PROJECT REPORT (IR)NC-41

EAST AFRICA SEMINAR AND WORKSHOP ON

REMOTE SENSING OF

NATURAL RESOURCES AND ENVIRONMENT

Held at Nairobi, Kenya
March 21 to April 3, 1974

U. S. Geological Survey. [Reports – Open file series]
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Final Report
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EAST AFRICAL SEMINAR AND WORKSHOP ON REMOTE SENSING OF

NATURAL RESOURCES AND ENVIRONMENT

Held at Nairobi, Kenya, March 31 - April 3, 1974

by

Morris Deutsch
U. S. Geological Survey

CONTENTS

FIGURES

TABLES

APPENDICES

A. SEMINAR PROCEEDINGS

B. SELECTED WORKSHOP LECTURES AND OUTLINES

F. PARTICIPANTS' CRITIQUES (CONT.) Page

G. PARTICIPANTS REPORTS: POTENTIAL APPLICATIONS OF FUTURE OPERATIONAL EARTH SATELLITE SYSTEM FOR THE PARTICIPATING AFRICAN NATIONS*

EAST AFRICA SEMINAR AND WORKSHOP ON
REMOTE SENSING OF
NATURAL RESOURCES AND ENVIRONMENT

By Morris Deutsch, U.S. Geological Survey

INTRODUCTION

The East Africa Seminar and Workshop (S/W) was held at Nairobi, Kenya, during the period March 21 - April 3, 1974, and informally extended to April 5, 1974. The primary purposes of the program were to introduce potential applications of remote-sensing technology to the exploration, development, and management of East Africa's natural resources; and for monitoring and management of environmental conditions. Emphasis was placed on the first Earth Resources Technology Satellite (ERTS-1) because of availability of global coverage and the fact that the satellite was specifically designed to provide data directly relevant to natural resources and environmental conditions.

The S/W was conducted in the English language by the U.S. Geological Survey (USGS) for English-speaking East African nations on behalf of the Kenya Ministry of Natural Resources and the Office of Science and Technology, Agencey for International Development (USAID), U. S. Department of State. This report is submitted in accort with section 19 B-1 of PASA TA(IC) 02-72 PIO/T 931-11-995-902-72-3189C5 dated 19 September 1973. The Kenya Ministry of Natural Resources served as host and co-sponsor on behalf of the Kenya Natural Resources Secretariat. Planning for the S/W was reported by Deutsch, 1974.

Members of the Organizing Comittee were:

CAHUSAC, Arthur Barry	Executive Secretary National Environment Secretariat Ministry of Natural Resources P. O. Box 30126 NAIROBI, KENYA
ODINGO, Richard S.	Lecturer Department of Geography University of Nairobi P. O. Box 30197 NAIROBI, KENYA

MENDONCA, Andrew D. — Geologist
National Environment Secretariat
Ministry of Natural Resources
P. O. Box 30126
NAIROBI, KENYA

MAITHA, S. M. — Ministry of Foreign Affairs
P. O. Box 30551
NAIROBI, KENYA

OLSEN, Norman — USAID
P. O. Box 30261
Nairobi, KENYA

The S/W consisted of a two-day Seminar held at the Cinema of the Kenyatta Conference Center (fig. 1) in Nairobi, Kenya, on Thursday and Friday March 21 and 22, 1974 followed by lectures and workshops at the University of Nairobi and three field trips to various parts of Kenya during the period March 23 - April 5, 1974. The Seminar was open to resources scientists, to administrators and environmentalists of Kenya, and of other African nations. As a conference of the United Nations Environmental Program (UNEP) was being held concurrently in adjoining space in the Kenyatta Conference Center, delegates to that conference were admitted to the Seminar on a space-available basis.

Registration for the Seminar was conducted by the staff of the Kenya Natural Resources Secretariat. A total of 116 persons formally registered. An actual count of people at one time showed 160 persons in attendance. It is estimated that more than 200 people attended all or part of the Seminar.

During the week of March 19, 1974, 18 table-top display panels describing the Earth Resources Technology Satellite and examples of applications relevant to East Africa were exhibited in the lobby of the Kenyatta Center. The panels evoked considerable interest as evidenced by the detailed examination of them by Seminar and UNEP delegates and other visitors to the Kenyatta Center. In addition to the display panels, ERTS imagery of African scenes pre-processed in the United States for use at the Workshop were displayed in the Cinema for inspection by the Seminar delegates and news media.

Invitations

An ad hoc Committee chaired by A. B. Cahusac issued invitations to an international group of diplomats and experts in natural resources or remote sensing to prepare and deliver speeches on assigned topics at the Seminar. The Kenya Natural Resources Secretariat invited 17 other African Nations to the S/W on behalf USAID (table 1).

Figure 1. Kenyatta Conference Center, Nairobi, Kenya

Table 1. International participation in the East Africa Seminar/Workshop on Remote Sensing of Natural Resources and Environment, Nairobi, Kenya, March 21 - April 3, 1974

Invited nation	No. of participants	Invited nation	No. of participants
Botswana	3	Nigeria	2
Burundi	--	Ruanda	--
Ethiopia	1	Somalia	--
Ghana	2	Sudan	--
Kenya	17 a/	Swaziland	1
Lesotho	--	Tanzania	3
Liberia	2	Uganda	--
Malagasy	1	Zambia	--
Malawi	1 b/	Zanzibar	1
		TOTAL	34

a/ Kenya also provided seven co-instructors including five who attended on essentially a full-time basis and were awarded Certificates of Achievement.

b/ Represented by participant from Institute of Geological Sciences of Great Britain, Overseas Division.

At the request of USAID the invitations were not restricted to East African nations as the Sahelian Zone Remote Sensing Seminar/ Workshop, held at Bamako, Mali, April 17-28, was conducted in the French language, and several English-speaking West African nations did not participate. Inasmuch as a few French-speaking countries did not participate in the earlier course, invitations were extended to them also. Ten nations responded by accepting the invitations for one or more participants. A total of 34 full-time participants were enrolled for the program, including 17 from Kenya. The teaching staff, which was provided by the USGS, was augmented by Mr. Merrill Conitz of AID and 8 volunteer co-instructors of various departments of the Government of Kenya, University of Nairobi, and the United Nations Environmental Program. Figure 2 shows most of the participants, co-instructors, and staff. A listing of the participants by country, and of co-instructors, and their discipline specialties as follows:

Participants:

Botswana:

HUTTON, Susan	Technical Records Officer Geological Survey Dept. Private Bag 14, Lobatsi BOTSWANA	Geology Multi-disciplinary Surveys
PRATCHETT, David	Dept. of Agricultural Res. Private Bag 33, Gaborone BOTSWANA	Range Ecology
WILSON, Brian H.	Dept. of Water Affairs Private Bag 29, Gaborone BOTSWANA	

Ethiopia:

ABATE, Alula	Chairman & Assoc. Professor Department of Geography Haile Selassie I University Addis Ababa ETHIOPIA	Geography

Ghana:

BARING, Kwasi	Senior Petrologist Geological Survey Department P. O. Box 586, Kumasi GHANA	Petrology Geochemistry Economic Geology
OCRAN, Victor Kafi	Senior Agricultural Officer Ministry of Agriculture P. O. Box M37, Accra GHANA	Agriculturist

Kenya:

ABSALOMS, Walter Juma	Superintendant of Surveys Survey of Kenya P. O. Box 30046 NAIROBI, KENYA	Cartography Photogrammetry
BHATT, Nayankant V.	Lecturer Department of Geology University of Nairobi P. O. Box 30197 NAIROBI, KENYA	Structural Geolo Hydrogeology Geophysics
BHOGAL, Pravin Singh	Tutorial Fellow Department of Physics University of Nairobi P. O. Box 30197 NAIROBI, KENYA	Geology Geophysical Explo ation Emphasis on Geo- thermal Explora
DODHIA, Shirish A.	Senior Geologist Mines & Geological Department Ministry of Natural Resources P. O. Box 20009 NAIROBI, KENYA	Geology
GACHUI, J. K.	Economist/Statistician Central Bureau of Statistics P. O. Box 30266 NAIROBI, KENYA	Economics Statistics
HOVE, Alf Roy Tariro	Lecturer Department of Geology University of Nairobi P. O. Box 30197 NAIROBI, KENYA	Geomorphology Sedimentology Photogeology
LUSIGI, Walter J.	Habitat Ecologist Kenya Wildlife Management Project P. O. Box 30559 NAIROBI, KENYA	Ecology
MBUVI, Joseph P.	Soil Surveyor National Agricultural Labs Ministry of Agriculture P. O. Box 30028 NAIROBI, KENYA	Soil Surveying
MUMIUKHA, Pius W.	Kenya Wildlife Management Project P. O. Box 30559 NAIROBI, KENYA	Game Biology

MWANIKI, Jotham Anthony	Government Demographer Central Bureau of Statistics P. O. Box 30266 NAIROBI, KENYA	Demography Demographic Cartography
NYMBOK, Isaac	Tutorial Fellow Department of Geology University of Nairobi P. O. Box 30197 NAIROBI, KENYA	Geology
RODRIGUES, Edmund B.	Lecturer Department of Geology University of Nairobi P. O. Box 30197 NAIROBI, KENYA	Geology Geophysics
RUARA, W. W.	Forest Inventory Branch Ministry of Natural Resources P. O. Box 30241 NAIROBI, KENYA	Forest Inventory
TAITI, Simon	Head, Reasearch Division Game Department P. O. Box 40241 NAIROBI, KENYA	Ecology
WAIREGI, Wilfred J.	Senior Geologist Mines & Geological Department P. O. Box 30009 NAIROBI, KENYA	Economic Geology
WANYEKI, Simon	Water Department Ministry of Agriculture P. O. Box 30521 NAIROBI, KENYA	Geology Groundwater Development
ZAMIEROWSKI, E. E.	Lecturer Department of Botany University of Nairobi P. O. Box 30197 NAIROBI, KENYA	

Liberia:

DUNDAS, Thomas A.	Assistant Director Cartographic Service Ministry of Lands and Mines Monrovia, LIBERIA	Photogrammetry
RICHARDSON, Nathaniel	Liberian Geological Survey P. O. Box 9024 Monrovia, LIBERIA	Geology Geophysics

Malagasy:			
	RAZAFINDRAKOTO, Raymond	Chief of Agricultural Statistics Office B.P.N. 7086 Tananarive, MALAGASY	
Malawi:			
	BENNETT, John D.	Geological Survey Department P. O. Box 27 Zomba, MALAWI	Geology
Nigeria:			
	ODUOLOWU, Akin	Department of Geology University of Ibadan Ibadan, NIGERIA	Geophysics Mineral Exploration Groundwater
	OKUWA, Babatunde Oluyinka	Air Survey Officer Federal Survey Department Federal Ministry of Works & Housing P.M.B. 12596 Lagos, NIGERIA	Cartography Photogrammetry Land Use
Swaziland:			
	DLAMINI, Allen S.	Dept. of Geological Surveys and Mines P. O. Box 9 Mbabane, SWAZILAND	Geology
Tanzania:			
	GRIMSDELL, Jeremy James Russel	Senior Ecologist Serengeti Research Institute P. O. Seronera Arusha, TANZANIA	Ecologist
	KAJULA, Stephen	University of Dar-es-salaam (Bralup) P. O. Box 35097 Dar-es-salaam, TANZANIA	Photo Interpretat
	MUJWAHUZI, Mark Rugemalira	Assistant Research Fellow University of Dar-es-salaam P. O. Box 35097 Dar-es-salaam, TANZANIA	Geography
Zanzibar:			
	WINTERS, Anthony	Research Officer East African Marine Fisheries Organization P. O. Box 668 ZANZIBAR	Oceanographer

Co-instructors:

McCLYMONDS, Neal E.	USGS/USAID Ministry of Agriculture Water Department P. O. Box 80261 (USAID) NAIROBI, KENYA	Hydrology
CROZE, Harvey Dr.	Lecturer Department of Zoology University of Nairobi P. O. Box 30197 NAIROBI, KENYA	Ecology
GWYNNE, Michael Douglass Dr.	UNDP/FAO Office Habitat Monitoring Project P. O. Box 30218 NAIROBI, KENYA	Ecology
KARANU, Joseph Kibore	Photogrammetrist Survey of Kenya P. O. Box 20046 NAIROBI, KENYA	Aerial Photography
KIRORI, D. M.	Water Department Ministry of Agriculture P. O. Box 30521 NAIROBI, KENYA	Hydrology
NYANDAT, Nelson N.	Head Kenya Soil Survey National Agricultural Labs. Ministry of Agriculture P. O. Box 30028 NAIROBI, KENYA	Soils, Land Use, Agriculture
SOMBROEK, William G. Dr.	Project Manager Kenya Soil Survey National Agricultural Labs. P. O. Box 30028 NAIROBI, KENYA	Soil Survey Land Classification Soil-Vegetation Relationship
WALSH, John Dr.	Chief Geologist Mines & Geological Dept. P. O. Box 30009 NAIROBI, KENYA	Geology

Teaching staff

The teaching staff was selected by the USGS from active investigators on the ERTS Program in the United States who were working on a variety of disciplinary applications of interest to the invited African nations. An important factor involved in the selection of the staff, in addition to their discipline specialties, was the broad representative background of cumulative experience in government, industry, and university remote-sensing programs.

The staff consisted of Mr. Morris Deutsch, who served as principal instructor, Dr. David M. Carneggie, and Dr. George A. Rabchevsky. Mr. Merrill Conitz, USAID Coordinator for the S/W, served as a fourth staff member. The addresses and discipline specialities of the staff are as follows:

DEUTSCH, Morris Principal Instructor	Research Coordinator, Hydrology U.S. Geological Survey/EROS Reston, Virginia 22090 U.S.A.	Water Resources Hydrogeology Water Quality Coastal Environm
CARNEGGIE, David M.	University of Calif., Berkeley 16 Brookwood Road Orinda, California 97563 U.S.A.	Agriculture Forestry Range Management
RABCHEVSKY, George A.	Director, Image Analysis Photo Science, Inc. 7840 Airport Road Gaithersburg, Maryland 20760 U.S.A.	Geology Meteorology Land Use
CONITZ, Merrill	Physical Scientist A.I.D. Office of Science and Technology State Dept. Bldg. Washington, D.C. 20523 U.S.A.	Cartography Engineering

Facilities

The 2-day opening sessions of the Seminar were held in the Cinema of the Kenyatta Conference in Nairobi. The space, which was leased for the purpose by the Kenya Ministry of Natural Resources, was superb. Normal seating capacity of 125 was increased to accomodate about 160 attendees.

Visual and audio facilities were provided by the Kenyatta Center. On Saturday, March 23, the participants and staff reconvened at the American Wing of the Faculty of Engineering Building of the University of Nairobi for lecture and workshop sessions, where attendance by visitors and observers was limited. Lectures were held in the Auditorium and workshops in the Photogrammetric Laboratory. The space was provided at no charge by the University of Nairobi.

Objectives

The following basic objectives for the program were established at the planning meetings, which were described in detail by Deutsch (1974):

1. To provide a background of fundamentals of remote sensing, emphasizing ERTS data, and related state-of-the-art techniques.

2. To determine practical applications of remote-sensing technology, and especially ERTS data for resource and environmental appraisal and monitoring in those African countries represented by participants at the Seminar and Workshop.

3. To demonstrate the feasibility for African nations to develop an in-house capability to collect, process, analyze, and apply ERTS data under a future operational program.

Although not specifically stated in the planning report, an attempt was made to develop, in each participant, a high degree of confidence in his capability to apply ERTS data to his nation's resource and environmental programs with a minimum of external assistance other than imagery and hardware acquisition.

Guidelines

To aid in achieving the objectives the following guideline criteria were employed in preparing the curriculum and in teaching, workshop, and discussion activities:

Workshop aspects were emphasized, and a special effort was made to generate data products useful to each participant.

Workshops were devoted to practical problems of data processing and interpretation, and to interpretation of practical--as opposed to academic--resource and environmental problems.

Data covering areas of African countries represented by the participants was used in preference to examples from the United States or elsewhere.

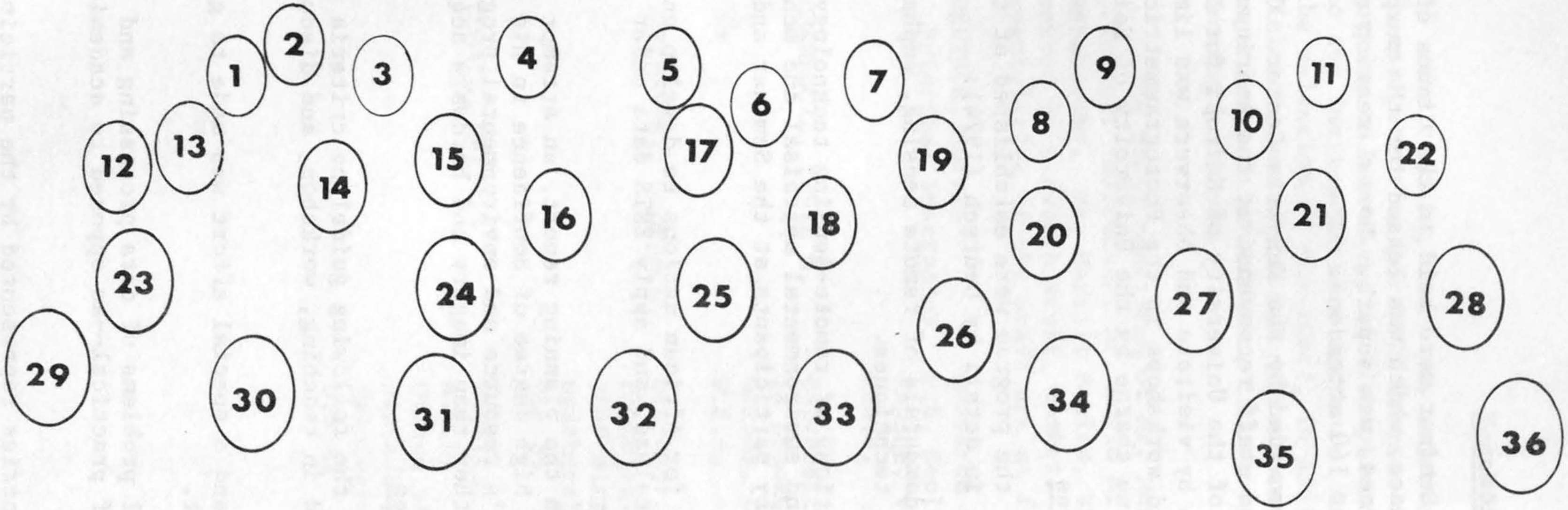
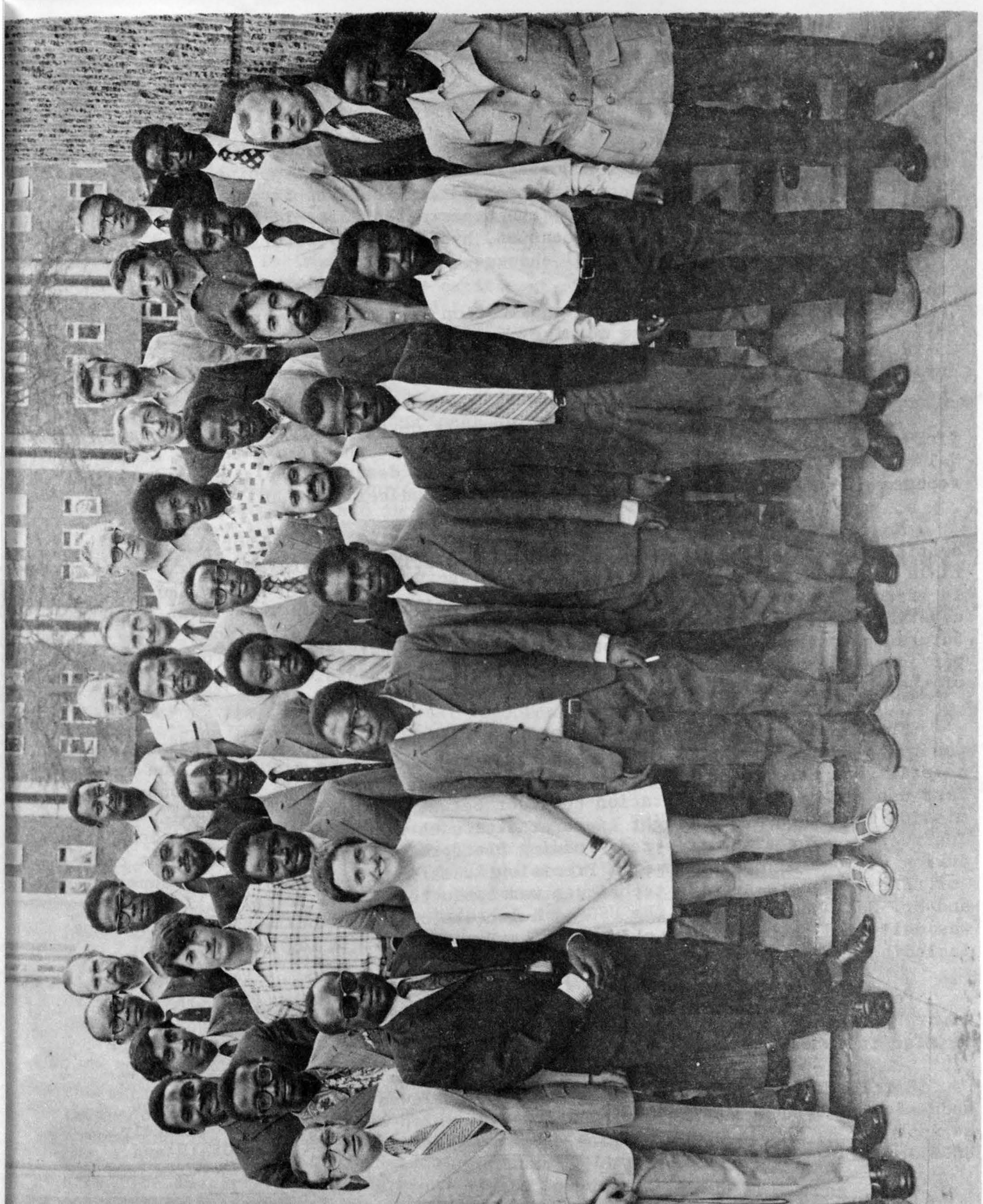


Figure 2. Participants and staff of the East Africa Seminar and Workshop on Natural Resources and Environment, Nairobi, Kenya, 21 March - 3 April, 1974.

1. J.A. Mwaniki, Kenya
2. Merril Conitz, U.S.A.I.D.
3. Simon Taiti, Kenya
4. Daniel Kirori, Kenya
5. Neal McClymonds, USGS
6. Brian Wilson, Botswana
7. Michael Gwynne, UNDP
8. Gwynn Owens, Kenya (visitor)
9. John Bennett, Malawi
10. Jeremy Grimsdell, Tanzania
11. David Pratchett, Botswana
12. Akin Oduolowu, Nigeria
13. Andrew Mendonca, Kenya
14. David Carneggie, USA
15. P. S. Bhogal, Kenya
16. Joseph Kibore Karanu, Kenya
17. A. S. Dlamini, Swaziland
18. W. J. Waisegi, Kenya
19. Nathanial Richardson, Liberia
20. W. J. Lusigi, Kenya
21. Alula Abate, Ethiopia
22. Walter J. Absaloms, Kenya
23. V. K. Ocran, Ghana
24. B. O. Okuwa, Nigeria
25. J. K. Gachui, Kenya
26. Shirish Dodhia, Kenya
27. Anthony Winters, Zanzibar
28. George Rabchevsky, USA
29. Morris Deutsch, USA
30. Kwasi Barning, Ghana
31. Susan Hutton, Botswana
32. Simon Wanyeki, Kenya
33. Pius Mumiukha, Kenya
34. Mark R. Mujwahuzi, Kenya
35. Joseph P. Mbuvi, Kenya
36. Thomas A. Dundas, Liberia



Lectures and fieldtrips

Two concurrent field trips were held on March 29 and 30, 1974 which covered ground-truth techniques and spatial extrapolation of point data employing pre-processed ERTS images. One trip stressed applications in geology, physiography, and mineral resources; the other stressed applications in range management, agriculture, soils vegetation, hydrology and water resources, coastal zone environment, and environmental changes.

Lectures on interdisciplinary application of ERTS-1 and other relevant data were conducted during the morning periods Monday through Thursday March 25-28, and workshops in data processing and interpretation techniques were held during the afternoon sessions.

Friday and Saturday, March 29 and 30, were devoted to concurrent 2-day field trips, one to the Mount Kenya-Samburu area and the second to the Kerio Valley in the great rift zone of Kenya. Detailed descriptions and participant's reports on the field trips are presented in Appendices C and D.

Monday, Tuesday, and Wednesday morning (April 1-3) were devoted to continuation of the workshop sessions, extrapolation of features observed in the field on ERTS imagery, preparation of thematic map products, and preliminary interpretation of ERTS imagery for areas of national interest. Written reports covering the field trips along with reports on projected applications of a future operational ERTS-type system on various natural resources programs in the participating nations, were submitted by the participants. Unedited transcriptions of these reports are included herein as Appendices C, D, and G.

The Kenya Air Force provided a 23-seat Caribou aircraft on April 5 for observing hydrologic, agriculture, and land-use conditions along the Tana River; coastal zone conditions between Malindi and Mombasa; and range conditions and land use along the transportation corridor between Mombasa and Nairobi. The mission was flown along flight lines at altitudes requested by the Principal Instructor. The aircraft's rear loading platform was opened by the flight crew during periods of operation of a Precision Radiation Thermometer. A demonstration of thermal remote-sensing techniques was conducted by the Principal Instructor and Mr. Neal McClymonds of the USGS. A lecture on fundamentals and applications was delivered on the ground at Mombasa by Mr. Deutsch. A log of this trip, including the data collected, is contained in Appendix E.

For Dr. George Rabshevsky the Kenya Air Force also provided a seat on an aircraft for a flight to the Eldoret area on April 4. His report on the trip is also included.

Participant's critiques of the S/W were reviewed in an open session on Wednesday afternoon, April 3. The critiques, which also are included herein as Appendix F, should prove to be a valuable reference for future USAID and USGS activities in the participating countries.

Closing ceremonies were held on April 3, 1974, at the Norfolk Hotel, adjacent to the University. Certificates of Achievement were awarded and photographs of each participant taken.

THE SEMINAR

The Seminar was particularly valuable in arousing a high degree of interest in ERTS and its resources and environmental applications potential for Africa. Press, radio, and television coverage widely disseminated the news of the Seminar and the story of ERTS throughout Africa.

The Hon. W. D. Omamo, M.P., Kenya Minister for Natural Resources, in his Address of Welcome reflected the excitement of Africa in potential applications for ERTS, and emphasized the need for learning the process involved. He stated, "What we are gathered here for today is to learn just exactly what those space pictures can tell us--what that little speck or colouration means--what the subtle changes in colour between pictures of different dates mean--what the reflective values of each and every object on the surface of the Earth comprises." (Mr. Omamo was injured in an accident prior to the Seminar and the address was given by Mr. J. H. O. Omino, Permanent Secretary.)

U. S. Ambassador Anthony D. Marshall also voiced enthusiasm for ERTS applications that might aid in the development of Africa. He pointed out that the cooperation generated by ERTS and Skylab could "form models for further cooperation in the peaceful uses of outer space." He declared that satellite systems are international and no nation should be deprived of the benefits derived from them.

The first technical session of the Seminar entitled "Prospectus for Remote Sensing as as Aid in Resources Development and Environmental Protection" was designed primarily as an introduction to the applicability of remote-sensing technology to the fields of natural resources and environmental problems. In East Africa and elsewhere, especially in the developing world, this new and rapidly expanding technology appears to have been accepted by African and U.N. officials as having considerable promise for ultimate beneficial applications.

Dr. Nicholas Otieno, Chief of the Environment Unit, U.N. Economic Commission for Africa, made a particularly eloquent appeal for implementation of remote-sensing technology in the "underdeveloped world." This new technology could offset the "paucity of information concerning such topics as the extent and quantity of natural resources, population dynamics and grave problems of human settlements, environmental changes and/or degradations such as decay of agricultural land, coastal pollution, etc." Dr. Otieno subsequently authorized the USGS to use excerpts from his speech in the preparation of a display indicating important applications of ERTS data. Figure 3 is a black and white copy of the display.

Dr. Peter Thatcher, UNEP, cited from an impressive list of statistics the estimated extent of natural resources worldwide. He pointed out the tremendous need for environmental data, much of which could be provided by remote-sensing, especially by earth resources satellites. Dr. Richard S. Odingo of the University of Nairobi predicted a great demand for, and use of, satellite imagery for meeting requirements for data to guide resources development and environmental monitoring in Africa.

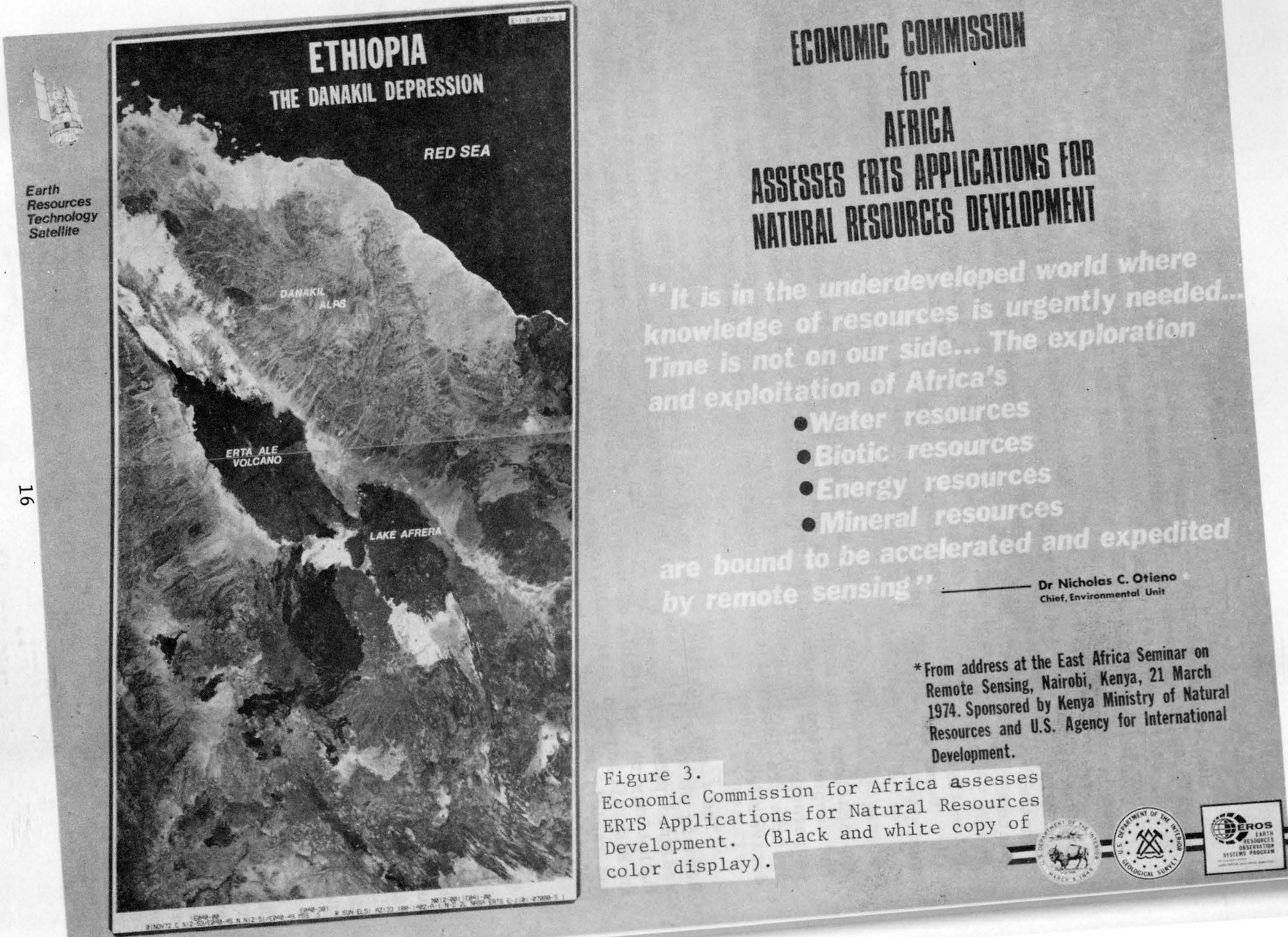


Figure 3.
Economic Commission for Africa assesses ERTS Applications for Natural Resources Development. (Black and white copy of color display).

The Friday session of the Seminar, titled "Technical Overview of Remote Sensing for Earth Science Applications," was designed primarily to expose the delegates and participants to remote-sensing technology in general, and to demonstrate the feasibility of applying the technology to a wide variety of problems. Attendance remained at about the same level as the opening sessions on Thursday. The highlight of this session,which drew a large and interested audience, was Astronaut Russell Schweikart's description of the status and accomplishments of NASA's Earth Observations Program.

Considerable discussion and questions from the floor followed the Friday sessions. The audience appeared genuinely receptive to the ERTS program of the United States and of this country's efforts to provide ERTS data as well as the training and technical assistance needed for its implementation. An exception to this apparent feeling was voiced from the floor on two different occasions when delegates stated their opinion to the effect that ERTS was being used to spy on other nations' resources--apparently for surreptitious extranational exploitation. On the first occasion, Schweikart forcefully, but tactfully, refuted this allegation. Schweikart stated that the ERTS program posed a challenge to developing nations to explore, develop, and monitor their own resources aided by the imagery provided by the United States. He pointed out the fact that no foreigner could enter any sovereign country and remove its mineral or other resources without a license from the government of that country.

Essentially the same allegation was made following a later session, this time--curiously--by an expatriate member of a private engineering corporation in Kenya. Deutsch reiterated Schweikart's response to that allegation in a forceful manner.

The Seminar program follows. Texts of those speeches, lectures, and panel discussions submitted by the speakers are presented in Appendix A.

Banquet activities

As shown on the invitation (See next page), a banquet for Seminar/Workshop participants and invited guests was hosted jointly by the Kenya Minister for Natural Resources and the Acting Director, USAID Mission in Nairobi.

Approximately 80 to 90 persons attended the affair at the Inter-Continental Hotel.

The banquet address by Russell Schweikart, titled "Earth Science Experiments of the U.S. Manned Spacecraft Program", was illustrated by numerous 3¼ x 4 inch lantern slides. The sudience appeared tremendously impressed not only by Schweikart's presentation of outstanding photography from the Manned Spacecraft Program, but especially by his expertise in relating the photographs to earth resources applications.

The banquet was well covered by press and radio and contributed greatly to the exposure of the U.S. Space Program in Africa.

The Honourable William Omamo, M. P.,
The Minister of Natural Resources
and
Mr. Edward B. Hogan
Acting Director U.S.A.I.D. Mission in Nairobi
request the pleasure of the company of

....

to a Banquet, followed by an Illustrated Speech by Russel Schweikart,
Astronaut on Earth Science Experiments
of the U. S. Manned Spacecraft Program.
on Thursday 21st March 1974, at the Inter-Continental Hotel, Nairobi;
at 7.30 p.m.

R. S. V. P. (regrets only)
U. S. A. I. D. 31160 Ext 251
Minister of Natural Resources 28411 Ext. 2211

Ball Room,
Inter-Continental Hotel,
Nairobi.

(Following dinner), Morris Deutsch, Principle Instructor at the Seminar/Workshop, presented a framed special enhancement of an ERTS image showing Mt. Kenya at a scale of 1:500,000 to the Minister of Natural Resources, which was accepted on his behalf by Mr. A. A. Ochwada, Assistant Minister for Natural Resources (fig. 4).

The photograph was signed by Russell Schweikart, Merrill Conitz, George Rabchevsky, David Carneggie, and Morris Deutsch.

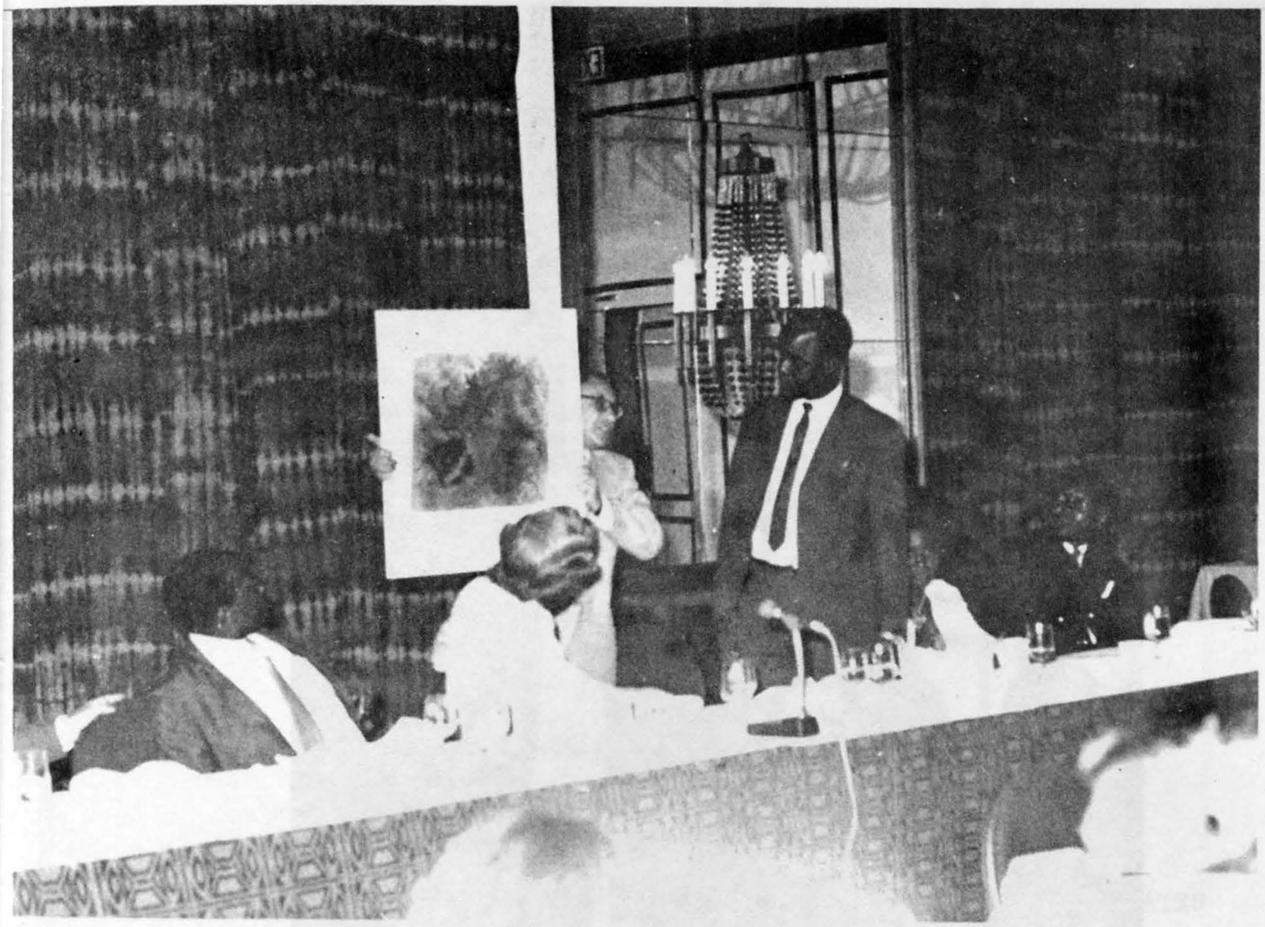


Figure 4. Presentation of ERTS image showing Mt. Kenya to the Kenya Minister of Natural Resources. Photograph caption: "Presented to the Honourable William Omamo, M. P., Minister of Natural Resources, Republic of Kenya, by the U.S. Space Science Staff at the East Africa Seminar/Workshop, Nairobi Kenya, 21 March 1974."

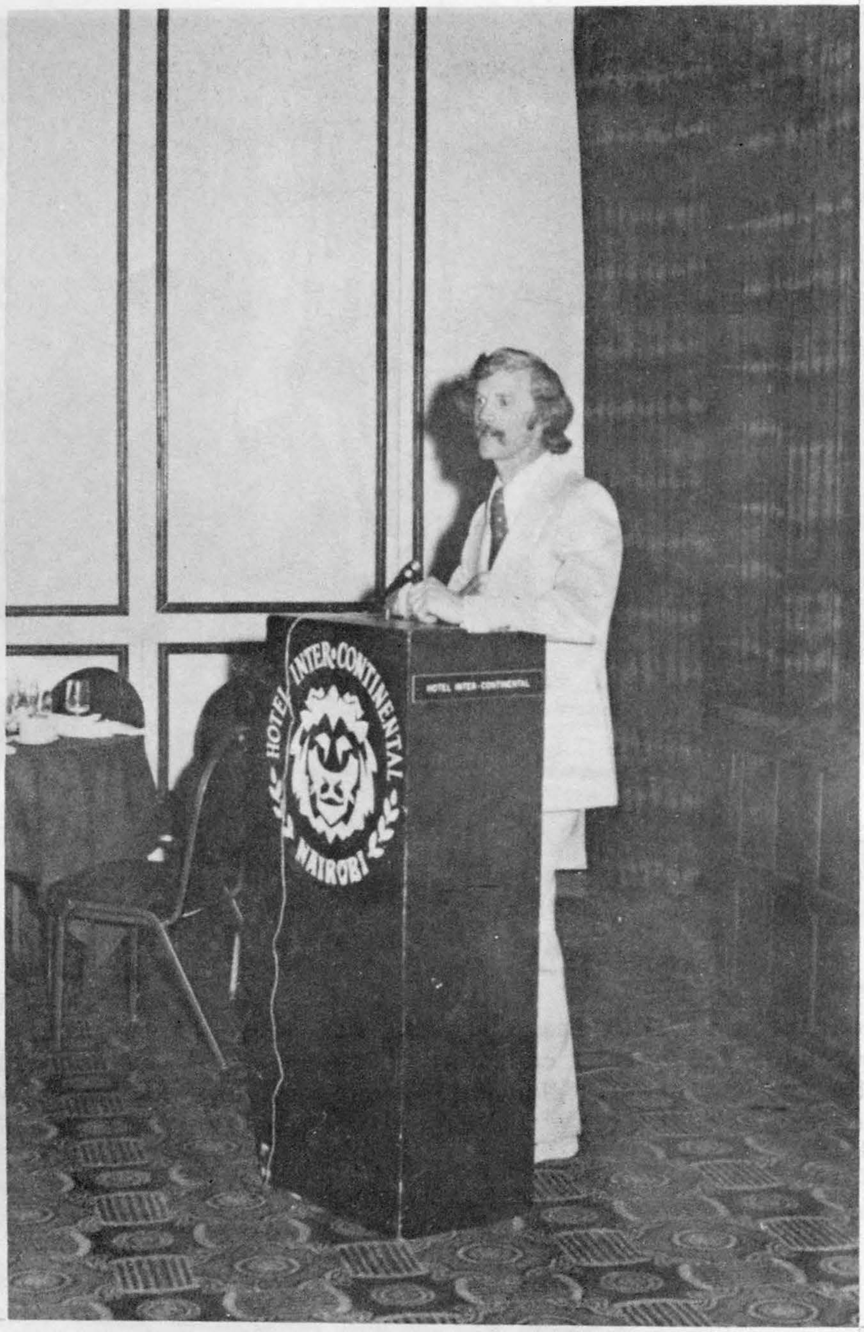


Figure 5. Astronaut Russell Schweikart delivering banquet address, East Africa Seminar/Workshop.

