GL00655

U.S. DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE

COOPERATIVE AGREEMENT

ID FORM-182
(Rev. 05-80)
Ref: CMD

PURSUANT TO AUTHORITY OF PL 93-410, PL 93-438, PL 93-473, PL 93-577, and PL 95-91

1.a. Agreement No.: DE-FC07-80ID12147

1.b. Modification No.:

2. Agreement Period
From: 09-30-80 To: 11-15-81

3. Participant Name and Address
Stanford University
c/o Sponsored Projects Office
Stanford, California 94305

4. Participant Type
☒ Educational ☒ Nonprofit
☐ State or Local Government ☐ Profit

5. Project Title
A Theoretical and Experimental Evaluation of the Na-K-Ca Geothermometer.

6. Project Will be Conducted per
See Article II

7. Technical Reports Are Required
See Article II and Appendix B

8. Principal Investigator(s) or Program Director(s) Name and Address
Amos Nur/George Parks
Stanford University
Stanford, California 94305

9. DOE Program Officer (Name and Address)
M.A.Widmayer, Energy & Technology Div., U.S.Department of Energy, Idaho Operations Office, 550 Second St., Idaho Falls, ID 83401
Telephone No. (208) 526-1466

10. Accounting and Appropriation Data

11. Method of Payment
☐ % At Award, % When Requested, 5% Upon
☐ Letter of Credit Receipt of Final Report
☒ Reimbursement
☐ Other (specify) See Article

12. Submit Vouchers to Director, Contracts Management Division, U.S. Department of Energy, 550 Second St., Idaho Falls, ID 83401

13. Funding Sources

Source	Amount
DOE:	$ 98,815
Participant:	$ 6,988
Total Funding:	$ 105,803

14. Remarks:

15. Amount Obligated By This Action: $ 98,815

16. DOE Issuing Office (Name and Address)
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

17. DOE Contracting Officer
J. F. Marmo 9/26/80
Signature of Contracting Officer (Date)
Name (typed) J. F. Marmo
Telephone No. (208) 526-1478

18. Participant Acceptance
By [signature] SEP 3 0 1980
Signature of Authorized Official (Date)
Name (typed) FRED A. GUSTAFSON
Title CONTRACT OFFICER

(Replaces ID F-182 (11-79))

SCHEDULE

ARTICLE I - STATEMENT OF JOINT OBJECTIVE

The purpose of this Cooperative Agreement between the United States Department of Energy (DOE or Government) and Stanford University, Stanford, California (Participant) is to develop and demonstrate a theoretical and experimental evaluation of the Na-K-Ca geothermometer. This action is authorized by Federal law and is in furtherance of the U.S. Government's objective of energy independence.

ARTICLE II - THE PROJECT MANAGEMENT PLAN

A. DOE will provide technical assistance and guidance for the program and will provide a portion of the funding for the program. The Participant is solely responsible for securing all facilities, services, and supplies in order to complete the program. Requirements of the project are further set forth in Appendix B to this Agreement which is titled "PROJECT TASKS, SCHEDULE BACKGROUND, AND REPORTING REQUIREMENTS" and which is made a part hereof by this reference. The Participant shall provide the funding and reports as specifically provided for elsewhere in this Agreemeent.

B. In addition to DOE personnel, the Participant agrees to permit non-DOE personnel who are under contract with DOE, and identified from time to time by the Contracting Officer, to assist the DOE representative in performance of his duties and to have necessary access to the Participant's and major subcontractors' facilities and records pertaining to the project. DOE correspondence, if any, with subcontractors shall be routed through the Participant.

ARTICLE III - FINANCIAL SUPPORT

A. Estimated Cost. The total estimated cost of the work under this Agreement is One Hundred Five Thousand Eight Hundred Three Dollars ($105,803.00). If at any time the Participant has reason to believe that this or any revised estimate is in error by more than ten percent (10%), the Participant shall so notify DOE in writing and provide DOE with a new estimate.

B. DOE's Financial Support. The total cost to DOE for all the work under this project is Ninety-Eight Thousand Eight Hundred Fifteen Dollars ($98,815.00), and under no circumstances will DOE's support exceed this amount. This limitation includes termination costs, if any. The initial increment available is Ninety-Eight Thousand Eight Hundred Fifteen Dollars ($98,815.00).

ARTICLE III - FINANCIAL SUPPORT (Cont'd)

C. Participant's Financial Support. All costs in excess of the Ninety-Eight Thousand Eight Hundred Fifteen Dollars ($98,815.00) to be provided by DOE, will be borne by the Participant. The estimated cost to the Participant is Six Thousand Nine Hundred Eighty-Eight Dollars ($6,988.00).

D. Obligated Funds. The amount of funds presently obligated to this Agreement by DOE is Ninety-Eight Thousand Eight Hundred Fifteen Dollars ($98,815.00).

ARTICLE IV - METHOD OF PAYMENT

A. DOE will make incremental payments by Treasury check to the Participant in the amounts set forth below at such times as the specified milestones are achieved and upon receipt of invoices or vouchers and a cost statement from the Participant. Such invoices or vouchers must be supported by a statement that the costs are allowable as defined in ARTICLE VIII of this Agreement, and will clearly show DOE's cost share and the Participant's cost share.

B. At any time or times prior to final payment under this Agreement, the Contracting Officer may have the costs incurred under this Agreement audited. The total of DOE payments cannot exceed the total, actual, allowable costs incurred. If the Contracting Officer finds, on the basis of audit or otherwise, that allowable costs as defined in ARTICLE VIII do not equal or exceed the amount of funds DOE has agreed to provide, total payments shall be reduced accordingly.

C. Final payment will not be made until the Final Report is received and accepted by DOE. In no event will the final 5% of the amount of obligated funds be paid to the Participant until DOE has received the Final Report and the Final Cost Report described in Article VI of this Cooperative Agreement.

D. As more definitive project cost and schedule data become available, the parties may review the milestone and payment schedule and, by written agreement, make adjustments. Under no circumstances, however, will DOE's costs exceed the amounts provided for in ARTICLE III.

ARTICLE V - TERM OF THE AGREEMENT

The work under this Agreement shall be completed by November 15, 1981, or within any extension of time as may be mutually agreed to in writing by the parties.

ARTICLE VI - PROJECT INFORMATION SYSTEM

Reporting Requirements. The Participant shall furnish to DOE the reports and information identified in Appendix B.

ARTICLE VII - RESPONSIBLE PERSONS AND PERSONNEL

A. The Participant agrees to permit any specified DOE personnel to have necessary access to the Participants and/or major subcontractor's facilities, personnel, and records pertaining to the project. Such DOE personnel may be used to assist the Program Officer in carrying out his responsibilities.

B. (1) The Program Officer for DOE under this Agreement, and the person who shall be the Participant's contact for all technical matters pertaining to this Agreement shall be the person named below or such other person as may be designated in writing by the Contracting Officer:

M. A. Widmayer
Energy and Technology Division
Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, Idaho 83401
(208) 526-1466

(2) The representative for the Participant for the purposes of this Agreement shall be the person named below or such other person as may be designated in writing by the Participant:

Amos Nur
George Parks
Department of Geophysics
Stanford University
Stanford, California 94305
(415) 497-3716

AS EXECUTED

ARTICLE VIII - ALLOWABLE COST

Costs shall constitute allowable costs as specified in OMB Circular A-21.

ARTICLE IX - ACQUISITION OF GOODS AND SERVICES

A. In furtherance of the work under this Agreement, each subcontract or purchase order for goods or services which, separately, exceeds Ten Thousand Dollars ($10,000), shall require the written approval of the Contracting Officer. The Participant may request such approval by submitting to the Contracting Officer a copy of the proposed subcontract document along with justification for the selection of the proposed subcontractor. If the Contracting Officer fails to respond to the request for approval within ten (10) days after receiving such request, the Participant may award the subcontract or purchase order.

B. The subcontractors for the goods and services referred to in paragraph A. above, shall be selected competitively except those subcontractors who were specifically identified in the Participant's proposal.

ARTICLE X - TERMINATION

A. It is the express intent of DOE and the Participant to fund their respective cost participation for the project, as such cost participation is set forth under Article III of this Agreement, so as to provide continuity and completion of the project. If, notwithstanding this original intent, it becomes apparent to either party that incremental funding for its cost participation will not be available as needed, either in whole or in part, in order to provide continuity for the completion of work under this Agreement, each party agrees to promptly advise the other of such funding problem, and if practicable and consistent with their mutual interest at the time, the parties may attempt to cooperatively adjust the schedule and/or the content of the work towards best serving the objectives of this Agreement within the available committed and planned funding of each party.

B. Notwithstanding the foregoing, it is understood that DOE may at any time upon giving written notice to the Participant by the Contracting Officer terminate this Agreement for its convenience for any reason.

C. Also, notwithstanding the foregoing, it is understood that the Participant may at any time upon giving written notice to DOE terminate this Agreement for its convenience for reasonable cause. The Participant may not terminate for convenience after seventy-five percent (75%) of DOE's contribution to the project has been committed, and should such termination occur, it will constitute a breach of contract.

D. In the event of termination for convenience by either party, the parties will cooperate to reasonably phase-out the Participant's costs and cost commitments incurred prior to the termination. If the termination is for the convenience of the Government, the termination cost claim may include those costs provided for in paragraph G. of this Article X. If the termination is for the convenience of the Participant, the cost claim may include only those costs incurred prior to termination. In either case, the approved costs will be shared in accordance with the following: ninety-three percent (93%) Government and seven percent (7%) Participant; provided; however, that the total amount obligated by the Government under this Agreement shall not be exceeded.

E. In the event of termination for convenience by either party, the Participant shall:

(1) Place no further orders or subcontracts for materials, services, or facilities intended to be invoiced to the Government for its contribution.

(2) Terminate all orders and subcontracts to the extent that they relate to the performance of work.

ARTICLE X - TERMINATION (Cont'd)

(3) Notwithstanding subparagraphs E.(1) and (2) above, the Participant has the right to proceed with such orders and subcontracts should it decide to continue performance of the work at its expense only.

F. After a termination for convenience by the Government, the Participant shall submit to the Contracting Officer its termination claim. Such claim shall be submitted promptly but in no event later than one (1) year from the effective date of termination unless one or more extensions in writing are granted by the Contracting Officer.

G. Termination claims:

(1) There shall be included therein the Government's share, as set forth in paragraph D., of the cost of settling and paying claims arising out of the termination of work under subcontracts or orders which are properly chargeable to this Agreement as determined by the Contracting Officer.

(2) There shall be included therein the reasonable costs of settlement, including accounting, legal, clerical, and other expenses reasonably necessary for the preparation of settlement claims and supporting data with respect to the termination and settlement of subcontracts thereunder, together with reasonable storage, transportation, and other costs incurred in connection with the protection or disposition of termination inventory.

H. Costs claimed, agreed to, or determined pursuant to this article must constitute allowable costs as defined in Article VIII, "Allowable Cost."

I. If in the opinion of DOE, the Participant fails to substantially perform under this Agreement and does not cure such failure within a reasonable time after written notice of such failure by the Contracting Officer, DOE may by written notice to the Participant terminate this Agreement. Such termination notice, signed by the Contracting Officer, shall be effective upon receipt by the Participant. The Government shall not be liable for the incurrence of any obligations under this Agreement from the date of the receipt of such termination notice. Upon any such termination, the Participant agrees to promptly, upon DOE's request, transfer to DOE all information resulting from the work performed to the date of the termination notice.

ARTICLE X - TERMINATION (Cont'd)

J. Except with respect to defaults of subcontractors, the Participant shall not be in default by reason of failure to substantially perform under this Agreement if such failure arises out of causes beyond the control and without the fault or negligence of the Participant. Such causes may include, but are not restricted to, acts of God or of the public enemy, acts of the Government in either its sovereign or contractual capacity, fires, floods, epidemics, quarantine restrictions, strikes, freight embargoes, and unusually severe weather, but in every case the failure to perform must be beyond the control and without the fault or negligence of the Participant. If the failure to substantially perform is caused by the failure of a subcontractor to perform or make progress, and if such failure arises out of causes beyond the control of both the Participant and a subcontractor, and without the fault or negligence of either of them, the Participant shall not be deemed to be in default unless the supplies or services to be furnished by the subcontractor were reasonably obtainable from other sources. Upon request of the Participant, if the Contracting Officer shall determine that failure to perform was occasioned by any one or more of the aforementioned causes, this Agreement shall be revised accordingly. This provision does not preclude DOE from exercising its right to terminate for convenience.

K. As used in this article, the term "subcontractor" means subcontractor at any tier.

ARTICLE XI - TITLE TO PROPERTY AND SITE RESTORATION

A. The Government will own and maintain title to all items of materials, supplies, and all tangible property purchased in full or in part with Government funds provided under this Agreement. The Government will determine disposition of such property at completion of the work under this Agreement or upon termination by either party and agrees that those costs incurred by the Participant in final disposition will be allowable costs.

B. The Participant agrees that the Government shall not be subject to any obligation to restore or rehabilitate any of the premises, facilities or equipment owned and/or leased by the Participant which are altered, improved or otherwise affected by this Agreement.

ARTICLE XII - INDEMNIFICATION

It is recognized that the Participant as title holder of the facilities to be constructed under this Agreement is responsible for the design, installation, operation, repair and maintenance of such facilities. The Government therefore will not be liable for payment of damages for injuries to any person, or loss of life or personal property, or loss suffered or sustained and arising from use or operation of the facilities which are a subject of this Agreement. The Participant agrees to indemnify and save the Government harmless from any and all claims, demands, damages, actions, costs, or charges against the

ARTICLE XII - INDEMNIFICATION (Cont'd)

Government arising as the result of the above-mentioned injuries, damages, or loss, except for any such damages or claims arising out of the negligent act of the Government, its employees or representatives in the course of their official duties.

ARTICLE XIII - PUBLIC INFORMATION RELEASES

The parties agree that public disclosure or dissemination of new data or information arising out of the design, construction or operation of the project will be coordinated by the parties, it being understood that the intent of both the Participant and DOE is to release all data and information to the greatest practicable extent in order to achieve the objective of obtaining maximum public value from the results of this project. It is understood that the foregoing is not intended to afford either party the right to prevent a public release by the other; however, nothing in this article shall impair the rights of the parties set forth elsewhere in this Agreement, including but not necessarily limited to General Provision 19. entitled "Patent Rights."

APPENDIX A - GENERAL PROVISIONS

COOPERATIVE AGREEMENTS

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APPENDIX A

GENERAL PROVISIONS

COOPERATIVE AGREEMENT

1. ORDER OF PRECEDENCE

In the event of an inconsistency between the provisions of this Agreement, the inconsistency shall be resolved by giving precedence as follows: (a) schedule; (b) statement of work; (c) the general provisions; (d) other provisions of the Agreement, whether incorporated by reference or otherwise; and (e) Participant's technical proposal, if incorporated in the Agreement by reference or otherwise.

2. DEFINITIONS

As used throughout this Agreement, the following terms shall have the meanings set forth below:

A. The term "head of the agency" or "Secretary" as used herein means the Secretary, the Under Secretary, any Assistant Secretary, or any other head or assistant head of the executive or military department or other Federal agency; and the term "his duly authorized representative" means any person or persons or board (other than the Contracting Officer) authorized to act for the head of the agency or the Secretary.

B. The term "Contracting Officer" means the person executing this Agreement on behalf of the Government, and any other officer or civilian employee who is a properly designated Contracting Officer; and the term includes, except as otherwise provided in this Agreement, the authorized representative of a Contracting Officer acting within the limits of his authority.

C. Except as otherwise provided in this Agreement, the term "subcontract" includes purchase orders under this Agreement.

D. The term "DOE" means the U.S. Department of Energy.

3. INSPECTION

The Government, through any authorized representatives, has the right at all reasonable times, to inspect, or otherwise evaluate the work performed or being performed hereunder and the premises in which it is being performed. If any inspection, or evaluation is made by the Government on the premises of the Participant or a subcontractor, the Participant shall provide and shall require its subcontractors to provide all reasonable facilities and assistance for the safety and convenience of the Government representatives in the performance of their duties. All inspections and evaluations shall be performed in such a manner as will not unduly delay the work.

APPENDIX B

PROJECT TASKS, SCHEDULE BACKGROUND, AND REPORTING REQUIREMENTS

Task I

An evaluation of existing information about aluminosilicate thermochemistry and kinetics as it relates to alkali geothermometry will be completed within the first three months of the contract period. An analysis of all the experimental work the Contractor and others have performed to date as it applies to geothermometry will be included. An assessment of the effects of experimental variables such as surface area, initial solution composition, flow rate, differential stress, and permeability on exchange processes that fix K/Na ratios will be performed. The degree of sophistication required in the use of chemical analytical data in geothermometry will be addressed.

Task II

The experimental work is aimed toward elucidating some of the fundamental problems identified in Task I, including whether equilibrium between bulk phases is necessary for the K/Na geothermometer to work reliably. This will be evaluated by performing two basic experiments. The first, reacting albite, orthoclase, and various solutions over a range of temperature and pressure, is intended to indicate the rates at which various subprocesses occur. By monitoring the solution composition as a function of time at any given temperature and pressure using "Dickson" type, agitated, hydrothermal apparatus, rate determinations of K/Na exchange processes relative to bulk dissolution rates will be made. Rate data will be used to identify actual reaction mechanisms using the approach of Dibble and Tiller (1980, 1981). By using distribution-of-species programs, the solution compositions measured at room conditions will be extrapolated to experimental conditions, and activity diagrams showing the path the solution composition takes in time will be constructed.

A second experiment will include reacting glasses of composition similar to the solid mineral assemblage used in the previously described experiment, and monitoring the solution composition.

Based on results of our previous glass/solution interactions it is anticipated that an assemblage of zerolites may form in some experiments and that proper K/Na ratios can still be developed. The possibility that zerlite assemblages can fix K/Na ratios in solution consistent with the K/Na geothermometer will also be tested by experiments in agitated hydrothermal equipment using analcime and either mordenite or clinoptilolite starting materials.

The experiments described above will be done under conditions thought to be appropriate to geothermal systems. Several temperatures ranging from 75° to 300°C will be employed at a pressure of 500 bars. The water/rock mass ratio will be set at 10 to 1 so that enough solution will be available for sampling, but solution compositions will be dominated by the solid phases. Initial solution compositions will be varied to evaluate the effects of pH and salinity on the rates of exchange and dissolution reactions and on the steady-state K/Na ratios obtained. Using the flow-through system, the effect of non-hydrostatic stree on rates of ion-exchange and dissolution reactions will be evaluated. The experimental work will be finished within the first year of the contract period and a full report on the results will be submitted.

Task III

Solution composition data obtained from the experiments performed in Task II will be processed using available distribution of species computer programs to obtain activities at temperature. Both the steady-state concentrations and activities will be plotted as a function of temperature. Curves fitted to these data points will determine the activity exchange constant and an exchange constant associated with concentration. This will provide an experimental calibration of the geothermometer as well as determine the level of confidence when the geothermometer technique is applied to rocks with minerals other than alkali feldspars. Solution activities will also be plotted on activity diagrams to trace the path the solution follows with time. Activation energies will be determined from the rate of the ion-exchange reaction as a function of temperature. Reaction mechansim for the dissolution and growth reactions by interface processes will be determined.

Steady state solution concentrations in the flow through system when plotted as a function of flow rate and temperature will give information on exchange reactions and extraction of components under realistic reservoir conditions. Changes in alkali and alkaline earth concentrations with time in the flow through experiments will be analyzed to estimate how the measured geothermometer values in a geothermal system might change during the evolution of the system.

Task IV

Brief monthly reports will be submitted in accordance with DOE reporting requirements. These reports will consist of details of the technical aspects of the work as well as an evaluation of the progress relative to the planned milestone and Task schedule. A semi-annual report will be prepared covering a detailed review of the Task I research as well as an up-to-date overview of the Task II research. This will be presented to the DOE Technical Program Manager during a semi-annual meeting. A complete draft of the final report will be submitted within one month of the end of the contract period.

Task V

The results of the work proposed will be transferred to potential users in two forms. Part of the results will be presented at national scientific meetings, i.e., American Geophysical Union.

Details of the experimental and theoretical results will be published in appropriate journals before or soon after the end of the contract period. At least two published papers are anticipated, one focusing on theoretical aspects of geothermometry, and another presenting the experimental results in detail.

4. EXAMINATION OF RECORDS BY COMPTROLLER GENERAL

A. This clause is applicable if the amount of this Agreement exceeds $10,000 and was entered into by means of negotiation, including small business restricted advertising, but is not applicable if this Agreement was entered into by means of formal advertising.

B. The Participant agrees that the Comptroller General of the United States or any of his duly authorized Government employees shall, until the expiration of three (3) years after final payment under this Agreement, unless DOE authorizes their prior disposition, have access to and the right to examine any directly pertinent books, documents, papers, and records of the Participant involving transactions related to this Agreement.

C. The Participant further agrees to include in all its subcontracts hereunder a provision to the effect that the subcontractor agrees that the Comptroller General of the United States or any of his duly authorized Government employees shall, until the expiration of three (3) years after final payment under the subcontract, unless the DOE authorizes their prior disposition, have access to and the right to examine any directly pertinent books, documents, papers, and records of such subcontractor, involving transactions related to the subcontract. The term "subcontract" as used in this clause excludes (1) purchase orders not exceeding $10,000 and (2) subcontracts or purchase orders for public utility services at rates established for uniform applicability to the general public.

D. The periods of access and examination described in paragraphs A. and B., above, for records which relate to (1) appeals under the "Disputes" clause of this Agreement, (2) litigation or the settlement of claims arising out of the performance of this Agreement, or (3) costs and expenses of this Agreement as to which exception has been taken by the Comptroller General or any of his duly authorized representatives, shall continue until such appeals, litigation, claims or exceptions have been disposed of.

E. Nothing in this Agreement shall be deemed to preclude an audit by the General Accounting Office of any transaction under this Agreement.

