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NATURAL RESOURCES PROGRAM

SPACE APPLICATIONS PROGRAMS

TECHNICAL LETTER NASA-59

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

Technical Letter
NASA-59
August 1966

Dr. Peter C. Badgley
Chief, Natural Resources Program
Office of Space Science and Applications
Code SAR, NASA Headquarters
Washington, D. C. 20546

Dear Peter:

Transmitted herewith are 2 copies of:

TECHNICAL LETTER NASA-59

ANALYSIS OF EARTH ORBITER

TEST SITE PROGRAM IN

RELATION TO U.S. MINERAL NEEDS*

by

W. D. Carter**

Sincerely yours,

William A. Fischer
Research Coordinator
Earth Orbiter Program

*Work performed under NASA Contract No. R-09-020-013
**U. S. Geological Survey, Washington, D. C.

UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TECHNICAL LETTER NASA-59

ANALYSIS OF EARTH ORBITER TEST SITE PROGRAM IN RELATION TO U.S. MINERAL NEEDS*

by

W. D. Carter**

August 1966

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Prepared by the Geological Survey for the National Aeronautics and Space Administration (NASA)

*Work performed under NASA Contract No. R-09-020-013

**U. S. Geological Survey, Washington, D. C.

CONTENTS

INTRODUCTION

An analysis of the objectives, scope, and results of the current NASA Earth Resources Program and specifically its Test Site Feasibility Program is timely and necessary to determine its relation to the Nation's needs for mineral resources. It is hoped that such an analysis will help formulate a better, more complete program, for it is mainly through this program that we will determine the criteria and develop an ability to recognize geologic features by remote sensing. Through this analysis we hope to find areas of weakness that will lead to recommendations as to where and on what mineral commodities to focus such portions of the Natural Resources Program as the aircraft test site feasibility studies and, thereby, do a more effective job.

Heretofore, most geologic test sites have been selected by proposals submitted on a voluntary basis by individuals specifically interested in remote sensing and actively working in the areas listed (See Test Site List Appendix 1). Although most of these sites cover a wide variety of geological problems and many include mineral deposits or commodities of national importance, it is believed that certain mineral commodities currently in short supply and great demand, may have been overlooked. It is for this reason, that the following analysis is made.

A list of the mineral commodities in critical shortage has been developed (Table 1) and is compared with a list of sites presently under investigation. Such a comparison suggests areas where aircraft feasibility studies might be conducted in addition to those areas already scheduled. Competant scientists who could analyze data from areas known to contain critical mineral commodities are proposed.

SUMMARY OF OBJECTIVES:

The general objectives of the Natural Resources Program are summarized as follows:

Feasibility and Research Phase:

a) To determine the type of geologic, mineral resources, hydrologic, geographic and cartographic investigations most amenable to solution by remote sensor data,

b) To ascertain which remote sensor data are most useful to perform these investigations,

c) To determine what resolutions, areal and temporal coverage, and other parameters will provide the most meaningful data for those investigations,

d) To define and develop spacecraft experiments to acquire the necessary data,

e) To develop a community of scientists capable of productive use of remote sensor data.

Operational Phase:

To gather natural and cultural resource data with spaceborne instruments in an operational, repetitive manner for the benefit of mankind.

TEST SITE PROGRAM

The aircraft overflight feasibility program is specifically designed to test the use of the various remote sensing instruments over sites where ground information on what the instruments are recording. The study is designed not only to test the instruments but to determine the way geologic features react and are recorded by a given instrument. The reactions recorded by the instruments are referred to as "signatures" and are used for identification just as fingerprints are used to identify people. Experience in recognizing signatures of specific mineral commodities is needed if we are to take full advantage of earth orbiting space vehicles equipped with remote sensors.

ANALYSIS OF PRESENT STUDIES:

Figure 1 shows that economic growth of the nation is paralleled by an ever increased consumption of minerals and fuels. Part A is from the U.S. Geological Survey Long Range Plan, published in 1964. Part B is merely a straight line projection of trends based on the data presented in Part A. This type of projection shows that the Gross National Product will probably more than double by 1990 as will fuel consumption. Mineral consumption, on the other hand, will also increase, but at a somewhat slower rate. Most easy to locate high grade deposits have already been found. Lower grade concealed deposits are the object of most exploration projects today and new tools are required to find them. Remote sensing tools borne by air and spacecraft can help provide some of the data needed to improve our ability and rate of resource discovery.

