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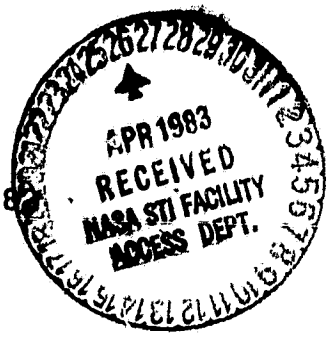
Neotectonics of the San Andreas Fault System - Basin and Range Province Juncture

NASA Grant NAG 5-177



Progress Report

1 May 1981 - 30 October 1982

Submitted by:

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Neotectonics of the San Andreas Fault System - Basin and Range Province Juncture

Introduction

This report briefly summarizes the progress of research at the University of California, Santa Barbara, on National Aeronautics and Space Administration Grant NAG 5-177. As part of the NASA Geodynamics Program, the ultimate objective of our study is an improved understanding of the development, active processes, and tectonic interplay of the southern San Andreas fault system and the Basin and Range province. Structured as a three-to-four year study, our investigation to date (1 May 1981 - 31 October 1982) has consisted of data acquisition and evaluation, technique development, and image interpretation and mapping. These efforts are briefly discussed below, as are some preliminary indications of potentially significant geologic findings and our current thinking on future research directions. Figure 1 shows the location and extent of our study area.