PROGRAMME

EAST AFRICA SEMINAR ON REMOTE SENSING OF NATURAL RESOURCES AND ENVIRONMENT

Kenyatta Conference Centre
Nairobi, Kenya

THURSDAY, March 21, 1974

8:30 a.m. REGISTRATION

(U.S. Geological Survey and NASA exhibits on display in lobby)

10:00 a.m. INTRODUCTION

J. H. O. Omino
Permanent Secretary to the Kenya Ministry of Natural Resources

10:10 a.m. ADDRESS OF WELCOME FROM THE GOVERNMENT OF KENYA

The Honorable William O. Omamo
Minister for Natural Resources

10:20 a.m. WELCOME TO PARTICIPATING NATIONS BY THE UNITED STATES

The Honorable Anthony D. Marshall
U. S. Ambassador to Kenya

10:30 a.m. Welcome from Vice Chancellor, University of Nairobi

PROSPECTUS FOR REMOTE SENSING AS AN AID IN RESOURCES DEVELOPMENT AND ENVIRONMENTAL PROTECTION

J. H. O. Omino, Presiding

10:45 a.m. REMOTE SENSING FOR RESOURCES AND ENVIRONMENTAL APPLICATIONS IN DEVELOPING COUNTRIES

Dr. Nicholas C. Otieno
Economic Commission for Africa

11:30 a.m. WORLDWIDE RESOURCES AND ENVIRONMENTAL DATA NEEDS

Peter Thacher
United Nations Environment Programme

12:15 p.m. LUNCH

2:15 p.m.	U.S. DEPARTMENT OF INTERIOR EROS PROGRAM PROGRESS IN REMOTE SENSING OF EARTH RESOURCES Morris Deutsch, Research Coordinator U.S. Geological Survey (EROS Program)
2:35 p.m.	PROJECTED AFRICAN IMPLEMENTATION FOR REMOTE SENSING TECHNOLOGY IN RESOURCES DEVELOPMENT AND ENVIRONMENTAL MONITORING Dr. R. S. Odingo University of Nairobi
3:00 p.m.	BREAK
3:20 p.m.	REMOTE SENSING TECHNOLOGY - A STATE-OF-THE-ART REVIEW IN LAYMAN'S TERMINOLOGY Dr. David Carneggie University of California, Berkeley
4:00 p.m.	ADJOURN
7:30 p.m.	Banquet, Followed by Speech: Earth Science Experiments of the U.S. Manned Spacecraft Programs Russell Schweikart, Astronaut NASA, L.B. Johnson Space Center, Houston, Texas

FRIDAY, March 22, 1974

TECHNICAL OVERVIEW OF REMOTE SENSING FOR EARTH SCIENCE APPLICATIONS

Merrill Conitz, Presiding

9:00 a.m.	REMOTE SENSING AS A NEW DIMENSION IN MAN'S UNDERSTANDING OF THE EARTH Dr. George Rabchevsky Photo Science, Inc.
9:45 a.m.	AFRICA'S PROJECTED APPLICATIONS OF REMOTE SENSING TECHNOLOGY AND BENEFIT POTENTIAL J. H. O. Omino
10:30 a.m.	BREAK

11:00 a.m.	RESULTS OF THE USAID REMOTE SENSING COST-BENEFIT STUDY AS RELATED TO AFRICA
	Merrill Conitz U.S. Agency for International Development
11:30 a.m.	STATUS AND ACCOMPLISHMENTS OF NASA'S EARTH OBSERVATIONS PROGRAM
	Russell Schweikart
12:15 p.m.	LUNCH
	<u>PANEL DISCUSSION: SELECTED RESULTS OF ERTS-1 EXPERIMENTS</u>
2:15 p.m.	AGRICULTURE, FORESTRY, AND RANGE RESOURCES
	Dr. David Carneggie
2:30 p.m.	LAND USE AND MAPPING
	Merrill Conitz
2:45 p.m.	GEOLOGY, MINERAL, AND LAND RESOURCES
	Dr. George Rabchevsky
3:00 p.m.	INLAND AND COASTAL ZONE HYDROLOGY
	Morris Deutsch
3:15 p.m.	BREAK AND DISCUSSION
3:45 p.m.	NASA Movie: "Earth Resources Technology Satellite"

WORKSHOP PLANS AND PREPARATION

Following the Seminar at the Kenyatta Conference Center, the Participants, and Co-Instructors, reconvened at the American Wing, Engineering Building, University of Nairobi on 23 March 1974, for lectures, workshops, demonstration, informal discussions, and preparation for field trips. Appendix B presents selected lectures or outlines of lectures delivered at the Workshop.

In addition to meeting the objectives under guidelines, planning called for the extensive use of ERTS imagery covering parts of those countries of Africa represented by the participants for purposes of:

*Demonstration of practical means of ERTS data processing locally to avoid complete dependence on the EROS Data Center at Sioux Falls, or NASA's Goddard Space Flight Center.

*To develop a confidence among the participants in their ability to process ERTS data, interpret it, and plan for its implementation on national programs.

*To provide participants with ERTS data covering their own country, both to improve their perspective of the imagery, and to stimulate use of the imagery upon return to their home countries.

In preparation for this function, in January 1974, Deutsch obtained the following ERTS data products from the EROS Data Center for the delegations from each of the 18 invited countries:

*An up-to-date computer readout of the best quality--cloud free (30 percent or less) imagery available on a country-by-country basis.

*One or more scenes covering each country were selected and data sets sets ordered for use and distribution at the Workshop including:

70 mm positive transparencies for color compositing by use of a color-additive viewer

1:1,000,000 black and white transparencies for color compositing by Diazochrome processing

"Standard" existing color composites as feasible within funding limitations

*EROS Data Center pamphlets describing the facility and data products.

*Order forms for ERTS data

*Country-by-country catalog of ERTS coverage previously published by the U.S.G.S. under AID contract.

Prior to departure from the United States, Dr. Rabchevsky preprocessed selected scenes along with a wide variety of spectral enhancements of the African imagery. These were used first for lectures and workshop demonstrations and subsequently distributed to participants as supplies permitted. The ultimate use of these data was for preparation of reports assessing potential applications of ERTS-type imagery for resource and environmental applications in the various participating nations, assuming an operational system is made available.

Preparation of Materials
by David M. Carneggie

Materials prepared in the States prior to the Workshop include: photographs, map overlay, lantern slides, diazochrome composites, lecture material, and reprints. The photographs purchased and prepared for the Workshop include: one 1:250,000 enlargements of the Mt. Kenya ERTS frame (dated January 30, 1973) for band 5, band 7, and the Goddard color composite: twenty 8 x 10 inches enlargements of the area around Mt. Kenya where the field trip was conducted; one 9 x 9 inch black and white photograph of bands 4, 5, and 7 for approximately fourteen ERTS frames of various African countries; twenty 3 x 5 inch color infrared photographs of a range site in northeastern California seen on two dates. (These photos accompanied the reprint titled "Range Resource Monitoring"); and six 3 x 5 inch color prints of 8 ERTS images, which also accompanied the Range Resource Monitoring reprint.

A transparent acetate overlay was prepared for the 1:250,000 ERTS color composite prior to departure for Kenya. Land use patterns and resource types were delineated to demonstrate the mapping capabilities afforded by the ERTS imagery. The twenty 8 x 10 inch enlargements of the Mt. Kenya area were distributed to the participants who accompanied the field trip around Mt. Kenya. These ERTS images were retained by the participants. The aforementioned 1:250,000 enlargements were left in Kenya in care of the Secretary of the Ministry for Natural Resources.

Prior to the Workshop the USGS made available to the author approximately 30 ERTS images of various African countries. Included in the ERTS imagery were four Goddard composites. From the 30 ERTS frames, 15 of the highest quality were selected for further processing to photographic composites and for diazochrome composites. The diazochrome composites were made on a diazochrome machine at the University of California. Photographic composites were also made as 2 x 3 inch slides. Moreover, copy transparencies were made from the Goddard ERTS composites which included scenes from Mt. Kenya, Uganda, Tanzania, and Lake Rudolf.

As many as ten reprints were made available for each of the participants. Most of the reprints were xerox copies of the originals. The Remote Sensing Program at the University of California made available a hardbound book entitled "Monitoring Earth Resources From Aircraft and Spacecraft", published by NASA, which described the research results of the interpretation of Apollo-9 multispectral photography.

The importance of prior preparation of materials for the Workshop was not fully appreciated until arrival in Nairobi. It was apparent that the making of 1:250,000 enlargements would have been dificult, expensive, relative to $US, and time consuming. Moreover, only crude equipment existed for preparing diazochrome composites. The wealth of reprint materials which were shipped to Nairobi would not have been available through any local sources. To the extent that a portion of the success of the workshop was attributed to pre-workshop preparation, it was indispensible to the orderly conduct of the seminar/workshop.

Description of workshop activities

by D. M. Carneggie

Activities conducted during the time periods allocated for "workshops" during the Workshop included: demonstration of equipment for making ERTS composities; demonstration of change detection techniques using diazochrome composities; interpretation of ERTS imagery of participants countries; interpretation of ERTS imagery examined during field trip; preparation of land type overlays of ERTS imagery; amplification of lecture materials; personal consultation regarding remote sensing problems of participants.

Whereas a variety of important and essential activities were performed during the time periods allocated for workshops, these workshops would have been even more effective had more time been provided to allow each participant more time to work with their own imagery for interpretation and enhancement purposes. Because of a transformer malfunction in the diazo-ultraviolet light source, it was not available for making diazochrome composities after the initial demonstration. Fortunately, diazochrome composites were available as part of the preprocessed material, for most of the ERTS frames. The diazochrome images that were produced with the equipment shipped to Nairobi were very light. Probable causes include weak light source, sensitivity of film; inadequate strength of local ammonia developer.

Although an attempt was made to supply each participant with ERTS imagery of his own country, in most cases the imagery was not familiar to the participants making meaningful interpretation difficult. Moreover, many participants had little previous experience interpreting small scale imagery thus incerasing the difficulty of the participants for producing thematic maps. More interpretation time coupled with reference to existing resource maps for the areas depicted on the ERTS images would have facilitated interpretation of the ERTS imagery.

A portion of the workshop time was devoted to study of ERTS imagery of the area to be visited during the field trip. Most of the participants took advantage of this time to acquaint themselves with the resource types which could be interpreted from the ERTS imagery. Moreover, the participants were exposed to the different kinds of information that can be extracted from band 5, band 7, and the ERTS color composite. The pre-field trip interpretation performed in the workshops prior to the field trip, designed to verify interpretations made on ERTS imagery, as well as provide an opportunity to discover the amount of detail (or lack of it) which could be discerned on the ERTS imagery.

The latter portion of the workshops were devoted to preparation of map overlays either on ERTS imagery of areas of participants specific interest or on the imagery examined during the field trip. In addition, the workshops provided the opportunity for preparing reports regarding the findings of their interpretation, their reaction to the amount of detail contained in ERTS imagery, and the applications of ERTS imagery to their particular problems.

<u>Data products generated at the workshop</u>

Employing 70 mm or 1:1,000,000 scale black and white transparencies, the following data products were generated, photographed, and duplicated in color <u>in Nairobi</u> by the participants and staff.

*Spectral composites of varying recipes on I^2S Color-Additive Viewer

*Temporal (time-change) images depicting environmental changes (see fig. 11).

*Color diazochrome composities (the diazo machine failed due to transformer malfunction after a small number were produced).

*Color composities at several scales directly from 70 mm transparencies by local color laboratory 1/ under Dr. Rabchevsky's direction, demonstrating a local capability to provide special products.

<u>Publications, reprints, and maps distributed at workshop</u>

Because there is a dearth of remote-sensing literature available in most of the African countries participating, a special effort was made not only to provide literature relevant to Seminar and Workshop speeches and lectures, but also to provide a fundamental library for each participant. The literature was eagerly received by all participants, although in some cases the supply was inadequate for distribution to all participants and Co-Instructors. The auditorium and laboratory where the reprints were stored were relatively accessible to nonparticipants, and apparently some pilferage occurred as some publications that arrived in

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1/ This work was performed under an informal open-market agreement with Mr. Zulfiquar Ahamed Mehar, proprietor of PHOTOMURALS, a local commercial photographic laboratory (P.O. Box 45259, Nairobi). Color reproductions and enlargements were made by COLOUR CENTRE, Nairobi.

*Color copies of existing composites

adequate quantity could not be distributed to all. Distribution therefore was made first, on a country-by-country basis; and then, on an individual basis.

From 10 to 50 copies of more than 70 separate documents were distributed. It is felt that although there obviously was inadequate time for detailed perusal of each, their availability greatly enhanced the workshop and provided a fundamental library for follow-up ERTS activities in each country. The following is a listing of the materials distributed:

Allied Research Associates, 1971, The best of Nimbus: Allied Research Associates, Inc., Rept. on NASA contract NAS 5-10343, p. 1-120.

Anderson, J.R., Hardy, E.E., and Roach, J.T., 1972, A Land-use classification system for use with remote sensing data: U.S. Geol. Survey Circular 671, 16 p.

Boyle, C.P., 1973 Space among us: some effects of space research on society: NASA Goddard Space Flight Center, 133 p.

Brooks, D.J. and G.A. Rabchevsky, 1973, Geologic implications of a satellite view of Ellesmere Island, Canada: Modern Geol. 4, pp. 131-135.

Carneggie, D.M., and DeGloria, S.D., 1973, Detecting changes in rangeland resources using ERTS-1 data: Univ. Calif., Berkeley Dupl. Rept., 9 p.

Central Treaty Organization, 1971, CENTO Seminar on the application of remote sensors in the determination of natural resources: CENTO Proc., Ankara, Turkey, Nov. 10 - 13, 1971.

Colvocoresses, A.P., 1974, Remote sensing platforms: U.S. Geol. Survey Circular 693, 75 p.

Colvocoresses, A.P., and McEwen, R.B., 1973, EROS cartographic progress: Reprint from Photogram. Eng. (Also presented at 2nd ERTS-1 Symposium), Mar., 6 p.

Colwell, R.N., 1973, Remote sensing as an aid to the management of earth resources: Am. Sci., 61(2), Mar.-Apr., p. 175-183.

Colwell, R.N., et al., 1971, Monitoring earth resources from aircraft and spacecraft, NASA vol. SP-275, 170 p.

Crea, W., Agriculture, forestry, range: ERTS-1 investigator status review: Agric., For., Range Res. Applications Working Group, Interim report for eventual publication in 3rd ERTS-1 Symposium Proc., Dec. 1973, 28 p.

Deutsch, Morris, 1973, Hydrological applications of the Earth Resources Technology Satellite: U.S. Geol. Survey open file rept. 26 p.

__________ 1974, Survey of remote-sensing applications for groundwater exploration and management: U.S. Geol. Survey open-file rept. 14 p.

Deutsch, M., Ruggles, F.H., Guss, P., and Yost, E., 1973, Mapping of the 1973 Mississippi River floods from ERTS-1: Am. Water Resources Assoc., Remote Sensing and Water Resources Management, Proc. 17, p. 39-55.

Draeger, W.C., and Pettinger, L.R., 1972, A regional agricultural survey using small-scale aerial photography: Photogrammetria, 28, p. 1-15.

Fischer, W.A., and Lathram, E.H., 1973, Concealed structures in Arctic Alaska identified on ERTS-1 imagery: Oil and Gas Jour., May 28, 5 p.

Freden, S.C., and Mercanti, E.P., 1973, Symposium on Signficant Results Obtained from ERTS-1, March 5-9, 1973: NASA Goddard Space Flight Center, Discipline Summary Rept., V. III, 118 p.

Freden, S.C., Mercanti, E.P., and Becker, M.A., 1973, Selected abstracts: Symposium on Significant Results Obtained from ERTS-1, March 1973: NASA Goddard Space Flight Center supl. rept. Nov.

__________ 1973, Symposium on Significant Results Obtained from ERTS-1 March 5-9, 1973: NASA SP-327, Technical Presentations, v. I, Sec. A, p. 1-878; Sec. B, p. 879-1730.

Freden, S.C., Mercanti, E.P., and Witten, D.E., 1973, Symposium on Significant Results Obtained from ERTS-1, March 5-9, 1973, NASA Goddard Space Flight Center, v. II-Summary of Results: 198 p.

General Electric Co., Earth Resources Technology Satellite reference manual: G.E. Space Div. Philadelphia, Pa. 19101.

Kodak Corp., 1973, Earth images from space: Kodak Tech Bits, Vol. 4, p. 1-3, 6.

Lathram, H., 1973, "Mini-manual" EROS Programme, ERTS satellites and ERTS image use: U.S. Geol. Survey EROS reprint 171, p. 1-8.

Lawrence, M.R., ed., 1973, Seminar on the Application of Remote Sensors in the Determination of Natural Resources: Central Treaty Organization, Proc., Ankara, Dec. 1971, 179 p.

Mercanti, E.P., ed., 1973, ERTS-; Teaching us a new way to see: Astronautics and Aeronautics, Sept., p. 32-63.

National Aeronautics and Space Administration, 197?, Mission screening and summary reports, bibliographies, site maps, site investigations, etc. related to aircraft missions: Johnson Space Flight Center Bibliography, p. 6-52.

__________ 1971, National Aeronautics and Space Administration's remote sensing vechicles: U.S. Govt. Printing Office Leaflet 1971-0-471-630, 12 p.

__________ 1972, ERTS - For the benefit of all mankind: NASA Goddard Space Flight Center pamphlet.

__________ 1972, Skylab: U.S. Govt. Printing Office leaflet 1972-0-459-254.

__________ 1972, Space shuttle: U.S. Govt. Printing Office leaflet 1972-0-456-744.

__________ 1973, ERTS-1 Cumulative U.S. standard catalog no. U-9, Vol. II: Coordinate listing, May 31, 1973: NASA Goddard Space Flight Center, 107

__________ 1973, Photography from space to help solve problems on earth: NASA Goddard Space Flight Center dupl. rept., 18 p.

__________ 1974, Abstracts of the Thrid ERTS Symposium, December 10-14, 1973, NASA Goddard Space Flight Center.

National Geographic Society, Map of Africa, : Nat. Geog. Soc. Planimetric Map, scale 1:10,000,000, Washington, D.C.

__________, 1966, Map of northeastern Africa, Nat. Geog. Soc., scale 1:7,920,000, Washington, D.C.

__________, 1971, The Heritage of Africa: Nat. Geog. Shaded Relif Map, scale 1:14,572,800, Washington, D.C.

__________ 1971, Ethnolinguistic map - the peoples of Africa, Nat. Geog. Soc., scale 1:14,572,800, Washington, D.C.

Orr, D.G., 1967, Multi-band color photography for space applications: Am. Soc. Photogrammetry, October, 41 p.

Pescucci, R., G.A. Rabchevsky, and A. Stancioff, 1973, ERTS application to mineral exploration in Sonora, Mexico, Am. Soc. Photogram. Symposium on Management Util. Rem. Sensing Data, Proc., Sioux Falls, S.Dak.,

Rabchevsky, G.A., 1970, Remote sensing of the earth's surface: Jour. Remote Sensing 4 (3, 4, 5), p. 1-32.

__________ 1971, Satellite observations of temporal terrestrial features: Huntsville Assoc. Tech. Soc. Proc., Huntsville, Alabama.

Rouse, J.W., Jr., and Riter, S., compilers, 1973, A summary of ERTS experiments GeoSci. Electronics, GE-11 (1), Jan. special issue, P. 1-77.

Sabatini, R.R., Rabchevsky, G.A., and Sissala, J.E., 1971, Nimbus earth resources observations: Allied Research Assoc., Inc., Tech. Rept. 2 on NASA contract 5-21617, 256 p.

South Dakota State University, ERTS mosaic of South Dakota, scale approx. 1:1,000,000: S. Dak. Univ. Agr. Expt. AES Info. Series 5, and S. Dak. Univ. Remote Sensing Inst., SDSU RSI 73-17.

South Dakota University Remote Sensing Institute, 1973, ERTS mosaic of South Dakota showing soil types and values: S. Dak. Univ., scale 1:1,000,000, negative print ERTS band 7 (IR) imagery from speing 1973.

Teleki, P.G., G.A. Rabchevsky and J.W. White, 1973, On the nearshore circulation of the Gulf of Carpenteria, Australia--A study in uses of satellite imagery (ERTS) in remotely accessible areas: Am. Soc. Photogram. in Remote Sensing in Oceanographic, Orlando, Fl.

U.S. Geological Survey, Earth Resources Technology Satellite information: U.S. Geol. Survey EROS reprint 167 modified from NASA "Earth RTS Educational Package," 10 p.

__________, ERTS lithoprint, Amazon Basis map and image, NASA ERTS-1 comparison and description: U.S. Geol. Survey, 1:1,000,000 color composite MSS 4, 5, 7, 1008-13481, 1972, map 1948.

__________ 1971, Studying the earth from space: U.S. Geol. Survey Inf. pamphlet 71-17 (R-2), 19 p.

__________ 1972, The EROS Data Center: U.S. Geol. Survey Inf. pamphlet 72-24(R-1), 19 p.

__________, 1972, ERTS lithoprint of northwest of Managua, Nicaragua, image and fracture patterns, 1972: NASA ERTS-1 imagery color composite 1154-15385, MSS 4,5,7, black and white MSS 7, 1:1,000,000.

__________, 1972, ERTS lithoprint of St. Louis, Missouri, and southern Illinois area: NASA ERTS-1 image 1071-16104, color composite MSS 4,5,7, 1:1,000,000.

__________, 1972, ERTS lithoprint of Upper Chesapeake Bay: NASA ERTS-1 gridded image with explanation, color composite 1080-15192, MSS 4,5,7, 1:500,000.

__________, 1973, Developing country coverage of Earth Resources Technology Satellite, ERTS-1: July 1972 - June 1972, Botswana: U.S. Geol. Survey EROS Data Center Catalog prepared under contract of Office of Science and Technology, U.S. AID TA/OST 73-19, July, 28 p.

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__________, 1974, ERTS coverage U.S.A.: U.S. Geol. Survey ERTS Data Center index release.

White, J.W., Teleki, P.G., and G.A. Rabchevsky, 1973, Image processing and enhancement applied to ERTS photography: A case study of the Bay of Carpenteria: Am. Soc. Photogram. Symposium on Management Util. Rem. Sensing Data, Proc., Sioux Falls, S. Dak.

Woodward, P.A., 1971, How to get started in remote sensing: U.S. Geol. Surveys EROS reprint 101, p. 1-23.

Schedule for Workshop and Field Trips

Saturday, March 23, 1974

9:00 a.m.	Orientation Program objectives	Deutsch
9:30 a.m.	Natural resource and environmental projects of participating nations	Participants
10:30 a.m.	Introduction to remote sensing Electromagnetic spectrum	Carneggie
11:30 a.m.	Remote data collection platforms for earth resource surveys Aircraft Spacecraft, including Gemini, Apollo, ERTS, Skylab	Deutsch
12:00 noon	Introduction to workshop Equipment demonstrations	Rabchevsky
12:30 p.m.	Weekend break	

Sunday, March 24, 1974 Open

Monday, March 25, 1974

8:45 a.m.	Spatial, spectral, and temporal Nature of remotely sensed data	Deutsch
10:00 a.m.	Earth Resources Technology Satellite: Orbital characteristics Data collection capabilities Data processing techniques	Staff
11:00 a.m.	Meteorological satellite data for earth resources	Rabchevsky/ Kenya Met. Dept.
12:00 noon	Lunch	
1:30 p.m.	Introduction to remote sensing (continued) Sensors, films, training aids	Carneggie
2:30 p.m.- 5:00 p.m.	Interpretation techniques workshop Equipment, training aids	Rabchevsky/ Carneggie

Tuesday, March 26, 1974

8:45 a.m.	Introduction to applications	Deutsch
9:00 a.m.	Applications of remote sensing to demography	Conitz
10:00 a.m.	Remote sensing of agriculture, range, and forests	Carneggie
12:00 noon	Lunch	
1:30 p.m.	Remote sensing of agriculture, range, and forests (continued)	
2:30 p.m.- 5:oo p.m.	Concurrent workshops Data enhancement by optical techniques ERTS image interpretations	Rabchevsky, Staff

Wednesday, March 27, 1974

8:45 a.m.	Remote sensing applications in inland and coastal zone hydrology	Deutsch
12:00 noon	Lunch	
1:30- 2:30 p.m.	Use of ERTS data for determination of environmental conditions	Rabchevsky
2:30- 5:00 p.m.	Concurrent workshops Optical data processing Interpretation techniques	Rabchevsky Carneggie

Thursday, March 28, 1974

8:45 a.m.	Plans for concurrent field trips	Deutsch
9:00 a.m.	Mapping of soils from ERTS	Carneggie
10:00 a.m.	Mineral resources, geologic structures, and landform surveys	Rabchevsky
12:00 noon	Lunch	
1:30 p.m.	Ground truth techniques	Staff Kenya co-instructors

Thursday, March 28, 1974

3:30– 5:00 p.m.	ERTS image analysis for field trip sites and preparation for trips (See Friday agenda)	Staff and Participants

Friday and Saturday, March 29, 30, 1974

	Field Trips	Leader
a)	Rangeland, agriculture, soils and vegetation Co-instructors: Nyandat Gwynne	Carneggie
b)	Hydrology, hydrogeology (Combined with trip a). Co-instructors: Taiti McClymonds	Deutsch
c)	Geology, landforms and mineral resources Co-instructor: Walsh	Rabchevsky

Friday, April 5, 1974

d)	Basin hydrology, coastal zone and estuarine hydrology (Post-workshop aerial survey). Co-instructors: McClymonds Kirori Rabchevsky	Deutsch

Note: Applications not limited to the principal disciplines listed. Staff will describe spectral characteristics of data and modes of interpretation. Field interpretations of conditions may be made by Kenya co-instructors.

Monday, April 1, 1974

8:45 a.m.	Concurrent workshops Extrapolation of features observed on field trip to ERTS imagery Classification of thematic data by spectral characteristics of imagery covering areas of national interest Conversion of multispectral imagery to thematic maps	Staff

Monday, April 1, 1974

10:00 a.m.	Thematic mapping	
12:00 noon	Lunch	
1:30 p.m.	Optional group tours Demonstration of photographic processing of multispectral imagery: Photomurals, Inc. Cartographic techniques: Survey of Kenya	
3:30 p.m.	Thematic mapping (continued)	

Tuesday, April 2, 1974

9:00 a.m.	Workshops on preliminary interpretation of ERTS imagery for areas of national interests	
10:30 a.m.	Techniques of report writing	Staff
12:00 noon	Lunch	
1:30 p.m.	Preparation of multidisciplinary reports and data products	
4:00-5:00 p.m.	Begin report reviews	Staff

Wednesday, April 3, 1974

8:45 a.m.	Review of workshop results	
10:00 a.m.	Panel discussion Projected implementation of remote sensing technology in Africa	
12:00 noon	Lunch	
1:30 p.m.	Critique of Seminar and Workshop	
3:30-4:30 p.m.	Closing ceremonies	

FIELD TRIPS

Three field trips were conducted as part of the training program; two were held concurrently on Friday and Saturday, March 29 and 30, as follows:

Field trip to the Mt. Kenya area by D.M. Carneggie

Carneggie and Deutsch lead one group who travelled north from Nairobi around the west side of Mt. Kenya to the Ewaso Ngiro River. An overnight stay was at the Samburu Lodge. The return trip on March 30 was along a route around the east side of Mt. Kenya. Transportation was by a school bus provided by the Kenya Ministry of Natural Resources. Accommodations at the lodge were paid by each of the participants.

Prior to the Seminar/Workshop, it was decided to conduct the agriculture, forestry, range field trip to the Mt. Kenya area. Rationale for this decision centered upon the fact that excellent ERTS imagery existed for that area, and that representative resource types could be examined on the ERTS imagery and on the ground. Thus, 8 x 10 inch enlargements of an ERTS image containing the Mt. Kenya area were preprocessed in California before the workshop and disseminated to those who participated in the Mt. Kenya field trip. Figure 6 is a black and white copy of a display featuring the Mt. Kenya image and the Mt. Kenya field trip.

The primary objectives of the field trip were to visit an area relatively close to Nairobi where participants could verify the validity of their interpretations of resource types delineated on the ERTS images; compare the information content and contrast the differences in appearance of resource types on the various ERTS bands and composites; and determine on the ground the amount of detail which could be seen on the ERTS imagery and compare this with the amount of ground detail which could not be seen on the ERTS imagery.

During the two days allocated for the field trip, 600 kilometers were travelled and numerous stops were made along the route within the area seen on the Mt. Kenya ERTS scene. At each stop participants were asked to verify their location, and compare the resource types which could be seen in the immediate area with the corresponding images seen on the ERTS imagery. On the first day of the field trip, emphasis was placed on examination of soil type, landform, land use, and vegetation type and condition. During the second day, emphasis was on hydrologic parameters and characteristics for evaluating hydrologic potential. Because the ERTS imagery were obtained at a different season from that of the field trip, considerable discussion arose concerning the differences in appearance of ground features at the time of the field trip compared with their apparent appearance at the time the ERTS images were obtained.

Figure 6. Display featuring ERTS imagery used for Mt. Kenya field trip, March 29-30, 1974. (Black and white copy of color display).

Moreover, some concern was expressed that the field trip was conducted in an area where very few detailed resource maps existed, and which was relatively unfamiliar to most of the participants and co-instructors. Despite the minor objections, the field trip objectives were satisfactorily met.

In the field trip reports the participants documented the features and resource types which could be discerned through interpretation, enumerating the image, identifying characteristics used to determine the identity or condition of the feature. In addition they discussed their concern over those features of the landscape which could not be detected or identified through interpretation, and thus required field verification to establish their identity. The field trip served a valuable function in that it demonstrated that, through interpretation training combined with well designed field surveys, valuable resource information could be acquired from ERTS imagery that would update existing resource information or that would provide some resource data where little or none previously exists.

The following Workshop participants joined in the field trip:

David Carneggie, Leader; Agriculture, Land Use

Nelson N. Nyandat, Co-instructor. Head - Kenya Soil Survey

*Michael D. Gwynne, Co-instructor, UNDP, Nairobi

Morris Deutsch, Leader, Hydrology, Geology

*Simon Taiti, Co-instructor - Head, Research Div., Kenya Game Dept.

Neal McClymonds, Co-instructor - Hydrology, U.S. Geological Survey

*Thomas A. Dundas, Assistant Director, Liberian Cartographic Service

Anthony Winters, East African Marine Fisheries, Zanzibar

Brian H. Wilson, Department of Water Affairs, Botswana

Joseph Kibore Karanu, Survey of Kenya

*Victor K. Ocran, Ghana Ministry of Agriculture

Simon Wanyeki, Kenya Water Department

*Puis W, Mumiukha, Kenya Ministry of Agriculture

*Edward E. Zamierowski, Department of Botany, University of Nairobi

*Raymond Razafindrakoto, Chief, Malagasy Agricultural Statistics Office

*Jeremy J. R. Grimsdell, Serengeti Research Inst., Tanzania

*J. K. Gachui, Kenya Central Bureau of Statistics

Walter J. Lusigi, Kenya Wildlife Management Project

*Stephen Kajula, University of Dar-es-Salaam, Tanzania

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* Submitted trip report, see Appendix C.

Most of March 29 was devoted to detection and identification of soil types, land forms, land use, and vegetation type and condition as described above by Dr. Carneggie. Mr. Nelson Nyandat, head of the Kenya Soil Survey made particularly important contributions by his observation on applicability of ERTS data for African-style agricultural practices.

On March 30, hydrologic conditions were emphasized, especially possible practical applications of ERTS data for hydrogeologic analysis. (See report by Simon Taiti, Kenya Game Department).

Participants were requested to submit an informal trip report on their observations and interpretations made during the trip. Copies of unedited transcripts of the reports as submitted are included herewith as Appendix C.

<u>Eldoret-Kerio Valley Field Trip</u> by G. A. Rabchevsky

On March 29 and 30 Dr. Rabchevsky lead a trip to a portion of the Rift Valley of Kenya for purposes of demonstrating ERTS applications and ground truth techniques for geology, landforms and mineral resource projects. Dr. John Walsh served as co-instructor and made arrangements for accommodations and visits to points of interest. Participants on this trip also were asked to submit informal trip reports. Unedited transcripts are included herewith (Appendix D).

The primary objectives of the two-day field trip were to familiarize the participants of the workshop in ground truth observations, correlation of field observations to ERTS imagery interpretations, to collect field data to be used in class for final analysis of ERTS imagery, and to become familiar with the various surface covers and their electromagnetic signature (visible) characteristics.

The following workshop participants took part in the field trip:

George A. Rabchevsky, Leader

John Walsh, Co-Leader, Chief Geologist, Geological Survey of Kenya

*John D. Bennett, Geological Survey of Malawi.

Mrs. Margret Bennett.

*Susan Hutton, Geological Survey of Botswana.

*Allen S. Dlamini, Geological Survey and Mines, Swaziland.

*Babatunde O. Okuwa, Cartographic Survey of Nigeria.

*Akin Oduolowu, University of Nigeria.

W. J. Wairegi, Geological Survey of Kenya.

*Nathaniel Richardson, Geological Survey of Liberia.

*Kwasi Barning, Geological Survey of Ghana.

*Daniel M. Kirori, Water Department, Kenya

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*Submitted trip report. See Appendix D.

Itinerary

Twenty-five (25) miles northwest of Nairobi descend eastern wall of Rift Valley (Kedong area). Make field observations.

Proceed past Suswa crater, Longonot Crater, and Lake Naivasha.

Stop at late Pleistocene lake deposit locality, observe obsidian artifacts and lake sediments. Lake was part of water body that had connection with Lake Naivasha, a feature evident on ERTS imagery.

Enter town of Nakuru (elevation 5,800 feet).

One party proceed to Menengai Crater, a caldera 7 miles across, highest elevation rim at 7,800 feet. Stop for observations.

Another party proceeded to Lake Nakuru, a soda lake containing some trona deposits in dry seasons. Lake shores are populated by thousands of pink flamingos and white pelicans. Stop for observations, and ERTS correlation.

Return to Nakuru, 25 miles northwest of Nakuru ascend western wall of Rift Valley; A gentle slope covered by a volcanic ash mantle. Road Skirt Mt. Londiane, a small Pleistocene volcanic crater, elevation 9,872 feet.

Continue 65 miles northwest on undulating, dissected plateau underlain by phonolite, made photographic records.

Drive past late Pleistocene diatomite mine at Gil Gil, and Hyrax Hill, Leakey's archeological site, visible on ERTS imagery.

Stop at the equator, with view west to Kavirondo Valley.

Stop south of Timboroa at Lake Narasha, observe phonolite outcrops (late Miocene) and contact of soils with basement complex; Photos.

Stop overnight at Eldoret Country Club, in Eldoret, 200 miles northwest of Nairobi; Three of the participants stayed at Hotel New Lincoln. Several of the participants met mayor of Eldoret, Jonah Macharia.

Leave Eldoret, past Chepkorio and Kaptegat forest to Nyeru (25 miles southeast of Eldoret); made photographic records.

Stop at western rift escarpment, elevation 9,000 feet. Meet Chief Geologist of Fluorspar Mine, Sultan Rhemtulla. Made visual observations, presentation of local geology by S. Rhemtulla. Collect Tinderet nepheline phonolite, and took pictures of the group.

Desend the one-mile drop to Fluorspar Mine in Kerio Valley. Observe stratigraphy and surface cover on descent: phonolite capping porphyritic augite basalt; basalt overlying Pre-Cambrian basement system; made photographic records of the valley.

Tour Fluorspar Mine. Fluorspar replaces marble + crystalline limestone. Fluorspar veinlets in places cut Eocene veins, indicating Miocene age of the fluorite; group photos and mine operations.

Lunch in "mine" cafeteria.

Discuss and interpret ERTS photo maps with local geologists and participants.

Return to Nairobi via Kipkabus, Gill Gill, and Hyrax Hill.

Total Mileage for two day trip = 808 km.

The following ERTS data were available for field trip participants:

Two sets of Kerio Valley ERTS black and white images, scale 1:250,000.

Two sets of above at scale 1:500,000.

Two sets of above at scale 1:1,000,000.

Two sets of mosaics (five scenes) at scale 1:1,000,000 with geology and road overlays.

Color composites of the Rift Valley at 1:1,000,000.

ERTS cibachrome mosaic of four scenes, at 1:1,000,000, with Kerio Valley located in the northeastern corner of the mosaic.

The following published geology reports were available as collateral reference data:

1. Walsh, J., 1969, Geology of the Eldama Ravine-Kabornet Area (with maps): Geological Survey of Kenya, Report No. 83.

2. Geologic Map of Eldama Ravine-Kabarnet Area, enlarged to 1:250,000 scale.

3. Geologic map of the Fluorspar Mine.

Tana River - Coastal Zone aerial survey

The Seminar/Workshop formally ended on Wednesday April 3. Because the Staff and some of the participants planned to remain in Nairobi until the weekend, it was decided to use this time period for a third field trip devoted primarily to aerial platform remote-sensing techniques for hydrology, coastal zone, and wetlands applications.

As stated previously, the Kenya Air Force provided a 23-seat Caribou aircraft for this purpose on Friday, April 5. The objectives of the flight were as follows:

To demonstrate aircraft remote-sensing techniques

To explain the correlative role of aircraft and spacecraft remote sensing

To describe thermal imagery techniques, including demonstration of actual surface radiometric readings in the 9-11 micrometer range employing a Precision Radiation Thermometer (PRT-5)

To give all participants an opportunity to view a wide variety of surface features, from the same perspective as remote sensors

To point out areas of apparent groundwater potential along the Tana River Valley as interpreted from surface indicators

To obtain color-infared and color ektachrome photographs for subsequent interpretation exercises and for corrolation with radiometric readings in the thermal infrared region detected by the PRT-5 (9-11 micrometers)

The following participated in the flight:

Morris Deutsch, leader, U.S. Geological Survey

Neal McClymonds, Co-instructor, U.S. Geological Survey

Daniel M. Kirori, Co-instructor, Kenya Water Department

Pravin S. Bhogal, Dept. of Physics, University of Nairobi

Simon Wanyeki, Kenya Water Department

Jotham A.Mwaniki, Central Bureau of Statistics

William G. Sombroeck, Kenya Soil Survey

Michael D. Gwynne, UNDP, Nairobi

Puis W. Mumiukha, Kenya Wildlife Management Project

Shirish A. Dodhia, Kenya Mines and Geological Department

W. J. Nauta, UNESCO

Derek J.W. Cahusac, visitor

Rose Ellen Morrell, M.D., U.S.A., visitor

Helen Van Houton, Color photography, Writer, Nairobi

George A. Rabchevsky, Color-infared photography, U.S.A.

The flight crew consisted of the Pilot, Lt. Ish Chouhan; Co-pilot, Lt. Tom Chelimo; and Navigator, Lt. Charles Chege.

The flight originated at Eastleigh Air Force Base, Nairobi. The route of the flight was from Nairobi northeastward to the Tana River east of Mount Kenya, then directly over the Tana River Valley to Garrissa, then to the Indian Ocean Coast at Lamu, and southward to Malindi. A luncheon stop was made at Malindi. The flight then continued on to Mombasa where a second stop was made. The Principal Instructor, Deutsch, lectured to the group on the ground on thermal imagery techniques and observations made to that point. Following refueling, the flight turned inland and returned to Nairobi along a path between the Tanzania boundary and the Mobassa-Nairobi transportation corridor.

Deutsch made numerous radiometric readings from the end of the open rear cargo platform. McClymonds recorded the data upon signal from Deutsch.

The flight log and radiometric data are included herein as Appendix E. Rabchevsky took about 100 35-mm color infrared photographs and Miss Van Houton took about 60 35-mm color ektachrome photographs.

Technical observations made from the aircraft and subsequent cursory data analysis include the following:

Inverse relationship between infrared transmittance of vegetation on the photographs and radiometric temperatures.

Uncalibrated radiometric readings of the Tana River show a temperature profile from about 23°C east of Mt. Kenya to 29°C near the coastline.

Numerous areas of lush vegetation along the Tana River are easily detected on infrared photography, which indicate ground-water potential and may be a guide for future ground-water exploration.

Many African land-use patterns are small and non-geometric and will require high-resolution aircraft imagery for analysis and interpretation.

Some photographs along the coast indicate possible submarine discharge of ground-water.

Heavily grazed areas are characterized by high reflectance in color infrared photographs and high emitted radiation levels, suggestiong a quantitative measure for assessing grazing conditions.

Severely eroded areas are readily detected on photography, particularly infrared, and by lack of dense vegetation, which result in higher radiometric values in the thermal region, suggesting environmental applications of remote sensing.

PUBLIC INFORMATION RELEASES

In order to better inform the peoples of Africa and their governments about the potential benefits of the ERTS and related remote-sensing programs of the United States, and also to emphasize the importance of the Program to seminar delegates and workshop participants, plans were made to obtain maximum public exposure for the Seminar/Workshop. Results were quite gratifying. By the time the staff departed from Nairobi, the public was very much aware of the program and its significance, as determined by encounters with individuals not associated with the program.

News media

Media coverage as known to the author was made as follows:

At least four articles appeared in three of Nairobi's newspapers (fig. 7).

News articles released by the Kenya Ministry of Natural Resources

News articles released by the U.S. Information Services including taped interviews with participants from five countries, the tapes to be sent to the participant's home country for radio broadcast.

Live local television and radio coverage of the opining sessions.

Staff interviews taped by Mr. Mwangi Gichohi of the Voice of Kenya for later radio broadcasts.

Radio broadcasts by the Voice of America. (Two Dartmouth University students engaged in a geologic mapping project in Ethiopia heard the VOA broadcasts, and drove to Nairobi; they were permitted to sit in on the last days of the Workshop lectures).

In addition to the above, numerous photographs were taken of participants and activities at the Seminar/Workshop. Some of these were made available to AID Washington for a feature article on the Seminar/Workshop published in Front Lines, V. 12, no. 13, May 2, 1974. Copies of the article were obtained by the USGS staff and are being sent out to various participants.

Display panels

At the request of the USAID Mission in Gaborone, Botswana, 12 of the 19 panels displayed at Nairobi were sent by air pouch for exhibit at the Botswana Trade Fair held in September 1974. Because of the high degree of interest in the panels observed in Nairobi, and because many data products covering areas in Africa were generated at the Workshop, Deutsch arranged to have a set of eight new panels (listed below) prepared for display as appropriate in the United States and Africa. The panels all feature color-composite (multispectral) images of African scenes. Black and white copies are included above as figures 3 and 6. (See also figures 8, 9, 10, and 11).

U.S.G.S. iden. no.	Scene/Theme
E-193-75	Rift Valley, Kenya/Cartography
E-194-75	Mt. Kilimanjaro/Grazing conditions
E-195-75	Mt. Kenya/East Africa Seminar/Workshop
E-196-75	Ethiopia/Geology
E-197-75	Botswana/Land use
E-198-75	Swaziland/Multidisciplinary applications
E-200-75	Malagasy/Environmental changes
E-204-75	Ethiopia/Danakil Depression/ECA

14 The Sunday Post, April 7, 1974

MR. SIMON WANYEKI (right), Kenyan Water Department geologist, studies a space photograph of Kenya with (from left), Dr. David Carneggie, University of California; Mr. Raymond Razafindrakoto, Chief of Agricultural Statistics, Malagasy Republic; and Mr. J. D. Bennett, Geological Survey of Malawi.

AFRICA STUDIE[S] BENEFITS OF SPACE PHOTO[S]

by Michael Ngwalla

AFRICA is experiencing the far-reaching impact of the Earth resources Technology Satellite (ERTS). This week resource administrators and technical experts from 10 African countries completed at the University of Nairobi a seminar/workshop on remote sensing of earth's resources. Through a series of lectures and practical demonstrations of space data analysis, the workshop aimed to acquaint participants with the possibilities of practical application of data from ERTS in their countries.

Man's first comprehensive inventory of the resources he requires for survival was ... with the launching of ERTS ... its outpost in space, this ... "pathfinder," shaped like a ... fly and carrying remarkable ... called remote sensors, is ... cing decisions about agric... forestry, geology, land man... ment, hydrology, pollution, ... ography and meteorology.

The two-week workshop/se... nar was sponsored by the ... Ministry of Natural Resou... the U.S. Agency for Internati... Development (USAID), the Univ... sity of Nairobi and the U.S. ... logical Survey. While the ... Government and USAID pro... the financing, the U.S. Geolo... Survey furnished the experti... equipment.

Among those who lectured ... seminar were Apollo 9 Astro... Russell Schweikart; Dr. ... Deutsch, chief hydrologist ... USGS; Dr. George Rabche... from Photo Science, Inc.; ... David Carneggie of the Unive... of California; and cartogra... Merrill Conitz of USAID.

The participants analysed ... graphs of various parts of ... and considered their applica... to studies of resources and ... environment in their own coun...

ERTS, they learned, can con... bute immensely to man's un... standing of agriculture. With ... world food situation becom... critical (production must be ... by the year 2000), data from ... sensors have provided neede... formation on soil conditions, ... diseases, rainfall and land u... for food production. Remote ... ing can inventory cropland ... monitor crop development, de... ing the threat of drought and ... disease early enough to allow ... fensive action.

Environmental monitoring ... still in its infancy, but if ma... to improve his ecology, he ... accurately monitor the cond... of the air, water and land. ... has provided detailed data on ... tion of coastal areas, of the ... and inland seas and waterw... The data helps determine the ... tent and nature of damage cause... pollution and some forms of ... use. There is now a good cha... for developing nations to make ... per use of the environment ... avoid the mistakes made by ... industrialised nations.

The enrgy crisis lends ... urgency to the need for intens... search for alternative source... energy to oil. It has been esti... ted that by the year 2000 the w... will require three times as ... mineral resources as it uses ... ERTS data has helped locate ... logical formations which may ... tain fossil fuels, natural gas ... minerals vital to human devel... ment.

Imagery from ERTS has sh... a large crater-like depression ... miles wide in northern Ken... "Such depressions," says Dr. Ra... chevsky, "are usually conne... with mineralisation, and this ... ression in northern Kenya ... well contain oil."

