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RELATION OF ERTS-1 DETECTED GEOLOGIC STRUCTURE TO KNOWN ECONOMIC ORE DEPOSITS

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ABSTRACT

A preliminary analysis of ERTS-1 imagery of the Northern Coast Ranges and Sacramento Valley, California, has disclosed a potentially important fracture system which may be one of the controlling factors in the location of known mercury deposits in the Coast Ranges and which appears to be associated with some of the oil and gas fields within the Sacramento Valley. Recognition of this fracture system may prove to be an extremely useful exploration tool, hence careful analysis of subsequent ERTS imagery might delineate areas for field evaluation.

INTRODUCTION

The intent of this report is to summarize, in a preliminary way, the regional geologic structure of the Northern Coast Range and Sacramento Valley, California and to suggest a possible relation between the geologic structure and known occurrences of mercury, hot springs (geothermally active areas), and some of the oil and gas fields of northern California. The area covered by the study includes all of northwestern California, extending from the latitude of San Francisco Bay on the south, to the California-Oregon border on the north, and the Pacific Ocean on the west, to the western foothills of the Sierra Nevada on the east (figure 1).

The original objective for examining the ERTS imagery was to determine the feasibility of detecting gross lithologic and structural data from satellite imagery. In preparation for the examination of the satellite imagery, ERTS-compatible photographs were obtained from NASA, U-2 aircraft underflights, which were flown in conjunction with an on-going environmental study of the San Francisco Bay Region by the U.S. Geological Survey. These photos were taken at varying time intervals during 1970 to 1972 and under various climatic conditions. In addition, the photographs from a single stereo-strip along the 39th parallel, extending from the Pacific Ocean to the crest of the Sierras, a distance of about 320 km (200 miles), were flown for another ERTS investigator and copies were made available to the project. From these various sets of photographs, visual interpretive criteria were developed for each multispectral bandwidth and,

