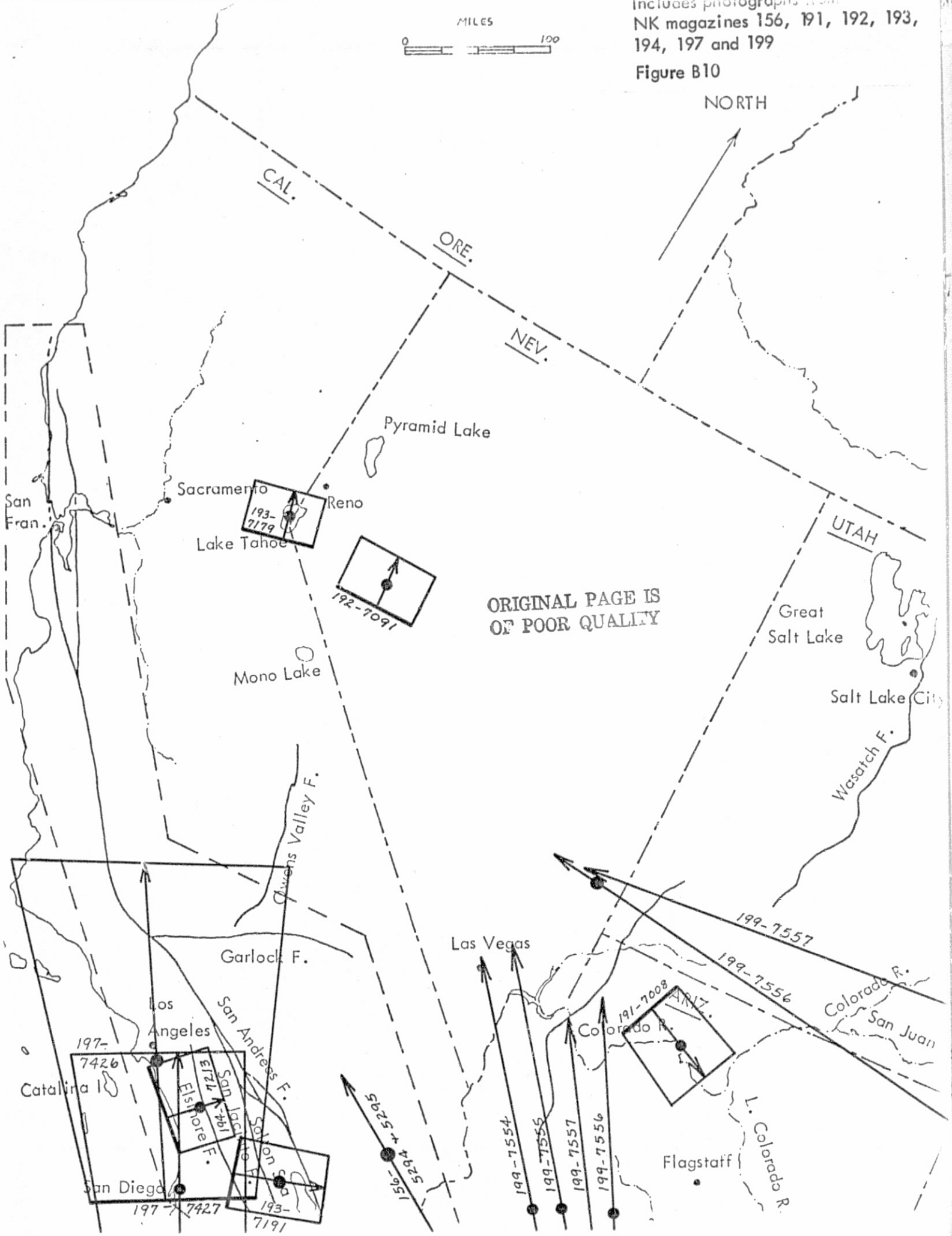


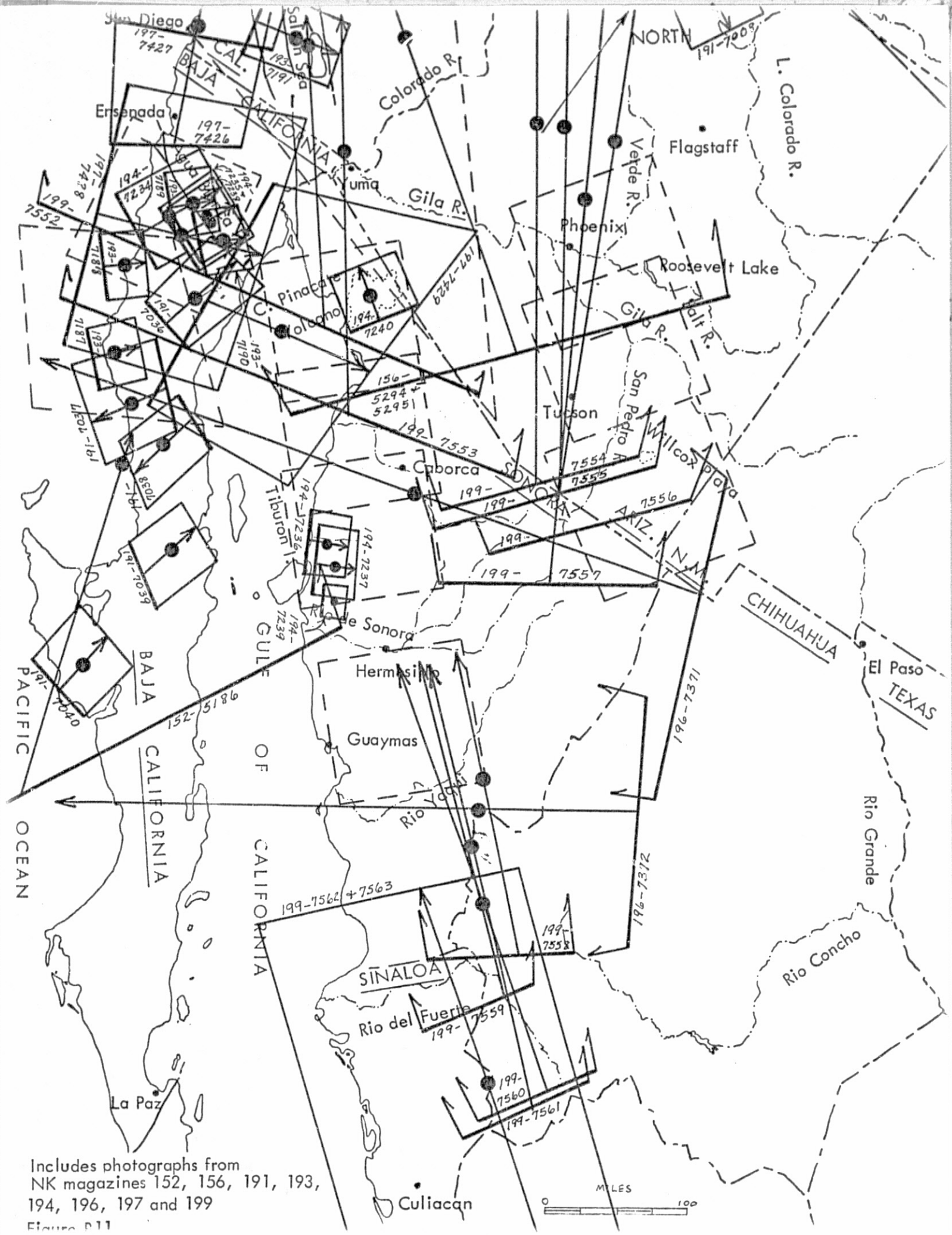
Includes photographs from
HDC magazine 142

Figure B9

Includes photographs from
NK magazines 156, 191, 192, 193, 194, 197 and 199

Figure B10



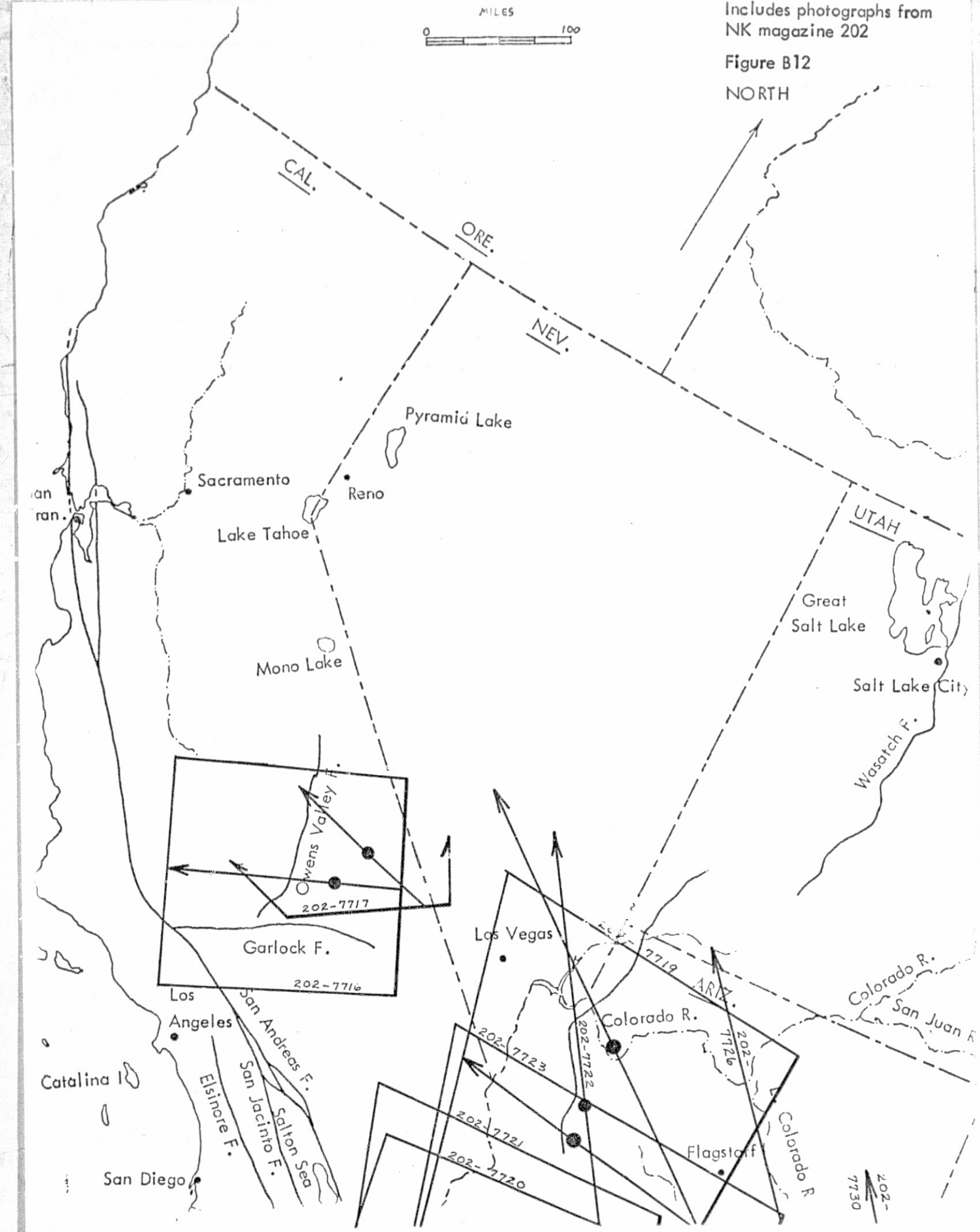


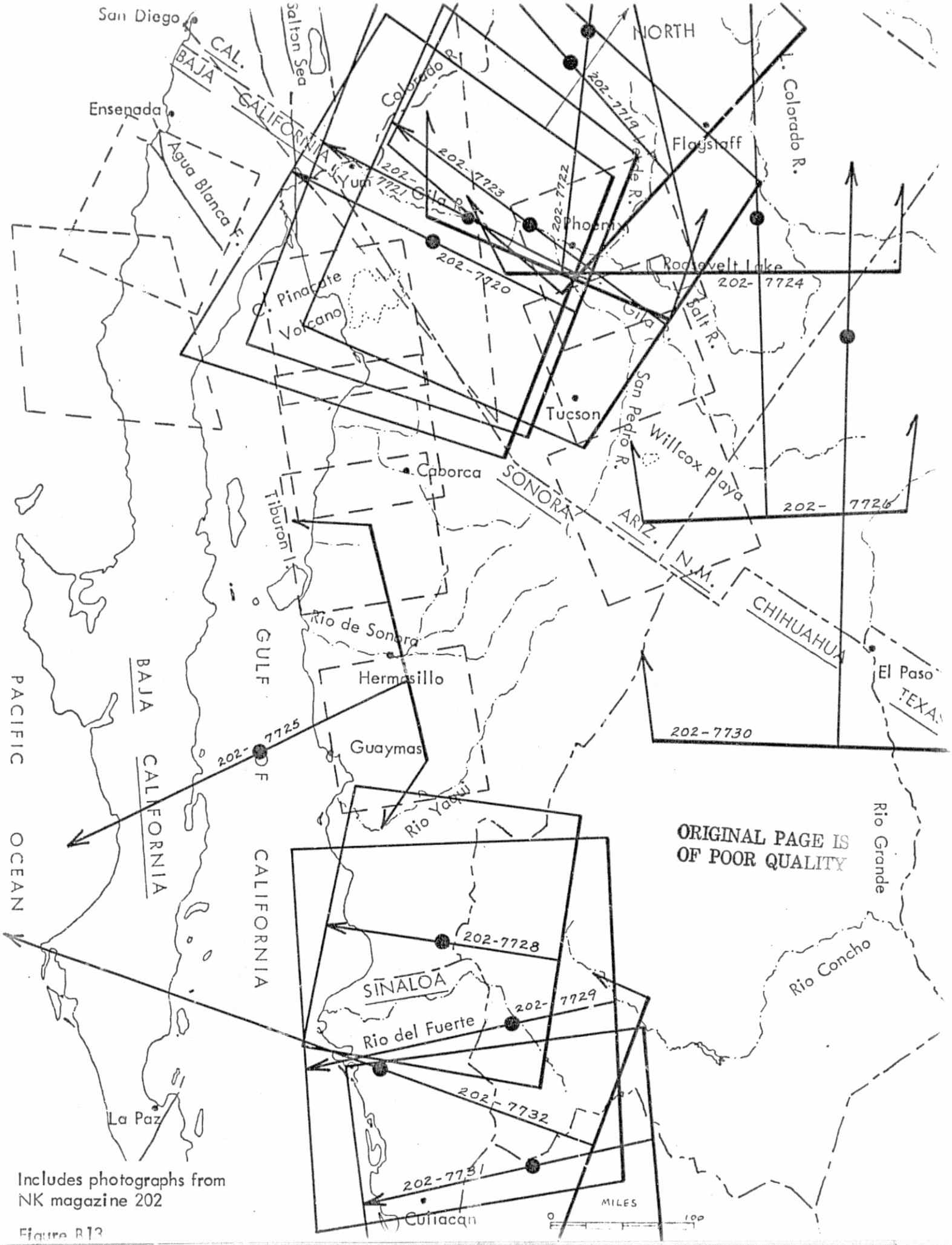
Includes photographs from NK magazines 152, 156, 191, 193, 194, 196, 197 and 199

Figure 511

Includes photographs from NK magazine 202

Figure B12



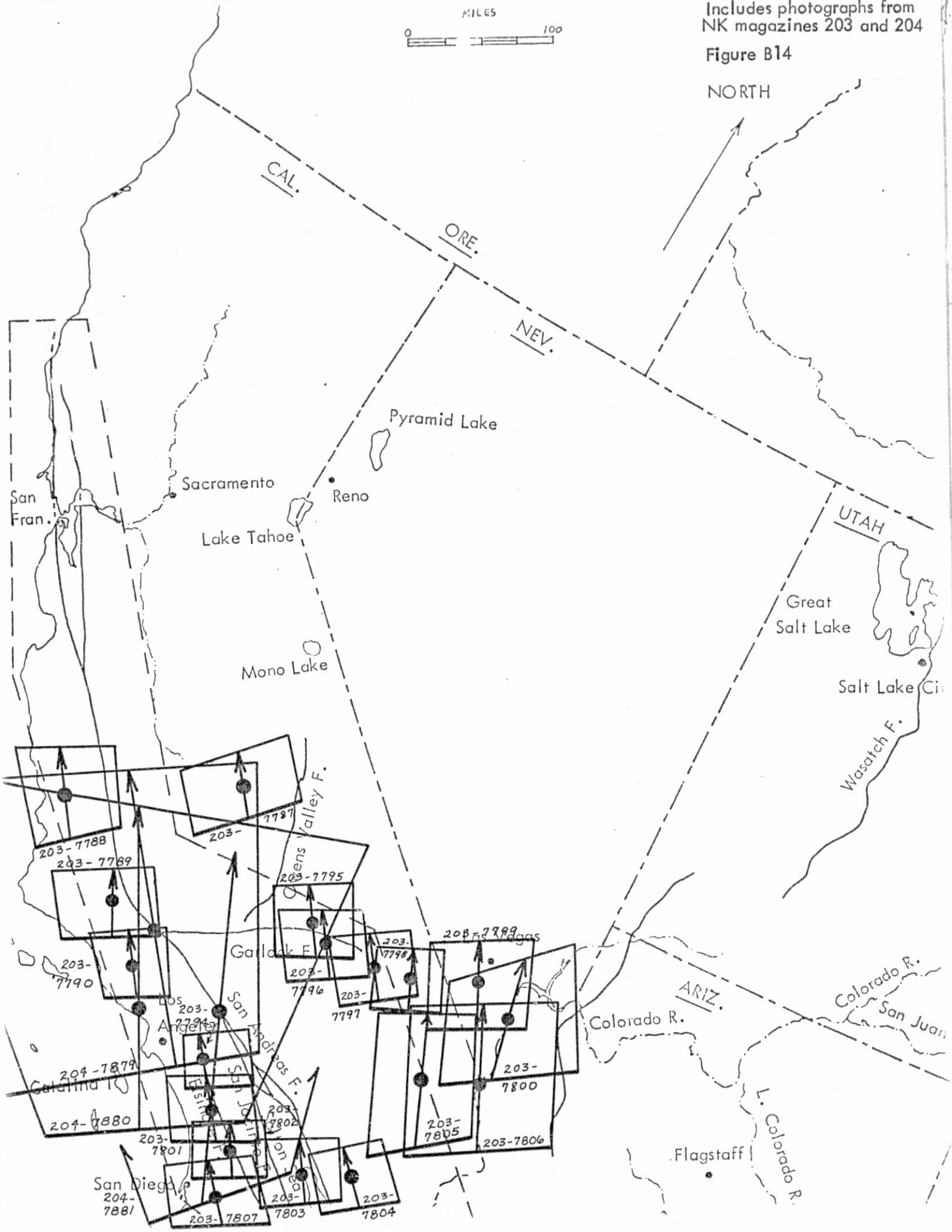


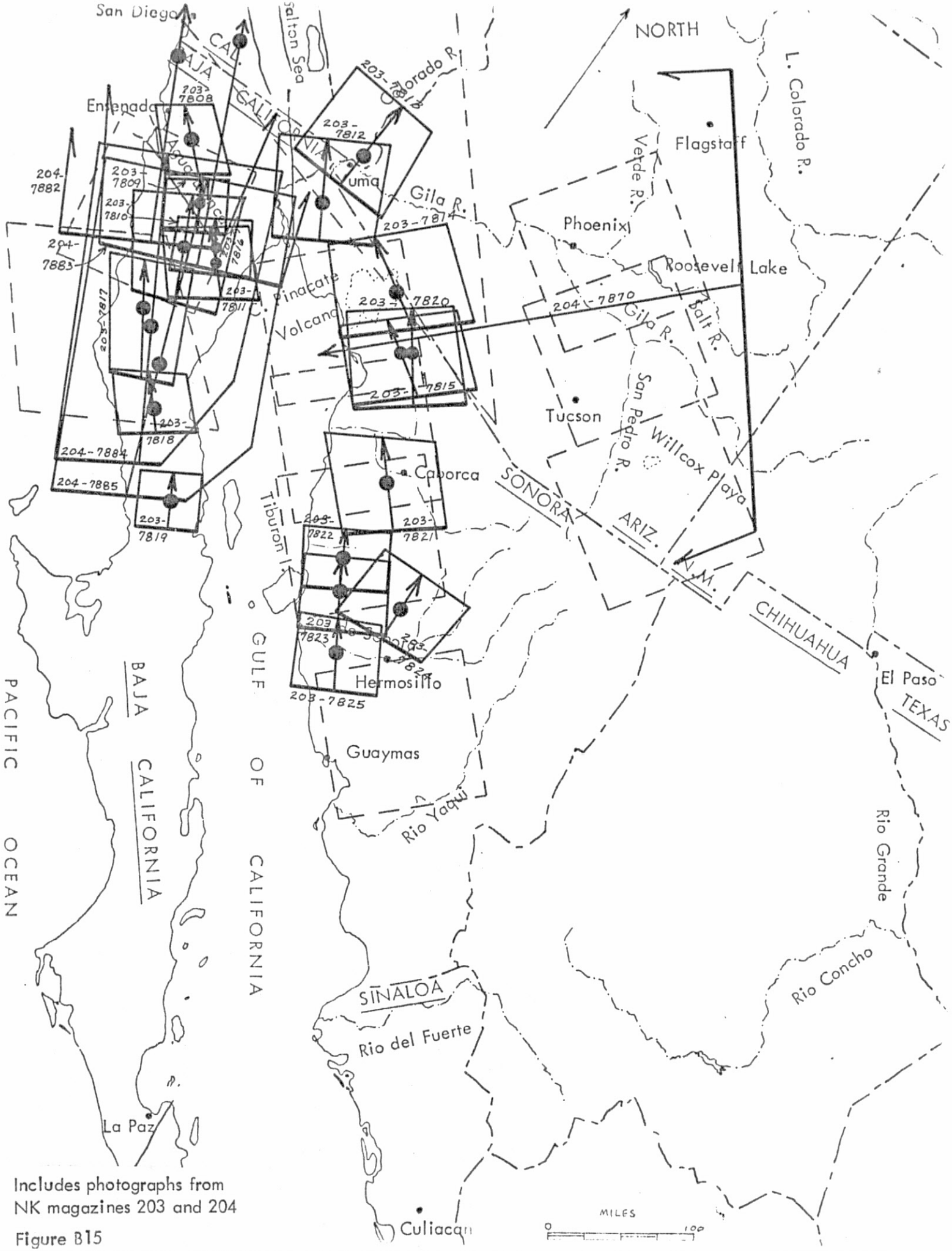
Includes photographs from
NK magazine 202