5. CONVICT LABOR

In connection with the performance of work under this Agreement, the Participant agrees not to employ any person undergoing sentence of imprisonment except as provided by Public Law 89-176, September 10, 1965 [18 U.S.C. 4082(c)(2)] and Executive Order 11755, December 29, 1973.

6. OFFICIALS NOT TO BENEFIT

No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

7. COVENANT AGAINST CONTINGENT FEES

The Participant warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies maintained by the Participant for the purpose of securing business. For breach or violation of this warranty the Government shall have the right to annul this Agreement without liability or in its discretion to deduct from the Agreement price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

8. NOTICE AND ASSISTANCE REGARDING PATENT AND COPYRIGHTS INFRINGEMENT

(The provisions of this clause shall be applicable only if the amount of this Agreement exceeds $10,000.)

A. The Participant shall report to the Contracting Officer, promptly and in reasonable written detail, each notice or claim of patent or copyright infringement based on the performance of this Agreement of which the Participant has knowledge.

B. In the event of any claim or suit against the Government on account of any alleged patent or copyright infringement arising out of the performance of this Agreement or out of the use of any supplies furnished or work or services performed hereunder, the Participant shall furnish to the Government when requested by the Contracting Officer, all evidence and information in possession of the Participant pertaining to such suit or claim. Such evidence and information shall be furnished at the expense of the Government except where the Participant has agreed to indemnify the Government.

C. This clause shall be included in all Subcontracts.

9. COMPETITION IN SUBCONTRACTING

The Participant shall select subcontractors (including suppliers) on a competitive basis to the maximum practicable extent consistent with the objectives and requirements of the Agreement.

10. AUDIT

A. The Participant shall maintain, and the Contracting Officer or his representative shall have the right to examine books, records, documents, and other evidence and accounting procedures and practices, sufficient to reflect properly all direct and indirect costs of whatever nature claimed to have been incurred and anticipated to be incurred for the performance of this Agreement. Such right of examination shall include inspection at all reasonable times of the Participant's plants, or such parts thereof, as may be engaged in the performance of this Agreement.

10. AUDIT (Cont'd)

B. The materials described above, shall be made available at the office of the Participant, at all reasonable times, for inspection, audit or reproduction, until the expiration of three (3) years from the date of final payment under this Agreement or such lesser time specified in Title 41, Code of Federal Regulations Part 1-20 and for such lesser period, if any, as is required by applicable statute, or by other clauses of this Agreement, or by subparagraphs B.(1) and (2) below:

(1) If this Agreement is completely or partially terminated, the records relating to the work terminated shall be made available for a period of three (3) years from the date of any resulting final settlement.

(2) Records which relate to appeals under the "Disputes" clause of this Agreement, or litigation or the settlement of claims arising out of the performance of this Agreement, shall be made available until such appeals, litigation, or claims have been disposed of.

11. CLEAN AIR AND WATER

[Applicable only if the Agreement exceeds $10,000 or the Contracting Officer has determined that orders under an indefinite quantity Agreement in any one year will exceed $100,000 or a facility to be used has been the subject of a conviction under the Clean Air Act [42 U.S.C. 1857c-8(c)(1)] or the Federal Water Pollution Control Act [33 U.S.C. 1319(c)] and is listed by EPA, or the Agreement is not otherwise exempt.]

A. The Participant agrees as follows:

(1) To comply with all the requirements of Section 114 of the Clean Air Act, as amended (42 U.S.C. 1857, et seq., as amended by Pub. L. 91-604) and section 308 of the Federal Water Pollution Control Act (33 U.S.C. 1251 et seq., as amended by Pub. L. 92-500), respectively, relating to inspection, monitoring, entry, reports, and information, as well as other requirements specified in Section 114 and Section 308 of the Air Act and the Water Act, respectively, and all regulations and guidelines issued thereunder before the award of this Agreement.

(2) That no portion of the work required by this Agreement will be performed in a facility listed on the Environmental Protection Agency List of Violating Facilities on the date when this Agreement was awarded unless and until the EPA eliminates the name of such facility or facilities from such listing.

(3) To use its best efforts to comply with clean air standards and clean water standards at the facility in which the Agreement is being performed.

(4) To insert the substance of the provisions of this clause into any nonexempt subcontract, including this subparagraph A.(4).

11. CLEAN AIR AND WATER (Cont'd)

B. The terms used in this clause have the following meanings:

(1) The term "Air Act" means the Clean Air Act, as amended (42 U.S.C. 1857, et seq., as amended by P. L. 91-604).

(2) The term "Water Act" means Federal Water Pollution Control Act, as amended (33 U.S.C. 1251 et seq., as amended by P. L. 92-500).

(3) The term "clean air standards" means any enforceable rules, regulations, guidelines, standards, limitations, orders, controls, prohibitions, or other requirements which are contained in, issued under, or otherwise adopted pursuant to the Air Act or Executive Order 11738, an applicable implementation plan as described in section 110(d) of the Clean Air Act [42 U.S.C. 1857c-5(d)], an approved implementation procedure or plan under section 111(c) or section 111(d), respectively, of the Air Act [42 U.S.C. 1857(c)-6(c) or (d)], or an approved implementation procedure under section 112(d) of the Air Act [42 U.S.C. 1857c-7(d)].

(4) The term "clean water standards" means any enforceable limitation, control, condition, prohibition, standard, or other requirement which is promulgated pursuant to the Water Act or contained in a permit issued to a discharger by the Environmental Protection Agency or by a State under an approved program, as authorized by section 402 of the Water Act (33 U.S.C. 1342), or by local government to ensure compliance with pretreatment regulations as required by section 307 of the Water Act (33 U.S.C. 1317).

(5) The term "compliance" means compliance with clean air or water standards. Compliance shall also mean compliance with a schedule or plan ordered or approved by a court of competent jurisdiction, the Environmental Protection Agency or an air or water pollution control agency in accordance with the requirements of the Air Act or Water Act and regulations issued pursuant thereto.

(6) The term "facility" means any building, plant, installation, structure, mine, vessel, or other floating craft, location, or site of operations, owned, leased, or supervised by a contractor or subcontractor, to be utilized in the performance of an agreement or subcontract. Where a location or site of operations contains or includes more than one building, plant, installation, or structure, the entire location or site shall be deemed to be a facility except where the Director, Office of Federal Activities, Environmental Protection Agency, determines that independent facilities are collocated in one geographical area.

12. PREFERENCE FOR U. S. FLAG AIR CARRIERS

A. Pub. L. 93-623 requires that all Federal agencies and Government contractors and subcontractors will use U.S. flag air carriers for international air transportation of personnel (and their personal effects) or property to the extent service by such carriers is available. It further provides that the Comptroller General of the United States shall disallow any expenditure from appropriated funds for international air transportation on other than a U.S. flag air carrier in the absence of satisfactory proof of the necessity therefor.

12. PREFERENCE FOR U. S. FLAG AIR CARRIERS (Cont'd)

B. The Participant agrees to utilize U.S. flag air carriers for international air transportation of personnel (and their personal effects) or property to the extent service by such carriers is available.

C. In the event that the Participant selects a carrier other than a U.S. flag air carrier for international air transportation, he will include a certification on vouchers involving such transportation which is essentially as follows:

CERTIFICATION OF UNAVAILABILITY OF U.S. FLAG AIR CARRIERS

I hereby certify that transportation service for personnel (and their personal effects) or property by certificated air carrier was unavailable for the following reasons: (state reasons).

D. The terms used in this clause have the following meanings:

(1) "International air transportation" means transportation of persons (and their personal effects) or property by air between a place in the United States and a place outside thereof or between two places both of which are outside the Untied States.

(2) "U.S. flag air carrier" means one of a class of air carriers holding a certificate of public convenience and necessity issued by the Civil Aeronautics Board, approved by the President, authorizing operations between the United States and/or its territories and one or more foreign countries.

(3) The term "United States" includes the fifty states, Commonweath of Puerto Rico, possessions of the United States, and the District of Columbia.

E. The Participant shall include the substance of this clause, including this paragraph E., in each subcontract or purchase hereunder which may involve international air transportation.

13. USE OF U.S. FLAG COMMERCIAL VESSELS

A. The Cargo Preference Act of 1954 [Pub. L. 664, August 26, 1954, 68 Stat. 832, 46 U.S.C. 1241(b)], requires that Federal departments or agencies shall transport at least 50 percent of the gross tonnage (computed separately for day bulk carriers, dry cargo liners, and tankers) of equipment, materials, or commodities which may be transported on ocean vessels on privately owned United States flag commercial vessels. Such transportation shall be accomplished whenever:

(1) Any equipment, materials, or commodities, within or outside the United States, which may be transported by ocean vessel, are:

(i) procured, contracted for, or otherwise obtained for the agency's account; or

13. USE OF U.S. FLAG COMMERCIAL VESSELS (Cont'd)

(ii) furnished to or for the account of any foreign nation without provision for reimbursement.

(2) Funds or credits are advanced or the convertibility of foreign currencies is guaranteed in connection with furnishing such equipment, materials, or commodities which may be transported by ocean vessel.

Note: This requirement does not apply to small purchases as defined in 41 CFR 1-3.6 or to cargoes carried in the vessels of the Panama Canal Company.

B. The Participant agrees as follows:

(1) To utilize privately owned United States flag commercial vessels to ship at least 50 percent of the gross tonnage (computed separately for dry bulk carriers, dry cargo liners, and tankers) involved whenever shipping any equipment, material, or commodities under the conditions set forth in A. above pursuant to this Agreement to the extent such vessels are available at fair and reasonable rates for United States flag commercial vessels.

Note: Guidance regarding fair and reasonable rates for United States flag vessels may be obtained from the Division of National Cargo, Office of Market Development, Maritime Administration, Washington, D.C. 20230, Area Code 202, phone 377-3449.

(2) To furnish, within 15 working days following the date of loading for shipments originating within the United States or within 25 working days following the date of loading for shipments originating outside the United States, a legible copy of a rated, "on-board" commercial ocean bill of lading in English for each shipment of cargo covered by the provisions in A. above to both the Contracting Officer (through the prime Participant in the case of subcontractor bills of lading) and to the Division of National Cargo, Officer of Market Development, Maritime Administration, Washington, D.C. 20230.

(3) To insert the substance of the provisions of this clause in all subcontracts issued pursuant to this Agreement except for small purchases as defined in 41 CFR 1-3.6.

14. PERMITS AND LICENSES

Except as otherwise directed by the Contracting Officer, the Participant shall procure all necessary permits or licenses and abide by all applicable laws, regulations, and ordinances of the United States and of the State, territory, and political subdivision in which the work under this Agreement is performed.

15. REPORTING OF ROYALTIES

If this Agreement is in an amount which exceeds $10,000 and if any royalty payments are directly involved in the Agreement or are reflected in the Agreement price to the Government, the Participant agrees to report in writing to the Contracting Officer or Patent Counsel during the performance of this Agreement and prior to its completion or final settlement the amount of any royalties or other payments paid or to be paid by it directly to others in connection with the performance of this Agreement together with the names and addresses of licensors to whom such payments are made and either the patent numbers involved or such other information as will permit the identification of the patents or other basis on which the royalties are to be paid. The approval of DOE of any individual payments or royalties shall not stop the Government at any time from contesting the enforceability, validity or scope of, or title to, any patent under which a royalty or payments are made.

16. AUTHORIZATION AND CONSENT

The Government hereby gives its authorization and consent for all use and manufacture of any invention described in and covered by a patent of the United States in the performance of this Agreement or any part hereof or any amendment hereto or any contract hereunder (including any lower-tier subcontract).

17. NONDISCRIMINATION IN FEDERALLY ASSISTED DOE PROGRAMS - CIVIL RIGHTS

Recipients of DOE financial assistance awards which are provided under DOE Federal Assistance programs shall comply with Part 1040, Chapter X, Title 10 of the Code of Federal Regulations "Nondiscrimination in Federally Assisted Programs" (10 CFR Part 1040) as published in the FR Vol. 45, No. 116, Friday, June 13, 1980 (pages 40514 through 40535). 10 CFR Part 1040 provided that no person shall on the ground of race, color, national origin, sex, handicap, or age be excluded from participation in, be denied the benefits of, be subjected to discrimination under, or be denied employment, where the main purpose of the program or activity is to provide employment or when the delivery of program services is affected by the recipient's employment practices, in connection with any program or activity receiving Federal assistance from the DOE.

18. ADDITIONAL TECHNICAL DATA REQUIREMENTS

A. In addition to the technical data specified elsewhere in this Agreement to be delivered, the Contracting Officer may at any time during the Agreement performance or within one (1) year after final payment call for the Participant to deliver any technical data first produced or specifically used in the performance of this Agreement except technical data pertaining to items of standard commercial design.

B. The provisions of the "Rights in Technical Data" clause included in this Agreement are applicable to all technical data called for under this Additional Technical Data Requirements clause. Accordingly, nothing contained in this clause shall require the Participant to actually deliver any technical data, the delivery of which is excused by paragraph E. of the "Rights in Technical Data" clause.

18. ADDITIONAL TECHNICAL DATA REQUIREMENTS

C. When technical data are to be delivered under this clause, the Participant will be compensated for appropriate costs for converting such data into the prescribed form, for reproduction, and for delivery.

19. RIGHTS IN TECHNICAL DATA - LONG FORM

A. Definitions.

(1) "Technical Data" means recorded information regardless of form or characteristic, of a scientific or technical nature. It may, for example, document research, experimental, developmental, or demonstration, or engineering work, or be usable or used to define a design or process, or to procure, produce, support, maintain, or operate materiel. The data may be graphic or pictorial delineations in media such as drawings or photographs, text in specifications or related performance or design type documents or computer software (including computer programs, computer software data bases, and computer software documentation). Examples of technical data include research and engineering data, engineering drawings and associated lists, specifications, standards, process sheets, manuals, technical reports, catalog item identification, and related information. Technical data as used herein does not include financial reports, cost analyses, and other information incidental to Agreement administration.

(2) "Proprietary Data" means technical data which embody trade secrets developed at private expense, such as design procedures or techniques, chemical composition of materials, or manufacturing methods, processes, or treatments, including minor modifications thereof, provided that such data:

(i) Are not generally known or available from other sources without obligation concerning their confidentiality;

(ii) Have not been made available by the owner to others without obligation concerning its confidentiality; and

(iii) Are not already available to the Government without obligation concerning their confidentiality.

(3) "Contract Data" means technical data first produced in the performance of the Agreement, technical data which are specified to be delivered in the Agreement, technical data that may be called for under the "Additional Technical Data Requirements" clause of the Agreement, if any, or technical data actually delivered in connection with the Agreement.

19. RIGHTS IN TECHNICAL DATA - LONG FORM (Cont'd)

(4) "Unlimited Rights" means rights to use, duplicate, or disclose technical data, in whole or in part, in any manner and for any purpose whatsoever, and to permit others to do so.

B. Allocation of Rights.

(1) The Government shall have:

(i) Unlimited rights in contract data except as otherwise provided below with respect to proprietary data.

(ii) The right to remove, cancel, correct or ignore any marking not authorized by the terms of this Agreement on any technical data furnished hereunder, if in response to a written inquiry by DOE concerning the propriety of the markings, the Participant fails to respond thereto within sixty (60) days or fails to substantiate the propriety of the markings. In either case DOE will notify the Participant of the action taken.

(iii) No rights under this Agreement in any technical data which are not Agreement data.

(2) The Participant shall have:

(i) The right to withhold proprietary data in accordance with the provisions of this clause.

(ii) The right to use for its private purposes, subject to patent, security or other provisions of this Agreement, contract data it first produces in the performance of this Agreement provided the data requirements of this Agreement have been met as of the date of the private use of such data. The Participant agrees that to the extent it receives or is given access to proprietary data or other technical, business or financial data in the form of recorded information from DOE or a DOE contractor or subcontractor, the Participant shall treat such data in accordance with any restrictive legend contained thereon, unless use is specifically authorized by prior written approval of the Contracting Officer.

(3) Nothing contained in this "Rights in Technical Data" clause shall imply a license to the Government under any patent or be construed as affecting the scope of any licenses or other rights otherwise granted to the Government under any patent.

19. RIGHTS IN TECHNICAL DATA - LONG FORM (Cont'd)

C. Copyrighted Material.

(1) The Participant shall not, without prior written authorization of the Contracting Officer, establish a claim to statutory copyright in any Agreement data first produced in the performance of the Agreement. To the extent such authorization is granted, the Government reserves for itself and others acting on its behalf a royalty-free, nonexclusive, irrevocable, worldwide license for Governmental purposes to publish, distribute, translate, duplicate, exhibit and perform any such data copyrighted by the Participant.

(2) The Participant agrees not to include in the technical data delivered under the Agreement any material copyrighted by the Participant and not to knowingly include any material copyrighted by others without first granting or obtaining at no cost a license therein for the benefit of the Government of the same scope as set forth in subparagraph C.(1) above. If such royalty-free license is unavailable and the Participant nevertheless determines that such copyrighted material must be included in the technical data to be delivered, rather than merely incorporated therein by reference, the Participant shall request the written authorization of the Contracting Officer to include such copyrighted material in the technical data without a license.

D. Subcontracting. It is the responsibility of the Participant to obtain from its contractors technical data and rights therein, on behalf of the Government, necessary to fulfill the Participant's obligations to the Government with respect to such data. In the event of refusal by a subcontractor to accept an article affording the Government such rights, the Participant shall:

(1) Promptly submit written notice to the Contracting Officer setting forth reasons for the subcontractor's refusal and other pertinent information which may expedite disposition of the matter; and

(2) Not proceed with the contract without the written authorization of the Contracting Officer.

E. Withholding of Proprietary Data. Notwithstanding the inclusion of the "Additional Technical Data Requirements" clause in this Agreement or any provision of this Agreement specifying the delivery of technical data, the Participant may withhold proprietary data from delivery, provided that the Participant furnishes in lieu of any such proprietary data, so withheld technical data disclosing the source, size, configuration, mating and attachment characteristics, functional characteristics and performance requirements ("Form, Fit and Function" data, e.g., specification control

19. RIGHTS IN TECHNICAL DATA - LONG FORM (Cont'd)

drawings, catalog sheets, envelope drawings, etc.) or a general description of such proprietary data where "Form, Fit and Function" data are not applicable. The Government shall acquire no rights to any proprietary data so withheld except that such data shall be subject to the "Inspection Rights" provisions of paragraph F., and if included, the "Limited Rights in Proprietary Data" provisions of paragraph G. and the "Participant Licensing" provisions of paragraph H.

F. Inspection Rights. Except as may be otherwise specified in this Agreement for specific items of proprietary data which are not subject to this paragraph, the Contracting Officer's representatives, at all reasonable times up to three (3) years after final payment under this Agreement, may inspect at the Participant's facility any proprietary data withheld under paragraph E. and not furnished under paragraph G. for the purposes of verifying that such data properly fell within the withholding provision of paragraph E., or for evaluating work performance.

20. CONTRACT WORK HOURS AND SAFETY STANDARDS ACT - OVERTIME COMPENSATION

[This Agreement, to the extent that it is of a character specified in the Contract Work Hours and Safety Standards Act (40 U.S.C. 327-333), is subject to the following provisions and to all other applicable provisions and exceptions of such Act and the regulations of the Secretary of Labor thereunder.]

A. Overtime Requirements. The Participant or contractor contracting for any part of the Agreement work, which may require or involve the employment of laborers, mechanics, apprentices, trainees, watchmen, and guards, shall require or permit any laborer, mechanic, apprentice, trainee, watchman, or guard, in any workweek in which he is employed on such work, to work in excess of eight (8) hours in any calendar day, or in excess of forty (40) hours in such workweek, on work subject to the provisions of the Contract Work Hours and Safety Standards Act, unless such laborer, mechanic, apprentice, trainee, watchman, or guard receives compensation at a rate not less than one and one-half times his basic rate of pay for all such hours worked in excess of eight (8) hours in any calendar day, or in excess of forty (40) hours in such workweek, whichever is the greater number of overtime hours.

B. Violation; Liability for Unpaid Wages; Liquidated Damages. In the event of any violation of the provisions of paragraph A., the Participant and any contractor responsible therefor shall be liable to any affected employee for his unpaid wages. In addition, such Participant and contractor shall be liable to the United States for liquidated damages. Such liquidated damages shall be computed with respect to each individual laborer, mechanic, apprentice, trainee, watchman, or guard employed in violation of the provisions of paragraph A. in the sum of $10 for each calendar day on which such employee was required or permitted to be employed on such work in excess of eight (8) hours or in excess of his standard workweek of forty (40) hours without payment of the overtime wages required by paragraph A.

20. CONTRACT WORK HOURS AND SAFETY STANDARDS ACT - OVERTIME COMPENSATION (Cont'd)

C. Withholding for Unpaid Wages and Liquidated Damages. The Contracting Officer may withhold from the Government Prime Participant, from any moneys payable on account of work performed by the Participant or contractor, such sums as may administratively be determined to be necessary to satisfy any liabilities of such Participant or contractor for unpaid wages and liquidated damages as provided in the provisions of paragraph B.

D. Subcontracts. The Participant shall insert paragraphs A. through D. of this clause in all subcontracts, and shall require their inclusion in all subcontracts of any tier.

E. Records. The Participant shall maintain payroll records containing the information specified in 29 CFR 516.2(a). Such records shall be preserved for three (3) years from the completion of the Agreement.

21. PATENT RIGHTS - LONG FORM

A. Definitions.

(1) "Subject Invention" means any invention or discovery of the Participant conceived or first actually reduced to practice in the course of or under this Agreement, and includes any art, method, process, machine, manufacture, design, or composition of matter, or any new and useful improvement thereof, or any variety of plants, whether patented or unpatented under the Patent Laws of the United States of America or any foreign country.

(2) "Contract" means any contract, grant, agreement, understanding or other arrangement, which includes research, development, or demonstration work, and includes any assignment or substitution of parties.

(3) "States and domestic municipal governments" means the States of the United States, the District of Columbia, Puerto Rico, the Virgin Islands, American Samoa, Guam, the Trust Territory of the Pacific Islands, and any political subdivision and agencies thereof.

