LARS Contract Report 063080

Final Report

Training Course Entitled
"Remote Sensing for Mineral Specialists"

Award No. YA-553-RFPO-2

Contract Period: December 21, 1979 - June 30, 1980

Submitted to: Bureau of Land Management
Denver Federal Center
Mr. Jean Juilland, Technical Monitor

Principal Investigator: Shirley M. Davis
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Contents

Appendices

I. Introduction

In partial fulfillment of a contract from the Bureau of Land Management, staff from Purdue University presented a training course for BLM mineral specialists to introduce them to remote sensing technology. It was envisioned by BLM that this course, which focuses on visual interpretation techniques, would be the first in a sequence, with the second course focusing on numerical enhancement and analysis techniques.

II. Preparation for the Course

On January 17-18, 1980, Mr. Jean Juilland, Technical Contract Monitor from BLM, visited LARS in order to meet the course staff, discuss the objectives of the course, and become acquainted with LARS' work overall. During that visit Mr. Juilland and the staff talked through the possible content of the course day-by-day and came to an agreement on the general objectives of the course. This discussion formed the basis for the statement of the course objectives. (See Appendix A: Course Objectives.)

During that meeting a number of other decisions were made about the course, in some instances decisions that altered statements contained in the original proposal:

a) Because of the time of year of the course and the likelihood of snow cover in the Denver area, the field trip was eliminated;

b) The materials sent ahead to students would be limited to introductory reading materials and not include imagery;

c) No formal examinations or rating of students' progress would be made;

d) To avoid uncertainties of EROS' delivery schedule, multiple copies of imagery would be obtained through a local photo processor who could promise 1-week service on color and black-and-white.

The only other major change in plans concerned the location of the course: the course was moved to Building 50 of the Denver Federal Center, with required audio-visual equipment provided by BLM. The change in location from Denver University also resulted in a change in the method of videotaping the course. The need was met through BLM supplying the videotaping equipment and the contract providing the camera man and the videotape cassettes.

Preliminary materials were sent to students three weeks before the course. At that time and throughout most of the planning period, approximately thirty students were expected, and materials for that number were acquired. (Appendix B lists the pre-registered participants. Unused student materials were left with Jean Juilland at the conclusion of the course.)

III. Presentation of the Course

The course was held March 24-28, 1980, for fourteen participants, who are listed in Appendix C. All of the participants had previously acquired B.S. degrees, and more than a half had master's degrees as well. Formal course work had in all cases been in geology and related fields. Although some of the participants reported having attended the BLM photointerpretation course or using photointerpretation in field work or in the military, most had no prior experience with Landsat imagery, radar imagery, or the merging of geologic data from various sources.

The final course outline appears in Appendix D; while some minor changes in the course schedule were made during the week, the staff felt that the schedule as planned was appropriate for meeting the needs of the participants.

One change in approach that is not reflected in the course schedule was related to the evening activities. While it had been LARS' intention to hold evening sessions for "optional" work designed to help individuals augment their backgrounds through conferences and individual study, other activities arose for the participants on two of the four evenings. The one evening session we held, on Tuesday, was attended by only a few participants, whose interests tended to center on BLM situations rather than on remote sensing. The planned Thursday evening session was therefore cancelled.

Certificates from Purdue University were presented to students upon completion of the course.

IV. Course Documentation

Complete course documentation was prepared so as to enable BLM to teach the course themselves in the future. The documentation is contained in five units:

1) A notebook containing Student Notes, i.e., all handouts, imagery, and maps distributed to the students during the course;

2) Instructor's Notes, a notebook containing all slides and transparencies used during the course, with commentary;

3) Videotapes of the actual presentation, including all lectures, major demonstrations and sections of the laboratories;

4) Single copies of all maps, posters, and imagery displayed during the course;

5) Original transparencies from EROS that can be used to make multiple copies of imagery that was distributed to students.

To assist a future instructor in correlating the materials in the various media, a sequence number, from one through eighteen, has been assigned to each presentation unit of the course. These numbers appear on the course outline (Appendix D) as well as on other materials in the Student Notes and Instructor's Notes. All materials identified with an "April 1980" date were modified or revised in some way after the course; those marked "March 1980" exist in the course documentation as they did for the course.

The most complete documentation of the course itself is contained in nineteen 3/4-inch videotape cassettes. An index to the tapes appears in Appendix E. Even though they are black-and-white and unedited, the videotapes capture the content of the course better than any other part of the course documentation and can serve as an essential resource for the person wishing to present this material. They contain concrete information about the way the materials included in the Instructor's Notes were used, about the pace of the course, the questions that arose from the students, and how they were answered. (A word of caution is in order, however: these tapes were created for the instructor who is already familiar with the field; they are not judged to be adequate for use with students who have not previously been exposed to the concepts presented.)

V. Evaluation of the Course

Evaluation of the course took place at four times, with different groups of people. First of all, the students evaluated the course orally at the beginning of Wednesday afternoon. This "mid-course evaluation" was moderated by Shirley Davis, the course coordinator, and is included on videotape number 10.

A formal, written evaluation was completed by the students at the conclusion of the course. Thirteen of the fourteen participants returned evaluations, and those returned are summarized in Appendix F.

Staff evaluations were held twice, first with the contract monitor at the conclusion of the course and then after arrival back at Purdue. A formal evaluation from the Staff appears as Appendix G. Donna Scholz submitted a written evaluation, which is also included as part of Appendix G.

VI. Suggestions for the Course on Numerical Techniques

Purdue project staff prepared a preliminary description of the approach they would recommend for teaching a follow-on course for mineral specialists that would address numerical enhancement and analysis techniques. That preliminary statement was submitted to BLM as part of the monthly report for April 1980 and is included here as Appendix H.