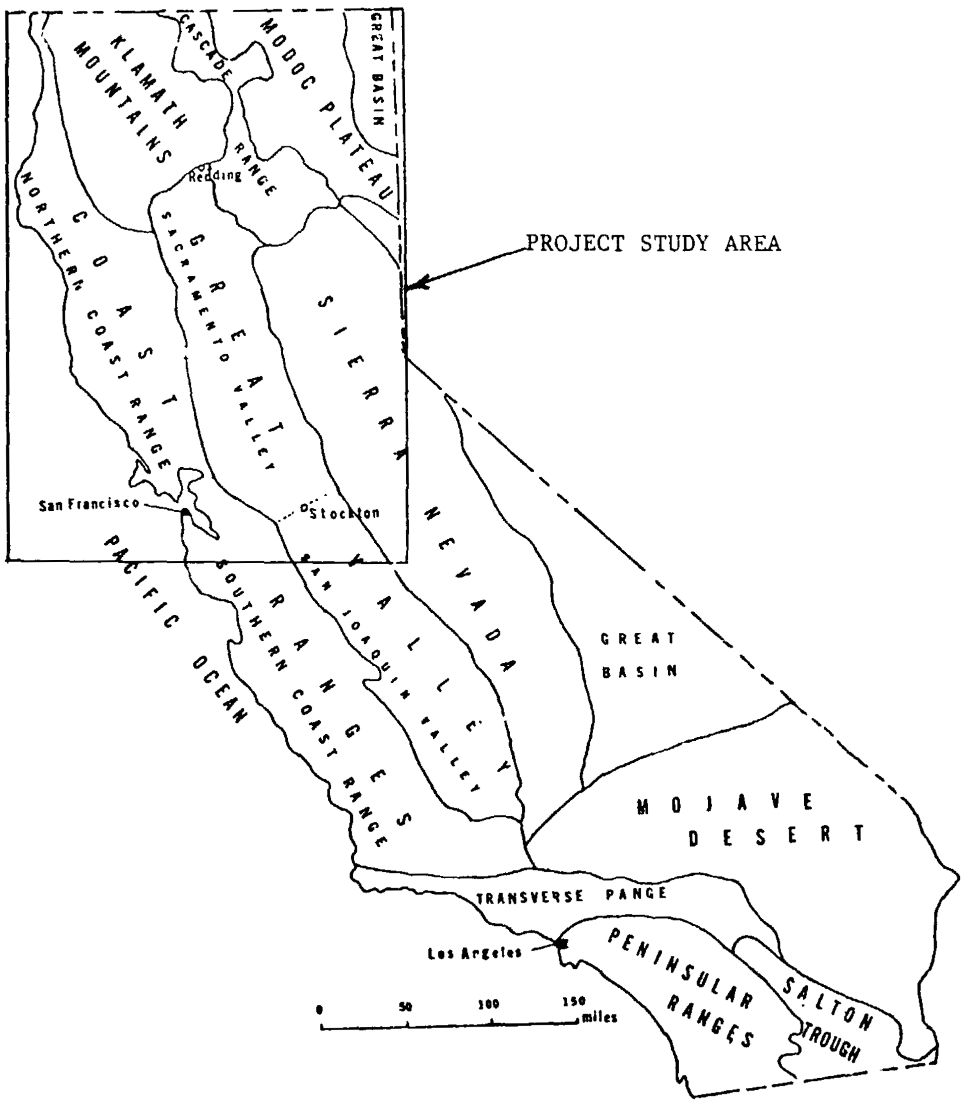

FIGURE I

OUTLINE MAP OF CALIFORNIA SHOWING PHYSIOGRAPHIC PROVINCES within the limits of the available photography, the photo-characteristics of the various rock types under seasonally different climatic conditions were evaluated and recorded for later use. Data from these underflights suggested that the objective of the project could be best served by grouping the wide variety of lithologic types within the area into three broadly defined lithologic groups: 1) ultramafic igneous rock, including peridotite, serpentinized peridotite, and serpentinite; 2) extrusive volcanic rocks, including andesitic-basalt contained within the late Mesozoic Franciscan assemblage, rhyo-dacitic flows of the Pliocene to Recent Sonoma-Clear Lake volcanic fields, and Pliocene to recent basaltic volcanic flows of the Modoc Plateau (northeastern California); and 3) sedimentary rocks, including the late Mesozoic marine sedimentary rocks of the Great Valley sequence, Tertiary marine and nonmarine sedimentary rocks along the margins of the Sacramento Valley and parts of the coastal belt, and recent unconsolidated sediments, such as the alluvium within the Sacramento Valley and along the major drainages.

Reliable lithologic identification depends, to a large extent, on relating the photogeologic criteria to vegetation changes, which occur on the various lithologic groups, during the annual seasonal changes (wet to dry season and/or dry to wet season). ERTS data for all of these time periods are not presently available. A regional geologic structural interpretation has been made from the available ERTS imagery, independent of the lithologic data, and is presented here. Undoubtedly the structural interpretations will need to be modified when the lithologic groups can be more clearly identified.

The regional geologic structure was not studied in detail during the preliminary preparatory stage of the project as it was believed that the structural features could be independently evaluated. After receipt of the first ERTS-1 imagery, the frames were carefully analyzed and the chief geologic structural elements were recorded. Each frame was enlarged and the geologic data transferred to a topographic base map of northern California (1:500,000 scale). Data on the locations of mineral and fuel deposits were obtained from resource maps published by the California Division of Mines and Geology.

GEOLOGIC STRUCTURES

The geologic structure of the Coast Ranges is extremely complex and poorly understood. Recent ideas based on plate tectonics, or seafloor spreading, attribute the structural complexity (mélange-style deformation) to the piling-up of oceanic-plate material along a subduction zone associated with a late Mesozoic trench (Ernst, 1970). The coeval marine sedimentary rocks of the Great Valley sequence are little deformed and are thought to have been derived from a Sierran arc and to have been deposited in a late Mesozoic "arch-trench gap" which probably existed between the Coast Range Trench and the Sierran Arc (Dickinson and Rich, 1972).