(4) "Government agency" includes an executive department, independent commission, board, office, agency, administration, authority, Government corporation, or other Government establishment of the Executive Branch of the Government of the United States of America.

(5) "To the point of practical application" means to manufacture in the case of a composition or product, to practice in the case of a process, or to operate in the case of a machine and under such conditions as to establish that the invention is being worked and that its benefits are reasonably accessible to the public.

21. PATENT RIGHTS - LONG FORM (Cont'd)

(6) "Patent Counsel" means the DOE Patent Counsel assisting the procuring activity.

B. Allocation of Principal Rights.

(1) Assignment to the Government. The Participant agrees to assign to the Government the entire right, title, and interest throughout the world in and to each Subject Invention except to the extent that rights are retained by the Participant under subparagraph B.(2) and paragraph C. of this clause.

(2) Greater Rights Determinations. The Participant or the employee-inventor with authorization of the Participant may request greater rights than the nonexclusive license and the foreign patent rights provided in paragraph C. of this clause on identified inventions, in accordance with 41 CFR 9-9.109-6. Such requests must be submitted to Patent Counsel (with notification by Patent Counsel to the Contracting Officer) at the time of the first disclosure pursuant to subparagraph E.(2) of this clause, or not later than nine (9) months after conception or first actual reduction to practice, whichever occurs first, or such longer period as may be authorized by Patent Counsel (with notification by Patent Counsel to the Contracting Officer) for good cause shown in writing by the Participant.

C. Minimum Rights to the Participant.

(1) Participant License. The Participant reserves a revocable, nonexclusive, paid-up license in each patent application filed in any country on a Subject Invention and any resulting patent in which the Government acquires title. The license shall extend to the Participant's domestic subsidiaries and affiliates, if any, within the corporate structure of which the Participant is a part and shall include the right to grant sublicenses of the same scope to the extent the Participant was legally obligated to do so at the time the Agreement was awarded. The license shall be transferable only with approval of DOE except when transferred to the successor of that part of the Participant's business to which the invention pertains.

(2) Revocation Limitations. The Participant's nonexclusive license retained pursuant to subparagraph C.(1) of this clause and sublicenses granted thereunder may be revoked or modified by DOE, either in whole or in part, only to the extent necessary to achieve expeditious practical application of the Subject Invention under DOE's published licensing regulations (10 CFR 781), and only to the extent an exclusive license is actually granted. This license shall not be revoked in that field of use and/or the geographical areas in which the Participant, or its sublicensee, has brought the invention to the point of practical application and continues to make the benefits of the invention reasonably accessible to the public, or is expected to do so within a reasonable time.

21. PATENT RIGHTS - LONG FORM (Cont'd)

(3) Revocation Procedures. Before modification or revocation of the license or sublicense, pursuant to subparagraph C.(2) of this clause, DOE shall furnish the Participant a written notice of its intention to modify or revoke the license and any sublicense thereunder, and the Participant shall be allowed thirty (30) days, or such longer period as may be authorized by the Patent Counsel (with notification by Patent Counsel to the Contracting Officer) for good cause shown in writing by the Participant, after such notice to show cause why the license or any sublicense should not be modified or revoked. The Participant shall have the right to appeal, in accordance with 10 CFR 781, any decision concerning the modification or revocation of its license or any sublicense.

(4) Foreign Patent Rights. Upon written request to Patent Counsel (with notification by Patent Counsel to the Contracting Officer), in accordance with subparagraph E.(2)(i) of this clause, and subject to DOE security regulations and requirements, there shall be reserved to the Participant, or the employee-inventor with authorization of the Participant, the patent rights to a Subject Invention in any foreign country where the Government has elected not to secure such rights provided:

(i) The recipient of such rights, when specifically requested by DOE and three (3) years after issuance of a foreign patent disclosing said Subject Invention, shall furnish DOE a report setting forth:

(A) The commercial use that is being made, or is intended to be made, of said invention, and

(B) The steps taken to bring the invention to the point of practical application or to make the invention available for licensing.

(ii) The Government shall retain at least an irrevocable, nonexclusive, paid-up license to make, use, and sell the invention throughout the world by or on behalf of the Government (including any Government agency) and States and domestic municipal governments, unless the Secretary or his designee determines that it would not be in the public interest to acquire the license for the States and domestic municipal governments.

(iii) Subject to the rights granted in subparagraphs C.(1), (2), and (3) of this clause, the Secretary or his designee shall have the right to terminate the foreign patent rights granted in this subparagraph C.(4) in whole or in part unless the recipient of such rights demonstrates to the satisfaction of the Secretary or his designee that effective steps necessary to accomplish substantial utilization of the invention have been taken or within a reasonable time will be taken.

21. PATENT RIGHTS - LONG FORM (Cont'd)

(iv) Subject to the rights granted in subparagraphs C.(1), (2), and (3) of this clause, the Secretary or his designee shall have the right, commencing four (4) years after foreign patent rights are accorded under this subparagraph C.(4), to require the granting of a nonexclusive or partially exclusive license to a responsible applicant or applicants, upon terms reasonable under the circumstances and in appropriate circumstances to terminate said foreign patent rights in whole or in part, following a hearing upon notice thereof to the public, upon a petition by an interested person justifying such hearing:

(A) If the Secretary or his designee determines, upon review of such material as he deems relevant, and after the recipient of such rights, or other interested person, has had the opportunity to provide such relevant and material information as the Secretary or his designee may require, that such foreign patent rights have tended substantially to lessen competition or to result in undue market concentration in any section of the United States in any line of commerce to which the technology relates; or

(B) Unless the recipient of such rights demonstrates to the satisfaction of the Secretary or his designee at such hearing that the recipient has taken effective steps, or within a reasonable time thereafter is expected to take such steps, necessary to accomplish substantial utilization of the invention.

D. Filing of Patent Applications.

(1) With respect to each Subject Invention in which the Participant or the inventor requests foreign patent rights in accordance with subparagraph C.(4) of this clause, a request may also be made for the right to file and prosecute the U.S. application on behalf of the U.S. Government. If such request is granted, the Participant or inventor shall file a domestic patent application on the invention within six (6) months after the request for foreign patent rights is granted, or such longer period of time as may be approved by the Patent Counsel for good cause shown in writing by the requester. With respect to the invention, the requester shall promptly notify the Patent Counsel (with notification by Patent Counsel to the Contracting Officer) of any decision not to file an application.

(2) For each Subject Invention on which a domestic patent application is filed by the Participant or inventor, the Participant or inventor shall:

21. PATENT RIGHTS - LONG FORM (Cont'd)

(i) Within two (2) months after the filing or within two (2) months after submission of the invention disclosure if the patent application previously has been filed, deliver to the Patent Counsel a copy of the application as filed including the filing date and serial number;

(ii) Within six (6) months after filing the application or within six (6) months after submitting the invention disclosure if the application has been filed previously, deliver to the Patent Counsel a duly executed and approved assignment to the Government, on a form specified by the Government;

(iii) Provide the Patent Counsel with the original patent grant promptly after a patent is issued on the application; and

(iv) Not less than thirty (30) days before the expiration of the response period for any action required by the Patent and Trademark Office, notify the Patent Counsel of any decision not to continue prosecution of the application.

(3) With respect to each Subject Invention in which the Participant or inventor has requested foreign patent rights, the Participant or inventor shall file a patent application on the invention in each foreign country in which such request is granted in accordance with applicable statutes and regulations and within one of the following periods:

(i) Eight (8) months from the date of filing a corresponding United States application, or if such an application is not filed, six (6) months from the date the request was granted;

(ii) Six (6) months from the date a license is granted by the Commissioner of Patents and Trademarks to file the foreign patent application where such filing has been prohibited by security reasons; or

(iii) Such longer periods as may be approved by the Patent Counsel for good cause shown in writing by the Participant or inventor.

(4) Subject to the license specified in subparagraphs C.(1), (2) and (3) of this clause, the Participant or inventor agrees to convey to the Government, upon request, the entire right, title, and interest in any foreign country in which the Participant or inventor fails to have a patent application filed in accordance with subparagraph D.(3)

21. PATENT RIGHTS - LONG FORM (Cont'd)

of this clause, or decides not to continue prosecution or to pay any maintenance fees covering the invention. To avoid forfeiture of the patent application or patent the Participant or inventor shall, not less than sixty (60) days before the expiration period for any action required by any Patent Office, notify the Patent Counsel of such failure or decision, and deliver to the Patent Counsel the executed instruments necessary for the conveyance specified in this paragraph.

E. Invention Identification, Disclosures, and Reports.

(1) The Participant shall establish and maintain active and effective procedures to ensure that Subject Inventions are promptly identified and timely disclosed. These procedures shall include the maintenance of laboratory notebooks or equivalent records and any other records that are reasonably necessary to document the conception and/or the first actual reduction to practice of Subject Inventions, and records which show that the procedures for identifying and disclosing the inventions are followed. Upon request, the Participant shall furnish the Contracting Officer a description of these procedures so that he may evaluate and determine their effectiveness.

(2) The Participant shall furnish the Patent Counsel (with notification by Patent Counsel to the Contracting Officer) on a DOE-approved form:

(i) A written report containing full and complete technical information concerning each Subject Invention within six (6) months after conception or first actual reduction to practice whichever occurs first in the course of or under this Agreement, but in any event prior to any on sale, public use or public disclosure of such invention known to the Participant. The report shall identify the Agreement and inventor and shall be sufficiently complete in technical detail and appropriately illustrated by sketch or diagram to convey to one skilled in the art to which the invention pertains a clear understanding of the nature, purpose, operation, and to the extent known, the physical, chemical, biological, or electrical characteristics of the invention. The report should also include any request for foreign patent rights under subparagraph C.(4) of this clause and any request to file a domestic patent application under subparagraph D.(1) of this clause. However, such requests shall be made within the period set forth in subparagraph B.(2) of this clause. When an invention is reported under this subparagraph E.(2)(i), it shall be presumed to have been made in the manner specified in Section 9(a)(1) and (2) of 42 U.S.C. 5908 unless the Participant contends it was not so made in accordance with subparagraph G.(2)(ii) of this clause.

(ii) Upon request, but not more than annually, interim reports on a DOE-approved form listing Subject Inventions and subcontracts awarded containing a Patent Rights article for that period and certifying that:

21. PATENT RIGHTS - LONG FORM (Cont'd)

(A) The Participant's procedures for identifying and disclosing Subject Inventions as required by this paragraph E. have been followed throughout the reporting period;

(B) All Subject Inventions have been disclosed or that there are no such inventions; and

(C) All subcontracts containing a Patent Rights clause have been reported or that no such subcontracts have been awarded.

(iii) A final report on a DOE-approved form within three (3) months after completion of the Agreement work listing all Subject Inventions and all subcontracts awarded containing a Patent Rights clause and certifying that:

(A) All Subject Inventions have been disclosed or that there were no such inventions; and

(B) All subcontracts containing a Patent Rights article have been reported or that no such subcontracts have been awarded.

(3) The Participant shall obtain patent agreements to effectuate the provisions of this clause from all persons in its employ who perform any part of the work under this Agreement except nontechnical personnel, such as clerical employees and manual laborers.

(4) The Participant agrees that the Government may duplicate and disclose Subject Invention disclosures and all other reports and papers furnished or required to be furnished pursuant to this clause. If the Participant is to file a foreign patent application on a Subject Invention, the Government agrees, upon written request, to use its best efforts to withhold publication of such invention disclosures until the expiration of the time period specified in subparagraph D.(1) of this clause, but in no event shall the Government or its employees be liable for any publication thereof.

F. Publication. It is recognized that during the course of the work under this Agreement, the Participant or its employees may from time to time desire to release or publish information regarding scientific or technical developments conceived or first actually reduced to practice in the course of or under this Agreement. In order that public disclosure of such information will not adversely affect the patent interests of DOE or the Participant, patent approval for release or publication shall be secured from Patent Counsel prior to any such release or publication.

G. Forfeiture of Rights in Unreported Subject Inventions.

(1) The Participant shall forfeit to the Government, at the request of the Secretary or his designee, all rights in any

21. PATENT RIGHTS - LONG FORM (Cont'd)

Subject Invention which the Participant fails to report to Patent Counsel (with notification by Patent Counsel to the Contracting Officer) within six (6) months after the time the Participant:

(i) Files or causes to be filed a United States or foreign patent application thereon; or

(ii) Submits the final report required by subparagraph E.(2)(iii) of this clause, whichever is later.

(2) However, the Participant shall not forfeit rights in a Subject Invention if, within the time specified in (1)(i) or (1)(ii) of this paragraph G., the Participant:

(i) Prepares a written decision based upon a review of the record that the invention was neither conceived nor first actually reduced to practice in the course of or under the Agreement and delivers the same to Patent Counsel (with notification by Patent Counsel to the Contracting Officer); or

(ii) Contending that the invention is not a Subject Invention the Participant nevertheless discloses the invention and all facts pertinent to this contention to the Patent Counsel (with notification by Patent Counsel to the Contracting Officer); or

(iii) Establishes that the failure to disclose did not result from the Participant's fault or negligence.

(3) Pending written assignment of the patent applications and patents on a Subject Invention determined by the Secretary or his designee to be forfeited (such determination to be a final decision under the "Disputes" clause of this Agreement), the Participant shall be deemed to hold the invention and the patent applications and patents pertaining thereto in trust for the Government. The forfeiture provision of this paragraph G. shall be in addition to and shall not supersede other rights and remedies which the Government may have with respect to Subject Inventions.

H. Examination of Records Relating to Inventions.

(1) The Contracting Officer or his authorized representative, until the expiration of three (3) years after final payment under this Agreement, shall have the right to examine any books (including laboratory notebooks), records, documents, and other supporting data

21. PATENT RIGHTS - LONG FORM (Cont'd)

of the Participant which the Contracting Officer or his authorized representative reasonably deems pertinent to the discovery or identification of Subject Inventions or to determine compliance with the requirements of this clause.

(2) The Contracting Officer or his authorized representative shall have the right to examine all books (including laboratory notebooks), records and documents of the Participant relating to the conception of first actual reduction to practice of inventions in the same field of technology as the work under this Agreement to determine whether any such inventions are Subject Inventions, if the Participant refuses or fails to:

(i) Establish the procedures of subparagraph E.(1) of this clause; or

(ii) Maintain and follow such procedures; or

(iii) Correct or eliminate any material deficiency in the procedures within thirty (30) days after the Contracting Officer notifies the Participant of such a deficiency.

I. Withholding of Payment (Not Applicable to Subcontracts).

(1) Any time before final payment of the amount of this Agreement, the Contracting Officer may, if he deems such action warranted, withhold payment until a reserve not exceeding $50,000 or 5 percent of the amount of this Agreement, whichever is less, shall have been set aside if in his opinion the Participant fails to:

(i) Establish, maintain and follow effective procedures for identifying and disclosing Subject Inventions pursuant to subparagraph E.(1) of this clause; or

(ii) Disclose any Subject Invention pursuant to subparagraph E.(2)(i) of this clause; or

(iii) Deliver the interim reports pursuant to subparagraph E.(2)(ii) of this clause; or

(iv) Provide the information regarding subcontracts pursuant to subparagraph J.(5) of this clause; or

(v) Convey to the Government in a DOE-approved form the title and/or rights of the Government in each Subject Invention as required by this clause.

21. PATENT RIGHTS - LONG FORM (Cont'd)

(2) The reserve or balance shall be withheld until the Contracting Officer has determined that the Participant has rectified whatever deficiencies exist and has delivered all reports, disclosures, and other information required by the clause.

(3) Final payment under this Agreement shall not be made by the Contracting Officer before the Participant delivers to Patent Counsel all disclosures of Subject Inventions and other information required by subparagraph E.(2)(i) of this clause, the final report required by subparagraph E.(2)(iii) of this clause, and Patent Counsel has issued a patent clearance certification to the Contracting Officer.

(4) The Contracting Officer may, in his discretion, decrease or increase the sums withheld up to the maximum authorized above. If the Participant is a nonprofit organization, the maximum amount that may be withheld under this paragraph shall not exceed $50,000 or 1 percent of the amount of this Agreement, whichever is less. No amount shall be withheld under this paragraph while the amount specified by this paragraph is being withheld under other provisions of the Agreement. The withholding of any amount or subsequent payment thereof shall not be construed as a waiver of any rights accruing to the Government under this Agreement.

J. Subcontracts.

(1) For the purpose of this paragraph the term "Participant" means the party awarding a subcontract and the term "subcontractor" means the party being awarded a subcontract, regardless of tier.

(2) Unless otherwise authorized or directed by the Contracting Officer, the Participant shall include the Patent Rights clause of 41 CFR 9-9.107-5(a) or 41 CFR 9-9.107-6 as appropriate, modified to identify the parties in any subcontract hereunder having as a purpose the conduct of research, development, or demonstration work. In the event of refusal by a subcontractor to accept this clause, or if in the opinion of the Participant this clause is inconsistent with DOE's patent policies, the Participant:

(i) Shall promptly submit written notice to the Contracting Officer setting forth reasons for the subcontractor's refusal and other pertinent information which may expedite disposition of the matter; and

(ii) Shall not proceed with the subcontract without the written authorization of the Contracting Officer.

21. PATENT RIGHTS - LONG FORM (Cont'd)

(3) Except as may be otherwise provided in this clause, the Participant shall not, in any subcontract or by using a subcontract as consideration therefor, acquire any rights in its subcontractor's Subject Invention for the Participant's own use (as distinguished from such rights as may be required solely to fulfill the Participant's Agreement obligations to the Government in the performance of this Agreement).

(4) All invention disclosures, reports, instruments, and other information required to be furnished by the subcontractor to DOE, under the provisions of a Patent Rights clause in any subcontract hereunder may, in the discretion of the Contracting Officer, be furnished to the Participant for transmission to DOE.

(5) The Participant shall promptly notify the Contracting Officer in writing upon the award of any subcontract containing a Patent Rights clause by identifying the subcontractor, the work to be performed under the subcontract, and the dates of award, and estimated completion. Upon the request of the Contracting Officer the Participant shall furnish him a copy of the subcontract.

(6) The Participant shall identify all Subject Inventions of the subcontractor of which it acquires knowledge in the performance of this Agreement and shall notify the Patent Counsel (with notification by Patent Counsel to the Contracting Officer) promptly upon the identification of the inventions.

(7) It is understood that the Government is a third party beneficiary of any subcontract clause granting rights to the Government in Subject Inventions, and the Participant hereby assigns to the Government all rights that the Participant would have to enforce the subcontractor's obligations for the benefit of the Government with respect to Subject Inventions. The Participant shall not be obligated to enforce the agreements of any subcontractor hereunder relating to the obligations of the subcontractor to the Government regarding Subject Inventions.

K. Background Patents.

(1) "Background Patent" means a domestic patent covering an invention or discovery which is not a Subject Invention and which is owned or controlled by the Participant at any time through the completion of this Agreement:

21. PATENT RIGHTS - LONG FORM (Cont'd)

(i) Which the Participant, but not the Government, has the right to license to others without obligation to pay royalties thereon; and

(ii) Infringement of which cannot reasonably be avoided upon the practice of any specific process, method, machine, manufacture or composition of matter (including relatively minor modifications thereof) which is a subject of the research, development, or demonstration work performed under this Agreement.

(2) The Participant agrees to and does hereby grant to the Government a royalty-free, nonexclusive, license under any Background Patent for purposes of practicing a subject of this Agreement by or for the Government in research, development, and demonstration work only.

(3) The Participant also agrees that upon written application by DOE, it will grant to responsible parties for purposes of practicing a subject of this Agreement, nonexclusive licenses under any Background Patent on terms that are reasonable under the circumstances. If, however, the Participant believes that exclusive or partially exclusive rights are necessary to achieve expeditious commercial development or utilization, then a request may be made to DOE for DOE approval of such licensing by the Participant.

(4) Notwithstanding the foregoing subparagraph K.(3), the Participant shall not be obligated to license any Background Patent if the Participant demonstrates to the satisfaction of the Secretary or his designee that:

(i) A competitive alternative to the subject matter covered by said Background Patent is commercially available or readily introducible from one or more other sources; or

(ii) The Participant or its licensees are supplying the subject matter covered by said Background Patent in sufficient quantity and at reasonable prices to satisfy market needs, or have taken effective steps or within a reasonable time are expected to take effective steps to so supply the subject matter.

L. Atomic Energy.

(1) No claim for pecuniary award or compensation under the provisions of the Atomic Energy Act of 1954, as amended, shall be

21. PATENT RIGHTS - LONG FORM (Cont'd)

asserted by the Participant or its employees with respect to any invention or discovery made or conceived in the course of or under this Agreement.

(2) Except as otherwise authorized in writing by the Contracting Officer, the Participant will obtain patent agreements to effectuate the provisions of subparagraph L.(1) of this clause from all persons who perform any part of the work under this Agreement, except nontechnical personnel, such as clerical employees and manual laborers.

M. Limitation of Rights. Nothing contained in this Patent Rights clause shall be deemed to give the Government any rights with respect to any invention other than a Subject Invention except as set forth in the Patent Rights article of this Agreement with respect to Background Patents and the Facilities License.

22. FLOOD INSURANCE

The Participant shall comply with the flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973, Public Law 93-234, 87 Stat. 975, approved December 31, 1976, Section 102(a) requires, on and after March 2, 1975, the Purchase of flood insurance in communities where such insurance is available as a condition for the receipt of any Federal financial assistance for construction or acquisition purposes for use in any area that has been identified by the Secretary of the Department of Housing and Urban Development as an area having special flood hazards and provisions prescribed by the Federal Insurance Administration in 24 CFR Chapter X, Subchapter B., will be complied with.

23. UTILIZATION OF LABOR SURPLUS AREA CONCERNS

(The following clause is applicable if this Agreement exceeds $10,000.00)

A. It is the policy of the Government to award contracts to labor surplus area concerns that agree to perform substantially in labor surplus areas, where this can be done consistent with the efficient performance of the Agreement and at prices no higher than are obtainable elsewhere. The Participant agrees to use its best efforts to place its subcontracts in accordance with this policy.

