COMUNICACIONES BREVES

LINEAR FEATURES OF THE REGION OF THE NORTHERN GULF OF CALIFORNIA AS MAPPED FROM ERTS-1 SATELLITE IMAGERY

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INTRODUCTION

Under a NASA contract, (Principal Investigator, J. R. Hendrickson) the University of Arizona is engaged in Oceanographic studies in the Northern Golfo de California in cooperation with the Secretaría de Marina of Mexico, the Consejo Nacional de Ciencia y Tecnología, the

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Universidad Autónoma de Baja California and the Universidad Nacional Autónoma de México. During our oceanographic analyses of the imagery from the Earth Resources Technology Satellite, we discovered recurring plumes in the water near 114° longitude, 31° 30' latitude. These plumes were sometimes as much as ten nautical miles in diameter and appeared to be bodies of clear water, contrasting to the sedimentladen turbid water, and thus becoming visible as black spots during the late summer and fall when the waters of the Gulf in that region appeared to be quite heavily sedimented. These plumes were seen on imagery acquired by the Satellite on three different dates: 7 August and 29 and 30 September 1972 (see Figure 1, 1a). Although these features might be an indication of deep water upwelling from Wagner Basin, they also might arise from large submarine springs. In either case, they are important because they occur offshore of the Gran Deserto where 1) geothermal or fresh water resources are important for the energy or water resources of the area and 2) knowledge of an area of upwelling is important to the fisheries of the region.

To pursue the hypothesis that the plumes indicate floating spring water near a submarine seep, we examined the ERTS imagery in search of linear features which may indicate geologic structures affecting the outflow of underground water. In view of the importance of regional lineaments to the study of the tectonics of the region, we analyzed ERTS imagery of the entire land region adjacent to the northern Gulf of California.

DATA

We have been receiving images of the northern Gulf of California obtained by the satellite ERTS-1 since August 1972. Photographic copies of this imagery each cover an area of 185 x 185 kilometers ar repeated intervals of 18 days. For our oceanographic analysis, we used all four spectral bands from the multispectral scanner, .5 to .6μ, .6 to .7μ, .7 to .8μ, and .8 to 1.1μ. For the lineation analysis described in this paper we used the .6 to .7μ red band and the .8 to

1.1μ near infrared band in the 9 1/2 x 9 1/2 inch format of 1: 1 000 000 scale transparencies over a light table. We also used mosaics of electronically dodged 1: 1 000 000 scale mosaics (figures 1, 2, and 3) and very small scale (1:3 400 000) moisaics of 70 mm prints and mosaics to better detect the very long (several hundreds of kilometers), but sometimes subtle lineations.

METHODS

The map of linear features shown in figure 2 is a result of an intentionally naive analysis. We did not refer to published maps nor to other photographic data but treated the imagery as if they were pictures of the surface of a strange planet. We took this approach for two reasons: 1) to provide a fresh look at the region to avoid preconceptions of the location and continuity of known faults; 2) to enable an objective evaluation of the use of ERTS imagery for the mapping of major lineations.

For our preliminary analysis we used uncontrolled mosaics at 1:3 400 000 scale to produce a working map of the large, long regional patterns which were several hundreds of kilometers in extent.

We then produced several versions of lineation maps at 1:1 000 000 scale from the transparencies of bands 5 and 7 over a light table. We found that the infrared band 7 is particularly useful because the eye was not distracted by forest cover of the higher mountain ranges which shows as black in the visible bands but nearly the same shade of light gray as the rock of the mountains in the near infrared bands. We also plotted the alignment of locations where the plumes appeared to emerge from the subsurface in the offshore regions. The map of figure 2 is a photographically reduced version of a simplified 1:1 000 000 scale map wherein only those lineaments that we believe to be most significant for a regional picture are reproduced and somewhat smoothed. This map is thus subjective in that much data has been eliminated for regional clarity. This map has not been modified to fit data other than that derived from ERTS.

RESULTS

The map described here is considered by the authors to be only the first step in an analysis of tectonic features seen in ERTS imagery. Subsequent iterations of tectonic mapping should be, of course, based upon all available geological and geophysical data. The original purpose of the study, to determine the suitability of the ERTS imagery to trace lineaments which may indicate structural control of the outflow of the hypothesized submarine springs, was accomplished.

