

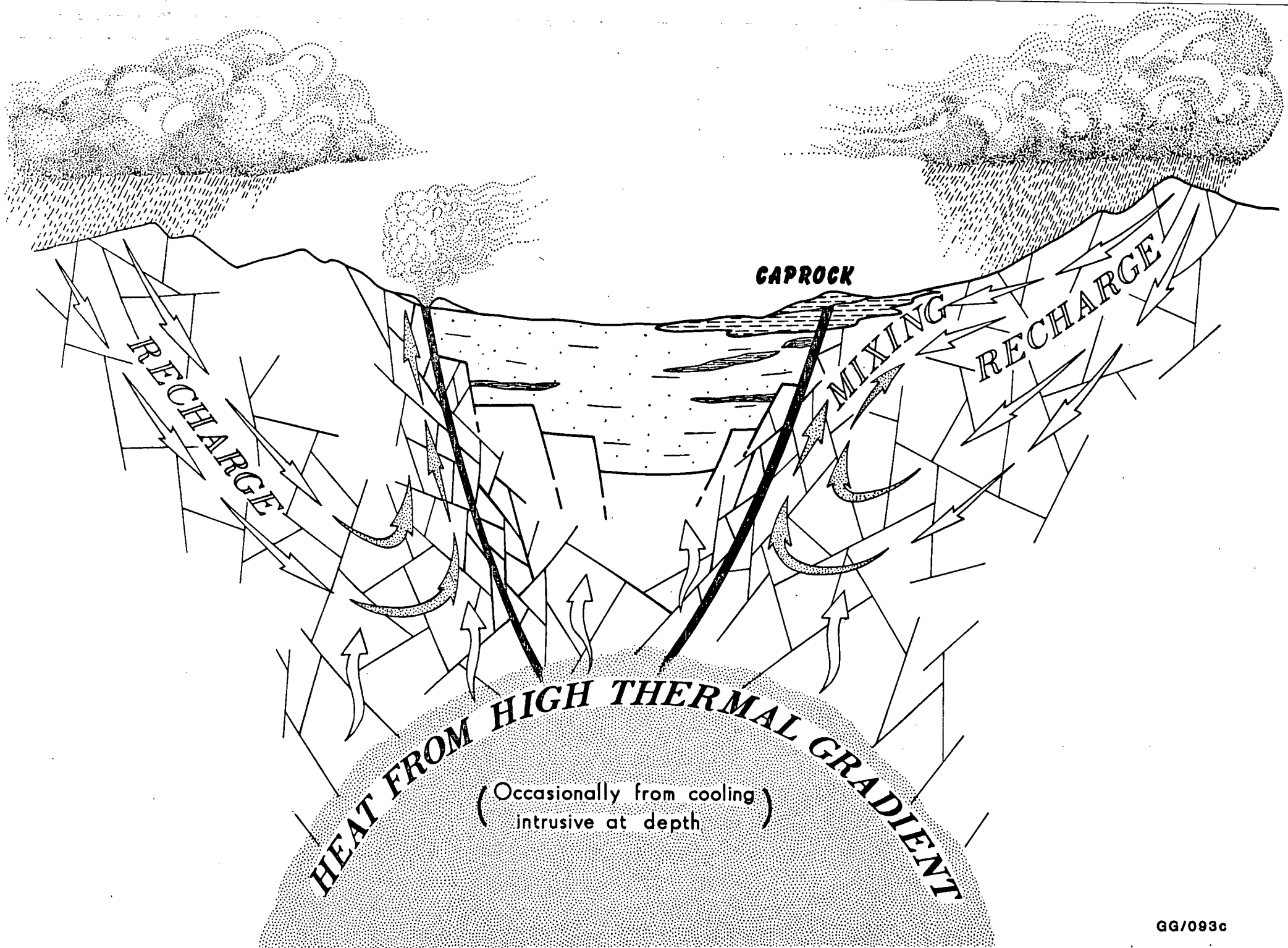
Nature of Geothermal Resources

Nature of Geothermal Resources

S2 0368

Characteristics of Geothermal Resources

- **Source of heat**
 - **Volcanic activity**
 - **Igneous intrusion**
- **Water to transfer heat**
- **Permeable rocks**