B. In complying with paragraph A. of this clause and with paragraph B. of the clause of this Agreement entitled "Utilization of Small Business Concerns Owned and Controlled by Socially and Economically Disadvantaged Individuals," the Participant in placing its subcontracts shall observe the following order of preference: (1) Small business concerns that are labor surplus area concerns, (2) other small business concerns, and (3) other labor surplus area concerns.

23. UTILIZATION OF LABOR SURPLUS AREA CONCERNS (Cont'd)

C. (1) The term "labor surplus area" means a geographical area identified by the Department of Labor as an area of concentrated unemployment or underemployment or an area of labor surplus.

(2) The term "labor surplus area concern" means a concern that together with its first-tier subcontractors will perform substantially in labor surplus areas.

(3) The term "perform substantially in a labor surplus area" means that the costs incurred on account of manufacturing, production, or appropriate services in labor surplus areas exceed 50 percent of the Agreement price.

24. LABOR SURPLUS AREA SUBCONTRACTING PROGRAM

A. The Participant agrees to establish and conduct a program which will encourage labor surplus area concerns to compete for subcontracts within their capabilities. In this connection, the Participant shall:

(1) Designate a liaison officer who will (a) maintain liaison with duly authorized representatives of the Government on labor surplus area matters, (b) supervise compliance with the "Utilization of Labor Surplus Area Concerns" clause and (c) administer the Contractor's Labor Surplus Area Subcontracting Program;

(2) Provide adequate and timely consideration of the potentialities of labor surplus area concerns in all "make-or-buy" decisions;

(3) Assure that labor surplus area concerns will have an equitable opportunity to compete for subcontracts, particularly by arranging solicitations, time for the preparation of bids, quantities, specifications, and delivery schedules so as to facilitate the participation of labor surplus area concerns;

(4) Maintain records showing the procedures which have been adopted to comply with the policies set forth in this clause and report subcontract awards (see 41 CFR 1-16.804-5 regarding use of Optional Form 61). Records maintained pursuant to this clause will be kept available for review by the Government until the expiration of one (1) year after the award of this contract, or for such longer period as may be required by any other clause of this contract or by applicable law or regulations; and

(5) Include the "Utilization of Labor Surplus Area Concerns" clause in subcontracts which offer substantial labor surplus area subcontracting opportunities.

B. (1) The term "labor surplus area" means a geographical area identified by the Department of Labor as an area of concentrated unemployment or underemployment or an area of labor surplus.

24. LABOR SURPLUS AREA SUBCONTRACTING PROGRAM (Cont'd)

(2) The term "concern located in a labor surplus area" means a labor surplus area concern.

(3) The term "labor surplus area concern" means a concern that, together with its first-tier subcontractors, will perform substantially in labor surplus areas.

(4) The term "perform substantially in labor surplus areas" means that the costs incurred on account of manufacturing, production, or appropriate services in labor surplus areas exceed 50 percent of the contract price.

C. The Participant further agrees to insert, in any subcontract hereunder which may exceed $500,000.00 and which contains the "Utilization of Labor Surplus Area Concerns" clause, provisions which shall conform substantially to the language of this clause, including this paragraph C., and to notify the Contracting Officer of the names of such subcontractors.

25. DISPUTES

A. Except as otherwise provided in this Agreement, any dispute concerning a question of fact arising under this Agreement which is not disposed of by Agreement shall be decided by the Contracting Officer, who shall reduce his decision to writing and mail, or otherwise furnish a copy thereof to the Participant. The decision of the Contracting Officer shall be final and conclusive unless within 60 days from date of receipt of such copy, the Participant mails, or delivers a written notice of appeal to the Department of Energy Financial Assistance Appeals Board in accordance with 10 CFR Part 1024 (See Rule 1). The decision of the Department of Energy Financial Assistance Appeals Board shall be final and conclusive unless determined by a court of competent jurisdiction to have been fradulent, or capricious, or arbitrary, or so grossly erroneous as necessary to imply bad faith, or not supported by substantial evidence. In connection with any appeal proceeding under this clause, the Participant shall be afforded an opportunity to be heard and to offer evidence in support of its appeal. Pending final decision of a dispute hereunder, the Participant shall proceed diligently with the performance of the Agreement and in accordance with the Contracting Officer's decision.

B. This "Disputes Clause" does not preclude consideration of law questions in connection with decisions provided for in paragraph A. above; provided, that nothing in this Agreement shall be construed as making final the decision of any administrative official, representative, or board, based on a question of law.

26. BUY AMERICAN ACT

A. In acquiring end products, the Buy American Act (41 U.S. Code 10a-10d) provides that the Government give preference to domestic source end products. For the purpose of this clause:

(1) "Components" means those articles, materials, and supplies which are directly incorporated in the end products;

(2) "End products" means those articles, materials, and supplies which are to be acquired under this contract for public use; and

(3) "A domestic source end product" means (i) an unmanufactured end product which has been mined or produced in the United States, and (ii) an end product manufactured in the United States if the cost of the components thereof which are mined, produced, or manufactured in the United States exceeds 50 percent of the costs of all its components. For the purpose of this subparagraph A.(3)(ii), components of foreign origin of the same type or kind as the products referred to in subparagraphs B.(2) or (3) of this clause shall be treated as components mined, produced, or manufactured in the United States.

B. The Participant agrees to give preference in all purchases under this Cooperative Agreement to domestic source end products.

27. UTILIZATION OF SMALL BUSINESS CONCERNS AND SMALL BUSINESS CONCERNS OWNED AND CONTROLLED BY SOCIALLY AND ECONOMICALLY DISADVANTAGED INDIVIDUALS

A. It is the policy of the United States and the Department of Energy that small business concerns and small business concerns owned and controlled by socially and economically disadvantaged individuals shall have the maximum practicable opportunity to participate in the performance of contracts let by DOE.

B. The Participant hereby agrees to carry out this policy in the awarding of subcontracts to the fullest extent consistent with the efficient performance of this Agreement. The Participant further agrees to cooperate in any studies or surveys as may be conducted by the United States Small Business Administration or the Department of Energy as may be necessary to determine the extent of the Participant's compliance with this clause.

C. (1) As used in this Agreement, the term "small business concern" shall mean a small business as defined pursuant to Section 3 of the Small Business Act and relevant regulations promulgated pursuant thereto.

(2) The term "small business concern owned and controlled by socially and economically disadvantaged individuals" shall mean a small business concern:

(i) Which is at least 51 per centum owned by one or more socially and economically disadvantaged individuals;

27. UTILIZATION OF SMALL BUSINESS CONCERNS AND SMALL BUSINESS CONCERNS OWNED AND CONTROLLED BY SOCIALLY AND ECONOMICALLY DISADVANTAGED INDIVIDUALS (Cont'd)

or in the case of any publicly-owned business at least 51 per centum of the stock of which is owned by one or more socially and economically disadvantaged individuals; and

(ii) Whose management and daily business operations are controlled by one or more of such individuals.

The Participant shall presume that socially and economically disadvantaged individuals include Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, and other minorities, or any other individual found to be disadvantaged by the Small Business Administration pursuant to Section 8(a) of the Small Business Act.

D. Subcontractors shall provide a notarized statement to the Participant certifying their status as either a small business concern or a small business concern owned and controlled by socially and economically disadvantaged individuals.

28. UTILIZATION OF WOMEN-OWNED BUSINESS CONCERNS

A. It is the policy of the United States Government that women-owned businesses shall have the maximum practicable opportunity to participate in the performance of contracts awarded by any Federal agency.

B. The Participant agrees to use its best efforts to carry out this policy in the award of subcontracts to the fullest extent consistent with the efficient performance of this Agreement. As used in this Agreement, a "woman-owned business" concern means a business that is at least 51% owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management. "Women" mean all women business owners.

APPENDIX B

PROJECT TASKS, SCHEDULE BACKGROUND, AND REPORTING REQUIREMENTS

Task I

An evaluation of existing information about aluminosilicate thermochemistry and kinetics as it relates to alkali geothermometry will be completed within the first three months of the contract period. An analysis of all the experimental work the Contractor and others have performed to date as it applies to geothermometry will be included. An assessment of the effects of experimental variables such as surface area, initial solution composition, flow rate, differential stress, and permeability on exchange processes that fix K/Na ratios will be performed. The degree of sophistication required in the use of chemical analytical data in geothermometry will be addressed.

Task II

The experimental work is aimed toward elucidating some of the fundamental problems identified in Task I, including whether equilibrium between bulk phases is necessary for the K/Na geothermometer to work reliably. This will be evaluated by performing two basic experiments. The first, reacting albite, orthoclase, and various solutions over a range of temperature and pressure, is intended to indicate the rates at which various subprocesses occur. By monitoring the solution composition as a function of time at any given temperature and pressure using "Dickson" type, agitated, hydrothermal apparatus, rate determinations of K/Na exchange processes relative to bulk dissolution rates will be made. Rate data will be used to identify actual reaction mechanisms using the approach of Dibble and Tiller (1980, 1981). By using distribution-of-species programs, the solution compositions measured at room conditions will be extrapolated to experimental conditions, and activity diagrams showing the path the solution composition takes in time will be constructed.

A second experiment will include reacting glasses of composition similar to the solid mineral assemblage used in the previously described experiment, and monitoring the solution composition.

Based on results of previous glass/solution interactions it is anticipated that an assemblage of zeolites may form in some experiments and that proper K/Na ratios can still be developed. The possibility that zeolite assemblages can fix K/Na ratios in solution consistent with the K/Na geothermometer will also be tested by experiments in agitated hydrothermal equipment using analcime and either mordenite or clinoptilolite starting materials.

The experiments described above will be done under conditions thought to be appropriate to geothermal systems. Several temperatures ranging from 75° to 300°C will be employed at a pressure of 500 bars. The water/rock mass ratio will be set at 10 to 1 so that enough solution will be available for sampling, but solution compositions will be dominated by the solid phases. Initial solution compositions will be varied to evaluate the effects of pH and salinity on the rates of exchange and dissolution reactions and on the steady-state K/Na ratios obtained. Using the flow-through system, the effect of non-hydrostatic stress on rates of ion-exchange and dissolution reactions will be evaluated. The experimental work will be finished within the first year of the contract period and a full report on the results will be submitted.

Task III

Solution composition data obtained from the experiments performed in Task II will be processed using available distribution of species computer programs to obtain activities at temperature. Both the steady-state concentrations and activities will be plotted as a function of temperature. Curves fitted to these data points will determine the activity exchange constant and an exchange constant associated with concentration. This will provide an experimental calibration of the geothermometer as well as determine the level of confidence when the geothermometer technique is applied to rocks with minerals other than alkali feldspars. Solution activities will also be plotted on activity diagrams to trace the path the solution follows with time. Activation energies will be determined from the rate of the ion-exchange reaction as a function of temperature. Reaction mechansim for the dissolution and growth reactions by interface processes will be determined.

Steady state solution concentrations in the flow through system when plotted as a function of flow rate and temperature will give information on exchange reactions and extraction of components under realistic reservoir conditions. Changes in alkali and alkaline earth concentrations with time in the flow through experiments will be analyzed to estimate how the measured geothermometer values in a geothermal system might change during the evolution of the system.

Task IV

Brief monthly reports will be submitted in accordance with DOE reporting requirements. These reports will consist of details of the technical aspects of the work as well as an evaluation of the progress relative to the planned milestone and Task schedule. A semi-annual report will be prepared covering a detailed review of the Task I research as well as an up-to-date overview of the Task II research. This will be presented to the DOE Technical Program Manager during a semi-annual meeting. A complete draft of the final report will be submitted within one month of the end of the contract period.

Task V

The results of the work proposed will be transferred to potential users in two forms. Part of the results will be presented at national scientific meetings, i.e., American Geophysical Union.

Details of the experimental and theoretical results will be published in appropriate journals before or soon after the end of the contract period. At least two published papers are anticipated, one focusing on theoretical aspects of geothermometry, and another presenting the experimental results in detail.

U. S. DEPARTMENT OF ENERGY

REPORTING REQUIREMENTS CHECKLIST

DOE Form CR-537
(1-78)

(See Instructions on Reverse)

FORM APPROVED
OMB NO. 38R-0190

1. IDENTIFICATION	2. OBLIGATION INSTRUMENT:
DE-FC07-80ID12147	

3. REPORTING REQUIREMENTS

A. PROJECT MANAGEMENT	Frequency
1. ☒ Management Plan	0
2. ☐ Milestone Schedule & Status Report	
3. ☐ Cost Plan	
4. ☐ Manpower Plan	
5. ☒ Contract Management Summary Report	M
6. ☒ Project Status Report	M
7. ☐ Cost Management Report	
8. ☐ Manpower Management Report	
9. ☒ Conference Record	A
10. ☒ Hot Line Report	A

B. TECHNICAL INFORMATION REPORTING	Frequency
1. ☒ Notice of Energy RD&D Project (SSIE)	0
2. ☒ Technical Progress Report	Q
3. ☒ Topical Report	Y
4. ☒ Final Technical Report	F
C. PMS/MINI-PMS	
1. Cost Performance Report	
☐ Format 1 WBS	
☐ Format 2 Functional	
☐ Format 3 Baseline	
☐ Format 5 Problem Analysis	
2. ☐ Cost/Schedule Status Report	
3. ☐ Management Control System Description	
4. ☐ Summary System Description	
5. ☐ WBS Dictionary	

FREQUENCY CODES:
A – As Required
C – Contract Change
F – Final (End of Contract)
M – Monthly
O – One Time (Soon After Contract Award)
Q – Quarterly
S – Semi-Annually
X – Mandatory for Delivery with Proposals/Bid
Y – Yearly or Upon Contract Renewal

4. SPECIAL INSTRUCTIONS

A.5., A.6., and A.7. - Copies are due within fifteen days after end of the calendar month.

B.2. - Copies are due within fifteen days after end of the calendar month.

B.3. - Submit 2 copies in draft forty-five days prior to completion of the yearly term. After DOE approval is received, submit copies as required on attached "Report Distribution List."

B.4. - Submit 2 copies in draft forty-five days prior to completion date of contract term. After DOE approval is received, submit eleven copies including one camera-ready copy.

5. ATTACHED HEREWITH:

☐ Report Distribution List ☐
☐ WBS/Reporting Category ☐

6. PREPARED BY (Signature and date):	7. REVIEWED BY (Signature and date):

REPORTING REQUIREMENTS CHECKLIST

PURPOSE

A checklist to identify and communicate additional reporting requirements which are not otherwise set forth in the General Purpose clauses of DOE contracts and agreements. It will be included as part of the contract or agreement. This form will be completed for each proposed contract or agreement and can be modified as required in Special Instructions to adapt it to a specific situation.

INSTRUCTIONS

Item 1 – Enter the title as indicated in the Procurement Request, Interagency Agreement, or initiating memorandum.

Item 2 – Enter the identification number of the Procurement Request or Interagency Agreement, the date of the memorandum, and contract number after award.

Item 3 – Check spaces to indicate plans and reports required. For each reporting requirement checked, indicate frequency of delivery in column provided using one of the frequency codes shown.

3.A.1 *Management Plan* – The contractor's plan to manage the effort described in the statement of work or similar document. It will contain management methodologies, control systems, and procedures he will use. Includes milestones and other planning schedules, organizational identification and descriptions, and special and critical plans, such as test plans, plans for handling of Government owned property. Work breakdown structures, key personnel identification, and methods for monitoring progress toward objectives may be required.

3.A.2 *Milestone Schedule and Status Report* – The contractor's milestone schedule for all work breakdown structure items, line items, or deliverables specified in the contract. Updated periodically (usually monthly) with status, progress toward completion, and percent completion of each line item and of the total contract.

3.A.3 *Cost Plan* – A baseline plan for incurring costs on a contract or agreement to measure progress in terms of cost; update and forecast contract fund requirements; plan funding changes; and develop fund requirements and budget estimates.

3.A.4 *Manpower Plan* – A baseline plan to allocate manpower to each reporting category identified in the contract or agreement.

3.A.5 *Contract Management Summary Report* – A single-page graphic presentation of integrated cost, major milestones, and manpower for rapid visual analysis and trend forecasting.

3.A.6 *Project Status Report* – A periodic report to communicate to DOE management an assessment of contract status, to explain variances and problems, and to discuss any other areas of concern or achievements.

3.A.7 *Cost Management Report* – A periodic report of the status of costs compared to the Cost Plan. Data is used to: report actual and projected accrued costs; evaluate performance against plan; identify actual and potential problem areas; construct cost experience for projects and budgeting efforts; and, to verify the reasonableness of contractors' invoices.

3.A.8 *Manpower Management Report* – A periodic report of the status of actual and projected manpower expenditure against the Manpower Plan. Data is used to evaluate performance against plan; identify actual and potential problem areas; and to construct manpower experience for projections and planning efforts.

3.A.9 *Conference Record* – Documentation of the contractor's understanding of significant decisions, direction or redirection or required actions resulting from any meeting with DOE representatives.

3.A.10 *Hot Line Report* – A hardcopy report by the fastest means available, (TWX, etc) documenting critical problems, emergency situations, and important technical breakthroughs.

3.B.1 *Notice of Energy R&D Project* – A formatted, two-page report to provide information on unclassified DOE R&D projects for dissemination to the scientific, technical, and industrial communities and to the public. Also provides information to the Smithsonian Scientific Information Exchange.

3.B.2 *Technical Progress Report* – A formal, structured technical report, submitted periodically to communicate project results for dissemination to Government agencies, the scientific, technical and industrial communities and the public.

3.B.3 *Topical Report* – A special technical report prepared when a project has reached a point at which a major milestone or a significant phase has been completed; when unexpected results have been achieved, when it is logical to summarize results achieved, or when a new scientific or technological finding is deemed to warrant prompt publication.

3.B.4 *Final Technical Report* – Technical Progress Report reporting final results of DOE supported RD&D and scientific projects.

3.C *PMS/Mini-PMS*

1) *Cost Performance Report (PMS Application)*

Format 1 – Reports current period and cumulative budget, actual costs and earned value data by work breakdown structure elements. Identifies cost and schedule variances and provides contractor's estimate to complete comparisons to budgets.

Format 2 – Reports current period and cumulative budget, actual costs, and earned value data by contractor functional elements.

Format 3 – Provides periodic updating to the established performance measurement baseline. Incorporates authorized contract changes and internal re-planning into the performance measurement baseline.

Format 5 – Provides a narrative analysis of contract variances.

2) *Cost/Schedule Report (Mini-PMS Application)* – Periodic, usually monthly, report of cumulative budget, actual costs and earned value by summary work breakdown structure elements. Identifies cost and schedule variances and provides contractor's estimate to complete comparisons to budgets.

3) *System Description (PMS Application)* – Contractor's description of the management control system to be used in performing contract work. Must address all elements of the PMS criteria.

4) *Summary System Description (Mini-PMS Application)* – Contractor's summarized description of the management control system to be used in performing contract work.

5) *WBS Dictionary* – Lists and defines work breakdown structure. For more detailed instructions see PMS Manual.

Frequency Codes – Each code must have an identified time period (i.e., As Required – 5 days after event occurrence). These time periods are suggested in the solicitation and negotiated at contract award.

Item 4 – Identify any special reporting requirements not indicated in Item 3 and/or qualifiers to those selected. (Use additional sheets as necessary.)

Item 5 – Check appropriate blocks.

Report Distribution List – A comprehensive informative listing of reports by frequency of submission, addresses and number of copies for each addressee.

Reporting Categories (level of detail) – An identification by WBS level of task elements for which reporting will be required by DOE.

Item 6 – Signature of person or persons preparing the checklist and the date prepared. Preparation is by person or persons responsible for preparation of Procurement Request or Statement of Work.

Item 7 – Signature of the person reviewing the checklist and date reviewed.

U.S. GOVERNMENT PRINTING OFFICE: 1981—331-320/611

ID F-129 (Rev. 08-79)
Ref. DOE 13302
(use with DOE CR-537)

U.S. DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE

REPORT DISTRIBUTION LIST

Contract No.

DE-FC07-80ID12147

Addressees	Milestone Schedule & Status Report	Management Plan	Contract Management Summary Report	Cost Plan	Manpower Plan	Project Status Report	Cost Management Report	Manpower Management Report	Conference Record	Notice of Energy RD&D Project (SSIE)	Hot Line Report	Technical Progress Report	Topical Report	Final Technical Report	Cost Performance Report	Cost/Schedule Status Report	Management Control System Description	Summary System Description	WBS Dictionary
	Number of Report Copies																		
M. A. Widmayer, Program Manager Resource Definition Branch U. S. Department of Energy Idaho Operations Office 550 Second Street Idaho Falls, ID 83401	2					1	1	1				1	1	1	5				
C. Bufe U. S. Department of Energy Division of Geothermal Energy MS 3344 Federal Building 12th and Penn, N. W. Washington, D. C. 20461	1					1	1	1					1	1	5				
Dennis Nielson University of Utah Research Institute 420 Chepita Way, Suite 120 Salt Lake City, UT 84108	1					1	1	1					1	1	1				

Special Instructions

UNIFORM DOE CONTRACTOR SCIENTIFIC, TECHNICAL AND ENGINEERING REPORT NUMBERING SYSTEM

Effective with the implementation of the Procurement/Contract numbering system as shown in the example below, the following guidelines are established for identifying scientific and technical reports (progress, interim, final topical, etc.) conference papers, proceedings, theses, and translations.

1. All DOE contractors now applying uniquely identifying codes and systems approved by TIC are to continue using such codes and systems.

2. DOE Field Office codes such as ALO, IDO, COO, HCP, NVO, ORO, RLO, SAN, and SRO; and program codes such as FE, DSE, etc.; are no longer approved for use by contractors.

3. Contractors having no approved unique codes are to number information products as shown below. All contractors in this category should create unique report numbers by (a) identifying the report with a DOE code, (b) selecting the final seven characters from the applicable contract number (two alphabetic and five numerals), and (c) adding suffix numbers sequentially for each report generated under the contract. For new contracts, the sequential number should begin with 1. For existing contracts the established sequence should continue. Slash marks and hyphens should be applied as shown in the examples.