There is considerable concern about our current balance of payments and the outflow of gold from the United States. Much of this problem stems from the fact that we have become largely a consumer nation, importing more than we export. Much of what we import is raw materials, principally mineral and fuel commodities. There are two reasons for this: 1) certain raw materials either do not occur within the conterminous United States or they can be obtained more cheaply elsewhere due to better grade of ores or lower production costs conditions; and 2) certain other raw materials are consumed at a faster rate than we are able to discover, develop and exploit them.

Figure 2 shows the estimated reserve life of certain basic mineral commodities. Special attention is called to those that have less than 100 years reserve life.

This list is compared with twenty of the geological test sites that include and are oriented primarily toward mineral resource studies (Table 1). This comparison shows the present test sites of interest, their principal commodities and by-products as well as the responsible investigator. Table 2 is a matrix diagram listing the mineral commodities considered to be in short supply and remote sensor instruments. The x's indicate the instrument or

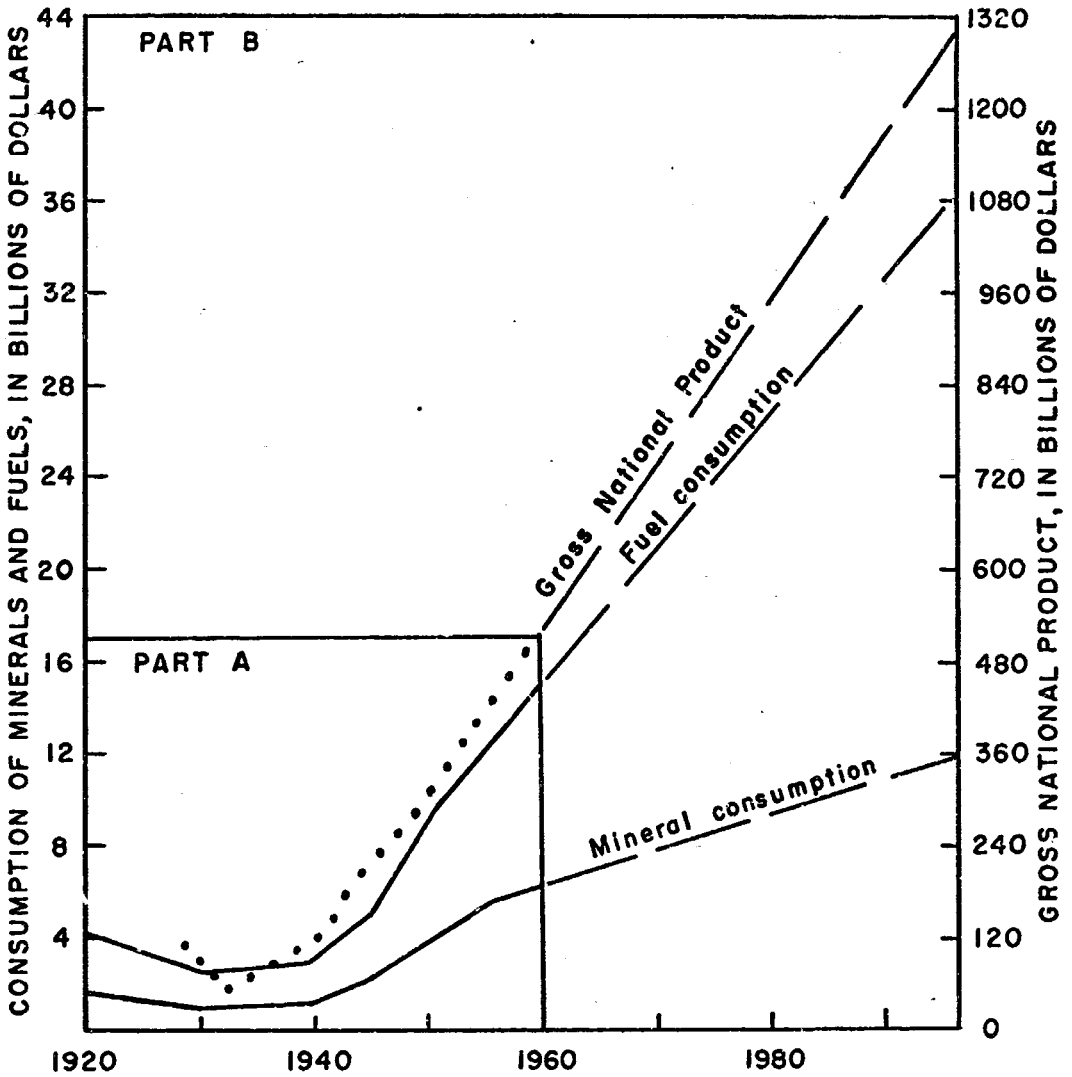
instruments most likely to be of use in search for the corresponding commodity and those for which data signatures should be determined or developed. The numbers at the base of the table indicate the total numbers of current projects that contain deposits of these commodities. It is readily seen that areas containing silver(10), gold(9) and copper(7) are receiving greatest emphasis. Iron is included in five project areas, as are zinc and lead. Mercury has been mined from two sites within the program while antimony, manganese, liquid hydrocarbons, natural gas and molybdenum are reported from or have been produced from single areas.