CAPROCK

RECHARGE

MIXING

RECHARGE

HEAT FROM HIGH THERMAL GRADIENT
(Occasionally from cooling
intrusive at depth)

GEOHERMAL EXPLORATION

GEOLOGY

Structural Mapping and Analysis

GEOCHEMISTRY

Water Sampling → Geothermometry

Trace Element Analysis

Isotope Studies

GEOPHYSICS

Thermal Gradient Measurements

Heat Flow Measurements

Gravity Surveys

Seismic Studies

Aeromagnetic Surveys

Electrical Methods

DRILL TESTS

Characteristics of Geothermal Resources

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

UURI

MILITARY GEOTHERMAL PROJECTS

(to April 1982)

COSO HOT SPRINGS, CA - China Lake Naval Weapons Test Center

- geological mapping
- geophysical surveys
- well geology - DOE well site, 1977
- STATUS - successful well recently drilled by California Energy

HILL AFB, UT

- geological mapping
- geochemical surveys
- gravity and seismic surveys
- test well siting and drilling
- STATUS - inactive - no thermal water found

WILLIAMS AFB, AZ

- review of existing resource data
- review of proposal to USAF RFP
- STATUS - inactive - recommended USAF drop project

M-X/RES, NV and UT

- lead contractor for M-X/RES geothermal assessment
- program plan and presentation
- STATUS - inactive

LACKLAND AFB, TX

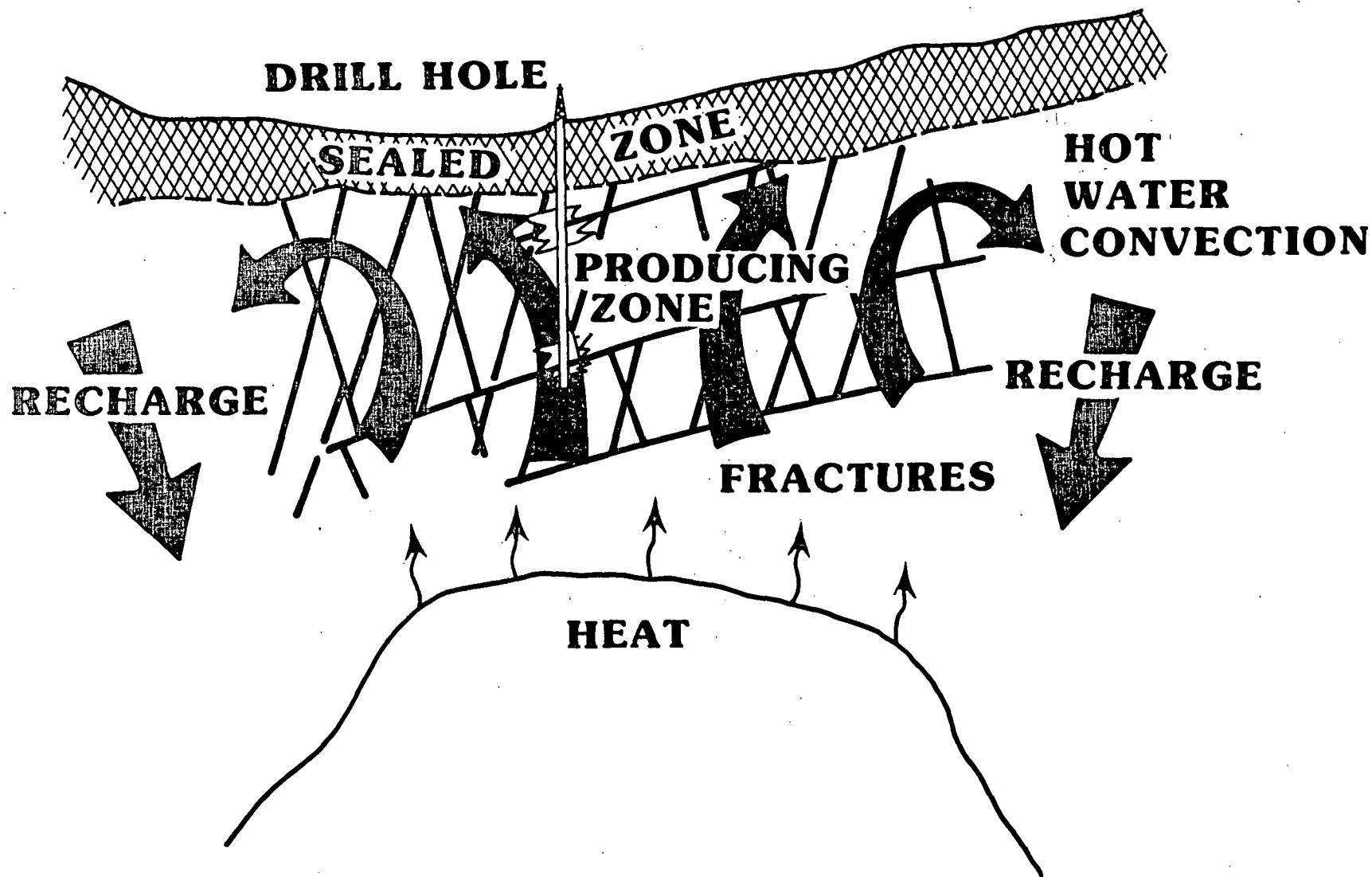
- site and drill production well
- STATUS - workscope now being negotiated