Since then, I have had the opportunity to deepen my understanding of the IDIMS system through twelve hours of hands-on work using the IDIMS at EROS Data Center. As a result of this work, I have a much clearer appreciation of the strengths of the system and feel that in general the plan described in Appendix H can stand as a valid point of departure. There are, however, a few important observations that now must be added.

First the IDIMS is a very strong image display device with a great deal of flexibility for implementing many analysis schemes. The ease of creating enhancements and of manipulating color hues and intensities is, on one hand, an attractive feature of the system but, on the other, an aspect that can lead to creating "pretty pictures" that cannot be quantitatively described. Time for pure experimentation with images will need to be provided but controlled in order to leave time for following repeatable, identifiable steps to image creation.

Four hours of hands-on experience on the system for each student is not a long period of time given the versatility of the equipment. This situation can be helped somewhat if prior to using the processing functions students are thoroughly familiar with the control language for that function and with the options and defaults that can be chosen. The system is very good at prompting the user, but that help is negated if the user has to check the meaning of the prompts and the ramifications of the choices while at the terminal.

Reference documentation for the system is extensive and good, for the experienced user. As a neophyte in using the system, however, I did encounter some problems that were not easily solved with existing documentation. A new user who was also not completely comfortable with the numerical enhancement and analysis concepts would likely encounter more serious problems. While it is possible that tutorial documentation of the system exists, it was not evident at EDC. If BLM intends that many of its staff become capable users of the system, the careful design of geologically based tutorial sessions would be a great contribution both to this course and to the training of future users of IDIMS.

In the time I had on the system, I was not able to go through the steps needed to see a classification of a scene through from beginning to end. With the steps clearly outlined and an appropriate data set, this should not create a serious problem in the context of the BLM course suggested, particularly if many of the functions are implemented on the array processor. Costs of using the system and the processing times required (particularly for large data sets) will need to be assessed carefully by the course design staff, however, since the competition for processing time will increase with the two pairs of users working on the system simultaneously.

In conclusion, the previous suggestion of working closely with a BLM staff geologist to develop appropriate and workable exercises is viewed now as an even more desirable arrangement, given the great versatility of the system and the diversity of processing it can perform.

VII. Conclusion

The Course staff members were pleased to have this opportunity to design a new course to meet the needs of a specific group of participants. As is always the case, we are aware of changes we would make if we were to offer this course again for a group with similar backgrounds; these changes are described in our evaluation. However we believe that the course went well and that the students gained valuable information; we will look for other ways to work with BLM in the future.

Appendix A. Course Objectives

REMOTE SENSING FOR MINERAL SPECIALISTS: IMAGE INTERPRETATION

Presented for: Bureau of Land Management, Denver
March 24-28, 1980

Presented by: Laboratory for Applications of Remote Sensing
Purdue University

Course Objectives

Upon completion of the course, students will be able to:

1. describe in general terms the sources of electromagnetic radiation and the spectral reflectance characteristics of earth surface materials, with particular emphases on geologic features;

2. discuss image characteristics (e.g., spectral and spatial resolution, data quality, scale) of data from frequently used imaging sensors;

3. assess aerial photography and satellite imagery as sources of geologic information for land management projects;

4. describe the derivation of common Landsat image products and be knowledgeable in ordering and in using these products and in interpreting analyses based on them;

5. conduct a step-by-step visual analysis of Landsat imagery to develop a geologic interpretation of an area;

6. explain to others the utility and efficiency of using Landsat data in making management decisions, including assessment of mineral-resource potential;

7. recognize situations in which geophysical and geochemical data may make a contribution to a project;

8. describe how data from many sources may be integrated to provide a fuller understanding of the study area;

9. describe the typical steps in numerical analysis of data and assess the merits of using this approach to extract information about an area; and

10. describe some recent developments in interpretation of satellite images for geologic purposes.

Appendix B. Preliminary List

List of Participants - Training Course 9100-11A

Remote Sensing for Mineral Specialists

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Appendix C. Actual List

List of Participants - Training Course 9100-11A

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Appendix D. Revised Course Outline

Remote Sensing for Mineral Specialists
March 24-28, 1980

Monday, March 24

8:00 - 8:40	I.	Introductory comments	JJ, SMD
8:40 - 10:00*	II.	Principles of Remote Sensing:	LAB
		1) What is Remote Sensing	
		2) Electromagnetic radiation	
		3) Electromagnetic spectrum, with emphasis on optical wavelengths	
		4) Sources of EMR and effects of atmosphere	
		5) Reflectance/reflectivity; emittance/ emissivity	
10:00 - 11:20	III.	Spectral characteristics of earth-surface materials	LAB
11:20 - 11:30	IV.	Spectral characteristics of geologic materials	DKS
11:30 - 1:00	LUNCH		
1:00 - 2:00		Spectral characteristics of geologic materials (cont)	DKS
2:00 - 3:30*	V.	Detection of EMR	
		1) Photographic detectors	DKS & LAB
		2) Photon and thermal detectors	LAB
		3) Optical-mechanical scanner systems	LAB
		4) Instataneous field of view (IFOV), spatial resolution	LAB
		5) Geometric and radiometric fidelity	LAB
3:30 - 5:00	VI.	Characteristics of Imaging Systems	DKS

*There will be a 20-minute break during this session at a time determined by the instructor.