Figure B13

Includes photographs from NK magazines 203 and 204

Figure B14



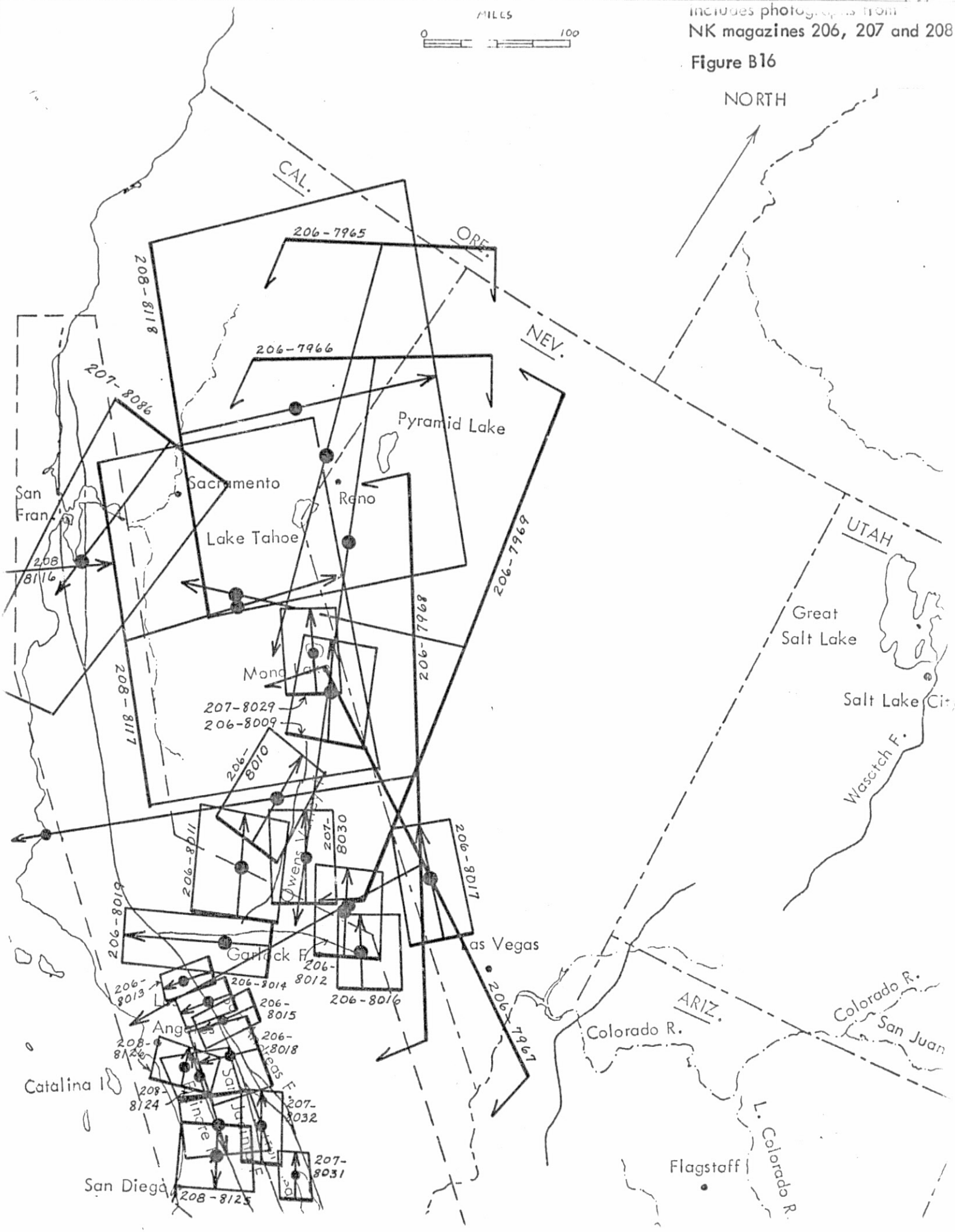


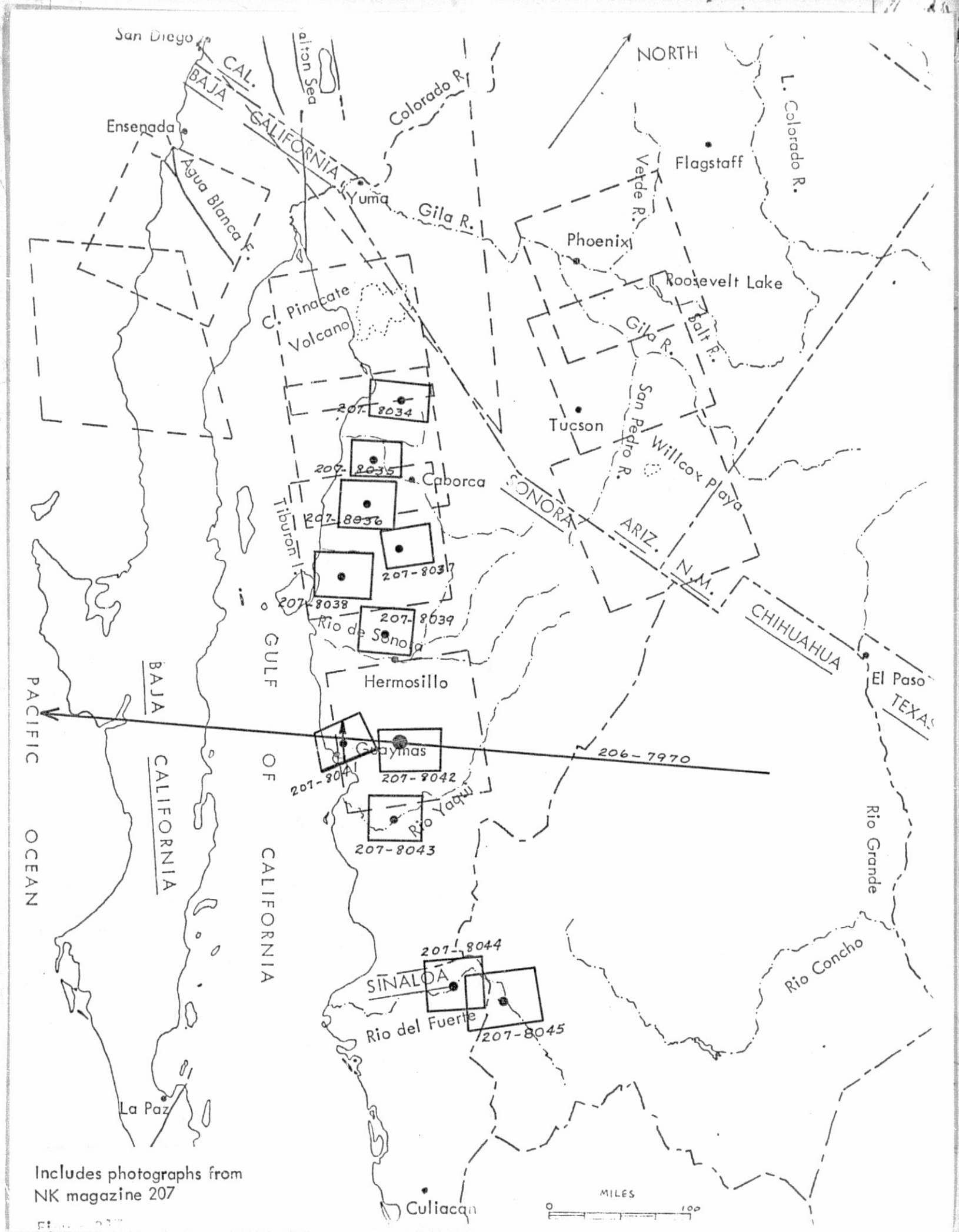
Includes photographs from NK magazines 203 and 204

Figure B15

Includes photographs from
NK magazines 206, 207 and 208

Figure B16





Includes photographs from
NK magazine 207

APPENDIX C

SKYLAB-4 VISUAL OBSERVATIONS PROJECT - GEOLOGICAL FEATURES OF SOUTHWESTERN NORTH AMERICA

L. T. Silver and others

1. Letter from E. G. Gibson
2. Transcript of March 12 Crew Debriefing

THE AEROSPACE CORPORATION

Post Office Box 92957, Los Angeles, California 90009, Telephone: (213) 648-5000

10 June 1975

Dr. Leon T. Silver
Professor of Geology
Mudd Laboratory
California Institute of Technology
1201 E. California Ave.
Pasadena, CA 91125

Dear Lee:

I have read through our visual observations debriefing on geology and have relatively few corrections. The few I have are pointed out on the enclosed xerox copies of the appropriate pages. A summary of our conclusions on best viewing conditions is also included.

I would also like to mention some additional points which we discussed and warrant emphasis in any publication affecting future manned earth observations. They are:

1. The human eye equals or exceeds the photographic techniques used in all Skylab earth looking experiments in perceiving color tones and differences, textural differences, the third dimension, linears and detail (with 10 power glasses) and in ability to observe over a wider dynamic range of intensities.

2. Even through the EREP equipment was far superior, the visual observations program returned significant information because the observer was free to exercise selectivity in data acquisition. For example:

   a) Rapidly scan field of 2π steradians and select most important features.

   b) Select when to acquire data.

   c) Select field of view (camera and lens).

   d) Add verbal description.

   To be compared accurately, the manned and unmanned systems should both have the same data acquisition equipment capabilities.

3. Large systems (>300 km) with oblique photography.

4. Repeated coverage of the same area is jus tified because significantly different observables result from varying conditions of lighting, cloud cover, snow/water cover, viewing angle and vegetation.

5. Every frame of data should have automatic recording of f stop, exposure time and Day/GMT. It would be additionally useful to also automatically record coordinates of the spacecraft, the sun angle, and the viewing angles relative nadir and north.

6. The voice recording should be easily tagged, perhaps automatically inflight, with frame numbers as taken, Day/GMT and spacecraft coordinates.

7. The voice recording should be able to be easily accomplished during data acquisition as well as before and after.

8. Automatic as well as manual exposure settings should be possible.

9. An automatic second exposure taken after an adjustable time delay should be possible for stereophotography.

10. A color standard should be taken with each roll of photography, and a color wheel should be used to optically define the color of important features.

11. Haze filters should be available.

12. A wide angle should precede most small field of view shots.

13. A significantly larger film size than 70 mm should be available.

14. A tracking telescope, which is coaligned with the cameras, should yield a real time or near real time ground readout of the coordinates of the center of its field of view. This will be used to track subtle features not observable on film or TV or those significant features whose locations are time dependent. This implies the existance of an inertial platform, readouts of the gimbal angles of the tracker and a computer which calculates the coordinates.

15. Continous communication on a science-dedicated channel should be available between the onboard observer and the science support team.

16. Real time TV should be available for downlink (data) and uplink (briefing and question response -- see page 160 of the debriefing).

17. Onboard maps should include topographic features, faults, other significant geological features, vegetation, national boundaries, cities and sites selected for special study.

18. A Mercator's projection map should be available onboard which displays the spacecraft's ground track and present position.

19. Onboard observation and photography in the near IR (reflected radiation) for IR (emitted radiation) should be possible.

Dr. Leon T. Silver

10 June 1975
Page 3

20. The onboard observer should be either a scientist trained on all areas relevant to visual observations (geology, oceanography, meterology, etc.) or a specialist in only one of them (full-time geologist). The observer should have no other significant training and inflight responsibilities than visual observations.

21. Training should include:

    a) Feature recognition - use of maps, single photos and stereo-photos.

    b) Rapid concise description of significant features and rapid decision on data to be taken. Observe photo for 30 seconds and describe features and observations.

    c) Aircraft flights over selected sites.

    d) Field trips to selected sites.

    e) Thorough familiarization with the scientific significance of the selected observations.

No doubt, Lee, you have questions and reservations on many of these points. Use what you like and feel free to call on me if I can be of help.

Best wishes,

Edward G. Gibson

EGG:jk
Encl.

Best Viewing Conditions

Feature	Local Time	Viewing angle relative to ground	Viewing angle relative to feature
Faults/Topography	Sunrise/Sunset	Visual: Oblique (if length of feature >> orbital height)	along
	Sun angle ≈ 20-30°	Photographic: not highly oblique of light scattering (a haze filter will help, eye/mind can see through it)	along
Color Differences	Noon	Nadir	—

SKYLAB 4 VISUAL OBSERVATIONS DEBRIEFING ON GEOLOGY EXPERIMENTS

March 12, 1974

Johnson Spacecraft Center
Houston, Texas

PARTICIPANTS

Skylab IV Astronauts:

Colonel Gerald P. Carr, Dr. Edward G. Gibson and Colonel William R. Pogue

Visual Observations Geology Experiments Teams:

W. R. Muehlberger, P. R. Gucwa, A. W. Ritchie and E. R. Swanson
L. T. Silver and T. H. Anderson

Visual Observations Experiment Team:

J. L. Kaltenbach, W. B. Lenoir, M. C. McEwen and V. R. Wilmarth

ASTP Astronauts:

V. D. Brand and D. K. Slayton

Observers:

F. El-Baz and R. B. Parker

SKYLAB 4 VISUAL OBSERVATIONS DEBRIEFING ON GEOLOGY EXPERIMENTS

March 12, 1974

Johnson Spacecraft Center
Houston, Texas

Wilmarth: Last October, we had this group of recalcitrant geologists in; listened to talks. Arm waved. You know, all that good stuff, you know, one Saturday morning. Here we are back again. We've got them, and they've had a chance to look at all eight of the cassettes of the 70mm. As you well know, they haven't looked at a 35 yet, but we've still got time for that, follow-on. So this morning we do have a lot to do. We're going to start out with essentially letting Bill Muehlberger and his crew consisting of Paul Gacua, Eric Swanson and Zan Ritchie. They're part of Bill's team, and then we'll get Lee Silver and Tom Anderson cranked into the picture as soon as we can. And I'm going to let them talk. Let them carry on. They're the ones who have done the work, looked at the pictures, listen and take care.

Three general things that we want to cover here, and be sure that we hit the highlights, and that, of course, is what are the

science accomplishments, and how the data that you people obtained, how it will work into the science programs, the geology that they're doing in Baja and related areas, and some of the excellent stuff on New Zealand that you obtained. Of course, another important point is to be sure that we clearly understand man's role and the things that you observed, and the things that should be done; and better understand what can be done from that standpoint, to look ahead for ASTP and Shuttle. And I think those are the major things that we want to accomplish here today in this debriefing. You know this is not formal. We have no series of questions. We're letting the guys take over. So, I think Lee is first, if he's ready. And you're on.

Silver: Thank you. I guess I have to spill a few words first. In our thinking, we've kind, and in kind of preparing for the debriefing, we thought we'd like to try to emphasize that there are two general areas we want your inputs on. We see, as Dick's just pointed out, the importance of learning how to operate. And I think you're the only guys who have had the experience which can tell us how to do visual observations up there. And there are all kinds of questions

we have which are probably uninformed questions, which very quickly you can help put us into a better perspective about lighting, timing, sequencing, observations all the way through, many other operational aspects. And then there is a second category, and that is the specific scientific observations that you all have made, and the potential for getting science information out of both your visual observations and out of the photography. And we've all been jumping up and down looking at the photographs, because they're just beautiful. But a little reflection says that sometimes the photographs don't contain the full content of your impressions. And not only do they not contain the full content of your impressions, but they may, in fact, in certain areas that we would use them, be somewhat misleading. In areas, for example, of such things as color values, the photography, that is, these rolls coming through, are so variable that we just aren't quite confident about them. So we'd very much like to have you tell us about all the observational facts that need rectification or amplification all the way. So, I say, in terms of the science category, there are probably two areas that your contributions are going to develop. One is the explicit areas

where you've either spoken about things or actually taken photographs. Then, I think probably just as large on a longer term basis, maybe larger, especially if we have the chance to debrief you and talk about this together, is a bunch of implicit stuff which we can develop with time. So, make it - translate it implicit to explicit. And this morning, we thought we'd be relaxed and we've mounted some of these slides, chosen a few specific areas to talk to. We don't want to go into the formal operational thing -- operational aspects immediately, but we would like to, at the end, and be sure that we've had a chance to summarize what you guys think, or that you've had a chance to summarize what you think are the most important operational things to learn. And so if we get carried away with geology, sometime before you all leave, we've got to stop and summarize on the operational aspects that are in there. Okay?

Gibson: Very good.

Carr: Let me say just one thing to you. I think that's one fallacy that we fell to, and that was the tendency to depend upon the photography. We've gotten back; and we've looked them in this photography now;

and it doesn't capture everything that's there. And I think you guys understand that. I don't think we understood it as well as we should have before we left. Some of the stuff we've looked at just does not hold a candle to what you really see with the old mark 8 eyeball. And this is something we're going to have to do in future programs, and that is to either get better photography, or start training a little bit more toward being able to get good verbal descriptions of what you're looking at, because these pictures just don't have all of it at all.

Silver: Well, that's an experience that we all learned, too.

Gibson: It's got to be something like the Earth terrain camera to even come close.

Carr: Yeah.

Gibson: I know we're not going to be able to do that.

Carr: That thing seems to hit it closer than any other photography we've taken so far.

Silver: Well, we brought a few Earth terrain pictures for comparison. I've got them out right now, but any time you want to haul them out, we can haul them out and look at them and see what you got.

Silver: Well, I thought I'd start with a couple of splendiferous shots of Baja, California that I get turned on by. And this has built in it an operational question right off the bat.

Gibson: You can't see the Agua Blanca Fault all the way to the east coast.

Pogue: We looked and looked. We tried Yoga and everything else.

Silver: I heard you. I heard you.

Carr: And I still can't find out where the other end of that transformer is.

Silver: Well, let's build on that. You know, I spent about 3 days -- days on the ground a number of years ago when we had no photographs, zero photographs, trying to walk out, or locate where to walk out that east end. We didn't know then, this was in 1955, 1956, we didn't know then the things we know now about the Gulf of California and its role as a spreading phenomenon. And the fact that you can't see it going through is very important to us because it suggests to us a new kind of fault mechanism that we didn't even realize at that time; that's the transform fault concept. And I'll come back to it in the pictures a little bit when you get to the Gulf.

Pogue: Do you have an IR picture of that area?

Silver: No, we have gotten no IR photography so--

Gibson: You know, I thought the reason we couldn't see it is the whole land in there was relatively low and it looked as though you had sand which had been eroded (i.e. formed by weather erosion) and moved along and covered up anything that ever would have been there.

Silver: Well, there is an interesting point because there is about 1600 feet of relief in there. It looks low from your elevation, but there is a lot of rugged relief in there. And there is a valley floor that is alluviated and filled with gravel. That's the San Felipe Valley that you commented on. But we were looking for it in the ranges east of the valley on the projection of the line. And that's where you are looking and that's where these photographs are. And that gives -- that gives us some problems. Can we have the first one in here? This doesn't go clear across right now.

Let me get -- let me get you oriented here and here's an operational question right off the bat. As near as we can tell, identifying this photo, is that a point when you said, "Baja is as clear as a bell"?

Carr: No.

Silver. Okay, we can be wrong in our tie of photography to -- to the

transcript, but the Agua Blanca Fault zone comes into sharp focus. It's this feature coming right on up through here.

Carr: The sun angle doesn't make any difference on that dang fault either. You can see that son-of-a-gun on any kind of sun angle and it looks like a big "K".

Silver: Okay.

Carr: And you can see it from very oblique angles, too.

Silver: That is one of the cross structures that you refer to.

Carr: Right, and I was looking for the other end of that mother.

Silver: Okay. That mother on the ground, now we're going back in to look at it again, since we've looked at it and these photographs were taken, our whole thinking has changed, does not seem to be anything more than erosion following a big fracture zone. Whereas this is the major fault coming from here all the way on up through here.

Carr: Goes all the way to the water. Does it fork off the south there?

Silver: Yes, there is another fork off, right off...

Carr: Okay. You can't miss that, Lee.

Pogue: What's the other frame over there, the one where --

Silver: This one right here?

Pogue: Yeah.

Silver: This is one of the regional rivers. This is called the Rio San Vicente and it comes back in and it's eroded headward. And finally, it's just about ready to capture the drainage of this valley here and take it away from - from this stream which comes in through here and turns out this way, comes on out this direction.

Gibson: You're saying that feature's independent of the fault?

Silver: That feature's independent and is just headward erosion coming back to it, but it makes a nice "K", as you guys pointed out on the ground.

Gibson: Nearly parallel to the other ones, I guess, along the coastline, that's why you...

Silver: Now you guys know that there is a tremendous fault scarp in here. And we'll have some other pictures of the east face of the Sierra San Pedro here. And there is about 8500 feet of relief, straight up and down right in there. And this is Valle de San Felipe and this is where you took the fault right here, but couldn't catch it across here or out into these ranges right across here. Now there

is about 1500 or 1600 feet of relief in these ranges right out here - all bedrock, granites, volcanics, things like that, but it's interesting to go through it. I just have to agree with you. I've got no argument whatsoever. Okay?

Wilmarth: All right now, let me ask you a question. You said something that - as you fly into the Agua Blanca Fault, you said, your thinking has changed since you've seen the picture. Now what do you mean by that?

Silver: Well, our thinking has changed, not just since — I didn't quite say that, Dick. I said, "Since we did the groundwork in here, our thinking has changed because we weren't aware of the Gulf of California and the way that it was formed."

Wilmarth: Right.

Silver: And it was a case then of thinking we just lost it on the ground and weren't successful in following it. But now with the photographs and seeing the relationship to this valley right here, there is another question that is developing and that is the question of whether - when this fault was active -- and I need to ask some more operational questions. Jerry, I think it was you who thought you could see somewhere where this thing loses some of its definition

and I thought that it was in here. Some suggested of stream offset here.

[illegible] Yeah, it was right in there.

[illegible] Am I right ...

[illegible] It seemed to kind of fade out and lose some definition there and I was wondering if I could - I was hoping on a subsequent pass to really home in on that area and look for some streams that would be offset. But I never got a chance to do it.

[illegible] Okay. You did verbalize one impression and I was trying to figure -- to find the same spot. You can't remember where it was? The transcript does have you making it an interpretation right - right in through there.

[illegible] Yeah, I would have to - I would have to sit down and look at a print of the photo.

[illegible] Okay. What is the effect of viewing when you're viewing the photos since at this time? You on right off the bat we have a stereo view. And we don't have the ability, as Bill says, to fixate through all the holes and see the structures as you're in stereo.

Carr: I tell you, thin cirrus like that doesn't bother you too much when you are moving over.

Gibson: It all shows up pretty well.

Silver: IR photography would probably go - wipe out some of this thin cirrus cover right off the bat. And it would be interesting to see what the cirrus is doing. Okay, let's go on to the next slide.

Carr: Is that San Quintin down there with the volcanic?

Silver: Yes, yes, it is. I was going -- I was going to come in and take a look at that. Back for just a minute, I just wanted to get -- This is San Quintin. These are all these little cones and craters that are scattered around out in there. And let's pick up this end problem in the next slide if we can. This was a very, very nice pass coming through. And here comes the fault zone again right on down and it stops. Now --

Gibson: Lee, when you get right to the coastline though, what - is that not pretty much of a sand, very low?

Silver: This stuff right here - this is the delta of the Colorado, of course, right in here. The new grading part of the delta. But these ranges are all bedrock. And that's bedrock. That's granite

right to there and there on all of those spots. So there is sand in here, but there is a lot of opportunity. You see this mask coming out across through here?

Carr: Yeah.

Silver: If the fault zone were to come on through, it would be in this range, or in this range, this range that we would hope you'd picked up some linear features.

Gibson: What if it came and took a jog up there to the east and then down again so that it went around the bedrock? No - straight down. Now come on straight down. Now jog to the --

Silver: To there? --

Gibson: Yeah.

Silver: Well, that's a possibility. I mean this could be a very, very complex fault zone. Let me tell you, though, that we can see at the base of this scarp, a whole series of jogs and breaks, in which it is quite clear that it's been probably more than two miles of displacement. From bedrock here to below this surface, which is now 8500 feet below the high point right in here, you see. And this valley fill we know is at least on the order of a thousand or

several thousand feet thick. We don't really know how thick it is. And we think that the basement has been just down drop ed in that block. But the model of the -- of the Gulf right in here is that this is now a series; and let me just get them identified for you, a series of spreading centers, which are oriented in this direction like this in which the mantle underneath the crust of the Earth is moving in opposed directions. And there is a long fault which comes up through here and then it steps along and moves back up to here and then it heads back up here and goes all the way up into California, probably on the San Jacinto Fault zone on a line that goes right through here about like that. What we are thinking now is that a preliminary separation of this kind, one that didn't extend for a very long time, may well have happened right in this trough, right in through here. And this was a rifting zone which the crust literally collapsed and fell in. And then that rifting was displaced along the Agua Blanca Vault zone out into the Southern California offshore borderline. And the interesting thing is, that right in that place, Jerry, where you said that thing loses its erosional definition, in there,

there is nevertheless good evidence of recent offsettings. And the place that you picked for showing stream offset is about the best place going. The questions that were phrased -- were phrased to see how fine a resolution or definition of features that you could get. And I'd sure like to look at the clear shot of these things to see what it brings back in your thinking. Okay, again I'll ask you about.... You see even here in this photograph there is clearly a cirrus cover here, but we can see most of the geology through that. And I take it that your visual observation in real time just integrates right through that.

Carr: Yeah. We wouldn't call that clear as a bell. It has to be just cloudless.

Silver: Fair enough. Then we have probably blown it in our identification. Let's go on to the next slide. This is a picture going the other way. And this is a picture. This is an oblique. It's not quite in the same series, but it sure integrates one heck of a lot of coast since this is San Diego and then here is L.A. up in through here, and San Andreas just comes into -- just comes into the rim of that picture on up through here. And here is the Agua Blanca

again, coming right in through here. And the -- unfortunately, on this frame we don't get to see San Quintin very well. And I was just showing you this to give you this effect of -- of the cirrus to get your comments on it. Now I want to turn to a different aspect, from this picture to the next one. The next picture is the Apollo 7 picture that we used as a photographic base for your map book, your visual ops. Color values are absolutely absurd in here. And this is one of the places where we are going to make this point of -- about quality of color and realization.

