Department of Energy
Idaho Operations Office

Federal Building Program and Alternative Energy Development

Technical Assistance to the Department of Defense

Purpose

- Reduce expenditures for energy
- Make bases more self-sufficient with noninterruptible energy sources

Assessment and Development of Geothermal Power at U.S. Air Force SAC Bases

- Introduction
- UURI qualifications and experience
- Nature of geothermal resources
- EG&G qualifications and experience
- Current applications of geothermal energy
- Geothermal applications at SAC bases
  - Bases with geothermal potential
  - Proposed program
  - Proposed organization

S2 1780

Geothermal Team

- DOE — Idaho Operations Office
  - Lead office federal buildings program
  - Geothermal support contractors
    - EG&G, Idaho, Inc.
    - University of Utah Research Institute (UURI)
- UURI
  - Exploration and resource evaluation
  - Drilling supervision
- EG&G
  - Drilling supervision
  - Reservoir engineering
  - System design and construction supervision

S2 1777

University of Utah Research Institute, Earth Science Laboratory Division Geothermal Experience

Contractor to DOE-ID

Provides primary technical support for:

- Industry Coupled Program - Nevada and Utah
- State Coupled Program - Western U.S.
- Exploration Technology Program - Nationwide
- User Coupled Confirmation Drilling Program - Nationwide

Provides technical support for:

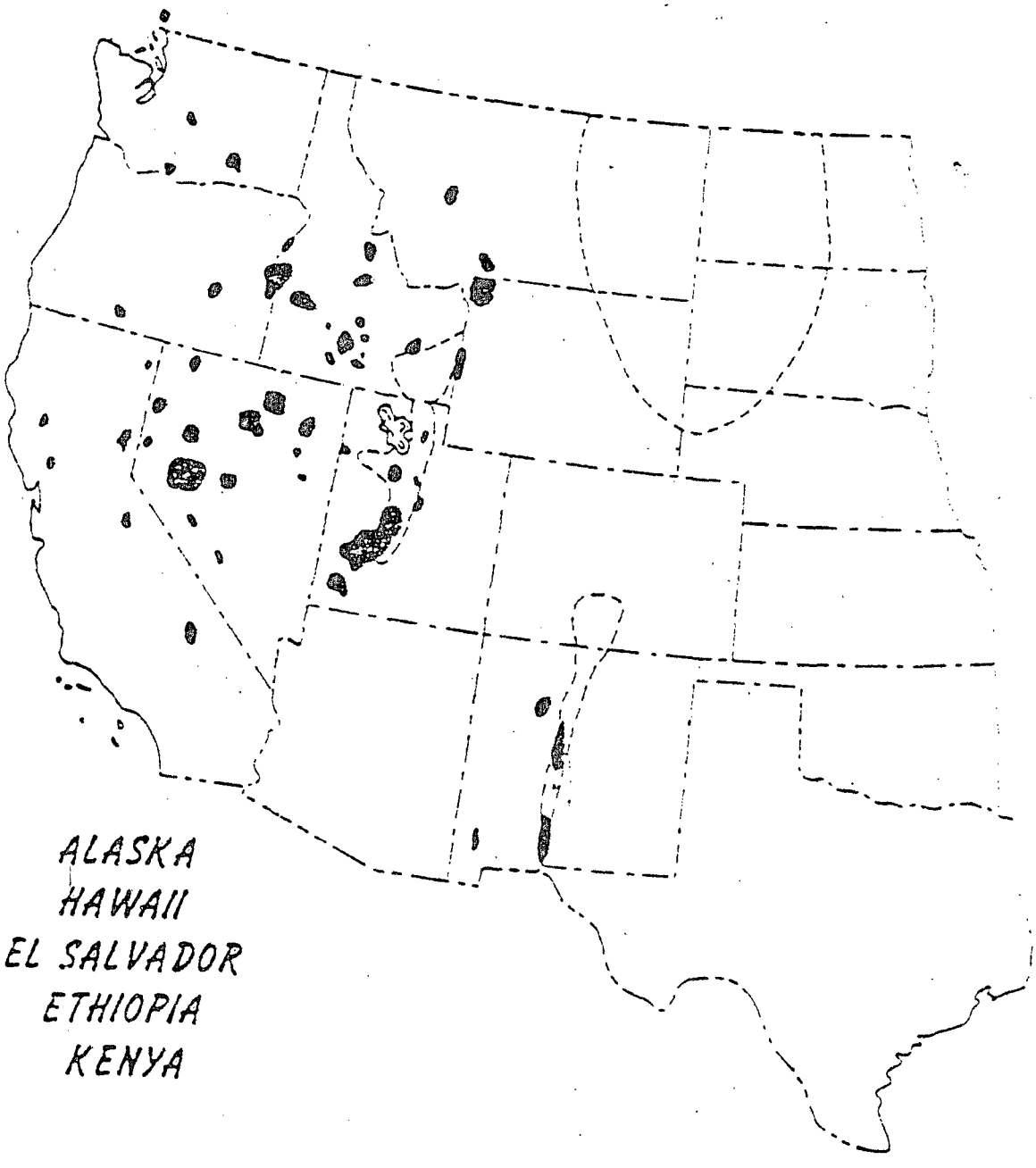
- Technology Transfer - Western U.S.
- Induced Seismicity - Roosevelt Hot Springs, Raft River
- Program Planning

University of Utah Research Institute
Earth Science Laboratory Division
Major Accomplishments

- High quality geologic mapping developed in nine geothermal areas
- Trace element geochemical techniques developed and tested
- Geochemical modeling programs implemented for fluid / rock interaction
- Unique geophysical modeling techniques developed
- Cost effective geothermal exploration architecture defined
- Major contributions made to geothermal science - 245 reports, papers, publications
- Management and technical assistance provided for $45M in DOE funded programs

