ARGUS EXPLORATION COMPANY
A Research Subsidiary of
Cyprus Mines Corporation
523 West Sixth Street
Los Angeles, California 90014
Telephone 629-5771

E72-10192
CR-128390

9 November 1972

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Attn: NASA Scientific & Technical Information Facility
ERTS Contracting Officer, Code 245, GSFC
ERTS Technical Officer, Code 430, GSFC
ERTS Project Scientist, Code 650, GSFC
ERTS Scientific Monitor, Code 650, GSFC

Subject: Type 1 Progress Report, 1 September through 31 October 1972
Proposal - A Reconnaissance Space Sensing Investigation of Crustal Structure for a Strip from the Eastern Sierra Nevada to the Colorado Plateau: April 1971.

Reference: Proposal Control No. SR103
GSFC Principal Investigator ID PRO 15
ERTS-A Contract NAS5-21809, Ira C. Bechtold, P.I.

Gentlemen:

In accordance with Article II, Item 3, and Paragraph 3.1 of the referenced contract, the following reports the status of our ERTS-1 investigation.

1. Contract Objectives:

   A. Analysis, interpretation and evaluation of ERTS-1 data for application to study of regional crustal structure.

   B. Comparison and evaluation of selected available remote sensing techniques, including Apollo 9, X-15 and U-2 photography.

   C. Field Investigations to confirm interpretation studies and evaluate significance and practical applications of geologic phenomena visible in ERTS imagery.

(E72-10192) A RECONNAISSANCE SPACE SENSING INVESTIGATION OF THE CRUSTAL STRUCTURE FOR A STRIP FROM THE EASTERN I.C. Bechtold, et al (Argus Exploration Co., Los Angeles, Calif.) 9 Nov. 1972 11 p CSCL 08G G3/13

N73-10371

Unclas 00192

II. Summary of Work Performed:

A. Data Handling and Organization:

Efficient organization and handling of ERTS-1 imagery has required the design of an indexing and filing system for both prints and transparencies. Indexing and plotting of areas covered by NASA U-2, USAF U-2, NASA SLAR, X-15 and NIMBUS imagery are progressing satisfactorily.

B. Literature Research:

Research for available geologic and geophysical data has continued as an integral part of the ERTS-1 project. This task has included multiple reference indexing of data from both published and unpublished sources. Data sources include REDAF, NASA-MSC; WESRAC, University of Southern California; EROS, Sioux Falls, South Dakota; Pomona College, Claremont, California; U.S. Geological Survey.

C. Scientific Communications and Correspondence:

The ERTS-1 users conference held at Goddard Space Flight Center October 1972, was attended by W. E. Hosken, President, Argus Exploration Company; and Mark A. Liggett, Co-Investigator of ERTS-1 Project. Extensive discussions of ERTS-1 research progress were conducted with NASA monitors, Dr. Paul D. Lowman, Jr. and Mr. Edward W. Crump.

We have continued correspondence or discussions with many investigators involved in research relating to the ERTS-1 program. As appropriate, we have exchanged relevant data, analytical techniques, or interpretation. Correspondents include:

Mr. Roy A. Bailey, U.S. Geological Survey, Washington, D.C.
Mr. Homer Lasitter, U.S. Naval Civil Engineering Laboratory, Port Hueneme, California
Dr. Monem Abdel-Gawad, North American Rockwell Corporation
Mr. Robert E. Frazer, Jet Propulsion Laboratory, Pasadena, California.

D. Image Enhancement Analysis:

Additive color viewing and false color enhancement experimentation has been conducted on key RBV and MSS imagery. This work has used a modified Spectral Data Corporation additive color viewer. Several methods for photographically recording color composite imagery are now in development. Experimentation with structural pattern analysis has been

conducted on ERTS-1, NASA U-2 and NASA SLAR imagery using a Ronche grating, and photographic edge-enhancement processes for directional filtering.

E. Imagery Comparison and Evaluation:

Initial coverage of the ERTS-1 test site by excellent MSS imagery has permitted preliminary comparison of this and the limited available Apollo 9 photography covering the same areas. Repetitive vertical coverage by ERTS has proved to be an advantage over the highly oblique Apollo photography. Available coverage of color infra-red and multi-spectral U-2 photography and NASA SLAR have been used to complement ERTS MSS imagery in ground based reconnaissance and mapping.

F. Geologic Field Reconnaissance and Mapping:

Reconnaissance field work from 1 September has concentrated in the following areas:

1) Owens Valley, Bishop Tungsten District, California
2) Long Valley Caldera, California with Roy A. Bailey, USGS
3) San Gabriel Mountains, California
4) White Mountains, California
5) Spring Mountains, Nevada
6) South Muddy Mountains - Bitter Spring Valley - Pinto Valley Area, Nevada
7) Cerbat Mountains, Arizona
8) Black Mountains, Arizona, including fixed wing flying
9) Newberry Mountains, Nevada, including fixed wing flying
10) Eldorado Mountains, Nevada, including fixed wing flying
11) River Mountains, Nevada
12) Death Valley, California

Emphasis was placed on regional tectonic interpretation with some detailed mapping of key areas in the southern Muddy Mountains, Pinto Valley, Newberry Mountains, and Colorado Mountains, Nevada; and Black Mountains, Arizona. Large scale structural anomalies found in ERTS, Apollo and X-15 imagery were reconnaissance field checked in order to determine what the large scale features are, and how they might relate to each other in a regional pattern. Detailed field work was conducted to determine what, if any, small scale structures are typical of these major features, and what differences in the large scale features exist from place to place along their strike. Detailed work was also conducted where the geology of key areas has not been described in the literature.