I would like to go back to the previous picture, if we can, for just a minute. Now there is a major difference, we think, in the seasonal effects between these two pictures. This is now at the end of a wet fall and an early winter. And the previous one, we think, is probably in September at the peak of the long, hot, dry season. And there is some overlap in there, but I want to ask you about two kinds of questions. Were you conscious of vegetated cover changing in Baja California during 84 days of the mission, which would change the definition of the geological features that you were looking at?

Carr: Not in Baja, I'm afraid.

Silver: Okay. The feature called the San José pluton -- was it one that you could pick up every time -- that big egg-like colored mass?

Pogue: Yeah.

Silver: Okay.

Carr: That was a real grabber. The real grabber was the fault.

Silver: Well, a fault has the advantage of a very strong erosional definition, but features which give you more of a color contrast are lost in some of the photograph prints. And that was a question that we couldn't figure.

Pogue: Okay, I think I have an answer for that. I think it's the obliquity of the photograph which affects that more than the season.

Silver: Oh, that's interesting. Now tell me why. How do you rationalize that?

Pogue: Well, because when you look at that at an angle, you -- it seems to me -- now that pluton you were talking about and trying to recognize the geologic area of -- well say -- mafic or dark as opposed to light -- I found it extremely difficult to pick that up until I got very close to the area.

Carr: I think Bill's got a good point.

Silver: Well, then that brings up a line of questions we asked. Is there, then -- are there some optimum viewing angles?

Pogue: Yes sir. It depends on the time of day locally.

Silver: Okay. Would you give us some clues on that? Can you organize it?

Pogue: Well, if you want to see good contrast between lights and darks, it's got to be a high Sun angle and you have to be close to straight over it, or -- you know -- close, say plus or minus 25 degrees - 30 degrees, or something like that.

Silver: Okay, I don't really have a feel for what you can do out of your viewing ports. How much -- how close to the vertical can you go?

Pogue: Oh, it depends on your orbit, Lee.

Silver: Okay, so ...

Pogue: I mean, it depends on ...

Silver: On the way the aircraft is tilted?

Carr: Yeah, the beta stripe. It's the Sun angle.

Silver: Okay. One of the things we had hoped to get from you, and it may take a while for us to process the photographs and to appreciate Sun angle, phase angle, and the angle of the picture itself one

C-3

way or another, that is...the angle from the vertical in there. We would like to get some sense where the photography becomes most effective. And then we would like to ask parallel questions. Is visual observation parallel to the -- what we might call optimal photographic angle?

Pogue: It -- it parallels, but it is much better than the photograph.

Carr: It's much better.

Gibson: ....in almost all cases. Lee, one thing you can really do by eye is to look along a fault zone. You get an oblique and you look maybe out 45 or 60 degrees even.

Silver: Right.

Gibson: You can see that fault jump right out, whereas you take a picture of that and because it is oblique, it just won't show up hardly at all.

Silver: It's flat.

Carr: Yeah.

Gibson: But it really will show up by eye. If you get yourself right along it, it will just jump right out at you.

Carr: Yeah. I think there is sort of an area there between a low Sun

angle and a high Sun angle where things are really rotten. But at low Sun angles you can really -- the relief just --

Pogue: The relief --

Silver: ...pops out at you.

Carr: ...leaps at you. But then you get like, a what, 20 degree Sun angle or so -- You get above 20 and things start washing out and you don't get back in business again until you're back to say -- within 20 or so degrees within the vertical and then all of a sudden, bam, everything comes back at you.

Silver: Okay.

Pogue: You start getting real good contrast and your eye picks up the lights and darks very easily.

Carr: But that - well, that one picture of New Zealand that shows the Alpine Fault there, we didn't get that until we had low Sun angles. High Sun angles, you couldn't see that mother at all.

Silver: You want to go to that right now? Have you got those pictures mounted? Why don't we take a look at these right now?

Gibson: It shows up in that photograph almost much better than we have ever seen it by eye.

Carr: We whistled over New Zealand, must have been 10 times before we finally saw that fault. We were beginning to think you guys were lying to us.

Gibson: Then, all of a sudden one day it really jumped out.

Muehlberger: They didn't tell you they had a picture of it taken by another crew. That picture is nowhere near the quality of the one you got.

Carr: We spent a lot of film trying -- getting that one picture, I tell you.

Pogue: That's what you've got to do. You got to be able to waste film.

Gibson: You got the one adjacent to that also, which takes it off to the south.

Muehlberger: Yeah, we had the other one.

Carr: But, see that one Sun angle is what gives that one away for you. You're overhead looking down at a low Sun angle.

Muehlberger: That was clearly the picture of the groove on the Alpine Fault. And I gather -- were you watching all the way up as you came?

Carr: Yeah.

Muehlberger: So that you knew it was coming up and had really spotted it and took the picture.

Carr: Yeah, we knew the damn thing was there. We just couldn't see it. You might change that Sun angle by 10-20 degrees and it will just wash right out on you.

Muehlberger: The late afternoon view apparently made these escarpments show up really nice for you.

Pogue: Yeah, now there's another case. If you had tried to take that photograph obliquely, you may lose that because of atmospheric scatter.

Carr: But you can look straight down at a high Sun angle and you can see the offsets of the streams and you know that mother is down there, but you can't see it.

Muehlberger: This picture also really updates the one that is in your book that you carried up with you. And without any trouble at all, I think you can look along this thing and see the actual jogs in the continuity of the escarpment here. And this thing is supposed to be a great big huge strike-slip fault with this side going that way hundreds of miles. And it's got offsets in it and that immediately suggests that that thing is going to be having a hard time doing that. Therefore, it's a strike-slip fault that

had to be earlier than the present history we are looking at, which is a point I hadn't really appreciated before the mission, until I saw that picture. And then with all of the literature that Eric Swanson had been researching out, it became clear that these things going out this way are the modern ones of strike-slip displacement on the country. And, in particular, when you work your way north along the fault, the thing makes a big hook here.

Carr: Yeah.

Muehlberger: And that again is hard to do if you have a strike-slip fault.

Carr: I was also impressed that some of the rivers and lakes are up there in the mountains and the fact that you've got a river that runs just straight as a die right up the mountain. Then all of a sudden gets a jiggle in it and there is a big long lake up above it, but there doesn't seem to be anything connecting the two.

Muehlberger: That would be in the next chunk of country to the south.

Pogue: Oh, there sure is a variation of color of the lakes, too.

Carr: Yeah.

Pogue: Really weird.

Muehlberger: Your lakes are the river systems draining right out of the glacier country and therefore they are carrying an enormous amount of rock which gives the light-colored streambeds -- the dry streambeds in this case. Here's one of the reservoirs which -- that's clear because it has had time to drop out all the silt.

Carr: One of the lakes up there has got all different shades of green in it, too, but they're algae contents, I guess.

Gibson: Eric, have you seen those in the pictures?...

Carr: The water guys must be very interested in them.

Pogue: You know, they seemed like they were so close together. And then there would be -- one of them would be almost turquoise, or --

Carr: Yeah.

Muehlberger: How about putting the next frame up there? Takes us to the south here; return to this thing a bit.

Carr: Yeah, Bill's point is an interesting point, too. The fact that you get a dark blue lake and right next to it would be a turquoise green one, you know, not separated by more than 5 or 10 miles.

Muehlberger: Well, that's something I don't have the --

Carr: I'm sure the water guys might be interest.,

Pogue: There they are.

Gibson: There they are.

Pogue: There they are. There are three colors.

Muehlberger: Here's a bunch of the lakes.

Carr: Yeah.

Muehlberger: I don't think it's sunglint.

Pogue: No.

Muehlberger: Because the Sun is behind us. You can tell by the shadows. So it's strictly whatever the quality of silt, coming in or the algae that are growing in the darn things.

Carr: Or the depth. We saw a lot of that down in Argentina, too.

Muehlberger: Or the depth.

Pogue: Yes.

Carr: Lakes all different colors right next to each other.

Pogue: It seemed like such a gross change in such a small geographic area. You've got all kinds of variety here too in New Zealand. It's also the same thing down in southern Chile and Argentina. An awful -- this is a tremendous variety of structure within a very small region.

Muehlberger: Remember that is about the size of California, both of those islands combined. And if you stuck California, starting at about Oregon and worked your way northward, you'd be in the same climate belt. These people have the advantage of having practically nothing but open ocean facing them on both sides for evermore. And they can get battered by the weather pattern a great deal more. Here is your compass -- well, on this view, because of the cloud cover, I guess, the outline zone is almost invisible.

Carr: Yeah.

Muehlberger: I thought that your statements on the orientation from the rivers relative to the zone was a real neat one because it had basic fundamental relationships to the big zone. So that thing is going that way, these faults all fit in the ideal pattern of shearing that goes on associated with it, at that small angle. I think you said 20 degrees.

Carr: It sure seems as obvious as hell, when you are looking at it, too, which way things are going and everything just kind of streaked along the same direction there.

Muehlberger: This thing is a much more complicated fault than we indicated in the book. It had an enormous strike-slip history, in other words, the south end comes up to the fault and then is offset to the north end of the island. That seems to be pretty well documented. About 350 miles of horizontal motion is all there, but now in the later history, essentially the current one, this thing is turning into having the mountainside just simply being rammed up and over the fault, it's changing into -- this side going up and that side down. There still is a little bit of horizontal shift involved in that thing. There is literally miles of uplift of the mountain block relative to the ...

Carr: They still have all the seismic activity down there?

Muehlberger: Yes, they do.

Carr: A lot of earthquakes and all of that?

Muehlberger: And it's concentrated mainly in this band and in the northern band. This band where it heads south out of the islands and off into a deep ocean trench to the south. And if we could go back to the other pictures.

Muehlberger: Okay, please.

Pogue: Lee called our attention to that thing and then you got something else that looks like it there.

Muehlberger: There are a lot of those darn little promontories that stick up here around the top of the picture. Upper Christchurch sets just out of sight there under the clouds. The main big activity is now concentrated along particularly that one. As you can see, comes almost in, but it doesn't quite make it. Comes in here and there is an offset. And you may have noticed that there, or did you have time to notice, that the mountain ranges are big diamonds, outlined by the valleys?

Carr: I didn't notice that.

Muehlberger: Those are fault blocks' boundaries in there and the whole country is trying to be twisted and torqued and these diamond-shaped pieces are the individual blocks that are doing it. We are talking a big size here, too.

Gibson: Can I ask what are the time scales that you're talking about here? You did mention that there were two specific time scales for the changes which have taken place. The original slip and then the ...

Query: The main slip -- the main strike-slip motion is Jurassic to mid-Cretaceous. There is ...

Muehlberger: Okay.

Query: About 400.

Muehlberger: 150 to 100 million years ago was the main horizontal motion.

Query: There are mid-Cretaceous dikes about 150 million years ago that are offset by about 120 kilometers. There has been that much motion since 120, 150 million years ago. The new set of motions that is producing these Marlborough group of faults, the faults spraying off to the top of the photo, has been since mid-Miocene, so within the last 20 million years...

Muehlberger: ...the Hope Fault and the other ones that are named in through here. The stream offset there is the terraces; that's one of the classic areas you use teaching, because of the detail. They have so many different stream terraces. The oldest one has been offset the most and the youngest one just barely, but on a small scale, 10 feet to a separation, you can add them up and play geometric games...come up hundreds. That's this system through here.

Gibson: Well, the ones that went right along the fault, you can certainly see that those rivers have changed their course by the slip motion.

Carr: Yeah, yeah. Now that's recent, you say?

Muehlberger: ...offsets in here -- and there still is a horizontal component to this thing in spite of the fact that it right now is dominating the uplift stage.

Gibson: So what you can see by eye as far as continuity of streams and so forth is really like 20 million years ago and not 150.

Muehlberger: Yeah, because this same zone, even though the horizontal motion is dominantly horizontal in the earlier history, it is still doing it today in a little smaller -- small amounts. Call it one to one, if you want. One to one up, and one to one horizontal, so that streams still get kinked the same style. We should have realized the fact that there are huge mountains here and plains here, and that's different from the San Andreas where it is quite common to have huge mountains on both sides. There is some purely horizontal motion going on. That difference in elevation should have given them the clue.

Carr: Are you going to talk about the Red Sea area too? I think we saw some action over across the Red Sea from the Afar Triangle.

Muehlberger: Matter of fact, there are some very neat regional analogies you make between some of the twisting that is going on here and the north end of the Dead Sea structure into the Sea of Galilee.

Carr: What do you know about Argentina and Chile and down there in the southern end of it? Is there any of that kind of action going on? I didn't see anything; it just kind of jumped out at us. But it's...

Muehlberger: Of strike-slip motion, you're talking about? All -- all that's visible there is a huge valley that gets drowned by the fjord land, big, deep things. And that looks like it's basically a down-faulted block, a graben, rather than one that's been generated by horizontal motions. I suspect before we get too carried away in some of these, we might come back to New Zealand, but I'm sure we've also got things that Lee needs to return to unless you want to talk more specifically to that one.

Carr: I've got the feeling that we've got so damn much to talk about that we are going to drive ourselves crazy just picking around the edges, not getting into anything.

Pogue: Right.

Muehlberger: We've picked out a few spots to talk to mostly, because those were the photos we had available. And we'd like to get back to you and some of these other areas later, if there is an opportunity.

Carr: I think we ought to make the opportunity.

Silver: Parenthetically, that fault zone was active just about the time this began to appear as a chunk of crust. That is, that none of these rocks were probably in existence at the time this fault zone was first active. And that Agua Blanca Fault zone, just to give you a time scale, has been active probably in the last million years. Now that's one of the next set of questions I was going to ask. Were you at all aware we focused your attention very strongly on this fracture system; this is a very obvious one. Erosion brings it out very nicely. Were you aware of any other fractures besides the "K" features themselves?

Carr: No.

Gibson: You could see the other streambeds, but you couldn't really attribute those to fault zones.

Carr: I was just starting to focus my attention on that linear zone that

you had pointed out in the book, but I didn't get to it. But it was clearly discernible and nowhere near the "K" there, but you could see that linear feature and I just never got a chance to start looking at it. I think we covered it photographically, but we just didn't get to looking at it.

Silver: Well, the reason...

Carr: But, see -- that's perpendicular to this, isn't it?

Silver: That thing is coming off in this direction, down through here.

Carr: I didn't see any other source of fault or linear areas that kind of parallel the Agua Blanca at all.

Silver: ...that was a strike.

Carr: No.

Silver: No, it turns out that you may barely be able to see it here. You see a linear feature that tends to go up like this right in through here? The reason the Agua Blanca Fault is a big one and should have been seen, except that there were no photographs, no maps of Baja California until very recently. And we first went down to look for structures there because there was a big earthquake in 1954 down here, and the ground actually broke. We came down and

we recognized that this structure here and the ground may have broken on here. And we spent a lot of time walking up and down it -- couldn't find any recent ground breakage, but right up in there -- right up in here, a little village was just transected and offset 20 inches. There were about 8 or 10 adobe houses and shacks and things and they collapsed. And the word never got to Ensenada even that something had gone wrong in town. And there is a new break forming. It isn't a very strong or obvious feature. That was another thing we didn't tell you about; just wanted to see whether it was something that might appear to you as you came on. Okay, I have three more pictures now that I kind of like to look at and these are obliques. And this has to do with the operational aspects of oblique viewing. This is a case of features to be seen obliquely and when you become aware of some of their characteristics. And the first thing I would like to look at is -- looking at the Agua Blanca from this angle, you understand -- and knowing where to look, I can see that there probably is a feature coming right in, like that. Okay? But I don't think that most people who don't know that would spot it here. Could you spot it?

Gibson: Yeah, if we knew where it was and we'd seen it before, you could spot it. But the best way to see it if you're 90 degree from where we are -- you're looking over that way, looking along it. Then you can see it, even with that Sun angle.

Silver: All right. Now, this is as much relief as we have in Baja and probably in the western U.S. or southwestern North America. How much does that relief pop out at you? At high Sun like this?

Pogue: I think that you can see relief.

Carr: Oh yeah, yeah. It pops out very nicely.

Pogue: Better than the picture there.

Silver: Much better than the picture?

Gibson: Oh yeah. Even the high Sun angles.

Carr: Yeah, especially one of the areas where relief would really leap out at you was up around Denver and also down around Mexico City. The way those mountains just kind of swoop right up to the west of Mexico City, you don't have to have much obliquity at all to see the way those mountains just sweep up there. And, of course, the smog and everything from Mexico City starts working up the mountain when you've got your wind from the east.

Gibson: There are fairly sharp edges of those types of mountains that run all the way along the -- all the way up to the whole west coast. The Rockies essentially all are very obvious, even at high Sun angles -- you go over to the Appalachians and they are much harder to see.

Silver: In the photographic usage, without going into stereo, we just get very little sense of relief on these things.

Pogue: Yeah, but you've got a lot of other things working for you, too. Texture -- your eyes picking up textural differences -- don't show up there.

Carr: Yeah.

Pogue: Light and dark that don't show up here as much and a lot of other things. The pictures just look terrible, after, you know -- you remember what it looks like -- you look at a picture like this, it looks terrible.

Silver: Well, it's not really that bad. That's the same picture, I'll tell you. For those of us that's been -- that's pretty good.

Muehlberger: We haven't had the opportunity of you guys. These are fantastic.

Silver: Okay, I would like to pick up on some more fault structures right here, and this is the ...

Carr: This is the San Andreas.

Silver: This is the San Andreas.

Pogue: It comes right down in there.

Silver: It comes right down in through here and then out here is another one. This is the San Jacinto system, right in through here. You remember...

Carr: That's not quite as clear as San Andreas.

Silver: Yeah. Okay, let's go on to the next frame and on that thing...

Pogue: Maybe we can see the Grand Canyon out...

Silver: Okay, but if we moved a little further north in this particular case, and I'm wondering whether as we changed our obliquity in the sense...

Gibson: That's a good picture of Agua Blanca.

Silver: See, and the Agua Blanca starts to come in a heck of a lot more.

Carr: Yeah.

Silver: And I haven't yet had a chance to figure out what the angles are, where we were, and what the heck we're seeing here. So I'll try

to get some sense -- the question I'm really asking is a question like: if you're one track over, can you still see the ... features? See, if you're two tracks over, can you still see the features? If you're planning to take photographs and make observations of the target, how many tracks away can you be and do some good?

Pogue: One -- one track...

Carr: Depends on how far you are from the Equator.

Pogue: Okay. On this -- in this latitude right here -- if you had one good track, neither the one before or after is going to be any good. If you could -- you could possibly be straddling that and have two poor shots at it.

Silver: So you really have to be in pretty close?

Carr: Yeah.

Pogue: Right. Now that's 50 degree inclination.

Carr: But you start getting up around Canada and down around the southern area, you know, Argentina and New Zealand and Australia, where your tracks are starting to converge again, man -- you can get three tracks, one track after another, where you can just really pin something down.

Pogue: That's how we got to see it on New Zealand.

Gibson: But, Lee, I would say one thing is not quite the same there. If you're looking along the fault zone, even if you're one track away, you can see it.

Silver: Those features which are oriented properly for you, or you're oriented properly for.

Carr: Yeah.

Gibson: Right.

Pogue: What's the inclination of ASTP?

Gibson: It's about the same.

Carr: 51.

Pogue: Okay

Wilmarth: 51, at least.

Silver: Because that makes a difference.

El-Baz: But are you still saying in general at high Sun angle the obliquity does help relief the section, right?

Carr: Yes.

Pogue: Yes, very much. But I found, Farouk, if you try to take a picture from a long distance at low Sun, the pictures are not any good.

You can see the relief very well with your eyes. So at low Sun angle, you've still got a way to get over that area you want to take a picture of.

El-Baz: Right.

Silver: Okay. Now in just looking at the pictures, the feature I was trying to see was the extent to which you would pick up from this angle to this fault zone, which is an extremely prominent one, if you're looking down, right here. This - come out of the San Andreas right through here and come swinging on down through here -- the San Jacinto. And I don't know whether you were aware of this particular pass or this kind of perspective or positioning. Have you got any comments on it. Could you see that feature?

Carr: Oh yeah. We could see the San Andreas, the San Jacinto, the Garlock...

Silver: Elsinore? Could you pick up this one that was coming in through here?

Carr: Yeah, the Elsinore was no problem.

Pogue: The Garlock is very...

Carr: And the Garlock is easy to see.

Silver: Oh yeah. That's this feature coming right up through here. Okay, let's go on to the next, which is not the same sequence, but has an entirely different lighting aspect on this thing. And the San Jacinto -- the lower part of the San Jacinto is this distance that we're coming through right through here. And it actually breaks in several places and comes on down across the area. I was talking about the spreading in the Gulf. Probably this is the active fault right now in the Gulf region, coming right down through here, stepping down. Once again, here's the Agua Blanca with an entirely different lighting, coming right in through here.

Carr: Did you notice that son-of-a-gun just jumps out at you in almost every picture you've got? All different Sun angles, all different obliquities.

Pogue: Show me that new fault there, Lee, that one you talked about, you know, that goes there.

Carr: The one that looks like...

Silver: It's not a terribly obvious thing, Jerry. It's just slightly oblique and it's right in there. It's no crime for you not to see it because it's not that obvious a feature. What I didn't

have a sense of was just how close you'd be able to -- how much resolution you'd be able to have on the ground. And that's what the...

Carr: Well, the old bridge term about a peek is as good as two finesses is good here. If you know what you're looking for, you can see a whole lot more than if you're just looking at something flat cold.

Silver: So, if you -- if you had been briefed and organized...

Carr: That's the whole key to this Earth observations program -- is being briefed and knowing what to look for.

Pogue: And being briefed again and again, because there's a lot of this stuff we could have done a lot better job on if we would of had a whole year to train on it.

Silver: Get your geography in hand and...

Pogue: Well, I think it's worth it.

Silver: Well, that's a major question we have. We were aware of your learning processes as you were flying. But you guys got to the point where you were no longer trying to figure out where you were. You knew where you were and you were looking for the geology, you see.

Carr: Yeah, we could sit in the wardroom and just look out the window and spot and say, I know - you know - we know where we are. We didn't have to resort to the map.

Gibson: But I think you also have to have some time before you come up against this. Whether it's early in the mission, it might take 15 minutes or so to really study the area, know where the fault zones are on a map and then when you come up against it, you're prepared -- or it may take 5 minutes if you're further downstream in the mission. But, in any case, you really need the time to prepare to get yourself mentally tuned to what you're going to be seeing, so you got some time to actually be trying to explore the new facets of it rather than just finding your way around.

Silver: Can I ask you a little bit about -- on this picture, once again, there's a -- there's several cloud decks in here and the cirrus covering here, would you have been conscious of this thing?

Gibson: If you know it, the cirrus wouldn't bother you anywhere near as much. For example, there, it would be a good photo to try and see the Agua Blanca Fault goes over to the coast and with that cirrus you can't do it on the photo, but I suspect in real life you'd

be able to make a good judgment.

Carr: Lee, I think the clouds have a definite advantage to you, too. They give you a little extra dimension of depth there to kind of compare things with.

Query: I was looking at your picket fence bit in there.

Carr: Yeah.

Query: Yeah.

Carr: Yeah. It's not a bad thing at all to have a cloud or two in the area. But it seems -- I don't know who took this picture -- I suspect it was Ed, because he was the only guy that ever got to look out the window when we were in this neck of the woods because Bill and I were busy EREPing all the time. But this is the kind of pass where I'd be looking like mad for where that Agua Blanca Fault dips into the Gulf of California because the lighting -- it just brings out the relief like mad. And you know if you're going to see it, this is the kind of day where you're likely to see it.

Silver: But once again here, from the point of view of the geological interpretation, the failure of being able to pull this thing farther than this suggests to us that for a very short period of

time this is what we would probably call the spreading center, and a rift was here and the crust started to move. I'm not going to tell you yet which way the crust moved because I hope to wrestle you guys at least once more. Some of the best pictures here are still on these reels. We haven't had a chance to cut up or anything.

Carr: Yeah. Well, you've got some 300 mm Nikon stuff.

Silver: And we want to see that stuff, too.

Pogue: Well, I'll tell you another thing that I looked for in particular. If you'll notice there's a suspicious little spur on the other side of the Gulf of lower California over there. It's a very subtle feature.

Silver: Where? Out here?