BLM/LARS
April 1980

Tuesday, March 25

8:00 - 8:30		Follow-up on yesterday	DKS
8:30 - 9:00	VII.	Elements of Image Analysis	DWL
		1) Principles of photointerpretation for geology	
		2) Drainage patterns and anomalies	
9:00 - 11:00*	VIII.	Elements of Image Interpretation	DWL
		1) Lithologic Interpretation	
		2) Structural Interpretation	
11:00 - 11:30	IX.	Remote sensor Imagery - an appraisal of applications in geology and mineral inventory	DWL
11:30 - 1:00	LUNCH		
1:00 - 1:45		Remote sensor Imagery - an appraisal of applications in geology and mineral inventory (cont)	DWL
1:45 - 3:00*	X.	Lineament mapping - Colorado	
3:00 - 5:00	XI.	Development of a geologic interpretation - Colorado	DWL
		1) Correlation and land form, drainage, and cover-type patterns for geomorphic interpretation	

Wednesday, March 26

8:00 - 10:00*		Development of a geologic interpretation (continued) 2) structural and stratigraphic interpretation	DWL
10:00 - 11:30	XII.	Introduction to Image Enhancement	DKS
11:30 - 1:00	LUNCH		
1:00 - 1:30		Mid-course evaluation	Staff
1:30 - 3:00*		Development of a geologic interpretation (continued) 3) development of geologic models, using ground-water example	DWL
3:00 - 5:00	XIII.	Image Enhancement techniques and interpretation: ratio, linear stretch, edge enhancement, principal components	DKS

Thursday, March 27

8:00 - 10:30*	XIV.	Interpretation of Mineral Potential 1) Development of a geologic model 2) Landsat data 3) Integration with gravity and magnetic data 4) Development of a field plan for geochemical sampling	DWL
10:30 - 12:30	XV.	Computer Processing of Landsat MSS Data 1) Analog and digital formats 2) Digital processing of multispectral scanner data 3) Principles of Multispectral classification techniques	LAB
12:30 - 1:30	LUNCH		
1:30 - 2:45 } 2:45 - 4:00 }		Parallel Sessions, repeated Tour of BLM IDIMS facility Review and organize notebooks; minicourses	 L. HALL SMD
4:00 - 4:30	XVI.	Availability of Remote Sensing Data	DKS

Friday, March 28

8:00 - 9:00		Availability of Remote Sensing Data (continued)	DKS
9:00 - 10:00	XVII.	BLM use of remote sensing	JJ, DiPaolo, Marker
10:00 - 11:30*	XVIII.	Future Systems	LAB
		1) Thematic mapper	
		2) SPOT-type imaging systems	
		3) Advanced concept remote sensing satellite systems	
11:30 - 12:00		Course evaluation and wrap-up	JJ/SMD

Appendix E. Index to Videotapes

Remote Sensing for Mineral Specialists
March 24-28, 1980

Monday, March 24

1-000*	I.	Introductory comments	JJ, SMD
450	II.	Principles of Remote Sensing:	LAB
		1) What is Remote Sensing	
		2) Electromagnetic radiation	
2-000		3) Electromagnetic spectrum, with emphasis on optical wavelengths	
		4) Sources of EMR and effects of atmosphere	
		5) Reflectance/reflectivity; emittance/emissivity	
3-000	III.	Spectral characteristics of earth-surface materials	LAB
500	IV.	Spectral characteristics of geologic materials	DKS
	LUNCH		
4-000		Spectral characteristics of geologic materials (cont)	DKS
4-500	V.	Detection of EMR	
		1) Photographic detectors	DKS & LAB
5-000		2) Photon and thermal detectors	LAB
390		3) Optical-mechanical scanner systems	LAB
		4) Instataneous field of view (IFOV), spatial resolution	LAB
		5) Geometric and radiometric fidelity	LAB
6-000	VI.	Characteristics of Imaging Systems	DKS

*Tape numbers are followed by approximate counter numbers that mark the beginning of each presentation

<u>Tuesday, March 25</u>

6-448		Follow-up on yesterday	DKS
670	VII.	Elements of Image Analysis	DWL
		1) Principles of photointerpretation for geology	
816		2) Drainage patterns and anomalies	
	VIII.	Elements of Image Interpretation	DWL
7-298		1) Lithologic Interpretation	
748		2) Structural Interpretation	
8-250	IX.	Remote sensor Imagery - an appraisal of applications in geology and mineral inventory	DWL
	LUNCH		
		Remote sensor Imagery - an appraisal of applications in geology and mineral inventory (cont)	DWL
9-199	X.	Lineament mapping - Colorado	
726	XI.	Development of a geologic interpretation - Colorado	DWL
		1) Correlation and land form, drainage, and cover-type patterns for geomorphic interpretation	

Wednesday, March 26

		Development of a geologic interpretation (continued)	DWL
		2) structural and stratigraphic interpretation	
10-215	XII.	Introduction to Image Enhancement	DKS
	LUNCH		
763		Mid-course evaluation	Staff
		Development of a geologic interpretation (continued)	DWL
		3) development of geologic models, using ground-water example	
11-440 12-000	XIII.	Image Enhancement techniques and interpretation: ratio, linear stretch, edge enhancement, principal components	DKS

Thursday, March 27

13-115	XIV.	Interpretation of Mineral Potential	DWL
		1) Development of a geologic model	
		2) Landsat data	
580		3) Integration with gravity and magnetic data	
		4) Development of a field plan for geochemical sampling	
14-120	XV.	Computer Processing of Landsat MSS Data	LAB
		1) Analog and digital formats	
520		2) Digital processing of multispectral scanner data	
770		3) Principles of Multispectral classification techniques	
	LUNCH		
		Parallel Sessions, repeated	
16-000		Tour of BLM IDIMS facility	L. HALL
		Review and organize notebooks; minicourses	SMD
15-600	XVI.	Availability of Remote Sensing Data	DKS

Friday, March 28

17-000		Availability of Remote Sensing Data (continued)	DKS
18-150	XVII.	BLM use of remote sensing	JJ, DiPaolo, Marker
18-750	XVIII.	Future Systems 1) Thematic mapper 2) SPOT-type imaging systems 3) Advanced concept remote sensing satellite systems	LAB
19-400		Course evaluation and wrap-up	JJ/SMD