S2 0349

UURI GEOTHERMAL EXPERIENCE



ALASKA
HAWAII
EL SALVADOR
ETHIOPIA
KENYA

ESL Staff

- Most earth science problems require interdisciplinary work for solution
- ESL has a balanced interdisciplinary staff

	PhD	MS	BS	Total
Geology	4	3	4	11
Geochemistry	2	1	1	4
Geophysics	5	0	1	6
Computer	0	3	1	4
Electronics	0	0	2	2
	11	7	9	27

S2 0344

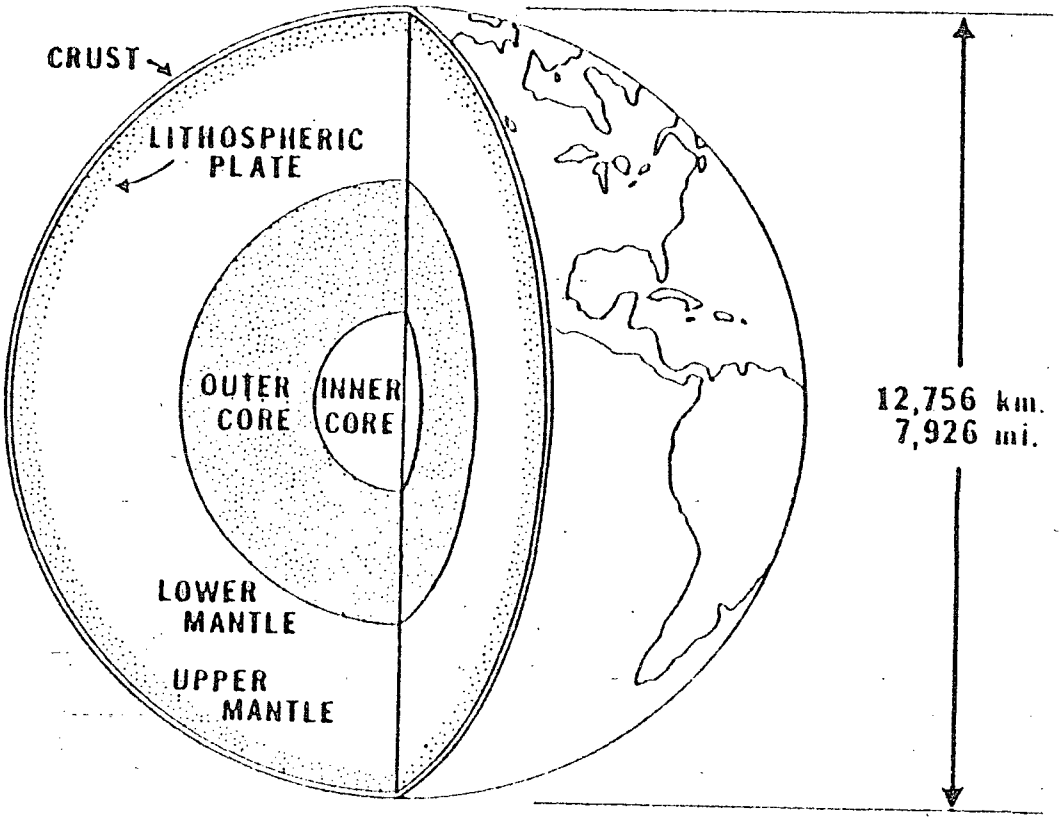
Nature of Geothermal Resources

S2 0368

Characteristics of Geothermal Resources

- Source of heat
  - — Volcanic activity
  - — Igneous intrusion
  - — Earth's thermal gradient
- Water to transfer heat
- Permeable rocks