III. Conformance to Work Schedule:

A moderate shift in research scheduling has been required to cover project administration during illness of the Principal Investigator. We feel this has not had significant effect on research progress.

All work planned for this reporting period has been successfully accomplished.

IV. Analysis of Research Progress:

Analysis of preliminary ERTS-1 data has indicated a number of previously unrecognized geologic features having regional significance. Ground based reconnaissance is being conducted to verify interpretation study. Specific studies having adequate ground truth support are abstracted in Section VI.

A problem has resulted from poor duplicate ERTS-1 imagery provided by the NDPF, Goddard S.F.C. Degredation of the 70 mm transparencies has greatly interfered with additive color viewing and analysis.

V. Efforts to Achieve Reliability and Recommended Changes in Operation:

Defects in NDPF supplied ERTS-1 imagery have been monitored and re-orders for imagery submitted to the NDPF.

In order to counter problems with ERTS-1 imagery, we have concentrated on development of our own photographic processing capabilities, including production of color composite imagery.

VI. Significant Scientific Results:

Geologic field reconnaissance is continuing on structural and igneous phenomena recognized in interpretation of ERTS-1 imagery. The following abstracts summarize significant findings having adequate ground truth support as of this report:

ABSTRACT 9 November 1972

Structurally Controlled Dike Swarms Along the Colorado River, Northwestern Arizona and Southern Nevada

Bechtold, I.C., Mark A. Liggett, and John F. Childs,
Argus Exploration Company, 4120 Birch Street/Suite 108,
Newport Beach, California 92660

An area of anomalous linear topographic grain and color expressions was recognized in Apollo 9 and ERTS-1 satellite imagery along the Colorado River of northwestern Arizona and southern Nevada; 35° to 36° north latitude. Field reconnaissance and analysis of USAF/USGS U-2 photography has shown the anomaly to be a zone of north to north, northwest trending dike swarms and associated granitic plutons. The dikes vary in composition from rhyolite to diabase, with an average composition nearer rhyolite. Dikes range in width from a few feet to over 75 feet, and can be traced along strike for as far as two miles. Most are steeply dipping to vertical, and in portions of the Newberry Mountains, Nevada, closely spaced dikes comprise approximately fifty percent of the rock volume.

In the Eldorado Mountains, Nevada, radiometric age dates from a 15,000 foot sequence of intermediate volcanics range from 18.6 to 13.8 m.y. (Anderson et al, 1972). The dike swarms described here are believed to be feeders for much of this volume. This is supported by the similarity in compositions of the dikes and volcanics, and the scarcity of dikes cutting upper members of the volcanic pile. Dated dikes fall within this age span, and further K-Ar dates for representative dikes are presently being obtained. A maximum age for intrusion is indicated for the dikes that cut a 15.9 ± 0.3 m.y. granite pluton at Spirit Mountain, Nevada (Anderson et al, 1972). Reconnaissance has indicated similar plutons in the Newberry, Eldorado, and Black Mountains that may form a Tertiary aged composite batholith.

Shearing and displacement of host rocks along dikes suggest dike emplacement along active fault zones. Post-dike deformation has resulted in shearing and complex normal faulting along a similar north-south trend. Some of these faults form present range-front scarps, and have locally been sites of hydrothermal alteration and mineralization.

The epizonal plutonism and volcanism of this north-south belt appears to represent a structurally controlled volcanogenic province which ends abruptly in the vicinity of Lake Mead at a probable eastern extension of the

ABSTRACT (Continued) 9 November 1972

Structurally Controlled Dike Swarms Along the Colorado River, Northwestern Arizona and Southern Nevada

Las Vegas Shear Zone. Fleck (1971) postulated the Las Vegas Shear Zone as a transform fault separating two areas of crustal spreading. The magnitude and chronology of extensional faulting and plutonism recognized in the north-south zone described here, supports this hypothesis.

References:

Anderson, R.E., Longwell, C.R., Armstrong, R.L., and Marvin, R.F., 1972, Significance of K-Ar Ages of Tertiary rocks from the Lake Mead region, Nevada-Arizona: Geol. Soc. America Bull., V. 83, No. 2, p. 273-288.

Fleck, R.J., 1970, Age and possible Origin of the Las Vegas Valley Shear Zone, Clark and Nye Counties, Nevada: Geol. Soc., America Abs. with Programs (Rocky Mtn. Sec.), V. 2, No. 5, p. 333.