Dr. Alula Abate, chairman ... Department of Geography at ... Selassie I University in A... Ababa, expressed the hope th... country can "use space image... assess the hydrology of Ethiop... drought area and to find way... preventing recurring disaster... have happened in the last few ye... in these dry areas." Perhaps, ... said, ERTS data can "locate und... ground water in Ethiopia and ... areas suitable to resettle some ... the excess population" of the ... regions.

Evening News March 28, 74

ASSISTANT Minister for Natural Resources, Mr. A. A. Ochwada (standing) accepts from Apollo 9 Astronaut Russell Schweikart a photograph of Mount Kenya made from a U.S. Earth Resources Satellite. The presentation was made at a banquet for participants from 10 African countries who are attending a two-week seminar-workshop on the use of remote sensing data as an aid to national development. The Government of Kenya, the University of Nairobi, the U.S. Agency for International Development and the U.S. Geological Survey are sponsoring the workshop.

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4 Evening News, Tuesday, March 26, 1974.

SKY SPY SHOT MAKES GREAT KENYA FIND

KENYA Ministry of Natural Resources announced today the discovery of a major geologic structure north of Mt. Kenya.

The discovery was described by Dr. George Rabchevsky of the United States along with Dr. John Walsh, Chief Geologist, and W. J. Wairegi of the Kenya Geological Survey at the East African remote sensing seminar on Natural Resources and Environment.

Dr. Rabchevsky is a member of the U.S. Geological Survey space science team who will be conducting workshops in remote sensing at the University of Nairobi which began on Saturday.

According to U.S. and Kenya experts attending the seminar, which is sponsored by the Ministry of Natural Resources, the University of Nairobi and the U.S. Agency for International Development, the discovery is of great potential significance.

It will aid scientists in gaining an understanding of geologic controls on vegetation distribution, mineral potential, the occurrence and movement of surface and underground waters, and the physical conditions which affect man's environment and habitat.

Dr. Walsh stated that detailed geological surveys of the area employing satellite data will begin in April.

The discovery was made on a specially processed photograph from data collected by the U.S. Earth Resources Technology Satellite as it passed over the Mount Kenya area at an altitude of 560 miles.

The dramatic colour photograph was presented to the Hon. William Omamo, M.P., Minister for Natural Resources by Mr. Morris Deutsh of the U.S. Geological Survey in a special ceremony at the banquet held for the seminar delegates at the Inter-Continental Hotel.

DAILY NATION, Wednesday, March 20, 1974 3

US space scientists arrive for seminar

THREE American space scientists who are using satellite and aircraft data for protection of the environment and natural resources arrived yesterday in Nairobi. Two others will join the team this week. The US team will join with natural resource scientists and administrators from 10 African nations in a 2-week programme of seminars, workshops, and field trips.

The programme, which begins at the Kenyatta Conference Centre tomorrow, is aimed at determining how best to use remotely sensed data, principally from the first US Earth Resources Technology Satellite.

It is being sponsored by the Government of Kenya and the University of Nairobi, in co-operation with US Agency for International Development.

African nations at the seminar will include Ghana, Tanzania, Malawi, Nigeria, Ethiopia, Sudan, Botswana, Liberia, Malagasy Republic, Lesotho and Swaziland.

Figure 7. Nairobi press coverage of the East Africa Seminar/Workshop on Natural Resources and Environment.

It should be noted that images used on 7 of the 8 above-listed displays were generated from the same 70-mm positive transparencies as those used by the participants at the Workshop. These data products were used by the participants as background in preparation of their reports on potential applications of ERTS data for their respective countries, which appear in the appendix. Figures 8, 9, 10, and 11 are black and white copies of color display based upon participants' reports and related workshop activities.

CLOSING SESSIONS

Closing sessions were held during the afternoon of Wednesday, April 3, 1974, in a meeting room of the Norfolk Hotel, leased for the occasion. The Norfolk is adjacent to the University of Nairobi.

Field trip results

Participants who joined field trips to the Mt. Kenya area or the Eldoret-Kerio Valley in March 29 and 30, 1974, submitted brief written reports on observations, along with any comments they cared to make. These informal reports are incorporated below as Appendices C and D. They are unedited and do not contain map or thematic overlays prepared by the participants.

Because preparation of the trip reports was considered part of the training exercises, they were prepared rapidly and were not supported by prior bibliographic research or thorough field investigation, each should be considered as a preliminary and informal expression of the author, and they do not necessarily have the endorsement of agencies of his government. They are incorporated herein primarily for future reference by the authors and any use deemed appropriate by the Government of Kenya, Ministry of Natural Resources, or the other represented governments.

The aerial survey of the Tana River Valley and the Kenya Coastal zone (Appendix E) was conducted on a nonscheduled basis as a post-Workshop exercise. Hence it was not possible for the participants to prepare reports on their observations.

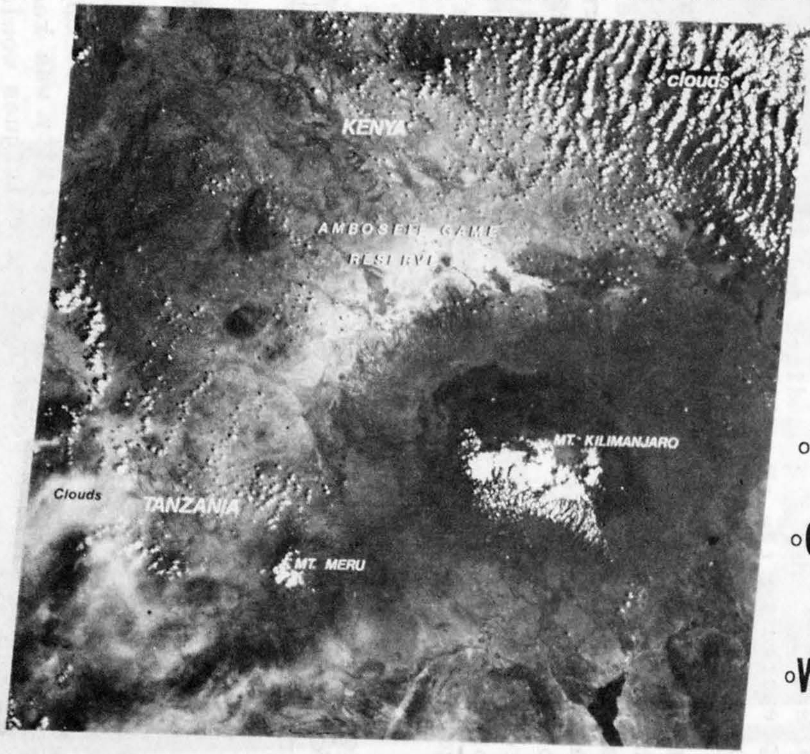
Participants' critiques

Early during the Workshop, the Principal Instructor requested that each participant submit a written evaluation of the effectiveness of the Seminar/Workshop in meeting the course objectives, which were specified, and are listed above. Brevity was requested, and it was stated that as time permitted the critiques would be discussed during the scheduled period. Unedited critiques are contained in Appendix F.

The concensus is that--for the most part--course objectives were attained.

GRAZING CONDITIONS REVEALED by ERTS*

* EAST AFRICA SEMINAR AND WORKSHOP FOR NATURAL RESOURCES AND ENVIRONMENT
NAIROBI, KENYA 21 MARCH - 3 APRIL 1974
SPONSORED BY THE KENYA MINISTRY OF NATURAL RESOURCES
AND THE U. S. AGENCY FOR INTERNATIONAL DEVELOPMENT



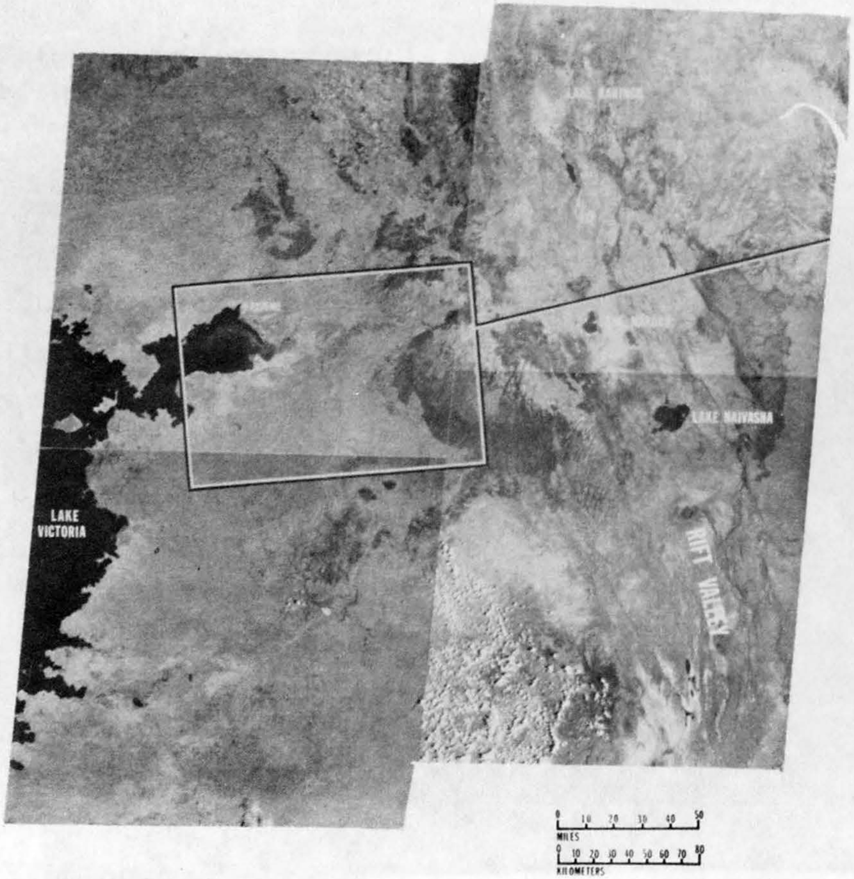
processed to show vegetation in red

ADVERSE GRAZING CONDITIONS WITHIN THE AMBOSELI GAME RESERVE ON 7 JANUARY 1974 ARE INFERRED FROM THIS ERTS COLOR COMPOSITE:

- **RED is vegetation shown by band 5...**
- **GREEN tones are moisture conditions shown by band 7...**
- **WHITE indicates lack of moisture and vegetation...**

Figure 8. Black and white copy of color display on grazing-conditions analysis in the Mt. Kilimanjaro area.

ERTS IMAGES used for new Kenya maps



preparation of a new map of the KISUMU QUADRANGLE 1:250,000 by the SURVEY OF KENYA is aided by the use of ERTS IMAGERY

KENYA and U.S. cartographers plan ERTS image map

Figure 9. Black and white copy of display on preparation of maps using ERTS imagery.

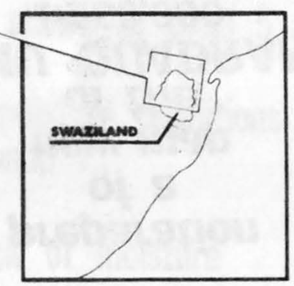
MULTIDISCIPLINARY APPLICATIONS for SWAZILAND

Applications of this ERTS image were identified* at the East Africa Workshop for Natural Resources and the Environment.**

GEOLOGY
- Economic
- Engineering

HYDROLOGY
- Dam Site Selection
- Ground Water Sources
- Surface Water Changes

AGRICULTURE
- Soils
- Crops
- Grazing



Two color composite processed to show vegetation in red.....

*SOURCE: A. S. Dlamini – Swaziland Department of Geological Surveys and Mines

Sponsored by
**KENYA MINISTRY OF NATURAL RESOURCES
and
U. S. Agency for International Development
Nairobi, Kenya 21 March–3 April, 1974

Figure 10. Black and white copy of color display listing multidisciplinary applications of ERTS data for Swaziland.

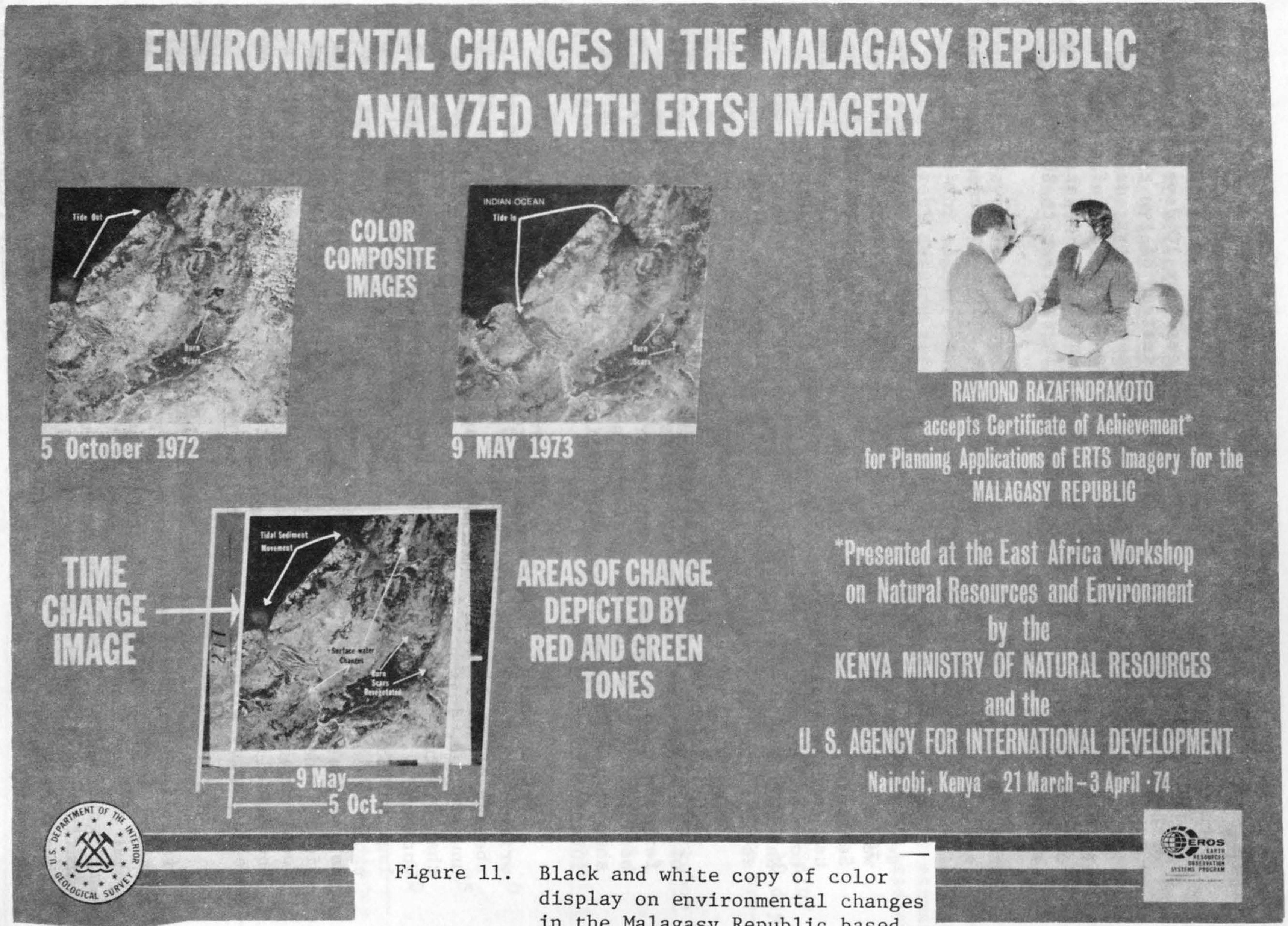


Figure 11. Black and white copy of color display on environmental changes in the Malagasy Republic based on analysis of ERTS data.

There was a general agreement that the workshop sessions were too limited in time, and "hands on" time on equipment was inadequate. Both criticisms were quite valid. Future workshops of this scope should be scheduled for a period of not less than 10 days. Inadequacy of equipment was due to loan of only one instead of two color additive viewers, as planned and promised by the manufacturers; malfunction of the diazochrome processer; inability to obtain loan of a zoom transfer scope from the manufacturer as tentatively offered; registration of 34 participants plus 8 co-instructors in contrast to 30 plus 4, respectively, as planned.

Solution: Future programs should use equipment owned or procurred by the U.S. or host Government.

Some criticism was directed toward redundancy of materials presented at Seminar and later at Workshop, with some merit. Redundancy was due mainly to the fact that a number of invited speakers for the Seminar did not appear, obliging the Staff to fill in these slots and use readily available materials. This was not unduly detrimental, however, as some of the non-Kenya participants did not arrive in Nairobi in time for the Seminar, and repeat showing of materials commonly assisted in their understanding.

Criticism was aimed at selection of field trip sites by several of the Kenya participants, and co-instructors. They would have preferred a trip to sites of on-going projects. This was not feasible, because the sites had been selected several months prior to the workshop on the basis of image availability and probable multidisciplinary interest in the sites.

Rather sharp criticism was recorded by a few--not only in the written critiques, but orally during the Workshops--concerning the absence of any computer-compatible tapes. This criticism was wholly unwarranted, inasmuch as it was determined during the planning sessions that digital processing and interpretation was beyond the scope of the Workshop. It was explained to those concerned that considerable time-lags were involved in obtaining tapes, that processing equipment was expensive compared to optical data processes, that such equipment was not available for use at the Workshop by participants in Nairobi, and finally that a principal objective of the Workshop was to develop a local capability for optical data processing--which was feasible-- and the guideline was to stress practical techniques which participants could employ within the scope of the limited budget.

A few of the participants would have preferred a more academically disciplined approach at the Workshops, i.e., more formal approach. As stated on page 10, the staffing plan was to provide a broad, but practical base of expertise reflecting academic (Carneggie), industry (Rabchevsky), and government (Deutsch) backgrounds in remote sensing. The plans for staffing were clearly stated in the planning report, and should have been made known to all participants and co-instructors, some of whom apparently expected either a wholly academic or wholly technical approach

As a solution, a brief statement of plans, objectives, guidelines, and scope should accompany future invitations to programs of this nature.

One of the co-instructors sharply criticised the failure of the staff to effectively employ him in an instructor capacity, with some justification. The list of co-instructors was expanded from 4 to 8 at the beginning of the Workshop so as to permit additional participation as well as additional instructional capability. This resulted in inadequate time or planning for effective collaboration between the staff and some of the co-instructors.

Several of the participants would have preferred concurrent workshop sessions to the combined workshop. Actually, original planning called for concurrent sessions, but due to the extension of the University of Nairobi session referred to above, the classroom facilities earmarked for concurrent sessions were no longer available. Concurrent sessions would certainly have been preferable if classroom and equipment facilities had been available.

Finally, the suggestion offerred by Mr. Norman Olsen of USAID/Kenya, that the staff should have arrived in Nairobi at least 10 days prior to the start of the Seminar, should be followed in future programs of this type.

Questionnaire for participants' evaluation of Seminar/Workshop

	Percent of answers		
	Adequate	Longer	Shorter
Was two weeks adequate for covering ERTS remote Sensing?	36	64	0
Was time allocated for lectures adequate?	75	0	25
Was the emphasis on instrumentation adequate?	32	48	20
	Satisfied	Prefer balance	
Were you satisfied with the emphasis in the course on ERTS, or would you have preferred a better balance of aircraft and spacecraft remote sensing?	73	27	
	Yes	No	
Would you have preferred working with imagery of a known area?	100	--	
Was it worthwhile to schedule a field trip?	100	--	
Was it worthwhile providing imagery of participants country?	100	--	

Q. Of those desiring more workshop time and longer course, what additional material should be covered?

ANS: More interpretation techniques, quantitative analysis, and sampling for ground data collection.

Q. How could the field trip be improved?

ANS: Select area for which maps of resources exist, or coinstructors are familiar with area.

Q. Should future courses emphasize multidisciplinary approach?

ANS: Introductory material should be multidisciplinary, but later workshops should emphasize specific resource disciplines; field trips should also be multidisciplinary.

Potential applications of an operational earth satellite system in national programs

As stated above, one of the Workshop objectives was "To provide participants with ERTS data covering their own country, both to improve their perspective of the imagery and to stimulate use of the imagery upon return to their home countries." Accordingly, participants from each country were asked to prepare a "brief report" on the potential applications of an operational earth satellite system for their respective countries, or for their agency programs in the case of the Kenya participants. The purpose of this exercise was not the preparation of formal documents, but rather to improve the capability of the participants in interpreting ERTS data and to develop their confidence in the probability of successful implementation of ERTS and other remotely-sensed data on national programs.

Appendix G contains unedited copies of the reports submitted for this exercise. It is believed that they represent not only a valuable first step for implementation of remote sensing for resources and environmental applications in some of the participating nations, but are a basis for follow-up dialog between AID and the African Governments that wish to pursue remote-sensing technology toward an operational status.

The applications reports contained herein were rapidly prepared as a training exercise and must therefore be considered as preliminary and unofficial expressions of the author. They do not necessarily reflect the position or policy of his government.

Certificates of Achievement

A Certificate of Achievement specially prepared for the S/W was presented to each of the participants and those Co-instructors, who in addition to their instructional activities, participated substantially in the overall program. Certificates were signed by Edward B. Hogan (AID), J. H. O. Omino, Permanent Secretary of the Kenya Ministry of Natural Resources, and Morris Deutsch (USGS) (fig. 12).

Presentation of the Certificate of Achievement was made to each recipient by Mr. Alvan Karanga, Deputy Minister of the Kenya Ministry of Natural Resources. Congratulations to the recipients was expressed also by A. B. Cahusac, Secretary, Kenya National Environment Secretariat. Dr. Richard Odingo, Department of Geography, University of Nairobi, and Mr. Merrill Conitz.

On behalf of the Kenya Minister of Natural Resources, the Hon. W. O. Omano, M.P., Mr. Cahusac presented each staff member with a color photograph of the Kenyatta Center, and a color-illustrated book titled "Kenya." The following notation was made on each gift:

"A token of our appreciation for your enthusiastic contribution to the Remote Sensing Seminar/Workshop held in Nairobi, March/ April, 1974." /s/ W. O. Omano, Minister for Natural Resources.

Through the courtesy of the USAID Mission/Kenya, a commercial photographer was engaged to photograph the acceptance of the Certificate by each participant. Following presentation of the Awards, tea was served to the participants by the Norfolk Hotel, compliments of the Kenya Ministry of Natural Resources.

EVALUATION AND RECOMMENDATIONS

Performance evaluation

Any attempt by the USGS to classify the success of the S/W to meet its stated objectives at this time would of necessity be premature. The ultimate success will be determined by the extent to which the S/W actually stimulated interest in, and use of, ERTS and related data, and the extent to which it resulted in beneficial implementation of remote-sensing technology by investigators and agencies of the participating governments.

Factors contributing to, or detracting from the success of the program, are listed as follows:

UNITED STATES OF AMERICA
AGENCY FOR INTERNATIONAL DEVELOPMENT
GEOLOGICAL SURVEY

REPUBLIC OF KENYA
MINISTRY OF NATURAL RESOURCES
UNIVERSITY OF NAIROBI

Certificate of Achievement

This certifies that, under the Program of the Agency for International Development, U. S. Department of State, in cooperation with the Republic of Kenya and the University of Nairobi,

____

has successfully participated in a Remote Sensing Seminar and Workshop on African Natural Resources and Environment at Nairobi, Kenya.

21st March to 3rd April, 1974.

U. S. Agency for International Development

Ministry of Natural Resources

Factors contributing to the success to the S/W: **

Detailed and coordinated planning by the ad hoc planning committee of the Kenya National Environment Secretariat, AID, and the USGS.

Collaboration by AID personnel in the program activities, including, especially, actual training assistance by Merrill Conitz.

Excellent facilities and logistical support by the Kenya Ministry of Natural Resources, arranged by Mr. A. B. Cahusac and his staff.

Enthusiastic and relevant addresses given at the Seminar by Government of Kenya and United Nations speakers.

Speech by the U. S. Ambassador, the Hon. Anthony D. Marshall, which illustrated the level of importance attributed to the program by the United States.

The assignment by NASA of Astronaut Russell Schweikart to present the Seminar and Banquet addresses.

Pre-processing of ERTS imagery over parts of the participating countries for display and distribution at the S/W.

Distribution of numerous remote sensing reports and documents to each participant.

Actual generation in Nairobi of ERTS data products covering most of the countries represented, as a demonstration of the feasibility for developing a local in-house capability for undertaking remote-sensing projects.

Field trips employing ERTS imagery for interpretation and technique familiarization.

Professional support by Co-instructors, especially on field trips.

Post-workshop aerial trip which provided those able to attend with an improved perspective and appreciation of aircraft underflight of satellites for collection of complementary data.

Timely photographic support of high quality by local contractor.

Thorough and effective communications media coverage including local press, radio, and television, reports and special feature coverage by the Voice of Kenya, Voice of America, and the US Information Service.

Development of close, cordial, and personal rapport between the Staff and participants.

** See also Appendix F.

Factors detracting from the success of the S/W**:

Late arrival of some participants and early departure of others.

Inadequate time and staff for the number of participants at the Workshops.

Reliance on manufacturers to loan equipment at no charge, some of whom were unable to fulfill early offers for a variety of reasons. This resulted in a shortage of workshop equipment.

Late shipment or late arrival of some equipment or material.

Unanticipated extension of class schedules by the University of Nairobi, which resulted in erratic attendance by participants from the University.

Failure to coordinate hotel accomodations for Staff and visiting participants. Housing at the same hotel for all except residents of Nairobi would have extended time and opportunity for informal discussions and improved effectiveness of communications.

Recommendations for follow-up activities

For maximum lasting benefit for the participating African nations, a variety of follow-up activities to the East Africa Seminar/Workshop are suggested. The suggestions are offered in the expectation that if followed, they will not only tend to make permanent the impact of the S/W, but to enhance its beneficial aspects. (Some of these steps have already been implemented):

Continuing assistance by USAID for African resource administrators or investigators for training or study in the U.S., including details to offices of Government agencies conducting pertinent remote-sensing activities. (This has already been implemented. Daniel Kirori, Shirish Dodhia, and Walter Absaloms of Kenya attended a month-long course at Sioux Falls during June, 1974.)

Preparation of additional ERTS data products covering African scenes as part of on-going programs, as possible within time and funding constraints.

Designation of U.S. experts to advise, consult, or collaborate with African investigators on an assigned basis by mail and (or) in the field, as need is indicated.

Assistance by USAID for individual African nations or international organizations, such as the Economic Commission for Africa, in establishing remote-sensing capabilities including data reception, data processing,

**See also Appendix F.

laboratory, and communication facilities.

An early meeting between African authorities and U. S. experts representing all facets of satellite remote sensing and applications planning.

Sponsorship by USAID and the Government of Kenya of a Remote-Sensing Symposium on African Natural Resources and Environment to encourage application of ERTS and related data. The Symposium should be directed to policy and administrative-level delegates as well as to technical personnel.

Sponsorship by USAID and the Government of Kenya for an ERTS Projects Workshop to be held in conjunction with the proposed Symposium. The Projects Workshop should be directed toward technical and planning personnel engaged in on-going or planned projects that could be significantly aided by remote-sensing technology.

Canvass of African Nations as to desirability of conducting another technical Workshop similar to the East Africa S/W of March-April, 1974. (This canvass should be accompanied by a copy of this report and (or) displays produced from results of the East Africa S/W).

REFERENCES

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Grolier, M.J., Fary, R.W., and Gawarecki, S.J., 1974, The Sanelian 7 Zone Remote Sensing Seminar/Workshop at Banako, Mali, West Africa April 17-28, 1973: U.S. Geol. Survey open-file rept. (IR) WA-3.

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APPENDIX A. SEMINAR PROCEEDINGS

INTRODUCTORY REMARKS

By J. H. O. Omino,

The Permanent Secretary
Ministry of Natural Resources
at the opening of The Remote Sensing Seminar, Nairobi

21st March, 1974

Mr. Minister, Mr. Ambassador, Distinguished Guests, Ladies and Gentlemen,

It really gives me very great pleasure to see so many keenly interested members of this audience, coming not only from Kenya but from many friendly African sister states. The pleasure derives largely from the fact that for the last three years it has been the responsibility of my Ministry to nurture this new concept of "a birds eye view of the earth" or remote sensing and to make sure that its benefits are available to all arms of our Government and our other institutions which can utilize them.

My pleasure also derives from the fact that, judging by the attendance this morning there is more than passing interest in the potentialities which this new tool of our technological age offers to us. Personally I am convinced by the results so far obtained from remote sensing, that this tool can benefit us and that we will be more than foolish if we fail to understand how to use it - we would then put ourselves in the hands of those who do have that knowledge and who cannot only sell their expertise to us but also learn more about our resources than we would know ourselves. If one does not keep abreast of technology, technology will not wait for us and we will forego the benefits which technology can offer us. To intelligently plan the running of our nations we must have accurate information and this is what this new system promises to provide.

Before I introduce the Hon. Arthur Ochwada, who is officiating on behalf of my Minister who yesterday suffered an unfortunate accident and who expresses his regrets at not being able to be present, I should like to convey the thanks of the Kenya Government to the University of Nairobi for their sponsorship and for making available accomodation and classrooms at the campus for the use of the workshop; and the staff of the United States Agency for International Development and the United States Geological Survey for all the very hard work they have put into preparing the materials needed for the Workshop, for the Exhibition on view outside this room and for enabling us to have the use of some of the latest analytical equipment for laboratory work; special thanks are also due to Russell Schweikart of NASA, one of the celebrated band of moonwalkers, for coming out here and contributing to our wider knowledge of space potentials; thanks must also go to Dr. Carneggie of the University of California and Dr. Rabchevsky of Photo Science for coming to share their knowledge and experience with us; finally the assistance and cooperation of the United States Government deserves special asknowledgement.

It is now my pleasure to invite the Hon. Arthur Ochwada, Assistant Minister in the Ministry of Natural Resources to say a few words of welcome to our participants. Mr. Ochwada.

ADDRESS OF WELCOME

By The Hon. W.O. Omamo, M.P.

Minister for Natural Resources

Mr. Ambassador, Distinguished Guests, Ladies and Gentlemen,

Looking back into the dim and distant past we can well imagine how our forefathers, climbing to the top of a hill, looked down into the next valley, perhaps to no-man's land of virgin forest and bush teeming with game. The leader of the little party points excitedly and exclaims, 'That looks good land down there - you, young fellow, go down, see what you find and come back tomorrow and tell us what you have found.'

And there, in that short sentence of instructions, you have the early elements of remote sensing technology - viewing from a remote point and evaluating what was viewed and then carrying out that necessary component - checking the ground truth by means of a simple sampling method.

Even less than a hundred years ago that system was still the only way in which man could discover more about the natural resources and the environment which surrounded him - plain footslogging aided by an intellectual assessment based on experience.

Then a sequence of inventions and technological progress in several different fields started to take place - first the balloon, filled with hot air and later with gas, lifted man high above his pedestrian standpoint - and with it the humble kite which played a part in 19th century war - and then the flying machine which gave man a controllable and mobile vantage point enabling him to overview thousands of square miles of his domain in a single glance. Then came the first camera - a toy of rather splendid simplicity - which provided man with a means of recording such a glance - something the human eye could only do through the process of memory - and something the artists pencil could never trace in its infinite variety and detail.

Then link the camera with a flying machine and hey! presto! you are in the aerial survey business! Aerial survey has revealed the topography and resources of countless square miles or this globe, mainly in straightforward black-and-white pictures and has been a tool of great value in man's ability to open up new lands, build highways, map the features of his countryside and evaluate forest resources.

But even with all the sophisticated aerodynamics which we have today the ordinary plane finds it hard to fly much above 10 miles high which means that width of a strip of air photographs is limited to approximately the same distance. So that to cover our country Kenya in that way would mean some 50 north south strips would need to be flown with an average of 50 pictures in each strip - and this is taking no account of overlap needed between strips and between pictures - allowing for all the logistic problems and other difficulties you might end up with some 400 pictures, each taken at a different time of day, from which to interpret what is going on below.

The new platform which circles this planet in 103 minutes derives from the old Chinese gunpowder rocket, the German V2 rockets of the second world war and the little bleeping Soviet Sputnik which made us all crane our necks in the sixties. Fitted up with all the gadgetry of electronics and miniaturisation this platform sends us, in a mere 25 seconds, a colour picture of our land 100 miles by 100 miles in size, meaning that we can, with a mere 30 or so pictures 'see' the whole of Kenya in colour!

What we are gathered here for today is to learn just exactly what those space pictures can tell us - what that little speck or colouration means - what the subtle changes in colour between pictures of different date mean - what the reflective value of each and every object on the surface of the earth comprises.

To participants in this Seminar/Workshop it is my very great pleasure to welcome you to this first meeting and for those of you from outside Kenya, to welcome you to our land and our city and indeed to this fine Conference Centre. This time here will be a meeting of minds - between minds versed in the expertise of a new technology, a technology which will inevitably affect our lives and our countries - and between minds geared to the processes of development and raising our nations to better ways of life. I wish you all well. Thank you.

Then link the camera with a flying machine and hey presto! you are in the aerial survey business. Aerial survey has revealed the geography and resources of countless square miles of this globe, mainly in straight forward black-and-white pictures and has been a tool of great value in man's ability to open up new lands, build highways, map the features of his countryside and evaluate forest resources.

But even with all the sophisticated aerial techniques which we have today the ordinary survey plane flies at [illegible] above 10 miles high which means that width of a strip of air photography is limited to approximately the same distance. So that to cover our country Kenya in that way would mean some 50 north south strips would need to be flown with an average of 50 pictures in each strip - and this is taking no account of overlap needed between strips and between pictures - allowing for all the logistic problems and other difficulties you might end up with some 400 pictures, each taken at a different time of day, from which to interpret what is going on.

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What we are gathered here for today is to learn just exactly what these space pictures can tell us - what these little specks or colours [illegible] mean; what our subtle changes in colour between pictures on different dates mean; what the reflective value of each and every object on the surface of the earth conveys.

To participants in this Seminar/Workshop it is my very great pleasure to welcome you to this [illegible] meeting and for those of you from outside Kenya to welcome you to our land and our city and indeed to this fine Conference Centre. This time here will be a meeting of minds - between minds versed in the countries of a new technology, a technology which will inevitably affect our lives and our countries - and between minds geared to the processes of development and helping our nations to [illegible]. I wish you all well in [illegible].

SPEECH AT THE OPENING SESSION OF THE EAST AFRICAN SEMINAR AND WORKSHOP ON NATURAL RESOURCES AND ENVIRONMENT

By Ambassador Anthony D. Marshall

Thursday, March 21, 1974

Mr. Minister,* Dr. Odhiambo,** Mr. Omino,*** distinguished participants in this Seminar and Workshop on Natural Resources and Environment, on behalf of the United States Government and particularly of USAID, I am pleased to have this opportunity to address you.

Seldom has an experimental program in science and technology met with such a high degree of success and enthusiasm as have the earth-oriented space programs of ERTS and Skylab. Based upon the keen interest shown and the extensive use that has already been made of the resources and environmental data collected by these satellites, it does not seem presumptuous to label them unqualified successes.

ERTS-1, which was launched in July 1972, has been recording images of the earth's surface at the prodigious rate of 13,000 square miles every 25 seconds while the scanner is operating. The data already accumulated by this remarkable satellite have given us an unparalleled opportunity for viewing resource and environmental phenomena at a level of completeness and sophistication undreamed of only a few years ago. Applications include recognition of mineral deposit zones, changing patterns in land use and urbanization, monitoring of crop production, identification of plant diseases, recognition of man's impact upon forest resources; the mapping of surface water distribution, including regional flooded areas, crop mapping, detection and monitoring of land and water pollution and analysis of coastal and wetlands ecology.

Despite these many advancements, much more is yet to come. The ERTS program, in terms of the number of satellites launched, is only half completed. When the equipment on board ERTS-1 has exhausted itself, ERTS-B will go into operation; this is expected to be in one year's time. However, if necessary, ERTS-B could be launched in October of this year. The ERTS program has met with such outstanding success that it is sometimes difficult to remember that it is still experimental. Indeed, rather than coax participation, NASA has sometimes found it necessary to remind countries scarce in financial resources that it may be too early for extensive investments in complex facilities.

The records of participation in earth science experiments offer proof of how great the response has been. Several <u>hundred</u> investigations

* Assistant Minister of Natural Resources
** For the Vice Chancellor, Dean of Faculty of Science
*** Permanent Secretary, Minister of Natural Resources

in 33 countries, including Kenya and Botswana, are being carried out under the ERTS-1 program alone. In addition to the experiments sanctioned and supported by NASA, countless more are being conducted on imagery purchased from the Earth Resources Observation System Data Center at Sioux Falls, South Dakota. Since this imagery is readily available for purchase, there is no way of knowing how many worthwhile, but yet undocumented, investigations are under way. Despite the experimental nature of the program, it is also known that much of the imagery has and is being used operationally by both public and private organizations.

The availability of the data can be regarded as another milestone in the program. ERTS and Skylab are entirely civilian projects with no government classification of either data or hardware. As such, these projects are prime examples of the kind of benefits and cooperation envisioned by the drafters of the United Nations Treaty on the Peaceful Uses of Outer Space. Let us hope that the spirit of free access and cooperation generated by ERTS and Skylab will form models for further cooperation in the peaceful uses of outer space.

While these remarks have been addressed to the uses of satellite technology in resource and environmental monitoring, we must not overlook the broader aspects of science and technology development and utilization. The space segment of the technology that we have come to know as remote sensing is only one element of a complex technological system. Other elements such as photography, video communication, aircraft surveys and image interpretation have been perfected over many years and even decades.

Satellites have served as a catalyst to stimulate man's imagination to produce the complex systems that we have available today. This catalytic action has many remarkable characteristics. Not only has it caused the bringing together of many technological elements but it has also been responsible for bringing together persons of many different interests and disciplines. This seminar is a typical example. We have represented here foresters, hydrologists, agronomists, engineers, range managers, soil scientists, environmentalists, and many others. The interchange that has thus been made possible is one of the most fascinating results of the programs.

International cooperation is another extremely important benefit of the programs. By definition satellite systems are international and no nation should be deprived of their benefits. Just as we have many different resources and environmental fields represented here, we have participants from 10 African countries. International cooperation in science and technology may lead the way toward increased international cooperation in other areas.

REMOTE SENSING FOR RESOURCES AND ENVIRONMENTAL APPLICATIONS IN DEVLEOPING COUNTRIES

By Dr. Nicholas C. Otieno
Chief, Environment Unit
United Nations Economic Commission for Africa

Mr. Chairman, Ladies and Gentlemen,

It gives me great pleasure to address you at the opening of this important seminar on Remote Sensing. But before doing so, I wish to convey sincere apologies from my colleague, Dr. Wasawo, who was prevented from coming to address you by urgent duties in Addis Ababa.

The concepts and practices of "Remote Sensing" are as old as mankind himself; and it is only the methodologies employed and equipment used that have changed and become more sophisticated and more reliable because of an increase in man's cumulative knowledge over the ages.

When the cave man climbed the nearest tree or clambered to a nearby hilltop to survey the terrain below him for the animals he would need for his next meal, he was remote-sensing the natural resources around him for his well-being and survival. As man continued to learn from experience and continuous search, knowledge of aerodynamics - combined with the use of the eye and photographic camera - introduced him to the use of the balloon, the aeroplane and the heliocopter which enabled him to view his mother earth much more rapidly and extensively from higher altitudes and with greater precision and detail.

The advent of rockets followed by the introduction of satellites - especially the manned satellite - carrying the most modern technological devices so far known - has enabled mankind to survey the earth's resources and to monitor environmental changes brought about by their exploitation in far-reaching dimensions undreamed of even a decade ago. The scope of work previously carried out by an aeroplane in ten years, for example, can now be accomplished by remote sensing techniques in about ten days or less.

This new technology of "Remote Sensing" has already paid great dividends to its innovators in the industrialized world in the fields of natural resources exploration and environmental monitoring. But it is in the underdeveloped world suffering from paucity of information concerning such topics as the extent and quantity of natural resources, population dynamics and grave problems of human settlements, environmental changes and/or degradations such as decay of agricultural land, coastal pollution, etc., that this new technology is called upon to play a major role. It is in the underdeveloped world where the masses are wallowing in the slough of despondent poverty and engulfed in a squalid vortex of unprecedented misery; where knowledge of resources which can be galvanized for the economic and social improvement of the masses is urgently needed; it is in these countries where sophisticated technology using the most up-to-date methodology as that provided by remote sensing is urgently required. And in this concern, time is not on our side. We must act now and act fast.

The under-developed world - and especially the continent of Africa - needs to be examined afresh in the light of the new technology if we are not to be caught up in a web of disasters. The exploration and exploitation of Africa's hydro-atmospheric resources,the biotic resources, the energy resources and the mineral resources for development are bound to be accelerated and expedited through the use of "Remote Sensing." Here, I will pause and cite a few examples which have either borne out the above statement or which are awaiting the benevolent onslaught of this new technology.

With respect to hydro-atmospheric resources, many parts of the continent are chronically short of water and are hard put to get enough quantities for man and his flocks - leave alone for irrigation purposes. Efforts are being made to exploit surface waters for irrigation and power production. Some countries have initiated projects to exploit the underground water resources without knowing their extent and rate of recharge on which should be based the rate of exploitation. Here is an important area where remote sensing would be of great benefit to the vast savannah plateaus of Africa including the widespread deserts. On the other hand, many African countries suffer from periodic flooding - river banks get submerged, lake levels rise and cover much valuable arable land and at the same time disrupt fishing activities for the population concerned. Here, use of remote sensing should enable Africa to predict weather changes over a long term basis - and any planning should be guided by the data so acquired.

In the field of biotic resources, Africa is richly endowed with unparalled concentrations of exotic flora and fauna which are being exploited without the knowledge to insure that they do not become depleted. The spatial distribution patterns of these living resources and the population dynamics are not properly understood. Tropical hardwoods which take up to a generation or more to mature are threatened with extinction due to uncontrolled exploitation. Wild animals are being decimated by the poacher. Remote sensing over a period would enable countries to accumulate enough reliable data which would enable Africa to plan for rational utilization of these resources on a sustained-yield basis.

Africa is subject to cyclical weather changes and often suffers from severe droughts as the one which has been experienced in the Sudano-Sahelian zone during the last few years; and one study estimates that the dry conditions will continue to be experienced in the continent up to the year 2030 AD. These climatic cycles have been aided and abetted by a spiralling increase in population of both man and his livestock and by his uncontrolled aggressive manipulation of the ecosystem so that environmental distortions and disequilibria have set in and brought in their wake the process of desertification. Through remote sensing, we would probably be able to acquire better knowledge about the reported southward march by the Sahara desert at the rate of some 10 kilometers per year - and hopefully devise workable plans to tackle this menace confronting the African environment.

When we come to consider energy resources, over 90 per cent of Africa's population depend on wood and its derivative - charcoal - for their energy requirements. This resource is being exploited at such a fast rate that I consider that the number one energy crisis facing Africa is the disappearance of firewood. This is evident when one notices the ever-widening desertic areas surrounding Africa's cities. This problem could also be studied by remote sensing and plans drawn to contain it. The Rift Valley System of Eastern Africa has extensive geothermal energy sources which are just beginning to be explored. Through infra-red photography, it has been found that one area covering some 5,000 km^2 of the Ethiopian Rift Valley has power potential of 250,000 megawatt years. Preliminary studies have been conducted in Kenya and Tanzania as well. Added to this, a geothermal survey in Ethiopia has revealed concentration of magnesium in the molten brine to a magnitude of 15.6%. The use of remote sensing will enable African countries not only to survey the extent and magnitude of these geothermal resources, but also of the vast mineral deposits that are likely to be associated with them. In addition, remote sensing techniques have expedited the location of geologic formations indicating the presence of minerals in many parts of the world. Africa, which hardly knows the total mineral wealth lying beneath her feet would do well to exploit this new and amazing technology of remote sensing.

Mr. Chairman, you are in charge of Natural Resources here in Kenya and I know that the Kenya Government and private companies have spent large sums of money trying to discover minerals and hydro-carbons using conventional means - but with very little success. I venture to suggest to you that the US, through the Skylab mission, might have acquired all the information you are looking for - and that this information is only waiting for you to put it to use.

But I believe you come against the bottleneck of the shortage of trained manpower with requisite technical skills who would study this information, interpret it, and put it on the ground to turn it into goods and products that would contribute towards economic and social development of your country. But here you are not alone. Most Africa is afflicted with the malady of shortage of expertise and trained manpower. This is why the ECA attaches great importance to training of specialists and has helped in the establishment of a Training Centre in Photogrammetry, Photo-interpretation and Aerogeophysics at Ife in

Nigeria. Another centre is planned for Yaounde, Cameroon; and I am glad negotiations for a similar centre in Nairobi are at an advanced stage.

Mr. Chairman, our only hope is that we will be able to get the necessary manpower soon and that with goodwill from the US authorities who possess this powerful tool of remote-sensing, we will be able to get the maps, the photographs and the necessary instruments that will enable African countries to use this new technique towards their developmental efforts.