Pogue: No, up a little bit to the right. See that?

Silver: That's it, right there.

Pogue: Well, I kept trying to see if there was anything on the other side that ties in to Agua Blanca. And there's nothing over there, as far as I can tell, that ties into it.

Silver: Well, we haven't been able to recognize anything over there. That's for sure.

Pogue: Because I -- just like Jerry and Ed -- I thought that a lot of this was being masked by the alluvium in there.

Silver: Okay. Can I ask you about some color qualities in this picture right now? When we're out on some of the desert -- desert photographs, we were thinking perhaps this reddish brown or purplish brown, these darker hues in here might be desert varnish, you know, on the rocks. But that's not what the case is in here, and I'm speaking just of color values right here -- most of this should be vegetation, right here -- the darkening right in here. Were you aware of vegetation on this high country as opposed to the bare stuff out here on the ground?

Pogue: No sir.

Carr: Not as vegetation, no.

Gibson: Vegetation is really --

Silver: When you're thinking geology, what does vegetation mean to you? In this kind of country here?

Pogue: Always shadey, but you don't know if it's vegetation or not.

Silver: Okay, you can't resolve vegetation,

Pogue/Carr: No.

Carr: Because it looks just like different rock colors. It's right along with it. It's the same way in Africa, too.

Gibson: There's so little vegetation there you can't see it. You've got to go over a jungle and then you know you're over vegetation.

Pogue: And the only time we were really conscious of the green stuff or growth was either an agricultural pattern -- and then only due to geometry like in the El Centro area there, or in some of the tropical islands where you've really got green, or...

Gibson: It's surprising you can be down on the ground and looking around and you can see an awful lot of vegetation, but when you get up above and just the ground itself seems to come through and very little vegetation. It's a subtle change.

Silver: It's wiped out on this photograph. For example, here's the San José pluton. That little spot right in there. And it's just barely visible on that thing.

Pogue: Pinacate is up there -- doesn't look -- isn't that thing Pinacate?

Silver: Yeah, that's Pinacate.

Pogue: See now, that does not just hit you -- that's a lot darker than that.

Silver: Contrast there is much greater is what you're telling me? Your visual contrasts in perception are just...

Pogue: Another thing, too, that's more oblique than the lower part of the picture.

Silver: Right.

Gibson: But I don't think you can say whether it's vegetation or not, because even though you...

Pogue: I agree.

Gibson: ...can see the contrast. The color jumps out at you, you can't say whether it's vegetation or what it is.

Pogue: Yes sir.

Silver: Okay.

Carr: But, you know, I think your color tones here are -- are fairly true, from that --

Pogue: Lower half.

Carr: -- particular lighting situation.

Pogue: Okay, that's particularly the lower half.

Silver: In other words, you would have gotten this impression of a brownish, reddish-brownish color.

Carr: Yeah, it's a little darker. I mean it is darker than what it really looks like. I think that's just the photography does that to you.

Brand: When you're looking down at clouds and snow, can you always distinguish the boundary between the clouds and the snow?

Carr: Yes, very easily. I tell you, the thing that really yanks me to was ice compared to clouds. Those ice islands and things we saw down near the Antarctic. Man! Ice looks pure and white and clear and the clouds look dirty. It's amazing!

Pogue: And the ice wasn't...

Carr: You can see the ice coming up, shining through the clouds. On those sort of low stratas kind of days you can see the ice through the clouds. It's amazing.

Pogue: Perfectly transparent --

Carr: Yeah, we're dragging another red herring through here. You're going to have to keep control of me, you know, or you'll lose.

Silver: Actually, what I thought I would do at this point is -- I wanted to flip the lights on here just a minute and come back and ask ourselves if we are hitting the points that we want to hit and maybe change the phase for just a little bit. One of the things again that we apologize for; as you know we just got to see these last few rolls last night. We'd like to do some stereoviewing with you on some of these things. And -- or Bill's got a whole block of topics he wants to get and I'd just as soon do a check-point in there.

Muehlberger: I think we're running fine right now. Give them a stereo set to take a run at. And we could set up something on the other one if you --

Silver: Yeah, why don't we take a minute, set up the stereo and let's set up a stereo of this -- this southern California / Baja California country and see whether there's anything else that comes out in that same mode for just a moment. Maybe we'll get some coffee, or do something like that.

Carr: I'll tell you, Lee, there was one pass when we came down over southern California on a descending pass and actually we came in

over San Francisco and came down and Bill was down in the ward-room with the Hasselblad clicking like mad and I was up in the 190 window with the Nikon and the 300 just clicking away like mad. And I tell you, we --

Pogue: That was a good pass...

Carr: -- went down the San Joaquin Valley and the whole thing was right there. All of the faults -- you could see the faults all radiating off and you could see the snow cover coming down the Sierra Nevada here.

Pogue: And this was like day 75 or 80 --

Carr: God, that was fun, I tell you. Seeing all that stuff and you didn't know where to say, "Gee Whiz" or take a picture, you know, you were just going like mad. Getting excited, the old adrenalin was just pumping like mad and you're just going as fast as you can.

Gibson: Yeah, I think there was another one with the Earth terrain camera. We had a pass, an EREP pass, and we had a gimbal on a stop and we went 20 degrees off attitude.

Pogue: Yeah! But it was beautiful because we were pointed right at the fault, right at the coastline, all the way down California then

and at a slightly oblique angle. And thought, gee, you're really seeing beautiful --

Query: Have you seen...?

Silver: Your height...

(Laughter)

Wilmarth: We're talking about visual observations and handholds. I want to keep you on track. You know better.

Gibson: But we didn't turn off the Earth terrain camera because we were off attitude. I figured we were doing better than looking down at what was right below us.

Query: That's good thinking.

(Laughter)

Silver: Well, why don't we take a break for a minute and get coffee ... find these frames.

* * * * * * * * * * *

Carr: Well, we better get that on record on the tape. Yeah, that's a good question.

Wilmarth: I want as much of this record as we can get. Okay, who's up? Lee, are you up?

Silver: Well, what we've done -- perhaps I should have organized this a little better than I did. I've had Bill and Jerry looking at the same region of Baja with the Agua Blanca Fault zone in the stereo right here and there is a question I'd like to ask and it's again one of those things that the photographs don't give me any confidence - that I can appreciate. What's your ability to resolve? -- I mean, how does the definition of resolution on these photographs compare with your own sense of fine detail?

Carr: I think looking at these films right here is about the same except that we see more with the eye and -- but looking at that picture right there, that stereo pair of the Agua Blanca Fault, I felt like I was really seeing most everything that I could see. That photography, looking at that kind of film is a whole lot better than the flat prints that we looked at.

Pogue: That's right. I would add one thing to that. I agree with that; however, by scanning with your eye and looking back and forth, you can pick up more. I don't know what the term is, but you can actually get effectively a better resolution by scanning with your eye. And you start picking up more. I don't know if it's the

mental process from processing the maze and doing some comparisons or what, subjectively --

Silver: Okay, but now there's another thing. Here you're doing 4 miles a second and you're coming over these targets. What's your effective seeing time for something you want to get a good look at down here? What are we talking about?

Pogue: 30 seconds.

Carr: Yeah. 30 to maybe 40 seconds.

Gibson: 30 to 40.

Silver: So, that if in fact you want to look, you can hardly do much photography?

Carr: That's right.

Pogue: That's right.

Carr: That was our initial guess before we left here, and we were right. You've got to make up your mind before you go in, what you're going to do.

Gibson: If you have a camera which you could have mounted and all you have to do is click it off at the right time.

Silver: You mean if you just went trigger, trigger -- like that?

Gibson: Yeah. Then you might be able to do something like that.

Silver: Or - or - or, you could team it.

Gibson: Yeah.

Silver: Did you do some teaming in this thing?

Carr: Yeah.

Gibson: Yeah, but very rarely did you get two guys --

Pogue: ... room at the one window.

Carr: That was a hard thing to do, was to team in the wardroom window, because you were banging heads to do something like that. But our old bit, we made the pitch, and we've made it to several people during debriefings and that's this idea of having an Earth observatory, where you've got all the right kind of equipment. Let's face it, the equipment we used to take your pictures with was horse and buggy stuff. They - it just doesn't have the dynamic range that is available right off your camera store shelf. We just didn't have it.

Silver: Jerry, have you ever sat down and sketched out a reviewing station?

Carr: Yeah, we haven't sketched one out, but we have vocalized --

verbalized one to the folks. The idea is like a bombardier's bubble in a B-29 or something. You've got a guy sitting out in a dome or an area where he can move and point. And he's got a camera array at his disposal where he can take, say, a 55 mm -- an overview -- shot, and then he can take a zoom lens and get in and get a zoom shot and then he can take the first of the pair -- stereo pair.

Pogue: Without taking his eye off the central viewing apparatus.

Carr: Then he can go for IR or any other wavelength. And then he can pick up his other picture of the stereo pair. And he can do all this in 30 seconds, if he's got the right kind of equipment. And you come off and all of a sudden you've got a target that you've colored -- covered in 2 or 3 wavelengths. And you've got stereo-pairs and you've got an overview, to key the whole thing. You've just -- you've got them all with the right equipment.

Gibson: What really became obvious to these guys who do EREP with very little human judgment required. You just sit there and throw the buttons at the times that they specify on the ground. And then we go up with this horse and buggy equipment in visual

observations and put - try to put as much judgment as you could into it. Some way you need to combine the two.

Carr: Yeah, take the instruments with the height data capability and combine it with the capability of exerting some judgment. And we all liked running the ATM because they allow you to do that. They had good instruments and allow you to exert some judgment. There's no reason we can't look back at the ground the same way we look at the Sun and do the identical thing.

Carr: But you can have your eye up to the eyepiece, or whatever this viewer thing is you've got, and you can be looking in the target and tracking it along and just by selecting the proper equipment with some sort of a little thing in the field of view that tells you what you've got, you've just brought to bear to take the pictures and select your next one. You can have still cameras with turrets on them and kinds like that.

Gibson: And we might be able to run a facility like that in the same way we run an observatory where you specify from the ground those targets which you know you want to cover in a precise way. And then you give observing time, or free time, if you will, also,

and the observers also onboard are free to change the observing program.

Silver: All right. As long as we're in this mode right now which isn't -- this is operational now rather than anything else, let me ask what the mode should be for permitting you to transfer all of your observations and judgments, since you can't literally verbalize every last observation, and you're going to have to integrate them in a form of summary judgments about what you've seen in one way or another? What was the best format for getting these judgments finally transferred and recorded one way or another?

Gibson: What do you mean, "verbal"? Verbal description?

Silver: Your verbal descriptions -- your verbal descriptions. I don't want to use the word just "description", because I'm sure you could sit there and describe. But you've made judgments; you've been apprised of the target, what the objectives are, what tasks you want to accomplish and you've gone ahead and you've made your visual observations and you're forming a set of impressions. And they are judgments about what's important and what's not important. Your eye dismisses. And the question then comes:

How do we, in fact, get that set of judgments transferred?

Carr: Tape recorders really --

Gibson: Tape recorder and what you want to ... have it so you don't have to try to remember everything and then do the tape recording afterwards. You'd like to be able to speak right into the tape recorder and have a time, too, at the time you're doing it. ... Not have an awful lot of things which you have to give in order to specify where you are, what frame you're taking, what settings you're using and all of that.

Silver: You mean, all you have to do is have good time tied to the target?

Gibson: That's right. All you do is mash the button that stays on, and you're talking on the loop, and it's all recorded. That way you can spend your full time giving your data rather than chasing down all the other details.

Carr: Or you say, "Okay, we're coming up on the southern California now, and right now I'm looking at San Diego and we're heading down -- we're on a descending pass, and we're headed for San Quintin. My intention is to start at San Quintin and then sweep down the Agua Blanca Fault to San Felipe." And, you know, you can just kind of

talk as you're going and tell what you see, and you can say "mark such and such an exposure." And --

Silver: Now that's the first generation judgment, but you in repeated orbit have reapproached that same target half a dozen times. You've had more or less opportunity each time to do something, and you're building an integrated set of judgments which are based, not only on today's lighting and today's opportunity, but what you've seen on previous passes. How do we record that? How do we get you debriefed adequately on that?

Pogue: I think through just simple viewing stations. The way I envision this is all the data and image recording and voice recording should be correlated with a video taken off a beam splinter. We could have video recording capability. So you're looking at it, Now, the way I envision it is that the operator does not have to take his eye off the selected area of observation. And in this area of -- in this viewfinder should be displayed the information about the cameras that are being used and the frame numbers and everything should be projected or at least recorded on this video scan.

At the same time, the man that's talking -- of course, the voice goes on this same thing -- on this same track. You should have the capability to specify an area by having, say, a pointer or something. You don't have to have a pointer -- you can have an electric pointer. But, say the area that I'm looking at now, you can add, by turning a knob or something, you could actually circle it with a --

Carr: Coordinate it one way --

Pogue: Coordinate it or something with a cross or something. And all you're doing is, you say what we're looking at now is such and such, and such and such, and so forth. And then -- you can dump that tape the next time that you have the opportunity. You have a total recording of the operation. Not only that, you pick up a lot of the subtleties that the man may fail to mention. For instance, if he real quick switches the view from one thing to another, you'll probably change it with the index or the pipper or whatever he's using so that you have a total recording of what was actually the subject of observation, and also probably you can follow the man's train of thought pretty well, too.

Carr: Up - and downlink video is what we need.

Silver: I can see that.

Carr: We've asked for that.

Silver: Yet, I'm also concerned about the ATM-ASTP program, where we're not going to have the idea by a long shot. And what I'm really concerned about is that there be -- would get from you some idea of what constitutes the best way for you to be debriefed.

Gibson: One thing which would be useful which they might be able to have onboard which we used in conjunction with the ATM was the Polaroid camera. And if there was anything of real significance which you... It might help more in weather. So you're looking at the changes of weather over the Great Lakes, for example. You may go successive passes, then it would be here, but still, if you see something really of note, you can have this thing mounted and readily accessible. You can take a picture; and even though you might not be able to see it on the picture, you can note where it should be, and that will trigger your mind.

Carr: Lee, if you're talking ASTP, if you want to try to focus on that, I don't see that there's a whole lot more we can do for ASTP. I

think the procedures that we started working are damn good. What we got to give the guys in ASTP, I think, is better photographic equipment to give them the opportunity to take these pictures more quickly, more easily.

Muehlberger: What would that be?

Carr: Well, the Hasselblad that you can look through for —

Muehlberger: A reflex?

Carr: A reflex.

Pogue: Another thing, too, is that they need Jerry's little tape recorder strapped on your armpit, or something, because, man, I tell you, it is hard to debrief a picture 15 minutes after you took it.

Carr: Yeah, especially when you've taken 10 or 15 pictures. You've had an orgy; you've just seen so many targets your mind is flooded and then you've got to say, "Oh Christ. It's going to take me half an hour to tell these guys what I've seen." Whereas, if you've got a tape recorder hooked onto you and your headset's on, and you're babbling on while you're taking your pictures, you're going to get a whole lot more out of it.

Muehlberger: Would you recommend that, or would you recommend just talking into the CM--

Pogue: DSE. It may not be available.

Carr: See, the DSE may not be available; that's the problem.

Pogue: You get through talking and you look down and that doggone talkback's been barberpole the whole time. And you won't notice it a lot of times until you get through. When you look down, it's barberpole. "Was it barberpole when I started talking? Oh, shoot! I've been babbling away for 15 minutes." And not only that but you've limited light, limited duration of DSE in command module. You've got to have this thing that Jerry's been talking about. And there's another thing, too, there. If you have that, you're much more likely to look at your camera and say, "I'm starting with frame number 12." Click, click, click, click, click. When you get through, you look -- ah ha! you know it. You'll get in a habit of doing this and you'll have a disciplined technique to use. But you sure do need something like that tape recorder, because many, many times -- especially toward the end there, when we were taking so many pictures. Boy, I'm sure we took many that were never ever documented.

Carr: Oh yeah, I took some. I go all day taking pictures and, finally,

at 10 O'clock when the other guys went to bed, I'd have confessional and I'd sit down in front of the tape recorder and try to remember what I'd done all day.

Pogue: You know how hard it is to try to remember your sins anyway. (Laughter)

Carr: It's terrible! (Laughter).

Brand: What, assuming you have this reflex Hasselblad, what do you need? Essentially, two lenses, one somewhere around 100 and one somewhere around 250?

Carr: Yeah, I think so.

Brand: With quick change capability?

Carr: Maybe -- maybe you'd need to go down more toward 80 or 70 of an overview larger lens.

Gibson: Seeing that your altitude is half of what ours is.

Pogue: That's right.

Carr: Yeah.

Gibson: So you really -- 250 is really going to be tough to use. We found the 300 pretty tough to use from our standpoint.

Carr: I'll tell you, that Nikon 135 we had that we couldn't use, that sure looked like it was supposed to be the right one.

Silver: It seems to me we need some very specific evaluation and recommendations on that.

Carr: But you need a wide field of view, kind of like a 55 or something like that. That will be the big picture, and then you need the right telephoto lens to get your detail that you want to get. I really couldn't say what's the right thing to do. But somebody ought to get those lenses for you. They ought to be available right off the shelf, if somebody would just figure out what's the right one and get it, and get permission and use the damn thing. And you might try it with the Hasselblad, learning how to quickly change magazines. Or maybe what you need is two Hasselblads, one with IR and one with color exterior, because, like I say, you're going to see a picture and you're going to say, "Hey, that's got you know, that's got implications; that's going to interest somebody like Lee or Bill or somebody. I ought to get an IR shot of it." And if you've got to wait and change back - you've got to change from a haze filter to a Wratten filter for IR or

something like that, by the time you got finished playing with the camera, the target's gone. And so you need another camera, essentially, loaded with IR and ready to go. And you've got to be ready to use IR. We weren't really ready to use it, because I don't think we appreciated it. We didn't study enough and plan enough as to how we were going to use IR. And when we got up there and all of a sudden we had IR film, we weren't sure. Well, hell, what will I -- what's a good picture to take? We decided, well, it ought to pick up plankton out of the water, so we ought to be able to take pictures of plankton. In volcanics, we ought to be able to see some good heat in the volcanics area and ...

Silver: On some of these fault zone pictures, the vegetation effects come out strikingly with the IR stuff. They're really outstanding.

Carr: I think we got some IR 35, but I'm not sure.

Gibson: The other thing we were -- if I were to refly again, what I'd do is take that book and almost have it memorized, because we didn't really get that book until rather late and go through it, and we really didn't have the time to learn it that well, so we had an awful lot of on-the-job training. I'd have it so I would open

up a page, and all of a sudden, everything that was on that page would click into mind. So that when the target started to come up, I'd know precisely what I was looking for and wouldn't have to read, like trying to put a model together on Christmas Eve. You know, you're trying to read the directions and you're in a hurry. You just can't do it all at one time; you've really got to know what you're after.

Carr: And also, any target you can fly in a T-38, you ought to do.

Silver: Ed, in that vein, do you think we ought to, in fact, run some exercises?

Gibson: Yeah. The...

Silver: In the science program?

Gibson: Yeah, I think if you can run exercises, even if you just draw something up on the board and say, "we're coming over, tell us what you could see of significance in this area."

Carr: Right, and only give them about 30 seconds to look at it.

Silver: Old aircraft identification bit... Here's the subliminal strain. Where are we? In other words, if we -- You guys have now taken so much photography and so much obliquity that there's actually

a basis for getting geographical orientation so that they don't have to go through this bit finding themselves.

Carr: That's right. That would help you a lot, because the first 10 or 20 days we were up there, we were busy trying to figure out where we were and which way was north and which way was this and that. Later on, it becomes second nature.

Muehlberger: Geography is number one then?

Carr: Yeah.

Pogue: That's right. You - you - first you keep turning yourself upside down. Even at the end, you know, you'd work your way around to the window until things looked right side up.

Carr: Yeah!

Pogue: Toward the end, you were starting to recognize it pretty good.

Carr: But you're not going to have that.

Pogue: After 20 days, we'll have been down -- splashdown already. And so you need to get that behind you and a lot of this photography, if you've got time to look at it, will be helpful.

Silver: If this photography is organized in sequence, you can get in effect several revs. You know you were able to view New Zealand 10 times

over and over again and get succeeding impressions, which is something we'll only get on extreme latitude and things like that. So, therefore, we visualize rather a canned program where we have extensive prebriefing on some detail and we know it extremely well, like Ed suggested. It's memorized and it's almost boiled down to yes or no questions in some cases...

Carr: You're not going to be satisfied with that when you get up there, with saying yes or no. You're going to want to...

Brand: I know that there will be expansions on that, but in our own minds we'll be looking toward -- I think that much of a detailed sort of question.

Carr: I think you guys are going to have to focus more on a fewer number of sites than we had; quite a few less than we had and focus on them and just get really up to speed on them and ready to go and look at every bit of photography you could see on them things. And then talk to people in all the different areas and say, "What don't you know about these sites that we're going to really concentrate on?" And go at it that way.

Muehlberger: So that means early in the business we've got to know the ground tracks that will be flown. So we're not planning places either at the terminator or in the wrong...

Gibson: Then, I can't overemphasize that you've got a book which you're going to work from and get that put together early and then just sit there and learn every little crinkle on the paper. You won't have the time in the last 3 or 4 months to do that.

Gibson: Sit around and talk about it.

Carr: Yeah, sit around and talk about it. The more you can talk about it, the better.

Gibson: Even if we just put a preliminary book together, something you can just sit there and really learn well. Unfortunately we just didn't get this whole thing going until late.

Carr: But Earth observations, I think, once you get started you're going to -- they're going to be very, very pleasant; even the training, they're going to be pleasant. And it's the sort of thing that you will almost gladly do nearly every day. You could have 15 or 30 minutes or so of just Earth observations every day, where you sit down and look at some stuff and go through a quick

thing and then go off and do all the other work but...

Brand: One other question is in line with this early orientation problem mentioned. One of my biggest concerns is: we'll look at the ground and we won't be able to find what we're looking for. Do we need some kind of -- or do we need to go to having a sighting device through a window or something like that at first...the first pickup targets? Like go to gimbal and such and such and look through the COAS and there it is or...

Carr: It'll help.

Pogue: Well, the way Deke described one restraint on your mission was that pointing restraint -- pointing restrictions during exercises during certain experiments. I think that during those phases it would be sufficient with the known attitude of the spacecraft, stellar inertial or whatever you call it, if you just specify a window for the command module, I think that's good enough.

Carr: Yeah!

Lenoir: Jerry, throughout the flight it was obvious that when you first started coming over New Zealand you saw islands in the water and then the last few times you came over, were you really seeing the

little nitty, gritty details of what was going on down there? If you had had the capability to overfly that repeatedly in T-38, do you think you could have cut out the beginning learning curve?

Carr: Oh, Yeah. I think so.

Lenoir: So you'd recommend doing any T-38 flying over target for target analog in this country to the extent that they could?

Carr: I think so, yeah. But that's a time-consuming thing and I don't think these guys are going to be able to spend that much time.

Gibson: If I had a choice, I'd rather sit there and look at...

Carr: It's an admirable goal.

Gibson: ...200 slides and know them well, then I wouldn't go with T-38...

Pogue: Well, I tell you something, one thing that would really help me was trying to find the Canadian shield for Lee. I kept wondering if I was seeing the right stuff. You know, I mean I knew that if I just pointed the camera out in on that general area, I'd probably get it. But that would have helped, looking at that from the T-38, 45,000 feet over Spokane or something like that I think I would have had a little better....

Silver: ...Having a few identification points defined so that you can tie

to those and then you know your orientation and everything else.

Carr: Houston to Los Angeles, that whole area out there, we've flow so many times in the T-38 that up there we'd look down and say, "Oh yeah, there's that same cinder cone; I remember that one, and there's this and there's that." You're used to it.

Muehlberger: I bet Lee and I could deliberately arrange the route from here to L.A. that would go over a lot of things that you haven't looked at that are really significant from the terms of things that we're interested in. Particularly the Big Bend region that I'm speaking of or area...

Carr: You know you guys...work that out because we fly that route so many times, we could probably make a lot of geological observations for you between here and L.A. whenever we fly the route.

Muehlberger: Will you take a camera?

Carr: Sure. (Laughter)

Query: We need a good piece of L.A.

Query: Okay, we'll make a guidebook for you. That's all from...

