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TITLE: STRUCTURAL AND LITHOLOGIC STUDY OF NORTHERN COAST RANGE AND SACRAMENTO VALLEY, CALIFORNIA

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Significant Results:

The first ERTS-1 data was not received by the Principal Investigator until October 23, 1972.

Preliminary analysis of the data received has disclosed two potentially important northwest-trending systems of linear features within the Northern California Coast Ranges. A third system, which trends northeast, can be traced with great uncertainty across the alluviated part of the Sacramento Valley and into the foothills of the Sierra Nevada. These linear features may represent fault systems or zones of shearing because topographic offset and stratigraphic disruption can be seen along one or two of the lineations. One of the systems of linear features is parallel or subparallel with the San Andreas fault and is confined to the Coastal belt (here referred to as the Coastal System). Another set, which acutely joins but does not appear to transect the Coastal System, is confined to the central part of the Coast Ranges. This system, the Central System, is less well defined but appears to be the chief influence on the structural and topographic grain of the terrain. The third set of linear features, the Valley System, trends northeasterly, about normal to the Central system. Stratigraphic offset and/or disruption of the Late Mesozoic sedimentary rocks along the western margin of the Sacramento Valley and in the western foothills of the Sierra Nevada can be seen on the imagery. Northeasterly trending linear elements, subparallel with the Valley System, can be detected within the alluviated part of the Sacramento Valley. These elements may reflect the continuation of the Valley System within the bedrock that floors the Sacramento Valley. The Valley System has not been recognized heretofore. Because of the limited imagery coverage received so far, the extent of these linear features or their tectonic significance cannot be ascertained.

Of interest, although not as yet verified, is the observation that some of the mercury concentrations and some of the geothermally active areas of California may be located at the intersection of the Central and the Valley Systems. This suggests that detailed analysis of the Valley System has become an important aspect of the investigation.

One, and perhaps two, stratigraphic unconformities within the Late Mesozoic sedimentary rocks were detected during preliminary examination of the imagery; however, more careful analysis of subsequent imagery and field examination is required to verify this preliminary interpretation.

A heretofore unrecognized, large circular depression, about 15 km in diameter, was detected within the alluviated part of the Sacramento Valley (Scene 1094-18231). The depression is adjacent to, and about 2 km southwest of, a large laccolithic intrusion (Marysville Butte) and may be geologically related to this intrusion. Although several geologic and geomorphic reasons can be postulated to explain this feature, such as caldera collapse, subsidence adjacent to oil fields, or differential compaction of post-Pleistocene alluvial deposits, no verifiable explanation is possible at this time. Changes in the photogeologic characteristics of this feature will continue to be monitored.

Data Analysis Plan:

a) Planned Schedule - The following is a tentative schedule of work on the project for the remainder of the investigation. The investigation has been divided into several tasks, some of which may proceed concurrently. These tasks are:

Task I - Delineate linear features detectable on ERTS-1 imagery and transfer onto a standard base map at a scale of 1:1,000,000 or 1:500,000

Task II - Determine photogeologic characteristics on ERTS imagery of known rock types in the various microclimates and monitor changes in characteristics with changes in season.

Task III - Delineate stratigraphic data on base maps prepared in Task I and plot known mercury deposits and other known ore deposits, and thermal steam areas on base map.

Task IV - Field check selected areas to verify or modify interpretations made from ERTS imagery.

Task V - Correlate geologic and climatic data obtained from ERTS and from underflights with published data to verify accuracy and reliability of interpretation.

Task VI - Preparation of final report.

These tasks are tentatively scheduled as follows:

Dates	Tasks to be performed
Dec. 1972 through Mar. 73	Tasks I, II
Mar. 1973 through June 73	Tasks II, III
June 1973 through Sept. 73	Tasks II, III, IV
Sept. 1973 through Dec. 73	Tasks V, VI

b) Changes in ERTS data requirements: Because of nature of investigation, bulk color composite paper prints in 9 x 5 inch format are requested on a standing order basis.

Problems:

No serious investigative problems have been encountered during the first few months of operation.

The equipment necessary to produce color composites from the 70 mm positive transparencies is not readily available to the project but this lack has not been detrimental to the progress of the investigation, so far. However, it is anticipated that the lack of the ability to produce in-house color composites (by projection or otherwise) will hinder the full evaluation of the imagery in the future. During the initial phase of the project, standard NDFP bulk color products for each scene were requested on a standing order basis to be used for comparison with the B&W positive transparencies, for rapid comparison of images obtained during the various orbits, and for field work. The change to retrospective order for color composites is time consuming and may result in some delays in the investigation.

The Principal Investigator has looked into various alternatives; but the costs of commercially available viewing systems or of "buying time" on locally available industrial equipment is fiscally prohibitive. Other avenues of obtaining this capability are continually being explored, as well as means of obtaining image enhancement of critical scenes. If it is possible, it would be advantageous to the project to obtain bulk color composites of each scene on a standing order basis.

The announcement by NASA (December 19, 1972) to supply data only once per season will seriously handicap the project. The experience of the Principal Investigator and preliminary examination of available ERTS-1 imagery suggests that seasonal variation in the vegetative cover is closely related to the type of bedrock and that the changes, or differences, in the character of vegetation that occurs just <u>at</u> the time of seasonal change is of utmost importance. For example, extrusive volcanic rocks and sandstone have similar photo characteristics during both the wet and dry seasons in California; however, subtle, but distinct differences in photo characteristics can be observed within the relatively short period of time during the change from wet to dry or dry to wet season. The original request and existing standing order was specifically designed to acquire data during these specified times.