The most important feature of this chart, however, is the indication of those commodities where little or no work is presently contemplated; namely, chromite, bauxite, cobalt, tungsten, bismuth, sulfur, fluorspar and titanium.

RECOMMENDATIONS:

It is recommended that sites known to contain those commodities listed above that are not included in the present program be selected as soon as possible to test airborne remote sensing equipment. Furthermore, selection of additional areas known to contain antimony, manganese, petroleum, natural gas and molybdenum is recommended to strengthen the program.

A list of potential sites is offered in Table 3. Competent geologists to study the suggested areas can be found within the Geological Survey or in the geological community. Perhaps, they or others can offer more appropriate sites on which to focus remote sensor studies.



Econo.nic growth depends on increased consumption of minerals and fuels.

Figure 1.

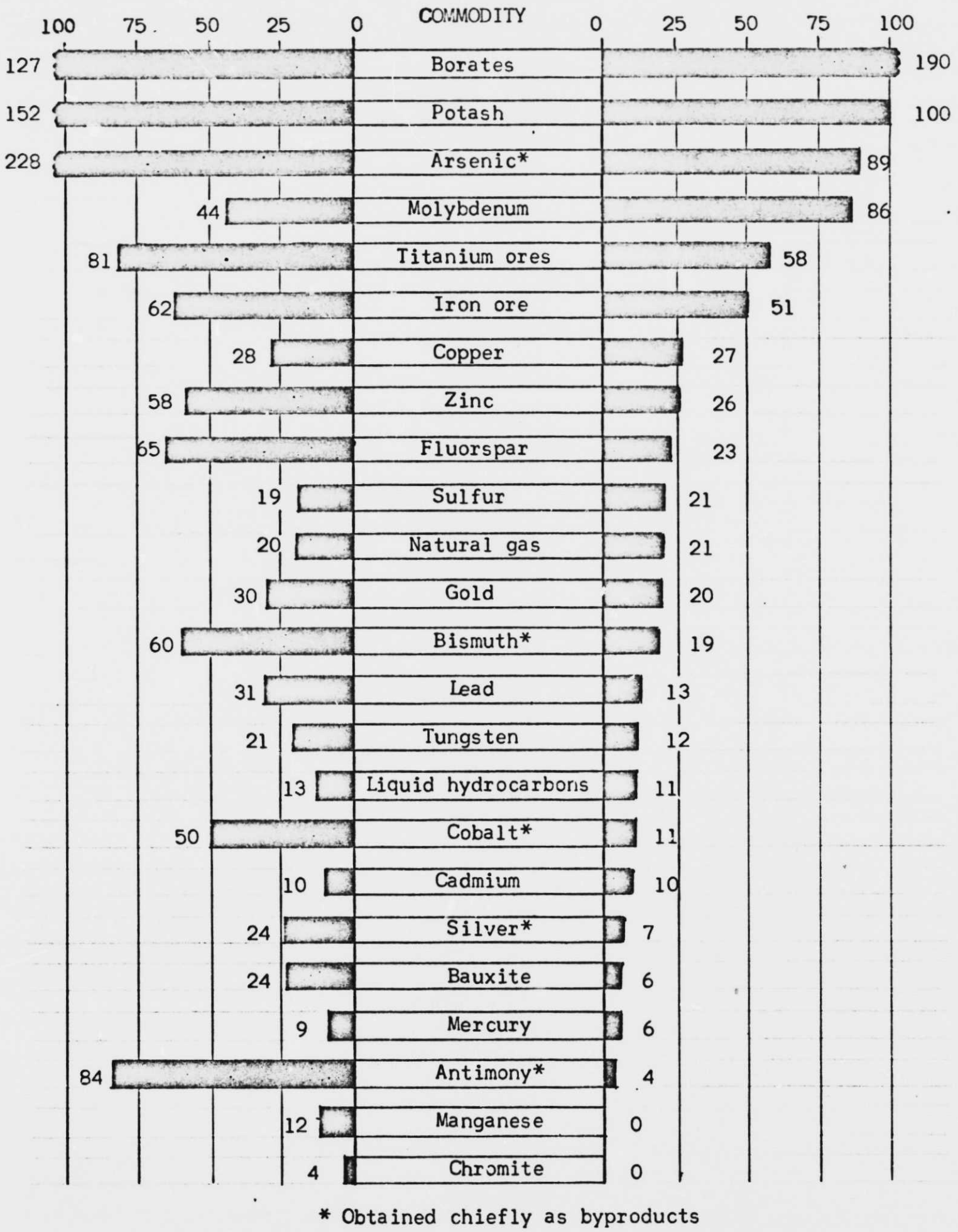


Figure 2. Known minable U.S. reserves of many minerals constitute only a few years supply; potential resources are substantial but must be developed.

TABLE I. Mineral Resource Studies included in the NASA Remote Sensing Test Sites Program

Test Site No.	Mining Districts Presently Included in Test Site Program	Element(s) or Commodity present	Responsible Investigator