Appendix F. Summary of Student Evaluations

Course Evaluation

Remote Sensing for Mineral Specialists

March 1980

1. What was the strongest aspect of the course?

2. What was the weakest aspect of the course?

3. To what extent did the course help you meet the stated objectives? (see list of course objectives)

Objectives	Completely	Mostly	Somewhat	Not at all
1	8	5		
2	8	4	1	
3	3	7	1	
4	7	3	3	
5	7	6		
6	4	6	3	
7	4	7	2	
8	7	7	1	
9	5	5	3	
10	3	9	1	
Totals	56	59	15	0

4. What <u>activities</u> should be added to the course to better meet the objectives?

5. What <u>objectives</u> should be added to the course to better meet the needs of the participants?

6. What <u>activities</u> or <u>objectives</u> should be deleted from the course? Please include your reasons.

7. What changes would you suggest in the way the course was conducted?

8. Please evaluate the following portions of the course in terms of relevance/importance and quality of presentation.

(CHECK ONE IN EACH COLUMN FOR EACH TOPIC)

TOPIC	RELEVANCE/ IMPORTANCE	QUALITY OF PRESENTATION
Principles of remote sensing	12 Very important	7 Excellent
	1 Somewhat important	5 Good
	___ Not very important	1 Fair
	___ Unimportant	___ Poor

TOPIC	RELEVANCE/ IMPORTANCE	QUALITY OF PRESENTATION
Spectral characteristics of Earth-surface materials	12 Very important	8 Excellent
	1 Somewhat important	5 Good
	___ Not very important	___ Fair
	___ Unimportant	___ Poor
Detection of EMR	10 Very important	7 Excellent
	3 Somewhat important	5 Good
	___ Not very important	1 Fair
	___ Unimportant	___ Poor
Elements of images analysis and image interpretation	13 Very important	9 Excellent
	___ Somewhat important	3 Good
	___ Not very important	1 Fair
	___ Unimportant	___ Poor
Development of a geologic interpretation	13 Very important	5 Excellent
	___ Somewhat important	5 Good
	___ Not very important	2 Fair
	___ Unimportant	___ Poor
Image enhancement	8 Very important	7 Excellent
	5 Somewhat important	5 Good
	___ Not very important	1 Fair
	___ Unimportant	___ Poor
Interpretation of mineral potential	13 Very important	3 Excellent
	___ Somewhat important	9 Good
	___ Not very important	1 Fair
	___ Unimportant	___ Poor

TOPIC	RELEVANCE/ IMPORTANCE	QUALITY OF PRESENTATION
Computer Processing of Landsat MSS data	9 Very important	7 Excellent
	4 Somewhat important	6 Good
	___ Not very important	___ Fair
	___ Unimportant	___ Poor
Introduction to IDMS	8 Very important	3 Excellent
	5 Somewhat important	6 Good
	___ Not very important	3 Fair
	___ Unimportant	1 Poor
Future Systems	6 Very important	6 Excellent
	7 Somewhat important	6 Good
	___ Not very important	1 Fair
	___ Unimportant	___ Poor

9. Overall the course was: (CIRCLE ONE)

Excellent	Good	Adequate	Fair	Poor
7	5			

10. Any additional comments or suggestions would be greatly appreciated.

Use the back of this sheet.

Course Evaluation

Remote Sensing for Mineral Specialists

March 1980

1. What was the strongest aspect of the course?

Excellent Organization, Capable Staff (varied sysles helped keep concentration up), The capability of the instructors and the use of hand-outs and visuals, The whole course was excellent and all parts were presented very well, A good background was provided from which to continue investigations into the use of Remote Sensing for Minerals Management. Instruction was quite excellent and explanation of questions were quite adequate. Distribution and availability of information was good. Technical content; practical exercises. Lab exercises, except the examples did not seem to prove we could find one bocket (?). Knowledge of the instructors - their hands-on experience. Instructional materials. The exercise in image interpretation. Geologic interpretation of Landsat imagery. Professional presentation. The mapping exercise using the various photos and geophysical data leading to potential mineralized areas. Dr. Levandowski's presentations on the elements of image analysis.

2. What was the weakest aspect of the course?

Lack of prior experience with BLM (should be corrected now that you've had a chance to see some of us). Using SLAR-what it is and how it is obtained and how to interpret. Possibly the use of the exercises were too long and didn't completely bring you through to a result that could be used. Slides were sometimes used as examples however they weren't fully explained. Course length. It was difficult to get a 'feel' for the subject in just one week; a lot of material was covered. Statistical. Participation by some of the class members- but that is beyond your control. Image enhancement. ratioing and image enhancement. Lack of discussion on the newer remote sensing techniques. Lack of precourse study materials. The exercise using stretch, edge, and ratio enhancement photos in Alaska didn't really convince me that I could use them to locate mineralized target areas. No specific aspect identified.

4. What activities should be added to the course to better meet the objectives?

Already fine. As a Government Geologist I would like to see more on how to id gravel deposits and mapping of those deposits. More actual photointerpretation. I felt the objectives were met. For the instructor to go through an image interpretation before having the class try one themselves. Some run-through examples. I would have liked to see information on SLAR data interpretation for geologic uses. Precourse study requirements. More ground related mineral applications within BLM.

5. What objectives should be added to the course to better meet the needs of the participants?

Possibly a more complete example of how remote sensing can be used in the BLM planning process. Needs well met as is. More geologic applications. More on the newer techniques. Could possibly be tied into the BLM minerals program more by the BLM instructors. In other words, at the beginning of the course someone from BLM who has used these techniques could give a convincing discussion on why and how we could better our minerals program by utilizing these techniques. More ground related mineral applications within BLM.

10. Any additional comments or suggestions (from Steven Barrell)

Donna talks too fast and doesn't listen too well.

DAVIS - Crisp style. Positive outlook. Was able to direct progression of course activity throughout with only few period of disorganization (and these were not the result of LARS but DSC). However needs to adjust to more relaxes nature of audience. I got the definite impression that you were disappointed in the lack of enthusiasm (I'm not trying to be negative here; just that it was apparent to me) (I was too). This is a new tool for the Bureau Mineral Specialist and it will just take time before the enthusiasm and interest develops. Notebook, special focus handouts, and all associated support items are tremendous. I have never been involved with a course or workshop where I was as comfortable about having course materials there right when they were needed. I was therefore able to concentrate on absorbing information rather than finding or relating to materials.