Silver: In trying to sort of maintain some balance between the observation and the science, I think we've spent some real — some really

important moments talking about operation aspects. I think some of it will come out if we get back to talking about some of the science targets. And, Bill, why don't you pick up and talk about some of these things you'd like to talk to right now? And one other thing I'll have to say - WAKE UP, PARKER. (Laughter).

Carr: He doesn't know about ATM...either...

Muehlberger: I would think that in terms of the training that you've each talked to two different kinds of things, and I think actually a combination would have been better. The photos are the things that you can do in 10, 15 minute shots. The T-38 thing gives you the moving approach over the target that you -- is the only way you might be able to duplicate or pre-prepare for the actual flying, from a really great height. But I think a couple of T-38 runs are going to be worthwhile just getting your eyes focused on things in the real world rather than from photography.

Gibson: Yeah, but large specific targets, I think you're -- I might -- first I feel I'd learn a heck of a lot more looking at the slides because you have a heck of a lot more -- takes so much time,

Carr: Yeah, but Ed, you never did do EREP sight training for 38 like we did. But if you don't have a feel for value...

Gibson: But I don't need the EREP sight training because I'm NOT operating a VTS.

Carr: Well, I know, but I'm saying that that transfers into a lot of good training that I don't think you're aware of.

Gibson: Well, it's not a VTS so I don't really agree with you.

Muehlberger: We were missing some of our photos of the Alpine fault, but I think I'd like to return to that for a minute to try to get a better feel for what were the main linear features that you saw that reiterate once again some of those items. Before we move on. Another fault that was overly simplified when we gave it to you was the Atacama in Chile. And then I'd like to move over into the Afar Triangle on north up through the rift zone as the three principal geographic areas. We'll have to leave Central America out, because they are mostly Nikons. So I can't do anything there, and there's a lot of other really neat areas we ought to do something about. Particularly some of the fault zones you guys identified that had never been mentioned to you, things in

India -- one good for instance. Oh, we have some other shots of the Caucasus we'd like to have you look at. They turned out to be really spectacular and I think that there are significant things that you can contribute to us on it. Could we have that first good Alpine Fault. Do you have this one on the slide which is vertical?

Carr: While we were busy looking for that Alpine Fault, I guess the thing that impressed me the most was the river structure on the eastern side, and the lakes up there. You had these long lakes and then they just -- go down below the lakes and you begin to pick up the river structure down there.

Pogue: Another thing, too, you see that sort of sky-blue area down there and that one flying across there? That thing really hits you in the eye, too.

Carr: Yeah, that whole alluvial area down there is super green, the whole time we were up there, very, very green and very verdant -- green, very verdant. That must be beautiful farmland or something all through the area.

Muehlberger: These are river systems and bands in here that you were describing.

Muehlberger: That's okay. That's the southern half - the southern third of it anyway.

Carr: Christchurch is that right off the margin?

Pogue: Right up there?

Carr: Right up here?

Muehlberger: Yeah.

Carr: Area of different colored lakes.

Gibson: That's so oblique

Muehlberger: Yeah, that's an oblique.

Silver: South is to the left then, right?

Muehlberger: No. South is off to the right. These lakes are angling to the south of the fault zone. A prominent part of it is hidden away from us here.

Pogue: ....clouds.

Muehlberger: Under the clouds. Yeah. The first one we looked at was on this one. Can we find -- this projector -- the very first Alpine Fault picture we had? Is this a bad angle for you guys?

Carr: No, it's okay.

Muehlberger: Yeah, it's not quite the same orientation, but it's impossible --- Okay, the left mo... there's the last leg tip right there.

Silver: Is that Christchurch in there?

Muehlberger: No, this is Christchurch; that's.... Eden. Excuse me, Christchurch is found up here.

Yeah, okay. No wonder we had geography going so badly. Here are two segments of the fault and unfortunately terrific look angles, or maybe fortunately, and I think they show some of the contrasting direction of valleys that you were commenting about. And there's another prominent one coming through in here.

Carr: Yeah, I was ... but it was further south, ...S Creek lake up there. It's just that the river, just was straight as a die right -- headed east, right down from the mountains. And then up above the river, after the river came part way up the mountain and then jogged to the north, up above the riv -- the river was this lake that looked like if you could just break the dam it would join with the river and you would have a straight shot from the lake all the way down to the water.

Gibson: And that was impressive.

Muehlberger: I suspect we're actually talking about this and then it jogs over apparently...it becomes this system.

Gibson: Bill, when you look at the one on your left there you see most of the rivers; you can see where the slip had moved left side up. Yeah, that side has moved up, except you come right to the center there -- right there -- and that one just looks completely opposite. What happened there?

Pogue: Look at that big block there. I attributed that to that big block.

Muehlberger: Big block mountain in here?

Pogue: Right. I never did say anything about it and I -- that's a good observation.

Muehlberger: You would think that maybe the stream, having gone through here at one time, or maybe even along this one...

Carr: Yeah, because that river - that streambed right there lies to you and tells you that it's slipping the other direction.

Muehlberger: This one just comes straight out - practically straight out.

Pogue: But a lot of them have a little tiny zigzag there. They zig to the left.

Muehlberger: And if you just take the part along the fault zone, that little zig

you see, it's a principal thing, because once you get out on these flats, they can capture each other and change the dire ion and change orientation. Did you have a chance to look elsewhere than along the main zone? I know in the south you did.

Carr: I did a lot of looking up north there around Cook Strait, on both sides of Cook Strait.

Muehlberger: Yeah, and unfortunately we don't have any frames available that really...

Carr: You might have...

Muehlberger: I think there are things that are still coming.

Carr: I took some pictures of them so they must be in the 35 files.

Muehlberger: Did you ever get a chance to think you could match things across the stream?

Carr: Yes, I felt like I could match the fault zone across the Cook Strait.

Muehlberger: Okay, we might better get back...

Carr: I hope we got -- I hope we can find the photography and I can show you what I saw, but the drawing you had on the map, it looked to me like I could match it up.

Muehlberger: You can match that.

El Baz: Do we have an estimate of the sun angle with pictures over there?

Muehlberger: This one? It's an afternoon shot because most of these escarpments are in partial shadow, and, I would guess, approaching 30 degrees from the horizontal or 20, somewhere in there.

Muehlberger: You know, it would be nice if there were a clock in the corner of these damn pictures. Then we wouldn't have to...

Carr: Exactly, because we know the time when that was taken.

Muehlberger: Yeah, that's right, we can go back to the transcript.

Carr: Thank heavens we've got all of the logs on the 70 stuff.

Muehlberger: Yeah. Can we move to the very southern end where the valleys are prominent? Which frame is that in?

Let's remove this one. No, let's take this one down and replace it. At least keep the...

Carr: But there must be some good pictures of both sides of Cook Strait on the days we were taking pictures of the oceanography in Cook Strait.

Muehlberger: I think we might have reversed that, I don't know. You guys sit up there in space and look at such tremendous - different angles from what I'm used to. We're still looking a little obliquely eastward at the very south end. Here's this big fertile valley

or cultivated area you were talking about. Yeah, and the island off to the south. There's another little one out off of -- pictured below us here with a little volcano.

Carr: Yeah, north is up.

Muehlberger: Yeah, north is up now. Yeah, here's that big zigzag lake again, and you just rotated 90 degrees from the one on the other screen, or a little more than 90 degrees. And the main big fault zones, unfortunately, are still off of this picture, that I was thinking was what you were carrying by eye...

Carr: Yeah.

Muehlberger: ...on down into here. When you were describing this, you were talking about a...the line shown on our map has...carrying on across, and I'm wondering whether there's anything in here that is what you were carrying on through. Whether it was this...

Carr: Don't you show...map, it cuts to the south and then veers off to the east...

Gibson: Yeah, veers off east and I'm wondering if the line I had drawn -- or, it <u>was</u> drawn, I didn't draw it, is roughly in here.

Carr: Yeah, and I think I remember saying one day that I couldn't see

anything on the ground that looked like it followed that line with the exception of that river there. Isn't that a river?

Muehlberger: This is a bunch of low ridges of different layers that all stand up here as ridges. And actually, when we look at a geologic map, this is the bottom of a syncline - fold under and the fault doesn't really parallel that anymore.

Carr: It wasn't very evident once you got out of the mountains and hit it...

Muehlberger: ...no good faults that you could see. We got the same feeling we did there in San Felipe Valley,that it just kind of disappeared in the alluvium and the civilization. The people just kind of plowed it over, it looked like.

Muehlberger: Okay, as a result of our focusing you in a few places, I was wondering whether you devoted any time to wondering about the patterns of the mountains and valleys on the plains in here.

Carr: The rivers showed up on the plains more than anything else. They were so straight and so east-westerly.

Muehlberger: Yeah. That's the plains north of this southern chunk. And they don't show here again, but they're going fairly straight out under those clouds.

Carr: But as far as hills and mountains were concerned, I didn't have any impression that there was much there; it just looked so flat. It looked like the ground just kind of swooped right down out of the mountains and got flat and went right to the ocean. And you didn't get much of a sensation of relief in that area.

Muehlberger: It's relatively low country compared to the Alps which are really big spectacular affairs.

Carr: That sure looks like fertile ground there. Boy, it's just so well cultivated and so green.

Muehlberger: The field patterns right there are super spectacular.

Carr: That was a whole lot more green than was the corresponding area over in Australia. The big wheat and cultivation area over there in southeastern Australia?

Muehlberger: Southeastern part...

Carr: No comparison between the two. This looked like it was a whole lot more verdant than was the same area in Australia.

Muehlberger: And they both are southeastern corners of the countries.

Carr: Yeah.

Muehlberger: Maybe it would be fairer to compare this since it sits right in

the winds in that southeastern corner of Australia - is the end of the big continent - it would be better to pick this...compare it with Perth, than the big fields in that part of the country. I don't know; you'd better talk to the agriculture guys on that one.

Carr: Yes.

Muehlberger: We sort of stepped out of my game again. I think you can see some of the prominent valley in here that are prominent faults. The other thing that shows up are a number of valleys in here in these low ranges that seem brown all the time. I assume the colors here are fairly typical of what you remember?

Carr: Yeah. Those are pretty good colors, wouldn't you say?

Pogue: Not too bad at all. The one thing that does show up, at least from eyeball as you fly over this, is the glistening sunglint off the streams here and in Australia, also. I don't know what chemical it is, or what leaching is, but Australia is even more dramatic than New Zealand, but you get an exaggerated highlight when you get a sunglint.

Carr: Just like silver ribbons.

Pogue: Yeah.

Muehlberger: This was better than across the U.S?

Pogue: Yes sir.

Carr: Yeah.

Pogue: And...

Muehlberger: Maybe the smog has a filtering effect.

Pogue: Well, it's different from any place in the world. I don't what it is that's in the water, but it sure does - or maybe it's the streambed itself.

Slayton: This isn't geology, I don't think, but in the lower left corner of the picture like a washboard cloud effect there.

Gibson: You know, we used to see a lot of that stuff, Deke, and you just couldn't explain - couldn't relate it to mountain features or waves off of anything. Every once in a while, you just find all kinds of linear features like that all stacked up.

Muehlberger: I know my knowledge of this is...I asked a meteorologist once when I was flying around the U.S. and saw these kind of clouds. He says it's ripples between two air masses, one on top of another, and the oscillation of that is just enough to produce clouds in the troughs and that sort of thing. I don't know whether that's the case here or not.

Lenoir: Sandy, would you like to comment on that?

Sandy: It could be that. It's the first time I've seen these pictures. I've seen that type thing...

Carr: The impression we get is something like that doesn't happen in very high winds. It's got to be in fairly moderate winds.

Gibson: For example, you see in the lower righthand corner of the other photo -- you see the same type of effect. Looks almost like roll clouds and if there were mountains around, you might call them roll clouds.

Muehlberger: It depends on the rate of shearing between the things. We get the same problem in building sand dunes or...

Carr: I bet you it's the same thing, too.

Muehlberger: ...you get this going too fast, so I suspect whoever said that... but this is a low shear rate would be a good answer.

Carr: Yeah. I bet it's the same sort of phenomena - just atmospheric mechanics.

Muehlberger: You're just moving fluids by fluids, and they can do it on thin ones or not. Eric, what other points do we want to worry about here?

Swanson: They noticed the Alpine Fault, the splays from the north to the south coming off - well, on this picture, to the top of the screen.

Muehlberger: Should we get back to the other picture here?

Swanson: Yeah. That might be better.

Muehlberger: Can we put that first one back? Thanks.

Swanson: Did you also notice the splays coming off towards the bottom of the screen here?

Carr: This direction?

Swanson: Right. Coming out more towards the north.

Carr: I think I was more impressed by the stuff to the east of it, and I guess I just didn't look well enough to the west and northwest to be impressed by it.

Muehlberger: The thing after you get... This is the obvious big thing. Where does it go up here, where it beoomes hard to claim it as a good strike-slip fault? I think that this picture made me horribly aware that, if that's going to be still moving horizontally today, we got a big problem there; therefore, something else must be happening to that fault. And that's where the fault that had been drawn on the map hooks around the end and curls around and then

curls back. Matter of fact, the San Gabriels, San Bernardinos, and San Andreas systems are doing those same kinds of bends today, cutting across the transverse range -- a smaller, different scale example of that style of thing.

Carr: I sure hope we can fill the gap there with some of this 35 mm stuff. I hope it's good enough to use, because I think we got coverage that goes clear across Cook Strait and into North Island.

Pogue: Yes, we do. I know several of the times.

Carr: Yeah.

Muehlberger: We have the North Island pictures. In your statement it sounded... it was fairly clear, but again they had that thin cirrus. And I think we've already answered that problem. You can see through underneath it.

Query: The Mt. Cook area -- is that on that frame?

Muehlberger: No, it's off -- off to the north. That's about another 1/3 of the island, or 1/4 of the island to the north here. We have no pictures mounted that would fill in that chunk right now, And -- nor do we have those dark zones. Oh rats! And that's something I should point out to you,..the dark zones that I was talking about.

Carr: Is that the Dunnite Trail?

Muehlberger: That's the Dunnites, yeah.

Carr: We sure couldn't see that.

Muehlberger: Well, now I know why, looking at your pictures — because they have a lot of iron-bearing minerals, a rather rusty color. And at the north end of the... there's one big band of practically no vegetation and it's kind of a ruddy colored hill - mountain.

Gibson: We were just looking for the wrong thing then?

Muehlberger: Yeah, I'd given you the wrong cue. On the other hand, on the south end of the thing, they are dark. Can we go back to that other picture we had there, please.

I think they're on there, or they just may be barely off. Most of these are forested areas. This happens to be one of those dark things but, unfortunately, it's forest you're seeing here rather than the dark stuff and this is another band of it. Part of the mountain range here is in the granitic rocks and the vegetation of the forest here is again giving us the color contrast rather than the rock. So we...down in here it's forest and the other end, apparently is a drier part of the island and it just stays unvegetated.

There are parts of the California coast ranges, north and south of San Francisco Bay where the...those super-dark rocks, those dark zones -- the scraped-up seafloor...that are part of the continent now, don't grow vegetation and they stand out as blank areas to you. Okay, I think I've missed some of the obvious things we ought to ask you about. You've given me a couple of points here. Have you got any other notions?

Swanson: We've talked about offset streams along the Alpine Fault. Did you notice any such thing along the splays to the north, the Marlborough Fault group?

Muehlberger: Yeah, back to the other slide over here, please. Here's the one you were worrying about as to whether they're offsets. Did you have any opportunity or time to look along these? To see if you saw any...

Carr: No, I'm afraid we were too ignorant to do much other looking. I wish we would have known more about the Marlborough Fault.

Muehlberger: For some reason... Well, I...

Carr: I was so hung up on the...

Muehlberger: From these things we can now focus in on some areas for the next guys to supplement there.

Carr: I was so hung up on the Alpine that I spent an awful lot of time just looking for that. Like I say, it took us so long before we finally got on it. And then once we got it, I was inclined to be looking strictly along the Alpine to just kind of fill in there. And I didn't even think to look for the splaying or the...or anything.

Query: Were glaciers obvious to you?

Carr: The glaciers here weren't, but the glaciers up in the Andes and Southern Chile were certainly clear.

Muehlberger: I would think the ones in the Alps would... Well, they may have been buried in the snow and not so visible. The glaciers are way in the southern part of this island and what you see in here are the prominent streams with no vegetation and just gravel banks that stand out.

Pogue: The thing that makes glaciers show up, to me at least, is the ... this sort of a characteristic streaking and discoloration on the top surface of them. It's sort of...

Query: That's a few lakes up there that are various colors. See the light-colored one? You establish a little color with glacier runoff. It's very light water.

Pogue: And in South America, you'll see that is exactly true.

Carr: Oh man! I'll say.

Pogue: The Andes, Chile.

Carr: Yeah.

Muehlberger: You backtrack that to the glacier?

Pogue: Yes, that's a very good technique.

El-Baz: Bill, could you see the streaking in the ice itself?

Pogue: I wish I had a picture of the southern Andes because that's...

El-Baz: Yeah, that's my instruction.

Pogue: I found them and then I found out I should have read the book first, because it had it described perfectly in the book, but I found them with the binoculars. I thought it looked like glaciers. And sure enough, it is. I didn't know there were any down there. That's a good technique -- is to use a lake. I got inverted relief, by the way. I thought the lake was feeding the glacier, first time I look at it, and that's how I went through a sort of sorting out, logical process, and finally figured out it couldn't be true.

Muehlberger: This is the Mt. Cook area, right at the head of that thing. Those are -- showing out there -- those fingers going into the valleys

are the dying ends of the glaciers. There's one right in here. This is the head of that same valley. So there it is -- without clouds on it -- dang near centrally located. In the norther part, all these faults come off this direction. Starting right here, they go off that direction. And there's some curved lines - faults - breaking through in here that sort of break up that band in the middle. Did you get one up here in the...

Carr: Bill, on there at the last three in that roll, are of North Island, and the last one is North Island and South Island - if that's any help getting across Cook Strait.

Muehlberger: Yeah, this is a terrific view of the ... Maybe the magnifier viewer would help on there.

Carr: Oh yeah. Now this stuff was taken late in the mission because they were doing a lot of burning at North Island -- lots of fires down there. No, this isn't the stuff that showed the geology across Cook Strait as well, but...

Gibson: I think that's on the 35 0300.

Carr: Hey! This is a...it's oblique, but it's a stereopair. These two are a stereopair across Cook Strait. I think if you framed those

in the right arrangement that might do it. You'd be able to see across the Strait on that one. But those pictures there are taken later than these.

Muehlberger: Yeah, we've already taken out the ones that are earlier.

Carr: These pictures are about mid-mission, and those pictures there are right near the end of it.

Muehlberger: Yeah, here you go. We've got the earlier ones coming up.

Pogue: I never could see it, from one island to the other.

Carr: Do you have a pencil? I'll show you what I took to be the fault. It's a line right across there. The sharp change in colorations - came right up - see that bay there? It came right up through that bay.

Muehlberger: Okay. That's one of the big faults.

Carr: You can see it coming up through that bay. That picture doesn't show the coloration. It's more offset to the west.

Muehlberger: Jer, what you're seeing is this fault on this side against that bay.

Carr: That little bay right there. That's where it comes in. Looks like something started and moved right in through here.

Muehlberger: The other one - the bent end of the Alpine Fault is coming right out of that.

Carr: Yeah, that's why...

Muehlberger: That lines it up. It's over on this side. It's off in a different direction again. See that reddish little spot right there? The point? That's the dang dark area. Take a look at it and get your eye tuned to what it looks like. I've got it centered right under the looking glass. Is this where you were drawing?

Carr: No. There's a line here.

Muehlberger: Nobody has been really successful with that matching across the strait.

Carr: Is that right?

Muehlberger: Yeah. That's why we were sort of hoping that you guys would get some notions up there as to what would happen.

Carr: Well, let's hang our hat on the 35's and see if we got some good tie-in photography.

Muehlberger Let's move in to Chile. We have a couple of pictures here and of these pictures...

Query: Bill, we were just questioned here. In discussing this fault in New Zealand, what were you really looking for? Are you really working on tectonic maps of the islands, and you're trying to find

more information to draw those maps or just what?

Muehlberger: Yeah. These things make it so easy to see everything at a glance, whereas there are probably 20 different maps that cover that hunk of the island and you start...you get lost in the forest because of the trees, and you can't see the whole major grain of the country. That's Step #1; that's the first thing that makes these so useful. There was nothing like that available before. I imagine when the New Zealanders see that frame, in particular, or any of these frames, they're going to go, "Holy Cow, I wish we had had this 30 years ago," kind of thing.

Query: Are you working on New Zealand up at Texas University?

Muehlberger: No. The purpose initially was, I thought, we should focus on some of the really big, important faults, recognizing the worth, whether or not we're working on them or not, just to have the photography for the locals to use.

Carr: That's the thrust we got. They had very little photography of New Zealand and that did them a lot of good and they were looking for more data just to start with.

Muehlberger: We picked four fault zones that went around the Pacific that were prominent. This is one. The Atacama in northern Chile is another,

the San Andreas system, which a lot is known about and more needs to be known, and Lee is primarily working that band of country. And the one that goes the length of the Philippines, as good examples of these features that are supposedly where continents and oceans are sliding together and stuff is being crunched under. Right off the bat, these pictures have jumped me 10 years up in my knowledge of the areas and the literature. So I gave to you stories that represented the things that are in current textbooks. And they're wrong. The current textbooks, even though they just got published a year ago, are still a whole bunch of years out of date, and what this has done for me, in other words, is jump my knowledge forward on these particular areas. And the guys here have been trying to do a lot of legwork for us.

Pogue: But don't fail to mention that Circum-Pacific Fault zone in the mirror-image effect with the San Andreas.

Muehlberger: Yeah, yet this thing isn't a good strike-slip fault today and the San Andreas is. But we've got, in other words, the model that was set there in the little drawing, where all four of those fault zones are shown at the same scale. And they're the same size. Every

one is different. That's what it turns out.

Pogue: So that you -- they're not really parallel mirror images?

Muehlberger: No, no exactly.

Pogue: But they are part of the same...

Muehlberger: I presented it to you as that because that was the level of my understanding on it at that time.

Pogue: Well, I'm glad I mentioned that because I was still thinking that was the current thinking.

Muehlberger: Well, it just shows that I've spent too many years recently on th Moon and I should have spent more back on Earth. (Laughter)

Gibson: That is a strike-slip. It's just a question of when it occurred and what's the...

Muehlberger: Yeah, there's no question that it is a strike-slip, but today this particular segment from here down to Milford Sound, all the earthquakes epicenters that are in this band are showing dominantly a vertical motion, rather than a horizontal motion. There's a component of horizontal that's still in the same direction that it used to be, and that's why you are still spotting offsettings in the streams; it's still going that way, This side is moving up.

But there's also a horrendous vertical lifting going on from that side. Then, in addition, this whole band of country, from here to here, that originally had -- roughly that shape has been squozed into a band like that...in other words, these diamond-shaped things elongating out. And that's what's causing the bending of this thing around this way.

Carr: Yeah, that smells like the Afar Triangle, too.

Muehlberger: And we've got similar things, particularly this kind of a process, going on at the north end of the Dead Sea system.

Pogue: Well, it looks to me, also, like you've got the same puzzle here, same dilemma you had in Agua Blanca. You've got a nice, well-defined linear system there that all of a sudden just terminates and there's no explanation.

Muehlberger: Exactly. These things over here have displacements on the order of 10 miles, whereas this thing is in the hundreds. So, if they -- and the offsets of this thing is also showing that there's a displacement going on in this big beet(?)

Carr: Yeah. You guys have got your work cut out for you in the Philippines, too, because we had a hell of a time finding any places where we

could see it. That was forever bugging us.

Muehlberger: Well, that's what we were afraid of; the tropics is a problem.

Carr: Oh, I'll say.

Muehlberger: Continuously.

Carr: If you ever get a clear day, you just need to have the film available to burn up. You really got to do it because you just don't get any opportunities to look at the Philippines. We saw northern Luzon about 3 times and the rest of the time it was socked in, and I saw Leyte one time.

Muehlberger: Wonder what their clear season is?

Carr: I don't know, but boy!

Muehlberger: Well, it's one day a century. We can hope. (Laughter)

Gibson: You know, even though that photo on the left is a good one, if we had had a reflex finder, e could have gotten just about the whole visible fault in there. Put it obliquely or put it along the diagonal.