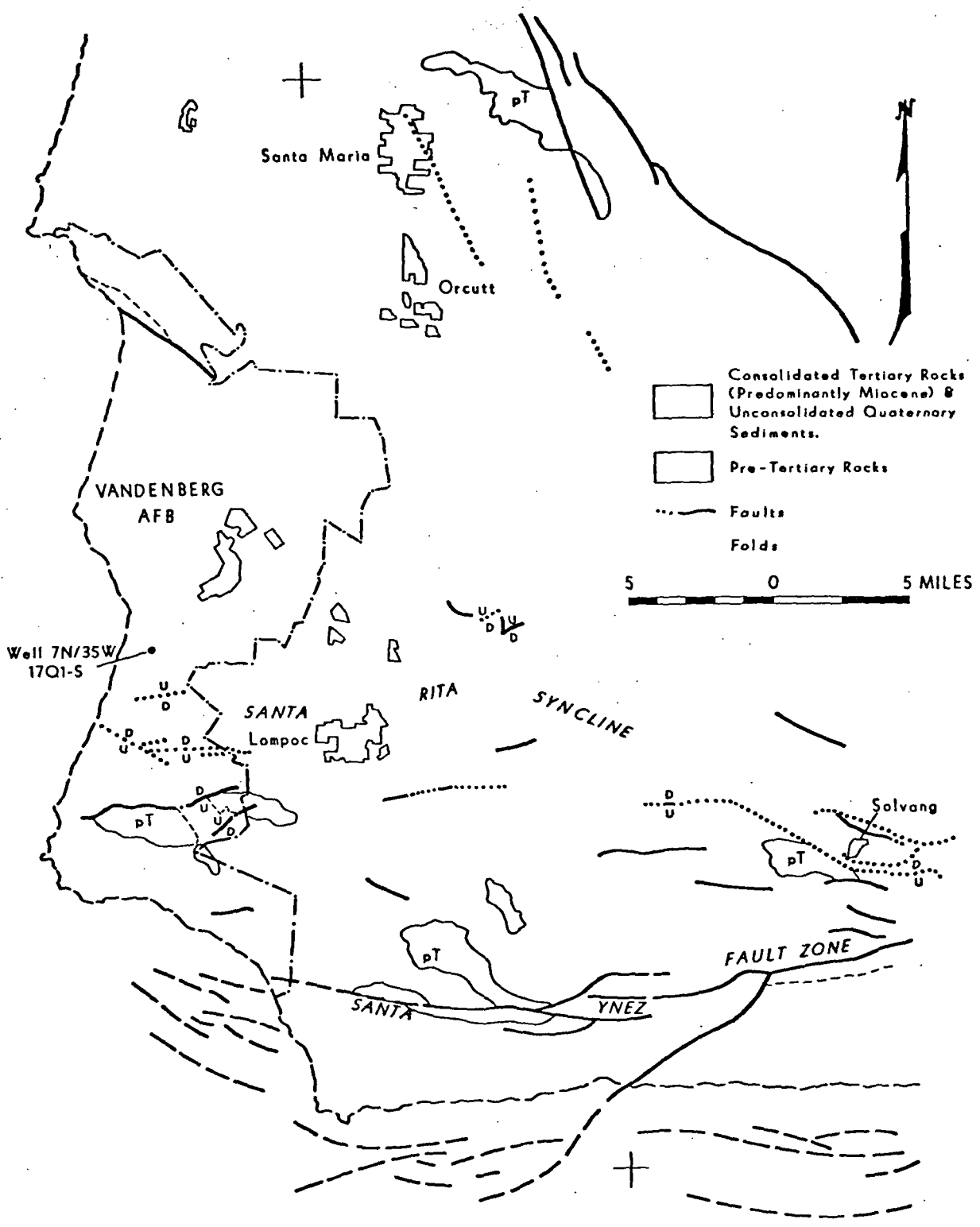
ASCENSION ISLAND

- geological mapping
- geochemical surveys
- design Phase II exploration program
- STATUS - awaiting Falkland Island resolution