A preliminary examination of ERTS imagery disclosed three potentially important systems of linear features within the Coast Ranges which may represent fault systems or shear zones inasmuch as topographic offset and stratigraphic disruption can be seen along some of the lineations (figure 2). Some of the linear features shown on figure 2 represent bedding traces, or unusual alignment of topographic features, and still others have no presently known explanation.

One of the systems is subparallel to the San Andreas fault and is confined to the Pacific coastal belt (Coastal System). Another set of lineations (the Central System), which at their northern terminus acutely join but do not transect the Coastal System, is confined to the core of the Coast Ranges. It is less well defined but it appears to be the chief control for the structural and topographic grain of the terrain. These two systems can be seen on figure 3 (ERTS-1, Frame No. 1094-18231-MSS-6). The third set of linear features (the Valley System) has not been clearly recognized heretofore. It trends north or northeasterly, at obtuse angles to the Central System, and one or two lineations within this system can be discontinuously traced from the core of the Coast Range across the alluviated part of the Sacramento Valley into the foothills of the Sierra Nevada, figure 4 (ERTS-1, Frame No. 1075-1870-MSS-5). Stratigraphic disruption of the late Mesozoic Great Valley sequence along the western margin of the Sacramento Valley (figure 4), is, in part, associated with the Valley System. Linear elements subparallel to the Valley System, can be detected in the Coast Ranges and the alluviated part of the Sacramento Valley. Within the Sacramento Valley, they may reflect the continuation of the Valley System within the bedrock that floors the Valley. In the northern part of the area the Valley System is roughly parallel to the off-shore Mendocino Escarpment and its landward extension.

The ERTS imagery of the Klamath Mountains and Modoc Plateau of northern California and southern Oregon have not been completely evaluated at this time; hence, some of the trends of the linear features in the northern part of the California Coast Ranges, shown on figure 2, may reflect the influence of these two large geologic features.

The locations of known mercury deposits and northern California oil and gas fields have been plotted on the map (figure 2). Some of the mercury deposits, recent volcanism, as well as some of the geothermally active areas near Clear Lake, in the Coast Ranges, are along the Valley System or at the intersection of the Central and Valley systems; however, other mercury deposits seem to be more clearly related to the Central System, or appear to show no direct relation to the linear systems. This preliminary review suggests, however, that recognition of the linear systems may prove to be an extremely valuable exploration tool.

All of the oil and gas fields in northern California are beneath the alluviated part of the Sacramento Valley. The locations of some of these fields are closely associated with some of the linear elements in the Valley System and others with the linear elements of the Central System. A thorough analysis of the published data is underway in order to determine the subsurface control in each of the fields. If the relations reported here prove reliable, the analysis of ERTS imagery may suggest other areas for mineral fuel exploration.