Although the alternate hypotheses of the origin of the plumes seen at 114° 5' west and 31° 30' north; 1) upwelling masses of deep water from the Wagner Basin or 2) floating layers of submarine spring water where neither proven or disproven by this study, several sets of linear features project to an intersection near the plumes, the most noticeable being an extension of the San Jacinto fault zone and an orthogonal system extending southwest from the Sierra del Pinacates. Many other lineations shown on the figure were plotted because they may be important in the study of crustal spreading and in the exploration for groundwater, geothermal, fuel, and mineral resources, and for evaluation of nuclear power sites.

DISCUSSIONS AND RECOMMENDATIONS

Bathymetric profiles taken in the region of the plume (personal communications, Daniel Brown of Scripps Institute of Oceanography), show small scarps and irregular topography which were unexpected due to the high velocity, heavy sedimentation, tidal currents in this area which would be expected to produce a smooth bottom. These and the lineations shown on figure 4 would tend to support Henye and Bischoff's (1973) hypothesized northward curvature of a northwest transform fault toward this region.

An airborne thermal scanning survey of the coastline of the northern Gulf, if obtained under favorable conditions, might provide valuable information on the location and temperature of submarine

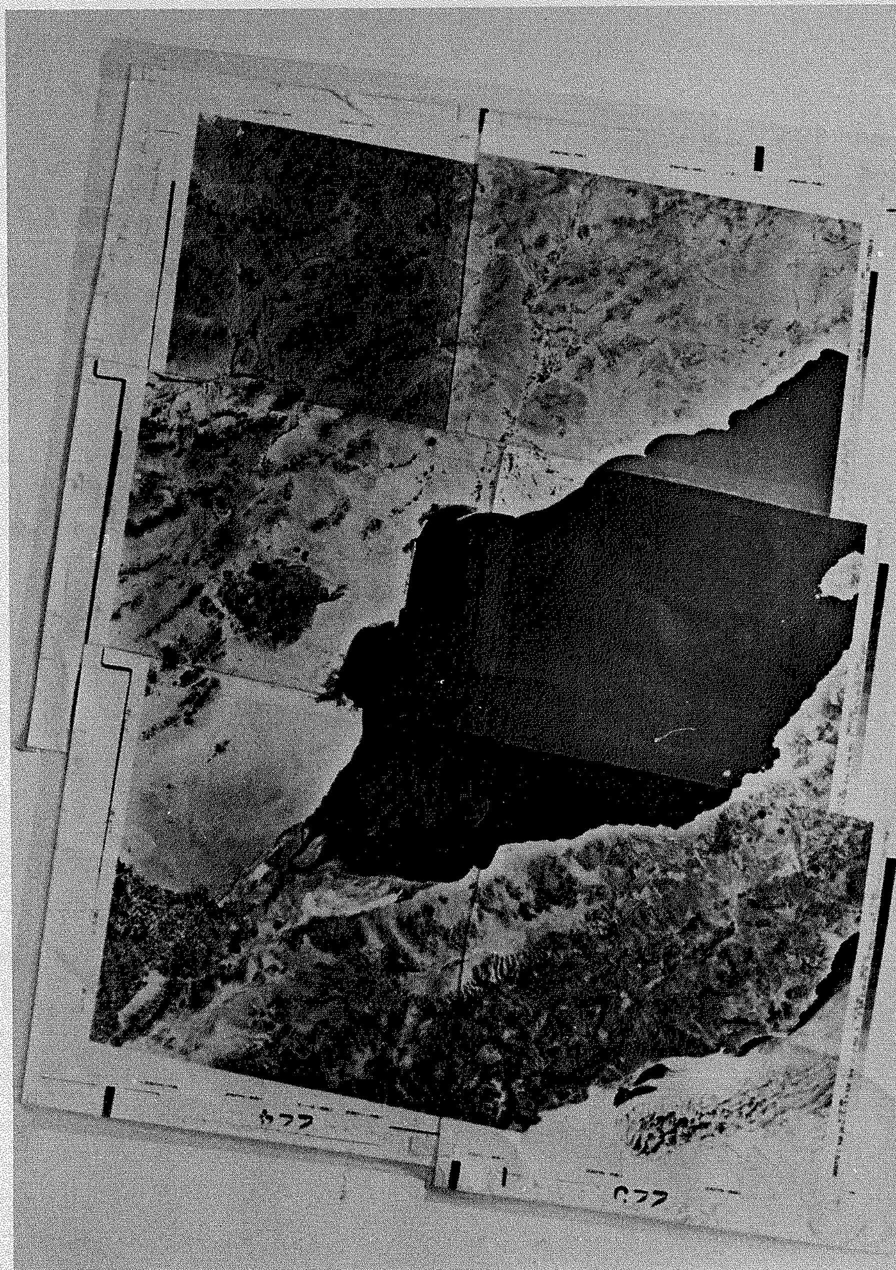

Fig. 1. Mosaic of electronically dodged 1:million scale prints of images in band 4 of September 28, 29, 30, 1972 showing the Sept. 30 plume at 10:45 am local time.

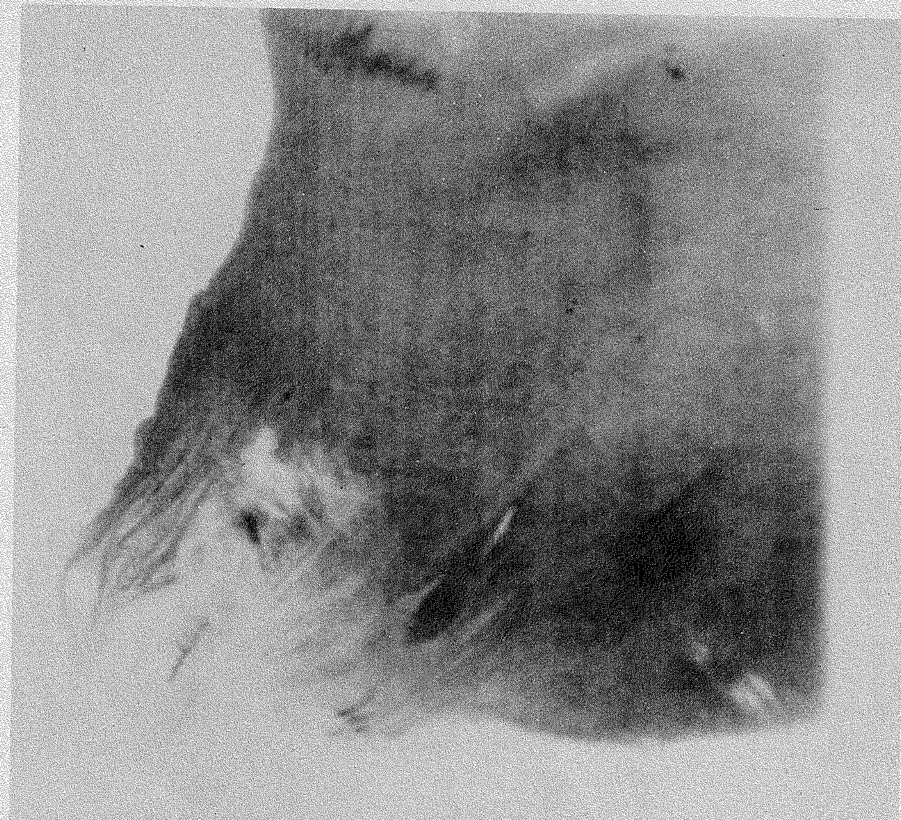

Fig. 1a. The plume as seen in band 7 (near infrared) on August 7, 1972, 10:44 am.

Fig. 2. Major regional linear features as seen in ERTS imagery.

spring outflows and thus the locations of structures controlling them. Converesely, a thermal scanning survey, by providing fine details of these plumes might also help to identify them as upwelling plumes or other oceanographic features.

A continuous seismic and bathymetric profiling survey of the shallow nearshore waters of the north and east coast of the Gulf might provide the data needed for connection of scarps in the basins of the Gulf (Henye & Bischoff, 1973; Van Andel & Shor, 1964) to faults on shore and to geophysical linears described by Sumner (1971). Sumner's figures show aeromagnetic lineations extending shoutheast and northeast from the vicinity of the plumes described in this paper.

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