WATER DOMINATED GEOTHERMAL SYSTEM

FLOW CONTROLLED BY FRACTURES

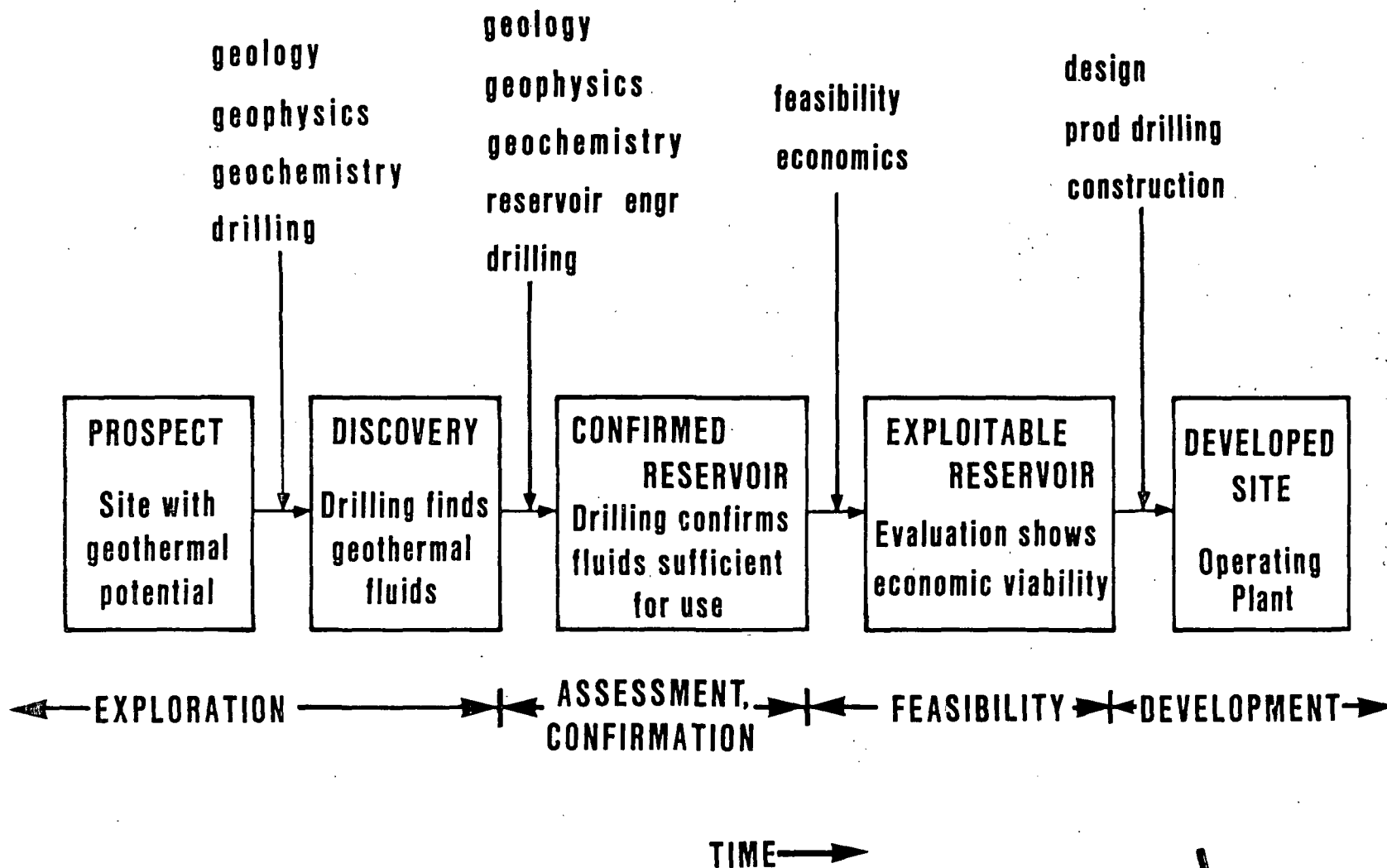




Exploration and Resource Assessment

S2 0314

GEOHERMAL DEVELOPMENT