U.S. DEPARTMENT OF THE INTERIOR EROS PROGRAM PROGRESS IN REMOTE SENSING OF EARTH RESOURCES

By Morris Deutsch
U.S. Geological Survey

Mr. Secretary, Seminar participants, and distinguished guests,

At the XII International Astronautical Congress held in Brussels, Belgium, in September of 1971, Dr. William H. Fischer, Senior Scientist of Earth Resources Observation System (EROS) Program described the potential applications of the yet-to-be-launched Earth Resources Technology Satellite. Many years of planning, engineering, and scientific research were expended in design and construction of the satellite. The USGS collaborated closely with NASA in the Earth Observation Program employing aircraft carrying cameras used to simulate the ERTS sensors. Many useful results in the field of Earth Sciences were obtained from the aircraft program and the projects were prototypes for the experiments being proposed for ERTS. By the close of 1971, the USGS and AID cooperative program with other countries had included a broad spectrum of activities, including participation in internatinal geologic, hydrologic, or topographic conferences, technical assistance to the developing countries, scientific exchange and cooperative research, and training of Earth Scientists. By that time the USGS provided earth science specialists for about 1000 assignments in more than 70 countries.

In addition the NASA aircraft program and the manned and unmanned Gemini and Apollo space programs provided data of immense value to the Earth Resources Community and to the planning of the ERTS program. Of especial interest to us attending this Seminar is the famous SO-65 experiment of Apollo when a multiple camera array was used to simulate photographically the multispectral data to be obtained by the two ERTS Sensors -- the Return Beam Vidicon (RBV) and the Multispectral Scanner (MSS). We are most fortunate to have with us today Astronaut Rusty Schweikart who operated the multispectral camera system on Apollo 9 for an earth resources experiment following successful trial of the Lunar Landing Module in Earth orbit.

Thus, ERTS was specifically designed to obtain data in those optimum parts of the spectrum to provide the kinds of information needed by earth scientists and resources managers. The EROS program, to which I have been priviledged to have been assigned for the past six years has as its objectives the employment of current technology to acquire data that will economically yield information to the broadest possible spectrum of earth scientists and managers and to utilize those data to improve our knowledge of resources and the environment, and to undertake necessary research.

After years of study and preparation, ERTS was finally launched in July of 1972. Its orbit, sensors, altitude, field of view all were planned to be of optimum value for natural resource and environmental applications. The design life was one year. We are now well into the 20th month of ERTS' life, and its performance has exceeded all expectations.

The motto of the ERTS Program is "For the Benefit of All Mankind." Among the numerous applications made of ERTS data that the United States expects to be of practical benefit to those nations participating in the program are the following*:

Metalliferous zone detection	Range conditions
Flood warning	Geologic mapping
Earthquake monitoring	Cartographic improvements
Water management model	Wetlands ecology
Snow-runoff prediction	Land use studies
Flood mapping	Census studies
Pollution detection	Environmental changes
Agricultural conditions	Ground-water exploration

*Each application illustrated with one or more pertinent slides.

The SO 65 experiment of Apollo 9 was not the only Earth application of the United States' Lunar Program. The view of the Earth in its entirety (fig. 13) has given scientists a new perspective of the Earth and its veneer-like and fragile atmosphere. It has shown that the expanses of land and fresh water are pitifully finite and need careful exploration, development and management if they are to fill the requirements of mankind.

The objectives of the EROS Program are to employ current remote-sensing technology to acquire data that will economically yield information useful to the broadest possible spectrum of Earth Scientists and resource managers, to use those data to improve our knowledge of natural resources and the environment, and to undertake necessary research.

It is my earnest hope that this Seminar and the Workshop to follow will be a first step in the achievement of those same objectives by Kenya

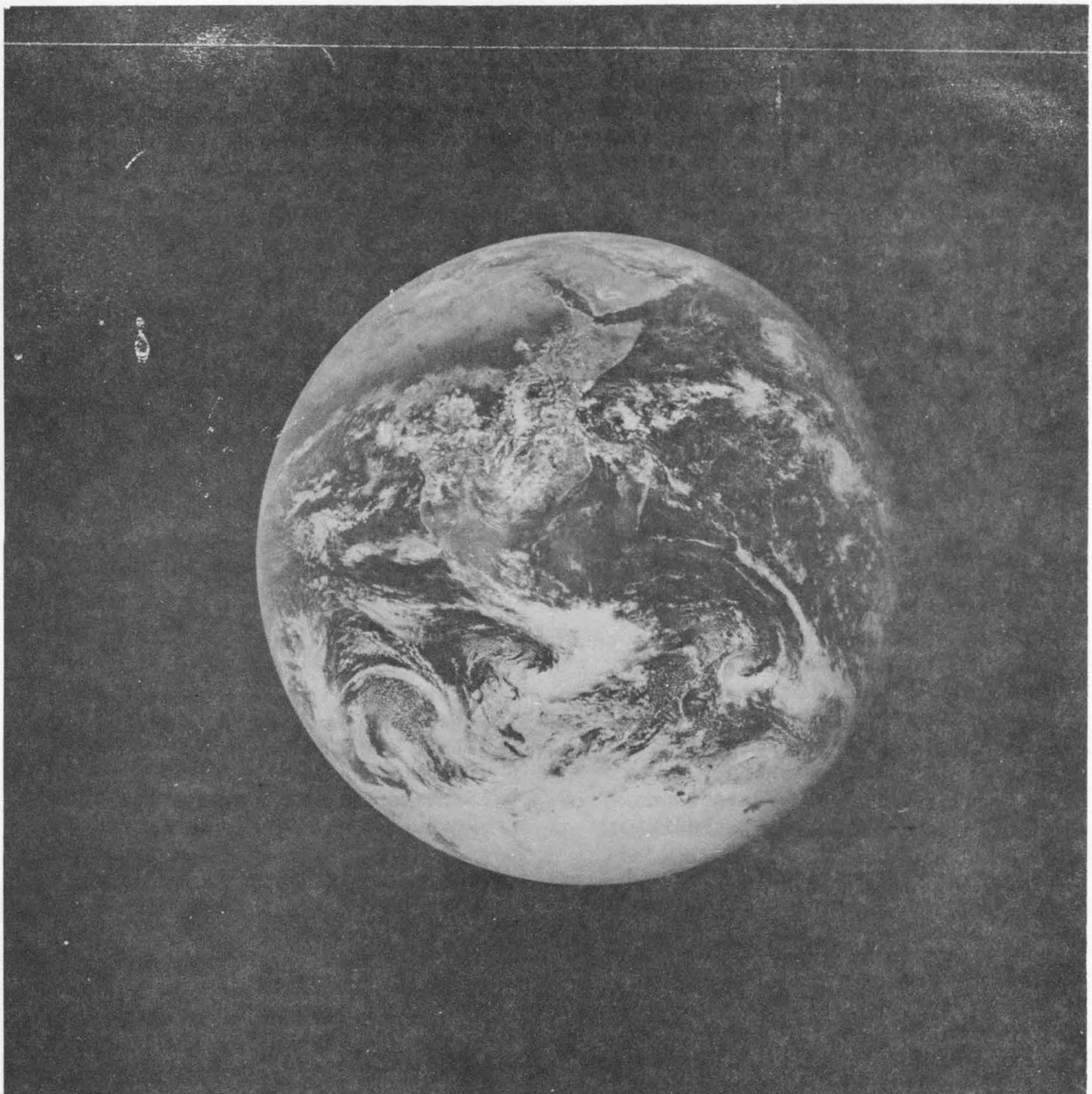

Figure 13. The full Earth, including the African Continent, as photographed by the Apollo 17 astronauts on their journey to the moon.

and all the other African nations represented here today, and that the ERTS Program motto "For the Benefit of all Mankind" will be widely fulfilled.

OUTLINE INTRODUCTION TO REMOTE SENSING -- IN LAYMAN'S TERMINOLOGY

By Dr. David M. Carneggie
University of California

Remote Sensing Defined: The activity of acquiring and interpreting imagery from aircraft and spacecraft.

Activities Implied by Remote Sensing:

(1) Use of remotely positioned aircraft and spacecraft
(2) Use of sensor systems to record reflected or emitted radiation
(3) Electromagnetic energy is what is being sensed
(4) Electromagnetic energy is recorded in the form of photographs, photolike images, called imagery, and magnetic tape
(5) Imagery is acquired for a specific purpose
(6) Imagery is interpreted by manual or automated techniques
(7) Information extracted from remotely sensed data is presumed useful for improving management information and making wiser management decisions

Remote Sensing Platforms include: Helicopters, single engine aircraft, multiengine aircraft, high flying jets, and various satellites.

Sensor Systems include: Cameras, both single and multilens; gamma ray spectrometers; optical mechanical scanners; thermal infrared scanners; radar devices; passive microwave radiometers.

Electromagnetic Energy: Regions of the spectrum where there is a capability for sensing include:

gamma rays	10^{-9} - 10^{-6} microns
ultraviolet	.3 - .4 "
visible	.4 - .7 "
near infrared	.7 - 2.5 "
thermal infrared	3.5-5.5, 8-14 "
passive microwave	
radar	1.0 - 3.0 cm.

Sources of E-m Energy: Sun; objects themself emit long wavelengths of radiation; radar devices generate their own energy.

Energy Interactions: Radiation is reflected, emitted, transmitted, scattered, and absorbed differentially by objects depending upon their atomic or molecular characteristics.

Interpretation Techniques: Manual techniques, stereoscopic examination; automated techniques involving computer classification of photographic or tape data: color enhancement techniques.

Applications: Remote sensing is a "tool" which is useful only when user groups can identify informational requirements which can rapidly, efficiently or inexpensively compared to conventional techniques for acquiring similar information.

COST AND BENEFITS OF REMOTE SENSING SYSTEMS

By Merrill Conitz
U.S. Agency for International Development
Office of Science and Technology

Remote sensing is an exciting technology. It is responsible for the many fascinating examples of imagery which we have seen displayed and illustrated here yesterday and today. It has resulted in a number of significant discoveries as well as improved resource and environmental management practices. The technology is interdisciplinary -- there is something in it for almost everyone. As you have already heard, there are applications in every field relating to the earth's physical features. In fact, almost every aspect of economic, physical and social development draws upon data which can be acquired by remote sensing methods. An element of glamor has been added with the development of satellite platforms for remote sensors. Man at last has the capability of observing any physical feature on earth at any desired scale, from the smallest grain of sand to the whole earth on a single image.

Yet for all the rhetoric about multidisciplinary applications and space age glamor, the final decision as to whether a country or organization will participate in remote sensing activities will be based upon simple economics. The prosaic cost benefit analysis will be the final determining factor in this decisions.

This is not to say that every such decision will be based on a rigorous and complete cost benefit analysis. Many of you here today are using remotely sensed imagery and perhaps few of you have thought of conducting a formal analysis. I doubt if any of you made a conscious and deliberate effort to produce such an analysis. Yet before the decision was made to participate, there was some perception of potential economic benefits to be derived from the use of the imagery. This was, in effect, a cost benefit analysis even though it was done intuitively rather than scientifically and systematically. The intuitive approach was used because there were no data available upon which to base such a decision. The technology looked so good that there simply had to be economic benefits from participation.

As data about costs and benefits are accumulated, these decisions can be made with greater assurance and less risk. Few people would use the intuitive approach if they had something better. And to provide that something better in the way of cost benefit data is the primary objective of the cost benefit studies now under way.

I am sure there are many such studies but I would like to focus on two of them, both sponsored by the U.S. Government. The first is one with which I have some direct contact as it is financed by USAID and conducted by a very capable and certainly very impressive sounding group made up of the Env. Res. Inst. of Mich., Systems Planning Corporation and Mathematica, Incorporated. I am particularly pleased to point out at this seminar that Kenya and Botswana were two of four case study countries selected. This selection was the result of their participation in ERTS. The other two countries in which case studies were conducted are Bolivia and Thailand. This study focuses upon an analysis of the costs and benefits which developing countries might expect as a result of participation in remote sensing activities. The question confronting many developing countries at this time is whether an improved natural resource and environmental information system will justify the required investment in trained personnel, equipment and information dissemination. In addition to seeking an answer to this question, the study will provide vital information for USAID, and perhaps other international aid agency planners. Because most of the developing countries of the world have resource-based economics and at the same time too little data about these resources, AID feels that this is a particularly appropriate technology for them. As a result, AID wishes to promote the application of remote sensing and the cost benefit study is necessary to help develop an appropriate strategy and to pinpoint areas of potential benefit.

The second study is a U.S. domestic study being conducted by the Earth Satellite Corp. and is a much greater effort in terms of man hours and financial investment. It too is designed to locate and quantify potential benefit for the users of remote sensing technology. The primary motivating factor behind this study, however, is to determine for the United States Government the economic criteria for developing an operational earth resources satellite system. As you know, both ERTS-1 and ERTS-B are experimental satellites. ERTS-B, which is scheduled for launch in early 1975, will hopefully produce imagery through 1977. Beyond ERTS-B there are, as yet, no commitments for follow-on system. It is hoped that the results of this study will show sufficiently great potential benefits to be a convincing argument for an operational system.

Before looking at these studies in more detail, I would like to discuss some of the hazards and problems confronting those conducting the analyses. As we have mentioned, many aspects of the technology are either in the experimental or early development stages. It is difficult to produce reliable analyses, even from established technological developments and almost impossible to produce them from new technologies.

Furthermore, the benefits accrue in different ways from different applications. By comparison, a cost benefit analysis of a road or factory would be a relatively simple matter. In both examples the costs can be estimated quite closely. The economic benefits of a road or factory would be somewhat more difficult but in most cases it would be possible to derive a numerical ratio with some degree of reliability so that investors would know that by investing x dollars, pounds or shillings they could reasonably expect a return of x + y dollars, pounds or shillings.

In remote sensing technology the benefits accrue in different and in some cases, altogether unpredictable ways. The less difficult way of estimating benefits is to compare the relative costs of collecting data by remote sensing and ground sampling techniques. The savings over conventional data collection systems would therefore be listed as benefits. But benefits also accrue from access to data which would otherwise be impossible or impractical to obtain. These benefits include such unpredictable items as mineral discoveries, improved crop forecasting, plant disease detection and many others. How do you quantify, for example a potential mineral discovery or knowledge about a plant disease?

The costs are equally difficult to assess. Costs include training of personnel, acquisition of equipment and facilities, acquisition of imaging systems, imagery and imagery processing. Then, in the case of satellite systems, there is the question of how much of the research and development costs of the space platforms and launch vehicles to charge against costs. What makes these costs particularly difficult to quantify is the fact that satellite remote sensing systems are only one element of the technology we have come to know as remote sensing. Ground truth, aircraft programs and data processing are other essential elements. Which of these to include as costs are questions that must be answered in the design of a model.

Despite these overwhelming and almost impossible obstacles, our cost benefit researchers are proceeding valiantly onward, resolute in their determination to provide some numerical results. In order to provide some insight into these complex issues, I would like to briefly review some of the key elements of the two studies mentioned above. I hope you will not expect me to present a firm numerical ratio at the conclusion of this discussion. Neither study is completed -- the AID study will be completed in June and the domestic study by the Earth Satellite Corporation, sometime later. I suspect that the final results in both cases will be subject to a great deal of further analysis to make them applicable for a given situation.

Still there are certain aspects of the studies that are of great value at this time. The methodologies that are being developed to analyze benefits will have general applicability. Both studies have identified most of the significant uses and applications and thereby provide an excellent insight into the scope of the technology. The studies have further identified which applications are productive and which are not which in itself provides useful investment decision data.

Since the AID study has been conducted in areas where remote sensing technology is in the very early stages of development there were few ongoing applications to observe. As a result it has been necessary to resort to a number of subjective indicators of progress and potential benefits.

In order to better understand what is involved in a remote sensing cost benefit analysis I would like to outline briefly the approach employed in the AID study. This study included five principal phases. They were: (1) selection of case study countries, (2) visit preparation, (3) visitations, (4) benefit-cost evaluations for specific case study applications and associated analyses, and (5) reporting.

In selecting countries for visitations, the objective was to strike a balance between geographical area, level and rate of economic development, functional applications of the ERTS principal investigators, and a judgment of the potential economic significance of utilization of the imagery in each country. Based upon the information sources indicated, Kenya, Botswana, Bolivia and Thailand were selected.

In preparing for the visits, available socio-economic data were studied, meetings were held with USAID, international organizations and embassies of the host countries. The attempt was made to anticipate the potentially most beneficial applications of the ERTS imagery, and to prepare briefing materials for these countries that reflected this initial effort. In retrospect, by showing the people in the sample country exactly how the information requested fitted into the study, it was possible to engender a large measure of interest and, hence, cooperation.

The visitations took place over a three month period and represented the largest part of the study effort. During each visit there was extensive contact with the local ERTS principal investigator or his designated representative and USAID representatives. Typically those interviewed included the ERTS principal investigator and coinvestigators, government officials, U.S. Embassy and AID officers, members of international agencies, officers of foreign AID teams (such as CIDA and SIDA), university people and representatives of the private sector. Every attempt was made to obtain independent opinions from those who were not directly involved with the ERTS experiment. A major task of each visit was the identification of some case studies for benefit-cost analyses of specific ERTS applications. The case studies selected were rice crop forecasting in Thailand, rangeland management in Kenya, watershed management in Botswana, and a non-country specific study of the potential from utilization of the imagery for minerals exploration.

In the case study of rice crop forecasts, it was expected that the interpreted imagery could be used for more accurate estimation of total acreage, patterns and intensity of cultivation. From this information more precise estimation of the allocation of total rice acreage among the three types of cultivation would be possible. Furthermore, a more accurate production, unit identification and description would permit more efficient statistical stratification for on-site sampling, and hence, a more accurate crop prediction. The model that was employed for this analysis postulates that economic welfare losses occur due to inaccurate crop forecasts, and these losses can be reduced with more accurate forecasts.

Obviously any improvement in the prediction through remote sensing technology will decrease this loss and is therefore a quantifiable benefit. The temporal data obtained from a satellite which is overhead every 18 days is expected to significantly improve crop predictions, not only in rice but in other agricultural products as well.

In the case study of rangeland management, economic benefits from ERTS imagery are attributed to more efficient allocation of the biomass for grazing of domestic and wild animals. In Kenya, cattle and wildlife are the major source of local income. Cattle and wildlife, which is the major attraction for tourism (now the number one foreign exchange earner) also requires large amounts of rangeland. It is likely that the ERTS imagery could be very useful for the development and implementation of a rangeland management model that would maximize returns from the cattle and tourism industries. This is an example of social and economic benefits which may accrue from effective utilization of the imagery.

Economic benefits from ERTS applications in minerals exploration are expected from three sources: reduced costs, increased likelihood of discovery and earlier realization of the net income from mining (due to reduced exploration time). Using the ERTS imagery it is possible to produce low cost regional geological base maps which are a necessary input to minerals exploration. It is also expected that information extracted from the imagery can substitute for higher priced information provided by conventional methods. It is to be emphasized that this may not be the same information - which makes a cost effectivenss comparison difficult - and the information may require a new approach to minerals exploration, but the result is likely to be lower cost discoveries. Due to the technical attributes of the ERTS imagery, information can be extracted which cannot be acquired by conventional methods. This information, combined with what is already known, will increase the efficiency of exploration by raising the likelihood that a given amount of funds will result in a find.

If the information extracted from the imagery serves as a substitute for conventionally acquired information and in doing so reduces the time as well as the cost of exploration, then additional economic benefits will be realized. This is for the fact that the economic value of the net revenue from mining operations depends upon when, (in time) it is received; and if it is a correct assumption that reducing the exploration period will reduce the time lag for accruing net income, then the ERTS imagery will yield benefits due to this attribute.

Other activities for which case studies have been prepared are the use of ERTS imagery in cartographic mapping and watershed management. Economic benefits which may accrue from these applications are due to the same properties of the imagery which have been discussed in review of the other case studies.

Preliminary Findings

Based upon this limited sample of countries and case studies of ERTS, we believe that the following observations are appropriate:

1. There exists a potential for significant economic benefits from ERTS imagery utilization in the developing countries. In some cases benefits are already being realized, although these are relatively minor at this time.

2. The actual magnitude of the benefits depends upon the values of economic and social parameters in each using country.

3. While the case studies have indicated potential benefits from certain applications, these benefits should not be simply projected or imputed to similar applications in other using countries.

4. Significant amounts of information may be extracted from the imagery by using relatively low cost interpretive techniques. That is not to say that the more advanced techniques may not be justified in the basis of benefit/cost criteria.

5. There exists the need for a central, readily accessible, responsive ERTS facility in each LDC.

REMOTE SENSING AS A NEW DIMENSION IN MAN'S UNDERSTANDING OF THE EARTH*

By Dr. George A. Rabchevsky
Photo Science, Inc.
Gaithersburg, Maryland USA

The first two decades of space exploration, and related activity, have provided the international community with sufficient testimony to an historical process through which remote sensing space data from satellites has added a new dimension in man's better understanding of the earth.

*Illustrated lecture-slides not duplicated herein.

Since some 115 years ago, when the first aerial photo was taken from a balloon, and the introduction of infrared technology for obtaining reconnaissance aerial photography during the Second World War, the technology for the remote sensing of the earth has progressed to where we are today. As you all know, prior to the ERTS satellite, weather and communication satellites, paved the road for the present satellite remote sensing technology. Weather and communication satellites continue to perform important functions, which benefit a large portion of mankind. Together with ERTS, these orbiting and stationary space platforms promise to bring benefits to an even larger number of countries in the future. We are now on the threshold of another practical application of space technology: the remote sensing of earth resources; a technology which could become (and in many instances it already has) a most effective means for obtaining information about the earth's environment and its resources, in order to alleviate the shortage of food, deal with pollution problems, and the conservation of nature (all very modern aspects of our concern for our own planet and personal survival). To contribute in the achievement of those objectives, the Republic of Kenya decided to participate in NASA's ERTS program, the Principal Investigator being Mr. Omino, who will describe the experiment following this talk.

Even though, I imagine, the first balloon photo may not have contributed much to our understanding of the earth, it certainly was a step in the right direction. Oblique aerial photos taken from unmanned balloons during WW1* and the more sophisticated aerial photography (b & w and IR) flown for military purposes, initiated the "true age of remote sensing". And with time such reconnaissance technology was being converted to serve for the benefit of man. An array of sensors was being flown on planes to produce detailed topographic maps, chart river courses, lakes and marshes in inaccessible areas, to map new geologic mineral structures, watch over the ripening crops for manifestations of diseases, and we began to realize, for the first time (from the remote sensing data) that our "environment" is one of our most precious natural resources.

The genetic process of evolution is uni-directional. Our own human (biologic) growth trends, parallel the evolution of our solar system--an expanding universe. A fetus cannot revert to an embryo, it strives to break the sack and enter our world as a bonafide member of the race, it if doesn't, it perishes. And a grown individual continues to contribute to this expanding process, man begans to break the confining borders of our universe. Rusty Schweikart here is one of such individuals. From our immense distances from space, man begins to view his birthplace, just as our grandfathers and grandmothers are reflecting on their own younger days, and we all derive benefits from such observations.

The first orbiting weather satellite was launched by NASA on April Fool's Day 1960 (in about a week it will be 14 years since that time). The primary function of that satellite, the TIROS, was to map

* World War I

the cloud distribution and help meteorologists in weather forecasting. TIROS was followed by a series of NIMBUS satellites, first one in 1964, and Nimbus 5 is at this time flying over us. But, in addition to clouds, scientists were picking up cloud-free areas, and began to use this meteorological data for earth resources studies. The manned and unmanned Gemini and Apollo missions were designed partly to view the earth surface from space and, I am certain, you are all aware of the success of both missions. Mr. Schweikart illustrated the achievements from those missions last night and will do it again later today. And now on July 23, 1972, NASA has launched the ERTS satellite for the sole purpose of earth resources studies. The benefits from all these combined missions, is the topic of conversations during these two weeks.

I have a few slide examples illustrating the remote sensing aspects from some of these missions. Please accept this only as a small sampling of those results at this time; a more detailed discussion will be held during the course of the workshop, and also later in the day.

* * *

Now ladies and gentlemen--when the planning for this seminar and workshop was under way last fall, it was decided that, insofar as possible, ERTS data covering portions of the participating African countries would be used in this program. Accordingly, representative data were acquired from the EROS Data Center of the U.S. Geological Survey in Sioux Falls, South Dakota. This provided me with the opportunity to pre-process the data, employing techniques that will be described in the scientific literature. It is now my pleasure to announce that your chief geologist, Dr. John Walsh, and Mr. W.J. Wairegi, also of the Kenya Geological Survey, agree that this ERTS image has provided the means for discovery of this geologic structure; which is of great potential significance to the understanding of geologic controls of vegetation distribution, recharge movement and discharge of surface and ground water, and the physical conditions which affect man's environment and habitat. This ERTS-aided discovery will provide the impetus for future studies, that we hope will directly benefit Kenya and its people.

AFRICA'S PROJECTED APPLICATIONS OF REMOTE SENSING TECHNOLOGY AND BENEFIT POTENTIAL

By J.H.O. Omino

Space programmes, whether they be probes to Mars, landings on the Moon or such fantasies as those in the film '2001', are familiar and even common-place paragraphs in the daily newspapers. The recent splash down of the crew of the last Skylab mission received, if my memory serves me, little more than a couple of sentences in the local press. The high adventure and sense of risk which once surrounded space exploits has faded to one of routine functions - efficiently executed indeed - but carrying none of the glamour which once highlighted man's first steps into that new unknown. The paradigm 'Familiarity breeds contempt' was never truer than in this context and is perhaps true of many of the technological developments which characterise our time. There is always the danger of adulating our technology and its fruits, placing them superior to the real miracles with which the natural world surrounds us and bringing us to believe that there is a technological 'fix' for each and every problem which confronts mankind. But no human systems can match, or probably ever will match, for instance, the genetic, sensory, physiological and reproductive systems of a termite which plays its infinitesimal role in the ecology of this country!

In these next few days we are bringing down to earth and making familiar to each of us some of the high flown generalities about the value of space to mankind. For the first time we will have an opportunity to translate into an African context, a context of development and of a very fresh environmental awareness, the benefits of a completely new approach to the management of our continent. Some of us have some realistic ideas about remote sensing, some rather less so, but I think I can safely say that each of us comes here with some degree of expectation that our discussions over the next fortnight will help to answer, more speedily, some of the management problems we face.

So much for generalities. Let me now turn to some specifics as regards our own participation in the ERTS programme. In 1971 a U.N. 'space expert' visited Kenya and as a result of a single short talk on space applications sparked off interest in the possible uses of ERTS data. This led to a desire to participate and in early 1972 our proposal was submitted to NASA - a proposal aimed at evaluating the applicability of ERTS data to the management of water, range and agricultural resources, to determine what data could be obtained from the ERTS system which would enable our planners in these areas to have more accurate and up-to-date information on which to base their planning.

As things turned out, several of the co-investigators in each area were either posted elsewhere or for other reasons were unavailable to perform their parts of the investigation. Also there were considerable delays before we obtained our first colour composites and this resulted in a decline in the original enthusiasm and commitment which had been evident at the start of the project.

Fortunately with this decline there came, as a result of the activities of our 'space committee', a corresponding awakening of interest in organisations which up to then had remained outside the original compass of the proposal - geologists, ecologists, wildlife managers and soil surveyors found, each in his own field, potential and actual uses for the imagery which we were receiving. Despite a complete lack of equipment and of information on techniques on how to use the imagery, very useful beginnings were made in understanding the images and extracting useful information. Let me give a few examples of what I mean.

In the geological field, a study of the sediments of the Omo delta at the north end of Lake Rudolf revealed clear changes since the last aerial photos of the area were taken. Revision of the lake shore configuration was also an obvious possibility. The recent discovery of a geological feature of considerable magnitude on an ERTS image is the subject of a special press release and will, I think interest those of you who are geologists.

In the ecological field, a start was made in determining our ability to distinguish vegetation types in Western Kenya. Bands 4 and 5 were of most use for this purpose, while Bands 6 and 7 were better able to indicate the extent of cultivated areas. In the forest and mountain areas it was possible to identify moorland, podocarpus forest, podocarpus - juniperus forest, exotic coniferous plantations, tea plantations and indigenous bamboo.

Turning to soil mapping, the Soil Survey Project in Kenya has begun to use ERTS imagery for extensive soil mapping of the arid areas of Kenya at a scale of 1:1,000,000. In these areas, covered for a good part with unconsolidated quaternary sediments, the soils show in general a very clear cut relationship with broad physiographic units such as sheetwash plains, river terraces and floodplains. Each such physiographic unit has its own characteristic infiltration rate, drainage condition, soil moisture storage capacity, effective rooting depth and salinity. With relatively few field observations it is possible to carry out extensive soil mapping.

In the area of wildlife management, the phenology of range vegetation, reflected in sequential imagery, appears to be closely correlated with the distribution of free range game animals, notably wildebeaste and zebra. Recently a special study of some 8,000 square kilometers of rangeland, using ground truth data, light aircraft 'eyeball' assessment and colour and infra-red photography from 20,000 feet (I am told that leaning out of a light aircraft with its doors removed at that altitude and taking photographs with a hand-held camera was an exercise in endurance!) - this coverage was done synchronously with the satellite overflight and the data from all three sources are now available for comparison, hopefully during the course of this present seminar. In another range area of about 600 square miles ERTS imagery was compared with earlier ground physiognomic vegetation type identification and it was deduced that about 35% of the 12 major types in the area could be identified on the imagery.

In summary, the Kenya experience has been that no doubt exists that extremely useful data is available from ERTS imagery but lack of equipment, expertise and repetitive coverage have all hindered our efforts at getting this data.

As a result of this preliminary success we have now applied to NASA for participation in ERTS-B, basing our application on the possibility of quantifying ERTS data by comparison with field (ground and aerial transects) data from a rangeland census and monitoring project.

We are also expecting to participate in a remote sensing census (that is demographic census) project in collaboration with the U.S. Bureau of Census which will enable us to refine and monitor our demographic statistics and which will enable us to get up a permanent facility in Kenya, equipped with the necessary equipment, to use the latest visual evaluation techniques.

Finally it will be of interest to know that we have high hopes of being able to acquire satellite data in real time from ERTS as it passes over Kenya, using the equatorial satellite tracking and launching station on our coast, with the cooperation of the Italian Space Agency. This taped data will hopefully be processed in Italy and then made available to us within a relatively short time. If we can carry through this project it will mean that we can by-pass the on-board tape-recorder and its limitations and utilise every satellite pass should we wish. I do not need to emphasize that for a project such as that of the census and monitoring of rangelands, it will be essential to obtain cyclical data, hopefully every 18 days, to monitor vegetation and moisture changes.

In conclusion I would like to repeat my colleague, Dr. Otieno's remarks that in all the areas of development of natural resources this new data source will have a part to play. This is true here in Kenya and I am convinced it will be found true elsewhere on this continent.

STATUS AND ACCOMPLISHMENTS OF NASA'S EARTH OBSERVATION PROGRAM*

By Russell Schweikart
U.S. National Aeronautics and Space Administration

The whole earth from space is a view which has recently become familiar to all of us. To some of us it evokes rather personal and somewhat emotional memories--but to all of us it has become the symbol of our interdependence on one another and a constant reminder of our shared dependence on a precious, somewhat fragile, and definitely limited environment.

Today, I would like to review the efforts we in NASA are making to better understand that environment and our relationship to it.

I will begin with a review of our most comprehensive effort to date, the Earth Resources Technology Satellite (ERTS-1). This review will deal almost exclusively with the results of the U.S. investigators since this is the area I have the most information on. However, there are

*Illustrated lecture; slides not reproduced herein.

also about 100 non-U.S. principal investigators and their findings are equally impressive although I do not have as much specific data on their results.

First, let me review some of the basic characteristics of ERTS. Launched on the 23rd of July 1972, it was placed into a 500 mile (900 KM) nearly polar orbit. The spacecraft was designed for a 1 year lifetime. However, at 20 months into the mission we're going along with relatively few problems. Shortly after launch we suffered a power supply problem in the Return Beam Vidicon System (RBV) which we have not used since. However, the multi-spectral scanner (MSS) which duplicates the 3 RBV channels and adds a fourth in the near infrared has performed flawlessly. We have also lost considerable tape recorder capability which has limited our ability to gather data for investigators outside of Canada and the U.S.

As you know this orbit provides repeating ground tracks every eighteen days. It is also sun synchronous, i.e., it passes overhead at the same local time, between 9:00 and 10:00 a.m., thereby providing nearly constant sun angle illumination characteristics for each image.

(A review of the ERTS results was presented using slides. The review highlighted applications in land use, hydrology, geology, agriculture and coastal zone studies.) Text not available.

Applications Program Other Than ERTS

This year's effort includes a number of major milestones in the space applications program. At least six and possibly eight applications satellites developed by NASA are to be launched and we are recommending several new or augmented activities which will provide valuable and unique future space applications opportunities. Among the satellites which are scheduled for launch this calendar year are the SMS A&B, ATS-F, Nimbus-F, and GEOS-C. Three of the missions, Nimbus-F and SMS A&B are dedicated to efforts in meteorology. The ATS-F continues our activities in the experimental communications satellite program and the GEOS-C is the beginning of our activity to demonstrate satellite techniques for use inthe earth and ocean physics program.

Weather and Climate

During this calendar year, NASA has scheduled three satellite launches which will materially augment the deployment of meteorological satellites for use in the national operational weather program. These launches are: The Synchronous Meteorological Satellites and the Nimbus-F satellite. With the launch of the SMS spacecraft, we add the capability for continuous weather surveillance over much of the Pacific and Atlantic Oceans and the American continent. These launches will mark the inauguration of the total national operational meteorological satellite system with both the global polar orbit monitoring and continuous synchronous orbit surveillance components in operational use.

The Nimbus-F satellite will flight test advanced infrared and microwave sensors designed to provide full global all weather data with improved resolution. This experimental satellite will contribute in many important ways as does the SMS satellite to the initial phases of the Global Atmospheric Research program (GARP) which will also be conducted this year.

To date, we have launched twelve operational and seventeen experimental meteorological satellites in support of national and international meteorological objectives permitting rapid progress in this important capability.

Earth Resources Survey

The successful missions of both ERTS-1 and Skylab and the analyses of the data to date show that earth resources information of this kind is tremendously valuable and of truly practical use. During this calendar year, we plan to continue our efforts in support of ongoing and follow-on investigations. A new set of proposals are currently being evaluated with heavy emphasis in the selection of those proposing quasi-operational activities. At the same time, we will work with known users in Federal, state and local areas, public and private, domestic and foreign, to identify their requirements and further develop practical and economic applications of this new technological capability. In addition, we will support in conjunction with other federal agencies several large scale demonstration projects.

Efforts will proceed to prepare the ERTS-B spacecraft for a launch in early 1975 as a replacement in event ERTS-1 fails. This launch date is about a year earlier than originally planned. This acceleration was approved after a reappraisal of the effect of the probable gap between ERTS-1 and a 1975 ERTS-B launch. The reappraisal carefully considered the performance achieved with ERTS-1, the results and progress of investigations and the support of Congress.

The initial results of our ERTS investigations suggest that certain applications will ultimately require greater spectral and spatial resolutions. Therefore, we have initiated instrument development for certain selected instrument engineering models that will improve capabilities for land resources management and land use inventory. In addition, we have requested from industry a systems definition study for an Earth Observatory Satellite (EOS); this satellite would be used in the late 1970's and 1980's to conduct earth observation research. The design concept is modular to provide low cost production and is designed to take advantage of the shuttle features which also enable low cost features. The contracted systems definition study will be awarded early this year and continue into the first half of 1975. Also during this year we will continue development of certain instruments. One in particular, the fifth band of the ERTS multispectral scanner will continue in development. The fifth band will be of considerable value for it will allow observation of conditions that require intercomparison of thermal data with those simultaneously obtained at visible or near infrared wave lengths. This information is useful for locating, mapping, and measuring thermal pollution of large lakes, bays, and estuaries; and for providing information about soil moisture. Further, it will provide valuable information on stresses in vegetation. This year we propose to continue the development and testing of flight hardware components and the initiation of flight model assembly. No specific satellite has been selected to fly this instrument, but it will be available for a flight in the 1977-78 time period.

The information obtained with the fifth band of the multi-spectral scanner is complementary to that obtained from the Heat Capacity Mapping Mission. This mission will involve the collection of data for the discrimination of rock and soil types which in turn will be useful in mineral exploration and assist in the proper location and construction of civil works, such as highways and canals. In addition, such thermal image data has potential for locating geothermal areas and for monitoring ocean currents and the temperature variations of coastal waters. We are recommending a Heat Capacity Mapping Mission to provide in the early 77-78 time frame a capability to obtain certain thermal data which can be obtained in no other way. The thermal maps generated by this mission will provide frequent coverage for important uses in such areas as mineral exploration, construction projects, and ocean surveillance. As compared with the fifth band, the HCMM will be several times more accurate and have a larger field of view. Most importantly it will be flown in a special orbit to maximize thermal differentiations produced by solar heating and nighttime cooling of the earth's surface. This special polar sun synchronous orbit will allow measurements to be made at times corresponding to surface temperature extremes, 1:30 p.m. and 2:30 a.m. local time and will provide repeat coverage within a two day period. Since we will have only a real time coverage capability, thermal information will be obtained of North America, Australia and most of Europe where we have ground receiving stations.

As you are probably aware, we have a very vigorous earth observation aircraft program. Its primary mission has been oriented toward developing measurement and interpretative techniques, in testing and evaluating of new space sensors, and in early demonstrations of the applications of remote sensing. During FY 1973, and through mid FY 1974, the aircraft program concentrated its effort on supporting Earth Resources Survey related investigations. In this role, the aircraft were used to acquire ground truth for ERTS and Skylab investigations and for verification of space sensor measurements and for multi-stage sampling. This year, the Aircraft Program will be used to support research activities of a more varied nature. We have scheduled operations in support of Meteorology, such as investigation of severe storm studies, in Pollution Monitoring, such as stratospheric surveillance, and Earth and Ocean Physics, such as tests of a side looking imaging radar. In addition, NASA aircraft will also be used to support ERTS follow-on investigations. Further, a number of flights are planned in support of instrument development for those sensors to be flown on the Nimbus G, SEASAT and EOS spacecraft.

Pollution monitoring

The major effort as well as the major funding requirement in the area of Polution Monitoring is associated with the development of the Nimbus-G satellite. During this year, we propose to complete contractual action for all sensor developments of both engineering and flight models and we will accomplish spacecraft design modifications as well as procure long lead time parts and components essential to meet a launch in calendar year 1978.

The pollution monitoring and oceanographic sensors that will be flown on Nimbus-G are:

- Lower Atmospheric Composition and Temperature Experiment (LACATE)
- Stratospheric and Mesospheric Sounder (SAMS)
- Measurement of Air Pollution from Satellites (MAPS)
- Stratospheric Aerosol Measurement (SAM-II)
- Coastal Zone Color Scanner (CZCS)
- Scanning Multichannel Microwave Radometer (SMMR)
- Earth Radiation Budget (ERB)
- Temperature Humidity Infrared Radiometer (THIR)
- Solar Backscatter UV/Total Ozone Monitoring System (SBUV/TOMS)

In our research and technology program for pollution monitoring, we are continuing our activities to optimize data extraction techniques for existing types of instrumentation; while at the same time conducting basic and applied research in remote sensing to better detect and monitor air, land, and water pollutants. We are now at a stage of development where the basic radiometer and spectrometers developed over the past several years are going to have to be replaced by instruments providing greater selectivity, sensitivity and coverage. In particular, our water quality sensing programs are in an early state of development.

Earth and ocean physics

Now let me turn to another very promising area, our Earth and Ocean Physics Applications Program (EOPAP). Tremendous strides have been made during this past decade in several fields of science and technology which now provide us with the necessary tools to better understand ocean dynamics and which could lead to more efficient ocean use through the monitoring and forecasting of ocean surface condition on a global, near real-time basis. Our program in earth physics has been designed specifically to develop and demonstrate space techniques to study the dynamics of the earth with the goal of demonstrating methods which might lead to earthquake prediction.

The launching of the GEOS-C satellite this year is an important step in our flight activities to demonstrate satellite and space related techniques for use in Earth and Ocean Physics investigations. The objectives of this flight are to demonstrate the feasibility of obtaining satellite altimeter measurements of the ocean topography in order to better understand the currents and tides of the ocean. This instrument is also to be used in measuring sea state and to provide a mathematical description of the earth's gravity field with more precision than is currently available.

We are presently at work on the definition phase of the SEASAT program. SEASAT will be the first satellite devoted exclusively to the acquisition of scientific data for the oceanographic user community. The SEASAT conceptual study effort has been completed and current effort is concentrated in establishing the preliminary design for both the instrument subsystems and the spacecraft.

From a scientific viewpoint, in addition to major contributions to geodetic science, significant advances in the fundamental understanding will be obtained in areas of wind-wave dynamics and propagation phenomena, ocean-storm interactions, ice-air-sea interactions, dynamic behavior of major ocean currents, materials transport, tide behavior in the open ocean, and tsunami propagation.

The specific role of SEASAT in this effort would be to provide precision measurements of wave height and wave directional spectrum, data for frequent update of maps of current patterns and ocean temperature, data to establish the fine structure of the ocean geoid, and charts of ice fields and leads.

When these data flow into the hands of the appropriate investigators, we would expect to see outputs affording not only an understanding of the physical conditions of the sea surface and its air and land interface, but the ability to predict or forecast future effects of these observations. If this in fact be the case, we would foresee at some future date a great many very practical applications involved with faster ship routing, improved design of ships and offshore structures, storm damage avoidance, coastal disaster warning, improved coastal protection and development; and better deep water part development, pollution dispersion, fishing predictions, iceberg avoidance, navigation in ice fields and weather prediction, to name a few. The SEASAT program, in effect, takes a rapidly evolving microwave capability and integrates it aboard a spacecraft to obtain answers in direct support of the states needs of oceanographers.

In FY 1975, we plan to begin the specific detailed design of instruments, as well as the construction of experimental or engineering models.

We are proposing to enhance and augment our activities in tectonic plate motion experiments. This effort is being emphasized because of its importance in the work which is currently underway to better understand the processes involved and which are expected to contribute to the development of an earthquake prediction capability. During the past two years, experimental data have been collected and major progress has been made in measurement systems and modeling capabilities which will assist in understanding the physics involved relative to the motion of the plates comprising the earth's crust. During FY 1975, we propose to conduct three experiments in the context of an overall study. These experiments are as follows: (a) a detailed study of the San Andreas Fault; (b) a validation study of a new measurement concept called ARIES; and, (c) a study of the relative motion of the Pacific plate with respect to the North American and Eurasian plates. These complementary studies should produce independent verification of the ability to measure those extremely slow and minute motions of the earth's surface.

With the launch of the LAGEOS satellite in 1976, a capability will be available to further improve the accuracy of these important measurements. /See p. 13/ This year we propose to procure the long lead time material required to fabricate the LAGEOS precision retroreflectors and to complete all of the remaining planning required for launch, including studies of the optimum orbital inclination and attitude.

LAGEOS is the acronym for the LAser GEOdynamics Satellite. This is a very dense satellite mounting laser retroreflectors. It will provide a permanent reference point in a very stable orbit for precision earth motion measurement, e.g., crustal motion, fault motion, polar motion and earth rotation variations. The satellite is a passive 2-foot diameter ball weighing about 1,500 pounds and is covered with approximately 500 precision laser retroreflectors. We have completed the required system studies and determined the optimum configuration for this satellite.

This has been a quick and fairly thin review of the ERTS program specifically and of the plans for future activities in the NASA Space Applications Program. I hope that through seminars such as this one a closer contact between the needs of the developing world and NASA's research and development activities can be established.

Best of luck in your seminar and workshop activities.

PANEL DISCUSSION: SELECTED RESULTS OF ERTS-1 EXPERIMENTS

Agriculture, Forestry and Range Management

By David Carneggie

The information summarized during the panel discussion was derived from the papers which were presented at the third and fourth ERTS Symposiums, October and December, 1973. In the agriculture discipline investigators reported crop species identification exceeding 80 percent. Many investigators found that improved identification accuracies were achieved when interpreting multidate images acquired at specific growth stages in the crop development. Spatial resolution and spectral coverage of ERTS-1 was not sufficient to perform stress detection, however, damage assessment in terms of dead trees, fire scars, flooded areas, and salt killed vegetation could be accomplished where the area of damage was sufficiently large (exceeding 10-20 acres). Crop identification was much higher where field size exceeded 20 acres.

Broad forest stratification was accomplished to a 90 to 95 percent accuracy level. However, the stratified types were often too broad to provide information which did not already exist. Broad stratification was valuable where preexisting resource information was not available. Multistage sampling techniques were used to determine timber volumes on a national forest management unit. The sampling errors associated with the timber volume estimate were below the acceptable level set by the Forest Service for their surveys using aerial photographs. The timber volume estimates were obtained at a very favorable cost/benefit ratio; however, the estimates were for regional timber volumes, not in-place estimates of timber volume by cover types.