   Examples: Report numbers generated from contract number DE-AC03-79ET01834.M001:

   DOE/ET/01834-1; DOE/ET/01834-2; DOE/ET/01834-3; etc.

   Note: It is essential that both the final five-digit numeral and the two preceeding alphabetical characters be extracted from the contract number as shown. The modification number, if any, normally shown as M001, etc., following the basic five-digit number is NOT used in the report number.

4. Reports issued in more than one binding, or reissued as revisions or later editions, are to be identified by adding the following aditional suffixes to the basic number: Rev. - Revision; Vol. -Volume; Pt. - part; Add. - Addenda; Ed. - Edition, etc.

   Examples: DOE/ET-01834-1 Rev.
   DOE/ET/01834-1 Rev. 2

   DOE/ET-01834-1 Pt. 1
   DOE/ET/01834-1 Pt. 2

It is intended that report numbers be structured exactly as specified in the examples insofar as possible. If modification to this basic format is essential, it is to be approved through normal channels before being used.

DOE # 011

4 of 5

Submitted to the Department of Energy
Idaho Operations Office

Solicitation for Cooperative Agreement Proposals
SCAP No. DE-SC07-80ID12147

IMPROVEMENTS IN GEOTHERMOMETRY

STANFORD UNIVERSITY

Name of Organization (including Branch, Title, if any)

Department of Geophysics, Stanford, California 94305

Address of Organization Zip Code

A theoretical and experimental evaluation of the Na-K-Ca Geothermometer

Title of Proposed Project

Funding Requested from DOE $ 98,815 Total Project Cost $ 99,803

Proposed Duration (in weeks) 52 Proposed Starting Date 12-1-80

Name of Principal Investigators Amos Nur, Professor of Geophysics
George Parks, Professor of Applied Earth Sciences

Position and Title

Telephone (with area code) (415) 497-3716

Approval

Signature Title

Name (Typed) Date

OMB Approval No. 29-R0218

FEDERAL ASSISTANCE

2. APPLICANT'S APPLICATION	a. NUMBER	3. STATE APPLICATION IDENTIFIER	a. NUMBER
	b. DATE Year month day 19 80 8 4		b. DATE ASSIGNED Year month day 19

1. TYPE OF ACTION (Mark appropriate box)
- ☐ PREAPPLICATION
- ☒ APPLICATION
- ☐ NOTIFICATION OF INTENT (Opt.)
- ☐ REPORT OF FEDERAL ACTION

Leave Blank

SECTION I—APPLICANT/RECIPIENT DATA

4. LEGAL APPLICANT/RECIPIENT

a. Applicant Name : Stanford University
b. Organization Unit : Sponsored Projects Office
c. Street/P.O. Box : 320 Galvey
d. City : Stanford
e. County : Santa Clara
f. State : California
g. ZIP Code: 94305
h. Contact Person (Name & telephone No.) : Carol Vonder Linden (415) 497-3715

5. FEDERAL EMPLOYER IDENTIFICATION NO.
94-1156365

6. PROGRAM (From Federal Catalog)
a. NUMBER DE-SC07-80ID12147
b. TITLE Geothermal Energy Program

7. TITLE AND DESCRIPTION OF APPLICANT'S PROJECT

A theoretical and experimental evaluation of the Na-K-Ca Geothermometer

8. TYPE OF APPLICANT/RECIPIENT
A-State; B-Interstate; C-Substate District; D-County; E-City; F-School District; G-Special Purpose District; H-Community Action Agency; I-Higher Educational Institution; J-Indian Tribe; K-Other (Specify):
Enter appropriate letter: I

9. TYPE OF ASSISTANCE
A-Basic Grant; B-Supplemental Grant; C-Loan; D-Insurance; E-Other
Cooperative Agreement
Enter appropriate letter(s): E

10. AREA OF PROJECT IMPACT (Names of cities, counties, States, etc.)

11. ESTIMATED NUMBER OF PERSONS BENEFITING

12. TYPE OF APPLICATION
A-New; B-Renewal; C-Revision; D-Continuation; E-Augmentation
Enter appropriate letter: A

13. PROPOSED FUNDING

a. FEDERAL	$ 98,815 .00
b. APPLICANT	988 .00
c. STATE	.00
d. LOCAL	.00
e. OTHER	.00
f. TOTAL	$ 99,803 .00

14. CONGRESSIONAL DISTRICTS OF:
a. APPLICANT
b. PROJECT

16. PROJECT START DATE Year month day: 1980 12 1

17. PROJECT DURATION: 12 Months

18. ESTIMATED DATE TO BE SUBMITTED TO FEDERAL AGENCY ▶ Year month day: 19 80 8 6

15. TYPE OF CHANGE (For 12c or 12e)
A-Increase Dollars; B-Decrease Dollars; C-Increase Duration; D-Decrease Duration; E-Cancellation; F-Other (Specify):
Enter appropriate letter(s):

19. EXISTING FEDERAL IDENTIFICATION NUMBER

20. FEDERAL AGENCY TO RECEIVE REQUEST (Name, City, State, ZIP code) Dept.of Energy
Idaho Op.Office, Rm HQ 117, 550 Second Street, Idaho Falls, 83401

21. REMARKS ADDED
☐ Yes ☒ No

SECTION II—CERTIFICATION

22. THE APPLICANT CERTIFIES THAT ▶
a. To the best of my knowledge and belief, data in this preapplication/application are true and correct, the document has been duly authorized by the governing body of the applicant and the applicant will comply with the attached assurances if the assistance is approved.

b. If required by OMB Circular A-95 this application was submitted, pursuant to instructions therein, to appropriate clearinghouses and all responses are attached:

	No response	Response attached
(1)	☐	☐
(2)	☐	☐
(3)	☐	☐

23. CERTIFYING REPRESENTATIVE
a. TYPED NAME AND TITLE: Edward C. Barrera, Staff Assoc. Sponsored Projects Office
b. SIGNATURE
c. DATE SIGNED Year month day: 19

SECTION III—FEDERAL AGENCY ACTION

24. AGENCY NAME

25. APPLICATION RECEIVED Year month day: 19

26. ORGANIZATIONAL UNIT

27. ADMINISTRATIVE OFFICE

28. FEDERAL APPLICATION IDENTIFICATION

29. ADDRESS

30. FEDERAL GRANT IDENTIFICATION

31. ACTION TAKEN
- ☐ a. AWARDED
- ☐ b. REJECTED
- ☐ c. RETURNED FOR AMENDMENT
- ☐ d. DEFERRED
- ☐ e. WITHDRAWN

32. FUNDING

a. FEDERAL	$ .00
b. APPLICANT	.00
c. STATE	.00
d. LOCAL	.00
e. OTHER	.00
f. TOTAL	$ .00

33. ACTION DATE ▶ Year month day: 19

34. STARTING DATE Year month day: 19

35. CONTACT FOR ADDITIONAL INFORMATION (Name and telephone number)

35. ENDING DATE Year month day: 19

37. REMARKS ADDED
☐ Yes ☐ No

38. FEDERAL AGENCY A-95 ACTION
a. In taking above action, any comments received from clearinghouses were considered. If agency response is due under provisions of Part I, OMB Circular A-95, it has been or is being made.

b. FEDERAL AGENCY A-95 OFFICIAL (Name and telephone no.)

ABSTRACT

Alkali and alkaline earth geothermometers have been found to be very useful for estimating geothermal reservoir temperatures. However, a theoretical basis and detailed experimental foundation for these methods have yet to be established. The purpose of the proposed work is to evaluate the reliability of the Na-K-Ca geothermometer under the wide variety of conditions encountered in geothermal systems.

The model for explaining the empirical success of the Na-K-Ca geothermometer relies on ion-exchange equilibria between feldspars and aqueous solutions which tends to limit the application of the technique to higher temperature systems. However, experimental water/rock interactions we have done suggest that the presence of feldspars is not necessary to produce close agreement between experimental temperatures and those determined from alkali geothermometry. In addition, equilibrium between bulk phases does not appear to be required. If these preliminary observations can be verified and extended by suitable experiments, alkali geothermometry may be applied to more geothermal systems over a greater temperature range than previously thought.

In addition to a thorough evaluation of all theoretical and experimental work that relates to alkali geothermometry, we propose to do a series of hydrothermal experiments to determine whether bulk equilibrium and the presence of feldspars are required to successfully apply the Na-K-Ca geothermometer. Experiments will include reactions at various temperatures up to 300°C between aqueous solutions and feldspars, zeolites, and glasses in both agitated and flow-through apparatus. The effects on exchange and dissolution rates of permeability, flow rate, and directed stress will also be determined.

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STATEMENT OF WORK

To fully evaluate the potential of a geothermal resource, fluid temperatures at depth must be known accurately. Various types of empirical geothermometers (White, 1965; Ellis, 1970; Fournier and Truesdell, 1973) have been developed to estimate geothermal reservoir temperatures using fluid compositions in springs and wells. If such methods can be applied to any hydrothermal system in general, tremendous savings can be realized during the exploration stage of geothermal energy development. The theoretical foundations of most geothermometers have not been established and even experimental calibration of these methods has not been accomplished. The purpose of the work described in this proposal is to use both theoretical and experimental approaches to evaluate the reliability of Na-K-Ca geothermometers under the wide variety of conditions encountered in actual geothermal systems.

Ion-exchange equilibria between feldspars and solutions define the basis of the Na-K-Ca geothermometer of Fournier and Truesdell (1973); however, equilibrium between bulk phases is not an explicit requirement of their model. Experimental work we have done reacting several rock types with solutions indicates that close agreement between experimental temperatures and those determined from K/Na ratios may occur without the presence of feldspar reaction products. In addition, close agreement between actual and calculated temperatures is approached even when glass appears to persist metastably. The experimental results and some theoretical work we have done strongly suggest that equilibrium between bulk phases, including feldspars, is not necessary to account for the empirical success of the Na-K-Ca geothermometer. Instead, it appears that the K/Na ratio in solution may be determined by partial equilibrium between the surfaces of tectosilicates and the solution, whether or not a stable equilibrium phase assemblage has formed. If this can be verified by suitable experiments, the usefulness of alkali geothermometry would be greatly enhanced.

Task I

The first deliverable, an evaluation of existing information about aluminosilicate thermochemistry and kinetics as it relates to alkali geothermometry will be completed within the first three months of the contract period. An analysis of all the experimental work we and others have performed to date as it applies to geothermometry will be included. We will assess the effects of experimental variables such as surface area, initial solution composition, flow rate, differential stress, and permeability on exchange processes that fix K/Na ratios. The degree of sophistication required in the use of chemical analytical data in geothermometry will be addressed as well.

Has this been delivered?

Task II

The experimental work we propose to do is aimed toward elucidating some of the fundamental problems we have identified. The most pressing issue is whether equilibrium between bulk phases is necessary for the K/Na geothermometer to work reliably. We propose to evaluate this by performing two basic experiments. The first, reacting albite, orthoclase, and various

solutions over a range of temperature and pressure, is intended to indicate the rates at which various subprocesses occur. By monitoring the solution composition as a function of time at any given temperature and pressure using "Dickson" type, agitated, hydrothermal apparatus, we can determine the rates of K/Na exchange processes relative to bulk dissolution rates. We expect to observe results similar to those of Lin and Clemency (1980) for muscovite dissolution - namely that constant K/Na ratios in solution may be attained long before equilibrium between the bulk solid and solution is approached. It may also be possible to use the rate data to identify actual reaction mechanisms using the approach of Dibble and Tiller (1980, 1981). By using distribution-of-species programs (Wolery, 1978, 1979), the solution compositions measured at room conditions can be extrapolated to experimental conditions, and activity diagrams showing the path the solution composition takes in time can be constructed (Potter and Dickson, 1980).

A second experiment is planned to help elucidate the equilibrium problem discussed above as well as the problem of whether the presence of feldspars is necessary for the proper K/Na ratio to be established in the solution. By reacting glasses of composition similar to the solid mineral assemblage used in the previously described experiment, and monitoring the solution composition, we expect to find that K/Na ratios consistent with the experimental temperature may be attained before all the glass has reacted. This can be determined by quenching the run and examining solid reaction products after a steady-state K/Na ratio is attained.

We anticipate, based on results of our previous glass/solution interactions, that an assemblage of zeolites may form in some experiments and that proper K/Na ratios can still be developed. The possibility that zeolite assemblages can fix K/Na ratios in solution consistent with the K/Na geothermometer will also be tested by experiments in agitated hydrothermal equipment using analcime and probably either mordenite or clinoptilolite starting materials. These zeolites are selected because of their common occurrence as reaction products in experimental water/rock interactions and occurrence in geothermal systems.

The experiments described above will be done under conditions thought to be appropriate to geothermal systems. Several temperatures ranging from 75 to 300°C will be employed at a pressure of 500 bars. The water/rock mass ratio will be set at 10 to 1 so that enough solution will be available for sampling, but solution compositions will be dominated by the solid phases. Initial solution compositions will be varied to evaluate the effects of pH and salinity on the rates of exchange and dissolution reactions and on the steady-state K/Na ratios obtained.

Some of the above described experiments will be performed using flow-through apparatus. The rocking, "Dickson" type, hydrothermal equipment is effective for greatly increasing reaction rates of mineral/solution interactions. However, flowing solutions through rocks or packed grains at low flow rates more closely approximates the conditions found in actual geothermal systems. Flow-through equipment presently available, designed and built by J. Potter, has been used to assess the effects of temperature and solution composition on the permeability of rock cores and packed mineral grains (Potter, 1979). We propose to use this approach to examine the

effect of flow rates and permeability on the kinetics of alkali ion-exchange and dissolution reactions. Solutions and solid starting materials similar to those described above will be used at temperatures up to 225C at various flow rates.

Using the flow-through system, the effect of non-hydrostatic stress on rates of ion-exchange and dissolution reactions can also be evaluated since the pore pressure and confining pressure can be varied independently. We have studied the coupling of chemical and mechanical processes for many years and have noted the importance of directed stress on chemical processes (Sprunt and Nur, 1977). The experimental work will be finished within the first year of the contract period and a full report on the results will be submitted.

TECHNICAL DESCRIPTION

Previous Work

Several problems related to the K-Na-Ca geothermometer have already been outlined by work done at Stanford. Many water/rock interaction studies have been performed using "Dickson" type hydrothermal equipment. Experimental reactions between solutions of varying composition and different rock types have demonstrated systematic variations between the temperature calculated from measured K/Na ratios and the experimental temperature. Work performed by J. Potter, an associate investigator, on rhyolite-NaCl solution reactions at 300°C and 500 bars has shown that the experimental temperature is approximated by K/Na geothermometry only after a time period which appears to be related to K extraction rates (Figure 1). R. Guillemette, working on andesitefluid interactions at the same temperature and pressure, has found similar results (Potter and Dickson, 1980; Guillemette and others, 1980).

There are two important observations from these experiments. The first is that the close agreement between experimental temperatures and temperatures determined from K/Na ratios may occur without the presence of any feldspars. For example, in many experiments performed with glass starting materials, only zeolites and clays were formed. This is of great importance since it would appear that the technique could be applied to the many geothermal systems containing mainly clay and zeolite alteration phases. Another interesting result is that a close agreement between actual and calculated temperatures is approached even when glass appears to persist metastably. These results strongly suggest that equilibrium between bulk phases is not necessary to account for the success of the Na-K-Ca geothermometer.

Theoretical work done by W. Dibble, an associate investigator, also supports the conclusion that equilibrium between minerals and solutions is not absolutely required for alkali geothermometry to be successfully applied to geothermal systems (Dibble, 1980). The preliminary theoretical and experimental work we have done suggests that the K/Na ratio in solution may be determined not by equilibrium between bulk phases but between the solution and surfaces of minerals containing the alkalies in major amounts. Rates of dissolution and growth reactions are orders of magnitude lower than rates of surface ion-exchange reactions (Dibble and Tiller, 1980, 1981). Partial equilibrium between surfaces and solution may be attained long before a stable equilibrium phase assemblage has formed.

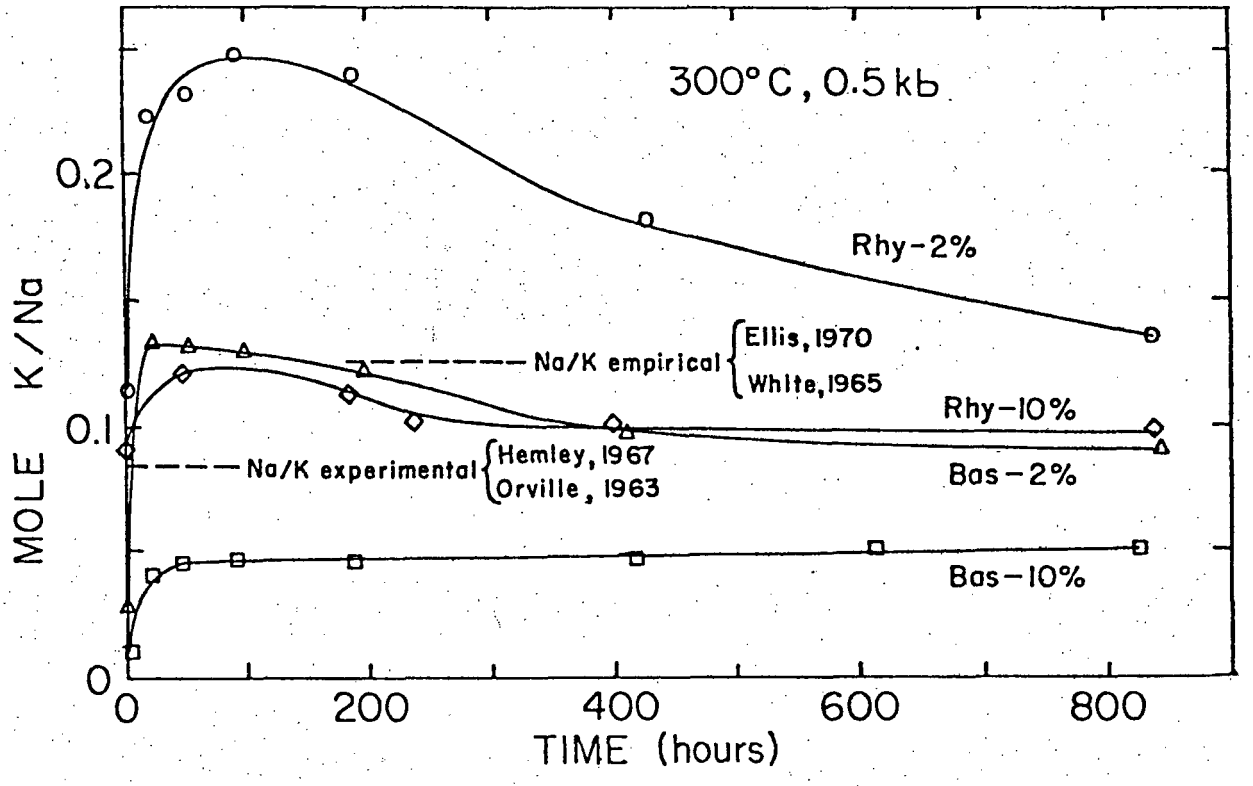

Figure 1. Molar K/Na ratios vs time from experiments done by Potter and Dickson (1980).

It is critical to understand the various processes occurring at mineral-water interfaces before the controlling mechanism fixing the K/Na ratio in solution can be identified. It has been recognized by many that rates of mineral dissolution reactions may be controlled chiefly by reactions occurring at the solid surface (Holdren and Berner, 1979; Aagaard and Helgeson, 1980). After working on this problem for a number of years, we have developed a rate model for interface-controlled reactions that is to be published in Geochimica et Cosmochimica Acta (Dibble and Tiller, 1980; see Appendix). Another paper on rate mechanisms for quartz dissolution has also recently been submitted for publication (Dibble and Tiller, 1981; see Appendix). In this second paper, ion-exchange reactions controlled by interface electric fields have been shown to be the primary factors determining rate constants for quartz dissolution. The rate-controlling processes, however, involve layer-edge detachment. A variety of concentration time dependences can occur depending on which detachment mechanism dominates (Figure 2). The exponential time dependence (Aagaard and Helgeson, 1980) is relatively rare. However, the more commonly observed linear dependence can also be explained quantitatively (Dibble and Tiller, 1980).

Other experimental work we have done has also provided insight about geothermal processes which have received little attention previously. Flow through studies done by J. Potter, an associate investigator, have elucidated the effects of temperature and solution composition on the permeability of fluids in rock (Potter, 1979). The accumulation of colloids on mineral surfaces has been shown to lower the permeability of St. Peter sandstone by 60% at elevated temperatures. By studying the coupling of chemical and mechanical processes, we have shown that dissolution rates of a variety of naturally occurring solids are controlled by surface reactions (Sprunt and Nur, 1977).

Equilibrium exchange processes provide the principal explanation for the Fournier-Truesdell Na-K-Ca geothermometer. In practice, a water analysis is used to evaluate a generalized exchange constant,

$$\log K = \log \frac{Na}{K} + \beta \log \frac{\sqrt{Ca}}{Na} \quad . \qquad (1)$$

Inasmuch as the equilibrium state of the exchange process is determined thermodynamically, the terms, Na, K, and Ca should be replaced by the thermodynamic activities of the ions Na^+, K^+, and Ca^{2+}. Computation of these activities from the water analysis requires correction for non-ideality (activity coefficient corrections) and for complexation and hydrolysis at the temperature of the system. The importance of these corrections is often underestimated as has been demonstrated convincingly by Nordstrom and Jenne (1977). Nordstrom and Jenne found that an earlier claim that most geothermal waters were supersaturated with repsect to CaF_2 was false. Careful reappraisal of the thermodynamic data set, consideration of a very exhaustive list of possible complexes, and correction to the temperature of the water in each case led to the conclusion that most geothermal waters are close to saturation or subsaturated with respect to CaF_2. . .not the reverse.