Accomplishments:

Prior to receipt of ERTS-1 data, several sets of U-2, high altitude, multiband imagery of the southern part of the project area were obtained through the courtesy of NASA Ames Research Center. This imagery was critically examined to determine the photogeologic characteristics of rock types under varying climatic conditions. From both the in-the-field experience of the Principal Investigator and from independent examination of the U-2 imagery by the Research Assistant, it was ascertained that it would be possible, and most profitable, to differentiate only three gross rock types, namely, sedimentary rocks, extrusive volcanic rocks, and serpentinite. Recognition of these three rock types on the ERTS-1 imagery was thought to yield maximum results and, if it were possible, to subdivide these gross rock types into specific units, this could be done only after critical examination of ERTS-1 data. As a consequence, a set of photo criteria, for each bandwidth of ERTS-1, was established and is summarized on the accompanying tables. Geologic structural data, which depends in part on an entirely different kind of photo criteria, were not studied in detail on the U-2 imagery.

The first ERTS-1 data was received October 23, 1972 and included orbits 1056 thru 1060. To date imagery includes 4 sets of passes (Nos. 56-60, 74-76, 93-96 112-114). Although only semi-qualitative analysis has been possible so far, gross structural patterns may be discerned (See: Significant Results); however, because of the seasonal differences between the U-2 and the ERTS-1 imagery presently on hand, no direct correlation of rock types is unequivocally possible. However, within the areas familiar to the Principal Investigator, differences may be detected - the full significance of which will depend on subsequent ERTS-1 data.

Analysis of the data has involved the use of the B&W positive transparencies of three band widths - MSS 4, 5 and 6. Color composites and enhancement capability have not been available to the project (See section: Problems); however, bands 5 and 6 appear to be the most useful for the project. Band 4 has unquestioned value in seasonal evaluation and as conformation of the data obtained from the other bands. Tentatively, band 4 will be critical to the project for the analysis of data during

TABLE 1. Gray-tone or color characteristics of various rock types observed on U-2 imagery. Abbreviations Serp. (s), serpentinite; Volc (v) extrusive volcanic rocks; lt. sed.(ls), light colored sedimentary rocks, dk. sed. (ds) dark colored sedimentary rocks, (a) alluvium. Tones based on ISCC-NBS color system.

Wavelth.	Rock type	General color	Tone	Differences from other units: Lighter	Same	Darker than
475-575	serp.	med. grey	lt. med. grey	v,ds		ls, a
	volc.	dk. grey	dk. dk. grey		ds	s,a,ls
	lt. sed.	white	white	s,v,ds	a	
	dk. sed.	dk. grey	dk. grey		v	s, ls, a
580-680	serp.	dk. grey	med. grey-dk. dk. grey	v,ds		ls,a
	volc.	very dk. grey	very dk. grey		ds	s,a,ls
	lt. sed.	white	white	s,ds,v	a	
	dk. sed.	dk. grey	dk. dk. grey		v	s,a,ls
690-760	serp.	med. grey	med. grey	a	v,ds,ls	
	volc.	med. grey	med. grey	a	s,ds,ls	
	lt. sed.	med. grey	med. grey	a	s,v,ds	
	dk. sed.	med. grey	med. grey	a	s,v,ls	
color	serp.	pink	grey purplish pink	v,a,ds		ls
	volc.	green	med. green-dk green		ds,a	s,ls
	lt. sed.	pink	pink grey	v,s,a,ds		
	dk. sed.	green	lt. green-dk. green		v,a	s,ls
color IR	serp.	greenish pink	pink white, red grey, lt. grey green	ds,v,a		ls
	volc.	dk. maroon-dk. red	deep red, med. red, dk. red			s,a,ls,ds
	lt. sed.	lt. pink	lt.-dk. purplish pink	ds,s,v,a		
	dk. sed.	red	deep pink, med. pink, strong red, very red	v		s,a,ls

TABLE 2. Geomorphic criteria of various rock types observed on U-2 imagery.

		Serpentine (s)	Volcanics (v)	Sediments (ls & ds)
Relief	1)regional	ridges	ridges(gen. higher than s.)	ridge & valley, gen.lower than s. or v.
	2)on unit	gently rolling	rugged	rugged, some rounded
Drainage	1)density	mostly low some medium	med. (higher than s.)	med. (higher than s.)
	2)pattern	dendritic	dendritic	dendritic and annular
	3)stream fill	a few valley fills	a few valley fills	more fill than s. or v.
	4)stream age	youthful	youthful, a few mature	youth to late youth
Veg.	1)type	brush	pine	diciduous and shrubs
	2)density	medium to high	high	low in ls., med. in ds.
Outcrop	1)structure	several bounding faults	some flows	bedding,more continuous than s
	2)shape	elongated N-S(often 1 st. side)	more massive than s.	elongated along N-S strike

seasonal changes (e.g. from dry to wet and from wet to dry seasons). No image enhancement has been attempted, to date; but it is anticipated that enhancement techniques will be used at a later date. An effort will be made to "buy time" on commercially available equipment, if fiscally possible.

The quality of the ERTS-1 data is excellent. Although there appears to be some variation in densities from orbit to orbit, this in no way has proved detrimental to the investigation.