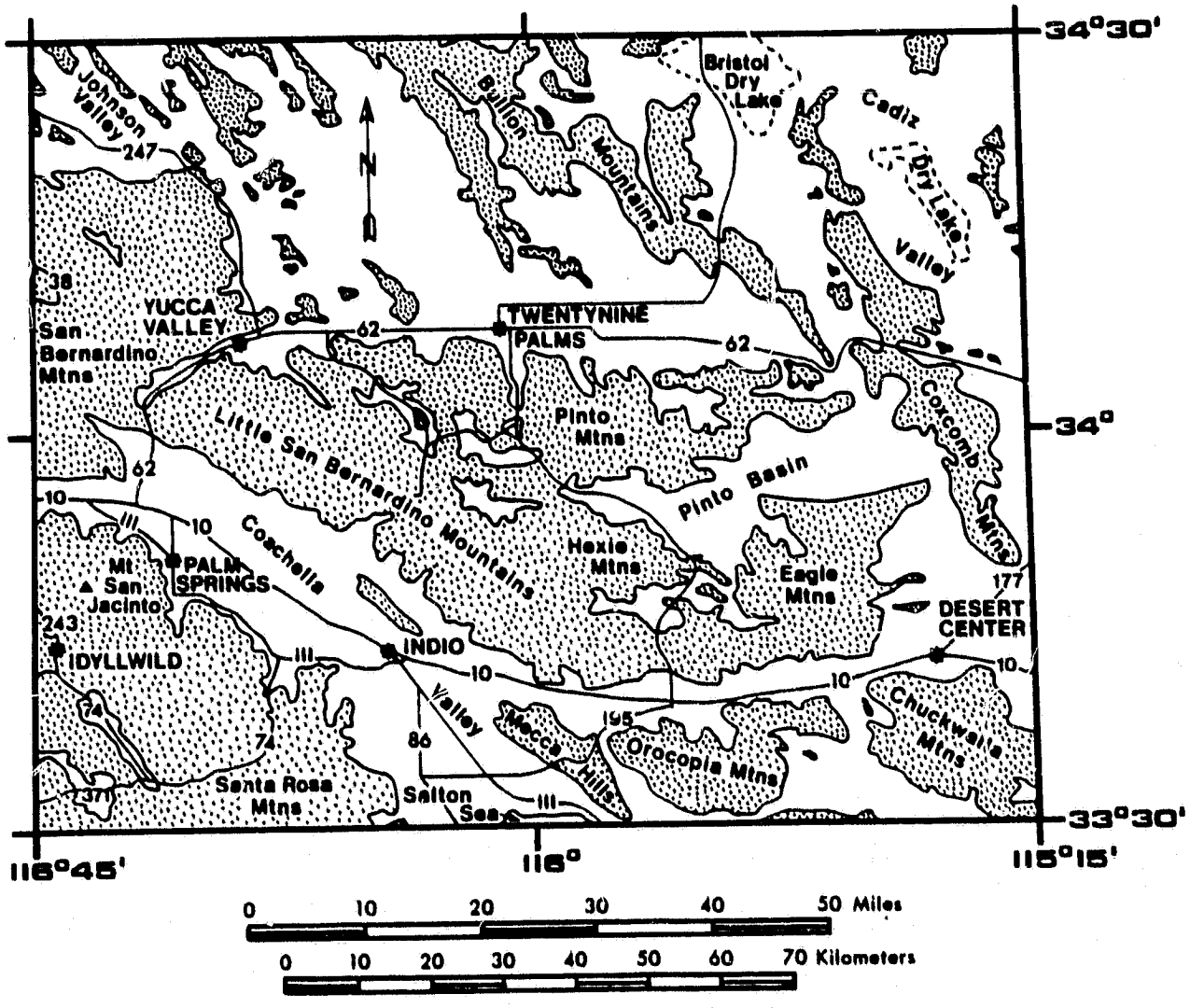
Data Acquisition and Evaluation

Primary data types to be used throughout the term of our project consist of digital Landsat, Seasat, and Heat Capacity Mapping Mission (HCMM) orbital imagery, digital and analog topographic data, high-resolution aerial photography,

Figure 1

STUDY AREA LOCATION INDEX

Selected Towns, Physiographic Features, and Major Highways Indicated



and seismic and other geophysical data. Most of these data resources have been acquired and are in active use by project personnel. Others are being acquired or accessed as specific project needs arise.

Project Landsat coverage consists of two consecutive (continuously recorded) scenes, acquired 25 November 1977 by Landsat-2. Careful evaluation of all available Landsat coverage preceded the selection of these scenes. Their outstanding atmospheric clarity, seasonal aspects (sun angle and vegetation), specific swath location, and objective data quality justified our wait for their production as CCTs by NASA Goddard.

Seasat synthetic aperture radar coverage consists of the Pisgah scene (revolution #882, 27 August 1978) and its southeastward continuation, a newly-produced scene covering the heart of our study area. The latter scene was requested from NASA Headquarters specifically for this study and has been digitally processed by NASA Jet Propulsion Laboratory. The northeast look-direction of this Seasat swath provides across-trend enhancement of structural features, especially those traversing alluvial plains and other low-relief terrain. In such areas Seasat imagery appears to provide significant information that is complimentary to the detail seen in the northwestwardly illuminated Landsat imagery.

HCMM coverage consists of a single night thermal digital scene (13 May 1978) acquired by the Heat Capacity Mapping Radiometer. This image displays significant feature patterns not evident on other imagery types. Boundaries between bedrock and alluviated areas appear much more distinct than on any of the reflectance Landsat bands, where signatures of detritus commonly blend with those of the neighboring parent bedrock. However, strong spatially-variable meteorological influences, such as temperature inversions, have been found to mask some of the petrologic information of the image.

High altitude U-2 imagery of our study area was inspected and studied at NASA Ames Research Center. Piecemeal coverage of various qualities was found to be available. We expect to request a new U-2 flight, scheduled so as to provide for minimal haze as well as a low sun angle. Such timing will enhance most of the tectonic and geomorphic features of importance in this study. Recent airborne photographic coverage has not been flown in the north central part of our study area, apparently due to the security restictions of the Twentynine Palms Marine Corps Training Center. Good quality Skylab stereo coverage is available, however, and this imagery was purchased to augment the Skylab imagery already available in our University collection.

Low altitude photographic coverage of much of our area has been obtained. Our first detailed study of this imagery, northwest of Twentynine Palms, has revealed numerous unmapped features of suspected neotectonic importance. These findings are discussed below.