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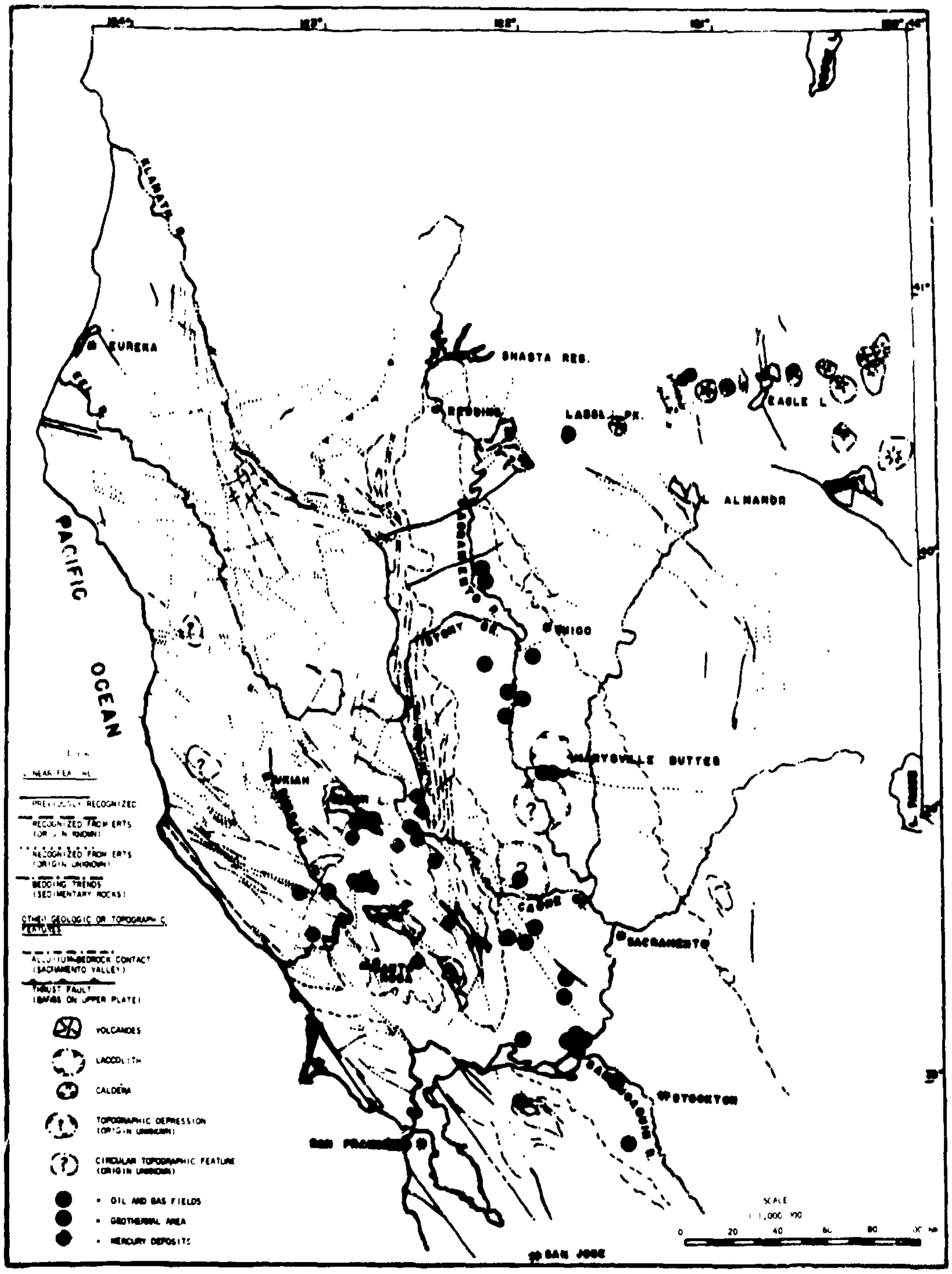

FIG. 2. MAP OF NORTHERN COAST RANGES AND SACRAMENTO VALLEY, CALIFORNIA SHOWING ERTS-RECOGNIZED GEOLOGIC STRUCTURES.