1)	Cedar City (Iron Springs) Utah	Fe	Lowell S. Hilpert
5)	Eureka (Tintic Dist.) Utah	Pb,Zn,Ag,Au	H. Morris/T. Lovering
6)	Salt Lake Dist., Utah	Cu (Bingham) Au,Mo	M. Crittenden/R. Roberts
9)	San Francisco, Dist.,	Ag,Pb,Zn,Cu	Lowell S. Hilpert
10)	Carson City (Comstock Dist.) Nevada	Au,Ag,Fe,Hg	D. White/G. Thompson
13)	Silver City (Central Dist.) N. Mexico	Ag	Recessed
14)	Little Dragoon Mtns, Ariz.	Cu	J. Cooper
15)	Twin Buttes (Pima Dist.) Arizona	Cu	J. Cooper/F. Simons/ F. Canney
21)	Battle Mtn., Nevada	Pb,Zn,Cu,Au,Ag,Sb	M. Crittenden/R. Roberts
22)	Tonapah, Nevada	Au, Ag,	H. Cornwall/P. Theobold
37)	Ouray, Silverton Creede Districts, Colorado	Au,Ag Tellurides	L. Schmitt
38)	Great Sage Plain, Utah Colorado	Au,Mn,U-V,Ag,Cu,Se, Oil, gas, K	D. R. Shawe/R. Brokaw
41)	Mesabi Range, Minn.	Fe	P. K. Sims

Test Site No.	Mining Districts Presently Included in Test Site Program	Element(s) or Commodity present	Responsible Investigator
42)	Gogebic Range, Mich.	Fe	W. Prinz
73)	Lynn Dist., Nevada	Au,Ag,Hg	R. Roberts
75)	Goldfield, Nevada	Au,Ag,Pb,Zn,Cu	J. Albers
78)	Cleveland Co., N.C.	Th (Monazite placers)	W. C. Overstreet
79)	Matewan, Kentucky	Coal	D. C. Alvord
83)	Ironton(s), Missouri	Fe	P. W. Guild
88)	Mississippi Valley	Pb,Zu	D'Agostino/Heyl
89)	Blackbird Dist. Idaho	Co	F. Canney
94)	NE Pennsylvania	Peat	C. C. Cameron