EXTRACURRICULAR: Perhaps schedule just an icebreaker session the first night of the course next time. Make it less formal and I bet you'll get more participation.

BARTOLUCCI - Effective relaxed informative.Positive outlook. I was truly amazed at his composure in a new situation. The content of the sections concerning the technical background of remote sensing was very clear. The examples used to illustrate process and mechanism aspects were translated into easily understood concepts. The visual aids including both prepared and spontaneous overhead transparencies, and slides complemented the lecture and the precourse reading assignments. Some people may prefer to have more complete notes on this section, I personally did not feel that was necessary. From a purely audience point of view when he and Donna were both trying to team teach I believe the flow of the course was interrupted. I think that one instructor in the front of the class focussed my attention more on the subject matter. When he was up front with Donna it appeared her confidence was slightly diminished. I don't see how the technical aspects of remote sensing can be reduced any further than Luis did in this course. In its present form I think it is most suited for the diverse backgrounds of the participants. Any expansion of technical level should be weighed carefully. I personally would leave it alone, it's just right. There was a noticeable gap in the transition between what Luis covered in the first day and what Donna did. Perhaps you could add some more transitional material.

If this was Luis' performance when he was feeling ill, you should keep him that way.

DONNA - (next time let someone else run the slide projector and try not to move around so much in front - it's distracting) Energetic, informative. I believe it took you a bit of time to relax. Established a good rapport with the group. Nervousness appeared to stem from lack of confidence about abilities to transfer geologic knowledge to students. This lack of confidence is unfounded. Good technical knowledge. Tended to rush statements occasionally. Slow down a bit and then when up front TAKE CHARGE. Mid-course correction that broke up overlay building worked. Sometimes tended to make explanations more complex than necessary. Answered all my questions, even the dumb ones. Spent time after class and during breaks clarifying problems for me about exercises. Really neat idea to have generated Landsat order example for us that was over our own areas.

LEVANDOWSKI - Effective relaxed, informative. Overcame a very brief initial disorientation with who he was talking to and where slide advance control was to do a fine job. Personable style captured audience concentration. Good coordination between lecture, handouts and slides. During the exercises his assistance on an individual basis was very important; part of the learning process could be lost with much increased class size. I would recommend that Bill Dipaolo be conscripted to act as an assistant providing individual assistance on the exercises and become more heavily involved with the class.

Pre-Training Session Required Readings

The pair of readings transmitted prior to the course provide an excellent overview of what platform or satellite remote sensing technology entails. I read Simpson's paper first and the USGS professional paper second. You might want to include Raeves, Offield, and Santo's paper on uranium mineralization identification as a third. The photogeology minicourse may have particular use as a training aid for those students who have not had much experience with airphoto geology. However, I believe that this lack of experience should be identified through a precourse questionnaire which would request the prospective student to identify his experience or lack of it. Thus you could more fully prepare these students so that they would benefit more from the airphoto geology section of the course. This precourse familiarization could take place several weeks before attendance. I briefly scanned the other available minicourses and it may be that your precourse questionnaire might be coordinated with the availability of each minicourse from the Denver Service Center's Remote Sensing Branch's or with copies held at each State Office. In this manner you could strengthen the understanding of your audience, and increase information reception during the lectures.

For example:

Prior to attending course 9100-11 we would like to know how much experience you have in the following areas:

	Little	Some	A Lot
Photogeology	____	____	____
Side Looking Radar	____	____	____
Etc.			

Several minicourses which discuss in general terms these areas are available from either your State Office or the Branch of Remote Sensing DSC. If you are interested, please indicate below

Photogeology ________
Side Looking Radar ________
Etc.

The course outline that was sent was very helpful. My Area Manager, and the Training Committee in my District reviewed it. Perhaps it could be reproduced in the overall BLM Training Catalog, which is where most training courses are found by area and district specialists, because the general description that I found in this years Catalog was not as good.

6. What activities or objectives should be deleted from the course? Please include your reasons.

   I would have liked to have gotten into Geomorphology (mapping), as that seems like it could relate to finding mineral deposits and if you do geologic interpretation it seems geomorphology is or should be part of it. Okay as is. I think it's fine.

7. I would like to do more lab (photo) interpretation, as the more you do the better you get and the more you can relate to the objectives of doing the interpretations. I mainly came to learn how to and what to look for in doing photointerpretation for minerals. I thought the course was conducted quite well. Felt that most of course information could have been learned from textbooks. Would have benefited from more personal experience of instructors i.e. real world approaches, pitfalls, expediences, etc. Put the Franch film or something similar at the beginning. More precourse material. Perhaps several exercises 35-45 days in advance which could be completed and sent for correction. No specific suggestions, however I assume with time the instructors' presentations will become more "polished."

ADDITIONAL COMMENTS (That arrived later)

1. What was the strongest aspect of the course?

   Don Levandowski - Geology
   Luis Bartolucci - Classification process
   Both well organized

2. What was the weakest aspect of the course?

   Some speakers were not as prepared as could have been (although I understood the circumstances). Some presentations seemed confusing. Hydrology example was too drawn out - possibly only northern or U.S.A. half of scene could have been analyzed.

4. What activities should be added to the course to better meet the objectives?

   I thought all activities and outline as presented were good. Maybe an activity on very simple geologic mapping based on a visual analysis of imagery may have been helpful. Hints were mentioned such as different types of drainage occuring on different parent materials, but a small practical exercise may have been useful.