Carr: Boy, you sure find yourself hipshooting with that damn Hasselblad.

Gibson: Yeah, we just ended up taking pictures of ... half the photo was of nothing in many of these, and we were off ...

Pogue: You get black sky.

Gibson: Yeah, black sky was a good example. We really missed some of the significant things just because of the aiming problem.

Carr: Hey, I got a hunch we're bogging down. We better...if we want to look at Atacama and the rest of them...

Muehlberger: Yeah, let's go. Can we change the slides please to the Atacama? Or two? Would you stick the other one up on the other screen? Here, Zan, you give us the geography. You're the guy that spotted these things. Come and show them to us. No, wait a minute. The crewmen spotted the faults first, as far as I can tell.

Ritchie: Okay. Here is the Antofagasta Peninsula. The Peru-Chile border would probably be about down here. This is the next section south. We're looking south here. You'll notice the main mapped Atacama fault theoretically runs right along here past Antofagasta, curves back and around to Taltal. Here the fault comes in. Now Taltal is here; there's a cross-cutting fault through here, theoretically, and then the Atacama goes on south.

Muehlberger: Okay, is that what you guys were calling the Atacama Fault?

Carr: Initially, yes.

Pogue: That's right.

Muehlberger: That's double spotting it?

Carr: And that cross-thrusting that transform area, we had a very difficult time convincing ourselves we could see it.

Muehlberger: The one over on the right screen there?

Carr: Yeah. See, you can see the Atacama coming down from the north. You can see it duck in right here. Just no sweat at all. You can see that rascal and it just ducks right into the water right there.

Muehlberger: Right.

Carr: And then we were busy looking for a transform area here, so that we could try and pick up the southern part of it, and carry it on down. And we just couldn't seem to do it. We could find some linear stuff in here that begins to look like maybe you've got it, but we kept looking for a broken-up thing and we started looking at these rivers here saying, "See, these rivers are kind of parallel; could they be in some way connected with the transform area here... the shifting?" But it's all so busted up in here that we found it hard to convince ourselves.

Ritchie: Part of the problem you ran into here is that opposed to the other

faults you were looking at, there's not a major escarpment associated with the fault. This is part of the problem why the location of the fault is as diffuse as it is. It's a little low weather tone with some green in it or some dark of some sort.

Carr: You can follow the fault quite a ways north.

Ritchie: You can carry it up to here, I guess.

Carr: Yeah, but...

Ritchie: Iquique is right about in here and on the classic maps, there's one of these shattered polygonal blocked areas up there, as we spotted in New Zealand. Were you able to see any elements of evidence of polygonal fracturing there around Iquique, or anywhere up here on the northern end? Or did it just seem to keep on going north?

Carr: The general impression was it was just kind of busted up there. Really, between the Iquique and Antofagasta, it looked to me like we could follow a very weak general line that we were willing to accept as being the Atacama Fault.

Ritchie: How about north of here, off towards the bend?

Carr: I couldn't see much of anything, frankly. This was one of the

things I looked at on the EVA. I did a lot of hollering during the EVA about what I could see, and I could see a hell of a lot more EVA than I could through the window from the inside. I just felt like I could see a whole lot more detail.

Ritchie: I wonder if it was because this was such a low contrast feature, really?

Carr: I think it must be. You get better contrast outside.

Silver: How is the color on that righthand slide? Is that good color?

Carr: It's a little too red, I think, don't you, Bill?

Pogue: Yeah.

Carr: I think the colors on the left are a little bit too gray. Your real color is right between these two.

Ritchie: In addition to the Atacama, looking a little bit further inland, were you able to see anything that appeared to be a parallel fault, further inland? Was there any evidence that there was a sharp break at the front of the Andes?

Pogue: Yes. Well, at least I thought there was.

Carr: There was a strong impression.

Pogue: In fact, it's in that picture there. See...

Ritchie: Well, the front of the Andes should be somewhere about here.

Pogue: Well, that's the line. You could see that straight line if you want to stretch your imagination a little bit.

Ritchie: Well, you can start picking out segments. One here, perhaps one here, and then one here, because they...

Carr: That's like the crest on the Continental Divide?

Ritchie: No, this is like the front...the base or the front...of the range. The front of the Rockies coming up across Kansas. Because I'm sure you observe further south. The structure down there is not at all parallel to this, at least in terms of classical interpretation. Further south, theoretically, there's a fairly large graben. The large downblock producing that large central valley. Further north we have the Atacama, which, theoretically again, was one of these major offset dextral strike-slip faults. The problem that comes up is if you go out here and look at the fault, all you see are a few tens of feet of modern displacement vertically. There's almost no lateral movement today, and we...I just got access to a recent dissertation down here and the results of some grant field-work is that it's the same deal. This just isn't a good strike-slip fault from either ground or air data. What I was wondering

was, if we've got that nice graben to the south, I'm wondering if that same type of geology might not extend up here, whereas what we have is - at least today - is mainly a graben breaking in here between the coast ranges and in the front of the Andes. It would sure be a lot easier to explain what we're seeing.

Muehlberger: If that valley had dropped a little further, it'd be below sea level. We'd have the analogous to what you saw farther south.

Ritchie: It'd be the same thing you had down south. I'm wondering if you had any impressions on this. Part of the problem we have here is that your tracks did not ... just didn't get you near enough to the critical area where the Atacama dies out and the Central Valley graben system picks up. It's right where the answer lies. I was wondering if you were able, in glancing - in passing over the coast and glancing north and south - if you could see anything that appeared to be a continuation of the Atacama - if its trend appeared to continue on down south of where that graben was.

Pogue: Now you're asking a different question than the book asked.

Muehlberger: That's right. This is it, we took a look at your pictures again and realized that's a lousy strike-slip fault.

Pogue: You see, what we were concentrating on ... we were trying to extend a line, and I'll tell you that my impression was that that line disappeared in the water and never was recovered, and that the coast on to the south there was actually the Atacama Fault itself. Now the coastline ...

Ritchie: The straight segments along the coast?

Pogue: But that's just guessing. The question that you just raised now is an entirely different question and one worthy of...

Carr: We weren't smart enough to even look for something like that.

Pogue: That's right.

Ritchie: Well, we weren't either, until we saw your photograph.

Gibson: You can't remember 2 months previous when you look at what you've seen in a given view. You really - even 10 minutes afterward, if you're not looking at the right thing, you don't really see it.

Carr: Now this kind of question is a question you ought to pose to Deke and the ASTP guys and say, "All right, you see this, the SL-4 and SL-3 and 2 guys have seen all these things, now here's the next step, and start looking for a tie-in between Atacama and the graben down to the south." That's an area for them to focus on.

Pogue: But if you'll make a stylized drawing - make a drawing and say, "look, does this trough correspond to the edge of this ridge?" something like that, because we weren't looking for that.

Carr: Yeah.

Muehlberger: Yeah, okay.

Ritchie: Were you able to see any stream offsets or anything along the trend of the Atacama? We always keep coming back to offsets.

Carr: No, I looked for that specifically and just couldn't see it. It's just too beat up around there.

Ritchie: I got the impression from the photographs that it's pretty well alluviated down there, and I doubt that there's anything showing up.

Carr: Yeah, the Atacama Fault itself, the fault line is pretty difficult to see, and looking for offset streams was just impossible.

Ritchie: Okay, here's an application of some observational questions again. Since this is a very low relief feature, one would expect low Sun angles to be almost valueless. In your observations of this at various Sun angles, did you notice whether the low Sun angles... when it was low ... when it was setting, would be directly perpendicular to the fault?

Carr: I think I made the point somewhere in one of my debriefings as to the fact that the Sun angle didn't seem to help with this or , whereas it did in the Alpine Fault and it did up in the Agua Blanca, but for some reason, no matter where the Sun was, this fault looked the same, weak, and it just ... we never got up to the ...

Muehlberger: You see, I don't follow the reasoning though ... you say it's a low relief and low Sun angle would not be of any help then. I would think it would be all the more, unless you'd get the very low Sun angle.

Gibson: Yeah, you'd have to get almost to a terminator.

Ritchie: I don't think a terminator would make any difference because -- we're talking about 10 meters here. That's just not going to make much of a shadow at all.

Pogue: Looks to me like what your eye is picking up here is secondary effects anyway.

Carr: Yeah.

Gibson: A change in vegetation.

Muehlberger: Yeah, contrast rock background and vegetation.

Ritchie: Okay, in addition you mentioned looking in for the cross fault

down here in Taltal. How about further north? Were you able to see any ... roughly northeast trending fault back north of Antofagasta, particularly right along in this stretch here, south of Iquique?

Carr: I sure didn't see anything.

Ritchie: Nothing?

Carr: I tell you what, frankly, I wasn't looking up there very much. I was concentrating like mad trying to find some volcanic form area. And every time I saw some [illegible], [illegible] of attention went. Once I located the [illegible], I [illegible] to [illegible] attention was in the [illegible] region trying to find some [illegible] to [illegible] it is.

Ritchie: [illegible]

[illegible]

Carr: [illegible]

[illegible]

instance...you'll look at the upper right of this picture, on the right side, and if you'll hold your pointer straight up and down at that point. I found myself really searching... now go on, up to the top of the picture...just...lay the pointer up and down. We were searching for crap like that. That's the only way. You know, we were just looking for...

Muehlberger: That's a good way to look for...

Ritchie: You really want to back off. You can follow the trend in here... there's something paralleling it here...there you go again.

Pogue: But that's the same sort of deal.

Ritchie: Are we seeing the same sort of deal?

Pogue: Are we seeing the same sort of deal?

Pogue: Beats the heck out of me!

Carr: Yeah, I don't know.

Pogue: But we were really searching to try and get linear trends in there.

Ritchie: The Sun angle didn't make any difference on it?

Pogue: Look at that. That's all shading that you're going with there.

Carr: Yeah, it's all color there, it's not relief. You look over there on your other side, on your left picture...

Pogue: Just use what you have. I guess that's the story. But, I just figured I was searching a little bit too hard on this. That whole area is so chaotic in here. There and to the north, even up to Lima and Lake Titicaca.

Muehlberger: That whole area is just all screwed up. There's a string of volcanoes setting here that show up on these pictures very nicely, but only the front-row people can...

Carr: I was looking...a lot of those dry lakes that kind of come down below -- Lake Titicaca -- to try to see if there appeared to be any rhyme or reason to the way they were arranged.

Pogue: And there doesn't seem to be. It looks like it's on the front edge of the Andes...is being pushed and it's just all crumpled and mixed up.

Muehlberger: There are some (pardon the expression) gross trends on some of these things that do make odd-shaped blocks, not the normal kind that you would expect. And part of the reason, I think, is because the Andes are trying to go around a big corner here and therefore the things are being shoved at funny angles and that just crumples up everything in between...makes odd little topographic basins.

Okay, any other... I think we ought to whip over to Africa and take a look at some scenes there to transfer around, starting at Afar.

Carr: That whole Afar area with all the rift zones were really interesting, but we seemed to invariably get our Africa observations at times of the day where it wasn't convenient to spend any time looking at them, and that really used to get us. Africa seemed to be our breakfast-time observation, and we would stand there at the window trying to get our breakfast and looking at the Afar. It was interesting, but I wish we had had more time to look that place over, because it's really...

Muehlberger: Your flight plan was just arrayed wrong?

Lenoir: Well, it was partly our fault on the ground, too, because that was in the prime viewing time early in the mission, before we really got going well, really homed in on the things you could do and not do, and started hitting them. By the time we started hitting those, it disappeared out the night side, and kept coming up while you were asleep, and then late in the mission it started coming up on your breakfast time, like you mentioned.

C. 4

Gibson: That really emphasizes again the need for a dedicated observer when you finally get to the type of program we would like to institute.

Carr: The good weather over the Afar was early in the mission. When we came around again, the weather was bad. But you know you were asking us to look across the Red Sea from the Afar...or see if we could see any kind of structures over there and I saw some things over there I don't understand, because they seem to be perpendicular to the folding we see in the Afar. They seem to lay across it this way. And if those pictures are in there, I'll try to show it to you. There's one area across there where there's a group sort of little islands in the Red Sea, and you'll all of a sudden see these mountains and they seem to be arcing in and linear; I hope you've got that here.

Ritchie: The first thing I wanted to ask is if they can remember anything that was striking there that isn't represented in the pictures.

Carr: A lot of the photography you've got of the Afar is good stuff, I thought. Some of the things that you had in the book along with your drawings were very easily matched on the ground.

Muehlberger: Yeah, that one Apollo strip turned out to be...

I think you've already got plenty good photography, and I don't know if we've added too much to the Afar area.

Well, main thing I want with the Afar, was to train your eyes for fault looking because we had good space photography then. These are the first pictures of the escarpment that have been taken. And here you're heading off to the southwest into the Ethiopian rifts and then on down into the main valleys.

Gibson: That thing's just too hazy compared to what your eye can see through that haze.

Muehlberger: Yeah, here's a good example of what you're saying about the obliques being hazier than the vertical.

Pogue: That area at the bottom central -- that should be much darker.

Gibson: Your contrast is just not what it is by eye.

Pogue: And also, that elephant skin effect in the center doesn't come through like it does when you're looking at it. You know, in the Afar -- that in the middle of the Afar itself.

Muehlberger: Here's that big gob of valley that we started the whole system with. Right in the middle of this big gap are some linears coming out this way. See them?

Carr: Yeah, and they are very evident up there.

Muehlberger: They're evident to that point. We didn't realize that again until seeing these photographs...this is sort of an axial thing right in the middle of this system, coming out of here. In other words, that looks as if -- this area is currently the thing that's dropping in, rather than the rim-to-rim dropping down into the hole. And way over in the other end where some of these volcanoes -- I guess they're off the top of the screen from here. They're right in line with this same structure. If we'd known, we'd have tried to get some observations to see where these come out into that hole up to the Red Sea. Did you guys ever find Addis Ababa?

Pogue: No, I looked many, many times and I could never see it; all I could see was this pall of smoke that I thought may be it.

Muehlberger: Should be off in here somewhere, and I'm not sure-just exactly sure either.

Pogue: I took pictures of the Nepal, but I never...I looked with the binoculars and I couldn't find it.

Carr: That one and Khartoum. I never saw Khartoum either, did you?

Pogue: No, one day we had a beautiful view of it, except it was -- the

only cirrus cloud in Africa was right over Khartoum.

Muehlberger: Okay, can we have one more up?

Pogue: Jer, you should be able to talk about this one on the other side there.

Carr: The area that ... here's the area that we really got interested in, and there seems to be some lines going in the direction of the pointer.

Gibson: You can see that line you just drew, Jerry.

Muehlberger: Yeah, there sure were a lot of clouds.

Pogue: You know, I didn't even see that until he called my attention to it, either.

Carr: Look at all this lineation all through here. See right from here all the way down, it's perpendicular to what we figured. All the folding and breaking and crunching was in Afar, so we got real interested in that.

Muehlberger: The Red Sea is sort of like the Gulf of Lower California, an area where everything can spread it, and I suspect it was somehow related to the borders on the other side, where we were just looking here at the borders on this side.

Carr: And then as you went in, you could see lots of little straight lines like -- that just kind of shoved it up. Look at these straight lines right here and here. And you just got this general trend in this direction but then you got all these radiations -- things or something and it really was interesting. Look over here, you got almost cross-hatching, perpendicular. This sort of thing was interesting because I took a 35 millimeter picture up around Goose Bay, and the mountains there and the snow had perfect cross-hatching as if someone had gotten in there and just clawed in two directions, or they froze the mountain and hit it with a hammer and shattered them...a wheat pattern...a tooth pattern. And you see, we saw an awful lot of that sort of structure, but this whole area right around this set of islands here on the Red Sea, just really impressed us as being all screwed up. There was this general trend here, but then you can see all this cross-hatching, shattering in every direction. We didn't know what to say about it, so we just took pictures.

Ritchie: That particular area, at least where it has been mapped, are faults, but it looks so complex because it has rocks from pre-Cambrian

to Recent, so it has a long...over 600 million years of geologic time, and there are different orientations, but one of them is parallel to the Coast, particularly parallel to the Red Sea.

Carr: You sure can't see those things sitting back here looking at them; you got to get right up next to that and look at them.

Muehlberger: And I think you spotted one of the areas that's truly unique and anomalous in that whole rim of the Saudi Arabian side, but based on existing maps that we have ...

Carr: You see now, we wouldn't even have been looking for that stuff. Bill, if you guys hadn't given us the word in that book and said, "We want you to go across the Red Sea and look at the other side and see if you can see anything over there that ties in with what goes on over in the Afar area." We wouldn't have looked at it and seen it.

Pogue: We were all hung up with that major rift zone.

Carr: So this is the value again of sitting down and talking things over before you go, and pointing out areas that can be significant. Here we were looking over and it wasn't making sense, so we decided it had to be significant if it just didn't make sense with everything

else. So we took some pictures of it.

Muehlberger: I'm afraid I don't know the answer as to how to make it make sense at the moment.

Carr: But at least you got something to look at, and think about.

Muehlberger: We've got something to work on -- exactly! This is a really messy hump of country, big blobs of rock, partly outlined by their color differences. And the young lava flows, sitting up here, super dark, holding up these big caps, and then really young lava flows that are extra dark.

Pogue: And if you had IR, different spectral bands of IR, think of all you could get out of it.

Gibson: We got some surface features there, in the center there, that run left and right. No, higher up. No, down a little - to the right. There - the darker stuff which is right above. They're all perfectly lined up. And they parallel. The color frontal was on there, too.

Carr: Roughly paralleling this thing where it seems to be changing its direction.

Gibson: But you also have a very sharp contrast in color which runs left-right, parallel to that also.

Pogue: It's just about the lower center.

Carr: First thing you say is "Hey, look at that line right there that comes in here, disappears here, and comes out here." And then you say, "Hey, that's something, a line down here," and all of a sudden you can say, "What have you got there? That one you can't see from up here, but you can see from over there."

Muehlberger: I'm in the trees -- I'm standing too close to it.

Carr: There's definitely that line there and it picks up right over here, and then from the back of the room you get sort of a line here, almost parallelogram. And then you get up close and look how... the rocks are folded. It begins to look like you got some real jamming going on there.

Gibson: Well, one inch right above that, you had some circular features which run parallel.

Carr: That's what you thought?

Gibson: Yeah, there's five of them that run right across there.

Carr: But when you get up close and look at these rocks, you can see the rocks look like they're kind of smeared in the direction of ... you've got smearing of the mountains here, and down here there's

sort of a smearing effect, around this corner.

Muehlberger: Remember how the Red Sea spreads apart here, and the direction of motion is roughly the way the pointers are going now? And up at the upper end of this, where it goes up the Gulf of Agaba through the Dead Sea to the Sea of Galliilee; in other words, this whole chunk of Saudi Arabia has been shoved up this way, the whole width -- the diagonal width of the Red Sea. And yet that ... where is all the shortening going on in the continent, because by the time you get up toward Turkey, you can go across the scenery there without crossing the big strike-slip faults. I suspect that what you're showing here is some of that twisting and mashing of this region that's accommodating shortening. Remember when we talked simple blocks -- rigid blocks moving around? When you look at the block itself, you find that periodically there's a band of stuff within it that does bad things.

Carr: You know, Bill, we also got what I thought was interesting photography down the east side of the Adriatic and on down into Arabia that really looked interesting. It looked like it connects things up, structured, all the way up into Europe down into Arabia.

Muehlberger: One of our faculty has spent a whole bunch of years working from Greece on up into Yugoslavia, and I have a sneaking hunch that he'll be able to use those to great benefit, and come up with some specific questions that maybe we can nail the next guys with to do something about. That is really the way the Alps and all those other ranges do funny twists and turns. It's a unique problem to try and solve. They need all the help they can get. This is to the right of the last one so this makes a neat stereo pair. The escarpment's standing up just lovely along the skyline. This is all visible salt lakes and here's a lava basin, and here's a string of big huge calderas, and there's the big black shield volcano... ... in the southern caldera. All of the ground surface from here is below sea level.

Pogue: That sure wasn't obvious looking at it.

Carr: It sure wasn't.

Gibson: Yeah, it sure wasn't. There was no water in it.

Ritchie: I just wanted to ask: Since that shows these central linears somewhat better than the previous ones, were they as obvious?

Carr: They were obvious. I remember seeing them, but the thing was, I

was focused on trying to get located around the graben and get you some more photography around the graben area. And I guess I didn't pay much attention to those central linears.

Pogue: Again, if we had been pre-briefed as to the variety of things to look for there .... You know, you see so much when you look -- you try to focus your attention on pre-briefed items.

Gibson: You really don't have much time when you go whistling over there -- 30 to 40 seconds is a good estimate and how long have we been talking about this picture? We're just now beginning to see the features. You've really got to know what you're looking for when you come up upon it.

Carr: That's why I think the ASTP guys should not allow themselves to get flooded with too many areas to focus on, because they don't have time to develop repetitive observations, so they better just focus on a few very important things and really bone up on them.

Muehlberger: The problem is weather -- so they'll probably have twice as many targets as they really will be able to get.

Carr: I don't think we did much for you in the Afar area, because I think you already had a lot of great stuff. We probably just added to some of it.

Muehlberger: This is a neat pair just by itself. If that was all you got, that's fantastic, because the stereo capability ... and there's some earlier views where these escarpments from a different angle... I've forgotten which angle, looking along it, they're really great.

Carr: We've got some 35 mm stuff -- I think our contribution was probably across the Red Sea there. We got a couple of sets of photography on that stuff there.

Query: Before we go up to the Dead Sea ... we didn't - just got a couple of photographs of other parts of the African rift system, and one question I wanted to ask you about. I didn't bring the photos because we didn't have that many -- there are several places along the rift system there that go from a highly symmetric narrow graben system to where it splays out kind of like the Afar area, and there are areas where it follows what are mapped as pre-Cambrian mobile zones, and then cuts across into the shield areas - granitic areas - and I was wondering if you could pick these out, or if you noticed these as you were flying over them? Or if you noticed any differences where it crossed from one type to another -- if you noticed any change in the pattern?

Pogue: Yes, I went right up the rift zone one morning, and although I had to take the picture out through the STS window, the weather was bad, and I noticed this. And I noticed it on subsequent passes, but if you get one good ascending pass up the rift zone, then after that you can start putting it all back together. That one pass, even though the weather was bad, enabled me to put everything in perspective. Another thing, the lakes ...

Carr: I never got that - Bill got that one, and I don't think Ed and I got that opportunity, so we're kind of ...

Pogue: The maps are all screwed up. The lakes are not the right shape. What we need ... if you could give us one good rift zone strip, with all the lakes the right shape and scale, it would sure help, because I was continually trying to ... you know, when you're flying, even using aeronautical charts and you look at the town, it's always wrong. But you got to just sort of use processes of elimination to identify it. And I was doing the same thing in that rift zone...trying to find myself in that.

Muehlberger: The thing that caught my eye on that Skylab II picture - looking north across the north half of Lake Baital and then comparing that

with the geographic maps that were available, including the set you carry with you -- they're wrong.

Pogue: Yes.

Muehlberger: And I think that, if nothing else, these are going to help our geography text a great deal, just to get things in the right damn place.

Pogue: But you're right, though; that is not a very clearly defined rift zone at all. It just keeps changing. And it widens out and gets messed up. Occasionally had that one or two little valleys there with a lake, west side of Victoria.

Carr: Yeah, a set of 70 mm stereo pairs right up the rift zone, like we did down in California that day would certainly be good.

Muehlberger: That would really be beautiful. Of course, that was the ideal dream. Weather, and the way the mission ran, got us to it too late, I guess.

Lenoir: We weren't smart enough to recognize when we were planning.

Muehlberger: Thinking early enough to really get the thing arranged, I guess, is what we lost out on there.

Brand: But that sets us up ahead for next time. One of you touched on maps, geographical maps. Do we need what you used? Do we need none but

just photographs of specific areas? What would you recommend?

Carr: Well, you need better maps than we had. I don't know if there are any better available, unless somebody sits down and starts on them. What we had is essentially, aeronautical maps. And, of course, we had all the runways on them -- all the airfields.

Pogue: But you do need maps, Vance, plus photographs.

Gibson: What was useful on those maps, though, was these folks had drawn in the major fault zones that we'd be looking for, and that was very useful.

Brand: Then I guess you're saying you don't need any political information to speak of on maps. You need purely something that duplicates what you see from the airways.

Silver: You want physiographic qualities.

Carr: That's really more important - graphs of some education guidance...