TABLE 2 - SUGGESTED REMOTE SENSOR INSTRUMENTS THAT MIGHT BE USED TO AID DISCOVERY OF NEEDED MINERAL COMMODITIES (THOSE SHOWN HAVE A RESERVE LIFE OF < 100 YEARS AT 1960 RATES OF PRODUCTION AND CONSUMPTION)

	MINERAL COMMODITIES IN DECREASING ABUNDANCE																				
INSTRUMENT	Molybdenum	Titanium ores	Iron ore	Copper	Zinc	Fluorspar	Sulfur (native)	Natural gas	Gold	Bismuth	Lead	Tungsten	Liquid Hydrocarbon	Cobalt	Cadmium	Silver	Bauxite	Mercury	Antimony	Manganese	Chromite
1. Metric Camera	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2. Panoramic Camera																					
3. Ultrahigh Resol. Cam.																					
4. Multiband Synoptic Cam.	?	?	?	?			?		x									?			
5. Radar Imager	x		x	x	x	x	x	x	x				x		x						
6. Radar Scatterometer	x		?	?	?		?	?	?	?			x	?	?		x				
7. Infrared Imager	x			x	x			x		x			x		x	x	x				
8. IR Radiometer/Spect.	x			x												x	x				
9. Microwave Imager																					
10. Microwave Radiometer																					
11. Magnetometer		x	x											x							x
12. Gravity Gradiometer							x						x	x							x
13. Absorption Spectrometer				x	x		x	x					x					x			
14. Radio Freq. Reflec.			?	x							x							x			
15. Ultraviolet						x						x	x								
16. Laser Altimeter							x	x					x								
No. of current projects covering mineral commodities	1	0	5	8	6	0	0	1	9	0	6	0	1	1	5	10	0	2	1	1	0

TABLE 3 - List of needed mineral commodities not presently included in the current test site program; and suggested areas recommended for study.

Mineral Commodity	Recommended Area to be Studied
1) Chromite	John Day area, Oregon, Great Serpentine Dike, California Stillwater Complex, and Alaskan Ultramatics
2) Manganese	Cuyuna Range, Brainerd, Minn. Boston Hill Dist., N. Mexico
3) Antimony	National Mine, Nevada Kern County, California Coeur d' Alene, Idaho
4) Mercury	Calistoga, California Terlinqua Dist., West Texas Steamboat Springs, Nevada
5) Bauxite and Attapulgite	Georgia-Alabama
6) Cadmium	a by-product of zinc ores Joplin District, Missouri
7) Cobalt	LaMotte & Fredricktown Mines, Missouri - Duluth Gabbro, Minn.
8) Liquid Hydrocarbons	Los Angeles Basin-California Region, Rocky Mountain - Texas Region - Appalachian Region
Oil Shale	Colorado, Utah (Uinta Basin)
9) Tungsten	San Francisco Mine
10) Bismuth	a by-product of lead ores
11) Natural gas	SE New Mexico for oil, gas, potash studies; Pt. Barrow
12) Sulfur	Gulf Coast area - Texas, La.
13) Fluorspar	Illinois - Colorado
14) Titanium Ore	Lake Sanford, N.Y., Iron Mtn., Wyoming, Cumberland, Rhode Island
15) Molybdenum	Climax, Colorado