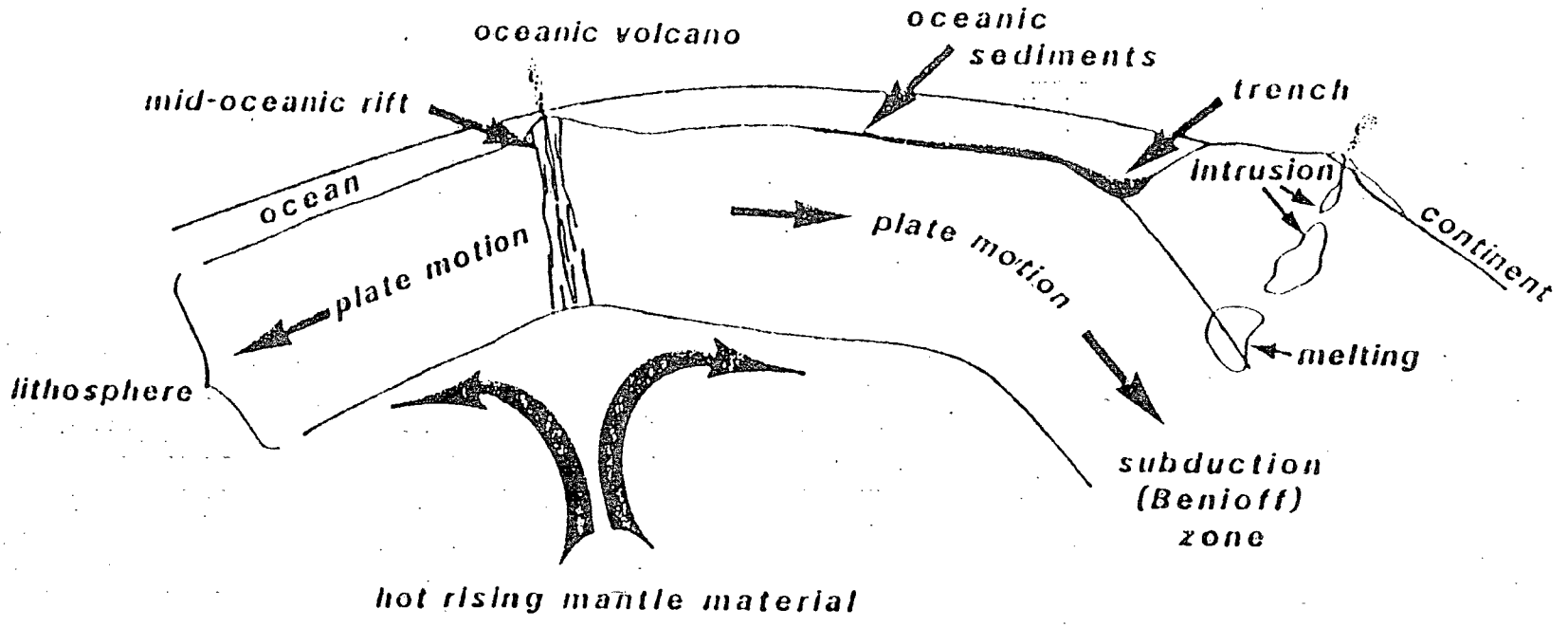
S2 0369


CRUST
LITHOSPHERIC PLATE
OUTER CORE
INNER CORE
LOWER MANTLE
UPPER MANTLE
12,756 km.
7,926 mi.

GG-005

CONCEPT OF PLATE TECTONICS

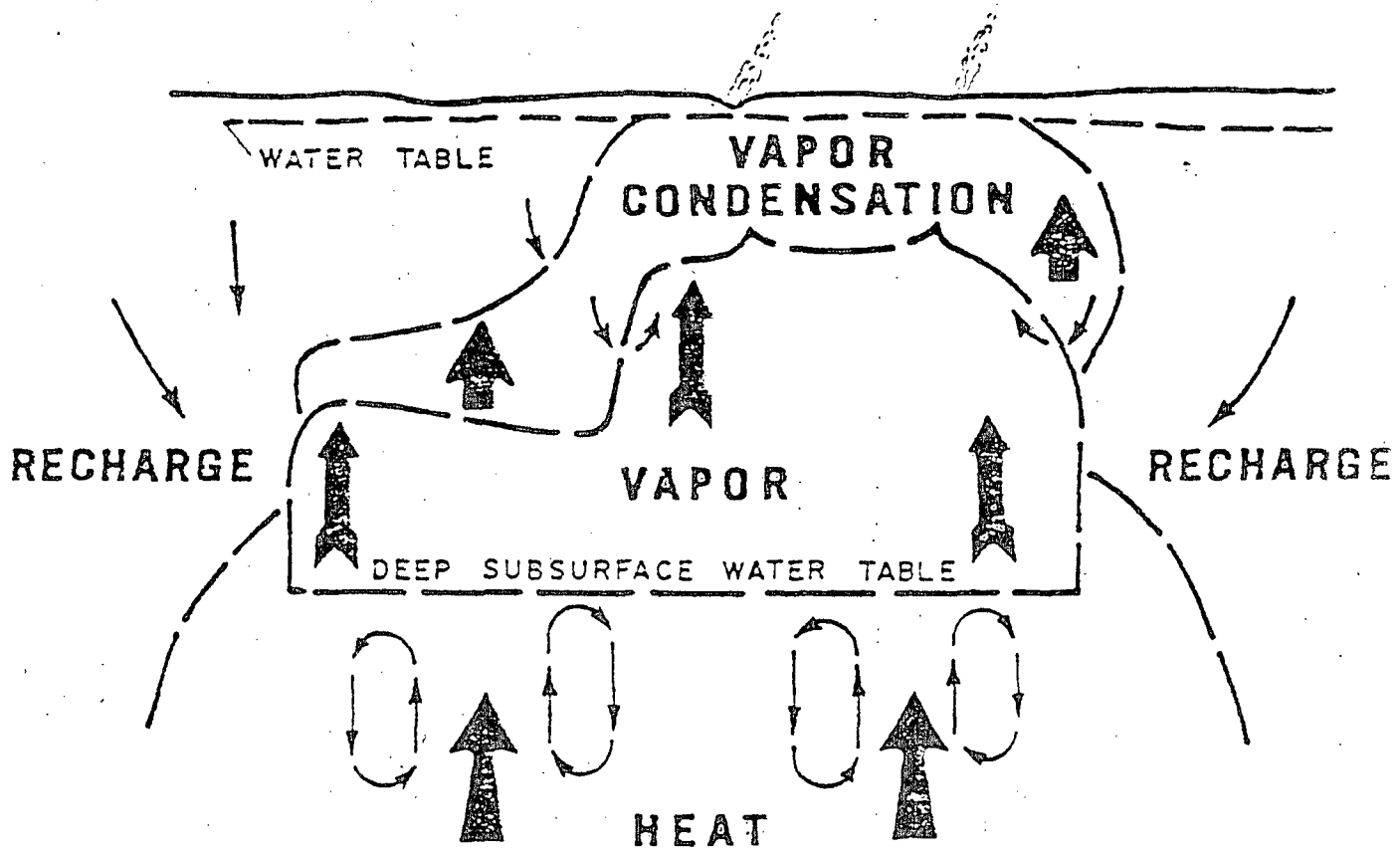
(not to scale)