Some geothermal systems have surface manifestation

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

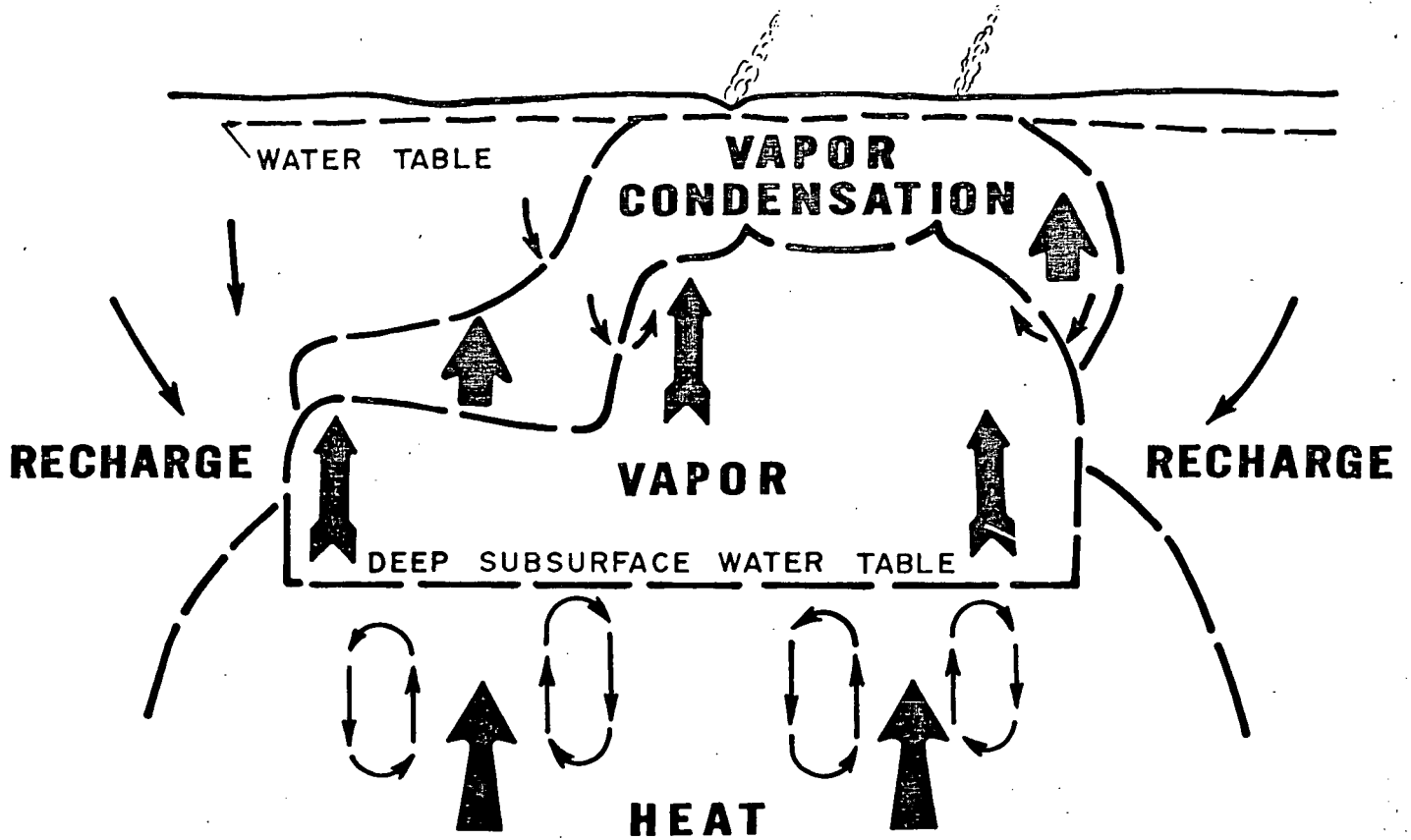
Others have none — geology, geophysics, geochemistry lead to discovery