Range specie/plant community vegetation mapping has been accomplished at various levels of success (69-90 percent). There is however, little evidence to determine if this information is useful, where more detailed information may already exist from previous surveys. Many investigators have obtained encouraging results in range biomass estimation and range readiness predictions. A few investigators have demonstrated the potential of ERTS for monitoring plant development throughout the growth season and determining range conditions (greenness or dryness).

ERTS imagery has been shown to be a useful tool in the identification of soil associations, and an excellent base map upon which soil association information can be superimposed.

Cartography and Land Use

By Merrill Conitz
U.S. Agency for International Development

Review of air photo applications in cartography.

The use of ERTS imagery in cartography.

Advantages and applications:

- --Broad areal coverage, approximately 120 miles square is many times more area than can be achieved from highest altitude air photos with considerable savings in need for ground control and/or aerotriangulation.
- --High altitude and stability of platform yield a near orthophoto image with minimal tilt and terrain relief distortion. With limited control, ERTS images can be mosaicked together to form image map.
- --Repetitive coverage offers opportunity for mapping seasonal phenomena. Satellite imagery has accelerated the trend toward the use of thematic maps, those which show one or two major themes such as snow cover or water distribution. Future mapping practices will probably be in the direction of a greater variety of maps, each of which has fewer themes.
- --Relatively lower cost of satellite imagery will have the effect of accelerating mapping activities world wide.
- --Map revisions can be accomplished more frequently because of the availability of satellite imagery.
- --Imaging in four spectral bands offers cartographers greater opportunities for mapping particular phenomena or themes.

Limitations:

- --Because the satellite flies very high the cone of light reflected into the lens of the scanner is relatively narrow--thus parallel of points on the surface of the ground is near zero making height measurements and topographic mapping impracticable. Also, there is not sufficient overlap for stereo coverage.
- --In some areas clouds present a serious limitation since it is not possible to direct the satellite over cloud free areas.
- --The scale and resolution of the imagery limit mapping to small and medium scales--up to approximately 1/250,000.

Applications in Land Use analysis:

- --The timeliness and availability of ERTS imagery make this an ideal tool for developing and maintaining land use inventories.
- --Classification system which recognizes the capabilities and limitations of various sensing systems is important.

--One classification system that is compatible with ERTS imagery is reported in USGS Circular 671. It was developed for use in U.S. but has application in developing countries, perhaps with slight modification

--Example of USGS system follows

Level I	Level II
01. Urban and Built up	
	01. Residential
	02. Commercial and Services
	03. Industrial
	04. Extractive
02. Agricultural Land	
	01. Cropland and Pasture
	02. Orchards and Groves
	03. Feeding operations
	04. Other
03. Rangeland	
	01. Grass
	02. Shrub
	03. Savannas

USGS experience indicates that level I and some categories of level II can be identified on ERTS imagery. High altitude photography is usually required to supplement ERTS imagery in completing level II classification. For finer classification than level II, medium and large scale photography and ground observation are necessary.

Geology, Mineral, and Land Resources*

By Dr. George A. Rabchevsky

Since the launch of the Earth Resources Technology Satellite (ERTS) in July, 1972, exceptional advances have been made in defining and, in some cases, implementing realistic applications in geology--mineral resources, geologic structures, and landforms. Also, because geology, more than several of the other disciplines, is firmly rooted as a basic science rather than as a technology-oriented field, it has gained significantly as well in new knowledge from ERTS that relates directly to the fundamental scientific principles from which the practical applications must emanate.

At the outset of this report, I will highlight a sampling of the most significant results. Thus, for the first time ERTS imagery has been used to pinpoint diagnostic surface conditions associated with known mining districts. This includes enhancements which bring out hitherto unrecognized surface alteration and analysis of ore-controlling

*Illustrated; slides not duplicated herein.

fracture distribution as seen in a regional context. ERTS has likewise observed previously unrecognized surface anomalies in large oil-producing basins that correlated closely with known oil fields. These observations offer promise of becoming a new and powerful technique for oil exploration especially if further work using more sophisticated enhancement-processing proves capable of emphasizing the anomalies. ERTS is showing a better-than-anticipated potential for producing accurate small-scale geologic maps, often containing details seldom before recorded on such regional maps. These maps can be prepared more effectively mainly because of the special and unique qualities of the synoptic, multispectral, and repetitive character of ERTS data. ERTS furthermore has produced extensive information dealing with possible geologic hazards. Many new "fractures" have been identified in several regions of the Pacific Coast seismic belt having a history of recent earthquakes. This has obvious implications for existing and new engineering projects.

In the early phases of the ERTS program, much of the effort, in the geological discipline investigations tended to be science - rather than applications - oriented. Most economic or cost-benefit payoffs will not begin to appear until a number of years after launch and operation of ERTS-1. In the oil and mining industries, particularly, this lag is the inevitable result of already established patterns of exploitation. In the petroleum industry, there is typically a 3-5 year minimum interval between the initial targeting of an area for exploration and the actual production of oil or gas. In mining, 3-5 years commonly elapse between the first exploration and the first drill holes, followed by another 5 years to develop the mines.

The practical use of ERTS by the mineral industries:

1. Defines areas of interest and, sometimes, focuses on specific structures and other surface anomalies as possible exploration targets.

2. Reduces time in reaching decisions on setting up a program; helps in planning other aspects of the program, including operations.

3. Provides better base maps than those already available in some regions of the world.

4. Assists geoscientists in gaining a better perspective of geologic factors and also aids in inspiring more imaginative overviews.

5. Saves time and money.

Some estimates of cost savings conclude that use of ERTS can reduce field time by 30 percent for 20 field geologists at a budget each of \$25K/man-year; this amounts to a savings of \$150K/year in operating costs of a single "state" geological survey. ERTS data can be used to eliminate large areas of unfavorable potential while targeting areas of high likelihood; this can translate into savings of 20 to 50 percent in petroleum exploration programs in which, for example, seismic survey costs up to $8,000 per line mile could be eliminated where prospects are shown to be poor.

However, ERTS imagery and processed data can only supplement rather than supplant the existing complement of exploration equipment and procedures. Other methods will continue to be employed much as they have been, especially where deeper mineral deposits do not influence the surface. The sequence of exploration remains: 1) selection of likely areas, 2) basic mapping, 3) selective geophysical prospecting, and 4) drilling to determine the amount and extent of the deposits. Because ERTS can only rarely "see" direct evidence of these deposits, its contributions are oriented toward (1) and to a lesser extent (2).

"Payoffs" in geology from ERTS are likely to be different in degree and timeliness from those in other disciplines. Agriculture, for example, will continue to extract benefits on a cyclic, seasonal schedule irrespective of any given year. Hydrology will also provide continuing data of seasonal or annual utility, in addition to sporadic data from unusual events such as floods. In geology, however, most individual payoffs will be sudden, random in time and place, and in some instances dramatically high in dollar value. Thus, a mineral deposit or an oil field may owe their discovery to a series of exploration activities initiated or accelerated by ERTS data, but once found, further observations of these specific sites will cease to be relevant. Interest will then turn toward the search for other deposits, or hazards, or local changes elsewhere. A hypothetical time sequence plot of "payoffs" in geology is likely to show a series of individual "big finds"--some of which can potentially be worth millions to billions of dollars--scattered more or less randomly through the first 5-10 years of satellite operations. The frequency and magnitude of these finds and other geologic applications will probably "tail off" over time unless new principles or methods evolve or until new and better sensor systems replace those of ERTS in space.

ERTS products are now being sought by many mining and petroleum companies but as yet these organizations have not reported discoveries of mineral deposits through direct use of ERTS data. Nevertheless, it is now becoming obvious that ERTS has singled out many new characteristics of the geologic component of the Earth's surface which, as our understanding increases, should eventually lead to real, documented benefits.

We recognize that many ERTS applications to geology need only a few good observations of a given scene owing to the generally "static" nature of most geological phenomena (important exceptions include certain dynamic processes such as volcanism, glaciation, offshore sedimentation, and landslides). It is obvious, then that most applications in geology will not stand as strong justifications for operational satellites that depend heavily on tasks requiring repetitive coverage does assist geologic interpretations because of variations in sun angle over the seasons, snow cover enhancement, and changes in vegetation and moisture associated with different rock types and/or structural controls.

Still, it is likely that most geologic applications will result from images already on hand, with the promise that improved resolution and measurements made in other regions of the spectrum from future satellite will add important extensions to our interpretative capability. However, there are already enough tasks arising from ERTS data now received to keep many geologists active for years to come extracting and applying relevant data. I thus see a continuing viable role for geology in Earth Resources well into the operational phases now considered.

Hydrology*

By Morris Deutsch
U.S. Geological Survey

Since its launch late in July 1972, a wealth of hydrologic information has been derived from ERTS-1. Before describing specific data obtained by ERTS and some of the significant observations and applications made to date, it will be useful to examine the role of ERTS as applied to determining hydrological conditions over any area, observing changes in storage or conditions, and in providing quantitative inputs for hydrological models.

Hydrology is a science of dynamic phenomena. It is concerned with the flux of water from the atmosphere to the Earth's surface; overland storage and runoff; infiltration, subsurface storage, movement, and eventual discharge; and return to the atmosphere by means of evaporation and transpiration. Hydrology is concerned also with water quality and changes in quality occasioned by its contract with the environment and man's effect on it. A major goal of remote sensing in hydrology, therefore, is to observe and measure dynamic conditions of water quantity and quality.

Water interacts with the Earth's atmosphere, soil, vegetation, physiography, and geology, and profoundly affects works of man. Hence, remote-sensing techniques can be used also to assess hydrologic conditions by indirect analysis of water along with other environmental parameters. ERTS data, for example, was used in development of a so-called ecological model in Florida. The model represents an important milestone in using remote sensing for environmental monitoring. The Florida investigators have devised a means of predicting success or failure of wood stork rookeries as one of the indices of hydrologic conditions in the Everglades National Park. Parameters upon which the predictions are based are water-level measurements made by technicians on the ground that can be relayed by the ERTS Data Collection System, the spatial distribution of water that can be measured on ERTS images,

* Illustrated--slides not presented herein.

and the density of small aquatic animals per unit area collected in quantitative traps. No hydrological data are being relayed to ERTS from so-called Data Collection Platforms (DCP's) in Africa, but if the ERTS program leads into an eventual worldwide operational system, the instant availability of ground data will be of great value for interpreting and quantifying the spatial data (imagery). At this point I would like to repeat the observation with which I think U.S. scientists studying hydrological applications for ERTS would agree: ERTS does not eliminate the need for ground data, traditional studies, test drilling, etc; it does, however provide a very power tool enabling the hydrologist to monitor and evaluate regional hydrological conditions; to find new sources of water, and to more effectively develop and manage water resources regionally.

Much has been written about the applications of ERTS for water quality, and indeed ERTS has made important contributions to that field. ERTS data can be used to reveal regionally or locally the distribution of anomalies in water quality due to difference in turbidity attributable to varying concentrations of sediment or other particulate matter in the water.

The very fact that the quantity--and generally the quality--of water in a given area is constantly changing requires that repetitive data be collected to monitor changes. While ERTS cannot continuously measure the discharge of streams or their quality, its 18-day repeat cycle is ideal for determining changing hydrological conditions as affected by climate, seasonal effects, or man's activities. Among the most comprehensive ERTS experiments dealing with hydrology is another being carried out in Florida. The design of a water-management model for the Everglades, employing quantitative inputs for areas of water surface from band 7 and water-stage data relayed by ERTS from surface recorders has stimulated planning for an operational satellite system of water management for Florida.

The chemical and physical quality of the water can be analyzed in the laboratory from samples collected on the ground. In the Delaware River basin and elsewhere in the United States, water-quality parameters at numerous points are measured and recorded continuously by automated monitors and may be relayed to the users of the data via the ERTS DCS. The data provided by ERTS can then be used to areally extrapolate the point-quality data. Thus sources, movement, and fate of pollutants, suspended sediments or waters from different sources can be determined. Such types of data can be extremely valuable in pollution abatement applications or in the design of engineering works to protest the land surface, beaches, or surface water intakes.

Prior to the launch of ERTS, it was not expected by the hydrologic community that existing flood applications capability would be greatly expanded by the ERTS data. Since its launch, however, ERTS has provided data, as described herein, permitting observations and analyses regarding floods far beyond those anticipated by the author. A large synoptic view of flooding along the entire Mississippi River Valley below

St. Louis was provided on only 16 images collected on two dates in 1973 during a total period of about 7 min. By color combining pre-flood coverage, a color-coded display was produced in which flooded area was automatically separated from areas normally covered by water. The unique water-detection capability of band 7 has made it possible for the first time to delineate areas from which flood waters have receded inasmuch as the flood waters leave a spectral signature on the surface. This capability is tremendously significant since it is not necessary to photograph or image the flood in progress. Imaging a flood in progress, of course, is of limited value because river valley reaches downstream from the peak have not yet experienced maximum inundation.

Water in streams less than a few meters to tens of meters wide, or less than a few hectares in areal extent, cannot be detected by ERTS. The presence of water in the soil or in vegetation along the stream valley, however, is readily detectable. Indeed, a highly significant fact, vividly portrayed by ERTS color-composite images of much of the United States and Canada, is the immense amount of water transpired to the atmosphere by vegetation. This is indicated by the almost totally red composite images covering much of the United States during the summers. On the standard composites of bands 4, 5, and 7, red is indicative of vegetation, and very dense vegetation is depicted by deeper tones of red. The hydrologist thus has at hand a powerful tool to aid in determining the percentage of the water budget involved in transpiration and the duration of the period of transpiration for predominant classes of vegetation. Thus, ERTS data can provide a sensitive synoptic evaluation of seasonal changes in the patterns of plant growth. This type of information will be useful in determining a variety of hydrobiological conditions, including range conditions for wildlife, or range readiness for grazing by livestock.

An estimated 90 percent of the freshwater resources of Earth consists of ground water stored in regional aquifers. Data from ERTS contain much information indicative of the distribution of ground water and the extent of its utilization.

Precise delineation of geologic formations, especially the upper or shallow units that, in most areas, form the best aquifers, is a requisite for hydrogeologic investigations. ERTS images of areas underlain by glacial, alluvial, eolian and other unconsolidated sediments often provide an excellent basis for delineation of shallow aquifers. Indurated sedimentary rocks, especially limestone and sandstone formations, compromise important and extensive aquifers in many regions of the world. In some instances, ERTS data can be used directly to determine their boundaries, recharge areas and discharge areas, including location of springs. The imagery is potentially useful in depicting the detailed surface structures of crystalline rocks in igneous and metamorphic terranes, where ground water commonly is stored in openings along joints and fractures.

Most applications of remotely-sensed data deal with surface phenomena, inasmuch as it is the surface that is being imaged by ERTS and other satellites or aircraft. The hydrogeologist, however, commonly infers subsurface hydrological conditions from surface indicators such as areal geological features and structures. Soils and soil-moisture anomalies, vegetative types and distribution, discontinuous ice cover on streams, differential snowmelt and springs that are detected by ERTS may also be idnicative of ground water. Accordingly, it is believed that remotely-sensed data, and particularly the synoptic, worldwide, and repetitive data collected by ERTS-1, could be effectively used as a tool for the exploration of ground water and for the monitoring and management of ground-water resources in selected instances.

Evidence of irrigation from nonsurface sources on ERTS data also indicates the presence and distribution of ground water, and the repetitive data can provide a basis for estimating ground-water use.

As I look at the ERTS image of the Mt. Kenya area which was specially processed by Dr. Rabchevsky (1:500,000 enlargement displayed) I am intrigued by the apparent similarity of the hydrogeology of that area with the Snake River Plain of Idaho in the Northwest United States. More than a century ago, when Americans from the East were settling and developing the West, many migrated over the Oregon Trail through the Snake River Plain, which they considered to be a great desert. Many that remained in Idaho to farm the land and raise livestock suffered severe privations in contending with the dry land. But they soon discovered that water from the Northern Rocky Mountains disappeared into the lava flows underlying the Plain and then reappeared as springs emptying in the Snake River to the south. They drilled thousands of wells to irrigate the land and this ERTS image* shows thousands of square miles of fields producing probably some of the greatest yields of potatoes, onions, and sugar beets in the world.

I would hope some day in the not-too-distant future that we may look at a new image of the Mt. Kenya scene and many others in Africa and see comparable beneficial developments to which remote-sensing technology has had a positive input. The government and people of the United States sincerely hope that ERTS data can assist Kenya and the other countries of Africa participating in this Seminar in the rapid, effective, and beneficial development and management of your water and related land resources.

* Slide not reproduced herein.

Most applications of remotely-sensed data deal with surface phenomena, inasmuch as it is the surface that is being sensed by EROS and other satellites or aircraft. The interpreter must, however, commonly infer subsurface hydrological conditions from surface features such as areal geological features and alignments. Soils and vegetation anomalies, especially where the distribution patterns [illegible] springs, differential snowmelt and [illegible] are indicative of ground water. [illegible] remotely sensed data, and particularly the [illegible], and support [illegible] data collected by EROS [illegible]. For [illegible] of ground water [illegible] ground-water [illegible] in [illegible].

Evidence of irrigation from repetitive surface [illegible] data also indicates the presence and [illegible] of ground water, and [illegible] repetitive data for providing a basis for [illegible].

An [illegible] of the ERTS image of the [illegible] area [illegible] produced by [illegible] (Figure [illegible]) [illegible] by the apparent [illegible] of the [illegible] data [illegible]. [illegible] in the [illegible] water [illegible] and [illegible] with the [illegible]. [illegible] the Northern [illegible] and their [illegible] to the [illegible] the world.

[illegible] in the [illegible] and [illegible] beneficial developments in which remote sensing technology has had a positive [illegible]. The [illegible] and [illegible] of the [illegible] [illegible] beneficial development and management of [illegible] and related [illegible] resources.

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APPENDIX B. SELECTED WORKSHOP LECTURES

Spatial, Spectral, and Temporal Nature of Remotely Sensed Hydrologic Data 1/

By Morris Deutsch

Introduction

Both dynamic and nondynamic hydrologic phenomena can be investigated and better understood through the use of remote-sensing techniques. Operational techniques utilizing aircraft and/or spacecraft data provide qualitative observations and quantitative measurements in three modes--spatial, temporal and spectral. Among the operational applications of remote sensing to hydrology are flood plain mapping, location and description of geologic structures controlling groundwater movement, identification of phreatophytes, monitoring of water losses and groundwater and thermal infrared studies.

Many experimental applications of remote sensing to hydrologic phenomena have been performed by the Earth Resources Technology Satellite. These include experiments in playa lake dynamics, determination of density and distribution of phreatophytes, flood plains and wetland mapping, and spring runoff forecasting. Such hydrologic studies will yield significant benefit to worldwide water resources management programs by providing a data base for future planning and development.

Hydrology is the science of water, and deals with its movements through the atmosphere, over and under the land surface, and eventually back to the seas. Water occurs in three states, gaseous in the form of vapor or clouds; liquid, whether falling as rain, stored in lakes, flowing in streams, or percolating underground, and solid, as snow or ice. It moves through the interstices of soil and rocks and is absorbed and transpired by vegetation.

Because of its essential nature to man and civilization, water in all its forms and occurrences has been observed and studied through antiquity. The rapid growth of remote-sensing technology during the

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1/ Adapted from Deutsch, Morris, 1971, Operational and experimental remote sensing in hydrology in CENTO Seminar on the application of remote sensors in the determination of Natural Resources: Central Treaty Organization Proceedings, Ankara, Turkey, Nov. 10-13, 1971.

NOTE: The entire proceedings volume, which contains numerous illustrations in color, was distributed to all Workshop attendees.

past decade has enabled man to better understand hydrologic phenomena, and the operational use of present experimental techniques will help man in the planning, development, and management of water resources programs all over the earth. Further technological developments, in collection, processing, and automated interpretation of remotely-sensed data will permit real-time monitoring and quantitative evaluation of hydrologic phenomena. Such developments will yield significant benefits to water-resources management and conservation in particular, and to environmental protection in general.

Because the U.S. Geological Survey deals primarily with water from the moment it reaches the surface as precipitation, until it evaporates to the atmosphere or discharges to and is mixed with the waters of the sea, this discussion summarized only remote-sensing studies and applications that same portion of the hydrologic cycle. Meterological and oceanographic applications will be discussed later in the program by Dr. Rabchevsky and me.

Contact Measurement of Hydrologic Data

Traditionally, observations and measurements of water parameters related to quantity and quality have been made at specific points at various time intervals. For instance, in its studies of water storage or subsurface dynamics, the Geological Survey measures water stage in wells, either automatically, by means of continuous recorders, or manually, at periods ranging from daily through weekly, monthly, quarterly to annually. Special purpose studies may require only intermittent or one-time measurements. Discharge (volume of flow) measurements are made at numerous points along many rivers and streams. Many of these measurements are made by means of continuous recorders, but others are made periodically, or intermittently for special purposes, such as flood or drought analyses. Water samples are collected periodically from streams, lakes, and estuaries for chemical analysis to detect changes in quality resulting from variations in volume, natural chemical contributions, or pollution loadings. Continuous monitoring of a few water quality parameters is now being performed at an increasing number of stations throughout the United States.

Streamflow and chemical quality data are examples of hydrologic data collected at point sources. These data can be said to represent an integration of all factors upstream resulting in the flow or chemical quality at the sampling point.

Remote-Sensing Data Collection Modes

Generally speaking, it can be said that before the advent of remote sensing as a tool in hydrologic data collection, qualitative observations and quantitative measurements were made in two modes--spatially (by integration of point data) and temporally. Remote sensing provides the capability to expand data collection in the temporal mode tremendously. In the spatial mode it adds an areal dimension for integration of point data. In addition, remote sensing adds a third mode, the spectral mode (Table 1).

Table 1. REMOTE-SENSING HYDROLOGIC DATA COLLECTION MODES

Spatial	Temporal	Spectral
Delineate	Continuous (real-time)	Detect
Measure (areas)	Intermittent (fast reaction)	Identity Relate
Quantify (parameters)	Periodic (repetitive)	Interpret
	One-time	

Spatial Data

Remote sensing now permits hydrologic and hydrologically-related data to be collected on an areal (spatial) basis, thus overcoming the limitations of the traditional point-source measurements. It is now possible to view hydrologic or related phenomena synoptically at virtually any scale. Low-flying aircraft, for example, can photograph or image areas at very large scale, while spacecraft in geosynchronous orbits can "see" an entire quadrant of the earth with a variety of sensors.

It is also possible to take a point measurement (such as temperature) of a significant parameter on the surface, measure a related phenomena (radiance in the thermal infrared portion of the spectrum) and extrapolate the temperature measurement spatially. Although the emitted radiance at a given wavelength is not the identical parameter to that measured by the thermometer near the surface of the water, they are closely enough related so that a spatially "quantitative" measurement of the thermal characteristics of the surface can be achieved.

Temporal Data

Temporally, hydrologic observations or measurements can be made continuously or at selected intervals from remote platforms, predominantly spacecraft or aircraft. Most of these measurements need to be repeated because of the dynamics of the hydrologic cycle, although some observations in hydrology may only need to be made once. To date, most operational use of such one-time remotely-sensed data has been confined to hydrologic studies such as determination of nondynamic geologic controls on occurrence or movement of water.

Some observations or measurements must be made continuously, as in the case of measuring the discharge of water in a stream or changes in chemical quality in an estuary. The temporal range to be considered for hydrological studies is, therefore, essentially infinite. Analysis of the temporal requirements for hydrologic data is critical in remote-sensing operations inasmuch as these provide the basis for orbit selection of spacecraft or scheduling for aircraft overflights.

Rabchevsky listed the frequency of observations presently possible and necessary for the detection of temporal terrestrial features, including hydrology. He noted that such observations as new snow areas and inland lake temperatures have been observed from space at frequencies as great as 12 hours, whereas important data on snowfall boundaries and reservoir development have been obtained on an annual basis.

Spectral Data

Water or water-related phenomena may be detected or measured by sensors operating in widely separated portions of the electromagnetic spectrum. For example, soil-moisture variations have been detected by their effect on gamma radiation, while variations in the water content of snow result in differences in emitted radiance in portions of the microwave region. Remote sensing for hydrologic applications has been largely limited to photography in the visible portion of the electromagnetic spectrum, although in recent years, infrared photography and thermal infrared imagery have produced significant results. As will be described later, thermal infrared imagery has also been used in an operational mode for hydrologic application. Every indication points toward a greatly increased use of thermal infrared imagery collected from remote platforms.

New applications in hydrology are being attempted experimentally using data collected from sensors operating in many portions of the spectrum. A number of Geological Survey scientists are engaged in applied research relevant to this discussion. I will make reference to these studies on Wednesday with appropriate slides during the sessions on hydrology.

Outline: Interpretation Techniques Workshop

By George Rabchevsky

I^2S Demonstration - (Color additive viewer)

References used:

1. Manufacturers Maintenance Manual
2. User's Guide, GSFC publication
3. Reprint of article on Image Enhancement: Teleki, P., J. White and G.A. Rabchevsky, Image Enhancement Techniques for ERTS Imagery: Sioux Falls, ASP Symposium Proceedings, 1973.

The following items were demonstrated:

1. Color additive I^2S Viewer construction.
2. Color additive I^2S Viewer operation controls.
3. General procedures for use.
4. Demonstrate operation.
5. Demonstrate procedures for photographing screen.

The following products were produced locally during the workshop:

1. Enlargement of chips to 1:500,000.
2. Various color composite renditions were produced for the following countries: Nigeria, Liberia, Swaziland, Malawi, Kenya, Ghana, Malagasy.

Lecture outline, Meteorological Satellite Data for Earch Resources

By George Rabchevsky

The oral presentation was based on excerpts from the following published sources:

1) Rabchevsky, G., 1971, Satellite Observation of Temporal Terrestrial Features: Proceedings, Huntsville Association of Technical Societies Space Congress, "Space for Mankind's Benefit," Huntsville, Alabama.

2) Rabchevsky, G.A., 1970, Nimbus Satellite Views Hydrologic Conditions: Proceedings of the First Western Space Congress, Part 2, Vandenberg Scientific and Technical Societies Council, Santa Maria, California.

3) Rabchevsky, G.A., 1970, Comments on the Geologic Use of Nimbus I Television Photography: ibid.

4) Rabchevsky, G., 1971, Hydrologic Conditions Viewed by the Nimbus Meterological Satellites: International Remote Sensing Workshop, Proceedings, Vol. 2, University of Michigan, Ann Arbor.

5) NASA, 1969, The Nimbus III User's Guide: Goddard Space Flight Center, Greenbelt, Maryland.

6) NASA, 1970, The Nimbus IV User's Guide: ibid.

7) NASA, 1972, The Nimbus V User's Guide: ibid.

8) NASA, 1965, Nimbus I High Resolution Radiation Data Catalog and User's Manual: ibid.

9) Ackermann, H.J., and G.A. Rabchevsky, 1971, Applications of Nimbus Satellite Imagery to the Monitoring of Man-made Lakes: Proceedings on Man-made Lakes Symposium, Knoxville, Tennessee.

10) NASA, 1971, The Best of Nimbus: Goddard Space Flight Center, Greenbelt, Maryland.

11) Sabatini, R.R., G.A. Rabchevsky, and J.E. Sissala, 1971, Nimbus Earth Resources Observations: NASA Technical Report No. 2, Contract No. NAS 5-21617.

12) Brooks, D.J. and G.A. Rabchevsky, 1973, Geologic Implications of a Satellite View of Ellesmere Island, Canada: Modern Geology, Vol. 4, pp. 131-135.

In support of the above presentation, exhibits were displayed illustrating interpreted Nimbus imagery and temporal Nimbus coverage. Fifty-one slides were used to accompany the verbal presentation.

Outline: Natural and agricultural resources

By David Carneggie

I. Introduction to Remote Sensing

A. Definition of terms and concepts used in remote sensing: Remote sensing, sensing devices, data, data formats, electromagnetic spectrum, image Interpretation, etc.

B. Rationale for Remote Sensing Applications
   1. NASA's Earth Resources Survey Program
   2. Scope of applications in various resource disciplines

II. Basic Matter and Energy Relationships Important for Remote Sensing

A. Characterization of the Electromagnetic Spectrum and its use to remote sensing

B. Discussion of important energy sources, and interactions of matter and energy for remote sensing.

C. Methods of determining energy responses of objects.

III. Description of Remote Sensing Devices; Advantages and Limitations

A. Passive remote sensing devices
   1. Gamma-ray spectrometers
   2. Cameras
      a. single lens
      b. multiple lenses
      c. multiple camera configurations
      d. panoramic cameras
   3. Optical mechanical scanners
   4. Thermal infrared scanners
   5. T.V. cameras (R.B.V.)

B. Active Remote Sensing Devices
   1. radar
   2. lasers
   3. X-ray
   4. Sonar

C. Properties of Different Films and Filters

D. Vehicles and Platforms used for Remote sensing
   1. Fixed platforms
   2. Aerial vehicles: aircraft, helicopters, balloons, pigeons
   3. Space vehicles

E. Summary of Advantages and Disadvantages of Sensing in Various Parts of the Electromagnetic Spectrum.

IV. Factors Governing Procurement of Interpretable Imagery

A. Selection of appropriate remote sensing device
B. Multispectral reconnaissance
C. Selection of appropriate scale of imagery
D. Selection of appropriate season of the year
E. Selection of appropriate time(s) of the day
F. Sequential or repetitive coverage

V. Calibration of test sites: Collection of Ground Data

A. Equipment for determining spectral or emittance response of features
B. Standard targets
C. Characterization of ground features
   1. Qualitative; e.g., color, health, condition
   2. Quantitative; e.g., density, height, area, distribution

VI. Methods for Extracting Information from Remote Sensing Data

A. Equipment for viewing remote sensing data
B. Preparation of "keys" and descriptive aids to identify features
C. Photo-image characteristics: tone, texture, size, shape, pattern, association
D. Relating spectral, thermal or microwave response to physical response or condition of features: temperatures, emissivity, hardness, dielectric constant
E. Use of Densichron or Microdensitometer to determine the optical density of photo images
F. Additive color enhancement systems
   1. Optical combiners
   2. Photographic method
   3. Diazochrome technique
   4. Electronic color enhancement systems
G. Comparison of time-lapse or repetitive remote sensing data
H. Techniques for quantifying features
I. Techniques for automated analysis of remote sensing data
J. Multistage sampling techniques

VII. Applications of Remote Sensing for Resource Evaluation

A. Agriculture
   1. Crop identification and census
   2. Determine crop area
   3. Determine crop condition and health
   4. Yield predictions
B. Rangeland, Natural Vegetation, Wildlife Habitat, and Forest-land
   1. Mapping vegetation types
   2. Identification of plant species and associated features
   3. Assessment of management problems
   4. Determine productivity or condition
   5. Detection of damaging agents
   6. Animal census

Lecture outline: Hydrology and Water Resources

By Morris Deutsch

I. Introduction

Definition

Unique remote sensing requirements of hydrologists
   Differences from other discipline requirements

Scope of EROS activities in hydrology

II. Data Collection Programs

Traditional measurement of hydrological parameters

Quantity: stage, volume, flux, distribution, use

Quality: physical, chemical, biological

Hydrologic parameters measurable or observable by remote sensing techniques

Direct
- Water, snow, and ice areas
- Anomalies in surface character

Indirect
- Ground water
- Soil moisture
- Transpiration flux
- Estuarine mixing
- Coastal discharge

III. Concepts of the Data Collection System (DCS) as used in the U.S.

Spatial (aerial) extrapolation of point data.

Use of DCS point data in conjunction with imagery in mathematical models.

Hydrologic parameters suitable for DCS.

Stage as related to:
- Stream discharge
- Surface storage
- Ground water storage

Research and development
- Requirements for DCS
- Sediment load
- Soil moisture
- Snow depth and/or water content
- Evapotranspiration

IV. Application of data from existing sensors

State-of-the art

Photography

Radiometry

Non-imaging
- Single point, single band
- Single point, multiband

Imaging
- Single band scanner
- Multiband scanner

R & D Sensors

- Radar
- Microwave
- Fluorescence detector (FLD)
- Laser spectroscopy
- Reflectance spectroscopy

V. ERTS experiments in dynamic hydrologic phenomena
- Playa lakes
- Snowline dynamics
- Basin characteristics
- Phreatophytes
- Land-water-plant community distribution ratios
- Sediment dynamics

VI. Illustrated descriptions of ERTS and related data inputs to hydrology*

- Water on the Earth
- Surface-water distribution in the Southern High Plains
- Storm track revealed by ERTS
- Plaza and reservoir monitoring in Northern California
- Lakes in the Gainsville, Florida area
- Snowline dynamics in Washington for runoff estimates
- Ground-water discharge into streams
- Thermal infrared imagery of spring discharge, U.S. and Jamaica
- Turbidity anomalies as indicators of submarine springs
- Glacial and alluvial aquifers in the Columbia River basin
- Delineation of saturated sediments in Illinois
- Alluvial aquifers in Israel
- Hydrogeologic conditions in Pakistan from flood imagery
- Delineation of sedimentary work aquifers
- Crystalline rock aquifers in the Adirondaks, Laurentian Shield, Canada
- Ground-water use for irrigation
  - Snake River Plain, Idaho
  - Platte River Valley, Colorado
- Spectral data enhancements of flood plains
- Temporal analysis of hydrologic changes
- Spatial resolution comparison, Nimbers/Apollo/Aircraft
- Industrial pollution, Lake Ontario
- ERTS 1 orbit concept for sequential coverage

* One or more slides used for each item. Not duplicated herein.

Seasonal change in spectral characteristics of phreatophytes
Land management boundary, Texas/New Mexico
Areal changes in ephemeral lakes, Texas
Comparison of hydrologic data on geologic vs. topographic maps
Long Island wetlands projected to scale of 1:20,000
Leakage from all America Canal
Delineation of coastal mangrove communities
Thermal discharges into Lake Ontario revealed by thermal images
Water pollution problems in the Cleveland area
Three-dimensional analysis of Tampa Bay turbidity by RBV
Color-coded aircraft MSS analysis of phosphate pollution, Florida
Detection of dying trees in flooded forest
Soil water differences detected by color lr and thermal lr, South Dakota

Lecture outline: Use of ERTS Data for Determination of Environmental Conditions

By George Rabchevsky

A variety of environmental conditions were illustrated with slides. Some of the ERTS examples included:

1. Seasonal effect, spring, summer, fall, winter, on ground conditions. Washington, D. C. scene.
2. Coastal sedimentation, temporal observations. Carpenteria Bay, Australia scene.
3. Alaska forest fires.
4. Ash fall covering ground in Iceland.
5. Deforestation. Oregon and Maine scenes.
6. Oil spill in the mediterranean.
7. New York Bight acid waste dump.
8. USA/Mexico irrigation practice and vegetation (crop) boundary.
9. Salt pans in Israel.
10. Ground water control by faults in Israel.
11. Flooding in Mississippi River and San Francisco area.
12. Jet contrails over Aegian Sea.
13. Logging operations and trails.
14. Erosion of crop lands in Mid-west.
15. Burning of croplands in California.
16. Sedimentation in lakes, Kenya.
17. Grazing vs. nongrazing rangelands, Kenya.
18. Rain water/sediment runoff, Washington, D. C. scene.
19. Strip mining and mining dumps, Zambia scene.

Lecture: Mineral resources, geologic structures and landform surveys

By George Rabchevsky

Mapping and Study of Geologic Features and Processes

1. MAP MAKING--In regions of the world characterized by sparse vegetation, good small-scale reconnaissance maps can often be prepared from ERTS imagery where distinctive outcrop patterns occur. Sometimes these maps are superior to ground-based geologic maps in that contacts may be better delineated in the overview. Good mapping from ERTS can be done at scales up to 1:250,000, usually cheaper and faster than by other methods (although the relative accuracies have yet to be assessed). Map editing to correct mistakes in existing maps is likely to be a common application for the next few years. ERTS regional mosaics afford an excellent photobase for geologic overlays.

It should be remembered, however, that ERTS images normally are suitable only for production of photogeologic maps. The units depicted are "remote sensing units" rather than materials units or units with stratigraphic (age) significance.

2. LAND FORMS --ERTS images, especially combined in mosaics, provide an unparalleled means for envisioning regional relationships of the larger geomorphic features on Earth. Among successful studies of this type are (a) descriptive and genetic classifications of sand seas (McKee); (b) location of major areas of soft surface erosion (Morrison); (c) recognition of surficial effects of recent and active glaciers, including striking views of continental glacial deposits and permafrost features (Morrison, Ferrians, Grybeck); (d) definition of features characteristic of intermontane basins, pediments, or semi-desert plains, and (e) vivid display of volcanic landforms and deposits. (Williams; Friedman) with particular ability to discriminate relative ages of flow units.

3. STRUCTURAL GEOLOGY--The major contribution of ERTS to geology, evident almost as soon as the first images were examined, continues to be its exceptional ability to depict the interrelationships of gross structural features -- folded mountain belts, major strike-slip fault systems, domes and uplifts, crystalline shield or pidemont terrain -- on regional or subcontinental scales. ERTS is remarkably effective in in revealing new "linears" many of which upon field examination prove to be faults, joints, or fracture zones. Since the earlier ERTS studies, the nature of linears is being placed in better perspective, and they are beginning to be used in practical ways as well as in theoretical interpretations (Lathram; Isachsen; Goetz; Mohr; Collins; etc.) Linears ranging in length from hundreds of miles to less than a mile are being disclosed. In some areas of the world, poorly mapped in the

past, the numbers of hiterto undetected linears have increased by factors of 2 to 5 or more. This substantial improvement in detecting linear features is of great importance in refining models for tectonic deformation, in more fully understanding the tectonic framework for continental evolution, in associating earthquakes with their causative sources, in setting forth new "targets" to explore for minerals whose emplacements were fracture-controlled, and in noting potential hazards to man's activities. As a result of ERTS, many tectonic maps are now obsolete and will require careful revision.

Many closed structural features, including folds and circular or arcuate structures, are being seen in a new light - either as new or poorly known features - from ERTS. Among these are such diverse structures as ring dikes and calderas of volcanic origin, intrusive plutons and stocks, salt domes, and astroblemes.

4. MODELING--Most models applied to geologic problems are conceptual or interpretive in nature. Such models usually require about 2 to 3 years to formulate after the first data are obtained. One common approach to geologic modeling in the ERTS program consists of testing concepts and methods by determining how the phenomena under study appear in well-known areas. Thus, the surface expressions of mineralization or petr-leum accumulation in established mining districts and oil fields are first described and characterized, from which models for recognizing these resources elsewhere can then be developed. Isachsen's model has, more than any other investigator, carried the analysis of linears from the generalizations made with ERTS imagery to the specifications that emerge from close-hand inspection on the surface and from aircraft. He has injected a sense of "real world" ground truth into linears interpretation that reminds us to be cautious in drawing any conclusions from linears that have not been field-checked. (Other models, Morrison, McKee, Asdel-Gawad, Mohr).

5. INTERPRETATIVE TECHNIQUES--Methods used in geologic studies have almost exclusively been those of conventional photointerpretation. In general, optical enhancement techniques such as color additive viewing have added to the information in black and white transparencies. Color composites do assist in delineating certain rock units when mapping is undertaken. The use of snow-enhanced images to emphasize topographic relief and associated fractures has also been convincingly demonstrated.

Specialized computer processing appears useful for some applications. This includes corrections (involving high frequency restoration and boosting to produce new images with increased resolution, spatial (directional) filtering to improve contrast and bring out subtle linear features, and multi-band ratioing. Under the right conditions geologic units maps can be generated by machine-processing, but most geologists will need to be "educated" in the use of these products. So far, most computer-based attempts to improve linears recognition have obscured or distorted the results compared with the straight-forward detection possible in the photoimages (mention spatial filtering technique adapted by Goetz and Bernstein).

Stereo-viewing is especially helpful in recognizing linears, defining direction and magnitude of dips, determining lithologies by their relative resistances to erosion, recognizing landforms, locating glacial deposits, and assessing slope stability. Ambuiguities associated with tonal differences are often resolved when relative relief can be established through stereo-coverage. Fuller utilization of the stereoscopic capability from side and overlapping ERTS imagery would be useful.

6. APPLICATIONS--Some applications are ongoing; others are being considered; and new ones remain to be proposed. Small-scale reconnaissance mapping can now be extended to many parts of the world where good maps are still scarce. Map editing, mainly to correct contact locations or to plot new fractures is a major application that should be initiated as a routine for all small-scale maps in the world. Classification and mapping of higher-order landforms are now strong possibilities for the U.S. and other regions covered by ERTS. Such a map has many engineering, land used planning, and environmental geology uses, as well as extensive value to geomorphic analysis. At present, about one-fourth of the western U.S., for example, has been mapped from ERTS for linears distribution. It is reasonable to complete this mapping for the entire U.S. without much more effort. Such a regional or subcontinental map of linears -- even though most will be initially unchecked and many will prove to be non-geological -- should be invaluable for tectonic synthesis of crustal structure. It is here estimated that ERTS has the intrinsic capability of increasing the number of known major (large and extended) fractures not recorded on maps by a factor of 2 to 3 in parts of the U.S. and no doubt even more in other parts of the world where mapping is less advanced (perhaps 5 times in East African, according to Mohr).

(End of Formal Presentation)

NEDED WORK - (Discussed informally during the course of the workshop

(1) New methods for recognizing and verifying linears must be developed and confidence levels in identifying those of geologic significance has to be established if the user community is to accept the results. (Isachsen). Computer-processing, while offering promise in linears analysis, must be applied with caution because fractures usually don't have constant expression along strike. A combination of interactive optical and computer processing improves detection but the role of the human interpreter remains essential by providing critical judgment in discriminating structural features from other kinds of linears.

(2) The mapping and analysis of landforms and dynamic processes from ERTS Comprise a fertile field that has hardly been touched by investigators. Such maps can be effectively used by engineers, landscape

architects, and regional land use planners and developers. A systematic approach to such efforts is surely needed now, culminating with documentation of each landforms type in a landforms photo atlas. Correlation of ERTS surface maps with those being designed in the emerging field of environmental geology (with emphasis on setting up land use and engineering surface units) is a natural coupling thatremains to be done. Other uses include mapping of drainage networks and old beach lines and terraces and a systematic study of the surface features characteristic of arctic and alpine geology. Among dynamic processes that are especially amenable to study with ERTS imagery are shoreline erosion and offshore sedimentation, redistribution of soils and soft sediments following transport by sheetwash during flooding, surface conditions favorable to ground water recharge, and development of cave-karstland topography.

Where ground truth and other photogeologic information are available, some rock types can be discriminated from on another in ERTS images with reasonable reliability. However, use of ERTS-type sensors (probably supplemented by others in different wave regions) to identify specific rock types by lithology and/or chemical composition has met so far with little concrete success. A few rock types are readily and consistently recognizable, primarily because of their unique appearance and geologic associations (e.g., basalts in flows). Mostly, however, neither lithologic nor stratigraphic units can be identified directly from the spectral reflectance (color and brightness) information sent back by ERTS, i.e., there appears to be no physical basis for rock identification using reflected radiation in the visible-near IR. Thus, unique solutions to identity have not been found. But specialized processing must be developed if better results are desired for lithologic identification -- a key to more comprehensive mapping -- by remote sensing. Band ratioing (Goetz, Vincent, Rowan) seems to be a positive step towards this objective. It may also prove useful to develop a classification of rocks using the clustering techniques applied to vegetation analysis. As signatures for major rock types accumulate, these can then be plotted on suitable cluster diagrams.

architects, and technicians [illegible] planners and developers. A systematic approach in each of [illegible] methodology, and [illegible] documentation of each landform [illegible] consequences of ERTS employment with [illegible] the [illegible] realm of environmental geology [illegible] and engineering pattern [illegible]. Other uses include mapping of drainage [illegible] and [illegible] lines and terraces and a systematic study of the [illegible] characteristic of arctic and alpine geology. Among [illegible] that are especially amenable to study with ERTS imagery [illegible] and offshore sedimentation [illegible] following transport by [illegible] favorable to ground water recharge, and [illegible] topography.

Where ground truth and other ancillary [illegible] are available, some rock types [illegible] ERTS images with reasonable reliability. However, [illegible] (probably supplemented by [illegible]) specific rock types [illegible] lar with little [illegible] consistently recognizable, [illegible] and geologic [illegible] neither lithologic nor [illegible] from the spectral [illegible] back by ERTS. A [illegible] identification using [illegible] unique solutions [illegible] propensity must be [illegible] identification -- a key to more comprehensive mapping [illegible] Band ratioing (Ghent, Vincent, [illegible]) seems to be a positive step towards this objective. It may also prove useful to develop [illegible] classification of rocks using the clustering techniques applied [illegible] As signatures for major rock types [illegible] they can then be plotted on suitable cluster diagrams.