GG-006a
Revised 1/81

High Temp System

VAPOR DOMINATED GEOTHERMAL RESERVOIR



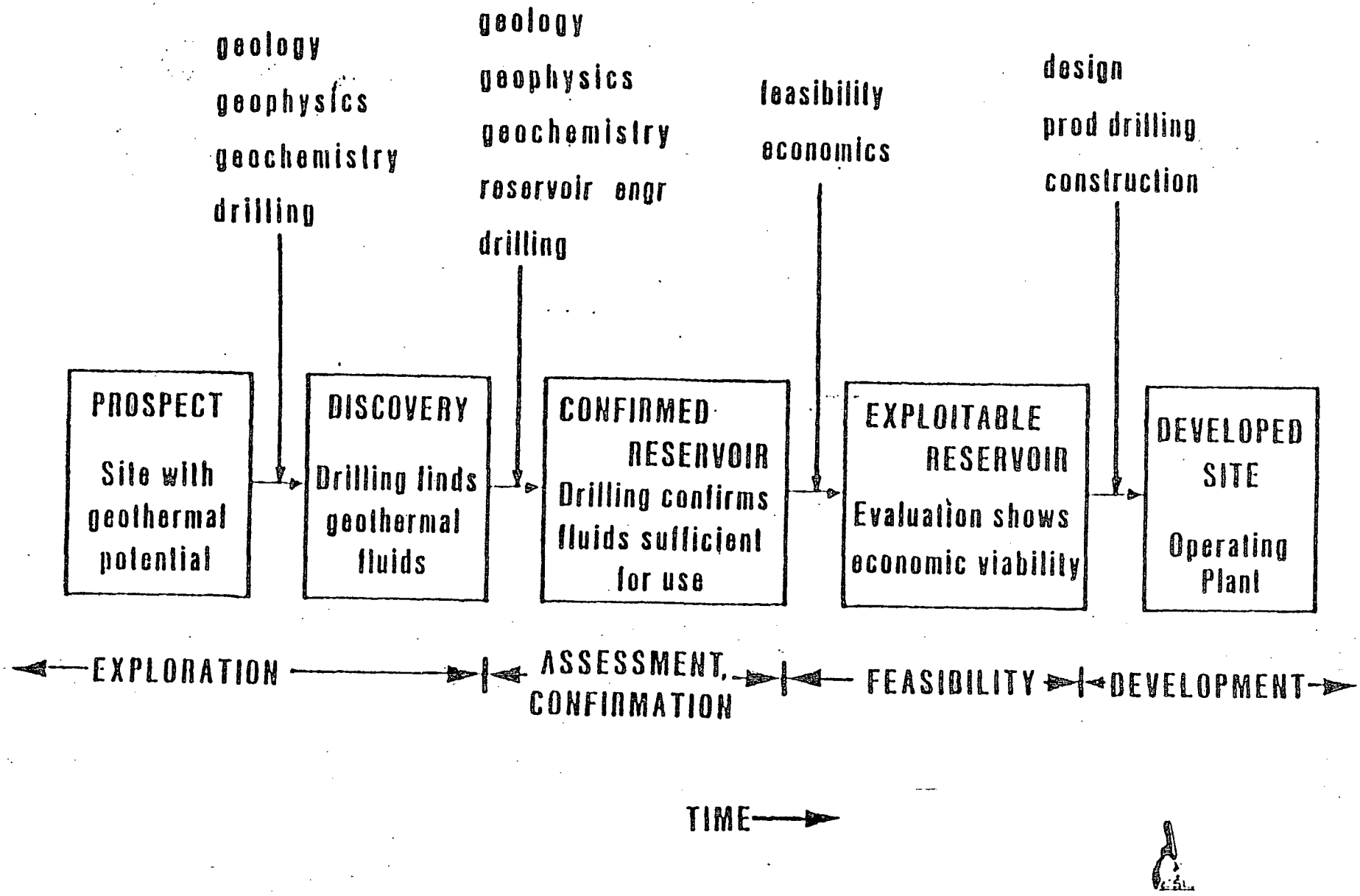
GG-011

Helen
Facts

Exploration and Resource Assessment

S2 0314

GEOTHERMAL DEVELOPMENT



GP-001

Some geothermal systems have surface manifestation

- The Geysers, CA
- Roosevelt Hot Springs, UT
- Iceland
- New Zealand
- Italy

Others have none — geology, geophysics, geochemistry lead to discovery

- Imperial Valley, CA
- Humboldt House, NV
- Newberry, OR

S2 0370

Details - Geol

- Geoch
- Geophy
expln techniques

Vandenberg

- H_2O

- geol map

- nodes

resource estimate

EG&G Idaho Geothermal Experience

Provides primary technical support for:

- Raft River, ID, Geothermal Binary Electric Demonstration Plant
- User Coupled Confirmation Drilling Program
- Program Planning
- Direct Heat Feasibility and Field Demonstration Programs (PRDA's, PON's)

Provides technical support for:

- Reservoir Engineering
- Technology Transfer
- Geothermal Loan Guaranty Program
- Electric Conversion Technology

User Coupled Confirmation Drilling Program EG&G/UURI Support

- Evaluation of proposals — Resource/Reservoir
  Drilling
  Utilization/Economics
  Institutional/Environmental
  Management/Business
- Negotiation — Technical support to DOE
- Monitoring — Environmental evaluation
  Exploration program
  Drilling
  Testing

S2 1770

User Coupled Confirmation Drilling Program

Cost Sharing of Wells with Industry to Confirm a Geothermal Reservoir

GeoProducts - Susanville, CA — 50MW Hybrid Wood Chips Power Plant

City of Alamosa - Alamosa, CO — Barley Malting Plant

Wine Valley Inn - Calistoga, CA — Space Heating

Vale GeoPark - Vale, OR — Fuel Alcohol Plant

Hydrothermal Energy-Reno, NV — Space Heating Hotel Complex

State of Delaware, Lewes, DEL — Process Heat

S2 1771

Geothermal Loan Guaranty Program EG&G Idaho Responsibilities

- Evaluate applicant design for technical feasibility
- Evaluate applicant project cost estimate
- In some cases, suggest alternate design because of feasibility problems or improvements in cost effectiveness
- Monitor project management and construction