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

WATER ANALYSES
WELL NO. 7N/35W-17Q1-S
SANTA BARBARA COUNTY, CALIFORNIA

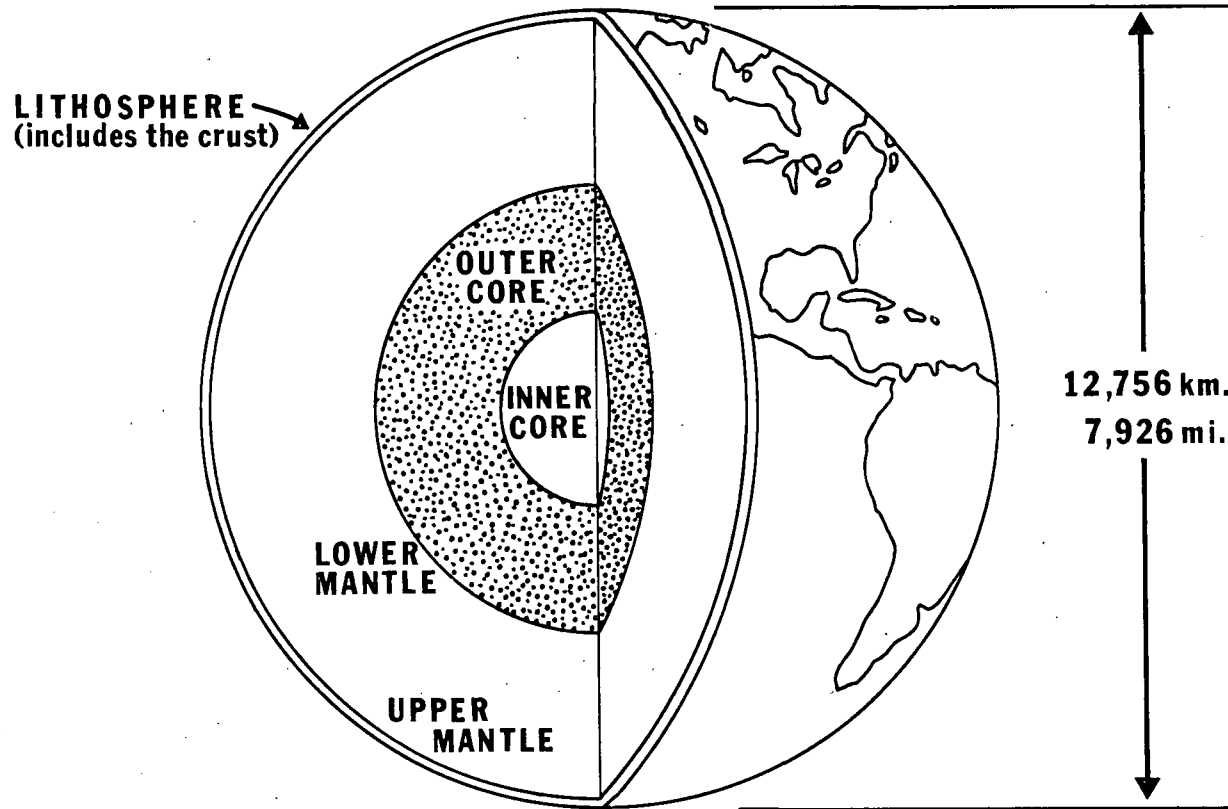
TEMPERATURE	41.7° C
TDS	—
H₂S	—
ALKALINITY	—
pH	7.8
TSS	—
B	5.4 ppm
Ca	34 ppm
Cl	2550 ppm
F	1.9 ppm
HCO₃	1547 ppm
K	46 ppm
Mg	31 ppm
Na	2100 ppm
NO₃	20 ppm
CO₃	NOT DETECTED