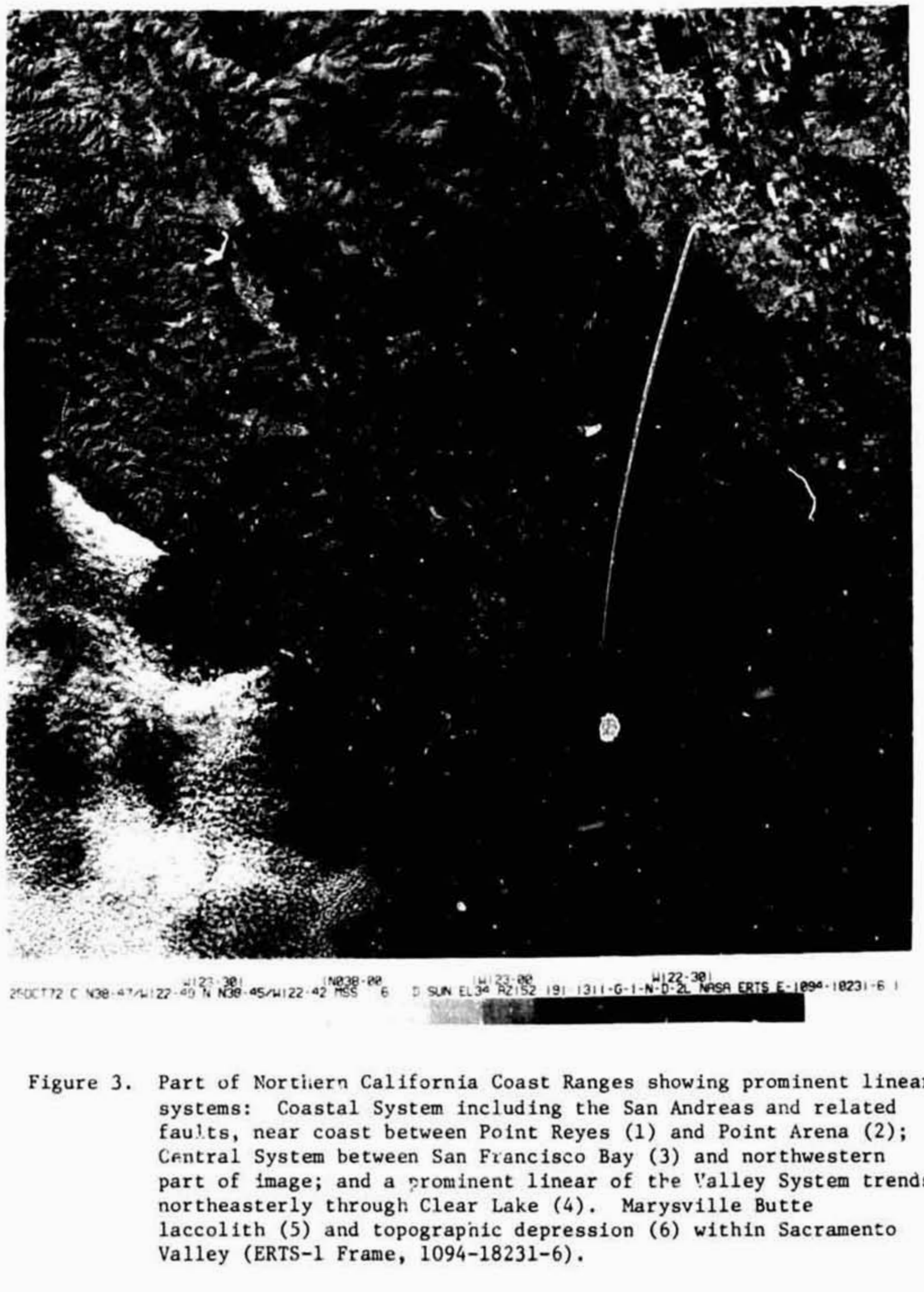

Figure 3. Part of Northern California Coast Ranges showing prominent linear systems: Coastal System including the San Andreas and related faults, near coast between Point Reyes (1) and Point Arena (2); Central System between San Francisco Bay (3) and northwestern part of image; and a prominent linear of the Valley System trends northeasterly through Clear Lake (4). Marysville Butte laccolith (5) and topographic depression (6) within Sacramento Valley (ERTS-1 Frame, 1094-18231-6).