S2 1778

Geothermal Loan Guaranty Applications Evaluated by EG&G Idaho

- Electric projects
  - 54 MW(e) power plant at East Mesa, CA
  - 45 MW(e) power plant at Westmoreland, CA
  - 45 MW(e) power plant at Brawley, CA
  - 50 MW(e) power plant at Roosevelt H.S., UT
  - 110 MW(e) power plant at the Geysers, CA
  - 20 MW(e) power plant at Coso, CA
- Direct heat projects
  - Onion dehydrating plant at Brady H.S., NV
  - Greenhouses at Susanville, CA
  - Space conditioning for mushroom growing at Vale, OR
  - Ethanol plant at Cove Fort, UT
  - Ethanol-livestock facility at Beowawe, NV
  - Ethanol plant at East Mesa, CA
  - District heating at Boise, ID

S2 1779

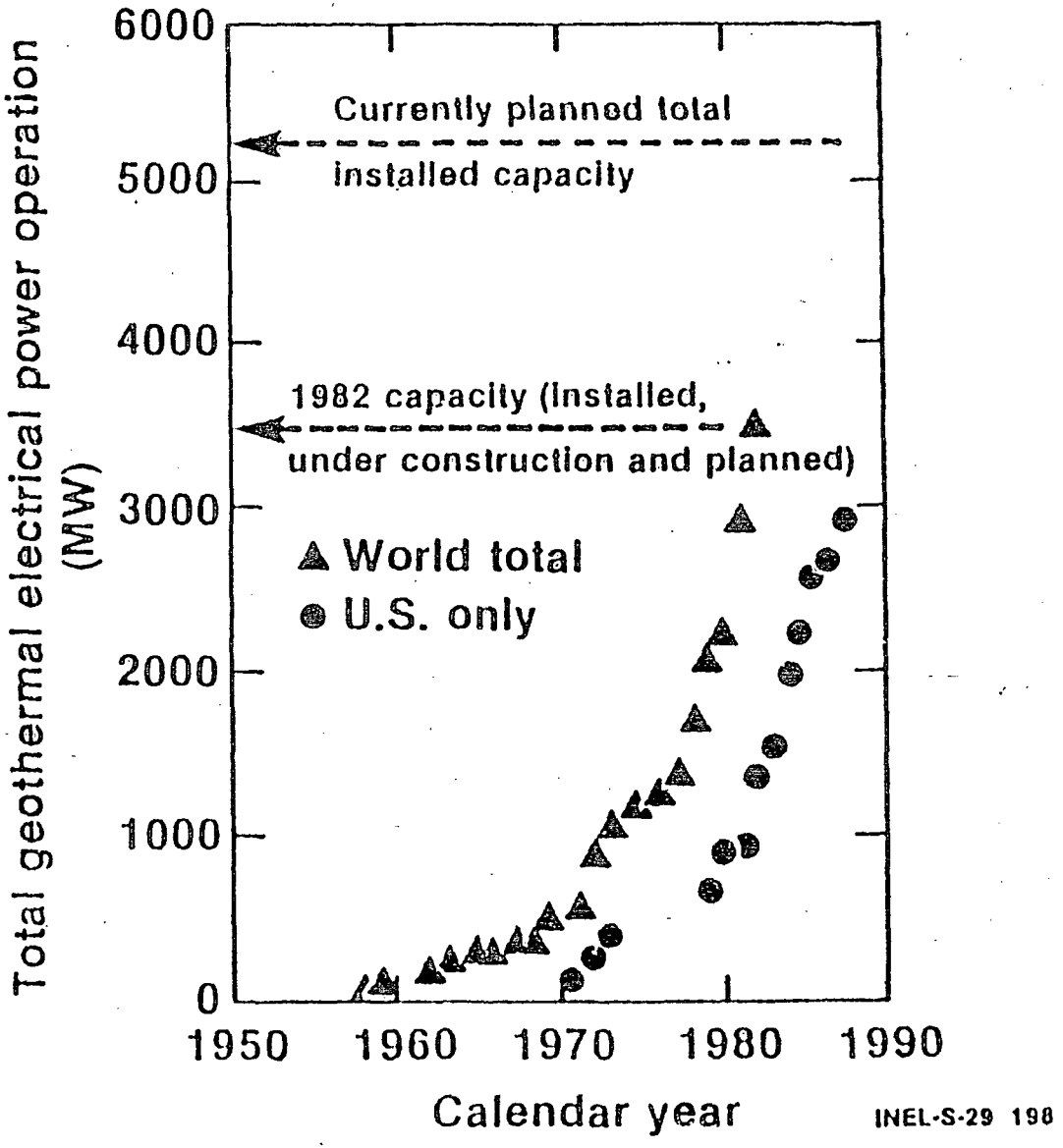
SAC Geothermal Assessments
INEL Administered Direct Use Projects

Number of projects	12
Applications	Space heating, industrial processing and domestic water heating
Peak heating size	1-100 million Btu/hr
Wells drilled	17
Wells successful	10
Projects terminated	3 (Inadequate resource)
Capital cost	$0.7 - 7.2 million
Energy cost	$2.50 - 10.00/million Btu