APPENDIX C. MT. KENYA FIELD TRIP REPORTS*

Observations from Field Trip Using ERTS Imagery

By Thomas A. Dundas

Liberia

March 29 - 30, 1974

Attempts were made to interpret features, i.e., roads, forests, lakes or rivers, cultivated areas, rangeland and habitated areas on the imagery using colour composits bands 4, 5, and 7 before going into the field. This exercise proved a bit difficult because the resolution of the imagery was very low and the persistent need for ground data prevented same. However, a few features were annotated and used as guidelines i.e., main roads and towns were traced from existing maps.

In the field commencing from Karatina, features tend to show up differently, i.e., cultivated areas did not carry any regular pattern which would have enabled us to detect them. These areas which consist primarily of cereal, potatoes and other crops were interspersed with grazing land and habitated areas. This gives rise to the development of some ground truth keys for this particular area which might not be applicable to other areas.

We observed that: (a) Roads are not easily discernible within highly vegetated areas. Where discernible, there exists a high degree of contrast, size and soil texture. (b) Basalt or lava terrain (which varied in age) tends to dominate vegetation by its high frequency of greenish blue. However, further investigations revealed that the same tone exists where areas have been recently prepared for cultivation (fresh soil exposure). Here we decided that several other aspects must be taken into consideration, typical of which is, location and association.

(c) Meadow and/or rangeland appeared in the same tone. However, careful investigation partially proved that meadows are closely associated with agricultural areas (areas being used for cultivation).

(d) Rivers can be traced under several conditions: (1) size (2) location and (3) surrounding vegetation. Care has to be taken in preparing a drainage pattern because the possibility of using some definite line features as creeks exist. Possibly I would suggest using band 7 which gives a good contrast with water (black).

*Informal report drafts. Not reviewed or edited by the authors nor by the U.S. Geological Survey for technical and editorial accuracy.

(e) Soil type within the entire area would be placed in the three groups: (1) red (2) brownish (3) black. However, there appeared areas of soil bearing white color which could be attributed to the presence of a high quantity of salt. Tremendous amounts of ground data is needed before one could use imagery in preparing a suitable soil map. Rather we attempted to associate vegetion to soil type in some cases but could not definitely say to what extent this would hold because of the constant change in color and location. Further, the same vegetation appears to thrive in all these soils.

(f) Forests fell into two catergories according to the color composite which was of great help. The densely forested areas gave up a very dark red tone whereas the sparsely and/or low forested areas gave up a light red to pink tone which was due to the reflectance of the terrain. Care must be taken here when using bands 4 and 5 because these densely forested areas tend to give the same contrast as water. Our clue was again placed on location.

CONCLUSION: In my opinion, ERTS imagery could be of great advantage where constant ground data is present for correlation. There is no possibility of applying ERTS imagery without previous knowledge of the area under investigation. Further, the imagery used on this field trip was over a year old, which created the problem of correlating seasonal change and the absence of data for that particular time the sensor was taken. However, good care and thorough investigation and comparison could lend a tremendous amount of information utilizing ERTS imagery.

Mount Kenya Field Trip

By J. K. Gachui, Kenya

We drove from Nairobi to Karatina where we started identifying features from the ERTS imagery of Mount Kenya area.

In and around Karatina we noticed agricultural fields of coffee and other field crops. This area was clearly marked reddish in ERTS imagery. However, it was not possible to tell the red soil around Karatina from the ERTS imagery. The bluish pocket along Karatina to Kiganjo road was a dam. As we drove uphill towards Kiganjo we identified elevated grounds with small valleys and strips of forest vegetation and grasslands. Features readily indentifiable from ERTS imagery were grasslands which appeared bright red and Nyeri hill and strips of forests which showed a red signature.

As we approached Naru Moro from Kiganjo we noticed vegetation change from grassland to forest-type vegetation. This vegetation had reddish signature interspersed with whitish specks which represented dried up grass which is highly reflective. The dark strips on the imagery represented exposed soils.

As we travelled to Nanyuki, the forest vegetation around Nanyuki showed a dark red signature. The whitish strips on the imagery represented drainage patterns, and the dark ones exposed soils.

The differences in vegetation between Nanyuki and Samburu is due to the intermittent transition from sparse grasslands to strips of forest and exposed soils. The whitish strips on the imagery represent sparse grasslands, dark areas, soils, and reddish strips, pockets of forest-type vegetation.

Uaso Nyiro lines was clearly marked dark in the ERTS imagery, and the dark black strip along Sankuni had a lightish red signature.

From Samburu we travelled through Meru district. In Meru district we noticed forests and croplands which had a red signature. There were several streams which were not identifiable from ERTS images. These streams were not seen from the colour composite because they were probably masked by the dense river bed forest-type vegetation. Between Meru and Embu the vegetation had a red signature indicating cropping land. The red signature is accentuated by the many trees the area allowed to grow together with the cultivated crops. The dark areas along the road in Embu represent the dark soils and rice fields. The reddish areas on the imagery are sparse grasslands.

Agriculture/Rangeland Field Trip

By J. J. R. Grimsdell, Serengeti

Mt. Kenya ERTS image (max. scale 1:250,000)
January 1973 colour composite

Objectives

To correlate ground data with ERTS image colour tones and/or textures in order to define habitat or land-use types on the image.

Methods

(i) Colour tones on ERTS image delimited using a transparent overlay; i.e., preliminary stratification of image.

(ii) Colour tones checked by ground, road survey. Only a very small portion of the ERTS image was verified in this way. Complicated by lack of synchronous data; i.e., ERTS image taken in January 1973; ground survey carried out in March 1974.

Results

The following habitat and land-use types could be delimited on the ERTS image:

(a) Soil features	Image tone
Basaltic	Black/blue
Sandy	White
Other (i.e. red soils)	Pink-red, due to vegetation cover (or yellowish)

(b) Habit types	
Bare ground	White, black, blue
Mountain vegetation	Pink/red tones
Bamboo zone	Pink (smooth)
Broad-leafed forest	Pink
Lower slopes of Mt. Kenya	Pink
Rangeland (cattle, goats)	Blue, white, pink
Basalt & thin woody cover	Blue-black
Open sandy patches	White
Open water	Black-blue

(c) Land use types	
Subsistence agriculture:	Pink and white mottling (villages)
Commercial agriculture:	Rectangular patches of red, pink, white or black
Rangeland:	Light pink, white, blue
Forest:	Dark red

Mount Kenya Field Trip

By M. D. Gwynne, UNDP/FAO Office, Nairobi

The field trip was an excellent idea which greatly helped the participants in understanding and interpreting the images.

The division between geologists and the others was unfortunate in that the exercise lost much of its multidiscipline impact.

It would have been better had the handout imagery to participants been at a recognizable scale that could have been applied to maps directly, e.g., 1:500,000.

To get the best out of the imagery interpretation there needed to be more supervised pre-trip work using aerial photograph print lay-down mosaics and conventional 9 x 9 aerial photos. In this way most of the signatures could have been checked out before leaving and then verified on the trip. A logical approach to such an exercise would be:

a. Initial pre-trip study of 1:1,000,000 colour composite and black and white images to delineate large areas of similarity.

b. Identify the above areas on 1:250,000 imagery.

c. Correlate the above areas with similar areas on conventional aerial photo print lay-downs.

d. Carry out systematic underflight coverage to annotate imagery.

e. Field trip to examine and check interpretation on the ground.

Nevertheless, the field trip did show the following:

a. Geology: that the basic structural geology could be discerned and that a number of features not readily detected by normal means could be clearly seen.

b. Drainage: it is excellent for showing drainage which is most useful to ecologists.

c. Soils: it is excellent for showing soil types and soil relationships and could be used for soil mapping: very useful to ecologists.

d. Land-use patterns: it is very good for delineating gross land-use patterns, i.e., over large areas. It is not useful in determining land-use patterns within a general peasant agricultural system, although it could be used for determining change in a more sophisticated agricultural system (i.e. Large scale).

e. Vegetation: very varied depending on type. Very good for showing dense vegetation, e.g., forest, bamboo, high cover grassland. It becomes less useful for determining vegetation patterns in the drier areas as there is a tendency for the vegetation signature to be masked by that of the background rocks and soil. It is possible that some of this difficulty can be overcome by choice of time of image vs. when the leaf flush is at a maximum, but this needs to be tested in the range areas. The resolution becomes critical in these areas as in even dense areas of tree cover the individuals are still widely dispersed. Its use in the range areas of Kenya is therfore still uncertain.

The conclusion from the field trip is that ERTS imagery at a suitable scale is of considerable use to ecologists, particularly in high to medium potential areas (East African Ecological Zones I-III, possibly IV) but is of less use in low potential areas (East African Ecological Zones V and VI).

In the above discussion only optical methods of evaluation are considered based only on the field trip and a comparison of the images on different bands with the colour composite.

Interpretation of Report and Field Trip

By S. Kajula, Tanzania

The interpretation was carried on three same imagery with different spectral. The imagery were in the following bands: 5, 7, black and white and the colour infrared.

The imagery of Mt. Kenya areas at a scale of 1:700,000 for black and white and the colour infrared at a scale of 1:685,000. In the first black and white imagery there one could make a good check up in the two bands which seem to clarify what is seen in the other band.

Images which were not seen in the band 5 in band 7 appeared, and those which do not appear in band 7 do appear in band 5.

The colour infrared is much more sensitive for it picks nearly every image which was picked by band 5 and 7 and as it is a colour composed it is a bit easier to delineate boundaries of different images. The identification of different images to some extent can be done easily, e.g., forest and rivers but to other image local knowledge is of importance, or a field check could solve the identification problem.

Field Trip Report. As I did not go to the field, I only had to depend on what the participant of the trip say on their field check. On the color infrared imagery there is no trace of the grazing and agricultural farming below the Mt. Kenya forest, but those people who went on the field trip mentioned of the grazing land. Therefore, in their imagery at such scale one should know that he will lose some information. Small towns will appear like dots which will be difficult to identify.

ADMINISTRATIVE REPORT ON TRIP TO MOUNT KENYA AREA - 29-3-74 and 30-3-74 (SEMINAR & WORKSHOP ON REMOTE SENSING)

By P. W. MUMIUKHA, GAME BIOLOGIST, KENYA

OBJECTIVE: To delineate bands 5 and 7 black and white as well as the colour composite of the above area and then ground check them.

PROCEDURE: The photolike imageries were delineated in the laboratory before the trip was made. After delineation the features were pre-identified where it was possible. It was found that band 5 was better than band 7 for showing vegetation types.

After delineating the colour composite also, the route was marked. It was the colour composite image that was used on this ground checking trip.

Although the imagery was taken in January 1973, it still revealed that there were few temporal changes in March 1974. It was found, on the first trip, that the pink areas on the image were intensive agricultural croplands of coffee, maize and bananas. These areas were also smooth to the texture.

The Kiganjo, Naru Moru, Nanyuki areas show red, black blue alternating.

The Kiganjo, Naru, Moru, Nanyuki areas that show red, pink areas alternating with blue black, blue and yellow on the colour composite were found to be as follows:

red for forest;
pink alternating with blue black for cereal and grass lands alternating with ploughed red soils;
Blue stands for water or moist areas.

Before reaching Isiolo, we passed through mature cereals which show pink or yellow on the colour composite.

In Samburu region, the following were found:-

Topographical features like basaltic hills gave rough texture to this region and were dark, dark blue and blue.

The light areas on the composite were found to be rhyolite lava.

Although the river Ewaso Nyiro should have shown blue or black like the Buffalo Springs, it showed red because of the dense riverine woodland along it.

On our second leg, which passes through Meru, Ishara, Embu and Mwea Tebere Rice Scheme i.e., the area South of East of Mount

Kenya, showed red, pink and then pink with wide light-patches. The red was the montane forest near Meru town and the pink for the agricultural croplands of upper Meru and Embu Districts. Passing through South East of Meru and East of Embu, which was the pink interspersed with large light areas on the composite, reveals it to be a rangeland area. It is a Combretum woodland and Acasia bushland area suitable for keeping domestic and wild animals only.

The trip through Mwea Tebere Rice Scheme revealed that the black blue patches were actually the water logged black cotton soils.

Conclusions: The above trip to me was very successful. It revealed clearly boundaries for soil types, forest lands and areas of underground water e.g., Buffalo Springs.

Although agricultural lands are also very well indicated, the vegetation types especially in more arid areas are masked by the back ground absorption of the soils and lava flows. This is because the ground cover of this vegetation is very low. But other areas like the forest types which show very well indicate that the ERTS-1 image is a big tool to be used in aerial photography in wildlife management.

Agriculture Field Trip on Remote Sensing

By V. K. Ocran, Agriculturist, Ghana

The preliminary objective of this field trip was to put what we had learned in the classroom into direct application in the field. To this end the following imagery obtained from ERTS were studied.

(a) Two black and white images produced on bands 5 and 7

(b) One colour infrared composite.

Previous knowledge on the techniques of identifying features on the ERTS imagery was applied to the black and white images and to the color infrared composite.

The color infrared composite was studied in detail.

The ERTS imagery studied for this field trip (i.e., both B & W and CIR composite) was the one obtained around Mount Kenya.

Before the field trip, various features such as roads, vegetation, rivers and streams, farms, basatl, etc., were delineated. In short, an attempt was made to delineate almost all linear and non linear features.

The route for the field trip was delineated (by using the existing roads around Mount Kenya) was as follows: (Not available).

The objective of the field trip then was to provide field verification of the preliminary interpretation done in the classroom, i.e., to provide the ground truth of the features delineated on the ERTS CIR composite.

A number of stops were made on the way to correlate the ground features to the classroom interpretation.

Stop 1: <u>Karatina</u>- The road passes through a dark strip as shown on the CIR composite. This indicated an area of agricultural activity. The dark appearance was due to the following: (a) intensive grazing, (b) recent planting of crops wheat, rice, which were still in the seedling stage.

The little white tones suggested human habitat and agricultural activity.

The changes in the soil types were also observed.

Stop 2: <u>Nyeri</u>- The following were observed: the soil changes, coarse vegetation, open land - savanna.

The density of the vegetative cover denoted by the red colour on CIR composite was identified as delineated previously. Where there was healthy vegetation this was clearly identified on the route.

Stop 3: <u>Nanyuki</u>- Other features identified were:

(a) The light-toned strips which indicated stubble which had not been ploughed, dry grass, and mature crops, rice, wheat.

(b) Many covers in dark tones.

(c) the healthy vegetation (forest) on the way to Isiolo stood out clearly.

The exposed or untarred road surface from Isiolo stood out clearly as a light tone on the ERTS imagery.

The white area about 5 km. from Isiolo to Semburce on the left was identified as sand or a white lava flow.

The basaltic flow on the way to Samburu was clearly identified as the black strip on the CIR composite in spite of the vegetative cover on it.

Some rivers, streams and springs appeared light red to pink in colour due to vegetative cover (grass) on them or lining their sides. Otherwise, they should have been dark blue to black in colour.

Other features which were difficult to delineate on the ERTS imagery were identified on the field, e.g., pond, reservoir, agricultural patterns (small and large-scale farms).

This confirmed the importance of always visiting the features delineated on the ERTS imagery to obtain the ground truth.

The preliminary mapping of the area correlated to a large extent to the ERTS data when the ground truth was verified.

This proves that the ERTS imagery is a useful tool in developing the resources of an area with regard to the specific disciplines: agriculture, range, hydrology, soils, land use, etc.

Remote Sensing of Earth Resources and the Environment

By Raymond Razafindrakoto, Malagasy

Critique of field trip

A) The objectives of the field trip are:

1) Comparison of different types of images (black and white ERTS images, colour infrared composite ERTS images) concerning a part of Kenya.

2) Making a preliminary mapping (land use patterns, thematic maps, etc.).

3) Eventual revision of maps about hydrology, geology and agricultural areas.

B) The method which is used consits in going round Mount Kenya and detecting, identifying, and determining on the ground features of resources and environment in view to extrapolate them to ERTS imagery.

C) Critiques of field trip

Critiques of the field trip can be summarized in the next points:

1) Scales of maps are not sufficiently large for exact identification on the map of what is observed on the ground. Therefore, although it was possible to distinguish forests, cropland, and basalt easily, on the other hand it was very difficult to know accurately what types of vegetation (acacias, grassland, meadows, etc.) or what types of crops (coffee, bananas, maize, potatoes, etc.) are precisely concerned.

It was difficult to evaluate different associations or successions of green grassland, dry grassland, acacias, cultivated soils, etc. It was also difficult to evaluate whether or not vegation exists above basalt. All of them involve the necessity of availability of previous documents concerning Mount Kenya and this region. We did not have these documents.

2) This method is objectionalbe because it is not possible to extrapolate the results of ground observations on the overall area. The appropriate method is to make a sample survey. Then it is possible to make a detailed survey on judiciously selected samples as a function of different parameters. The results of this detailed survey can be extrapolated easily by statistical methods on the overall ERTS imagery concerned.

A REPORT ON AN EXCURSION AROUND MT. KENYA WITH ERTS DATA

By Simon Taiti, Kenya

INTRODUCTION: The conceptual basis of Remote Sensing is in the understanding of the electromagnetic energy and the processes that can be used to record and locate objects which emit, absorb or reflect this energy in one or more forms. The important characteristics are color, texture, shape, size, and resolution.

Following a week-long seminar and workshop on remote sensing techniques at Nairobi there were concurrent field trips to various places in Kenya. Equipped with black and white and coloured ERTS data, participants with interests in range, wildlife, agriculture, soil, forestry, hydrology, and land-use in general made an excursion around Mt. Kenya via Karatina, Kiganjo, Nanyuki, Isiolo, Samburu Game Reserve, Meru, Embu, Mwea and back to Nairobi on March 29th and 30th, 1974.

The objectives of the field trip were (a) to make an on-the-spot diagnosis of ground truth and the satellite imagery, and thus compare the extents to which various ground features were signified on black and white images in bands 5 and 7 of the electromagnetic spectrum and on coloured Infra-Red Composite ERTS imagery. (b) feature identification, i.e., to provide field verification of interpretor-types resultant on indoor image-analysis, inerpretation, and identification characteristics. It was in the objective that in the exercise participants would appreciate the difficulties of detecting and identifying features and the necessity of ground work before the final discrimination of features on images. (c) to attempt the production of thematic maps of land-use in the areas shown in the ERTS imagery which were to be traversed on the field trip. (d) to examine the possibility of map-revision for existing resource maps and data with the help of ERTS data. (e) to survey the potential application of ERTS data on management of water, vegetation, tourist facilities, agriculture, wildlife, soils, rangelands, and in monitoring such resources in an operational programme of repetitive coverage.

This report presents and discusses the findings of the work which are deemed applicable and significant particularly relative to range, whildlife and tourism in the Mt. Kenya, Laikipia, Samburu and Shaba Game Reserves, with due regard to pre-existing reports.

MATERIALS AND EQUIPMENT

ERTS data of January 30, 1973 was used including an ERTS Coloured infra-red composite - a frame showing Mt. Kenya and Archer's Post area, ERTS black and white prints in bands 5 and 7, a transparent overlay showing the route of the trip, roads and towns, a hand lens, a soil map of the area and an overlay scale.

FIELD IMAGE AND GROUND TRUTH ANALYSES AND RESULTS

At various spots on the route the ERTS images were examined in relation to the ground features. Thus the following results were obtained at the various stations.

Karatina

Soils: The red soils in the neighboring agricultural country were signified in white-grey in band 5. The agreement with the pre-existing soil map was good.

Agriculture: The ground features were coffee, bananas, Kikuyu grass, tea, marketing centres and village shops. The coloured infra-red composite showed these features very well as magenta with white specks signifying the villages and shopping centres devoid of green vegetation. The pattern of such human settlements made it possible to discriminate between intensive agricultural and rangeland country on the ERTS imagery.

Settlements (Town): The position of Karatina township was shown by a white signature on the coloured composite. Smaller settlements could be discerned on the image.

Land Use: The lower agricultural country was very clearly distinctive from the upper forest zone in colour and texture of the red image signatures. Forest showed as dark red; agriculture as magenta. The agricultural zones were distinct from the bamboo zone in texture, colour and pattern.

Kiganjo

Kiganjo Police College: Identified as a white spot on the coloured infra-red composite.

Nyeri Forest: Indicated by a red signature in the composite; white patches indicative of grass-glades to the north were shown.

Nyeri Town: Indicated by a white sopt with blue signatures probably indicating the Chania river.

Nyeri Hill: Indicated by a red signature in the ERTS coloured infra-red composite.

The Grasslands: White-red signatures on the coloured composites were found to indicate the grasslands between Kiganjo and Narumoru. Riverine forests on the Naru Moru and other rivers appeared as magenta on the coloured composite.

Black/Red Soil Boundary: Black soils in the valleys tributary to the Ewaso Ngiro were indicated as blue. The boundaries between the red and black soils were definite on the ERTS coloured composite to the extent that soil scientists felt it would be possible to delineate small pockets of soil types in a detailed map; this is a rare capability for ERTS coloured infra-red composites.

Nanyuki

Dry Forest: The abrupt roadside boundary of the dry Euclea - Juniperus - Rhus forest between Naru Moru and Nanyuki was clearly descernible.

Agricultural Crop Fields: Between Nanyuki and Isiolo arable agricultural fields and paddocks in mixed farms were very clearly shown on the ERTS infra-red colour composites. It appeared possible to estimate the size of each plot without visiting the spot. It appeared one could estimate the crop in growth, with prior information of crops grown and their growing seasons. Plots in which stubble was burnt stood out as black. Cultivated (soil) plots appeared white. Plots with crops appeared red, with varying intensity according to the crop. Four colour types could be identified.

Ngare-Ndare Forest: To the north west of Timau, the Ngare-Ndare Forest appeared as a dark red in the ERTS color infra-red composite. This area is of interest to the Ministry of Tourism and Wildlife in the problems of poaching, game movement and game control, and it appeared that ERTS data could be used to plan a management strategy including location of antipoaching posts, location of game barriers, and in studying features related to movement of wild animals.

SAMBURU GAME RESERVE

The group arrived at the lodge late in the day and most participants were interested in water. It turned out that the water in the rooms was dirty and not drinkable; thus there arose a critical review of the available surface and ground water resources of the Samburu-Buffalo Springs Game Reserves in relation to the tourist facilities.

The ERTS coloured infra-red composites showed that there were basalt outcrops in the reserve the pediments of which could be ideal ground water sources.

The Ewaso Ngiro river bed was shown as a red line indicative green vegetation. Considering that normally January is a dry month, the presence of green vegetation may indicate the presence of ground water. This ground water seems to be available all year round as contrasted to the seasonal river. Considering that various parts of the Ewaso Ngiro catchment are undergoing intensive agricultural management and that the seasonal flow of the river may carry a concentration of pollutants in the dry season, it was hypothesized that upon the geohydrological interpretation of the ERTS Imagery the possibility of a ground-water supply for the lodge should be high and that such a source should be sought for the lodge which now utilizes the river water. Of what quality is the ground water in the Samburu-Buffalo Springs Game Reserve?

The hypothesis was soon proved with a visit to the Buffalo Springs. It was agreed in principle among the participants that there was a high potential of ground water supply in the area; that the Buffalo Springs signified this possibility of artesian water in pure and drinkable condition.

The conductivity meter failed to work; the rocks around the Springs were identified as rhyolite lava; it was postulated that the Springs emanated from a breach (crevice) in the junction between rhyolite and basalts; it was not possible to detect any water-level gauges on the Ewaso Ngiro.

It is concluded hence that:

(a) The ground-water potential of the Samburu-Buffalo Springs area should be explored further and characterised for development.

(b) That a special effort of supplying the Samburu Lodge with clean water - possibly from ground rather than the river- be made because the present water service in the magnificent lodge is disappointing.

(c) That the geological features detected on the ERTS imagery, particularly the oval structure detected by Dr. George Rabchevsky, should be investigated.

(d) That the water supply for the proposed lodge in the Shaba Game Reserve be considered in the light of this discussion and the situation be averted at the outset.

(e) That a project be set up to use experimental/operational remote sensing to plan the wildlife management of Samburu-Isiolo-Marsabit area.

Meru

Land-use: The agricultural areas could be discerned in the colour composite. The transition between the arable and grazing land use was detected on both the ERTS colour composite and the ground truth agreeably. The transitions from grazing to arable (crops) and forestry were easily detected, and agreed with the known facts.

Overgrazing: In the grazing areas of Tharaka areas of excessive grazing showed up as white on the ERTS colour composite.

Mwea

Dark Soils: The dark-blue signatures on the ERTS colour infra-red composite were found to be dark (black) soils in the Wanguru-Mutithi area.

Rice Crop: The major paddy area was not included in the Mt. Kenya ERTS frame.

CONCLUSION

There was in general great satisfaction among the participants on the applicability of ERTS data to planning, management, and surveys of resources.

The field work proved that use of ERTS data, to produce the best results, should be broad-base on interdisciplinary efforts and an individual user should transcend the confines of a single discipline and acquire the flair of extrapolation and tracing of remote relationships between goals and resource knowledge.

There were specific outputs in with regard to the Samburu Game Reserve and soil mapping. The recommendation that ground-water supply be explored for the Samburu Lodge and future tourist facilities was a tangible outcome which should be followed up. It was felt that a detailed soil map of the Nanyuki area could now be made.

In conclusion, this report endorses on the fact that the ERTS data shall be essential in any prelimary survey of resources, base map preparations, thematic mapping, management planning for wildlife (and indeed of other dynamic resources). The limitation that ERTS is not an operational programme is regretted. Any operational programme with the potential and capabilities of ERTS would be supported strongly.

FIELD TRIP REPORT:

By E. E. Zamierowski, Kenya

Donft think we spent enough time preparing for it--I had to make an overlay of the road around Mt. Kenya in the bus on Fri. (this may have been due to a breakdown of the diazochrome machine, however).

The field trip itself was an excellent experience and should be included in any future workshops as an aid in interpretation of ERTS data and in demonstrating the multi-disciplinary data which ERTS imagery provides.

I think we could have made more stops on Friday, especially after Nanyuki, with more on-site explanations of specific ground truth requirements needed for specific disciplines.

Main value to me was in seeing how the same signature can be produced by several features on the ground, e.g., burnt forest, freshly cultivated soil, dark soil with sparse vegetaive cover, or even exposed rock surfaces all give a blue-black signature and many vegetation types give a similar pink one. The necessity for checking original interpretation on the ground was thus graphically demonstrated as well as how the areas for detailed or reconnaissance checking can be pin-pointed and hence field work reduced.

A suggestion would be to use a morning early in the course to fly over the field trip area with the group--if the KAF could provide a Caribou--and further demonstrate ground-truthing at various levels and the use of hard-held IR and color photography to record details and discriminate details not evident from ERTS directly. I think most participants would have access to aircraft in their home countries and should have been able to see how this can supplement ERTS interpretation and specify areas for detailed ground checks.

As I'm mainly interested in vegetation analysis, I think this would have helped immensely, especially in the presence of experienced instructo The value of color I-R photography was a new insight for most of us and it should have been used in conjuction with the course more directly--possibly, as suggested above. The importance of phenological changes in vegetative cover was well demonstrated and it emphasized the necessity of ground truth at the time of ERTS overflights.

APPENDIX D. Participants' Reports on

Geology Field Trip to the Eldoret-Kerio Valley, Kenya*

By Kwasi Barning, Ghana

March 29 - 30, 1974

Introduction

This is a report on a geology field trip which was taken in the Nairobi-Eldoret area. The trip lasted from 29th to 30th March and formed part of an East African Workshop on Remote Sensing which was held in Narobi from 18th March to 3rd April. The purpose of the trip was to reconcile features seen in the field with those seen on ERTS 1:1,000,000 mosaic black and white imagery in channels 5 and 7.

Accessibility

The trip started in Nairobi on the eastern end of the Rift Valley, through Kedong, Ilkek and then to Nakum. It continued NW from Nakuru on the western wall of the rift through Timboroa and finally to Eldoret. From Eldoret it continued SE for 25 miles to Nyeru and then to Flourspar Mine in the Kerio valley. From the mine it retracked its route to Nairobi. It crossed the equator at Timboro 9025 feet.

Physiography

The trip was concentrated in the Rift Valley. Two most outstanding features observed are the Lusina caldera, Longonot crater and the Menengai crater at Nakuru. The Menengai, at an altitude of 7466 feet, surface area of 35 square miles and maximum depth of 1425 feet is the highest point in the rift. The road from Nakuru to Eldoret passes through an undulating dissected plateau. The area around Nyeri and Kerio mines show a rugged topography.

Geology

Most of the area covered by the trip is covered by Teriatry and Quaternary volcanics. These are mostly ash flows, bachytes, phenolites and basalts. Around Ilkek, Pleistocene lake beds were examined. In the Kerio valley, granite gneisses forming the basement are overlain by Elgeyo basalts. The basalts are overlain by Vasin Gishy phonolites which in turn are succeeded by Tinderet nephelinitic phonolites. Within the Menengai crater three disticnt lava flows were distinguished. Each flow had different vegetation on it. The contral cone was covered with what appeared to be recent ash flows.

*Informal report drafts. Not reviewed or edited by the authors nor by the U.S. Geological Survey for technical and editorial accuracy.

Economic Geology

The flourspar mine in the Kerio valley is currently being worked by the Kenya Flourspar Limited by open cast. The ore is worked, upgraded by gigging and the concentrates shipped to Japan and Russia.

Structural Geology

Few faults around Nyeri were observed on the 1:1,000,000 imagery. The contact between the volcanics and the basement in Kerio valley is clearly seen in the field.

Conclusions

1. The imagery was useful in delineating faults, lineaments, and geomorphological features in the field.

2. Water bodies, lakes were clearly shown on the imagery. Around Nyeru, the rugged forested topography was vividly brought out on the imagery.

3. It was easy to delineate farmlands, rangelands and scrubs in the valley using the imagery.

4. Different types of vegetation in the Menengai crater were distinct on the imagery.

References

1. Eldama-Ravine Kabarnet area - Report 83

2. Nolo area - Report 86

3. Naivasha area - Report 55

4. Nakuru - Thompson Falls - L.
Hannington area - Report 78

Geology Field Excursion Report*

By J. D. Bennett, Malawi

Introduction

The field excursion was designed to provide an insight to the geology of the Rift Valley and to provide field information to assist the assessment and interpretation of the ERTS imagery.

The route covered some 800 km, and an overnight stop was made at Eldoret. The excursion commenced and finished at Nairobi. Various stops and diversions were made en route.

Geological maps (1:125,000) and reports of the Geological Survey of Kenya were used to check field observations and in conjunction with the imagery. The imagery available comprised black and white prints of MSS bands 5 and 7, mosaiced at 1:1,000,000 scale. Individual enlargements at 1:250,000 of parts of the route were also carried. (Imagery dated Jan.-Fe. 1973) An overlay of the image mosaic accompanies the report.

Geological Elements

a) Eastern Shoulder of the Rift Valley

From Nairobi (c 5,000 ft) the route climbed to c 7,000 ft at the crest of the eastern escarpment. The volcanic land surface is discriminated on the imagery as a relatively homogeneous tonal feature.

b) Eastern Escarpment

The escarpment is prominent both in the field and on the imagery. Extensive views across the Rift Valley, and of volcanic features of the Rift floor were obrained in the Kedong area, notably Suswa and Longonot Calderas, both readily discriminated on the imagery.

c) Rift Valley Floor

Only the major features will be noted for the purposes of this report.

(i) Volcanic phenomena. Numerous volcanic craters and cones were observed both in the field and on examination of the imagery, elg., south of Lake Neivasha and south of Lake Elmenteita.

*ERTS image overlay not reproduced

(ii) Faulting. Fault scarp features were observed in the area east of Lake Naivasha and in the vicinity of Lake Elmenteita. These are distinguishable on the imagery as linears. Linears interpreted as faults form closely spaced, anastomozing N-S features at many other localities in the Rift Valley and are readily identifiable on the imagery, in addition to the main boundary faults of the valley.

(iii) Lacustrine deposits. The former greater extent of the Rift Valley floor lakes (Naivasha, Elmenteita, Nakuru) is indicated by the widespread lacustrine deposits of the area; these deposits generally give rise to flat or gently undulating terrain, against which faulted volcanics form distinctive scarps and resistant fault-controlled blocks, and good views of step-faulting are obtained in the Naivasha-Elmenteita area. The lacustrine deposits give rise to relatively flat-toned on the imagery and some delineation of them is possible.

The sediments were examined at Ilkek. The sandstones (semi-consolidated, soft) are of Late Pleistocene age and are notable in that they contain obsidian artifacts (the artifacts are of exotic origin, derived from obsidian outcrops west of Lake Naivasha).

Diatomite deposits were passed near Lake Elmenteita.

(iv) Surface Water. The major lakes of the Rift Valley floor are distincitive on the imagery especially MSS 7. Hell's Gate, an old overflow channel of Lake Naivasha is also distinctive to the south of the lake. On band 5 Lake Nakuru is partly coludy, and beach deposits (dry lakeshore and surrounding grassland) stand out as light reflectance zones on the imagery.

(v) Menengai Caldera. The caldera is imposing in the field, and forms a readily discriminated feature on the imagery. Tonal variations on the latter may reflect either vegetation differences of lava flows.

(vi) Land use. Intensive cultivation in the Nakuru area in particular is readily distinguished on the imagery.

d) Western Wall of the Rift Valley.

The section of the western wall traversed by the Nakuru-Eldoret road is unspectacular, due to the masking effects of post-rift faulting ash deposits. The road skirts Londiani and Kilumbe volcanic centeres, the former is believed to be responsible for the ash deposits mentioned. These centeres are disitinguishable on the imagery (more rugged, dissected features) but their significance would not be clear without field observation ("ground truth").

e) Western Shoulder of the Rift Valley.

The crest of the 'escarpment' stands at an altitude of some 9000 ft. and to the west gives way to rolling upland plateau country underlain by phonolites. This terrain is relatively homogeneous on the imagery, the main features on the imagery (MSS 5) being forested areas. The rectilinear limits of some of these are indicative of man-made plantations and cutting areas, firebreakes can be discriminated.

The plonolites weather to give residual soils and may be examined in a number of roadcuts (e.g., near Lake Narasha).

This section of the route crosses the Equator. Elevation drops to ca. 9000 ft. at the west to ca. 4000 ft. in the floor of the Rift Valley, and the western escarpment of this section of the Valley is truly spectacular.

The major features can be discriminated on the imagery, i.e., to Elgeyo Escarpment, Kerio Valley superficial (alluvial) deposits, the Tukin Hills, and the eastern well and shoulder of the Rift. The more detailed geology and the topographic expression of the various lithologies (Basement of Precambrian), Elgeyo Basalts (14 m.y.) and overlying alkaline volcanics (ca. 11-9 m.y.) was best observed from the top of the escarpment but more differentiation of these more detailed features and associated faults was possible on the 1:250,000 imagery.

The flourspar occurs in faulted basement gneisses, replacing limestones, and spreads out beneath the overlying basalt contact. Local veining within the basalt indicate a post-basalt age for the mineralization; the lack of mineralization in the clhouline volcanics suggests that it predates those rocks.

Results and Conclusions

The excursion provided the writer with a useful oversight of the Kenya Rift Valley, particularly helpful in view of his knowledge of the Malawi Rift Valley, and all part of the East African Rift System.

It was unfortunate that time was not available to visit the Hell's Gate overflow channel or Menengai Caldera.

The broad geological features, however, were readily observalbe from the vehicle, when viewed in conjunction with the available maps and imagery.

The excursion indicated the value of ERTS imagery in providing a readily assimilated synoptic view. The major structural features of the Rift Valley and the adjacent uplands of the Rift Valley shoulders are readily discriminated. The need for field observation to check and clarify some of the image features was, however, apparent. However, the imagery demonstrated the usefulness as a geologic mapping tool, particularly on the small scale, whilst applications to forestry and land use resource clearly also have potential on the basis of features observed during the excursion.

FIELD TRIP REPORT*

By A. S. Dlamini,

Department of Geological Surveys and Mines

Mbabane, Swaziland

Introduction

This is a skeletal report on the geological field trip to the famous Rift Valley northwest of Nairobi. During this trip some of the geological features seen on ERTS-1 images in the Workshop were confirmed on the ground.

Route and Stops

The trip started in Nairobi, Friday, March 29, 1974 to Eldoret via Nakuru. On Saturday March 30, 1974 the trip started at Eldoret to Neferi and Lerco Valley Muie and from there back to Nairobi. The total distance covered was 808 KM (505 miles) with 8 stops - six on Friday and two on Saturday.

Information Available

Published geological reports and map including a road map were used. ERTS-1 B & W composites at scale of 1:1,000,000 and 1:250,000 were used. The ERTS imagery had been worked on the workshop. Thus certain geological features had been mapped on overlays. Channels of the ERTS imagery MSS 4, 5, 7.

Observations, Ground Truth, Interpretation and Results

Stop 1 Kedong

Kedong is twenty-five miles northwest of Nairobi on the eastern wall of the Rift Valley. This wall is also called the Hikuyu Escarpment and it provides a majestic view of the rift valley escarpment and view to the west. From Kedong, these following features which had been mapped on ERTS-1 imagery were observed on the ground:

(a) Calderas: Suswa and Longonet calderas were seen from Stop 1. These appear as circular depressions on ERTS imagery and they are in form of cones on the ground.

(b) Faulting: Some of the linear features paralleling the Rift Valley walls were seen on the ground to be faults. Faulting of the volcanic cones in the rift valley could be seen on ERTS-1 imagery as sharp lines cutting across mounds of rock.

*ERTS image overlay not reproduced

Stop 2 Ilkek

Ilkek is 70 miles northwest of Nairobi and is underlain by lake beds of Late Pleistocene. There are obsidian artifacts in the lake beds.

Lake Naivasha was seen between Ilkek and Nakuru and could be best seen in MSS 7 imagery in which it appears as a blue-black roughly circular mass.

Stop 3 Lake Nakuru

My group went to Lake Nakuru while the other group went to Meueugai Caldera. Lake Nakuru and Meueugai caldera were identifiable on the ERTS-1 imagery on both scales (1:1,000,000 and 1:250,000). Meueugai caldera appears as a circular depression while Lake Nakuru appears as a white rimmed blue-black roughly circular mass. The white rim around Lake is due to reflectance of salt deposited on the lake-shores.

Stop 4 Lake Narasha

Lake Narasha is twenty miles northwest of Nakuru on the western wall the Rift Valley. The western wall of the Rift Valley is a gentle slope in contrast to the eastern wall which is a sharp escarpment. The area is underlain by phonolites which have considerable soil thickness downslope.

Stop 5 Equator

This stop is one mile from Lake Narasha and it is high on the plains of the western wall. The main highway could be picked up on ERTS-1 (scale 1:250,000) imagery.

Stop 6 Eldoret

This was an overnight stop. Eldoret is 200 miles from Nairobi and is underlain by volcanic rocks. The topography is gentle to rolling with medium grass cover and vegetation.

Stop 7 Nyeri

Nyeri is twenty-five miles southeast of Eldoret. This stop was on the eastern wall of the Rift Valley escarpment and provided not only a majestic view of the Nyeri Rift Valley escarprment but also an impressive correlation of ERTS-1 imagery with ground observations. The stratigraphy and structural geology of the escarpment could be discerned on ground as well as on ERTS-1 imagery. The stratigraphy consist of: Basement rocks which are unconformably overlain by Elgeno basalt (14×10^6 years) on which stand the Vasin Gishy phonolites ($11.5 \times 10^6 - 13.0 \times 10^6$ years) overlain by the Tinderet nepheline phonolites ($9+ \times 10^6$ years).

The Tinderet nepheline phonolite forms a hard resistant cap rock which form sharp cliffs and edges. The vertical drop from top to bottom of escarpment is nearly a rule. Contact of rock types could be seen on ERTS imagery as platforms and sharp lines. Linear features paralleling the escarpment and cutting across it mapped on ERTS-1 imagery were interpreted on the ground as faults. Some of these faults control the drainage pattern in the area.

Stop 8 Kerio Valley mine

This was the last stop of the excursion. This Flourspar Mine is in the bottom of the escarpment in the basement rocks of the Rift Valley. It is an open pit operation with flourspar being mined in pits which occur along tear faults. On ERTS-1 (1:250,000) some of the open pits could be seen.

From Kerio Valley mine the participants returned to Nairobi on the same route taken to Eldoret.

Conclusion

This excursion was of immense benefit in the exercise of interpretation of ERTS-1 imagery and also on how to confirm mapped ERTS data.

East African Seminar and Workshop on Remote Sensing, March - April 1974
Report on field trip from Nairobi to Eldoret, 29th-30th March 1974, with especial reference to geological observations.

By S. M. Hutton, Botswana

Section 1

Sketch map of route traversed showing stops and features of interest. Not to strict scale. (Not reproduced herein).
Cross-section of route from Nairobi to Eldoret.

Section 2 The following geological information was available:

Reports and maps at 1:125,000 published by the Geological Survey of Kenya
Naivasha area Report 55
Nakuru-Thomson's Falls-Lake Hannington area - Report 78
Moto area - Report 86 (?)
Eldama-Ravine-Kabarnet Area Report 83
Geological map of Kenya at 1:3 million published by the Geological Survey of Kenya.

Section 3 No aerial photography was available. Please note that this writer has had hardly any experience of airial photo interpretation.

ERTS-1 satellite data was available as balck and white prints at the following scales and in MSS bands 5 (red) and 7 (near IR)

1:1 million	1191-07115	30-1-'73
	1192-07174	31-1-'73
	1192-07180	31-1-'73
	1193-07232	1-2-'73
	1193-07235	1-2-'73

Image 1192-07174 was also available at scales 1:500,000 and 1:250,000 as black and white prints in bands MSS 5 and 7. Colour composite available afterwards but lack of time prevented close study.

The 1:1 million prints were put together in a very rough mosaic over which an acetate sheet was laid. Before going into the field, geological information was abstracted from the available maps and drawn on to the overlay while attempting to establish correlation with tonal differences on the prints.

The wirter worked with J. Beervelt from Malawi on this exercise on MSS 5 prints.

Reference was also make to the following 1:250,000 topographic maps of Kenya: Kisumu-Nakuru
Nyeri
Eldoret

<u>Section 4 Field observations of geological and geomorphological features and correlation to interpretation of ERTS-1 imagery.</u> MSS 5 imagery used unless specific reference is made to MSS 7.

Leaving Nairobi and travilling westwards there is a gradual rise to the eastern escaprment of the Rift Valley in Kenya.

The top of the escaprment is some 26 miles from Nairobi and the party stopped briefly at Kedong. The escarpment descends quite steeply to a fairly flat valley floor on which a number of craters stand, such as Suswa and Longonot. The western wall of the Rift Valley is visible in the distance, about 35 miles.

The eastern wall of the Rift had been traced on the ERTS overlay along a fairly marked linear feature which divided generally darker toned areas showing no north-south trending linears from lighter-toned areas to the west in which north-south linears were very prominent.

After reaching the valley floor, the party travelled fairly close to Longonot, a recent (Quaternary) crater. Lava flows form benches at the base of the crater while the summit has been dissected by erosion in the cinder mantle. Steam jets occur in this crater but were not visible on the field trip

Most of the craters seen on the field trip can be discerned on ERTS imagery as circular features of dark tones. The larger craters show radial drainage. However, I would not have been able to pinpoint Menengai Crater as such if I had not been informed of the fact and if I had not seen the landform in the field.

En echelon faulting is obvious in the volcanic rocks of the Rift Valley on a dominant north-south trend. The landfomes produced are 50-100 feet high.

This refers only to features seen in the eastern part of the valley. Similar features were not seen in the west of the valley where the road traversed a cinder mantled slope. The cinder was ejected mainly from Londiani.

On ERTS imagery, these fault-line scarps are clearly represented as north-south linears, often of darker tone.

Three fairly large lakes were seen en route to Eldoret, and a small swampish area, Lake Narasha, just north of the equator.

The first of the three lakes and the largest, Naivasha, is a fresh water lake. Lakes Nakuru and Elmenteita are alkaline lakes. All these lakes are very clearly outlined on MSS 7 imagery since they appear as black against a light background.

However, on MSS 5, there are certainly differences in tone. Naivasha appears a greyish-black, darker than Nakuru, which is in turn considerably darker than Elmenteita. These tonal differences may be attributed to salt content, sediment distribution, depth, or any combination of these factors.

The land surrounding the lakes is very flat; Elmenteita and Nakuru were once part of a much larger lake. Lacustrine deposits are widespread and can be differentiated on ERTS imagery as very light-toned areas.

A stop was made at Ilkek, a few miles before Gil Gil, at a cutting where the lake deposits were well exposed. They comprise beige to buff, contoured, *unconsolidated silts in horizontal strata. At this particular site, there were numerous chips of black obsidian which would indicate that prehistoric man used the locailty for fashioning implements. The chips occur in the lake sediments. Walsh (chief government geologist) maintains that the chips cannot have travelled very far if at all because they have not suffered pitting. This implies that the lake level must have varied in prehistoric times.