Silver: And perhaps some vegetation guidance in there.

Gibson: It helps to have cities and rivers named so you have something to reference things to, but you don't really need all that.

Pogue: The political boundaries sometimes are useful, Vance, because a lot of times the agricultural practices in one country would be

different from another, and it's a real nice crutch. There's some of them that are very sharp delineations, where one country will have a good land use discipline and the other one won't.

Brand: Well, do you need a map that sort of gives you a three-dimensional impression, like, for example, on some road maps I've seen. For example, there's one that shows a blowup of Rocky Mountain National Park that gives you a three-dimensional impression of what the mountains are like. Do you need something like that?

Carr: Yes, that sure would be good.

Pogue: Some of the people ... we're coming up with some other lecture, Bill. There are people concerned with this because I was talking to some of the people over at that party the other night that are all bent out of shape in this very area. Shading ... the new types of shading to give you the eyeball appearance of what the Earth's going to look like from orbit. And that would be neat, plus the relief, of course, they can put the relief in there, too.

Brand: Okay. So maybe a shaded relief map with some political information would be pretty good. Plus, I suppose, you need something to ... the overall chart of the Earth with a slider map - you need one of those?

Carr: Yeah.

Pogue: Yeah.

Silver: If I may make a comment -- for many of these regions there are no shaded relief maps which have the detail, the accuracy of detail that you'd like. It takes an enormous amount of effort to get an accurate shaded relief map. I'd like to say that a collection of the best photography with overlays and prominent things identified on them, might turn out to be the best use.

Gibson: Yeah, I think if you took the pictures you've had so far and put an overlay on with the fault zones on, they'd be very useful.

Carr: Well, with the political stuff on it, too. Cities, you do need.

Gibson: Sure.

Pogue: I still think you do need a map to tie it all ...

Muehlberger: That gives you the overall framework, or would that be for the local scenes?

Brand: Local, in a hell of a big sense.

Pogue: The point's well taken, though. If I'd had a rift zone in pictures when I went up the first time, I could have gotten 10 times as much good data.

Carr: I tell you, some of the drawings you guys put in there were worth their weight in gold, too. The ones around the Bay of Fonseca and this Afar stuff was really great, because you could - with your simple line sketches you pointed out where the main features were.

Gibson: I think southern California, too, and Baja.

Pogue: But the line sketch of the rift zone screwed me up. If I'd had photographs with it, I'd have been in business.

Muehlberger: The rift zone sketches exaggerate terrifically, because they're just trying to show you the rift zone.

Carr: Well, that's right. All the line sketches ...

Muehlberger: But they don't tell you which is the big side or which is the low side of a rift zone, because both of those little hatchered lines are the same size.

Carr: But they certainly are good supplementary information to go with what you got in the way of either maps or photographs.

Vance: Any map book that we would have for tying things together, since it would be used in the command module instead of a big room like you had in the SWS would be -- have to be smaller than what you had, don't you think?

Carr: I think it could safely be smaller than what we had, because I think a lot of the maps that we had were bigger than we needed.

Gibson: It was tough to work with, to some extent...

Pogue: You can chop 3 inches off the top and bottom of this.

Carr: But that map there is certainly ...

Gibson: Is this the one we really flew with?

Carr: No, this one's got metal in it.

Gibson: Yeah, we didn't have metallic in ours, did we?

Pogue: Yeah, this is an exact copy ...

Gibson: Is that right? I thought it was ... It had cardboard all the way through it; it felt so light.

Muehlberger: Listen, can we go on to the next slide?

Pogue: There you go.

Muehlberger: Sea of Galilee, huh?

Muehlberger: Sea of Gallilee. Yeah, we are jumping clear to the other end of the Sinai where things should be dying out. I think you spotted by your looks along the Saudi Arabian coast side the significant anomaly on that whole coast. To the best of my knowledge, you guys ... That's the one you saw in the earlier pictures. And I guess you've heard

of the Golan Heights? That whole line of volcanoes they keep fighting over. Here's the north end of the big fault zone in which the bright side mound has been moving northward. And down, if you measure it in the Red Sea, you're doing it on the order of 100 miles of motion. And this is the region where it looks like it's dying and now I guess particularly what we're interested in is what you might have been seeing and might have been thinking. This thing could have extended off the particular pictures. That continues off to the south. There's a little cloud patch. It makes a neat stereo pair, incidentally.

Gibson: What's the speckling in the upper part of that?

Muehlberger: In here? Over here? I assume they are little cultivated areas.

Gibson: Shell holes.

Muehlberger: They're awful big shell holes, if that's what they are, because there's a whole volcano. Most of the stuff they're firing would just make pock marks on the volcanoes. So that's bigger than the atom bomb size, so let's not go with those.

Silver: Can I ask about the color validity on that photography?

Carr: Who took these? I didn't.

Pogue: I don't remember.

Gibson: I don't remember. My own impression ...

Wilmarth: These are EREP.

Muehlberger: No. They are Skylab 3, not 4. In other words, you didn't take this pair, but you had some 35s and things that covered various blocks of this, I'm reasonably certain.

Pogue: Because I sure didn't remember taking those.

Muehlberger: No, you didn't.

Gibson: I don't remember seeing that area with that much color contrast.

Gibson: You may at low Sun angle, but I don't recall seeing it that way.

Muehlberger: You were dealing with the seasonal differences. You ran through it during their wintertime, which would be all the vegetation down. Therefore, the green cast would have been out of this.

Gibson: That must have been it, because I just don't remember ever seeing anywhere near that contrast, this bleached.

Pogue: What is this sort of a circular feature here? I guess that's not an oasis.

Muehlberger: Except there's a river going around, and the vegetation on the other side outlines a nice circular ...

Pogue: You see, we had another feature that we saw like this in Wisconsin, and it was only ... we were not able to see that due to snow ... relief induced by snowfall.

Muehlberger: Well, the only ... that got us to the maps because nobody had ever reported a meteorite crater there, and I think they told you what it was. It's a bowl-shaped bottom, very broad, shallow syncline, and the erosion has left the sandstone standing up as a ridge all the way around it, and the rivers have actually done the thing of going around it. And that's what gave that prominence. Then when you dust it with snow, it's especially visible. I don't know what that circular thing is. But the ... one of the interesting kinds of things is: here are these diagonal diamond-shaped broken-up patterns of countries similar to those we saw at the other end of the Alpine Fault zone, at the north end, comparing, but on a smaller scale, And then these things that are bending and breaking out may just simply be all separate faults similar to the ones at the north end of the Alpine Ridge spreading away from a single, big fault zone. And a comparative kind of thing on that would have been really nice, but, again, we weren't up to speed to have been able to spot it out

to ask for how these things might relate to it.

Gibson: There was some 35-millimeter out of SL-3 .

Muehlberger: There was one, yeah. This is the EREP, I guess.

Ritchie: We haven't any mountains. You don't have anything other than...

Muehlberger: We've got a bunch that we can look at in single frames, or we can take that pair and ... I think they're mounted such in glass slides that we could look at it in stereo right now without any trouble. It's time to switch scenes here.

Wilmarth: ...Afar related ... politicians over there. I think we ought to push on.

Muehlberger: You're looking north.

Ritchie: The one thing that struck me about these photographs, and I wanted to ask you if it was apparent to you is that there appears to be a northwest trending linear pattern going through there, particularly where the mountains bend. I just wondered if you happened to notice them, or if they were as obvious to you in visual observation as they appear to be?

Gibson: Let's see where you're saying that again, please,

Muehlberger: Right through here.

Pogue: I didn't notice.

Gibson: That's such a short segment of it.

Muehlberger: Go to the next one. Here's a band of country where everything seems to go crosswise; whereas, very prominent other features are running lengthwise down the thing, particularly this thing.

Carr: These are all evening shots, aren't they? They were in our morning, I think it was just when we were approaching ...

Gibson: That's such a short segment that you've pointed out there that I'm not sure that it would be the kind of thing that would stand out in your mind.

Pogue: The thing that impressed me in the Caucasus is ... I don't know if I'm seeing it here or not .. but there was one good, real well-defined major fault zone running, as you'd expect, along the length of the mountains. And I don't see it nearly as well.

Carr: I think it pretty well followed the one you had sketched on the map. I didn't even notice that cross up there. It's apparent, too. It just jumps out at you. That's the beauty of low Sun angle and snow. It really brings out the relief.

Muehlberger: We've had trouble getting photography that's designed for geology.

It's always designed for making topographic maps or that stuff so it's always high Sun and no snow. Both of those things you just pointed out are just great to enhance ...

Carr: Some of the photography we took in the Cascades and the northern Rockies, too, was all morning stuff, and boy, that was just breath-taking. I don't know how good the photography turned out, but I remember the magnificent views we saw going over that area -- Vancouver Island and looking up to the north.

Gibson: It's also why, early in the mission, you've got some beautiful pictures of Outer Mongolia, as if anyone really is interested, because it just looked so beautiful, it really jumped out at you. So much relief in the Sun angle we were seeing in that and in the snow.

Pogue: Beautiful from a geologic standpoint. It sure looked like the end of the Earth when you looked down at it. Man alive! Think of somebody scratching a living out there.

Muehlberger: Beautiful shearing going on in the clouds.

Carr: I've got a hunch that that may have been one of the reasons why that picture was taken, too.

Muehlberger: The shearing is off to the left of this still, too.

Carr: Well, I tell you, there were so many things to get excited about to take pictures of. We got some good pictures in, I guess it was, Greece and that area, of those roll clouds.

Pogue: Oh yes, Cyprus. Ed took them one morning -- the most beautiful set of roll clouds I've ever seen.

Carr: Got to thinking later -- I wonder if there was any good geology down there that you could see, too.

Muehlberger: Oh yeah. Cyprus is a doozer, but not only those clouds... Okay, why don't we turn on the lights - maybe we ought to take a 5-minute break ...

Carr: The Atlas Mountains ... we tried to take some ...

Muehlberger: Oh yeah, the Atlas. The big hangup is, we haven't looked at them enough to think - use your time fruitfully on some of these things. The Atlas and the Anti-Atlas, you got some doozers. You ran across through Spain and Portugal and took a strip in the Alps; that was spectacular set of things in there, but again, we haven't devoted the time to be able to do anything.

Carr: That was a rare day in Southern Europe. That's the day that we got

the Pyrenees and Valencia and all that area.

Muehlberger: And one of your obliques takes in all of central Europe, all the way through the bend in the Carpathians.

Gibson: One thing, we still have a tough time putting a finger on that we could, any one of us, look out the window and just see a small plot of ground and know what we were over, whether it was Africa or Australia, the United States. I don't know what it was, and I'm still trying to identify the characteristics ... whether it was color --

Carr: I think the color had a lot to do with it.

Gibson: You'd see a little reddish sand blowing; you could say you were right over Africa -- northern part of Africa.

Muehlberger: We get that feeling, too, because I can go through these reels now, and I've looked at so many, I think I'm starting to do what you're doing.

Gibson: It became very obvious after a little while. We used to always get out the slider map and try to figure out where we were, but then pretty soon you could tell at a glance roughly what country you were over but not exactly where.

Muehlberger: Can you describe that any better?

Gibson: I guess the texture.

Carr: Color and texture have a lot to do with it.

Gibson: For example, the jungles of South America and Brazil just was ... and cloud patterns -- in Brazil you could look out and you saw a jungle with cloud streaks that just went on forever; you knew you were over Brazil.

Carr: The only place you could ever confuse that area with was South Africa. Down there in the jungle area.

Gibson: Australia, especially the populated farmlands of Australia, always stood out there. The quiltwork pattern of farmlands which were not green, as we mentioned here, but more tan, brown, different shades of those colors. You can still see it even in these pictures, as bad as they are. Africa seemed to have a reddish ... it was not a uniform red, but seemed to have streaks.

Carr: Wind erosion is so very evident.

Gibson: Very apparent. You just cannot see that in other deserts.

Muehlberger: What about other crews giving color values, since they were there in different seasons?

Carr: Some of them might not have changed at all.

Wilmarth: You develop an inherent color classification system for red, green, bluish green.

Carr: Another area we never got to look at ... you were interested in the area of that big triangle around Tokyo. And the only place that was ever clear was Tokyo itself, but you get back to the mountains and you couldn't see it. And that one volcano up in northern Honshu... never saw it. It was forever under clouds.

Muehlberger: Volcano crowd is probably unhappy with that.

Carr: But let's see -- we got some real good, interesting pictures of Kamchatka. I would have liked to have taken more photography of that area -- the mountains and the color.

Pogue. The west half was okay; the east half was always cloudy. If I remember correctly, Kamchatka ...

Silver: Can I ask a question that has to do with this problem of how to make the best use of man up there -- and you pointed out that in many cases these photographs aren't as effective - because they're oblique - as the EREP photography has been. Do you think that there are arguments in favor of your being able to bring EREP cameras to bear?

Carr: Yes sir.

Silver: In other words, to add to the arsenal of what we've got, your opportunity is to say, here's a place where it's worth shooting.

Carr: One point we made was that there ought to be ETC-type of camera, or an EREP-type of camera permanently mounted in the spacecraft pointing down, available for pictures on an opportune basis.

Pogue: Preferably with some reasonable pointing capability. Toward the end of the mission we had flooding in northeastern Australia, the like of which they haven't had in years. And you could see engorged rivers, what looked to me like 500 miles inland. Wow! I tried to document this with 35-millimeter Nikon stuff, because that's all we had left. And I'm not expecting a whole lot, but if we'd had had the camera Ed was using where we could maybe have tilted it maybe 15 or 20 degrees, you know, either direction, then the detail would have been on the order of a magnitude better.

Carr: I guess they're really paying the price now for that drought because now that they got the water, it's all running along, just taking all the topsoil out and dumping it in the Gulf of Carpentaria.

Gibson: And you would like to be able to point your whole viewing assembly

to a given area, whether it be the Earth terrain camera, the infrared camera, the microwave setup, the whole works.

Carr: What you're talking about is an Earth observatory.

Gibson: But you know, we did that identical thing with the Sun, where you've got 5, 6 instruments and you just slew around where you want and take pictures of all different wavelengths, choosing your target. No reason you can't do the same with the Earth. People are used to looking at the Sun -- they're not used to looking at the Earth.

Brand: Another question is .. this is kind of to geologists. Out of what we see here, do we know now 80 per cent of the things ASTP should look at ... follow on the way ... or is this dependent on further analysis of photographs and things like that?

Muehlberger: I don't think we know 80 per cent yet, because we haven't even had a chance to look at 80 per cent of the photographs.

Silver: You have to remember that the first time you looked at any of these photos was last Tuesday.

Lenoir: See, these guys haven't seen one single Nikon photograph. It's still hung up with the Interagency Affairs Office in Washington.

Brand: Out of the debriefing, I presume there will come a certain number

of things where, like you said, "Well, this is an area where, if we'd known you were interested in that..." - it's a logical thing for the next mission. So we can pick up those things out of this debriefing, but there will be a lot of things over the next year...

Muehlberger: We've picked topics to talk to for which we've had the photos for a week, so we've had something concrete to talk with. Several of the things that we were after specifically for this mission that we haven't mentioned at all. Central America is one good "for instance" for our stuff, for which there is quite a lot of Nikon photography. So we can't really discuss that topic. The question of looking on the other side of the Red Sea just turned up a fantastic thing. So obviously, that's going to be of continuing interest to us. Maybe we can't get the gas to go look at it and you'll be the guys that get to go. Maybe Farouk can get us in.

El-Baz: Even not considering the photography at all, from the visual description alone, I'm sure that questions and the things that were said, answered many questions and also opened new fields for us on things to look at that we were not aware of or things that

will add a great deal to what we had.

Muehlberger: And you can see how Atacama Fault problem has grown beyond the story that we thought we had in following it to the south. This doctorate that we just got our hands on describes a chunk of it and, in effect, he says the same things. Here are some of these curved faults and it's not a good strike-slip fault zone today -- it has these cross structures and it's doing other kinds of things. It's suffering transformation in its lifestyle much like the Alpine Fault has been doing.

Silver: It seems to me, with the date for launch for ASTP fixed and with the time of the year and everything, the number of passes that you should have the beginnings of the matrix which will start selecting those possible areas in which you will look for targets of opportunity. And because there are so few passes per se, you're going to have to build all this into the selection. We may have a number of excellent things that you just never have ... lighting, daytime passes, or things like that ... weather.

Carr: Knowing what season you're going to be over an area, if you know the weather's not any good, there's no sense in messing with it.

Silver: But I would say that it's extremely important to factor the constraints which presently exist - the launch dates - everything else into searching for the most effective use of ASTP, and to start planning now how to bring together all the things that need to be brought together far enough ahead to be ready. ...need to start very soon.

Muehlberger: There's two optimum view angles - one's the low Sun and the other is nearly vertical Sun. And they bring out different kinds of things, so that if you're going over a spot at high noon, we'd probably be asking for different kinds of things than if you're going over it at low Sun angle that emphasizes relief.

Carr: Another thing, in oceanography, for instance, any time we start seeing sunglint, we grab a camera because you never know what's going to pop in and it's only going to be there for a few seconds in sunglint. And you're starting to reach for the camera as soon as you see the old sunglint moving in the water.

Muehlberger: Our stuff isn't that dynamic. It moves 2 inches a year and I don't think it'll give you glint.

Gibson: But it is in terms of how you can see it. In other words, you

might just be passing along and all of a sudden see a fault zone -- and it all of a sudden pops out -- and 10 seconds later, it's gone again.

Muehlberger: That was the hopes that you would be lining up on some of these things; that's why we're asking the obliques along with these things.

Carr: But you know, these Earth observation guys were beginning to develop their own Mafia over there in the MOCR, which was doing a pretty good job of getting the information up. That's what it takes over there. It's like what the solar guys said -- they had a good ATM backroom, and a good Mafia, and they had lots of hustle, and these guys were getting there near the end. And ...

Slayton: Yeah, we're going to be at the end when we get started. You got to recognize that.

Carr: If they're not organized and ready to go when you guys launch, they're not going to be much use to you.

Muehlberger: We better have a simulation to find out where everybody's sitting, much less who does what to whom. (Laughter)

Slayton: Our biggest problem will be lack of spacecraft time, not crew time. We got plenty of crew time. We're going to pay hell finding time

to get a window pointed where you can look out at all.

Brand: And, unfortunately, since it's a competition between visual sightings, and other experiment pointing, the Program Office wants to know right away what blocks Farouk wants.

Muehlberger: How about all of it? That makes it simple. (Laughter)

Lenoir: Yeah, start with 12 hours a day and then back off to 8.

Slayton: I think the way to attack this if you want to make any money at all is to start in with the assumption of relative.... receptive on everything else and see what's left. Do anything other than that... you're not going to end up with much.

Lenoir: Seems to me on a lot of these things we've discussed here today, you can put down on paper what it is you hope to get out of it and start trying to justify it that way. And I was talking with Deke earlier, a lot of the attitude constraints that you have now are for this experiment or that experiment and right now they've got the attitude tied up because, frankly, they asked for it first. Well, first is not necessarily best -- rarely is. And, I don't think you ought to give up with just what you get the first try, but to go to the wall and battle.

Carr: Well, it's a matter of stature, too. It's a matter of how much stature your experiment has, and I think Earth observation is gaining stature and it's going to command more time than it's probably got planned right now.

Brand: Okay, but one other aspect is -- I just read the mission requirement document over the weekend and I think it's got SO or MA-48, which is a pointing experiment, listed as first in priority and visual sightings either 10th or 11th. If that doesn't get changed, we've been wasting our time.

Query: That's right.

Query: That's right.

Query: That's right.

Brand: So that's a significant point.

Query: Okay, PI, get busy.

Silver: That raises a real gut basic question ... at least we have to get back to. We have to get back to the question of what our major objectives are and what we really hope we can get out of visual sighting. We can't kid ourselves about it. And one of the things I think we need to get from Skylab IV crew is some real hard words

about how to make the best use of that in this case. And, of course, we all ... the science is going to have to speak for itself ... the judgments come out of it. But right now, we're hardly in a position, I think, to use you most effectively on the science questions because we haven't even looked at the photos.

Carr: Yeah.

Silver: That timing is unfortunate....

Carr: What's emerging out of this is the same old thing we've always known. You get out of an experiment in orbit exactly what you put into it in preparation.

Silver: Yeah, in preparation. Right.

Carr: And we put some preparation into this one and we're starting to harvest a few benefits from it. The next time we better put some more preparation into it.

Gibson: I guess, in general terms, what you get out of it, is you get some selectivity of your data acquisition. Hopefully, this selectivity is going to give you information you can't get otherwise. If you can get it by airplane or by hoofing around on the ground with a reasonable amount of effort, then maybe we're wasting our time by

doing it from orbit. But, I don't think so. I think we're getting lots of information you can't get any other way. And it's useful.

Silver: Seems to me that's one thing that we should focus on very hard in the next month or two -- trying to define those selected areas where we've been most effective, where a degree of preparation and your selectivity has been effective. Find out ... analyze why it's been effective and factor that back out again. That's...

Gibson: Again, I think that we were just getting smart there about midway and half way through the mission on how to do this and why, even after the ASTP is ... what that says is, you got to really get smart from the beginning before you lift off, or certainly for future missions after that. There's so much more that can be done; we were just scratching the surface. We were just doing this part time.

Carr: Yeah.

Wilmarth: I think that basically is the objective of the whole report that we've got planned to get out; certainly the preliminary one which is due the first of April is going to be highlighted. And then the one which is going to be put out by, or completed by, the

first of July is going to be much more comprehensive, based on review of the ... I'll say evaluation ... of the transparencies, taking some of the data, and working with you people, and looking ahead as to how the data are used. In other words, what's the science input, and each of the team members will be preparing their own individual report, which is an assessment of the science inputs and the science accomplishments, both from a photo documentation and your observations, as well as your recall and inputs like that. So we'll know, from that standpoint, the areas, or topics, or problems, or features that will be optimized by observations and photo documentations on both a short term, a specific problem, as well as on a longer or building-block type thing. I hate to go to ATM like that, but that's exactly what they did. They did a building-block type thing and that's exactly what I think Earth observation is.

Carr: I'll tell you, there's a lot of satisfaction in being able to use your own initiative and your own creativity to do something, than to sit up there and look at a watch and punch buttons on time. There's no personal satisfaction in that at all and you can do

as well with a satellite on that kind of stuff. But when you've got the guy who's trained and can think and pick out interesting things and do something about them, that's when you're really paying off and that - that's what makes flying the mission worthwhile, too. I'll tell you, visual observation was one of the most enjoyable things we did up there. And it makes all that 84 days a whole lot more worthwhile than if we'd had nothing else to do but Earth resources and EREP and ATM and medical. It really made it more interesting for us and we looked forward to what we were doing. This to me is the most exciting part of the whole debriefing is what we've done today and what we're looking forward to in the next week and a half.

Lenoir: I had some questions here. We've talked about the way each time you learned a little bit more and looked a little bit deeper. It appeared to me that you never really passed over any given area - talking geology right now - and saw the same thing you saw before. You never saturated, so to speak, at any time in the 84 days. Is that - would you say that's true?

Pogue: Different every time.

Gibson: I always felt we were just beginning.

Carr: You begin to develop your little benchmarks, you know, going over, for instance, Agua Blanca, the old K brand, the running K brand. I'd see that down there and I'd start working off from that, just kind of radiating out from a benchmark that I knew and pretty soon I got so I recognized San Quintin and I'd start working between those two. And it was the same sort of thing down in New Zealand, the old spur, Christchurch and that area. We would get a couple of benchmarks and then you'd start radiating out from these benchmarks and looking at things.

Gibson: Things were always different. You'd see a different Sun angle and you'd see it at a different angle. And one variable, we didn't work with variables very much, was looking at it with different filters. When I was running S063 we had a good haze filter on there and that really cut out the ... just did what it was designed to do ... cut out the haze and you could see all the relief on the ground a heck of a lot better and clouds stood out exceptionally well - everything just very good contrast. I wish we had worked with that a little bit more.

Lenoir: Short of giving you a lot more time, just free time to just look out of the window, what could we have done on the ground differently to help you in geology?

Pogue: One of the things, is we could ask questions, for example, in Texas, to the - around the hill country, if you're over El Paso, or northern Mexico and looking to the east, there's a very, very suspicious arch in the south central Texas. I would have liked to ask the question, is this a significant thing? I took a couple of pictures of it, but bad pictures because ...