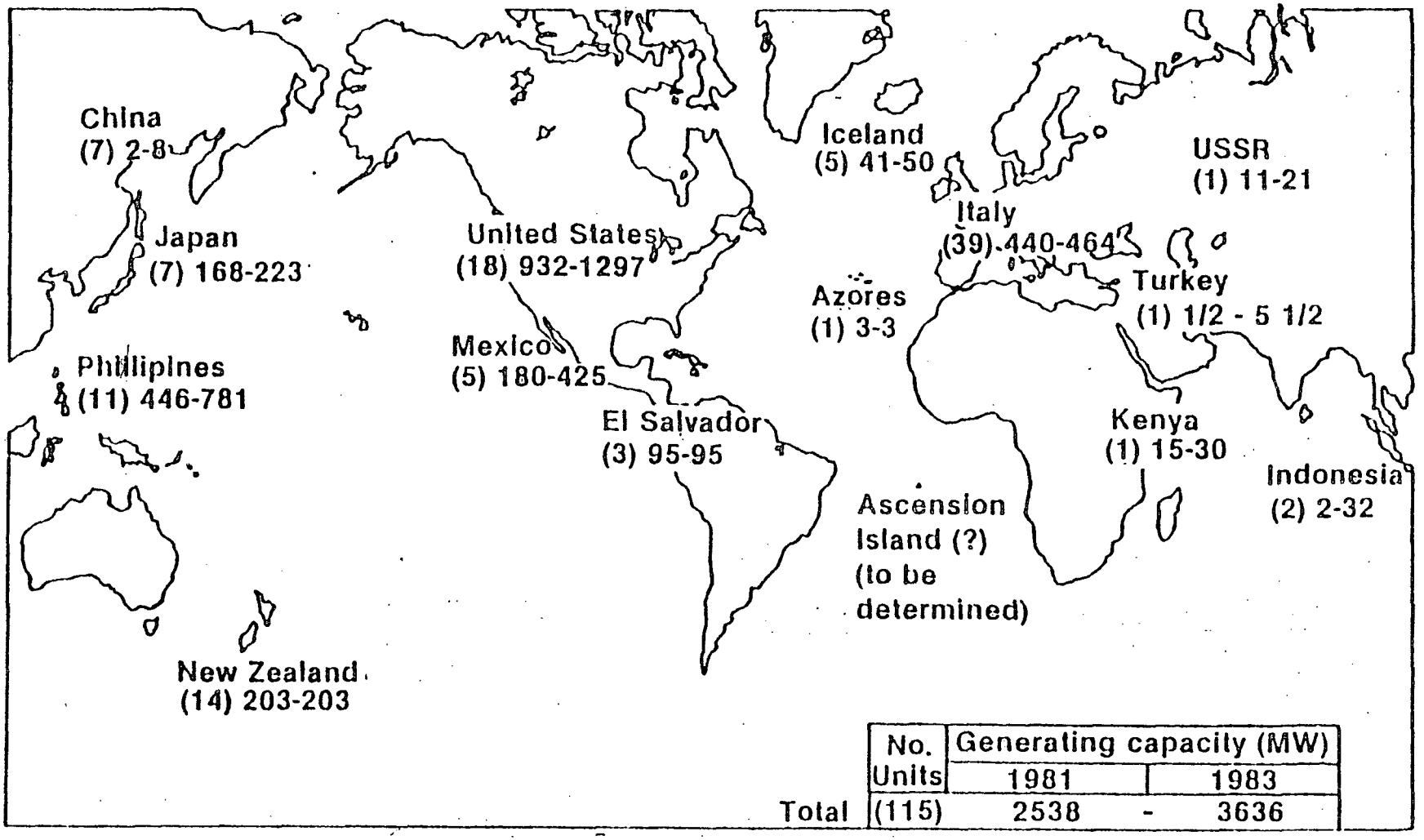
S2 1787

Background

Growth of Geothermal Electrical Capacity



Geothermal Power Plants in the World



	No. Units	Generating capacity (MW) 1981		1983
Total	(115)	2538	-	3636

Geothermal Energy Direct Applications

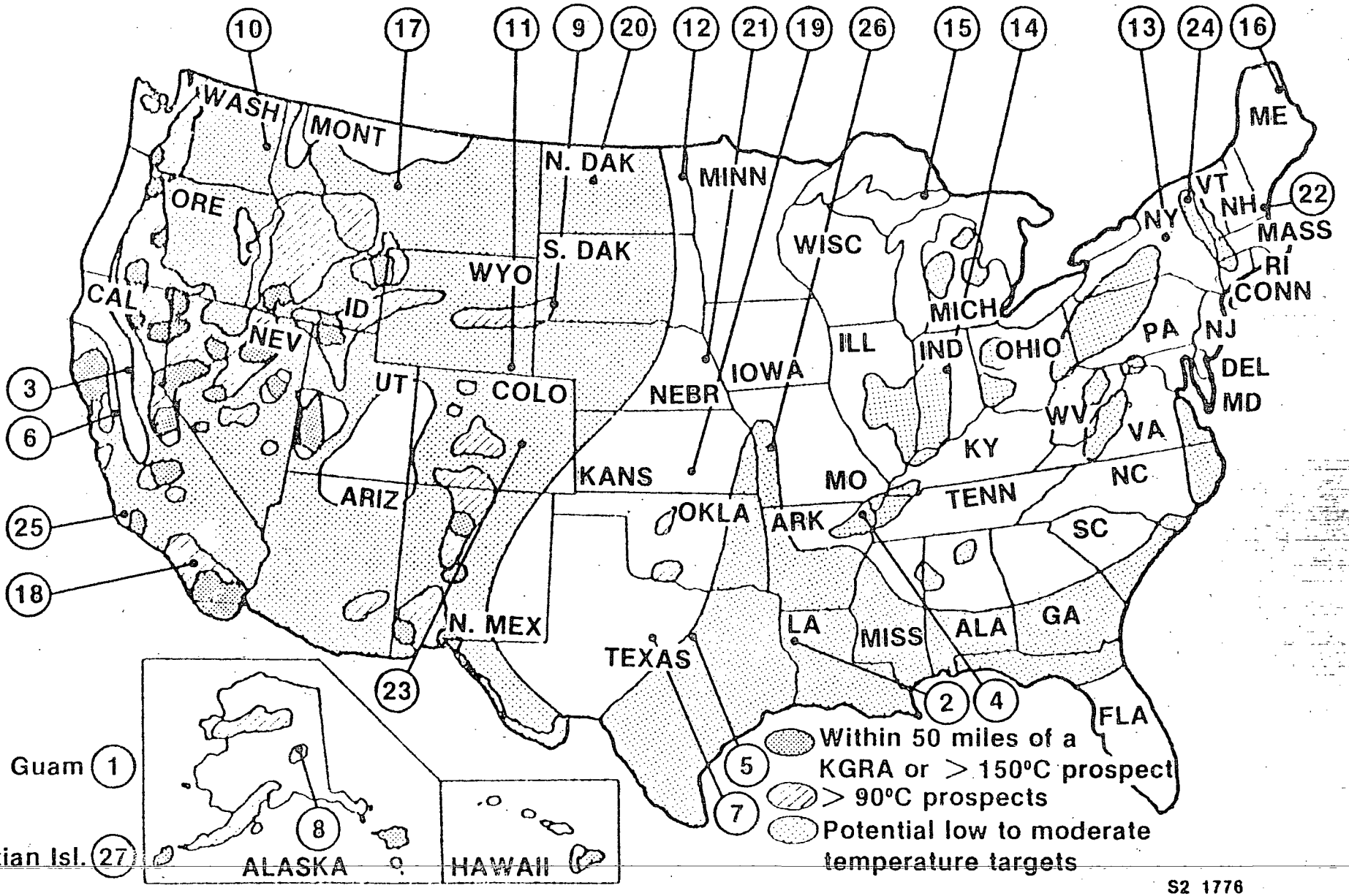
Applications (some)