5. What objectives should be added to the course to better meet the needs of the participants?

   Since this part of the course was on image analysis (mainly), possibly as an objective we could have the use and incorporation of various forms of imagery (B/W, color, CIR aircraft photos, U-2 or RB-57 type, Skylab, and Landsat imagery) into the daily work routine of the BLM District Geologist. Also, the use of digital classification and enhancement for smaller areas (i.e. planning unit) as a working tool for the BLM District Geologist. Also maybe more on planning or funding of Landsat projects.

6. What activities or objectives should be deleted from the course? Please include your reasons.

   Again - possibly decreasing the length or area of some of the overlay exercises (expecially hydrology); don't delete it, but somehow cut down time. Also, length of time spent on learning how to acquire Landsat imagery could have been cut down by just showing code strip which comes with all orders and interpret computer search sheets. Also, no mention was made of procedure for ordering NASA aircraft photos and indexing of photo strips.

7. What changes would you suggest in the way the course was conducted?

   Knowing this was a first cut, I think the general outline was good. The first part on the EM spectrum was a little confusing. I think the whole first day may have been presented more in a step-wise building fashion. I think this was the intent, but somehow it was confusing. Maybe too much time was spent on mathematical laws or solar curves?

Appendix G. Staff Evaluation

Remote Sensing for Mineral Specialists:
Image Interpretation

Evaluation and Recommendations from Course Staff

Evaluation of March 1980 course

The course staff are unanimous in their feelings that, for the most part, the course went very well. The students who responded on the evaluation said that overall the course was "excellent" or "good," seven and five votes, respectively; no student ranked it at adequate, fair, or poor. They felt the objectives were completely met 46% of the time, mostly met 49% of the time, and somewhat met 12.5% of the time. All course objectives were ranked as having been met at least to some extent.

Despite these generally favorable evaluations of the course, there are a number of recommendations that the staff would make for future offerings of this course. They are summarized below. Many of them evolved as a result of student comments and suggestions from the contract monitor.

Recommendations for Changes in Course Content

1. Include fuller explanation of how the numerical data Landsat collects can be used to construct black-and-white and color images.

2. Develop a case study that is based on actual remote sensing work that BLM has done. Such a case study would start with the specification of needs, discuss data selection and analysis for different land types, and, if possible, costs and work-months should be given. Such a case study could be used effectively as an interest-catching applications example early in the course; it would also serve later in the course as a scenario for geologists to follow in adapting the approach for their own areas. Demonstrations by <u>example</u> rather than <u>rule</u> are called for.

3. Add more material on the power of Landsat images as a data base, specifically their usefulness for planning other surveys and overlaying other kinds of data.

4. Add information about radar data in geologic work.

5. Add some material on thermal data.

6. Add an exercise on basic geologic mapping using Landsat images.

Recommendations Related to the Methods of Presentation

1. Adapt the Arizona data overlay workshop so that it takes less class time. This could be done by preparing and distributing each overlay half complete; students would then be asked to complete the overlays, using the completed half as a model. This change would save several hours of class time.

2. Make the presentation on the fundamental concepts (Monday) more approachable. Several strategies could be adopted; for example, intersperse the lectures with more activities, delete some of the formulas and physics material, either completely or until some time later in the course when students really have questions about the physics.

3. The fact that five of the seven students who responded thought that the discussion of enhancements was not important suggests that the material was not well presented. Some suggestions for improvement are to use different enhanced images (Nabesna quad is, however, a good area); show some enhancements as black and white images instead of color composites; develop a geologic mapping exercise in which students see what they can map from Landsat and then look at a gradient or ratio image to discover what more they can map with those images.

4. Develop a better example to show how additive colors interact.

5. Give several 15-20 minute quizzes, perhaps first thing each morning, for participants' self-evaluation.

6. Although technically correct, some of the slides used in the introductory lecture could be revised from an educational/visual point of view.

7. In presenting the elements of photointerpretation, show examples of each major rock type on both Landsat images and air photos and point out clearly what interpretations can be made. Supporting this discussion with printed hand outs would be helpful.

Recommendations for Student Materials

1. Develop and distribute technical bibliographies for all major sections of the course. (One of the three instructors did this.)

2. Develop and distribute a glossary of remote sensing terms and acronyms; sample entries: enhancement, multispectral classification, univariate, multivariate, geometric correction, preprocessing, radiometric correction, line printer format 1600 BPI, atmospheric correction, CRT, CCT, etc.

3. Include black-and-white printed versions of Landsat and aerial photos on which lithologic mapping is demonstrated.

4. Look through the existing literature for a basic, non-mathematical presentation of the basic principles of energy transfer, spectral characteristics, and energy detection. This material should be sent ahead for students to read before the course, perhaps in place of the USGS Professional Paper, supplied this year.

5. In order to reduce discrepancies in students' backgrounds, require that they study four basic minicourses prior to attending the course:

   a) those who haven't had a course in photogeology should complete the two minicourses: "Principles of Photointerpretation" and "Photogeology";

   b) those who have no experience with radar should complete the minicourses "Side-Looking Airborne Radar" and "Interpreting Radar Imagery."

6. Align imagery the same way in the notebooks and provide additional acetate sleeves for books that cannot be punched.

7. Give students more complete lecture notes, even verbatim transcriptions.

8. Look into different kinds of photographic papers that do not curl; someone suggested a paper called R.C. resin-coated paper.

Recommendations for Course Design Activities for Future Offerings of this Course

In order to get a better appreciation of the remote sensing work of BLM and to phase into the period when BLM staff will be conducting the training, the course staff makes the following recommendations:

1. BLM should appoint an experienced employee who can serve as one of the instructors for the course and be a part of the course team. This person's familiarity with BLM remote sensing projects and his access to project materials would be important in developing a good case study. Ideally he should spend a week or more with the course design team, helping the team better understand the needs of BLM. During the course he could present the sections that he is most comfortable with.