Several computation codes are available for calculating the distribution of the components of a water solution among species and estimating true

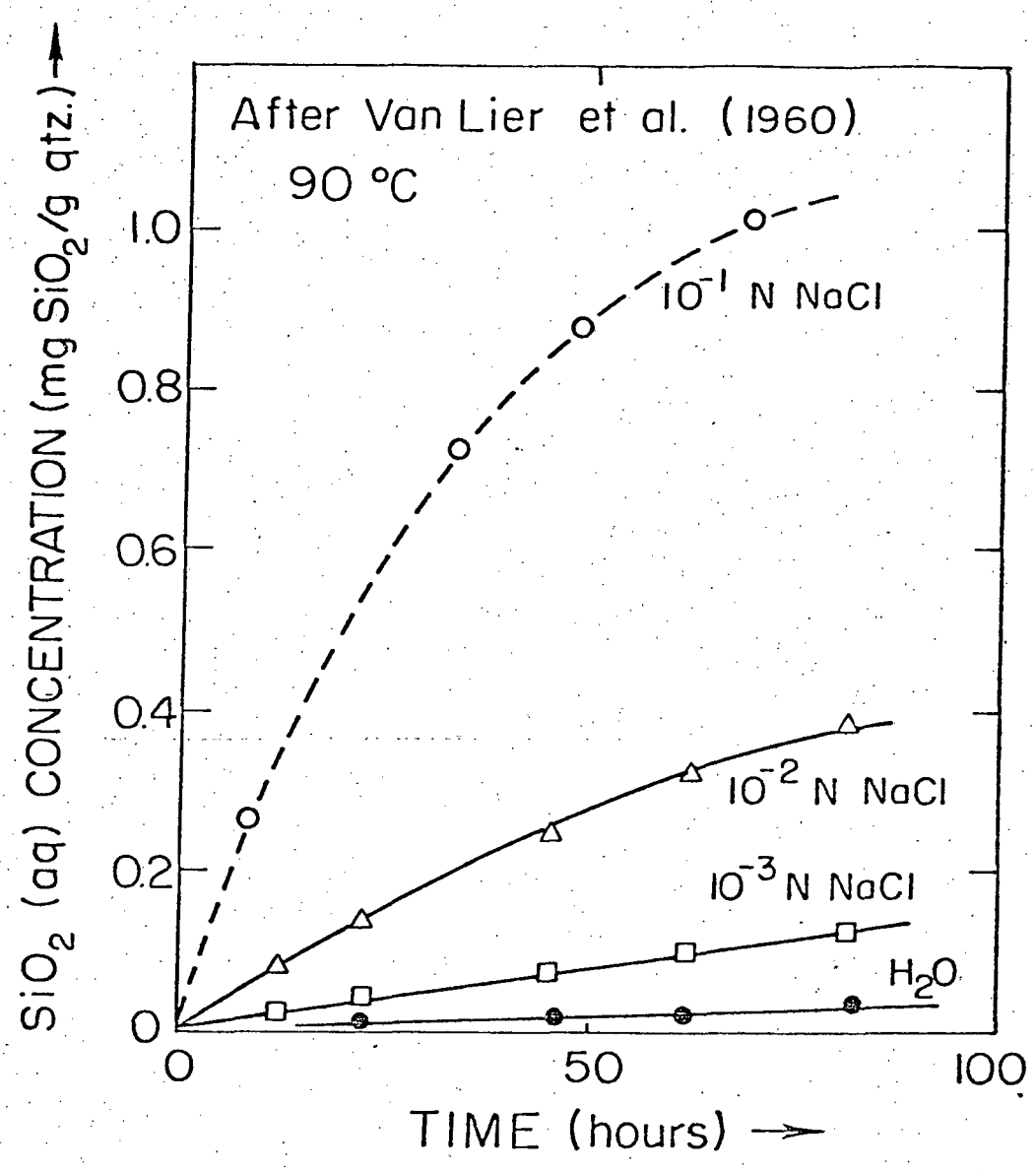

Fig. 2 . Rate data of Van Lier et al. (1960) for quartz dissolution in NaCl solutions at 90 °C and 1 atm.

activities of free, uncomplexed ions. Some of the codes include the capability of working at elevated temperatures and pressures. Nordstrom, et al. (1979) have reviewed such programs and assembled the information collected in Table 1. Of these programs, EQ3 and SOLMNEQ are, or soon will be, available on Stanford's computers and include provision for the temperature range 0 to 300 or 250°C. MINEQL, in several versions is available at Stanford, can be modified easily to accomodate thermodynamic data sets adapted to any temperature by one of the other programs, and incorporates subroutines developed at Stanford to deal with adsorption and ion-exchange reactions. Some of the characteristics and uses of MINEQL are described by James and Parks (1980).

We plan to use one of these programs to assist in determining the degree of sophistication needed in utilizying chemical analytical data in geothermometry. Is speciation necessary or advantageous or can analytical concentrations be used directly? Given that exchange equilibrium has been achieved, how far out of equilibrium are other solids in the system?

The β-term in equation 1 is determined by exchange stoichiometry. Fournier and Truesdell explored the expected variability of β to some extent. Given the additional knowledge about which phases are generated by our experimental work, we plan to review the range of β required and the value selected for use in generalized geothermometry by considering a wider range of mineral pairs.

Experimental Approach

Two experimental techniques will be used in the proposed research: (1) agitated "Dickson" type gold cell hydrothermal equipment; and (2) inert high temperature flow-through equipment. The agitated gold cell equipment has proven particularly valuable in the study of both the kinetic and steady-state parts of experimental hydrothermal reactions. Solution sampling can be done at any designated time without disturbance of the temperature and pressure conditions of the experiment. Reaction rates are greatly increased over static approaches because of the active mixing of solids and solutions. Steady-state levels in solution composition are obtained in about 30 days or less compared to the months or years required for similar experiments in static equipment. Another important facet of the gold cell equipment is the inertness of the container and the large size of the reaction cell (150-250 ml) permitting a large number of solution samples to be taken during an experiment. The major disadvantage of the agitated equipment is that the fluid-to-rock ratio changes systematically with time; however, this should have little effect on ion-exchange reactions.

A number of successful studies have been completed at Stanford using the agitated hydrothermal apparatus to investigate water/rock interaction. The most important include the basalt-seawater studies of Seyfried (1977), Seyfried and Bischoff (1977), and Bischoff and Dickson (1975); ultramafic-seawater interactions of Seyfried and Dibble (1979); rhyolite - NaCl-seawater experiments of Potter and Dickson (1980) and Dickson (1977); and andesite-NaCl experiments of Guillemette and others (1980).

Table 1
General Information

Program Name	EQUIL	EQ3	GEOCHEM	IONPAIR	MINEQL2	MIRE	MINEQL/ REDEQL2	REDEQL2	SEAWAT	SOLMNEQ	WATEQF	WATEQ2	WATSPEC	SIAS/ COMICS
Language	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	FORTRAN	PL/1	FORTRAN	PL/1 (optimizing)	FORTRAN	FORTRAN
Computers	UNIVAC 1110	CDC 6400/6600 7600	IBM 360/50	IBM 370/ 165II	CDC CYBER 74	IBM 360	IBM 370	CDC CYBER 74	CDC 6400 IBM 360 IBM 370 IBM 7094 DEC 10	IBM 370	IBM 370[1]	IBM 370 Honeywell 60/68/80	ICL 1903 IBM 370	IBM 360
Number of Cards	3300	3048	3630	606	1500	420	1500	4000	184	2000	1857	3000	423	253
Available[2] From	B. Fritz*	T.J. Wolery*	S.V. Mattigod* G. Sposito*	J. Thrailkill*	M.R. Hoffmann*	G.R. Holdren Jr.*	F.M.M. Morel R.E. McDuff*	M.R. Hoffman*	G.M. Lafon*	R.L. Bassett* Y.K. Kharaka[3]	L. N. Plummer*	J.W. Ball* E.A. Jenne*	Geo Abstracts[4]	T. M. Florence*

Program Name	EQUIL	EQ3	GEOCHEM	IONPAIR	MINEQL2	MIRE	MINEQL/ REDEQL2	REDEQL2	SEAWAT	SOLMNEQ	WATEQF	WATEQ2	WATSPEC	SIAS/ COMICS
Elements[1]	20	18	44	8	38	11	*	44	7	24	19	29	16	*
Aqueous Sp.	93	140	2000	26	*	49	*	266	23	181	105	220	69	*
Gases	3	8	2	1	*	0	*	2	1	3	3	3	2	*
Organics	0	0	889	0	*	1	*	35	0	10	0	12	0	*
Redox Sp.	9	14	20	0	*	0	*	24	0	12	8	12	6	*
Minerals	120	130	185	5	*	variable	*	154	variable	158	101	309	40	*
Activity Coefficients[2]	B-dot	B-dot	Davies or B-dot	EDH	Davies	EDH	Davies	Davies	B-dot	B-dot	B-dot or Davies	B-dot or Davies	B-dot or Davies	**
Temperature Range °C	0-300	0-300	25	0-25	25	25	25	25	0-100	0-350	0-100	0-100	0-100	25
Pressure range bars	1	to steam saturation or 500 bars	1	1	1	1	1	1	1-1000	1-1000	1	1	1	1
Iteration and convergence method	explicit equations	Monotone sequences and secant method	Newton-Raphson	Free ion molalities by difference	Newton-Raphson	continued fraction	Newton-Raphson	Newton-Raphson	continued fraction	continued fraction for anions only	continued fraction	continued fraction	continued fraction	brute force
Fresh Water[3]	<10	5	-	7	†	3	†	32†	-	7	1	2	1	†
Seawater[3]	<30	6	156	-	†	5	†	57†	4	11	4	4	5	29

[1]excluding those of water. [2]EDH - extended Debye Huckel, B-dot - extended Debye Huckel with added B˙1 term, Davies - Davies equation.
[3]Number of iterations where one iteration is defined as one pass through the mass action equations of the aqueous model. *depends on data base.
**Constant ionic medium. †depends on initial guess by user.

Table 1. Available distribution of species computer programs.

Table 2

Variables in Agitated and Flow-Through Experiments

Agitated Experiments	Flow-Through Experiments
Water/rock mass ratio	Total amount of fluid through core/ mass of core
Surface area	Same
Grain Size	Same
Initial solution composition ($NaCl$, pH, CO_2)	Same
Fluid Pressure (Fixed)	Pore pressure Confining Pressure Effective Confining Pressure
Temperature	Same
Agitation Rate (Fixed)	Flow Rate Permeability Differential Pressure Core Geometry

The flow through approach, although not a new design, has not been applied to hydrothermal experiments except in one low temperature study by Zielinski (1979). The problem in geothermal systems is the large number of variables involved. These, to be discussed later in more detail, can be handled most realistically using the flow through approach to simulate geochemical processes occuring in situ. The flow through equipment can, for example, give more realistic data on the kinetics of exchange reactions as well as determine the effect of flow rate on reaction rates. Changes in permeability and consequently flow rate due to alteration reactions can also be studied. Another advantage includes the ability to introduce non-hydrostatic stress in the sample through the use of a sleeved sample with a confining pressure (P_c) greater than the fluid pressure (P_p) within the core.

Some disadvantages of the flow-through equipment include: (1) longer times to reach steady state; (2) the leaching of some elements when a one pass (open) flow-through system is used; (3) possibly some difficulty in operation and maintenance; (4) the large number of variables that have to be controlled. These problems must be faced, however, if reliable results are to be expected.

Experimental Variables

Several important variables are involved in the proposed experimental approach, as listed in Table 2. Water/rock ratio is defined as the total mass of water in the of water in the system to the total mass of rock. In many experiments the water-to-rock ratio changes throughout the reaction due to the removal of solution samples. The water-to-rock ratio will be set relatively high in the experiments (10) so that its value will not change drastically, and will allow a relatively large number of solution samples to be taken.

Surface area will be set by the grain size (50-100 mesh) and the mass of rock used. Higher surface areas provide for greater reactivity, however systematic studies by R. Guillemette (personal communication) and J. Potter have indicated that very fine grain material (<1μm) may react so rapidly that a metastable phase of disordered clay may be formed which persists through much of the reaction. Careful sizing of the material using an ultrasonic cleaner will be done on all starting material.

Previous experimental work reacting various NaCl-H_2O solutions with volcanic rocks (Dickson and Potter, 1980) indicates that when distilled water is used in the experiments, large amounts of colloidal material are generated. Small amounts (100 ppm) of NaCl in the initial solution inhibit colloid formation. We proposed to use 100 ppm NaCl and 3 wt% NaCl (30,000 ppm) solutions in these experiments. The 3 wt% NaCl has an ionic strength close to that of seawater. Other solution variables such as CO_2 can effect reaction behavior. These experiments will be run in essentially CO_2 free systems. pH will be determined by solution equilibria and will not be buffered or preset in any of the experiments.

Temperature will be specific for each experiment; however, fluid pressure will be set at a constant 500 bars for all agitated experiments. Agitation rate in the gear is not variable and is a constant 5 turns a minute.

The most important variables in the flow through equipment center on the pressure and flow rate aspects of the equipment. In the agitated equipment, the rock powder is subject to a pressure which is equivalent in all directions (hydrostatic). In a jacketed core such as that used in the flow-through studies, the grains within the core make intimate contact with one another. The stress applied at these grain to grain contacts is directly proportional to the pressure applied to the outside of the sleeve minues the pressure of the fluid within the pores. These point contacts represent regions where reaction rates are enhanced due to increased stresses. As long as these point contacts exist the system will be in a state of non-equilibrium. We plan to use two widely different confining pressures (100 bars and 1.5 kbars) in the flow-through system to determine what the magnitude of the stress induced effects are on the exchange reactions, and how these relate to the empirical Na-K geothermometer.

The final and probably most important variable of the flow-through system is the flow rate of fluids through the porous core. The flow rate (Q) is a function of the permeability (k), cross-sectional area (A) length (L) of the core, viscosity of the fluid (μ) and differential pressure across the core (ΔP). These are related by Darcy's Law:

$$Q = \frac{k\Delta PA}{L\mu} \qquad (2)$$

We will use core with the dimensions of 1 inch diameter by 4 inches long. Permeability is determined by the size, shape and packing of the grains. Viscosity is an intensive property of the fluid at specified pressure, temperature, and chemical composition. Flow rate through core is determined by the differential pressure across the core. We proposed to use several flow rates ranging from 0.1 ml/min to 10 ml/min in these experiments. Flow rate dependence is a critical factor in evaluating the rates at which chemical equilibrium may be approached in an actual geothermal system.

Procedure

The design and procedures used in the gold cell agitated equipment have been described in detail by Seyfried and others (1979) and Rytuba and Dickson (1974). A schematic of the apparatus is shown in Figure 3. Starting minerals and solutions are placed in the gold cell which is then inserted into a large pressure vessel. The pressure vessel is heated in a furnace to a designated temperature. An initial solution sample is taken and the furnace is started rocking. Solution samples can be taken at any time without disturbance of pressure and temperature conditions of the experiment.

The flow-through equipment was built at Stanford for the study of fluid permeability in rocks at elevated temperatures. A schematic of the flow-through apparatus is shown in Figure 4. The equipment was specifically designed to be chemically inert. Fluid moves from a pump through a preheater and into the core. Pulsations from the pump are damped by a gas-fluid separator. Fluid moves through the core and out of the system through several metering valves. Permeability can be determined by simultaneous measurement of the differential pressure across the core. Flow rates in the system can be varied from 0.5 ml/hour to >450 ml/hour.

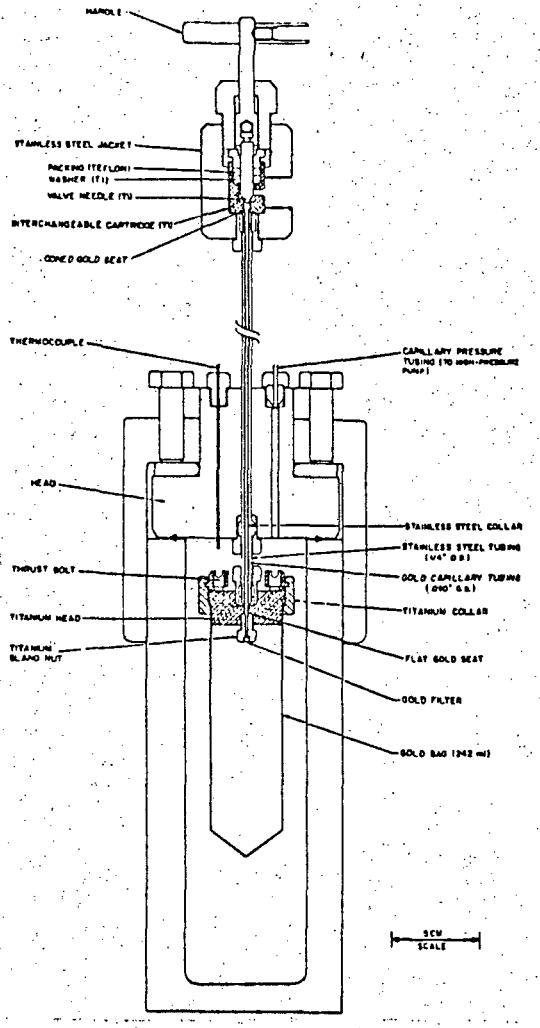

Figure 3. Schematic diagram of agitated experimental apparatus, from Seyfried and others,(1979).

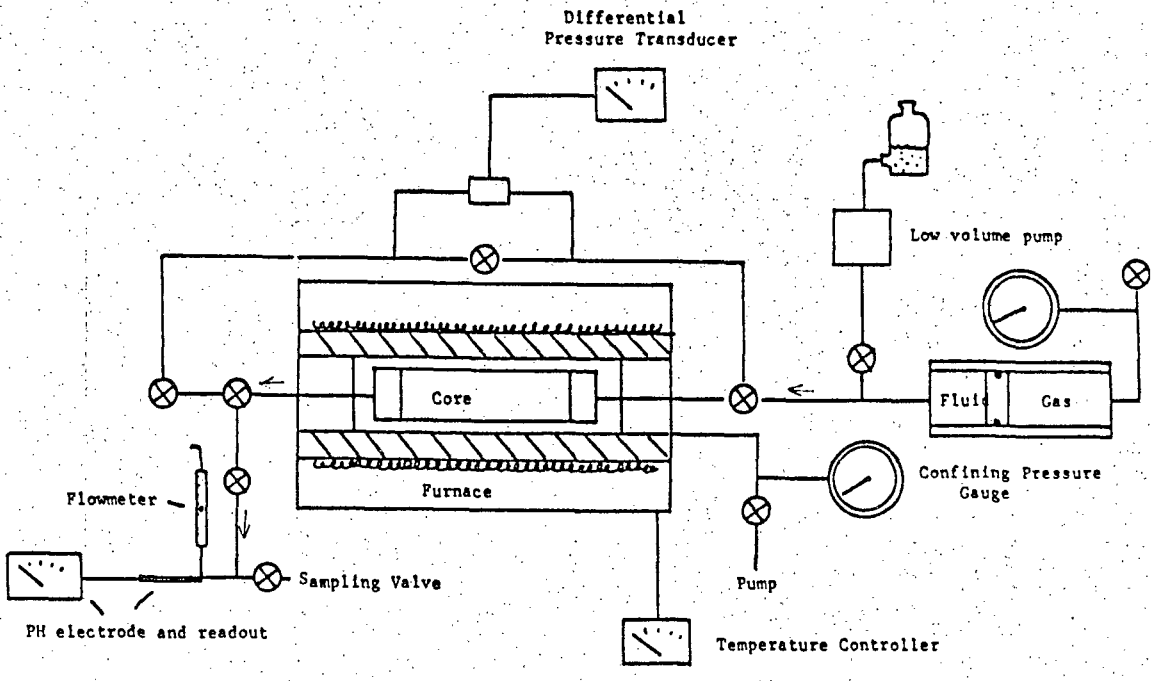

Figure 4. Schematic diagram of flow through apparatus designed and built at Stanford.

Analytical Approach

Careful attention must be paid to solution compositions as well as changes in physical and chemical properties of the solids. We have had a number of years of experience analyzing both solutions and solids by a variety of techniques. Exchangable cations (Ng, K. Ca Mg) in solution will be analyzed by flame atomic absorption; network species (Si, Al) will be analyzed by either A.A. or colorimetrically depending on concentration; solids removed from the cell will be analyzed by x-ray diffraction. Scanning electron microscopy and electron microprobe will be used to determine changes in mineralogy, texture, and chemical composition. Other analytical equipment including a TEM, STEM and Auger surface analysis are available through the Center of Materials Research at Stanford.

Several distribution of species computer programs are currently in use here including SOLVEQ by M. Reed (1976) and EQ3 (Wolery, 1979).

Experimental Sequence

Three specific sets of experiments are planned for the agitated equipment. A general description and reasons for each are outlined in the statement of work. In the first experiments crushed albite and orthoclase will react in 100 ppm and 2% NaCl solutions starting at 75°C. The reactions will be allowed to come to a steady-state as determined from monitoring solution composition. The temperature will be raised from 75°C to 150°C and the solution chemistry again monitored. This sequence will be repeated by 75°C increments to 300°C. The temperature will then be dropped in 75°C intervals at a rate approximately equal to the heating rate, again following solution composition as an indicator of steady-state. We expect this entire sequence to take around two months. We expect to show that ion-exchange reactions controlling K/Na ratios approach a steady state even though equilibrium between fluid and solid is not attained. The values for the exchange constant can be used to experimentally calibrate the geothermometer.

Two additional short experiments ($\sim$1 week) are also proposed in which we plan to heat the vessel directly to 300°C and monitor solution composition and then quench to room temperature. Monitoring solution chemistry at room temperature with time should indicate the kinetics of the retrograde ion-exchange reactions and their effect on the calculated Na/K temperature.

At least 3-4 of these experiments will be run using an intermediate plagioclase and orthoclase to determine the effect of a calcium component.