- Space conditioning
- Food processing
- Ethanol Production
- Greenhousing
- Mining
- Drying

	Projects	States	Energy
Installed (1980)	213	14	13 trillion BTU/yr
Developing	42	11	4 trillion BTU/yr
Planned	197	18	17.5 trillion BTU/yr

S2 9172

USAF SAC Base Locations Relative to Geothermal Resources



S2 1776

USAF SAC Bases

1.	Andersen AFB	Agana, Guam
2.	Barksdale AFB	Bossier City, LA
3.	Beale AFB	Marysville, CA
4.	Blytheville AFB	Blytheville, ARK
5.	Carswell AFB	Fort Worth, TX
6.	Castle AFB	Merced, CA
7.	Dyess AFB	Abilene, TX
8.	Eielson AFB	Fairbanks, AK
9.	Ellsworth AFB	Rapid City, SD
10.	Fairchild AFB	Spokane, WA
11.	Francis E. Warren AFB	Cheyenne, WYO
12.	Grand Forks AFB	Grand Forks, ND
13.	Griffiss AFB	Rome, NY

S2 1772

USAF SAC Bases (cont'd)

14. Grissom AFB	Peru, IND
15. K.I. Sawyer AFB	Marquette, MICH
16. Loring AFB	Caribou, ME
17. Malmstrom AFB	Great Falls, MONT
18. March AFB	Riverside, CA
19. McConnell AFB	Wichita, KAN
20. Minot AFB	Minot, ND
21. Offutt AFB	Omaha, NEB
22. Pease AFB	Portsmouth, NH
23. Peterson AFB	Colorado Springs, COLO
24. Plattsburgh AFB	Plattsburgh, NY
25. Vandenberg AFB	Lompoc, CA
26. Whiteman AFB	Knob Noster, MO
27. Shemya AFB	Aleutian Islands, AK

Golden Rules of Geothermal Development

- A commercial resource can be a cheap source of power
- Not all land has a commercial resource
- Commercial resources will not move