VAPOR DOMINATED GEOTHERMAL RESERVOIR



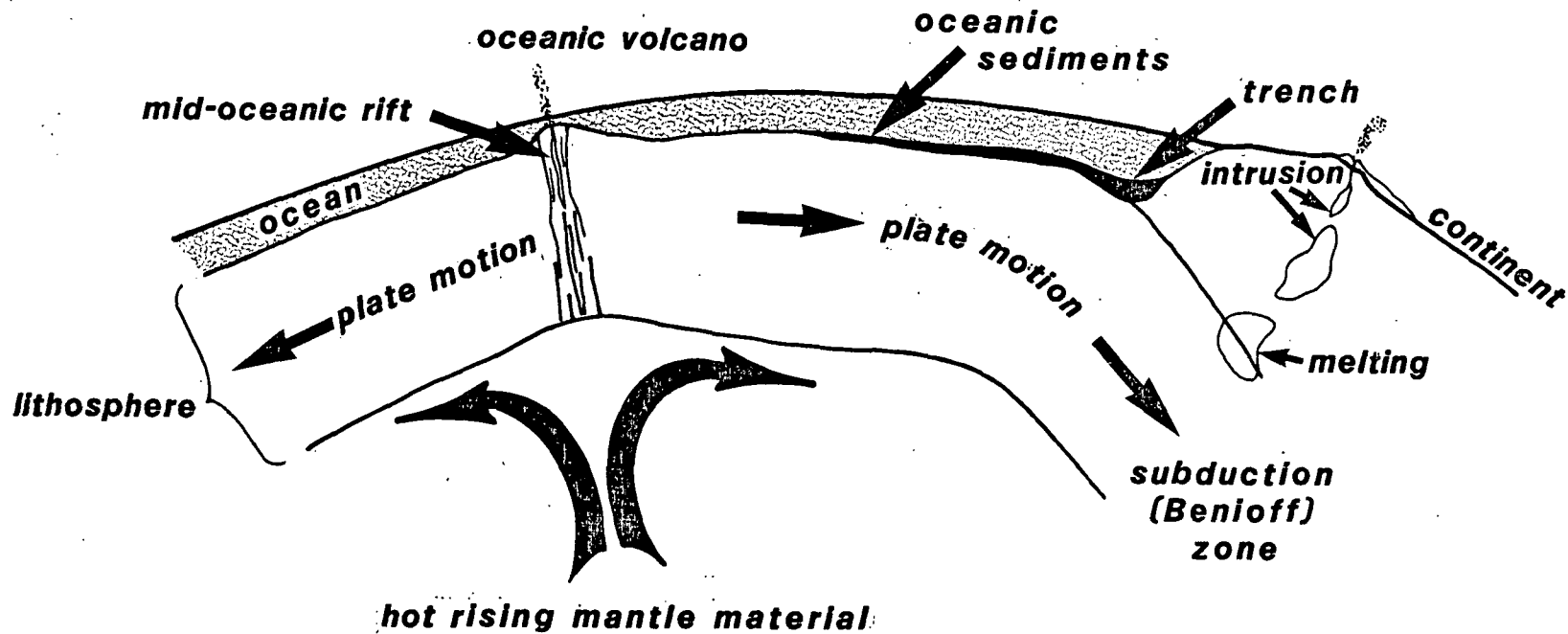
GG-011

INTERIOR OF THE EARTH



CONCEPT OF PLATE TECTONICS

(not to scale)