In the second set of experiments a glass of similar composition to the feldspar mixture will react with fluid. We expect to show that both true equilibrium is not necessary as discussed above and that feldspars are not necessary for the proper K/Na ratio. The experiments are conceptually simple. We will react the glass and monitor solution composition until some steady-state is reached. We will then quench the experiment and look for traces of original glass as well as the identity of secondary phases

using some of the techniques outlined in the analytical section. These experiments will be run at several temperatures (e.g. 150, 225, 300°C).

The third set of experiments will react a two zeolite assemblage to determine if Na-K zeolites can fix the Na/K ratio consistent with the Na/K geothermometer. These experiments will be run at a specific temperature and will be monitored until a steady state is reached and then quenched. Experiments at three temperatures are proposed: 150, 225; 300°C using two solution compositions. Either clinoptilolite or mordenite and analcime will be used in these experiments.

The flow-through experiments will be limited to a specific set of starting minerals (orthoclase and albite) with variables being temperature, confining pressure, and flow rate. At least three experiments will be done at a specific flow rate (0.1, 1.0, 10 ml/min) at three separate temperatures: 75, 150, 225°C. Solution composition will be monitored with time until a steady-state is reached. The temperature will then be increased and solution monitored until a steady-state is reached.

Two experiments will be run to determine the effect of confining pressure on the steady-state K/Na attained and kinetics of exchange reactions. Confining pressures of 100 bars and 1.5 kbar will be used in these experiments. Flow rate and temperature will be held constant.

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FEASIBILITY AND COST-EFFECTIVENESS

One of the problems with using the empirical K-Na-Ca geothermometer is evaluating its reliability in any given field situation. It is important to show (1) whether the method is based solely on bulk fluid/solid equilibria between feldspars or (2) whether partial equilibrium between surfaces of any crystalline tectosilicate and solution is all that is required to successfully apply the technique. If the latter can be demonstrated, the method could be applied to most geothermal systems with considerably more confidence and consequently with greater cost-effectiveness.

Any factors which cause a deviation between actual and calculated temperature must be assessed as well. Once the rates and mechanisms of alkali ion-exchange processes are understood, the identification of solutions from wells and springs which could potentially yield spurious data may be possible. The experimental work which we propose to do should elucidate many of these problems and lead to considerable savings during the exploration stage of geothermal energy development.

QUALIFICATIONS AND CAPABILITIES

The principal and associate investigators have made significant contributions to the disciplines underlying the topics discussed elsewhere in this proposal and together constitute a unique group with a body of insight and expertise which can be directed toward the problems of alkali and alkaline earth geothermometry.

The key personnel involved in the proposed project, their functions, and responsibilities are briefly outlined in the Project Management Plan.

Amos Nur has done extensive experimental laboratory work on the mechanical and chemical-mechanical aspects of fluids in porous and cracked rocks. His work, together with several past PhD students, includes high temperature wave propogation, hydraulic fluid flow, and stress induced solution rate under non-hydrostatic conditions. Much of this work has been directed towards geothermal reservoir exploration and evaluation. He has also shown the crack healing as detected by cathodoluminescence, can play a major role in basement rock permeability and fluid transfer in general. A. Nur will act as Co-PI on this project, in charge of the laboratory activities and the theoretical aspect of mechanics and mechanical-chemical interactions.

George Parks and his students in geochemistry, environmental engineering and metallurgy have had a continuing interest in water-mineral interaction for over 20 years. Much of this work has focussed on aqueous thermodynamics and surface chemistry. Early work utilizing spectrophotometric analysis of the reactions between water vapor and silica surfaces and the electrical conductivity of silica surfaces contributed to the currently accepted models for establishment of ionic equilibrium at solid oxide and silicate surfaces in aqueous solution. Other contributions include critical analysis and estimation of thermodynamic data for minerals, and reviews of the mechanism of surface charge development and adsorption in water-mineral systems.

Parks' research is currently centered on mathematical modelling of trace metal adsorption and exchange processes, experimental determination of moderate temperature solubilities of UO_2, and analysis of the effect of high surface area on the solubility of silica.

The bulk of the experimental work will be performed by Jared Potter who will work 100% on the project. Jerry has had extensive experience in designing, building, and operating closed, agitated and flow-through hydrothermal apparatus. Experimental work he has done previously has provided the key observations relative to the K-Na geothermometer discussed in this proposal.

Walter Dibble will work 50% on the project, will be partly responsible for assisting in the experimental work, and primarily responsible for the first deliverable and subsequent theoretical evaluation of the experimental results. Walter has made a significant contribution to the understanding of interface-controlled mineral-solution reactions (Dibble and Tiller, 1980, 1981) and has had a long association with the research on hydrothermal processes at Stanford.

BIOGRAPHIES

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Memberships:

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Sponsored Research Experience:

Inorganic Oxides in Aqueous Systems: The Zero Point of Charge
U.S.A.E.C. Contract AT(04-3)326 PA 3, 1960-68.

Contact Electrification of Oxides in Humid Atmospheres, NSF Grant G.P. 172, 1962-68

The Aqueous Surface Chemistry of Oxides and Complex Oxide Minerals
NSF Grant G.A. 1451, 1968-71

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Mercury in the Biogeochemical Environment, NSF, RANN, Grant GI-40614, 1972-75

GAP was Director and one of four Principal Investigators. An interdisciplinary study involving identification, characterization and modelling of release, transport and fixation processes responsible for dispersion of mercury in the aquatic environment through geochemical and biogeochemical processes.

Groundwater Reinjection of Reclaimed Water in Palo Alto, EPA contract R-804431-01-0, 1976-79

P.L. McCarty, Director. GAP was one of four co-principal investigators. An interdisciplinary study of chemical changes accompanying reinjection of reclaimed water into a shallow, clay-bearing aquifer.

Adsorption Process Models and Data for Application in Water Resources Research and Development, USGS Grant 14-08-0001-G-373, 1976-78

Poliovirus Adsorption on Oxide Substrates, EPA Grant R-805016, 1976-78 GAP and C.E. Schwerdt, Co-Principal Investigators

Development of Chemical and Biological Reaction Sub-models for Use in Groundwater Transport Simulation, OWRT Grant D.I. 8824, 1978-80. R.L. Street, R.V. Roberts, G.A.P., Co-Principal Investigators.

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Professional Positions:

Research Associate in Geophysics, M.I.T., 1969-1970

Asst. Prof. of Geophysics, Stanford University, 1970-1974

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Professor of Geophysics, Stanford University, 1979

Visiting Professor, Weizmann Institute of Science, Rehovot, Israel

Professional Activity:

Member, Lunar Sample Review Board, 1972-1973

Assoc. Editor, Journal of Geophysical Research, 1974-1977

Member, Committee on Seismology, National Research Council, 1974-1977

President, Tectonophysics Section, AGU, 1976-1977

Member, National Science Foundation Earth Sciences Advisory Board, 1974-1977

Member, National Academy of Science Earthquake Delegation to the People's Republic of China, 1976

Delegate, Japan-U.S. Earthquake Prediction Symposium, Tokyo, 1977

Director, The Stanford Rock Physics Project (SRP), 1977-

Assoc. Editor, Tectonophysics, 1979-

Member and Chairman, Earth Sciences Review Panel, LBL, 1980

Honors and Awards:

Research Fellow, A.P. Sloan Foundation, 1972-1974

J.B. Macelwane Award, American Geophysical Union, 1974

Mellon Fellowship, Stanford University, 1974-1975

Newcomb Cleveland Prize, AAAS, 1975

Fellow, American Geophysical Union, 1976

Member, New York Academy of Sciences, 1976

Fellow, Geological Society of America, 1980

University Fellow, Stanford University, 1980

Professional Societies:

American Geophysical Union
Geological Society of America
Society of Exploration Geophysicsts
Seismological Society of America
American Association for the Advancement of Science
Sigma Xi
Society of Petroleum Engineers

Books and Major Reports

1973 (with R.L. Kovach, editors) Proceedings of the Conference on Tectonics Problems of the San Andreas Fault System, Stanford University, Publ., Geological Sciences XIII, 512p.

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1979 (with M. Israel) A complete solution of a one dimnesional propagating fault with nonuniform stress and strength, J. Geophys. Res., 84, B5, 2223-34.

1979 (with K. Mahrer) Strike slip faulting in a horizontally varying crust, J. Geophys. Res., in press.

1979 (with H. Ito, J. DeVilbiss) Compressional and shear wave velocities in water filled rocks during water-steam transition, J. Geophys. Res., 84, B9, 4731-4735.

1979 (with K. Winkler) Pore fluids and seismic attenuation in rocks, Geophys. Res. Letters, 6, 1-4.

1979 (with K. Mahrer) Strike slip faulting in a downward varying crust, J. Geophys. Res., 84, B5, 2296-2302.

1979 (with Zvi Ben-Avraham) Volcano Height in subduction shear zones, submitted to JGR.

1979 (with E. Sprunt) Microcracking and healing in granites: New evidence from cathodoluminescence, Science, 205, 495-497.

1979 (with K. Winkler, J. DeVilbiss) Effects of fluid saturation on waves in porous rock, 7th Formation Evaluation Symposium of the Canadian Well Logging Society, Calgary, Oct. 21-24, 1979.

1979 (with J. Walls) Pore pressure and confining pressure depedence of permeability in sandstone, 7th Formation Evaluation of the Canadian Well Logging Society, Calgary, October 21-24, 1979.

1979 (with E. Sprunt) Another look at pore structure: Cathodoluminescence petrography (submitted SPWLA Transactions).

1980 Seismic velocities in low porosity rocks, Coulomb volume, in press.

1980 (with E. Kjartansson) Attenuation due to thermal relaxation in porous rocks, Geophysics, in press.

1980 (with Z. Ben-Avraham) Consumption of aseismic ridges and volcanic gaps in South America, GSA memoir, in press.

1980 (with W. Prescott) Accommodation of relative motion at depth on the San Andreas fault system in California, in press, JGR.

1980 (with Z. Ben-Avraham) The elevation of volcanoes and their edifice heights at subduction zones, in press, JGR.

1980 (with T.N. Narasimhan and W.N. Houston) The role of pore pressure in deformation in geologic processes, submitted, Geology.

1980 (with K. Winkler) Seismic attenuation: The effects of pore fluids and frictional sliding, in press, Geophysics.

1980 (with Z. Ben-Avraham, D. Jones and A. Cox) Continental accretion and Orogeny: From oceanic plateaus to allochthonous terranes, sumbitted, Science.

Associate Investigator: Walter E. Dibble, Jr.

Degrees: PhD in Geology, Stanford University, June 1980.

BA in Geology, University of California, Riverside, June, 1969.

Positions: Part-time at USGS associated with J.D. Vine and F.W. Dickson on Lithium Project determining the origin of Li-bearing minerals and fluids in sedimentary environments, October 1974 to January 1980. June 1980 to present, post doctoral fellow at Stanford.

Publications (exclusive of abstracts)

Dibble, W.E., Jr., and Dickson, F.W., 1976. The behavior of lithium in experimental rock-water interaction studies, in Lithium Resources and Requirements by the year 2000 (edited by J.D. Vine), USGS Prof. Paper 1005, 142-146.

Seyfried, W.E., Jr., Shanks, W.C., III and Dibble, W.E., Jr., 1978. Clay mineral formation in DSDP Leg 34 basalt. Earth and Planetary Sci. Letters, 41, 256-276.

Seyfried, W.E., Jr. and Dibble, W.E., Jr., 1980. Seawater-periodotite interaction at 300°C and 500 bars: implications for the origin of oceanic serpentinites. Geochim. et Cosmochim. Act., 44, 309-321.

Dibble, W.E., Jr., de Jong, B.H.W.S., and Cary, L.W., 1980. An ^{27}Al and ^{29}Si pulsed NMR study on the mechanism of zeolite precipitation. In: Proceedings of the Third International Symposium on Water-Rock Interaction. Edmonton, Canada.

Dibble, W.E., Jr. and Tiller, W.A., 1980. Non-equilibrium water/rock interactions. I. Model for interface-controlled reactions, Geochim. et Cosmochim. Acta., in press.

Dibble, W.E., Jr. and Tiller, W.A., 1981. Non-equilibrium water/rock interactions. II. Rate-mechanisms for quartz dissolution, Geochim. et Cosmochim. Acta., in press.

Dibble, W.E., Jr. and Tiller, W.A., 1981. Non-equilibrium water/rock interactions. III. Interface-controlled silicate dissolution, Goechim. et Cosmochim. Acta., in preparation.

Abstracts:

Dibble, W.E., Jr. and Dickson, F.W., 1974. Hydrologic processes involved in the genesis of oxidated ore deposits. Geol. Soc. America Abst. with Programs, 6, 3, 163-164.

Abstracts (cont'd)

Dibble, W.E., Jr. and Dickson, F.W., 1978. The influence of flourine on thermodynamic stability of sheet silicates. Trans. Am. Geophys. Union, 59, 12, 1218.

de Jong, B.H.W.S. and Dibble, W.E., 1979. An ^{27}Al and ^{29}Si pulsed NMR study on the molecular speciation of Al and Si in aqueous solutions. Trans. Am. Geophys. Union, 60, 46, 974.

Associate Investigator: Jared M. Potter

Degrees: PhD in Geology, Stanford University, expected October, 1980; MS in Geology, University of New Mexico, June 1978; BS University of New Mexico, June 1975.

Positions: Research Assistant, Los Alamos Scientific Lab, Summers, 1975-1977. Research Assistant, USGS, 1978 in M. Lampheres Isotope Lab.

Publications (exclusive of abstracts):

Potter, J.M., 1977, Permeability of Granitic Rocks as a Function of Temperature and Pressure, Los Alamos Scient. Lab., Report LA-7224-T, 101 p.

Potter, J.M., 1980, Laboratory Confirmation of Rock Core/Brine and Construction Material/Brine Correlations. Task II. Final Report. EPRI Grant RD-1195-4 (in press).

Potter, J.M. and Dickson, F.W., 1980, Reaction of Rhyolitic Glass and Holocrystalline Basalt with NaCl Solutions at 300°C; Effects of Time and Solution Composition on Alternative Mineralogy. In: Proceedings, Third Int. Symp. on Water Rock Interaction. Edmonton, Canada, pp. 107-173.

Dickson, F.W., and J.M. Potter, 1980, Rock/Brine Chemical Correlations. Final Report. EPRI Grant RP-653-2 (in press).

Abstracts:

Potter, J.M., J.P. Balagna, and R.W. Charles, 1976, Permeability of a Biotite Monzo-granite at Elevated Temperatures and Pressures, Trans. AGU abst., 57, 4, 353.

Balagna, J.P. and J.M. Potter, 1976, Delineation of Flow Channels in Crystalline Rock Using Different Radioactive Tracers, Trans. AGU abstr., 57, 12, 1016.

Potter, J.M., J.P. Balagna, R.W. Charles, and J.R. Vidale, 1976, A Leaching Technique Using Dilute Sodium Carbonate for Permeability Increase in Granitic Rocks. Trans. AGU abst., 57, 12, 1016.

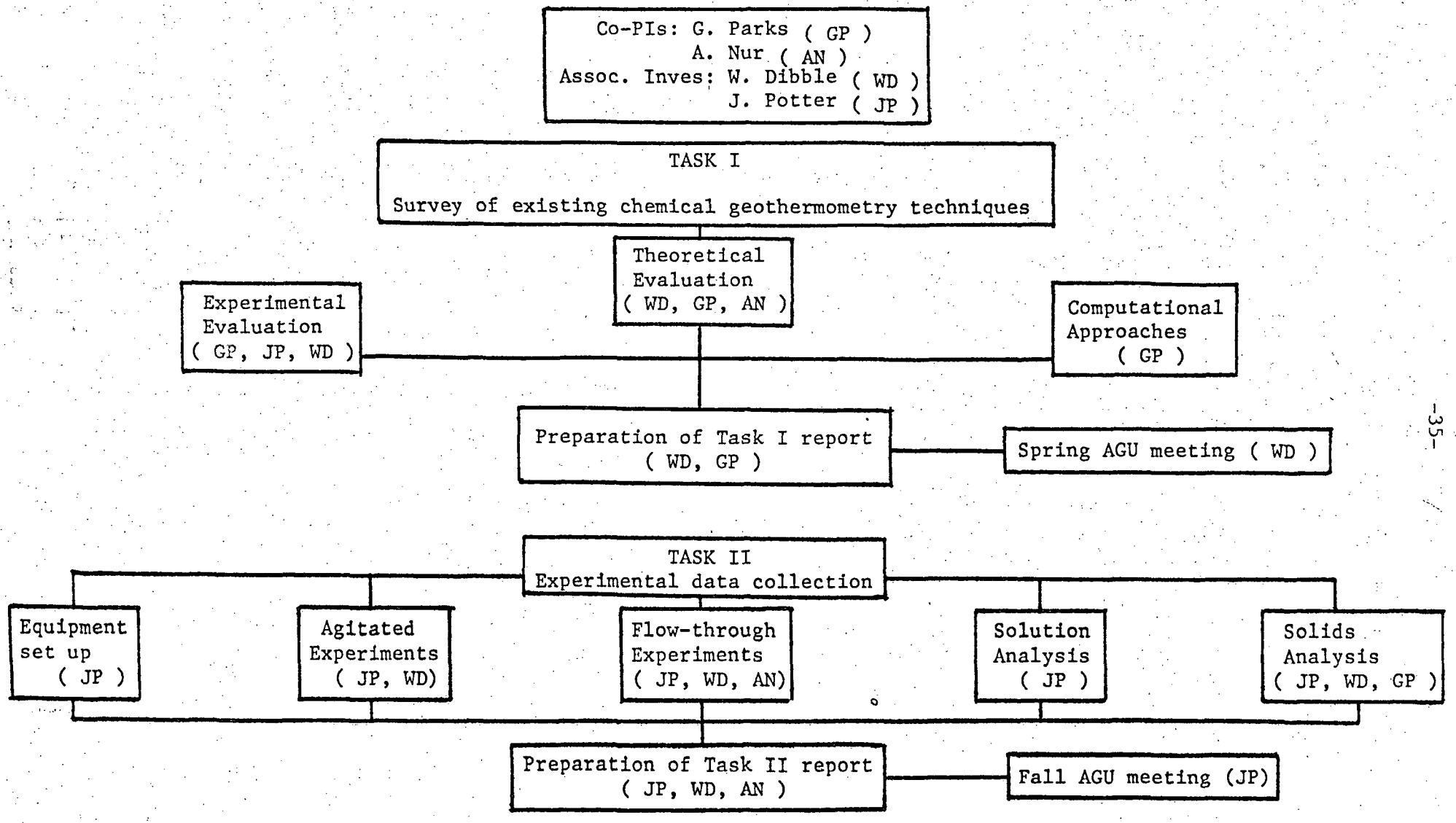
Rytuba, J.J., J.M. Potter, F.W. Dickson, and A.S. Radke, 1978, Experimental Alteration of Rhyolite glass at 300°C; Implication for Silicate Mineral Zoning in the McDermitt Mercury Deposit, Nevada, Trans. AGU abst., 59, 12, 1221.

Dickson, F.W., J.M. Potter, J.J. Rytuba, and A.S. Radke, 1978, Reaction of Rhyolite with H_2O and NaCl-H_2O at 300°C and 500 bars Pressure. Trans. AGU abst. 59, 12, 1221.

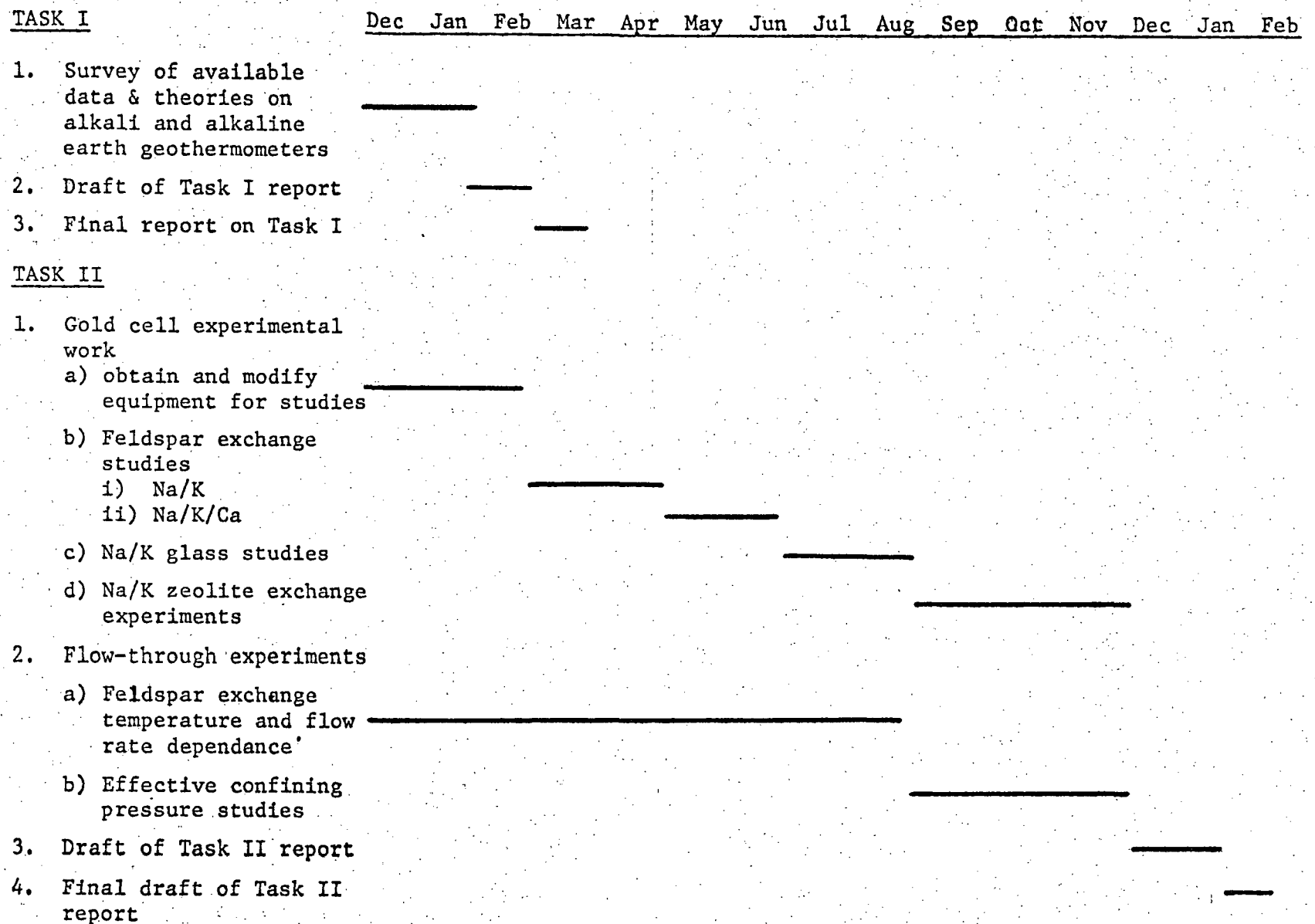
Abstracts (cont'd)

Potter, J.M. and F.W. Dickson, 1979, The Role of Solution Composition in the Alteration of Rhyolite Glass at 300°C. Geol. Soc. Am. Abst. 11, 7, 497.