Digital terrain ("arc-second") data of our study area has been obtained for quantitative topographic studies. Complete analog topographic map coverage of our study area has also be acquired.

Information regarding the availability of seismic and other geophysical data has been obtaiined from the California Institute of Technology and the National Geophysical and Solar-Terrestrial Data Center (NOAA/NGSDC, Boulder). Utilization of these data will largely come in the later stages of our study.

Literary Resources and Information Exchange

UCSB researchers have made a concerted effort during this first stage of our investigation to become fully aware of the previous and current research of others in and near our study area. Our desire to aggregate a variety of technical approaches has further added to the need for background information. Because of this, an extensive bibliography of geologic and methodological studies has been compiled. Currently this bibliography consists of more than 600 publications (primarily journal articles, symposium

proceedings, and government publications) and unpublished works (primarily graduate theses). In order to efficiently utilize and update such a large bibliography, a computerized referencing system was developed that provides access with "and/or/except" keywords, used in any combination and quantity. This system will continue to be heavily used throughout the study.

Interaction with other researchers has involved direct individual contacts and attendance at the meetings of the John Muir Geophysical Society, the American Society of Photogrammetry, the International Symposium on Machine Processing of Remotely Sensed Data, and the Geological Society of America (Cordilleran Section).

Geomorphometric and Computer Graphics Research

As an outgrowth of the research we are conducting on this project, a quantitative landform analysis technique has been developed that is applicable in the detection of topographic irregularities. A local measure of correlation between elevation and relief is used to detect deviations from "normal" fluvial concavity. Linear correlation is consistent with the logarithmic character of longitudinal stream profiles and has been found to be a close approximation to the general morphology of undisturbed alluviated areas. Deviations from strong positive

elevation-relief correlation indicate disruption of "normal" fluvial morphology by non-fluvial (presumably neotectonic) influences.

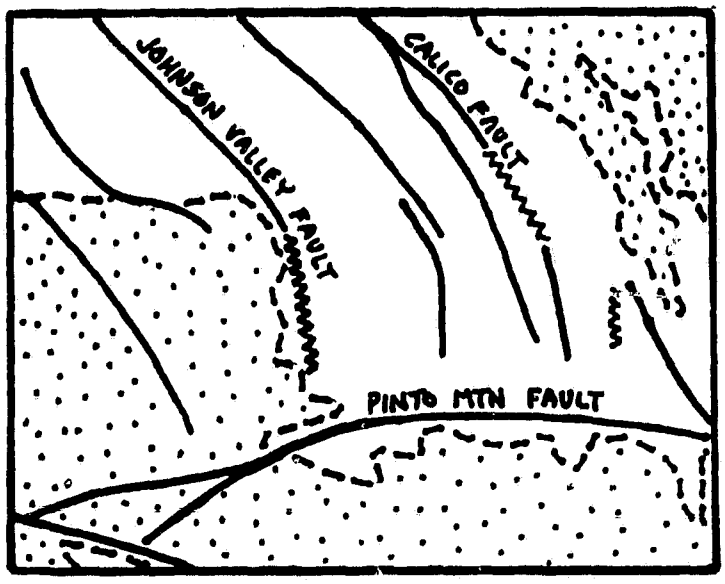
Testing of this technique at a test site outside our study area was successful in delineating the previously unrecognized surficial expression of a fault which was known from subsurface data. Application of the technique to the topographic information of our study area is forthcoming.

A true-perspective scene-depiction computer cartographic package has also been developed which will be used in analyzing and depicting tectonically significant geomorphic features. Each of the computer techniques shall be submitted to appropriate journals for publication in 1983.