2. Prior to course design activities, BLM should provide a functional job description for the students who will be attending, including specific responsibilities they have and tasks they are expected to perform. In addition sample training manuals for courses they already have completed would give instructors a fuller understanding of the base they can build on.

3. Review the course objectives and revise as needed.

Recommendations related to Logistics, Equipment, and Facilities

1. Shorten lunch to one hour; leave a half hour earlier in the afternoon.

2. Schedule more voluntary social activities, such as drinks on Monday and a "Dutch" dinner on Tuesday, or Wednesday. At lunch time, see about reserving tables in the cafeteria where course members can sit together.

3. Make the evening session(s) more structured, or drop them entirely.

4. Audio-visual equipment:

   a) have a blackboard available too
   b) keep slides in focus
   c) have a glass plate to put over negatives on the overhead projector to keep them from curling.

Evaluation from D.K. Scholz

Introduction

Overall, the "Remote Sensing for Mineral Specialists" short course at Denver went well. There were strong points as well as weak ones, but I believe participants felt the week well spent.

Strong Points of Course

One of the most positive aspects of the course was the interaction of the participants and instructor staff. This was possible because of the limited class size and the opportunities for discussions during break periods. This was due to the ideal situation of having classroom space so near snack bar, cafeteria and remote sensing staff offices.

A second positive feature of the course was the team teaching approach Luis and I used during the Imaging Systems session and the Image Enhancement session. It was impromptu at the time, but could be designed to optimize each person's knowledge and to add a variety to the instructing procedures for both participants and staff.

Weak Points of Course

One of the major weak points was the quality of imagery used in the Image Enhancement session. Along the same lines, handout materials should be generated to go with that session. Although there are slides and references to material the participants received prior to the course, there should have been a structured outline and some handout graphics. This is particularly true for principal components enhancement techniques and contrast stretch.

A second weak point I noted was the rapid manner examples of geologic image interpretation were gone through on Tuesday. More time spent in explanation of fewer examples coupled with a brief exercise or two might have been more effective.

Recommendations

Jean mentioned a few suggestions during the course week. A specific comment was to introduce the concept of Landsat color composites earlier in the week. Then the participants could start working with images the first day, but not be told how the images were derived until the Image Enhancement session.

There should be fewer examples, with more specific discussions of the Elements of Image Analysis concepts that are mentioned above, particularly, discussion of rationale during interpretation of images.

Better images for the Image Enhancement session are badly needed. This could be done either by a totally different Landsat data set (perhaps over a current BLM project area) or by simply improving the current Nabesna images.

As mentioned earlier, handout materials supporting the Image Enhancement session should also be prepared. This should include an outline and graphic figures where necessary (stretch, principal components, and ratio). Ideally, space would be included in the materials to allow participants to comment about advantages of specific enhancement techniques.

The demonstration on the BLM IDIMS was a good one, but an even better demo could be included that would show a geologic application with emphasis on concepts covered during the course week (particularly enhancement techniques since this part of the course deals with image interpretation).

Less time should be scheduled on the IDIMS system in discussion and more spent on some of the exercises earlier in the week. Ideally the image inter-the image interpretation and/or enhancement exercises could be expanded.

One of the most important recommendations should be that course size be kept down to around]5 participants.

Also, I felt I would have been more efficient as an assistant instructor to Dr. Levandowski if I had reviewed his overlay exercises with him prior to class time. Some exercise instructions were unclear as written and needed clarification before participants could proceed. Going through the exercises with the participants greatly aided me in understanding the problems that arose.

Another recommendation would be to have labels for the dividers in student notebooks. At times, handing out materials during class time was hectic. Perhaps preassembled and labeled sections would be easier on staff and students alike. This could be handled even by assembling sections and handing them out prior to each lecture day. Sutdents' notebooks were in differing degrees of disarray which caused some problems in finding material once it had been filed. Suggested labels could include:

- Principals of Remote Sensing
- Characteristics of Imaging Systems
- Image Interpretation
- Image Enhancement
- Computer Processing
- Availability of Data
- Future Systems

Luis' recommendation that a summary period be set aside at the end of each day with a lead-on for the material to be covered the next is an excellent way to add cohesion to the various instructors and their topics and help participants organize their thoughts.

Summary

We did an acceptable job for a first attempt. The second will be far better, for the insights we gained on almost every aspect of the course can do what no amount of planning could have.

Appendix H

Design for Part II of the Course "Remote Sensing for Mineral Specialists"

Introduction

Staff geologists employed by BLM were offered an introductory remote sensing course in visual interpretation of remote sensing data. The course, which was presented at the Denver Federal Center by Purdue University, was attended by fourteen mineral specialists.

The next step in the training sequence for these participants is to introduce them to digital techniques for extracting information from remote sensing data. The present availability of such data as well as user-oriented computer configurations makes remote sensing an attractive and effective tool for geologic analyses.

While photogeology techniques may continue to be the main means of Landsat interpretation, the amount of information recorded in the data far exceeds the amount that can be represented on a photograph. To make wise resource judgments, today's geologists need to have access to computer-aided technology, both through available hardware and through a familiarity with the technology that enables them to assess realistically the value of this tool to provide the information they need.

The approach described below has been designed by LARS/Purdue staff specifically for providing this training in digital techniques to BLM staff geologists.

1. Target audience

BLM geologists who wish to continue their study of remote sensing to include digital techniques should have a firm background in visual interpretation of photographic imagery and multispectral scanner imagery. Specifically they should understand:

a) sources of electromagnetic radiation and means of detecting it;

b) the interaction of earth surface materials with impinging radiation;

c) the principles involved in the formation of standard Landsat image products;

d) principles involved in the formation of enhanced imagery, especially linear stretch, principal components, and ratioing.

No previous experience with computer processing is necessary. Because of the individualized nature of the course and the limited facilities available, a maximum 16 participants should be enrolled. Where possible two from the same state should work together as a team; an alternative approach would be to pair participants who work with similar land types.