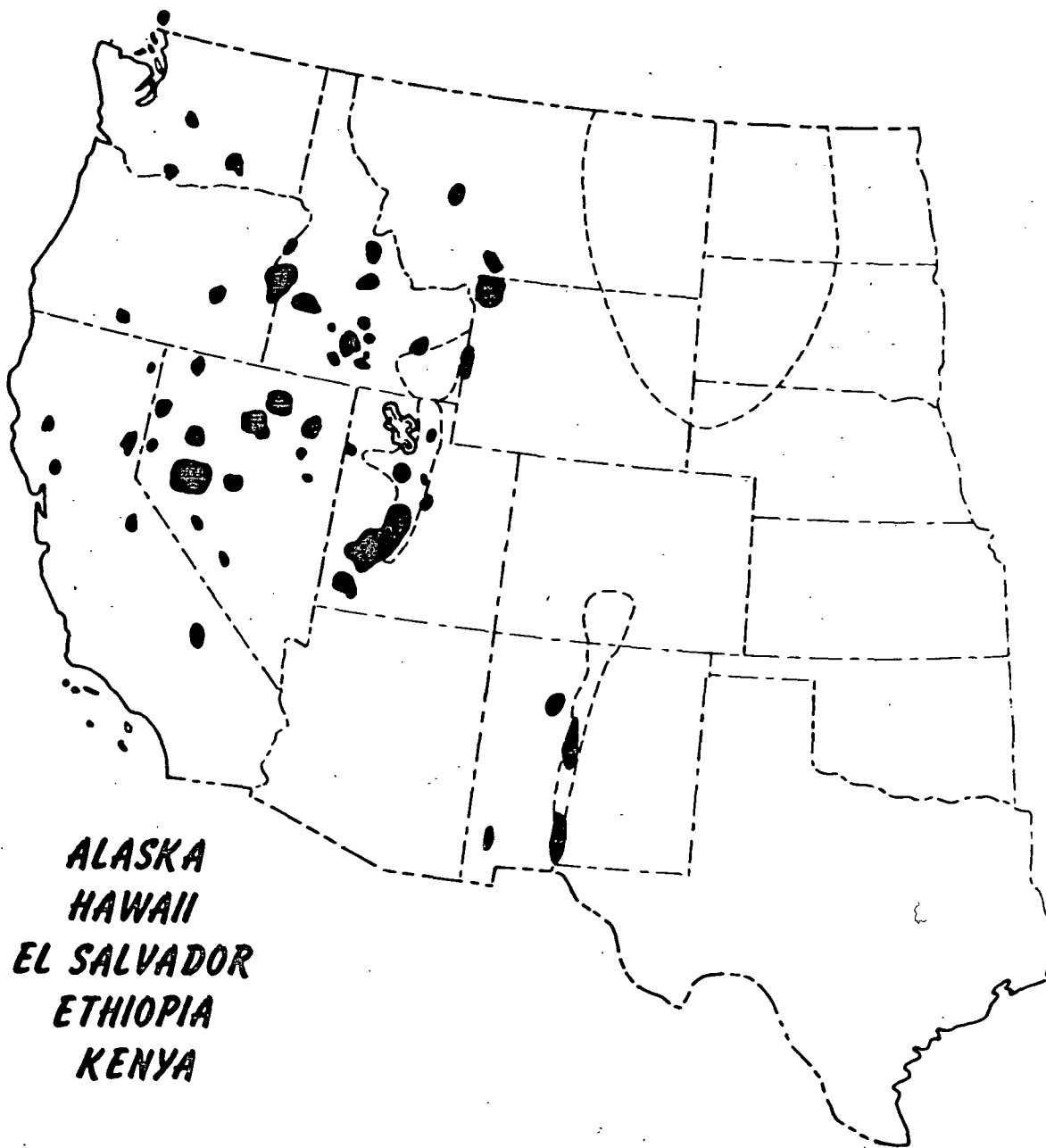


ESL Staff

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

	<u>PhD</u>	<u>MS</u>	<u>BS</u>	<u>Total</u>
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
	<u>11</u>	<u>7</u>	<u>9</u>	<u>27</u>

UURI GEOTHERMAL EXPERIENCE



ALASKA
HAWAII
EL SALVADOR
ETHIOPIA
KENYA

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**

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**