Aerial Photographic Mapping

A preliminary analysis of the northwest quadrant of our study area, primarily using low altitude aerial photography, has revealed a number of apparent fault traces that were not previously mapped. These traces include: (1) an extension of the Johnson Valley fault southward along the eastern margin of the San Bernardino Mountains; (2) a continuation of the Calico fault southward to connect with an unnamed previously mapped fault; and (3) numerous half-mile to three-mile long traces within the Central Mojave shear system and along the Pinto Mountain fault zone.

Figure 2



Sketch map of northwest quadrant of study area showing the southeasternmost portion of the Central Mojave shear system and the Pinto Mountain fault. See figure 1 for geographic location.

Previously Mapped Fault

Fault Inferred from Imagery Investigations and Preliminary Field Checks

These features appear to further define a southward bending of the southeasterly trending Central Mojave shear system as it approaches its terminus at the Pinto Mountain fault (figure 2).

Orbital Imagery Analysis

Digital processing of our orbital imagery data is in its early stages. However some features of possible significance have been recognized. The most intriging of these are numerous north-northwest trending lineaments that are oblique to the major northwest trending faults of the Central Mojave shear system. These features, seen on Seasat imagery, could constitute synthetic faults of the simple right shear model. Co-seismic faulting in recent years in this area has occurred on previously unmapped faults having this trend.

Various filter routines have been tested on the Seasat imagery and a low-pass median filter has been found to be very beneficial in the removal of radar noise (speckle).

Landsat enhancement and classification tests applied to a site within the Central Mojave shear system (figure 2) have revealed previously unrecognized features of neotectonic interest. This site consists exclusively of Quaternary alluvial deposits, therefore the depositional, erosional, and deformational characteristics here are not

disquised by remnant features of older tectonic activity. A tecto-geomorphic map of this area produced from analyses of all our data sources is a forthcoming product of our continuing research.

Summary of Results

The following list summarizes the major accomplishments of UCSB neotectonics research supported by NASA.

(1) Acquisition and evaluation of imagery and topographic data for continuing research as part of the NASA Geodynamics Program: The data include Landsat, Seasat, HCMM, and Skylab orbital imagery; high-altitude U-2 and low-altitude photography; and analog and arc-second digital topographic data.

(2) Compilation of an extensive literary reference list and development of a computerized keyword bibliographic access system: The system provides rapid access to the numerous and diverse geologic and methodological references of value in this study.

(3) Development of a new geomorphometric technique for the detection of tectonic surficial features: The technique provides a measure of spatial deviation from typical fluvial elevation-relief relationships, thereby delineating zones of inferred tectonic surficial deformation.

(4) Development of a new computer cartographic technique: This true-perspective graphics tool is useful in depicting tectonic geomorphic features.

(5) Testing of digital image processing methodologies and analysis of selected test sites: Tests include filtering techniques, contrast enhancements, classification routines, and principal components analyses.

(6) Identification of radar lineaments of apparent neotectonic importance within the Central Mojave shear system: These features are virtually indiscernible in aerial photography or in the field, but are necessarily geologic given their multi-date (and multi-view-angle) presence in barren terrain.

(7) Mapping of fault traces within the Central Mojave shear system that clarify a southward bending near its southeast terminus: Recogition of this tectonic pattern will be valuable in reaching our ultimate objective, an understanding of the relationship between the structures of the Mojave Desert and the more southerly San Andreas shear system.

Future Directions

In the next several months our efforts will concentrate on the processing, integration, and detailed analysis of digital imagery and topographic and photographic data. We expect this phase of our research to provide us with many tentative results that will necessitate careful field checks during the winter and spring seasons.

We will continue to concentrate our efforts in the northwest quadrant of the study area while further developing our methodologies. It is our considered opinion that following this line of research will allow us to produce major results long before the full study is completed. The southwest quadrant of our study area, overlying a portion of the San Andreas fault zone, will be the second area of concentrated effort.

We are satisfied with our progress to date and remain pleased with the prospects of important findings regarding the neotectonics of this structurally complex region along the Pacific-American plate boundary.

John E. Estes

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Robert E. Crippen

November 1982