2. Objectives and Methods

The general objectives of the course are to acquaint the participants with digital techniques for obtaining geologic information from satellite multispectral scanner data. Techniques used for this purpose include both enhancement techniques (for subsequent visual analysis) and digital analysis for classification. Because of the greater complexity of the later approach, relatively more class time will need to be set aside for work in topics related to computer classification if the students are to gain enough information and experience to be ready to use this tool in the future.

A person who wishes to start using digital enhancement and analysis techniques needs to complete a number of learning activities. Specifically, he/she needs to:

1) acquire an understanding of the fundamental concepts behind computer-aided processing,

2) learn to work comfortably in the computer environment and be familiar with basic user-oriented hardware and software,

3) practice using the hardware and key processing functions through tutorial exercises highlighting the fundamental concepts, and

4) be aware of related work that has been done in their field using these techniques.

A variety of lectures, exercises, and hands-on activities would be the best instructional media to use for meeting these objectives.

In one week's time and with the limited number of computer terminals available, it is unreasonable to expect that course participants would be able to use digital techniques with a high degree of skill at the end of the course, much less assess fully the utility of these techniques in their own work. Acquiring that amount of expertise requires extensive experience both with the data and with the software. However, it is not too much to expect participants to acquire a good foundation in understanding the theory of digital processing, feel comfortable working in the environment of a computer terminal, and be able to perform basic functions on data of their choice. Familiarity with some of the published work of other geologists will help guide their own experimentation. In addition, some advanced analysis techniques should be introduced during the course to give participants a glimpse of possibilities yet ahead. Examples include an introduction to hierarchical classifiers, use of spatial features in analysis, and building geographic information systems. This last topic may well form the basis for a third course in the sequence.

Their are many systems available today for digital enhancement and analysis of remote sensing data, and the next five years will doubtless see the arrival of others. For these reasons, it is essential that geologists who are to be trained for tomorrow as well as today have their learning focused not on specific, machine-dependent features, but on basic concepts, such concepts as ratio enhancements, minimum distance to the mean classifications, and separability measures which are basic to all fully developed digital systems. Although the way a user calls up the software will vary from one system to the next, these motor skills are quickly learned by the user who has a theoretical understanding of the operations the software is performing.

By necessity, the hands-on portion of the course will be focused on a single system, such as the IDIMS system, but instructors should strive to broaden participants' perspectives to encompass other systems and the machine-independent concepts basic to all systems.

3. Course Content

In keeping with these objectives and methods, the course content would include the following major topics, although not necessarily in this sequence. The percentages given indicate the relative class time devoted to each category.

I. Basic image manipulation (10%)

   A. Masks, grids, graphics overlay
   B. Radiometric and geometric transformations

II. Image enhancements for mineral investigations (25%)

   A. Examples of the usefulness and limitations of image enhancements, specifically contrast enhancing, edge enhancements, ratioing, principal components analysis

   B. Theory supporting the generation of enhancements with emphases on the selection of enhancement parameters

   C. How to obtain your own enhancements, from vendors and from interactive terminals

   D. Use of visual interpretation techniques for information extraction

   E. Evaluation techniques

III. Computer-aided classification of multispectral data (35%)

   A. Univariate classifications: single-band classifications, level slicing, change detection

   B. Fundamentals of computer-aided decision-making: look-up table, partitioning, pattern recognition; statistical distance measures

   C. Multivariate classifications: unsupervised, minimum-distance-to-the-mean classification, maximum-likelihood classification; selection of training samples

   D. Evaluation of results

   E. Introduction to hierarchical classifiers (layered classification, cascade classifier) and analysis using spatial features

IV. User-interface with data processing systems (15%)

   A. Characteristics of input and output devices; obtaining hard-copy output

   B. Impact of system characteristics on user's ability to do analysis: structure of data; storage methods; array processors

C. System evaluation

V. Brief introduction to geographically organized data bases (15%)

A. Data base design

B. Introduction of digital data from other sources

C. Analysis potentials

A variety of teaching approaches should be used throughout, including a minimum of four one-hour sessions for each pair of participants using an interactive image manipulation device. Activity-oriented laboratory exercises should be used to enforce theory and to give participants practical experience in working with the data. From the point of view of course relevancy and potential for future use of the techniques, it would be ideal for participants to work with multitemporal Landsat data from areas within their own districts. This would allow them to work with areas they know and to assemble existing support data prior to attending the course. The importance of current support data (e.g., topographic maps, aerial photos, ground data, etc.) in digital analysis must be stressed so participants learn to use the tool in a scientific way. By working with their own geographic areas, they would know what data would be accessible for future analysis and they would be better able to assess, at least summarily, the potential contribution of the newly learned techniques.

4. Student and instructor materials

As part of the creation of this new course, a body of tutorial materials will be assembled for use by both the students and instructors. In some instances, the materials may be identified from the open literature, for example reprints of tutorial journal articles that address aspects of the course at an appropriate level. In other cases, materials may be taken from existing teaching files of instructors, and in still others, materials may need to be newly created for the course. All should be carefully assembled and retained for future offerings of the course, whether by the initial development group or by other instructional teams.

Student materials include such items as preliminary reading sent prior to the course, printed handouts distributed during the course, and copies of photographs, imagery, maps, printouts, etc., that all students uded during the course. Instructor materials are more extensive, including, in addition to the student materials, such items as:

* outlines or abstracts of lectures,
* slides, transparencies, and display materials,
* descriptions of laboratory or hand-on exercises, including equipment needed and problems frequently encountered.
* reproducible copies of needed photography, computer data tapes, etc., or a list of the sources of these materials.
* evaluation of the course by the students and the instructors with suggestions for future presentations of this course

The full documentation of the course may include more than these items listed. The intent is that enough document exists to make it possible to offer the identical course in the future at considerably less cost or to be able to direct wisely the expenditure of funds for course improvements.