Space Heating System for Vandenberg AFB

Vandenberg AFB Evaluation

Engineering Parameters

Vandenberg AFB

Economic Parameters

Vandenberg AFB

System Schematic

Vandenberg AFB

Project Schedule

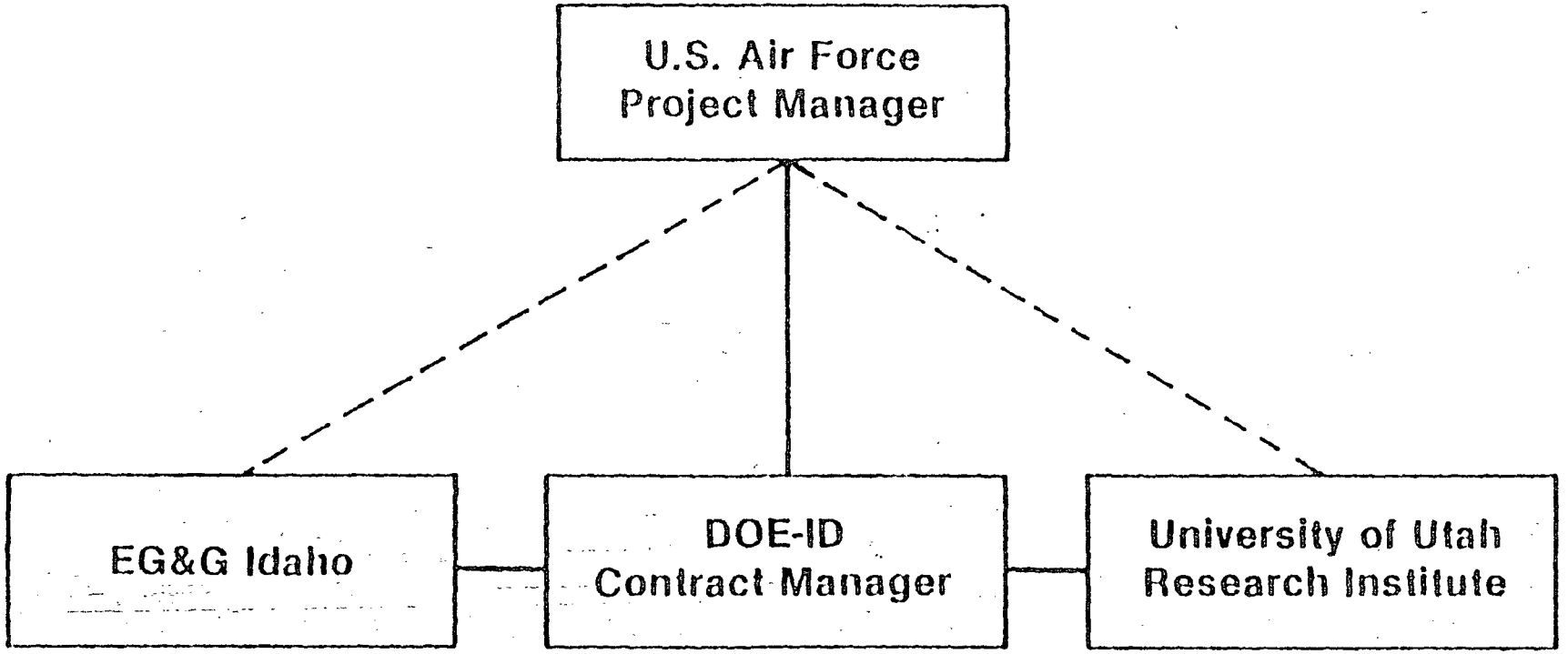
Vandenberg AFB

Project Costs by Phases

Proposed Project Organization

S2 0365

Organizational Structure



S2 0350

Responsibilities

- U.S. Air Force - establishes program direction and directs project management
- DOE-ID - provides contract management of EG&G Idaho and UURI support
- EG&G Idaho - provides project management and technical and economic analysis for reservoir engineering and systems
- University of Utah Research Institute - provides project management and exploration and resource evaluation

DF

Work Breakdown Structure - Vandenberg AFB Project

Phase I - 80K 10 mos

- Initial Geology
  - Compile and Interpret Existing Geologic + Hydrologic Data 35K
    Initial site visit
- Conceptual Design, Feasibility and Economic Evaluation 35K
- Prepare Report and Brief USAF incl. both → 10K
  (Project Mgt) 0

Phase II - (425K) 16½ mos

- Environmental Report + File Intent to drill gradient holes 10K
- Well Site Selection
  - ~~Reanalysis of Gravity Survey (Inexpy?)~~ Additional geology, geochemistry, geophysics 50 ~~20K~~
  - Gradient Hole Drilling 240K
  - Interpret results and develop geologic model incl 20-25 k well siting 50 ~~35K~~?
- Update Economic Evaluation 30K
- Prepare Report and Brief USAF incl both → 15K
  (Project Mgt) 80K 80K

Phase III (712K)

- Design Well 3K
- Environmental Assessment and Secure Permits 22K
- Drill Initial Production Well 47 ~~45~~K
  - Solicit Drilling Contractor Bids and Select Driller
  - Site Preparation, Well Drilling, Well Completion 70K (60K)?
  - Supervise Drilling, Interpret Geology
- Log Well 25K
  - Solicit Logging Company
  - Well Logging
- Test Well 67K
  - Procure Test Equipment
  - Pulse and Long Term Test
  - Data Analysis
- Update Economic Analysis 25K
- Prepare Report and Brief USAF 20K
  (Project Mgt) 96K

DF

Vandenberg AFB (cont)

Phase IV

- Drill and Log Additional Production and Injection Wells
- ~~Heater~~ System Design
  - Title I
  - Title II
- System Construction
  - Construction Contract Bid and Award
  - Construction and Title III
  - System Operation Tests and Startup

RF

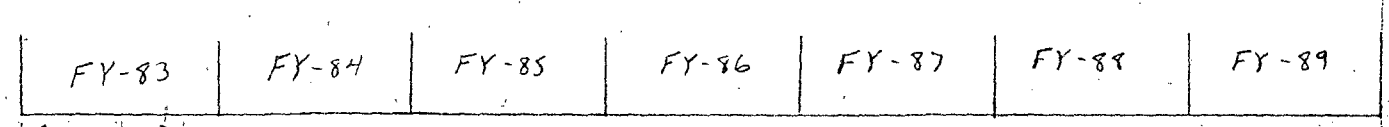
I initial geol — 8 wks (could be 6)
briefing — 2 wks (drafting, etc)

DF
Vandenberg
"tight" sched

II Well site sel'n
- surveys — 8-10 wks
- grad holes — 4 wks - 6 wks
- interp — 2-4 wks
- briefing — 2 wks

III Well design — 2 wks
- bids + selection — 2 wks + 5 wks
- site, drill etc — 4-6 wks
- interp. geol. — 3 wks
- logging — 1 wk. bids + 2 days logging
- briefing — 2 wks

IV Additional drilling ... ?



Phase I
- Initial Geology
- Conceptual Design
- Report + Brief USAF

USAF Decision

Phase II
- Environmental Report
- Well Site Selection
  - Survey
  - Gradient Hole Drilling
  - Interpret Results
- Update Economic Evaluation
- Prepare Report + Brief USAF

USAF Decision

Phase III
- Design Well
- Environmental Assessment + Permits
- Drill Initial Production Well
  - Solicit Bids and Select Driller
  - Site Prep., Drilling, Well Compl.
  - Supervise Drilling, Interpret Geol.
- Log Well
  - Solicit Logging Co.
  - Well Logging
- Test Well
  - Procure Test Equipment
  - Pulse and Long Term Test
  - Data Analysis
- Update Economic Analysis
- Prepare Report and Brief USAF

USAF Decision

Phase IV
- Drill and Log Additional Production + Inj. Wells
- Test Wells
- System Design
  - Title I
  - Title II
- System Construction
  - Construction Contract Bid + Award
  - Construction + Title III
  - System Operations Test and Startup