Discipline Classification:

Mineral Resources, Geological Structure and Landform Surveys

Mineral Exploration
Volcano Surveys
Lithologic Surveys
Structural Surveys

VII. Funding Status:

As indicated in Financial Reports 533M and 533Q, dated 13 October 1972, proposed project funding will be adequate to complete the contracted research program.

VIII. Scientific Staff and Backup Personnel:

In conformance with the rate schedule submitted 28 April 1972, as an addendum to the referenced proposal, the following personnel are presently assigned to the ERTS-1 investigation:

Scientific Staff

Ira C. Bechtold, Principal Investigator
Mark A. Liggett, Field Geologist
John F. Childs, Field Geologist

Technical Aids:

Paul L. McClay, Photographic Technician and Field Assistant
Richard L. Hutchens, Field Assistant

Backup Personnel (covered in G & A)

Secretary
Clerk-typist
Accountant

IX. Work Planned for Next Reporting Period:

A. Field Reconnaissance:

Field work will continue emphasis on compilation of ground truth along the Black Mountains Lineament of northwestern Arizona; eastern structural extensions of the Las Vegas Shear Zone, southern Nevada; and northern extensions of the Ivanpah fault zone of eastern California and southern Nevada. Data analysis and field reconnaissance will place particular attention on correlations of major structural features with distribution and types of volcanic activity. As necessary, detailed mapping will continue in key areas to determine age or specific phenomena relating to satellite imagery anomalies.

B. Image Ehnancement and Analysis:

Laboratory study will continue with additive color analysis of both ERTS-1 and multispectral NASA U-2 imagery. Additional photographic enhancement processes will be investigated for increase of contrast range in additive color viewing, edge enhancement processing, and

structural pattern analysis.

C. Data Source Research:

Compilation and indexing of relevant geologic and geophysical data will continue as an important augmentation of ground truth studies and imagery analysis. Specific attention will be given to compilation of published age dates for igneous rocks in the eastern portion of the test area. Additional sources for geophysical and aerial remote sensing data are being investigated.

X. Authorized Reports and Publications:

Orbital Remote Sensing for Mineral Resources Exploration (Abstract):
by: Ira C. Bechtold and Mark A. Liggett

(A General Discussion of Orbital Remote Sensing Techniques)

To be presented at the Ninth Annual Meeting of the AIAA,
8 January 1972, Washington D. C.

Requested by: Mr. Samuel Hubbard, NASA Headquarters, Washington, D. C.

Summary of ERTS-1 research project:

A Reconnaissance Space Sensing Investigation of Crustal Structure for a Strip from the Eastern Sierra Nevada to the Colorado Plateau: April 1971

Prepared for IEEE Transactions index of ERTS-1 investigations at the request of Mr. Steven Riter, Texas A & M University, College Station, Texas, 77843.

XI. Changes in Standing Order Forms:

A modified Standing Order Form was submitted on 18 October 1972. This modification supersedes the Form of 24 February 1972.

XII. NASA Data Request Forms:

A. Request for ERTS-1 9-1/2 inch positive transparencies; NDPF, Goddard Space Flight Center, 26 October 1972. Data not received as of this date.

B. Request for ERTS-1 70 mm positive transparencies to replace damaged imagery; c/o E. W. Crump, Code 430, Goddard Space Flight Center, 18 October 1972. Data not received as of this date.

XIII. ERTS-1 Image Description Forms:

(Attached)

Mark A. Liggett
Co-Investigator

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D
N
ID

DATE 8 November 1972

PRINCIPAL INVESTIGATOR Ira C. Bechtold

GSFC PRO 15

ORGANIZATION Argus Exploration Company

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
	plutons (granitic)	basin-range structure	fault zone	
1015-17433 M		b.		LAKE, Havasu & Mojave RIVER, Colorado DIKE SWARM (W114 45' - N 35 15')
1018-19001 M	a.	b.	c.	a. Sierra Nevada Batholith c. Owens Valley, Furnace Creek PLAYA, Owens Lake GLACIATION, mountain
1018-18010 M			c.	c. San Andreas, Pine Mt. Garlock, San Gabriel. ALLUVIAL FAN, Wright-wood COAST MOUNTAINS, Transverse Ranges. CITY, Los Angeles DESERT, Mojave PLAYA, Roger's Dry Lake
1052-17490 M	a.	b.	c.	a. Composite b. Las Vegas Shear Zone LAKE, Mead, Mojave RIVER, Colorado THRUST FAULT, (Cont'd)

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

GSFC 37-2 (7/72)

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D
N
ID

DATE 8 November 1972

PRINCIPAL INVESTIGATOR Ira C. Bechtold

GSFC PRO 15

ORGANIZATION Argus Exploration Company

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
(Continued from page 1)				Keystone, Thrust (W115 30' - N36 00') DIKE SWARM (W114 45' - N35 45')
1053-17545 M		b.	c.	c. Garlock, Death Valley Furnace Creek, Ivanpah. THRUST FAULT (Keystone (W115 30' - N36 00') PLAYA, Mesquite Valley
1055-19055 M	a.	b.	c.	a. Sierra Nevada Batholith c. Owen's Valley CALDERA (W118 45' - N37-45') GLACIATION, mountain LAKE, Mono

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406