The obsidian from which the tools were made occurs in small outcrops to the west of the lakes.

*There were no indications of current direction. Sediment - quiet.

Recent cinder cones, south of Lake Nakuru, show very young faulting. It could not be seen from the bus whether the underlying beds had been affected by this faulting and the cones themselves should probably be more easily distinguished on the ERTS enlargements. Personally, I could not see them on the imagery.

Diatomite deposits are fairly widespread in the lake sediments and are mined at Kariandus. The workings could be seen from the road.

The diatomite occurs as a white deposit in which muddy strata can be seen. To be exploitable, it must contain at least 80% SiO_2 which was secreted by algae in the Pleistocene lake(s). It is used as an insulator and in paint manufacture. I could not distinguish the workings on the ERTS imagery.

Twenty-five miles west of Nakuru, the party began a gradual climb up the western wall of the Rift Valley. Early rift features which are probably present have been concealed by ash and cinder ejected from Londiani.

As might be expected, there is no major feature on ERTS imagery which defines the western wall of the Rift Valley in this area.

We crossed the equator at 9109 feet.

Lake Narasha (not discernible on ERTS imagery) a stop was made at a roadside cutting where there was a 50-foot section in Tinderet phonolites (10 m.y.).

Fresh, grey-green, fine-grained phonolite occurred at the base of the section. The rock bore occasional phenocrysts of rectangular, well-formed, milky-white crystals of nepheline.

Upwards, the phonolite became more weathered until, at the top of the section, there was a fairly deep profile (about six feet) in brownish-red soil.

Spheroidal weathering was seen in the weathered phonolites. Fresh rock could be found at the centre of the spheroids.

Volcanic rocks west of the Rift Valley presumably account for the darker tones on ERTS imagery.

Further north in the Rift Valley, the patchy toned nature of ERTS imagery probably relates to volcanics much dissected by faults as shown on the geological maps.

Dr. Rabchevsky commented that at Timboroa we crossed a watershed. Small rivulets at each side of the road had originated as runoff from storm waters and were extremely discoloured by the sediment they bore. I don't consider it worth commenting further on this phenomenon, since it would not appear on ERTS imagery and I have no idea whether it would show up on aerial photographs.

Besides, I would only be able to discern major drainage systems on ERTS imagery (wet channels on 7, dry channels on 4 or 5) and I would only study ERTS imagery for that purpose.

Overnight at Eldoret.

Saturday 30th. Travelled about 15 miles east from Eldoret to the western wall of the Rift Valley at Nyeri, 9320 feet. At this point, the escarpment descends almost vertically to the valley floor which is at 4042 feet. The western escarpment can be drawn on ERTS imagery along a roughly NNE-SSW linear which swings further south into a N-S direction. Somewhere between this point and the route to the south, there must be a feature which accounts for the abrupt differences in height and this is probably a fault of approximate E-W trend which has not been described on the ground. This feature may be visible on ERTS imagery as an E-W line separating a very dark toned area from a less dark-toned area between the two points of observation.

From the top of the western scarp, the Kanasian Hills, a N-S ridge lying west of centre in the Rift Valley, are clearly seen and beyond that, the eastern escarpment at 45 miles.

Diagrammatic cross-section of the western escarpment below Nyeru. (Not shown)

The erosion surface between the phonolites of the Tinderet and Vasin Gishy groups and the Elgeyo basalt forms a prominent bench whereas the basalt Basement Complex contact is less easily defined.

On ERTS imagery, it is not possible by swift visual scrutiny to divide the basalt from the Phonolites* but the Basement Complex is clearly defined as a strip of lighter-toned country.

The Kanasian Hills emerge clearly on ERTS imagery as a darker-toned area. Individual lava flows can be defined. Forgot to note from the geological maps whether this ridge is a horst or an outlier of volcanic rocks in the Rift Valley but marked linears define the ridge on ERTS imagery and so it is suggested that the Kanasian Hills are a horst structure.

Alluvium in the Kerio Valley appears as a lighter-toned area.

*probably because the one occurs directly underneath the other

The Kenya Fluorspar Company operates a mine at the base of the western escarpment. Fluorspar bearing fluids travelled along gash faults* into the Basement Complex rocks. CaF_2 preferentially replaces limestone in the Basement Complex.

The main fluorspar body has assumed a lopolithic form and is "trapped" on the underside of the Elgeyo basalt. It pre-dates the phonolites (Walsh - comment at workshop).

The Basement Complex in which it is found is a series of whitish metamorphosed limestones and biotite gneisses (presumably former mudstones). The beds dip at any angle between 65° and vertical and the direction of younging has not been established. Bondins were seen in one of the darker beds but only from the bus.

Fluorspar has preferentially replaced the limestone in association with low temperature colloidal silica. The biotite gneisses are strongly kaolinitized and the whole sequence has been strongly brecciated.

The mining cut-off grade is 50 percent and the shipping grade about 89 percent. The processing plant was seen in operation.

The only signs of the mine on ERTS imagery are small white patches at the foot of the escarpment which are probably the quarry areas and dumps.

There are no sediments of Phanerozoic age prior to the Tertiary in this part of Kenya. From Archaean times to Tertiary, this part of Africa was a stable continental block.

<u>Section 5</u> Conclusions about applications of ERTS to geological analysis in the light of this field trip.

ERTS imagery is useful principally as a small-scale reconnaissance tool. It was possible to distinguish broad lithologies at all scales provided, and certainly the major structures and landforms.

In places, structures assisted interpretation of volcanic outcrops particularly where one group of rocks appeared much darker in tone than the adjacent rocks, and this part of the imagery could be interpreted in detail, e.g., east of the Kanasian Hills. Corresponding rocks on the western wall of the Rift Valley could not, however, be thus distinguished, probably because of the physiographic nature of the country.

MSS 5 imagery gave the best tonal contrasts and was therefore more useful for geological interpretation. In Botswana, I normally use MSS 7 which seems to give the greater amount of detail.

* the earliest Rift features.

Smaller landforms such as the cinder cones south of Nakuru could not be distinguished possibly because their reflectance characteristics are much the same as the surrounding sediments. Enlargements, enhancement techniques, colour imagery and digital processing of CCT's may help to bring out these features.

Synoptic view - enlightening!

Good quality controlled mosaics (e.g., D.O.S. editions at 1:50,000 of Orapa area, Botswana) show more detail.

Best use of A.P.I. and satellite data is complementary.

Section 6 Other observations

Around Nairobi - small fields, roadside cultivation. Bananas, subsistence.

Eastern wall of Rift to Naivasha - grassland, some shrub, very dry, cattle.

Nakuru - larger fields, cereals, cattle, pyrethrum, pyrethrin, co-op farming, automation, ploughing-field patterns visible on ERTS imagery.

Field Trip Observation By D.M. Kirori, Kenya

To complement the ERTS Seminar/Workshop, the geological group made a two-day field observation and ground truth trip to NW Kenya. The trip covered Nairobi-Naivasha-Nakuru-Eldoret=Kerio Valley-Sinabkoe and back to Nairobi. Six stops were made en route, and we separately discussed here below. Materials used include: five geological reports (see below) and space imagery (black-and-white) channel 5 and 7 of scale 1:1,000,000 on which the route map and stops are plotted.

Kedong

Kedong is about 40 km from Nairobi and marks the beginning of the escarpment (eastern limit of the R. Valley) at an altitude of about 7732 feet. It is here that the span of the rift floor with the Suswa and Mt. Longonot craters are observed. The eastern flank of the rift has dense forest while the rift floor on volcanics is mainly rangeland (light grey on band 5) with scattered shrubs. These two phenomena are clearly recognizeable on imagery. The rocks in the rift floor are mostly phonolites. Lake Naivasha was passed at km 88.

Ilkek

This station is about 112 km from Nairobi. We checked ground truth on Pleistocene lake beds which were not differentiable from other rocks on imagery. Two fossils (teeth) were found. These lake beds are believed to be an extension of the existing L. Kariandusi a few miles to the north.

The topographical feature here is the same as that of the whole rift that appears as light grey on channel 5. Further northwestwards, we noted L. Elmenteita and the diatomite deposits and the elevated rangeland to the west -- all in the rift.

Nakuru

This town is also in the rift valley about 155 km from Nairobi and stands at 6600 feet. Three land marks namely, L. Nakuru, the town itself, black spot on band 5, and the Menengai caldera (crater). The crater at 7460 feet is easily seen on black-and-white band 5, the vegetation on its southern part appears as black on band 5 while the lavas composed of volcanic ash and pumice are distinguished as white from the plantations to the east and north east, and the thick forest to the north. The millions of flamingos around L. Naivasha are not distinguishable from lake water.

NNE of Nakuru are the Aberdare mountains characterized by dark colour (forest - bamboo) and L. Olbolosat - dark spot west of Aberdare mountains.

North of Nakuru are two land marks: Lake Hannington and Lake Baringo (very dark spots on band 5).

At about 32 km NW of Nakuru the road ascends the western flank of the rift. The land along this stretch is mainly agricultural. The edge of the rift is hardly distinguishable from the dark shades of the forests.

The land rises from 6200 feet at Nakuru to 9797 feet at the Equator. At this altitude the area is characterized by vegetation, thick forest (dark belt on black-and-white) channel 5.

Timboroa

This station is situated immediately north of the equator. We checked ground truth and observed a volcanic outcrop on the western side of the road and opposite a small water pond. The rocks here are phonolites with felspathic phenocrystal incrusions of about 96 mm in length and showed a lithological sequence of red soils overlying a thin weathering layer which in turn overlie solid phonolites. The weathering is mainly of a circular pattern.

The rest of the stretch to Eldoret is represented by a belt of light forest to the east and agriculture land to the west. The landscape slopes northwards with Eldoret standing at an altitude of about 7050 feet.

The 40 km stretch along the Eldoret-Nyeru Road is mainly agricultural land with scattered bushes which is not easily recognized from the farm-lands on the black-and-white photos.

Below Nyeru at the entrance to Kerio Valley overlooking the mine below are phonolites and basalts. On the road, cuttings of phonolites, basalts, and metamorphic rocks are observed. Metamorphic rocks are composed of marbles, schists and amphibolites. Yellow sediments were seen to the far north (see diagram). At the mine, two types of fluorspar are distinguished, namely: those with low and high fluorspar content, with 45% and 65% respectively. One of the methods of extracting fluospar at Kerio is by crushing and gravity separation.

Several faults, N-S and two E-W oriented were clearly observed in band 5 of black-and-white ERTS imagery.

The return journey took the same route.

Geologic Field Trip to the North West of Nairobi (Nairobi-Eldoret) Kenya

By Akin Oduolowu and Babatunde O. Okuwa, Nigeria

Objectives: The basic objective was to crosscheck the interpretations made on the ERTS imagery of the East African Rift Valley. Different spectral band imageries were used.

It was also hoped that from this field trip participants will appreciate and get a feeling for the significance of the different ERTS spectral band images in mapping geologic features.

Field Trip

Office Preparation

1. Three mosaics of different spectral bands* (4, 5 and 7) were made by participants and as much interpretation were made on these mosaics.

2. To facilitate identification of structures, references were made to maps and existing geological bulletins on the area. These include:

a. Lake Naivasha area - K.G.S.R.** No. 55
b. Lake Nakuru-Thompson-Hannington area - K.G.S.R. No. 78
c. Mozo area - K.G.S.R. No. 86
c. Eldama Ravine - Kabarnet area - K.G.S.R. No. 83

*Band 4 (.4-.5 μm); Band 5 (.6-.7 μm); Band 7 (.8-1.1 μm)

**Here K.G.S.R. refers to Kenya Geological Survey Report.

3. There were no aerial photographs available and the ERTS imageries used were on scale 1:1,000,000. All mosaics used were in black-and-white print. Enlarged photoprints in scales 1:250,000 and 1:500,000 were also available.

Field "Ground Truth"

Stops were made at convenient points along the route where the ERTS office interpertations were checked, compared and confirmed with the actual field "ground truth." The stops include:

a. The Kedong area, about 25 miles NW of Nairobi, where the descent into the Rift Valley from the eastern walls commences through series of cascade normal (or escarpment) faulting.

b. At Ilkek, 70 miles from Nairobi, the outcropped bed lake deposits of an old large lake now constricted to form two lakes--Elmenteita and Nakuru--were observed and studied. These lake beds do not show up very well on spectral band 7 imageries. They appear as small dark-grey streaks and not significant.

c. Lava flows and vegetation patterns in the Menegai Crater (700 ft) were observed. This crater was accurately mapped on most of the spectral band imageries, particularly on band 7. The different colour tones of the basaltic flows observed on the imageries were found to correspond to different vegetation cover.

d. From about 25 miles NW of Nakuru, one gradually ascends the western walls of the Rift Valley by series of escarpment faults arranged in a spectacular cascade fashion. The western walls are observed to be covered on most parts by highly porous volcanic ash and hence supports poor grassland vegetation only. Below these volcanic ash, are the basaltic flows, containing a lot of rectangularly shaped phonolite crystals.

e. On the following day, starting from Eldoret, some 350 km from Nairobi, the Kerio Valley Mine of CaF_2 was visited. The mine, which is situated about 400' from the top of the western rim of the Rift Valley, is about 25 miles SE of Eldoret. The CaF_2 deposits occur between cracks and joints of the granite schists and gneiss of the basement complex. The unconformity between the basement complex and the basaltic flows can be easily mapped as an irregular white streak on the ERTS band 7 imagery. Also some of the faults identified on the imagery were found to check with field observations.

Conclusions and Comments

From the trip it was obvious that besides providing a chance of monitoring changes in dynamic phenomena like river floods, vegetation, etc., ERTS imagery may sometimes be useful in mapping geomorphology and surficial geological linear features if not obscured by vegetation.

Field Trip Observation   By N. Richardson, Liberia

Introduction

A field trip was organized so that those participants interested in geology would have a chance of doing some geology and relating ERTS imagery to ground observations. To aid the geologist we carried geologic maps of the area, scale 1:120,000 and ERTS imagery to the scale of 1:1,000,000. For the ERTS imagery we carried bands 5 and 7 but no color composites.

We left Nairobi on Friday morning, the 29th of March and returned on Saturday evening of the 30th of March.

Trip from Nairobi to Eldoret

From Nairobi our first stop was along the eastern escarpment of the rift in the area called Kedong. From there we could see straight across the Rift Valley. On the floor of the valley, we saw two craters--Suswa and Longonot. Also on the floor was the Mt. Longonot satellite tracking station.

Our next stop on our trip was at a place called Ilkek. Here we saw Pleistocene lake bed sediments. They appeared to be mainly clays, although the weathering of the material made it hard to determine.

At Nakuru the party decided to split up. Some wanted to see the Menengai crater and others Lake Nakuru. I was in the group that chose the crater. The Menengai crater is about seven miles in diameter and is the highest point in the Rift Valley and stands at an elevation of 7460 ft. In the crater we could make out three distinct lava flows, and because of the light tone of some of the vegetation and the color of the flow, the youngest flow was easily the more apparent.

The beauty of the view of the crater was equally matched by Lake Nakuru although in a different sort of way. Here in a soda lake there were what appeared to be millions of flamingos. They were restricted along the edge of the lake which was probably because of the depth of the water and the availability of food.

From Nakuru we crossed the Equator and here we stopped to take pictures. There was nothing there of geologic significance so we went on. Our next stop was at Timboroa, where on a small escarpment, we saw phonolites with large crystals of feldspar.

At about 4:30 pm we came into Eldoret where it had previously been decided we would spend the night.

Trip from Eldoret to Fluorspar Mine

We left Eldoret at about 9 am for the fluorspar mine along the Eldoret-Nyeri road. Our first stop was at the top of the escarpment overlooking the rift and parts of the mine. Here the Chief Geologist of the mine gave us a brief description of what was going on.

As we went down the escarpment, which we were told was about a mile above the mine, we went from nepheline phonolites into sasingish phonolite, through Elgeyo basalts and down into basement. The volcanics here were Tertiary in age and the basement material ran from gneisses, schists, amphibolites to marbles. Above the basalts are the Kinwarer sediments and then the phonolites. Although the road cut did not show the above sequence, stratigraphically the sediments, which were seen in the distance, came after the basalts and before the phonolite.

The fluorspar, which is mined, is crushed, screened, washed and separated by density differences of the fluorspar and the silicates.

At the mess hall, we looked at the ERTS imagery of the escarpment and mine area and saw that certain features were easily delineated - although a knowledge of the geology was necessary to interpret the imagery. Vegetation was also nicely shown and had we checked out the different types of vegetation that appeared, we could easily have mapped the boundaries of the different types.

After a good lunch we left the fluorspar mine, which is in the Kerio Valley, and returned to Nairobi roughly by the same route we had taken the day before.

Trip from Eldoret to Fluorspar Mine

We left Eldoret at about 8 am for the fluorspar mine along the Eldoret-Tot road. The first stop was at the top of the escarpment overlooking the rift and part of the mine. Here the chief geologist of the mine gave us a brief description of what was going on.

As we went down the escarpment, which we were told was about a mile above the mine, we went from nepheline phonolites into Kapsigi phonolites, through Elgeyo basalts and down to the basement. The volcanics here were Tertiary in age and the basement was Precambrian ranging from gneisses, schists, amphibolites to marbles. Above the basalts are the Kimwarer sediments and then the phonolites. Although the road cuts did not show the above sequence, stratigraphically the sediments, which were seen in the distance, come after the basalts and before the phonolites.

The fluorspar, which is mined, is crushed, screened, washed and separated by density differences of the fluorspar and the silicates.

At the mess hall, we looked at the ERTS imagery of the escarpment and mine area and saw that certain features were easily delineated although a knowledge of the geology was necessary to interpret the imagery. Vegetation was also clearly shown and had we checked out the different types of vegetation that appeared, we could easily have mapped the boundaries of the different types.

After a good lunch we left the fluorspar mine, which is in the Kerio Valley, and returned to Eldoret roughly by the same route we had taken the day before.

APPENDIX E: Tana River/Coastal Zone Aerial Survey
April 5, 1974
(See trip report, pages 42-44)

Emitted Radiation from Hydrologically Related Surface Features
(Radiance calibrated in ° C)
By M. Deutsch and N. McClymonds

Hour

0740 Took off from Kenyan Air Force base at Eastleigh's, Nairobi. Flew northward toward southeast flank of Mount Kenya. Mostly cloudy; some sun. Had rained from 0530 to 0700 hours in Nairobi. Crossed Tana River--on southeast slope of Mt. Kenya near Embu turned eastward to north flowing Tana River, thence followed river valley down.

0820 Started radiometer readings near Tana River east of Mt. Kenya. Temperatures in °C.

Hour	Radiance (°C)	1,500 ft. altitude
	36	On general land surface, forest cover
	30	Bare red soil, sparse vegetation
0825	23	Forest on hills, 70% trees
	25	Turbid river water 60% of view
	-02	Sky with clouds
0830	25	Village with thatched huts of dark, wet, bare ground
	25	Wet red soil, little vegetation
	27	Drying river bed
	25	Farm clearning, slightly wet, some vegetation
	24	Tana River, muddy water, 70% of view (Rabchevsky took IR photo near here.)
	24	Rock islands in river
	23	Tana River, 85% of view

700 ft. altitude

0840	25-1/2	Vegetation cover about 60%, evenly spread
	21	Cloud, about 80% of view
	25	Very turbid, muddy, Tana River - in cloud shadow
	26	Very turbid, muddy, Tana River - in sunshine
	27	Light colored, dry rock, 30% of view
	27	Dry river bed - 50% of view
0850	28-1/2	Dry river bed - 70% of view
	30-1/2	Dry, white soil with 20% vegetation
	28	Medium gray soil with little vegetation
	25-1/2	Tana River - 85% of view
	29	Mud flats near river
0855	26-1/2	Tana River - 60% of view
	27	Forest (high brush) - 75% cover
	31	Sand bank in river
	31-1/2	Dry, white mud flat near river
	27	Tana River, in cloud shadow
0900	31	Dark and light mud flats, partly wet

Approaching Garissa

	28	Tana River, muddy and shallow
0905	28	Wet, dark soil, 50% vegetation cover
	28	Tana River
	30	Damp soil, light brown, 30% vegetation

0915 Passed Garissa - partly cloudy (50% ±), warm

0940 Near Galole - farming increased here

0945	29	Wet mud flats, partly with grass
	34	Fresh green vegetation on mud flats

0950	34	Moist soil with 30% vegetation, in cloud shadow
	41	Dry (or nearly dry) whitish soil, 30% vegetation
	36	Moist gray soil, little grass, no brush, in cloud shadow
	43	Dry brownish soil, some grass, in sunshine
1000	29	Tana River, about 70% of view
	35	Wet, darker soil in Oxbow, grass and green brush
	31	Lush green forest (brush) vegetation
	34	Slightly wet, plowed fields, dark gray brown soil
	29	Standing water on flood plain - muddy
	37	Village (Garsen) - 20% house roofs, many tin
	44	Dry soil, light grass cover
	44	Dry, dark soil, sparse vegetation
1015	32	Lush forest vegetation
1025	30	Tidal channel - 50% mangrove island
	30	Estuary water
	45	Dry, white sand flats
1030	30	Estuary water
	35	Coconut grove
	40	Town (Lamu), mostly tin roofs - 50% of view
	28	Ocean water, in cloud shadow

Flying NE upcoast from Lamu

1035	28	Open water, in cloud shadow
	28	Open water, in sunshine
	22	Cloud - 100%
	29	Turbid open water, shallow
1040	29	Wet mudflats
	34	White, moist mud flats

Turned around, flying SWw down coast toward Malindi

1045	28	Deep, green water in sun glint
	31	Coastal mud flats
	32	Coastal mud flats, farther inland
	39	Dry land, brush about 80% cover
	40	Dune sands and vegetation
	42	White sands and vegetation - about 20% cover
	47	Dry white beach sand
1050	29	Open ocean water
1130	Landed at Malindi for lunch stop	
1410	Took off for Mombasa	
1420	26	Open ocean water
	28	Coast (no sand beach here, sharp wave cut beach)
	33	Inland, dry soil, bush and fields
	26	Ocean
1425	29	Beach, white sand about 30% of view
	34	Shore line, 20% ocean
	35	Inland - brush and fields, dry soil
	26	Ocean
	29	Beach
	27	Inland (shot farther away) - very oblique

About 1,000 ft

1430	26	Ocean
	43	Inland, fields, mostly barren, dry
	34	Inland, more short bush and grass, dry
	32	Inland, passed over thin cloud
	25	Inland, passed over thick cloud
	18	Slightly cloudy sky

1440	22	Sky - mostly cloudy, through sunshine
	40	Hill and brushland, dry
	32	Slope and thick brush
	29	Palm tree grove
	32	Sand flats
	30	Thick green vegetation
	28	Bayon and water (estuary)

1445 Landed at Mombasa; refueled

1540 Took off from Mombasa

1725 Landed at Nairobi

End of trip.

APPENDIX F. PARTICIPANTS' CRITIQUES

East African Seminar/Workshop on Remote Sensing: A Brief Assessment

By Alula Abate, Ethiopia

The objectives of the East African Seminar/Workshop on Remote Sensing was, I believe, twofold. In the first place, an attempt was made to familiarize the participants with techniques used in gathering data with remote sensors and with different kinds of optical instruments that are available to record as well as to print spectral images. Together with this, various U.S. Government Agencies and other private organizations that are directly involved in remote sensing work were described and specific references were made as to the kinds of services they offered. It must be pointed out, however, that the technological aspect of remote sensing was only lightly touched upon. The time available to the seminar being so limited, one would not expect to get a deeper perception of the technology involved in remote sensing. The brief examination of some of the instruments and the attendant technical terms has been to introduce the subject to the participants of the seminar and at best to help them make educated guesses about some of the features from ERTS imagery.

The second and yet the most important objective of the seminar was to elaborate on the many faceted uses which ERTS data could be applied to. Hence much more emphasis was put on applications. The amount of data contained in ERTS imagery is so much that its uses and users could be just as many and varied. Since ERTS-1 program is still in the experimental stage, it is still too early to define with any degree of certainty the limits of remote sensing and the application there of derived data. Of immediate concern to the world at large and to individual states in particular is to determine the earth's natural resources and once that is accomplished, to make a more regional use of them than has hitherto been the case. This is crucial to developing areas because a true assessment of their natural resources would help them to chart the direction and the parameters of their future growth in a much more meaningful way.

Finally, I can envisage great benefits that could be derived from an operational system employing a U.S. Observation Satellite for resource problems in Ethiopia. Ethiopia is primarily an agricultural country where 90% of the population earns its living directly from agriculture. It is this sector more than anything else that holds the key to the country's future. As far as maps go, a good many parts of the country are still "terra incognita." ERTS images would help to prepare as a first priority useful large-scale maps. One of the major tasks in rural development requires rearrangement of the rural landscape. Field sizes and forms, crop patterns and the spatial distribution of crops will have to be rearranged and in this, I believe, remote sensing can be a powerful tool. To map accurately soil types, specially of areas that have not yet been used for agriculture and to assess water resources, with regard to irrigation, remote sensing can be an indispensable tool. No less is the benefit to be derived from remote sensing in the realm of range and grazing land management.

When all is said and done, in the final analysis, decision to use ERTS data remains the prerogative of policy makers in individual countries. In the initial stage the efforts of the participants should be directed to influence decision makers to opt to use this powerful tool for data gathering.

Critique of Seminar/Workshop

By Kwasi Barning, Ghana

1. I think the ground which was covered in the purely academic lecture was not sufficient enough for someone who has never been exposed to the concepts of remote sensing.

2. In the workshop, I think there was not enough practical work on individual basis.

3. It would have been more convenient if after the introductory academic lectures the group had been split up into various disciplines so that topics relevant to each group could have been dealt with in more detail.

On the positive side, I think that

1. Seminar/Workshop has introduced me to tool which could be used in geological mapping and water resources management in Ghana.

2. In spite of the shortcomings of the workshop, I think I have developed enough background to be able to apply it at home, especially in delineating lineaments, faults and rock or lithology boundaries.

Workshop Critique

By J. D. Bennett, Malawi

Having previously had the opportunity of examining ERTS imagery of Malawi in the form of black and white prints at 1:1,000,000 scale, I was in a position to appreciate some of the applications and limitations of space imagery, particularly for geological purposes. I also had the uneasy feeling that a lot of potential data was not being extracted from the imagery, both geological and multidisciplinary.

My main purpose for attending the workshop, therefore, was to ascertain what observational and interpretational techniques exist and, equally important, are readily applicable using the facilities available in developing countries. I also wished to further my own knowledge in the field of remote sensing. In achieving these major objectives, I would consider the workshop successful and beneficial - but with one qualification: one got out of it what one put into it. (A more disciplined approach would probably have been more satisfactory.) As a result of the workshop, it should now be possible to apply ERTS-type imagery and remote sensing technology to natural resource problems in Malawi at a higher level of sophistication than was possible previously.

A number of criticisms should, nevertheless, be made:

(i) Organization was generally poor, partly due to logistical problems, partly due to an apparent lack of forward planning; "somebody somewhere should have done their homework better."

(ii) Time could have been used to better effect; much was wasted or used aimlessly. (The only time one had to work was during the last day (Tuesday, 2 April) at the report writing stage.

(iii) The lectures, while generally beneficial, often proved to be "loose" in content, heavy in "padding," and drawn out too long.

(iv) My main criticism is that far too little time was spent by participants on practical exercises, tackling specific problems (e.g., preparation of colour composites, subsequent examination, interpretation, etc.) under supervision of the instructors. It was unfortunate that the only real opportunity to do such work clashed with the period of report preparation. It should be borne in mind also that for such "course work" to be effective would require ample materials and better working facilities than were available, linked with considerably better planning and organization.

(v) Finally, to ensure that workshops of this type (which are essentially training courses) are effective from the viewpoint of both the sponsoring agency and the recipient governments or other agencies, some system of reporting on and assessing the participant's attitudes and approach would be worthwhile. This report should be made available in confidence to the recipient government or agency.

Remote Sensing Workshop, March-April 1974

By. P. S. Bhogal, Kenya

This critique just refers to the geological aspects of the workshop. The workshop in this section was very ably conducted by the instructor, and the displays were of first order. The materials made available for individual work were adequate, and a high degree of instructor-student relationship was available.

The workshop has been a great success as far as I am concerned in that before joining this seminar I vaguely knew just what remote sensing meant. Having been through the workshop, I can say with confidence that I could use ERTS imagery for geological mapping with great advantage. In the short time available, it was rather difficult to digest every aspect of remote sensing which was discussed, and I would like to suggest that the seminar/workshop should at least run for three full weeks.

Critique of Remote Sensing Workshop

By Harvey Croze, Kenya

1. The initial lack of organization (about field trips, fees, participants, etc.) could have been avoided by more communication between instructors and Kenya planners, and perhaps by more effort on the part of the latter.

2. What is a "co-instructor" for? Either define or scrap.

3. As it turned out, the workshop was actually more lectures and less workshop. Lectures should be called lectures. They were generally informative, but could have been better coordinated between lectures to avoid overlap and omissions.

4. I would have liked more first-hand experience, e.g., in interpretation, thematic mapping, etc. The opportunities were presumably there (time tested) but one didn't know quite what could be done with the tools at hand. It would have been useful to have a couple of previously worked-out studies (if they exist), which the participants could have been taken through--stating problems, questions asked, use of ERTS imagery and digital data, results, limitations, contributions of ERTS to results.

5. As D.C.* outlined in an early session, "Decision Making Policy" was not to be covered. This is okay as long as "Information Applications" shows ways in which applications can be put in context of the needs of the participants' countries. It struck me that the "I.A." section lacked depth.

*Dave Carneggie

6. It became clear quite early in the workshop that the images themselves are useful indicators of phenomena but that the analytical data, the really useful stuff, are contained in the magic mag. tapes. At the end of the workshop, we know a lot more about these colorful images, but very little about how to get at or use the digital data. This is either the result of (a) a fiendish CIA plot to keep the computer output in safe bounds, or (b) the possibility that most of the instructors are more image-technique than computer-technique oriented within their own fields of research.

7. Because of (6), one is (I'm not, but one may be) left with an understatement of the temporal usefulness of ERTS data, an aspect which is at least as important as synoptic or colour-inhancement attributes. Once you've soil-, geology-, and veg-mapped the world, then what are you going to do if not monitor? We'd get the thematic maps eventually without ERTS, but not the fantastic repetition.

8. Combined with a frustration at not getting the whole tool during the workshop (6), is a bemusement at the eagerness to sell the product (and I'm not talking about commercialism). This uneasiness culminated my comments with the suggestion that, if this type of workshop is, as advertized, an exchange between scientists, then it could do with less of the P.R. hustle, less side-show glitter.

(I still got a lot out of it. Thanks. H.C.)

Critique of Seminar and Workshop on Remote Sensing of Natural Resources and Environment

By A. S. Dlamini, Swaziland

INTRODUCTION

In view of the fact that I arrived late and missed the first day and part of second day of the seminar, my critique will only deal with the Workshop.

Critique of the Workshop.

1. Fundamental objectives of technique and application

It is my feeling that the workshop should have devoted more time on fundamental techniques of remote sensing explaining in detail the concept of remote sensing and the various techniques used in obtaining remote sensing data. More time was spent on applications. A considerable period of time was spent on showing slides.

Secondly, most of the laboratory workshop periods should have been devoted to working with participants on their own respective countries' imagery. Minimum amount of time, i.e., one laboratory session, should have been used on fieldtrip imagery.

Thirdly, it would have been beneficial to separate and group the participants on the basis of their disciplines after the first three days of the workshop. This would have made possible more and detailed discussions, lectures on participants' professional occupation.

2. Possibility for development of an in-house capability for Remote Sensing Techniques to Resource Projects

The workshop did provide useful information and material that will be useful to the establishment of a remote sensing sector in Swaziland involving the departments concerned with natural resources and environment.

I certainly feel that a joint section by the departments concerned could acquire remote sensing data. It has been adequately explained in this seminar where and how to obtain remote sensing data and material.

Equipment for obtaining colour imagery and processing is rather expensive and requires highly trained competent personnel to operate and interpret data and this appears to be beyond the reach of small departments in developing countries.

3. Implementation.

Certainly, I feel that this workshop did provide me with useful basic information on remote sensing to proceed on my own to solving some of the resources problems and also updating information and resource maps using remote sensing data especially ERTS-1 images.

A Critique on ERTS-1 Seminar/Workshop

By S. Dodhia, Kenya

The seminar and workshop have been very useful in giving an understanding of the theory and the workings of ERTS-1 in the global imagery.

The explanation of the working of the sensors by able and experienced staff has shown the scope of the imagery in its utilization for earth resources. The numerous examples by the staff on the problems they worked on further illustrated the capabilities of the imagery.

However, it has been noticed from the above examples that ERTS is very useful for dynamic systems such as agriculture, range management, forestry, etc. For such dynamic systems it is necessary to have repetitive coverage throughout the year. Non-dynamic systems such as earth sciences imagery over barren or arid areas is useful. Such imagery enables one to interpret structure and deductions therefrom. Vegetation cover where it accentuates the structure or geology is also a useful guide for such interpretation. ERTS imagery, because it covers a wide area, enables analysis of structural trends and lineations much more readily than the usual aerial cover.

It has been emphasized several times during the seminar and workshop that ERTS is no substitute for fieldwork and other aids to various resources problems, but that it is an extra aid. The writer agrees with this observation.

It is hoped that other sensors can also be used in future programmes to enable further insight into methods of solving resources problems.

Critique

By Thomas Dundas, Liberia

Remote sensing as would apply to resources development in Africa would have to go a very long way in meeting the demands and various problems. During my participation in the present workshop, I have arrived at the following conclusions from observations made:

1. We were fortunate to participate in a similar training course in Sioux Falls, South Dakota, one year ago, and I have carefully attempted to compare what was picked up there and here. I would therefore use these two participations in presenting my critique.

(A) Lectures: The lectures during the workshop were just right for beginners as an introduction to the course. However, it would serve well if these lectures were not crowded with several disciplines, i.e., hydrology, range management, soil classification. It would serve well if separate lectures were held for the various disciplines. Further, for introductory courses, the lectures should have less theory, unlike my previous participation which confused me with the varied disciplinary lectures, some of which I had not been exposed to.

(B) Practical: The practical aspect of the workshop could have been much more advantageous had said workshop been held in an area where all of the simple equipment were available. Here, we were only told and permitted to look on because there were not many such equipment for participants to actually have the feel of its operation and devise certain personal observations on the uses. Furthermore, for an international workshop of such technical nature, participants should have been requested to bring along any relevant data of his/her particular area of interest whereby comparison could be made. Secondly, remote sensing imagery should be made available of all nations participating which would then give the participants a correct idea of its advantages and disadvantages.

(C) Field investigation: I must give credit to the staff of this workshop, especially those that accompanied participants on the agriculture and range management field trip. They were very esplesive (sic), and the knowledge obtained from said trip amounted to my two participations in this course. Although the imagery were over one year old, with some background in photogrammetry I could with the aid of the staff follow and discern features from the imagery and ground.

I would therefore suggest strongly that more field investigations should be made possible because it is the comparison made from field investigations that one develops an interpretive ability of the imagery. Secondly, I further suggest that the entire workshop should be held in the location over which imagery are handed out because this would give the participants the chance of walking around and on his own make some attempt in relating ERTS imagery to ground truth.

Conclusion: Remote sensing as I have observed in both training courses would serve little or no purpose in tropical Africa for several reasons:

(a) The density of vegetation. However, there exists the possibility of utilizing the imagery in preparing a few types of thematic maps where there already exist very good topographic maps of appreciable scales, i.e., road or transportation photomaps over a very large area.

For those areas where remote sensing can be used, I feel a similar course should be held there whereby participants could better relate their observations.

It is therefore my firm belief that the West African nations should request a complete coverage and commence a joint experimental project in devising areas of possible usage of remote sensing which would in the near future diminish the tremendous amount of revenue now tied up in several scientific investigations on their resources.

Comments

By J. K. Gachui, Kenya

Remote sensing through the use of Earth Resource Technology Satellite (ERTS) is a new tool with a lot of application to many disciplines dealing with earth resources. Through ERTS one can monitor repetitively instant changes of the earth's resources through careful analysis and interpretation of ERTS imagery.

During the 10-day workshop I have been exposed to the fundamentals of remote sensing techniques and the uses to which they can be put. I have learned to read ERTS imagery and the interpretation of the various features on the image by discriminating the various colour signatures. I have been introduced on ways of monitoring ground truth and relating this to features on the ERTS imagery. In the workshop I was also exposed to the various techniques of making colour composite images and maps. I have been provided with various publications and papers which I consider to be a valuable source of reference in future work or training in remote sensing.

To develop an in-house capability for remote sensing in my agency, I feel that more training in ERTS is necessary because in agricultural statistics, for example, we are now more interested in cropping zones than in administrative areas. In this case, therefore, identification of the various major crops and vegetation types is necessary. However, a start can be made in soil mapping and possibly land use.

There is no project now going on in my agency where ERTS can be immediately applied. However, once remote sensing ideas are introduced to other employees of the Central Bureau of Statistics, many possible uses will arise.

In summary I must emphasize that application of ERTS in a country like Kenya has to be well coordinated with all possible users of ERTS data, and a central data bank needs to be established. In addition, frequent seminars and training sessions need to be held in order to keep abreast with this new technique.

Critique of Seminar/Workshop

By J. J. R. Grimsdell, Tanzania

A. IMPROVEMENT

(i) Have fewer people on the course; or have more instructors.

(ii) Reduce the formal lectures to a minimum and assume participants relatively well informed; do not waste time on basic mapping and aerial photo techniques. People can always ask questions if in doubt.

(iii) Concentrate on the workshop side and make sure everyone has time to cross-examine the instructors on specific problems.

(iv) Ensure that everyone knows exactly how to obtain ERTS data for their specific needs.

(v) In the future, give more attention to the quantitative side of ERTS data; i.e., computer methods for handling magnetic tape data.

(vi) For the field trip, make sure aerial mosaics available from survey department and, if possible, organize a systematic overfly in order to annotate the images.

(vii) A one-week course would probably suffice. Participants should submit a detailed account of their specific problems beforehand, so that the instructors are prepared in advance.

Seminar/Workshop Critique

By M. D. Gwynne, Kenya

1. The initial two-day seminar for administrations was a good idea and the level and form of production were just right for the purpose.

2. The workshop, however, continued on the same very general level and repeated much of what had been stated at the seminar. It gave a very general outline of the possibilities for using ERTS imagery that are being investigated in the U.S. Although there were many colourful and interesting examples shown, there were no in-depth case histories given illustrating in detail how ERTS has been used with benefit. These should have, in each case, shown:

a. the problem
b. the objectives
c. the reasons for using ERTS imagery
d. the actual methods used in analyzing that imagery including
   (i) how the data were lifted from the images
   (ii) how the data were treated after lifting including statistical handling
e. the preparation of thematic maps and the justification for their production
f. the final production and the conclusions reached
g. how these conclusions were translated into practical terms useful to the state.

It is in the latter part of their presentation that the workshop was particularly weak (i.e., items d-g, especially f & g) so that the participants were often left wondering whether the whole ERTS programme was not just a scientific toy that its sponsors were desperately trying to justify without knowing how. The fault lay more with the general manner of presentation than with the ERTS system.

3. The emphasis throughout has always been on methods of optical interpretation with hardly a mention of possible quantitative analysis using tape data. Yet, for example, this is most likely the only way that quantitative vegetation production data can be obtained.

4. The assembly would better have been called "a lecture course" on remote sensing rather than a workshop. There was almost no chance for

participants to actually do things for themselves and to actually use the equipment brought to Kenya at such expense. It was disappointing that there was no practical guided exercise in the construction of thematic maps. These need not have been from Africa, indeed, it would have been better to have used fully interpreted images from the U.S. for initial guided classwork, switching to individual country images only after several U.S. scenes had been interpreted as class efforts and checked out against the U.S. data. Few people from developing countries really have sufficient knowledge of their own country to be able to interpret usefully a scene without reference to maps, published data, etc.

5. There is no need for co-instructors from the host country. The instruction can best be done by the imported instructors using local expertise as and when it is found. Co-instructors find themselves ranked as neither instructor nor participants and this leads to frayed tempers and unnecessary misunderstandings, particularly as it is the co-instructors that are the ones most likely to use remote sensing data. As Dr. Sombroek of the Kenya Soil Survey eloquently put it, "Co-instructors are nothing more than second-class participants."

Critique of Seminar and Workshop

By S. M. Hutton, Botswana
on behalf of B. H. Wilson, J. A. Raffle, and D. Pratchett

1) Botswana is possibly unique among the countries represented at this meeting in that the main interest in ERTS products and their use has been among expatriates. Each officer therefore who has attended any of the sessions during the last two weeks has had some sort of background to remote sensing (i.e., aerial photo interpretation) through his professional training, and is thus in a position to implement results derived from analysis of the data using simple visual techniques to a greater or lesser degree.

2) I am not sure whether students in Botswana, for example at the Geography Department in the University, are receiving training in the more conventional A.P.I. techniques, whether they comprehend the potential of this sort of analysis or whether they could translate their experience to satellite imagery interpretation, let alone grasp the principals of colour film or colour IR film representations.

3) My comments will therefore be largely personal and perhaps should not be regarded as representative of a developing nation's view.

4) It will be part of my objective on my return to Botswana to stimulate interest (as has been my job in association with the ERTS-1 project) but hopefully more projected to the educational field than to other Government Departments who by now should know of the existence of ERTS and be able to make their own evaluations.

5) Personal comments

The workshop has been too short. Naturally, if I had the opportunity, I would elect to study on an approved academic course in remote sensing, probably of one year's duration. In this time, I would hope to thoroughly understand the principles of film representations, sensors, simple and advanced techniques of processing, continual practice in interpretation concomitant with discussions and comparisons and gain considerable experience in performing analytical techniques, i.e., photographic reproductions, operation of equipment, field experience, digital processing.

6) The workshop has been valuable as an introduction and I have gained a clearer idea into concepts such as reflectance in certain bands being a specific indicator of objects with specific reflective or emissive properties.

7) I have learned the elements of techniques, such as Diazo-chrome printing, colour additive viewing, simple enhancement techniques, and simple photographic processing.

8) I have made contacts and got some more addresses.

9) I have managed to glean a little information with respect to a discipline which is not my main interest (geology) since I feel I am a little more aware of differences in tone and colour as related to soils and vegetation types. I might add that my previous aerial photographic interpretation experience was largely self-taught in a couple of hours since the lecturer at my university was more prepared to sponsor discussions about the environment than teach his subject. His discussions were useless anyway.

10) The workshop has not dealt with administrative problems such as storage and indexing of data. In Africa, this could amount to a problem since a professional man would probably consider it below him to undertake this laborious task and the educational level of clerks on this continent makes them eminently unqualified to proceed with the job unless subjected to very close supervision (unlikely). Some time should have been devoted to this topic.

11) I would have liked a reasonably lengthy discussion with the workshop staff about the ERTS-1 project in Botswana. As it is, I was not made aware that they had read any of the Botswana reports, nor that they had this item on their schedule whether during or outside working hours. I feel that they should, in fact, have made the approach to us (the Botswana representatives) since we might have been able to respond more effectively if asked to make statements rather than grope around trying to explain elements of the work and the problems encountered. Fragments of our experience were explained to different members of the staff, but I would have preferred a complete discussion. I would have even liked

to talk in front of the whole class for a while, although I imagine that there would have been no time in view of the arrangement of the programme. Only at the end of the workshop did M. Conitz begin to get the idea that there are not identifiable control points in Botswana in order for us to draw up simple, reliable maps with ease; G. Rabchevsky: difficulties in getting decent photo reproductions.

12) Insufficient practical work. I appreciate the difficulties created by non-arrival of workshop materials, but I am not sure to what extent participants could have "made do" with coloured pencils, tracing paper, and a single ERTS frame. The aim would have been to get participants to produce a series of thematic maps, either in one or more disciplines or in one discipline from different frames. The latter suggestion would have been more feasible since there were a large number of frames from different countries which could have been passed around. In this respect, tighter discipline of participants' activities would have been ensured and staff might have had a better idea of what participants could do.

Seminar

From my point of view, something of a waste of time, but I quite liked the slideshows and certainly the banquet. I had the idea that this should have been directed at people like Permanent Secretaries, in which case, the intention should have been made more clear.

Critique

By Stephen Kajula, Tanzania

The use of satellite imagery is of importance for many different studies in our day-to-day activities. The imagery if studied with all the necessary technical equipment can give a good and reasonable information. The technique of interpretation is of importance too, which has also to be taken into consideration. The satellite imagery can solve many national problems if the imagery can be given to respective countries regularly. This may be of great use if the data is presented regularly with recent information.

The other problem which will be faced with our developing countries is the technology of using the data. We need equipment for using the data and at the same time the technology of interpretation, so that we can be informed of what is going on in our surroundings.