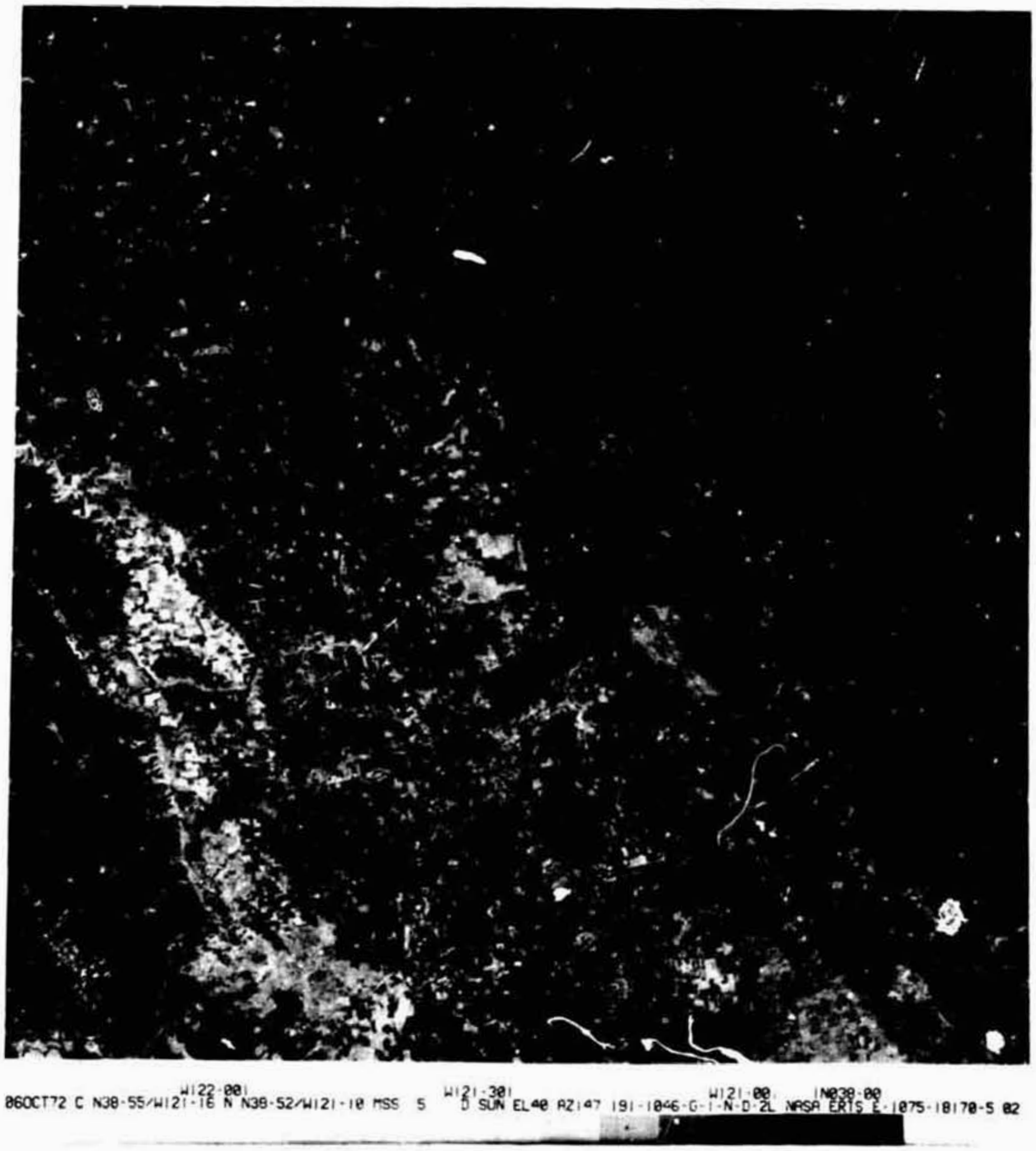

Figure 4. Part of Sacramento Valley and Sierra Nevada foothill belt showing extension of the Central System into the Valley alluvium near Lake Berryessa (1) and a prominent linear of the Valley System through Marysville Buttes laccolith (2). Circular topographic depression-caldera? (3). See figure 2 for details (ERTS-1 Frame, 1075-18170-5).