APPENDIX I

Geology Test Sites

Test Site Ident. No.	Area Names	Responsible Scientists
1.	Cedar City (Iron Springs, Utah)	L. Hilpert
4.	Carrizo Plains, Calif.	R.E. Wallace/R.M.Moxham
5.	Eureka(Tintic District, Utah)	H. Morris/T.Lovering
6.	Salt Lake (Salt Lake Dist.) Utah	M. Crittenden/R.Roberts
7.	Coast Range, Oregon/Washington	P. Snavely
8.	South Oregon Strip, Oregon	G. W. Walker
9.	San Francisco Dist., Utah	L. Hilpert
10.	Carson City (Comstock Dist.) Nevada	D.White/G.Thompson
11.	Yellowstone Nat'l Park,Wyo/Montana/Idaho	A. Campbell,et al
12.	Crater Lake, Oregon	G.W.Walker/R.M.Moxham
14.	Little Dragoon Mtns., Arizona	J. Cooper
15.	Twin Buttes(Pima Dist.) Arizona	J.Cooper/F.Simons/F.Canney
16.	Solitario,Texas	S.J. Gawarecki
17.	Baltimore(Harford-York,Md/Pa.)	D.L. Southwick D.U.Wise(Franklin&Marshall)
18.	Hagerstown(Central Appalachian Piedmont, Md./Pa./Va.)	J.C. Reed, Jr.
21.	Battle Mtn.(Rye Patch Res.-Ruby Mtns,Nev.)	M.Crittenden/R.Roberts
22.	Tonopah, Nevada	H.Cornwall/P. Theobold
23.	Inyo Nat'l Forest(Ward Mtn-Crater Mtn. site)	P. Bateman
24.	San Andreas Fault, Calif.	R.E. Wallace
28.	Winslow(Meteor Crater) Ariz.	G.G. Schaber
37.	Ouray(Silverton/Creed Dist.&San Juan 2° Quad.)	T. Steven
38.	Great Sage Plain(Lisbon Valley Dist.)Utah/Colo.	D. Shawe/A.Brokaw
41.	Mesabi Range	P.K. Sims (U. Minn) R.G.Reeves
42.	Ottawa Nat'l Forest(Gogebic Range)	W.Prinz/R.G.Reeves
52.	Nevada AEC	R.H. Morris
53.	Spanish Peaks,Colo/Cedar City,Utah	T.Steven/D.Wyant
54.	Smoke Creek Dsert/Heber, Utah	M. Crittenden/R.Roberts
56.	Mt. Lassen, Calif.	R.M.Moxham
57.	Hawaii	R.G.Reeves R.J.P.Lyon(Stanford U)
58.	Valles Caldera, N.M.	R.M. Moxham
61.	The Geysers, Calif.	R.M. Moxham
62.	Mt. Shasta, Calif.	R.M. Moxham
63.	Newberry Craters, Oregon	G.W. Walker/D.A. Swanson/ R.M. Moxham
64.	Central Cascade Range	G.W. Walker/D.A.Swanson
65.	Mt. Hood, Oregon	G.W. Walker/D.A. Swanson/ R.M. Moxham
66.	Mt. Adams, Washington	G.W.Walker/D.A. Swanson/ R.M. Moxham

67.	Mt. St. Helens, Washington	G.W. Walker/D.A. Swanson/ R.M. Moxham
68.	Mt. Rainier, Washington	G.W. Walker/D.A. Swanson/ R.M. Moxham
69.	Mt. Baker, Washington	G.W. Walker/D.A. Swanson/ R.M. Moxham
70.	Hopkinton-Milford/Templeton/Orane lines	R.N. Oldale/L. Page
71.	Hopi Buttes, N.M.	G.G. Schaber
72.	Coso Hot Springs, Calif.	H.H. Waldron
73.	Lynn District, Nevada	R. Roberts/R. Erickson/ K. Ketner
75.	Goldfield, Nevada	J. Albers
78.	Cleveland Co., N.C.	W.C. Overstreet
79.	Matewan, Ky.	D.C. Alvord
82.	Alvord Valley, Oregon	G.W. Walker
83.	Ironton, Mo.	P.W. Guild
88.	Mississippi Valley	J.P.D'Agostino/A. Heyl
89.	Blackbird District, Idaho	F.C. Canney
90.	Alberton, Montana	J.D. Wells
92.	Puerto Rico	R. P. Briggs
94.	NE Pennsylvania (Peat Bogs)	C.C.Cameron
96.	Dixie/Fish Lake Nat'l Forest, Utah	P. Williams/R.J. Hackman
101.	San Francisco Volcanic Fields, Ariz.	G.G. Schaber
102.	Statenville/Lake City, Fla. Phosphate	J.B. Cathcart
103.	Crystal River " "	J.B. Cathcart
104.	Wauchula/Tampa " "	J.B. Cathcart
109.	Sierra Madera, Texas	H.G. Wilshire (USGS)
110.	Clark Fork, Idaho	J.E. Harrison
111.	Wet Mountain, Colo.	Q.D. Singewald
112.	Northeast Range, Colorado	W.A. Braddock(U.Colorado)
113.	Fayettville,N.C./Newport, Tenn.	L.C. Rowan