Scale: Although satellite imagery is good for its coverage, but we have to know that much information is left. What we get in the imagery is the idea of what is happening. One can't do anything for detailed study. The scale is only for reconnaissance mapping. If one needs a detailed study, he has to turn to air photos taken by normal aircraft.

The original scale of 1:1,000,000 which was blown to 1:685,000 (Mt. Kenya) It is difficult to spot the towns which are below the mountain unless you have the local knowledge. The towns are big but what is seen is a dot, which one can't identify. This is due to the imagery scale.

Critique of This ERTS Seminar/Workshop

By D. M. Kirori, Kenya

In the past few months I have been involved in the ERTS discussion in the Kenya group but without much understanding. I therefore consider this seminar/workshop timely. It has provided an opportunity of knowing the ERTS potential and usefulness which I did not know before. I have also gained a better understanding of how remote sensing techniques can be useful if properly and effectively used.

ERTS can also be used to discover unknown geological structures and other environmental problems and at the same time be used as a tool to complement information based on ground observation. It does help us to study our country in a broad way.

It's proper use, interpretation and evaluation can help our developing country to plan, make decisions, and take appropriate measures on a variety of problems.

On the whole, the main objective of the seminar/workshop has been accomplished.

I think that more time should have been devoted to practical work and discussions. But time was very short.

I should look forward to a symposium in about a year from now.

A Critique of the Seminar and Workshop on Remote Sensing - 21st March to 3rd April, 1974 - Nairobi

By W. J. Lusigi, Kenya

OBJECTIVES

The use of remote sensing as an instrument in resource management is an important step in reducing the tedious mechanics involved in data collection for various mapping exercises in the field. The seminar was therefore a fantastic opportunity for those involved in various resource management fields in Africa. To date, although ERTS imageries were available for various parts of Africa, they had not been fully utilised as the technique is a recent scientific development. The seminar was therefore an important revelation as to the numerous possibilities that these imageries could be used for.

PLANNING AND ADMINISTRATION

The seminar was well planned as it included expert instructors from the various resource management fields--Range, Wildlife, Hydrology, Geology and Demography.

The plan was however too ambitious in wanting to cover all these areas and to master the technique in only two weeks. This therefore ended up in the seminar being only a broad introduction that needed a specific detailed followup in specific fields.

THE FIELD TRIP

The field trip had good objectives of seeing the areas and spot-checking them on the photos. This was very useful since it did open up the problems of office interpretation. Same colour indicated quite a few things that had not been apparent in the office. Blue for example came to mean either rock, water or some types of soils. It was therefore significant to delineate these features on the ground and see what they really looked like on the ground.

The field trip would however have been much better if local inputs would have been employed in its planning. A lot more would have been gained if the field trip went through areas where specific work was being done by people on the seminar. In this way, they would have been able to point out specific problems that were real. As it was the field trip boiled down into a sight-seeing tour for the co-instructors and the international participants while for the Kenyans they went through areas they were least concerned about in their present work. Specific real problems were not therefore looked into.

LIMITATIONS OF ERTS IMAGERY ON AFRICA

In view of the small countries we have in Africa ERTS photos are a little bit too big. I personally believe that we have to start more detailed maps which tend to go beyond the reaches of ERTS. Emphasis should be put on close up remote sensors that would give more detailed information.

OVERALL

The seminar was a useful introduction to the whole field of remote sensing and stimulated some scholarly thoughts in the participants regarding its future applicability for Africa.

Critique of Seminar/Workshop of Remote Sensing

By Mark R. Majwahuzi, Tanzania

I see the objectives of the current seminar/workshop on remote sensing as being (a) to inform the participants about the relatively new technique of remote sensing and (b) to impart skills needed in applying the technique.

As to the first objective, I think the programme as a whole was a success. The instructors presented the subject with clarity and confidence. Appropriate visual aids were used. I personally believe that I have learnt a lot about remote sensing and I have developed an interest in the application of this tool in resources study.

I don't think the second objective was very much achieved. Remote sensing is a relatively new tool. To ue it effectively one needs a sound background in the relevant sciences. For someone whose scientific background is not strong would need a strong remedial course in those fields that are directly relevant to the techniques of remote sensing. Such remedial work could hardly be accomplished in such a short time that we had during the workshop.

Great efforts were expended on the part of the instructors to try and get the participants to acquire the necessary skills. But as I have mentioned, time was short and yet too much was presented. There was a danger of confusion when so much is presented in so short a time.

My suggestion is that in future if such a workshop is organized, more time should be allocated to acquiring the basic techniques (skills). The workshop, if financially feasible, should allow the individual participants to deal with practical application of the techniques. Participants should, for example, be able to make sure their own colour composites and to get involved in interpretation of ERTS images.

Critique of the East African Remote Sensing Seminar/Workshop (21·3·74 - 3·4·74)

By P. W. Mumiukha, Kenya

The arrangement of having theoretical background first before having practical in the workshop made this seminar a very successful one. It meant that new ideas were repetitively met at various places and therefore were digested easily.

Since this was a seminar for multidisciplines, each member of the staff giving a background lecture helped us to learn more and use new knowledge in interpretation of ERTS-1 imagery. The best background lecture was given by Dr. Carneggie on sources and characteristics of energy. They are these characteristics that are exploited in remote sensing. We needed this kind of introduction in soils and geology.

Although I am a game biologist involved in habitat studies, I also need basic knowledge in soils and geology in order to make my work complete.

In cartography and photogrammetry, I feel a very good introduction by Dr. Conitz was given. Since all aspects of ERTS-1 were well covered and it is only one tool to be used in photography, other aspects like the use of lightmeters, optiscope, and stereoscope.

Lastly, I maintain that it was a well-organized seminar and workshop.

Critique of Seminar and Workshop

By V. K. Ocran, Ghana

Prior to this seminar I did not have any knowledge of "remote sensing."

As the lectures and demonstrations proceeded, I began to grasp the whole concept gradually. Now I am in a stage to comment because I feel I have known much.

Future lecturers should concentrate or stress the following task in addition to the programme or time table drawn up in order to facilitate a quick grasp of the lectures delivered:

(1) Refer participants to pages from handouts or booklets distributed for further reading and assign them other references for the next day's lectures.

Future organizers of such seminars should forward an advanced set of guidelines on the writing up of country reports relating to the various disciplines they intend to cover to participating countries.

These country reports could be read at the seminar so that each participant could have an idea of what obtains in each of the participating countries.

I believe this could bring about some comparisons which will bring the topic closer home.

Apart from the above suggestions, I should state that the volume of knowledge acquired within this short period has been enormous and could be put to use in Ghana on an experimental basis.

East African Seminar and Workshop on Remote Sensing of National Resources and Environment - March 21 - April 3

By Akin Oduolowu and Babatunda Okuwa, Nigeria

A. Place: The seminar was held at the Kenyatta Conference Centre, Nairobi, Kenya from March 21-22. The workshop was held at the Engineering Building of the University of Nairobi.

B. Achievements:

(1) During the first three days which covered introductory lectures on remote sensing, the participants were enlightened on

(a) the capabilities and limitation of ERTS-1 imagery
(b) methods of collecting and basic techniques of interpreting ERTS data
(c) a few shortcomings of the ERTS-1 as a sensor system

(2) Where necessary the talks were supplemented by slides and photographs.

(3) As a result of the activites of the first three days of the Seminar/Workshop, the participants and observers got a more intimate appreciation of the ERTS programme and other satellite remote sensors like the Apollo and the Nimbus series.

(4) The workshop and the accompanying fieldtrips (either around Mount Kenya or to the Rift Valley) were geared towards

(a) providing a competent background in remote sensing technology. This was achieved by series of lectures, slide shows; other illustrations and numerous publications were distributed to participants.
(b) developing an the individual participants the capability of interpreting the ERTS imagery according to his/her discipline with the ultimate hope of being able to do the work.

(5) These objectives were achieved by providing colour composites and black-and-white imageries of parts of Kenya for the fieldwork and classwork and colour imagery of part of the home country of each participant for his/her own practice in interpretation.

C. Critique:

(1) It is our opinion that the total time available for the workshop was too short and, as a result, even though participants had a fairly good idea of the subject matter, only a limited degree of competence in the interpretation of ERTS data was achieved.

(2) It must be mentioned, however, that a clear awareness of the usefulness of ERTS imagery to certain natural resources and environmental control disciplines has been generated and sustained.

(3) The workshop has also made available to participants simple ideas on how to apply some "home-made" methods to the handling and interpretation of ERTS data where more sophisticated methods are not readily available.

D. Potentials:

(1) Even though the achivements of the Seminar/Workshop cannot be described as spectacular, the application of satellite imagery for taking inventory, exploring and monitoring the natural resources of a country, e.g., in forestry, agriculture, wildlife, hydrology, are not in doubt.

(2) In a country like Nigeria with thick clouds and haze covers for most part of the year and with thick tropical forests in the southern part, the limitation of the ERTS-1 imageries is to be taken into account.

(3) A radar type of sensor mounted on an aircraft may be of a general and more immediate use in Nigeria; it must, however, be mentioned that the repetitive nature of satellite imageries, particularly the ERTS-1 with a cycle of 18 days and with a synoptic view coverage of large areas of interest, still warrants recommending its use on reconnaissance basis to monitoring our country (Nigeria) resources.

(4) It is reckoned that Nigeria may like to apply ERTS-1 imagery (where available) to disciplines like forestry, agriculture, wildlife, geological survey, water resources and waterways, physical planning and cartography. Its use in ecology may also be explored.

Critique of Seminar/Workshop

By Raymond Razafindrakoto, Malagasy

The availability of highly accurate and detailed data concerning earth resources and environment is recognized by the Government of Malagasy Republic such as an urgent necessity in making a rational development planning.

Therefore, the echo of launching of satellite "ERTS" and especially the potential utilization of remote sensing technology, involved this government to inquire about it.

However, none of adequate informations exist in this matter on the spot.

This lack of informations has implicated the Malagasy Government to send a Senior Statistician-Economist at Nairobi in order to participate at the East African Seminar/Workshop on "remote sensing of earth resources and environment" and to make maximum inquiries about this technology.

In these purposes, I think for myself that the seminar has been a real success, because I have now some ideas concerning technical requirements and applications of remote sensing.

This new technology is very complex, but in summary description we can say that it depends on the fact of every object, living or inanimate, radiates energy of different wavelengths. Heat energy is emitted, light energy is reflected and with the proper sensors and complex processing, appropriate images can be created.

What think about application of this technology?

These applications are very large and concern several disciplines. The next figure is a summary (actual or potential) applications of this technology.

Discipline	Applications
Agriculture	Vegetation density
	Grass - brush - timberland interfaces
	Plant species and vigor
	Soil series and moisture
	Irrigation water
	Drainage assessment
Geographic	Land use
	Transportation and linkage
	Settle and population movements
	Resources utilization
	Climatic conditions and air pollution
	Topo, mapping and geomorphology
Geologic	Composition
	Structure
	Stratigraphy - sedimentation
	Mineral deposits
	Engineering
	Crustal - mantle studies
Hydrologic	Evapotranspiration
	Rain distribution and infiltration
	Ground water discharge
	Water pollution
	Snow surveying and glaciology
	Effluents of major rivers

Oceanographic	Ocean currents
	Sea color analysis
	Shoals and coastal mapping
	Biological phenomena
	Ice surveying
	subsurface structure

This description is very summary and may be incomplete.

Moreover, every mentioned point must be developed in view to explain the real dimension of this technology.

Critique on Remote Sensing Seminar

By Nathaniel Richardson, Liberia

Prior to my coming to Kenya for this seminar, I was vaguely aware of what remote sensing was. Since then, however, I have been given not only the knowledge of what remote sensing is, but also the principal about how it works, what it does, and how it can be used in various natural resource problems.

The seminar has given us the basic tools for the in-house implementation of the many techniques that we have learned here. Some of the equipment needed to process the photo images are rather expensive and probably will be a long time before our survey is able to buy them, but there were less expensive means of producing certain imagery that can easily be applied back home.

For Liberia remote sensing techniques can best be used in our agricultural-forestry program. Because of the dense vegetation cover and deep laterite cover, the geologic aspect of this newly developed science cannot immediately be recognized. Possibly what is needed for Liberia would be thermal imagery, and if it could be acquired cheaply, radar imagery.

Comments:

I think that imagery from a tropical rain forest area might have been presented in this seminar since participants from at least three countries (Liberia, Nigeria, and Ghana) that fall under this heading could have really benefitted from it.

Critique on Workshop and Seminar

By S. Wanyeki, Kenya

Introduction:

On 21st of March and the day that followed, an open conference on Remote Sensing of Natural Resources and Environments was held at the Kenyatta Conference Center. During the conference, a general and concise presentation of the applications and interpretation of Earth Resources Technology Satellite was conducted by a team of US experts.

Workshop and Seminar:

A briefing on the electromagnetic spectrum was a good start for the seminar and workshop. I thought that it was a good basis for what was to follow. This was great because not everyone in the seminar was conversant with the light spectral bands, and that not the entire spectrum is used in ERTS and that some bands are better at identifying some objects than others.

The follow-up presentation of earth resources data collecting vehicles like aircraft, spacecraft including Gemini, Apollo, ERTS and skylab enlightened the participants on how some imageries are obtained. It was emphasized that every vehicle has its own data collection capabilities and resolution limits.

Applications:

It was shown by means of slide-show how Remote Sensing has been used in various parts of the US to evaluate ground water potentials, monitor floods and environmental conditions. Remote sensing has also been used to map inaccessible areas like the Amazon basin and has been used to monitor and manage agricultural, range and forest lands. I was interested in the range water hydrology applications and was impressed by the imagery on Snake river and the Craters of the Moon, Idaho, and the imagery on the area around Mt. Kenya.

Interpretation:

The basis for interpreting black and white and coloured imageries was explained with reference to electromagnetic spectral bands. Light energy is either reflected or absorbed on hitting an object and it is on this basis that ERTS imageries are interpreted. Using the visible to near Infrared portion of the spectrum, various spectral bands are either highly reflected or absorbed by various substances. An example is that band 7 is highly absorbed by water and it can be used to identify a body of water or a river. By using correct light filters, it is possible to identify a variety of features from negatives and positives and by combining certain spectral bands, and correct light filters, coloured composite image can be obtained. I must mention the emphasis said time and again by the instructors that ERTS and aerial photography are complementaries.

Conclusion: The workshop and seminar gave me a completely new outlook on information that can be extracted from both aerial and satellite images. I would however have liked to spend more time on ERTS interpretations, made my own coloured composites and become more familiar with filters. I look forward to future openings for such training facilities to enable the participants to extract more information from ERTS.

Report

By Anthony Winters, Zanzibar

The workshop has given me, I think, an adequate grounding in the potential and use of ERTS imagery. Any criticism must be tempered by remembering the difficulties which are inherent in bringing together people whose backgrounds in image interpretation are widely spread--from those who had never heard of ERTS to those who have used ERTS imagery for their own programmes--and trying to cover aspects of remote sensing useful to all. The physical background was covered sufficiently for me, but a few practical demonstrations of reflectance spectra would be most helpful--again perhaps this omission was due to nonarrival of equipment. One criticism of the lectures, I think, was the repetition. With four experts I think it would have been better to split the group up, with concurrent lectures on the various fields, allowing more time for practical work, or a certain condensation of the workshop. The assumption that large scale aerial photography and aircraft for obtaining suitable ground truth are readily available may be optimistic. The practical and field trip are, of course, an integral part in a course like this, and use of the colour additive viewer enables a feel for the potential of colour enhancement to be obtained.

The field trip was a success in that it enables 1) the delineation of boundaries due to different colours to be identified; 2) the size of features on the ground and on the two maps of different scales to be related; and 3) the interaction of water and vegetation and soil type and vegetation to be observed. Again it would have been better if direct spectral reflectances could have been measured at some points to relate to observed features. It would also have been instructive if a topographic overlay had been on hand (my omission, not yours!).

As for the future, I hope to be obtaining images with a view to identifying 1) temporal changes in coastal waters of Kenya and Tanzania of biological material 2) measurement of areal extent of mangrove swamps and coral reefs to estimate productivity and 3) water mass movements related to monsonal variations. These I can probably do with EROS imagery and/or "photomurals" help.

Any central agency set up should contain at least "browse" facilities, colour additive viewer and suitable back-up photographic equipment. It would also seem a good idea if the agency had control over suitable aerial photography aircraft for underflight, ground truth and more detailed surveys. An inventory of present availability of this equipment and aircraft, a list of people presently involved in remote sensing and their projects could also be compiled and circulated. I am not, at present, interested in the real time acquisition of data, but may be in the future, and certainly thermal infrared data would be invaluable.

Finally may I express my sincere thanks to you all for giving so much of your time and energy to us and for introducing me to the field of remote sensing. The financial generosity of the U.S. Government should not be overlooked either.

Once again, many thanks.

Critique

By E. E. Zamierowski, Kenya

1. CRITIQUE

Must preface my remarks with note that my principal interest is applications to plant ecology (Forestry, Range management), with particular reference to teaching post-grad. students use of these tools. Have had previous experience with ERTS imagery; tried to interpret vegetation types from 1:250,000 color composites of western Kenya, with reading of what literature was available in Kenya at the National Environmental Secretariat.

SEMINAR: Best part of it was presentations by D. Carneggie, G. Rabchevsky, and R. Schweikart; movie was excellent summary and overview.

WORKSHOP: General impression was very good; in spite of other university commitments, I feel my time was very well spent at the workshop.

--Handout material was a good background source and well selected. This is a necessary part of any further workshops.

--Technical presentations were not too detailed. Again Dave and George's presentations were most useful to me, but that reflects my interests. Definitely felt there was unnecessary duplication between movie, which was excellent, and some of the speakers--and between the speakers. We saw some of the slides several times, for example. Repetition may have been good, however, for many of the participants who were completely new to ERTS.

--Importance of color I-R as an interpretative aid and supplement to ERTS data was well done.

--My main criticism was over-emphasis on a lecture type presentation--morning sessions were too long without a break. I would have preferred much more "hands-on" experience with ERTS data products, under the supervision of the very qualified and experienced instructors present. For example, each participant should have been required to produce a false-color diazochrome composite from the transparencies of his area and try to do some interpretation of it while he could check his work and interpretation with the instructors.

--An area completely left out--from practical experience--was use of projection techniques to produce enlargements from chips or transparencies. We should have been exposed to this to see the limits of resolution of ERTS data and its possibilities with optical equipment readily available at home.

--I think another room should have been available for agriculture-forestry-range management people; the geologists seemed to get most use out of the available lab space and directed work. Maybe this is easier to do with geological material, I'm not sure.

--Have satisfied my personal objectives in that I now feel confident enough to plan and execute R-S experiments, especial use of color IR aerial photos, and can execute ground truthing in relation to ERTS overflights, as well as prepare students to use ERTS, where applicable, in their ecology work.

--Don't think we spent enough time preparing for it--I had to make an overlay of the road around Mt. Kenya in the bus on Friday (this may have been due to a breakdown of the diazochrome machine, however).

--The field trip itself was an excellent experience and should be included in any future workshops as an aid in interpretation of ERTS data and in demonstrating the multi-disciplinary data which ERTS imagery provides.

--I think we could have made more stops on Friday, especially after Manyuki, with more on-site explanations of specific ground truth requirements needed for specific disciplines.

--Main value to me was in seeing how the same signature can be produced by several features on the ground, e.g. burnt forest, freshly cultivated soil, dark soil with sparse vegetative cover, or even exposed rock surfaces all give a blue-black signature and many vegetation types give a similar pink one. The necessity for checking original interpretation on the ground was thus graphically demonstrated as well as how the areas for detailed or reconnaissance checking can be pin-pointed and hence field work reduced.

--A suggestion would be to use a morning early in the course to fly over the field trip area with the group--if the KAF could provide a Caribou--and further demonstrate ground-truthing at various levels and the use of hand-held IR and color photography to record details and discriminate details not evident from ERTS directly. I think most participants would have access to aircraft in their home countries and should have been able to see how this can supplement ERTS interpretation and specify areas for detailed ground checks.

--As I'm mainly interested in vegetation analysis, I think this would have helped immensely, especially in the presence of experienced instructors.

The value of color I-R photography was a new insight for most of us and it should have been used in conjunction with the course more directly--possibly, as suggested above.

The importance of phenological changes in vegetative cover was well demonstrated and it emphasized the necessity of ground truth at the time of ERTS overflights.

APPENDIX G. PARTICIPANTS' REPORTS: POTENTIAL APPLICATIONS OF A FUTURE OPERATIONAL EARTH SATELLITE SYSTEM FOR THE PARTICIPATING AFRICAN NATIONS*

Potential application and benefits of an operating system employing a U.S. EOS for resources problem in Ghana

By Kwasi Barning, Ghana

The main areas of resources development in which such an operating system would be applicable are in

1. Regional geological mapping
2. Water resources management and that includes location of potential borehole sites
3. Mapping of weeds in the Akosombo dam site

1. Regional geological mapping. (a) The Geological Survey Department is currently carrying out regional mapping on a scale of 1:1,000,000 in the southwestern part of the country. Because of tropical weathering, outcrops are scarce, making mapping very difficult. An ERTS type of system which would be able to penetrate through the forest and bring out faults, lineaments, landforms, would greatly help in the mapping programme.

(b) The gold belt in the country runs across the country in a NE-SE direction. Intensive exploration work is going on both sides of the belt trying to locate new mines. An ERTS type of system could be useful in delineating potential areas for detailed investigations.

2. Water resources management.

CIDA has signed an agreement with Ghana Government for the drilling of 500 boreholes in the northern part of the country to provide drinking water for over 2.5 million people. I think from the experience I have gained working with ERTS imagery, a U.S. EOS system may be a valuable tool in locating potential water sites.

3. Water weeds an Akosombo dam.

Weeds like those growing on the Kariba dam in Rhodesia are threatening the life of the Akosombo dam, which provides hydroelectric power for about two-thirds of the country. The lake behind is about 8-10 miles in places. I believe ERTS may be useful in mapping those weeds, thus making their control easier.

*Informal report drafts. Not reviewed or edited by the authors nor by the U.S. Geological Survey for technical and editorial accuracy.

Potential Application of an ERTS-type Operational System to Malawi

By J. D. Bennett, Malawi

It should be appreciated that the requirements and applications noted in this report represent my own personal views and cannot in anyway be construed to be those of the Malawi Government, for which organization I have no authority to speak.

The ERTS-1 imagery of Malawi that I have examined has revealed features and data of geological, agricultural, silvicultural and hydrological interest. This work was of a preliminary, unsophisticated nature, involving the visual examination of black and white 1:1,000,000 prints in MSS bands 4, 5, 6, and 7. Using optical enhancement techniques and suitable enlargements, it should prove possible to improve on this preliminary work.

ERTS is an experimental system. An operational system involving near real-time acquisition of repetitive data would require a national or regional data acquisition and processing centre. A national centre would be beyond Malawi's needs or means at this stage, and a regional centre, shared by a number of countries, would be more applicable.

Instrumentation on an operational system should, from Malawi's viewpoint, preferably include a blue band sensor for hydrological and fisheries research work (Lake Malawi) and a thermal sensor in view of <u>possible</u> geothermal applications in the Malawi Rift Valley.

Possible applications may be listed at this stage:

a) Geology
- (i) Rift Valley; fracture pattern analysis
- (ii) bedrock/residual soil distribution
- (iii) lithological discrimination
- (iv) hydrogeological applications, (i), (ii) also applicable
- (v) geothermal studies, possible correlation with known thermal spring areas, possible extrapolation

b) Agriculture
- (i) monitoring agricultural development schemes
- (ii) preplanning of new schemes, extension of extant schemes
- (iii) assessing terrain conditions, vegetation density, type, variations in moisture content, erosional features

c) Forestry
- (i) surface water distribution, seasonal changes, capacities
- (ii) plantation condition, disease, fire monitoring
- (iii) Viphya Pulpwood Scheme development

d) Hydrology (i) surface water distribution, seasonal changes, capacities

(ii) Lake Malawi research, water circulation, quality, pollution monitoring (especially with reference to (c)(iii)

(iii) thermal studies

e) Fisheries Research ..... see (d) above

Malawi's economy is agriculturally based, and forestry and pulpwood manufacture will become increasingly important in the short-medium term. A remote sensing system, including one providing a synoptic view and capable of monitoring and providing new real-time data or aspects of these disciplines would be of considerable interest to those concerned with planning and development.

Potential Applications and Benefits of an Operational System Employing a U.S. EOS

By P. S. Bhogal, Kenya

My research interest is in the exploration of geothermal resources in areas of recent volcanism. The applications set out below of an operational EOS are made on the assumption that there will be an additional thermal scanner in addition to the other four scanners.

The thermal data will be of great value during the exploration stage in that it will help to pinpoint probable prospects and thus reduce ground work. The geological setting of the prospect will help formulate a model of the geothermal system and help in determining drill sites.

The temporal nature of the data would be of value during the exploration stage of the geothermal energy, in that it may be possible to infer from imagery areas which have had too much drawoff and thus a drop in temperature. This information could be used to rectify such a situation so that the drawoff from a reservoir equals the recharge into the reservoir.

The whole mechanism (recharge, drawoff, etc.) of a geothermal system is an integral part of the hydrology of the area concerned. ERTS imagery would be invaluable as a source of hydrological data on a regional basis.

Potential Applications of an Operational System of US EOS for Resource Problems in Swaziland

By A. S. Dlamini, Swaziland

INTRODUCTION

ERTS imagery could find immediate application in these three resource provinces: geology, agriculture and hydrology. (See fig. 10).

Swaziland being a small country need two composites: northern area and southern area. Hence, the whole country can be seen in two images. The MSS 5 imagery shown very clearly vegetation; MSS 6 shows geology; while MSS 7 shows clearly hydrological and geological features. Colour imagery could also improve tremendously the desired features and would be of immense usefulness.

Geology

1. Regional mapping of the entire country could be undertaken. ERTS-1 colour imagery (5G + 7R) shows both vegetation patterns and geological features (especailly linear features), and there appears to be areas where vegetation appears to be structurally controlled. A major folded structure appears to exist NW of the country. Major NW linear features appear on the western part of the country, and these structures persist for long distances into the Republic of South Africa.

On the (5G + 7R) colour image, it appears possible to delineate areas underlain by metamorphic, igneous and sedimentary rocks on a large scale.

2. Economic Geology

Coal-bearing Karroo sediments occur in a narrow N-S belt adjacent to and west of the Lebomibo escarpment on the east of the country. Hence it appears possible that with ERTS imagery it would be possible to map this economic area accurately. It would be possible to map this economic area accurately. It would be possible to map some of the faults on the area.

3. Engineering Geology

Linear features shown on ERTS imagery can be seen in the western part of the country, and these features could certainly represent zones of structural instability and weakness and hence could have major influence on the selection of sites for dams, roads, building, etc.

Agriculture

1. Vegetation

The major man-made afforestation in the country is clearly seen in ERTS imagery (scale 1:1,000,000 and 1:250,000). Already colour images show colour variations which may be due to a number of causes. Certainly it appears possible that disease control measures can be implemented using ERTS imagery.

Grass distribution can be seen on ERTS imagery, and it already appears that most of the country is overgrazed. ERTS imagery is clearly showing this critical state of affairs on a regional scale. Hence drastic measures will certainly have to be taken to avert overgrazing. Repetitive imagery will certainly be of tremendous value to delineate grasslands.

Major sugar plantations and citrus areas can be seen on ERTS imagery MSS 5 while soils appear in MSS 6.

2. Soils

ERTS colour imagery could certainly be used to delineate arable and non-arable areas. This would certainly prove an important tool in selecting areas for settlement schemes in remote rural communities.

Hydrology

ERTS image could be an invaluable tool in hydrological resource problems. From ERTS imagery many structural features which have major influence in dam site selection, water resources, e.g., underground water and surface water, soils, etc., can be seen.

Potential Applications and Benefits of an Operational System

By Shirish Dodhia, Kenya

Potential applications and benefits to geology are to be dealt with here.

It has been observed, by looking at the various imagery of Kenya, that for geological mapping the imagery over arid areas where exposures are numerous the ERTS is very useful especially in deciphering the regional trends. In volcanic areas younger lavas are more easily recognized. In areas undisturbed by widespread human activities, vegetation is often a guide to rock types.

In relatively wet areas vegetation masks any differences, if any, shown by various rock types. The synoptic views afforded by ERTS imagery, however, helps in such areas in extending known linear features and by discovery of hitherto unknown linear features with attendant potential benefits.

It may be that a thermal band in a new system taking images soon after sundown of rocks which have differentially retained energy from the sun during the day, may help in distinguishing various rock types and structural features not seen during daylight imaging. The above is just a thought and has no experimental basis nor a basis in any professional work.

Potential Operational Study (System) Using Satellite Data/Images

By J. J. R. Grimsdell, Tanzania/Kenya

Area: Northern Tanzania/Southern Kenya
Especially the Serengeti Ecosystem, an area of some 12,000 sq. miles

Factors of Ecological Monitoring for which ERTS Data Could Be Used

(1) Rangeland greeness monitoring and possible estimates of vegetation browness (bands 7/5 ratio)
(2) Woodland density and woodland area changes
(3) Distribution of burning per month (or 18 days?)
(4) Changes in settlement patterns

Many 'ground truth' data have already been collected on these aspects over the last ten years and could therefore be matched with existing ERTS data (1972-1973). Data therefore exist for calibrating ERTS imagery of this region.

Requirements

(i) Assuming the ERTS data to be valuable, then the ERTS data would be required on a REGULAR basis. If processing and "browse" facilities were available at Nairobi, then much time would be saved.

For mapping ecological changes, the 1:250,000 colour images seem to be the most useful, since data from the images can be transposed directly onto base maps.

(ii) Representative ERTS 1:250,000 images of other areas in Tanzania would also be required for aerial survey work in game reserves and national parks with poor map coverage.

(iii) The IMMEDIATE requirements are thus the existing ERTS images of this region with minimum cloud cover.

Potential Application of ERTS for Kenya Rangeland Ecology

By M. D. Gwynne, Kenya

Future use of ERTS type data can be considered in two forms:

(a) imagery
(b) tape data

Imagery

Once only applications:

i. Drainage basins, principle drainage lines, etc. (very important for wildlife and pastoral livestock management).

ii. Soils: very important for ecological-management work.

Sequential applications (monitoring)

i. Floods, flooding and flood induced changes.

ii. Availability of free surface water; limited to lakes, rivers, and local surface acumulations of large size. The pixel size prevents monitoring of seasonal water hole changes as they are too small to be detected, but it is from such water holes that most wildlife and livestock in pastoral areas take their water.

iii. Seasonal bush and grass burns; knowledge of these is essential for rangeland/wildlife habitat management in E.A. Ecozones IV-Vi. This could be obtained from ERTS.

iv. Rainfall distribution and vegetation flush: most of pastoral Kenya (500,000 km^2) is an area of difficult access and low and erratic rainfall. It is important for management purposes to know where in this area rain has fallen and how the vegetation has responded. The resulting green flushes should show the growth areas clearly, particularly on non-volcanic rock and soils. This would be of great value for:

a. to advise nomadic pastoralists on suitable areas to which they should move some of their stock.

b. to know where wildlife concentrations are likely so that appropriate control over relevant hunting blocks can be exercised.

c. to provide locality data for data tape search for only vegetation production projects.

v. Advance of cultivation into rangeland areas.

Tape data

Sequential applications

There is a need for quantitative vegetation production figures for E.A. Ecozones V and Vi. This can be considered both on a standing crop basis.

It is possible that this information can be derived from ERTS data using individual pixel spectral values. Properly callibrated with adequate ground truth, this method might give mean production estimates (with variances) which could be incorporated directly in the ecosystem models at present being developed. Such a method could undoubtedly be established for the high potential areas (E.A. Ecozones I-III) but it is uncertain whether they would be successful for the drier regions (E.A. Ecozones IV-VI) due to the masking effects of the soil-rock substrate, particularly as volcanic rocks and soils.

This use assumes:

1. Adequate facilities in Kenya for obtaining repetitive real time or near real time data.
2. Adequate data processing facility.
3. Adequate computer facilities in Kenya for handling the tape data.

Future Plans for Remote Sensing in Botswana

By Susan M. Hutton, Botswana

We rely very heavily on aerial photo cover which is generally contracted out by the Department of Surveys and Lands. Starting with ERTS-1 imagery and possibly continuing with ERTS-B, Surveys and Lands hope to use ERTS photographs as background and base to a 1:250,000 map series. Topographic map cover complete only a 1:1 million and 1:500,000. Sparse cover at 1:125,000 and 1:50,000 confined to areas where there are distinct terrain features and population. Some good photo maps exist at 1:50,000, but there is no point in extending this scale of mapping over the whole country since there would be hardly any features to put on the maps. A conventional mapping programme to promote the 1:250,000 map series would cost Rand 3 million or more.

Surveys and Lands are Principal Investigators for ERTS-B. Botswana's proposal was sent to NASA Jan.-Feb. 1973.

Geological Survey holds the ERTS-1 collection. I know of no plans to underfly for ERTS-B, but the Director wishes to get technical assistance from U.K. in interpreting the imagery and two sets of colour composite imagery at 1:500,000 have been ordered. My experience is that ERTS interpretations are most "reliable" when used in conjunction with fieldwork, prior knowledge of the area, and other remote sensing techniques such as geophysics. Our big headache is sand. Eighty percent of the country is covered with it, and if you can get a device board a spacecraft which could penetrate tens to hundreds of feet of sand, we would be more than grateful. Study so far is mainly academic.

Hydrology - B.H. Wilson and the Okawango Swamps - would like to pinpoint flood fronts. Analysis of ERTS-1 data did not agree with field observations, but if it did, a lot of time and expense would be saved. To this end, Wilson require better resolution and possible digital processing. ERTS may not be the answer to his problem. Even if it were, I don't know to what use he would put the results.

Agriculture - the research station asked to participate in ERTS-1 but never once asked to see the imagery. The land-Use Division wish to participate in ERTS-B. The agriculturalists are the people in Botswana, who above all others, would benefit most from the repetitive monitoring of the country provided they received the data within a reasonable space of time. It would enable them to make decisions on rangeland management quite effectively, since large areas are involved at any one time. They do not like writing reports and this is probably one of the reasons why they have made no effective contribution to the ERTS programme as yet.

EOS v. ERTS - depends on sensors and requirements yet to be envisaged. Geologically, not much more can be gained although there is a lot of very recent faulting which may still be developing.

We in Botswana are still unsure of how far to pursue the idea of establishing a remote sensing centre. Even if we had the equipment and facilities and training courses, we still need the people who can carry interpretation through. There is a lack of skilled and educated manpower throughout Botswana, but nowhere is this more keenly felt than in the fields of science and technology. Government would probably prefer to employ consultants.

Potential Applications

By Stephen Kajula, Tanzania

Remote sensing on the satellite imagery can be applied in many fields with limits only to the experts' fields.

As we have seen on the different fields which the remote sensing imagery has been applied, it shows that in many of the fields a studied one could learn something out of the satellite imageries.

On the potential application I think it is possible to use the satellite imagery to detect many things from the earth surface provided we use proper spectral bands so that the image we get will give us all the information we need, as we have seen during the seminar workshop. The camera or lens used in the satellite are powerful enough even to pick the sand deposits in the sea. From this point, we can use the imagery to study the crop yield by having regular imagery to know if crops are affected or not. This will be of great use to agriculturists and also the imagery is good for mapping for its coverage, but keeping in mind that some information will be due to the scale.

What I think on the potential application, the remote sensing or satellite imagery will be of use for the study of natural resources--range, forests, and agriculture, soil and geology. These fields mentioned above can be interpreted in the imagery and some have same boundaries in the interpretation without forgetting the hydrology which is sometimes into drainage which is also identified very easily in the imagery.

With all that I have mentioned this can be achieved if the imageries will be given to the countries when the imagery were taken for their national studies.

Potential Applications of an Operational System Employing a U.S. EOS for Resource Problems in my Country - Tanzania

By Mark R. Mujwahuzi, Tanzania

The development strategy taken in Tanzania is to develop our natural resources. But to do this we have to be able to inventory and monitor the development trends of our resources. It is specifically in this aspect of inventory taking and monitoring the development of our resources that remote sensing will be of great practical use.

Currently, my country still suffers from poor transportation problems. Many areas of the country can hardly be reached. Consequently, very little of the area is known. To inventory the resources of these areas alone would take a vast amount of money and time and would require many people to do the job. With EROS resources of remote areas can easily be known.

At the moment I think EROS would be of very great use in the following fields of resource management in Tanzania: agriculture, forestry, wildlife management, water and soil conservation, and urban development.

With repetitive coverage, for example, my country will be able to monitor the degree in which the available forests get depleted. There has been a trend of felling trees for charcoal preparation. This has been a continuing trend and threatens our forests. At the present time, however, we have no clear method of determining the rate and spatial distribution in which our forests are being destroyed. With repetitive coverage by ERTS imagery, my country will definitely be able to keep an eye on the rate and location of such activities.

What I have said about forests development is applicable to range land development. With ERTS images one is able to determine moisture content of these areas and the nature of the vegetation from time to time. Looking on one colour composite ERTS E-1533-07091 covering Mount Kilimanjaro and the southern parts of Kenya, I could easily identify areas of luxuriant vegetation and other areas that were, at the time the image was taken, suffering from moisture deficiency. This observation is supported by prior knowledge of the moisture conditions in these areas. With such evidence, my country can easily plan for such areas now that the extent of moisture deficiency is determined.

Although there are great potential uses of ERTS images in our resources management, yet at the moment Tanzania cannot use these images. There are several constraints in using ERTS imagery. First, Tanzania has not been participating in this program. Consequently, no images are available in Tanzania. With special arrangements between the government and NASA, I hope these images may be made available to Tanzania. The major constraint, however, in using ERTS images is the unavailability of people with the necessary skills in using ERTS imagery. To effectively use ERTS images, certain people will have to undergo special training in using ERTS images.

In addition to manpower training, aspects of equipment must as well be given serious thought. At the moment, I do not think the necessary equipments in interpreting ERTS images are available in Tanzania. These would have to be made available at the time people are being trained.

The present repetitive coverage of ERTS-1 is said to be 18 days. For our purposes I think this would be adequate at the moment. However, there would be a need of reducing the time-lag between acquisition and analysis of the images.

Operational System for Ghana

By V. K. Ocran, Ghana

It is my opinion that Ghana will have much benefits from remote sensing if she became a member of the NASA programme.

The Environmental Protection Council of Ghana could involve the following ministries and institutions on ERTS programme in order to achieve maximum results:

1. Ministry of Lands and Mineral Resources
2. Ministry of Agriculture
3. University of Legon, Ghana
4. University of Science and Technology, Kumasi
5. University of Cape Coast
6. Council for Scientific and Industrial Research

In agriculture, remote sensing techniques could be used to detect the extent of drainage which the swollen shoot disease has caused to cocoa, a leading export crop in Ghana.

Remote sensing techniques could also serve as a useful tool in forecasting future spread of disease and measures taken to prevent it.

The small- and large-scale cereal (rice, maize, millet, sorghum) and cotton fields in the northern part of Ghana could provide distinctive features on the ERTS imagery which would be beneficial in the planning and implementation of agricultural activities in that area.

Other related benefits could be obtained in the fields of geology, hydrology, range, forestry, land use and soils.

The follow-up of this seminar must be emphasized. This could be arranged through the U.S. AID in Ghana.

There will definitely be the need for both short- and long-term training of specialists in the techniques of interpretation and use of remotely sensed data on the natural environment and its resources.

Potential Applications or Benefits of Operational System Employing a U.S. Earth Observation Satellite (EOS) for Resource Problems in Malagasy Republic

By Raymond Razafindrakoto, Malagasy

The major advantages of remote-sensing technology can be summarized as follows:

Synoptic, large area coverage:

The imagery produced allow direct interpretation and correlation of related features over great distances.

2/ <u>Repetitive coverage</u>

The 18-day cycle of the satellite allows for continuous monitoring of specific areas for earth resources applications. (See fig. 11).

3/ <u>Multispectral coverage</u>

Individual spectral signatures of natural and cultural features provided by the sensor systems can be analyzed separately or in combination.

4/ Versatile scale presentation

Original photographic product can be enlarged.

5/ Color presentations

The individual black and white photographic products for each spectral band can be combined photographically or optically to produce color renditions.

Proper choice of spectral bands and filter combinations can result in significant enhancement of earth resources features.

6/ Minimal data acquisition costs

Copies of data collected can be acquired for the only reproduction costs. Therefore, it is quite obvious that the utilization of this technology may be interesting for resources problems and environment of Malagasy Republic. For that purpose, I think thatit could be introduced efficiently in actual data collection systems.

a/ Census of agriculture

Its use can be facilitated the national crop inventory for type identification of various crops and production estimations.

It is like this, for the survey of global agricultural assessments (stratification of agricultural and non-agricultural areas and classification of limited crop typing).

In this effect, sampling strategy, signature extension, yield modeling, can be improved by its utilization.

b/ Census of population

The census could be facilitated by providing of settle and movement of populations characteristics of habitations.

Other areas could be concerned such as forestry, oceanography, geology, hydrology and in general every survey which allow a rational management of earth resources and environment.

3/ Conclusion

The key of problem is however:

a/ Find Malagasy scientists and technicians which are able to process and utilize ERTS data.

b/ Convince every people of the opportuneness in investing in this new technology (personal training, equipment, contracts with specialized society or organization).

Those involve the necessity of organization of other seminars for Malagasy technicians and scientists which usually speak French or Malagasy.

Potential Applications of ERTS

By S. Wanyeki, Kenya

Introduction:

For a long time man has attempted to evaluate the natural resources in the earth that contribute to his everyday life. Exploratory expeditions have been organized, using scientific equipments on ground and aerial expeditions using aircraft with equipments show how man has been conscious of the necessity to know what types of resources he can tap. Today man is using more sophisticated means to learn earth resources on a larger scale by studying his earth from outer space.

Potential applications of ERTS:

ERTS, short for Earth Resource Technology Satellite, is one of the vehicles used by man in the outer space for data collection of earth resource. From the little knowledge gained during the workshop/seminar, I have a strong conviction that ERTS imagery can be used to evaluate rangeland potentials in Kenya which is an agricultural country. Other applications are in fields of hydrology, forestry, agricultural country. Other applications are in fields of hydrology, forestry, agricultural environmental and geology but I shall comment on rangeland planning and management in Kenya.

A lot of money in forms of foreign loans and grants to develop rangelands in the Northern and South-Eastern Kenya. During the seminar, repetitive coverage imageries on same area taken at different seasons revealed the dynamic process on the grasslands. With such repetitive coverage of rangeland in dry and wet seasons in north-eastern Kenya, it would be more economical and quicker to define grazing blocks and what type grazing rotation patterns to be followed. With the information gained on dynamic processes taking place in the rangeland, it would help to choose what zones need priority development using the loan money. In addition to drawing grazing blocks, ERTS can be used to plan on the size of water-pans dug in various blocks to catch rainfall runoffs.

As regards rangelands in south and south-east of Kenya, ERTS can be of immense help especially in inventorying fault zones in the Rift Valley part of Kajiado-narok districts where huge range management projects are being started. Vegetative cover associated with fault zones as seen on coloured composite could help in delineating permeability and porosity parameters relating shallow subsurface conditions in some of the areas not in any great use and might be considered for future development. There are other fields that ERTS can be used but I am not in an authoritative position to expound further on them.

Proposals for an Operational ERTS Program

By E. E. Zamierowski, Kenya

--As my interests are mainly vegetational, suggestions will be biased in this direction.

--Present resolution available is adequate, considering what was mentioned above about projection of chips for enlargement to larger scale.

--Repetitive coverage of 18 days is OK, provided we can know precise location of ERTS spacecraft and time of overflight in advance.

--Must have capability of getting quick access to images with no more than 30% cloud cover, maybe with 50%, if area of interest is cloud-free. Real-time information on cloud cover with some rapid ordering system for imagery of interest as soon as cloud cover is known.

--Suggest that 70mm chips be made available within 2 weeks of overflight, with other formats possible on request at a later date, after evaluation of chips.

This would require additional ground receivers. San Marcos Station, on Kenya coast, with appropriate tape-recorder equipment could service most of East and Central AFrica. Another in West Africa could possibly do the job. Would then require expansion of an existing (?) data-processing facility in Europe to produce 70mm. chips quickly. EROS data center could probably continue to handle other data products that wouldn't be needed so quickly.

Thermal I-R data would be less valuable than rapid data acquisition in 70mm format of Bands 4, 5, 6, 7.

Suggest the establishments of Regional Centers for data storage, browse facilities, remote-sensing library, more expensive types of data evaluation equipment, e.g. color-additive viewers, with projector, tracer, camera; zoom transfer (which we didn't see, but sounds useful); and training facilities. For example, one in Nairobi, as it will have access to UNEP computer terminal (or this could be arranged) and could presumably provide computer facility for processing of digital data directly. Another, more modest facility could be established in West Africa, possibly near receiver facility.