Muehlberger: Balcones Fault zone.

Pogue: Is that what it is?

Muehlberger: It marks where everything in the interior is stable and all the rest is tipped toward the Gulf and just filled in one layer after the other to where...

Pogue: We were briefed on that and we couldn't have been briefed on everything, but you see, for instance, you were seeing that... you'd look and you'd see it. It would be nice if you could ask questions. A lot of times you'd see things that — the rule is, if you see it and it impresses you, take a picture of it. We

knew that, but at the same time, you always were wondering, "Is what I'm seeing a significant thing - can I - if I focus more attention on it now, I'll be able to get a better view of it than maybe on a subsequent pass and get it from a different angle and all.

Gibson: A single factor, which if I had this whole thing to do over again two years before launch is -- I'd get that book done earlier and I'd memorize it because it's so important when you come over a site that you know what you're going to be looking for. You don't have time to read the book and look at that, take photos, and make observations and all that simultaneously. You really got to know it cold.

Silver: I'd pick up some points in there. I could see you picking up speed on many of these items. At no point, however, or very few points, did it seem to me that you felt compelled - and I think probably with justification - to come to a set of conclusions. That is having had the problem defined and the questions asked and the task there for you guys to say, "Okay, I guess from all of this, I can say the following thing." We never really built

that into the flight procedures of the flight protocol in there and the question is, how do we integrate and sum up these 5 passes? I was trying to get at this a little earlier.

Carr: Yeah.

Silver: And I'm very anxious for that sort of thing to happen, because I have the feeling that it doesn't happen largely because you're novices in the geological interpretation field. You're tentative, and you perhaps feel that it's inappropriate to shoot your mouth off, or stick your neck out. I think that's wrong. I think it's very important for you to have the confidence that what you see, you know you see and nobody can take it away from you.

Carr: Well, one of the problems is the matter of what you said, summing up the data...

Silver: Yeah.

Carr: ...and getting it together and looking at it. Because when you're up there, the data is kind of all going out and you don't get much opportunity to gather and sum it up again. And that's where something like uplink/downlink television again, we keep harping on that, but that's a hell of a good way for you and I to talk

about, say, the Agua Blanca Fault, because I can send down all this data, and I might have a television camera hooked into my Earth observation, my Earth observatory, give you a little television and you and your guys can sit down there and work up a spiel and send me up a 15-minute dissertation in a cassette....

Carr: ...to say, "look here's the stuff that you've been talking about and we think that this is the case, what do you think" And we can work that way. Up and downlink TV, I think is going to be a very, very powerful tool where you get the visuals in with the audio communications link.

Muehlberger: In addition, you can have a whole stable of experts sitting there helping you when you need it.

Carr: Sure. I think that - that's in the future, but it's certainly a good way to get you your data - sum it up, and have a bull session about what it looks like it means.

Silver: I certainly agree that a collective effort would probably mean more than the individual effort in reaching some sort of effective conclusion. At the same time, when the practical situation does not permit you to do it, I think you guys did very well in just

drawing your own conclusions. And even though they may, in the end, let's say, some end conclusion may be wrong, all the positive things that you've used in building that argument retain their merit. And I'm saying this mostly for the benefit of the ASTP guys. Don't hesitate to draw your conclusions even if in the end they're wrong. If you're saying the things that you see that are in there, go ahead and shoot, and we'll filter out the logic of the arguments and the other things. But I do like to see you come to those conclusions because one of the consequences is this thing you were talking about, Ed, and that is, if you come to that conclusion, then we can groundlink up and say, "Well, if what you say is true, there ought to be a consequence, and you ought to look for such and such and such." And we go through the scientific process of testing that first-stage conclusion. You're the only guys who can come up with a preliminary working hypothesis.

Carr: Yeah. Another thing that, of course, works against this sort of idea is the fact that everything is so fragmented and piecemeal for us. You know, we whip over one part of the world at once, and then you don't expect to be there 5 days later, and if the

weather is good, you might get another look at it. But meanwhile, between then you're thinking of a million other things, and you're looking at a million other geologic features that garbage your mind all up.

Muehlberger: ...that's the toughest part of all...

Carr: Because of that, I think we begin to take on the role, "Well, I'm going to be a sophisticated sensor and observer here, and I'm going to feed the data down to them, but I'm going to try not to draw too many conclusions because I got too much ... data going on in my head.

Silver: If the backroom were putting your things together and then fired up a sort of an intermediate conclusion for you to test, that would have helped you?

Carr: It certainly would. Yes.

Silver: It would have helped you.

Gibson: Yeah, ASTP probably is going to be faced with that same thing.

Silver: Okay.

Carr: I don't know. They're on such a short fuse.

Silver: With real-time...do you have that much going on, or...

Gibson: You're not limited by experiment, you're limited by pointing, so maybe you got more time to be thinking about ... if you...

Pogue: ...Hey, is this...

Gibson: ...maybe you'll be able to do more...

Muehlberger: We've got lots of crew time available...

Carr: If you spotted ... you'd have time to ...

Gibson: That's good, that's interesting stuff...

Carr: Like the great Minnesota feature, you know, that...

Muehlberger: Right - yeah.

Carr: That really had us interested.

Pogue: ...and...Mexico City...

Carr: Yeah, that circular feature north of Mexico City, too.

Lenoir: Jerry, if you took, say, the VHF and split that off as a science channel so that whenever you had ground contact, you could have talked with the vis ops team, or the appropriate guy that was around at the time ... scientist ... would that have made a big difference, do you think?

Carr: I would think so, yeah.

Lenoir: So that you could have talked in real time, gotten an answer back

now, and then done something about it. That also is a potential lesson to ASTP because it's the same kind of command module with potentially more ground contact.

Brand: Yeah, that's a good idea. Another question is: just how would you arrange ... if you were to go up again on an ASTP mission, just how would you want to organize discussions with the ground? For example, let's say you had what Bill had; would you still want to have a daily conference? And how about debriefing passes? Would you want to do that on a daily basis, or would you want to...

Carr: If you could, I would do it. Because you can get that stuff done and out of your mind, and open your mind to the next thing you're going to do, and you can get a little feedback going. But if you try to store it all up and bring it home and dump it, you got no feedback.

Brand: Maybe if you'd want to ... if you were available ... debrief it over the next site on VHF, then who would want to be talking to it, if you had a VHF channel. Would you want to be talking to ...

Carr: Someone like Bill, who's got access to all these people and that can feed the data to him. You know you can't necessarily spread

out to all the different regimens ... to all the different areas of interest because there's too many of them. But the thing is, if you get a knowledgeable guy who can sit there and talk to all these people and pull the whole thing together and talk to you, you can get a lot done. But it takes a special kind of guy, and Bill was that for us. He spent an awful lot of time over there learning all this stuff, and not only the solar stuff, but, you know, this visual ops stuff.

Lenoir: One of the problems here when you start talking about this being an all-the-time, up-and-down, is you wind up almost with a CAP COMM because he has to be there -- a science CAP COMM who has to be there all the time -- and then you run into problems right away because if you have to be there plugged in with the earphones on all the time, you don't have the time to go talk to everybody and get into it.

Carr: That's right. No, you'd have to ... you couldn't do it all the time; you'd have to ...

Brand: That leads you to a daily conference - debriefing...

Carr: Yeah, maybe twice a day.

Silver: That has to tailored to the situation.

Muehlberger: But you're still up, that might be some time to summarize on when the dark sides of the Earth passes -- update every few hours, if need be.

Wilmarth: Yeah, let me just comment on the ... let's say this ground support GSE-type thing that turns out to be a man-machine. Like on the first day, as you did vis ops, why it was real easy to keep up with it. But as you get into it, it takes just about 3 to 4 guys, all their time to keep up and plan and look ahead. It's almost as much as an...

Carr: Sure.

Wilmarth: EREP kind of activity, so I want to tell the ASTP people that the first day is your day and you've got to be prepared to search, evaluate the science downlink, what you're doing -- plan ahead. Because we goofed up a lot in the early part of the mission and said, "Oh well, we'll get to it later," and you can't do that. You've got really very definitely to know what your're going to get done each and every day.

Gibson: For instance, you almost know exactly what orbit ... at any given time.

Carr: Yeah.

Wilmarth: You've got to do it. Right? You've got to do it and practically should have ... I can say this for ... That weather forecast done for those ten days in advance, because that's the way you're going to have to work it.

Carr: .....

Wilmarth: I understand that, but that's true.

Carr: Hurry up.

Wilmarth: And it's very important, and I want to say that again. Be sure your staff on the ground is really up to speed and ready to go because that's very important.

Well, look, here we are at ...

Query: Let me ask one more question, here.

Wilmarth: Go ahead.

Query: During this Skylab, I know we sent up a lot of kinds of optional schedule ... you know ... opportunities with very little weather consideration going into the visual ops objectives of the schedule that went up. What was your impression of the way that worked ... as far as availability within the weather when they came up? Did you basically work to those or did you basically work upon ...

knowing what the objectives were and then catch them as you saw them?

Carr: No, We used those options. We tried to be, you know, on station whenever an optional came up, and I think you might have helped a little bit by ... if you'd have canceled the ones due to weather. If you'd have said, "Hey, the one that's due up in a half hour, the weather in that area looks like it's bad, so don't bother." Because then that takes the sweat off us of trying to get to a window at the right time to take it. And it was disappointing to make time in your schedule sheet in order to get to the window and then have the damn place clobbered in. So, if you can do some of that kind of sorting, it helps take some of the sweat off the crew, and they can just skip things.

Gibson: But, on the other hand, you were also operating in the mode of whenever you had some free time, you'd go over to the window, and I found that any five minutes at the window, you could always find something that was worthwhile to take data on whether it be ocean currents, weather, geology, heck, anything. There was a whole host of things going by there every moment and as long as

you ... that's why I was saying, if you memorize this book, then anytime you look out the window, you know what you're looking at and you know what's significant.

Query: That's one of the reasons I think it would be hard to get some hard justification on crew time in ASTP because you're always fighting that thing. You can say, "Okay, for this hour on the flight plan here I'm going to have attitude," and then you wind up ... you can't get the real objective you're planning for because the weather's ...

Carr: Yeah. Well, you could always get weather pictures, too, if nothing else, but that's true. That's something you're going to have to fight all the time, and that is, you get a block of time that's the only time available because of attitude constraints and then you find out that everything you're going over is socked in, or something like that. But you just got to keep batting your head against that one and do the best you can with it.

Query: The fact that your discussion on those Earth observation station... I think one of the key drivers we got of keeping something like that is the minimum prep time to take data, so you can do it on

essentially a real-time basis without a lot of investment in preparation.

Carr: Overhead time just kills you, no matter what the science is that you're trying to do.

Brand: It was that way on Apollo, too.

Carr: Yeah.

Wilmarth: Lee, do you have any further thoughts because it's - we're moving on down to the last 20 minutes and we want to optimize this the best we can. What do you have in the way of ...?

Silver: Well, I just have one thought; I've already seen enough from the photographs right now to tell me that there's some very good science in there, and I want to realize as much as there is out of the crew's impressions. And the crew may not think that they have positive inputs to make, but they do. I've already seen it in their comments that are making me approach the photographs more realistically. So, I do have this one comment - that I do think that in order to get the most out of vis ops, there has to be a higher degree of follow-on discussion and tie-in -- and after we've been able to do some of these things, we ought to be able to select ... don't want to waste

your time and make you go through the whole route we did, but we'd like to be able to select some prime things and then come back to you with it again. I think that's very important to us.

Carr: I think you're right, Lee. I think we ought to try and get that working.

Silver: Yeah.

Query: We're going to have to have ...

Muehlberger: Somewhere in your banquet circuit -- and you'll be in L.A. -- you ought to take an hour off and go see them; maybe you'll even get to Austin.

Pogue: I think we've seen enough...

Query: Hey, we won't tack it on to an existing trip, we'll generate a new one.

Muehlberger: Oh, yeah, yeah, then they can take that guided tour from L.A. to Houston. (Laughter)

Query: Yeah.

Wilmarth: Like I said before, one of the very important things that closed the whole loop is that we started a training program and went through it, and we did a mission; we developed a system. It worked;

we got the data. We're trying to get the science outputs from it, and you people have to play an important part in that follow-on activity, people. If not, then the whole goddamn training that was done, and what we've learned on the training, and what we've learned during the mission is going to get lost like it did on Apollo, and I'll say that in front of everybody here because the goddamn reports have never been written on how good the training acoomplished the objectives and how good the science was done. And I'll say that and I mean it.

El-Baz ...all of the previous science reports had a section on visual observations starting from Apollo 8 and ... Apollo 17...

Wilmarth: But your training program was followed and never written, Farouk, and I'll tell you that. The results of the training and the effects of ... and the impact of the training on the science and what was accomplished was never written.

Muehlberger: It's never been written for the ground forces either.

Wilmarth: It's never been written, I know that. But we're not going to let that happen on this one. We want the follow-on and completed program; I know that. So that's what we want to do; we want your help on it.

Muehlberger: Well, the astronauts' training program is being ...

Silver: Don't give up on the Apollo program; it's not all lost, Dick, believe me.

Wilmarth: Just put a book in front of me and I'll accept and apologize to everybody.

Query: Is there any ...

Muehlberger: Give us a year; we'll get the ground one,

Lenoir: Anybody see any use or advantage to ... we've talked about, say, overflying with the T-38 a couple of areas in training for ASTP and so on as familiarization more than anything else. Is there any advantage at this point of any of these 3 guys doing it again to look at things that they had already seen, or to actually get down and wander around in the rocks at this point?

Silver: I've been thinking about that, Bill, and from my point of view, I think maybe getting these guys on the ground in Baja might not be a bad stunt. And I'd like to do that. I can't do that on an official NASA basis; Deke will tell you why. (Laughter) But if those guys will come out to San Diego some time and just tour it with me, it's not that long to get down there, and then we'd be

able to do this business of scaling from up and down to see what the problems were of seeing features of various scales and trying to ... We'll have the photographs with us and look at some of these things and see what is realistic to expect from 100 miles up or 200 miles up.

Carr: Well, I think - that's great if we can work it in. I'd be delighted to do something like that, you know, within the system. As far as Deke and his guys are concerned, do you remember I was talking about how the technique of picking a benchmark and working from the benchmark. You guys don't have the luxury of being able to do that from space, but it seems to me that's where your T-38 could come in. If you've got some areas that are reachable by T-38, you can go out and locate your benchmarks.

Pogue: Yeah.

Carr: ...and work from them a little bit.

Slayton: Yeah. That's the problem.

Pogue: Not only that, but you got a different problem than we had in that you're going to ... you say you're going to be at a lower orbit; what's your altitude going to be, roughly?

Slayton: About 225 kilometers which is 100 -- it's 115, actually.

Query: Yeah.

Pogue: Okay, well then, you've got a problem right off.

Query: Goddamn...

Carr: I remember when we went, you know, right after the shaping burn, we went to a 90-mile perigee. I thought we were scraping our tailfeathers on the ground. (Laughter)

Pogue: What I mean is, you're going to have less time to look at the area, and you're going to have to concentrate more on getting these benchmarks that Jerry's talking about, because...

Carr: For an attack pilot, it's an IP; get your IPs in.

Pogue: This 30 seconds we were talking about, I'd say, would probably disappear down to 20 seconds.

Carr: Uh-huh. See, you're going to be able to see under clouds more, too. I noticed that on the 90-mile perigee passes, we could see under-clouds down there; whereas up at 235 we couldn't.

Pogue: Boy, it looks like you're 45,000 feet... It really looked weird.

Carr: Yeah, but you can see back under the clouds and see what's going on.

Query: ...top of the damn mountain. (Laughter)

Carr: And you can see all the little towns, too, which we can't see. All of a sudden, as we were whistling over some of these areas, we knew where the big towns were, and all of a sudden, there was a whole bunch of little towns in between, that you could see, and that kind of changes your outlook on things, I believe.

Silver: Well, you know, it may sound like there's a disadvantage in the shorter pass time, but, in fact, we ought to be thinking very seriously about what advantages that you have.

Pogue: That's right.

Silver: You gain some advantages.

Pogue: ... resolution for one thing.

Carr: Oh, Yeah.

Gibson: If you went whistling along Agua Blanca Fault now down at that altitude, we may be able to pick up some of these smaller features which are just not evident. You might be able to see over to the coastline.

Pogue: Not to mention the airfields for ancient astronauts. (Laughter)

Carr: I'll tell you, Bill and I broke our .... trying to see those things.

Pogue: We must have taken 50 pictures of the Plains of Nazca.

Carr: That's all right. When we were trying to find it for you to give you some better information, I dug back to Al Bean's s ff because, you know, he said, "Hey, I think I see it," and he got a whole bunch of Nikon 300's; he was right up the coast; he wasn't even close, but ...

Pogue: We had the right area, I know we had the right area. But I never saw...

Query: ....

Pogue: ...The little eagles and...

Carr: Yeah, there's a target that's 1 mile wide and 30 miles long. And that's a mother, I'll tell you.

Query: Yeah.

Pogue: Boy, that's a hard one to ... (Laughter)

Carr: I was sure looking for that spider

Pogue: You couldn't see the eagle on the ground.

Carr: I wanted to see that spider, and I couldn't find it.

Pogue: But I bet you will be able to see a heck of a lot more, particularly, you mentioned ... you were asking about the glaciers; I'm sure that you'll be able to see those glaciers just plain as day from that altitude.

Muehlberger: The really good surging glaciers are too far north for you. It might ... and that would be fun to get the overall views.

Pogue: You know, that's why - I knew that in the, you know, the fiords and everything and Norway and Sweden, that's way north of ... so when I started seeing glaciers, I was really surprised. And it was in the book all the time.

Wilmarth: Well, people, we've run through it, and I hope everybody's got what he needed. We're going to do a wrapup with Lee and his crew and Bill and his crew at 01:00 in here to kind of summarize. We'll do that for each and every one of the groups that come in for debriefing to summarize and get that typed up, and give you a copy of it.

Carr: Let me leave one other thing with you here, too. A bit of information that we need and that is, people are already starting to ask me, who do they go to and what do they do about getting some of the data that we've gathered, and I've had people from the petroleum industry and the gas -- natural gas -- industry already making inquiries of me. And I need to know where to steer these people and how to see about getting them interested and behind us,

because people with that kind of swat in Washington can certainly do the program a whole lot of good. And we certainly do ... the three of us need to know how to channel these people to the right folks and get results for them and not get them lost in the bureaucracy.

Pogue: I've got a further suggestion in that respect and that is there is no feedback from these cats. They all got good need for these pictures and everything, but I have never heard of them closing the loop back. They seem to -- they grab the pictures, they study them, and they shut their mouths, and they fire anybody that even opens their mouth about anything.

Gibson: That's called "making whoopee."

Silver: Well, you're talking about something that we university types who work -- or compete -- with those guys know very well.

Carr: ....involved in some....

Muehlberger: It's always a one-way deal with us, too.

Carr: Some feedback of some kind that are...

Silver: I think you have to put up with it, Bill. The idea is that that's one segment of the potential community, and you know that's the way

it's going to go, and ...

Pogue: But, well, okay, I guess I'm being unrealistic. If nothing else, they'd say, "We got good out of it."

Silver: That much they owe us.

Lenoir: Right - that's a good point. Although I think you make a good point, Jerry, I think the way the system is set up right now, it's not easy, as a matter of fact, it's very difficult for them to -- in a reasonable time -- put in a request and wind up with the photos in their hands. They don't even know what photos...

Muehlberger: It doesn't matter who requires the photos; it's unreasonably long.

Query: Yeah, I mean we don't have...

Gibson: ...a book put together of, say, the best 10 per cent of these photos, 20 per cent, which we had for the Gemini.

Carr: Yeah, the Gemini book is a real good book.

Query: ...the Gemini book, but there is not a book from Skylab.

Query: It just got done flying, man, you should know --

Carr: Well, I think there ought to be something.

Query: Yeah, I agree.

Lenoir: There will be a lot of these in the final report, but they will

be tied in with words and descriptions that refer back to that particular photo, in particular.

Muehlberger: What you guys have done is set up a thing wherein we can say, "Here is the regional geology of the world from Skylab." Lot of significant areas in the world.

Wilmarth: Look, let's get back to you on that.

Carr: Sure would like to. Yeah, please get back to us because they're starting to ask us, and we're going to have to tell people things, and...

Gibson: And Lee, we're going to get with you on two things. One is when you see these photos - the new ones ... chance to really go through this and then try and get ... Unfortunately, once we get out of the next 3 weeks or so, we're all going off in different directions on the peas and mashed potatoes circuit.

Silver: We'll just work with your schedule. I would like to see you once more before, let's say, the final report is due on this thing.

Carr: What's the time scale on that?

Wilmarth: 1 July.

Silver: We have to be pretty much organized by, let's say, 1 June, in

order to give it to him by 15 June, so he can have it by 1 July, and that sort of thing.

Gibson: ...work it in.

Wilmarth: As soon as we can get the dupes and get it to them, they review it and science it, we'll get back to you people on the specific problems, specific questions and set up through some arrangements to get the teams back in. It's just, you know, we're just going to have to do that. Because we don't have the dupes and the 35's for the other teams, as well as for the geology. So we're going to have to do that. That's a tight schedule...

Carr: One opportunity we have to get with Lee and the folks on the West Coast is we're going to be - in Mid-May, we've got a swing through Downey and Huntington Beach to pay our respects to the people who built the bird. And this is an opportunity to spend a half a day together.

Silver: Let's not waste it. Okay.

Carr: We can add a half a day or something like that; it's an opportunity to talk about it. Yeah, things get real tight.

Lenoir: Yeah, I already know that.

Wilmarth: Let's see what we can work out....Ed.

Gibson: Can I ask you about ... we're working towards ASTP, and that's the intermediate thing which we ought to be, but to do this job right and whatever future program comes up, space station, if we ever get it evolved, or even maybe Space Lab, are we working towards getting an observatory - Earth observatory - like we've mentioned? And can we actually get this concept pushed into the system and made a real, viable, useful thing to do in everybody's mind?

Carr: Well, I think that was essentially what we're doing.

Gibson: That's what we're trying to get organized.

Silver: Is there a place in the vis ops section for crews' comments and recommendations? ... crew report? Part of this will be your pilot's report, and part of this should be focused ... for vis ops ...

Wilmarth: Someone ought to put that into their vis ops report, and there's going to be also a section which is directed entirely to ASTP on our recommendations to the ASTP and their program of visual sitings and things like that. In other words, the kinds of things that we see are important to work on from what we have learned in SL-4.

Gibson: Well, my concern is that they're ... going to be talking vis-ops and then picture some guy with a little Brownie sitting in front of a window and they're going to be talking Earth resources, which is this whole battery of equipment run by the ground, and they'll never bring the two together.

Muehlberger: ...some way we could get those words into one little phrase.

Gibson: ...and get people thinking on an Earth observatory which combines the two of them. We're saying it, but I'm not sure that it's just not going to keep falling on deaf ears.

Muehlberger: What you're talking about, Ed, is interlocking man with that battery and putting ... rather than just turning the switch on and off.

Lenoir: Turn the EREP over to the crew and let the ground ...

Gibson: That's right.

Muehlberger: How about manned Earth ops?

Silver: I think EREP has to be planned beforehand, and some of it has to be pre-programmed, but in order to really appreciate what you can do with Earth ops, you can't think of the Earth ops without thinking of what's been done EREP-wise at the same time with these things, and that's one thing that Bill and I are stressing. We're trying

very hard to see the photos you take in the light of what is available right now in the way of already taken EREP photography, and there's always this...

Gibson: We can't expect to do anywhere near as good as EREP; we don't have the camera gear. I mean, we had our ETC for EREP, and we had a little Nikon.

Silver: You may not be able to take the same quality of photography, but your opportunities in terms of lighting, angle, and approach is a very, very different thing. And you get some dimensions that are simply not very obvious.

Gibson: ...take that into account, yes.

Silver: That's the ... that you're talking about.

Gibson: That's right.

Muehlberger: You're putting them both together so that you get the maximum out of any frame that's taken.

Gibson: Let the ground specify the EREP pass in the same way they have been, but also let the guy have the targets of opportunity available to him also.

Wilmarth: Okay, any other comments or questions?

Silver: I was going to do a little looking on those reels, if you guys have any time, we could go through the ...

MS: Okay.

Wilmarth: Okay, why don't we adjourn and then you guys can...

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