PROJECT MANAGEMENT PLAN



TASK SCHEDULE
C.Y. 1981



COST ESTIMATE AND MILESTONE RECORD TO BE INCLUDED WITH MONTHLY REPORTS.

COST LEGEND (cost)

PLAN — — — ( )

ACTUAL ——— ( )

STATUS LEGEND

○ PLANNED

◇ SLIPPED
(Solid symbols indicate actuals)

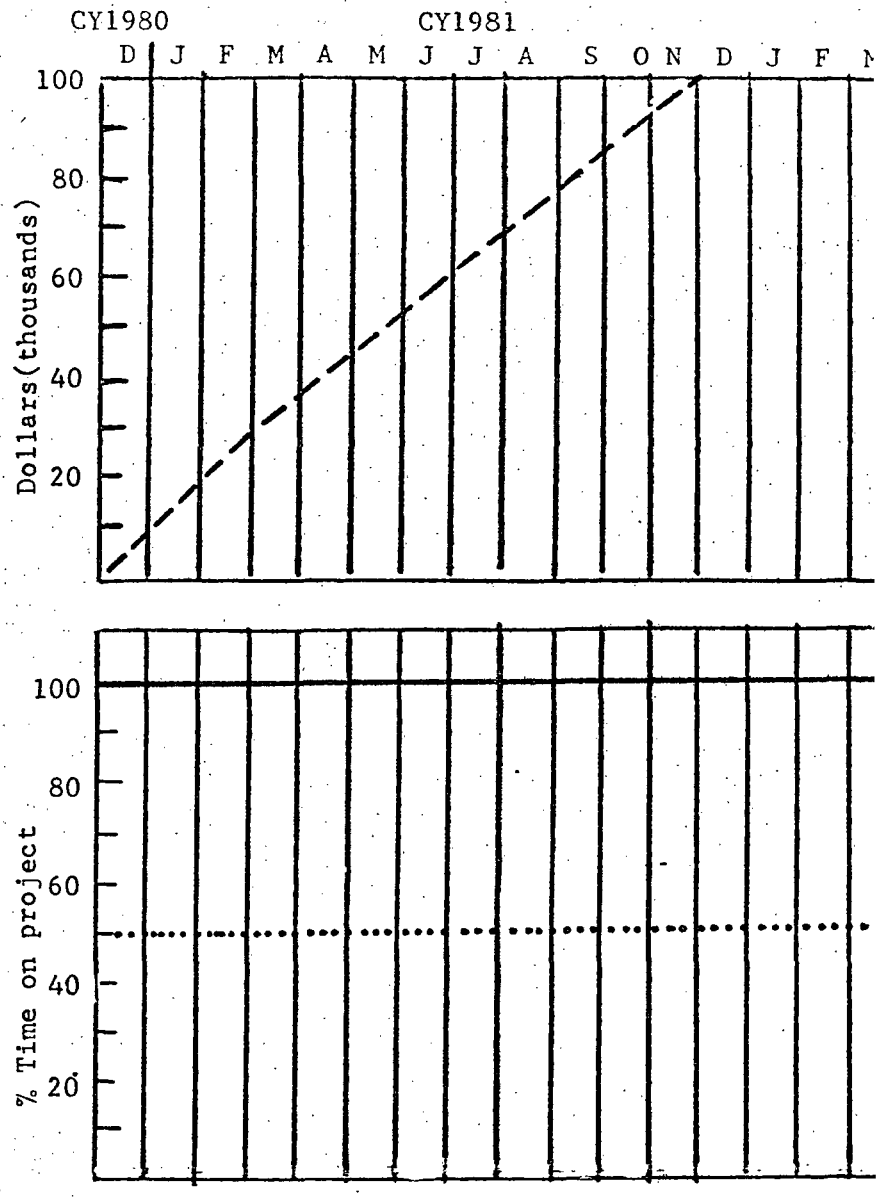
TIME SHARE LEGEND

—·—·— G. PARKS

— — — A. NUR

····· W. DIBBLE

——— J. POTTER



MILESTONES

Monthly Reports

Task I Draft

Task I Final Report

Spring AGU meeting (Baltimore, MD)
presentation of Task I results
Task I report submitted for publication

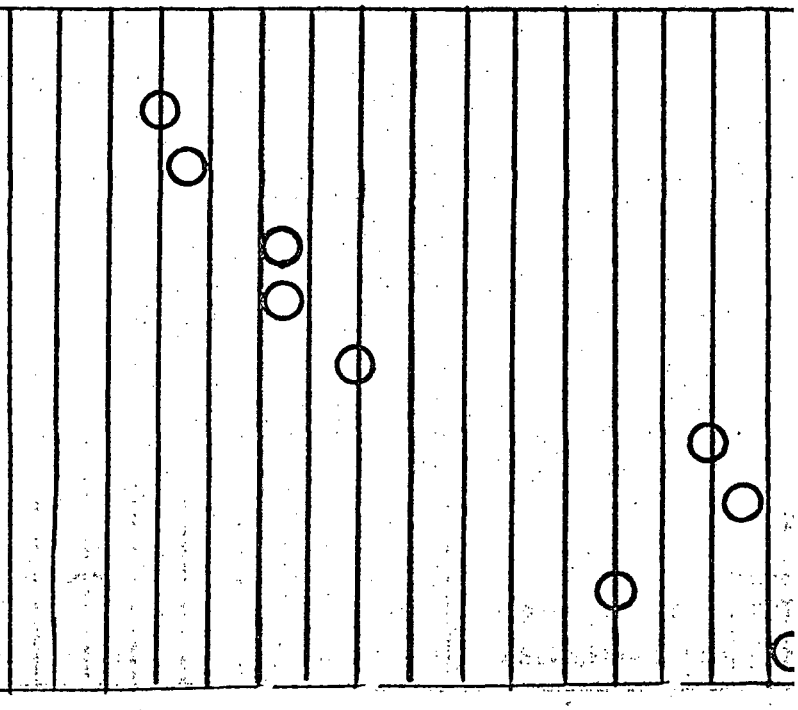
Semi-annual Report

Task II Draft

Task II Final Report

Fall AGU meeting (San Francisco, CA)
presentation of Task II results

Submittal for publication Task II report



CONTRACT PRICING PROPOSAL

(RESEARCH AND DEVELOPMENT)

Office of Management and Budget Approval No. 29-R0184

This form is for use when *(i)* submission of cost or pricing data (see FPR 1-3.807-3) is required and *(ii)* substitution for the Optional Form 59 is authorized by the contracting officer.

PAGE NO. | NO. OF PAGES

NAME OF OFFEROR: Board of Trustees of the Leland Stanford Junior University

HOME OFFICE ADDRESS: Sponsored Projects Office, Stanford, California 94305

SUPPLIES AND/OR SERVICES TO BE FURNISHED: A theoretical and experimental evaluation of the Na-K-Ca Geothermometer

DIVISION(S) AND LOCATION(S) WHERE WORK IS TO BE PERFORMED: Department of Geophysics

TOTAL AMOUNT OF PROPOSAL: $ 99,803

GOV'T SOLICITATION NO.:

DETAIL DESCRIPTION OF COST ELEMENTS

				EST COST ($)	TOTAL EST COST[1]	REFERENCE[2]
1. DIRECT MATERIAL *(Itemize on Exhibit A)*						
a. PURCHASED PARTS						
b. SUBCONTRACTED ITEMS						
c. OTHER—(1) RAW MATERIAL						
(2) YOUR STANDARD COMMERCIAL ITEMS						
(3) INTERDIVISIONAL TRANSFERS *(At other than cost)*						
TOTAL DIRECT MATERIAL					-0-	
2. MATERIAL OVERHEAD[1] *(Rate %X$ base =)*					-0-	
3. DIRECT LABOR *(Specify)*	~~ESTIMATED~~ HOURS	RATE/ HOUR	EST COST ($)			
	% effort					
See attached budget						
TOTAL DIRECT LABOR					34,838	A
4. LABOR OVERHEAD *(Specify Department or Cost Center)*[1]	O.H. RATE	X BASE =	EST COST ($)			
TOTAL LABOR OVERHEAD					7,368	B
5. SPECIAL TESTING *(Including field work at Government installations)*			EST COST ($)			
TOTAL SPECIAL TESTING						
6. SPECIAL EQUIPMENT *(If direct charge) (Itemize on Exhibit A)*					10,800	H
7. TRAVEL *(If direct charge) (Give details on attached Schedule)*			EST COST ($)			
a. TRANSPORTATION						
b. PER DIEM OR SUBSISTENCE See attached						
TOTAL TRAVEL					1,500	D
8. CONSULTANTS *(Identify—purpose—rate)*			EST COST ($)			
TOTAL CONSULTANTS					-0-	
9. OTHER DIRECT COSTS *(Itemize on Exhibit A)*					12,000	C E
10. *TOTAL DIRECT COST* ~~AND OVERHEAD~~					66,506	F H
11. GENERAL AND ADMINISTRATIVE EXPENSE *(Rate 58 % of cost element Nos. Indirect Costs)*[1]					32,309	G
12. ROYALTIES[1]					-0-	
13. *TOTAL ESTIMATED COST*					98,815	I
14. ~~FEE OR PROFIT~~ Cost Sharing					988	J
15. *TOTAL ESTIMATED COST AND FEE OR PROFIT*					99,803	K

OPTIONAL FORM 60
October 1971
General Services Administration
FPR 1-16.806

This proposal is submitted for use in connection with and in response to *(Describe RFP, etc.)*

DE-SC07-80ID12147

and reflects our best estimates as of this date, in accordance with the Instructions to Offerors and the Footnotes which follow.

TYPED NAME AND TITLE	SIGNATURE
Edward C. Barrera, Staff Assoc. Sponsored Projects Office	

NAME OF FIRM	DATE OF SUBMISSION
Board of Trustees of the Leland Stanford Junior University	

EXHIBIT A—SUPPORTING SCHEDULE *(Specify. If more space is needed, use reverse)*

COST EL NO.	ITEM DESCRIPTION *(See footnote 5)*	EST COST *($)*
	See attached budget	

I. HAS ANY EXECUTIVE AGENCY OF THE UNITED STATES GOVERNMENT PERFORMED ANY REVIEW OF YOUR ACCOUNTS OR RECORDS IN CONNECTION WITH ANY OTHER GOVERNMENT PRIME CONTRACT OR SUBCONTRACT WITHIN THE PAST TWELVE MONTHS?

[X] YES [ ] NO *(If yes, identify below.)*

NAME AND ADDRESS OF REVIEWING OFFICE AND INDIVIDUAL	TELEPHONE NUMBER/EXTENSION
DCAA, 420 Cambridge Avenue, Suite 424, Palo Alto, Ca. 94305	(415) 327-8411

II. WILL YOU REQUIRE THE USE OF ANY GOVERNMENT PROPERTY IN THE PERFORMANCE OF THIS PROPOSED CONTRACT?

[ ] YES [X] NO *(If yes, identify on reverse or separate page)*

III. DO YOU REQUIRE GOVERNMENT CONTRACT FINANCING TO PERFORM THIS PROPOSED CONTRACT?

[X] YES [ ] NO *(If yes, identify.)*: [ ] ADVANCE PAYMENTS [ ] PROGRESS PAYMENTS OR [ ] GUARANTEED LOANS

IV. DO YOU NOW HOLD ANY CONTRACT *(Or, do you have any independently financed (IR&D) projects)* FOR THE SAME OR SIMILAR WORK CALLED FOR BY THIS PROPOSED CONTRACT?

[ ] YES [X] NO *(If yes, identify.)*

V. DOES THIS COST SUMMARY CONFORM WITH THE COST PRINCIPLES SET FORTH IN AGENCY REGULATIONS?

[X] YES [ ] NO *(If no, explain on reverse or separate page)*

See Reverse for Instructions and Footnotes OPTIONAL FORM 60 (10-71)

PROPOSED BUDGET	12/1/80 - 11/30/
A. SALARIES AND WAGES	
Principal Investigators:	
Amos Nur, 2.5% academic year	873
George Parks, 2.5% academic year	930
1 month summer (100%)	4,135
Postdoctoral Research Affiliates	
J. Potter,1 year 100% time	15,000
W. Dibble,1 year 50% time	7,500
Student Research Assistant, one year, 50% time	5,400
Secretarial, 1 month 100% time	1,000
	34,838
B. FRINGE BENEFITS	
12/1/80 - 8/31/81 @ 21.% 9/1/81 - 11/30/81 @ 21.6%	7,368
C. EXPENDABLES & SUPPLIES	
Titanium, tops, valves, gold fabrication costs, analytical reagents, electrical equipment, bottles, AA tubes	4,000
Machining costs (approx. 5 hrs week)	5,000
Analytical costs, SEM 100 hrs @ $10/hr	1,000
Computer time	1,000
D. TRAVEL	
2 round trips to Maryland for spring AGU meetings (5 days)	1,500
E. PUBLICATIONS COSTS	1,000
F. MODIFIED TOTAL DIRECT COSTS	55,706
G. INDIRECT COSTS (58% of MTDC)	32,309
H. CAPITAL EQUIPMENT (COSTING OVER $500)	
1 RF rocking furnace assembly	5,000
2 Aminco pressure vessels @ $1700	3,400
2 Aminco pressure gauges with safety contacts	1,400
2 Omega digital temperature controllers	1,000
I. TOTAL REQUESTED FROM SPONSOR	98,815
J. UNIVERSITY COST SHARING*	988
K. TOTAL COST OF PROJECT	99,803

*Cost Shared by PIs salaries.

Technology Transfer Plan

The results of the work proposed will be transferred to potential users in two forms. Part of the results will be presented at national scientific meetings such as those of the American Geophysical Union. A presentation has been scheduled for the Spring 1981 AGU meeting in Baltimore. Another presentation has been set for Fall 1981 in San Francisco.

Details of the experimental and theoretical results will be published in appropriate journals before or soon after the end of the contract period. At least two published papers are anticipated, one focusing on theoretical aspects of geothermometry, and another presenting the experimental results in detail. Monthly, semi-annual, and final reports will be submitted as required by the funding agency. Copies of the final reports will be distributed to major universities, government agencies and private industries involved in geothermal exploration research. This distribution list will be determined during the contract period.

Business/Cost Requirements

Organization Information: Stanford University

Project Budget by Task:

Task 1. Evaluation of existing chemical geothermometry techniques

4 months total time, cost: $7,990

Task 2: Experimental Investigation of alkali and alkaline earth geothermometers

12 months total time, cost: $91,813

CURRENT GOVERNMENT SUPPORT : A. Nur

Agency	Abbrev. Title	Period of Funding	Amount	% Time PI	# of Persons Grad. St.
NSF/Geophysics	Attenuation in Rocks	Sept. 78 - Sept. 80	100,000/2yrs.	8%	2
NSF/Geology	Pressure Solution and Cathodoluminescence in Rock	Aug. 79 - Dec. 80	60,000/1.5yrs.	4%	1
DOE	Physics of Rock with Fluids	Aug. 79 - Aug. 80	96,000/1yr.	8%	3
NSF/ASRA	Borehole Permeability Studies	Oct. 79 - Mar. 81	96,000/1.5yrs.	8%	2
ONR	Mechanics of Granular Materials	June 80 - May 82 (est)	130,000/2yrs.	8%	2
Pending					
NSF/Marine Sciences	Ontong Java Study	Sept. 80 - Aug. 82	99,000/2yrs.	8%	2
DOE	Physics of Rock with Fluids (continuation)	Aug. 80 - Aug. 81	117,000/1yr.	16%	3 1/2
NSF/Geophysics	Attenuation in Rocks	Jan. 81 - Dec. 82	90,000/2yrs.	8%	2
NASA	Models for Rupture Mechanics	Jan. 81 - Dec. 82	89,000/2yrs.	8%	2
	G. Parks				
NSF	Uranium Transport Modelling	Jan. 80 - Dec. 81	89,848/2yrs.	10%AY 67% SMR	1

APPENDIX E

REPRESENTATIONS AND CERTIFICATIONS

[Instructions: Check or complete all appropriate boxes or blanks.]

The proposer makes the following representations and certifications:

1. SMALL AND SMALL DISADVANTAGED BUSINESS CERTIFICATION

(a) The bidder or offeror certifies that it is ( ) is not (X) a small business concern as defined in accordance with Section 3 of the Small Business Act (15 U.S.C. 632).

(b) The bidder or offeror certifies that it is a small business [as set forth in (a) above] and is ( ) is not ( ) owned and controlled by socially and economically disadvantaged individuals. Such a firm is defined as one -

(i) which is at least 51 per centum owned by one or more such individuals or, in the case of any publicly owned business, at least 51 per centum of the stock is owned by such individuals;

(ii) whose management and daily business operations are controlled by one or more such individuals; and

(iii) which certifies concerning said ownership and control in accordance with section (c) below.

(c) The bidder or offeror certifies that it is ( ) is not (X) a minority individual(s) in accordance with (c)(i) below or that it is ( ) is not (X) socially and economically disadvantaged in accord with section (c)(ii) or (c)(iii). Socially and economically disadvantaged individuals are defined as:

(i) United States citizens who are Black Americans, Hispanic Americans, Native Americans, or other specified minorities;

(ii) any other individual found to be disadvantaged pursuant to section 8(a) of the Small Business Act (15 U.S.C. 637); or

(iii) any other individual defined as socially, and economically disadvantaged, for purposes relating to other sections of the Small Business Act.

2. CONTINGENT FEE

(a) It ( ) has, (X) has not, employed or retained any company or person (other than a full-time bona fide employee working solely for the bidder) to solicit or secure this contract, and (b) it ( ) has, (X) has not, paid or agreed to pay any company or person (other than a full-time bona fide employee working solely for the bidder) any fee, commission, percentage or brokerage fee, contingent upon or resulting from the award of this contract; and agrees to furnish information relating to (a) and (b) above as requested by the Contracting Officer. (For interpretation of the representation, including the term "bona fide employee," see Code of Federal Regulations, Title 41, Subpart 1-1.5.).

3. TYPE OF ORGANIZATION

(X) non-profit educational institution

It operates as an ( ) individual, ( ) partnership, ( ) joint venture, ( ) corporation, incorporated in State of _____.
A body having corporate powers under the laws of the State of California.

4. EQUAL OPPORTUNITY

It (X) has, ( ) has not, participated in a previous contract or subcontract subject to the Equal Opportunity Clause herein, the clause originally contained in Section 301 of Executive Order No. 10925, or the clause contained in Section 201 of Executive Order No. 11114; it (X) has, ( ) has not, filed all required compliance reports; and representations indicating submission or required compliance reports, signed by proposed subcontractors, will be obtained prior to subcontract awards.

5. AFFIRMATIVE ACTION COMPLIANCE PROGRAM

The offeror represents that (a) it (X) has developed and has on file, ( ) has not developed and does not have on file, at each establishment an affirmative action program as required by the rules and regulations of the Secretary of Labor (41 CFR 60-1 and 60-2), or (b) ( ) has not previously had contracts subject to written affirmative action program requirements of the rules and regulations of the Secretary of Labor because (check as applicable):

_____ offeror does not have 50 or more employees

_____ offeror has not had a Government prime contract or subcontract of $50,000 or more.

6. CERTIFICATION OF NONSEGREGATED FACILITIES

By the submission of this proposal, the offeror, applicant, or subcontractor certifies that it does not maintain or provide for its employees any segregated facilities at any of its establishments, and that it does not permit its employees to perform their services at any location, under its control, where segregated facilities are maintained. It certifies further that it will not maintain or provide for its employees any segregated facilities at any of its establishments, and that it will not permit its employees to perform their services at any location, under its control, where segregated facilities are maintained. The offeror, applicant, or subcontractor agrees that a breach of this certification is a violation of the Equal Opportunity clause in this contract. As used in this certification, the term "segregated facilities" means any waiting rooms, work areas, rest rooms and wash rooms, restaurants and other eating areas, time clocks, locker rooms and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive or are in fact segregated on the basis of race, creed, color, or national origin, because of habit, local custom, or otherwise. It further agrees that (except where it has obtained identical certifications from proposed subcontractors for specific time periods) it will obtain identical certifications from proposed subcontractors prior to the award of subcontracts exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause; that it will retain such certifications in its files; and that it will forward the following notice to such proposed subcontractors (except where the proposed subcontractors have submitted identical certifications for specific time periods):

NOTICE TO PROSPECTIVE SUBCONTRACTORS OF REQUIREMENT FOR CERTIFICATION OF NONSEGREGATED FACILITIES

A Certification of Nonsegregated Facilities must be submitted prior to the award of a subcontract exceeding $10,000 which is not exempt from the provisions of the Equal Opportunity clause. The certification may be submitted either for each subcontract or for all subcontracts during a period (i.e., quarterly, semi-annually, or annually).

7. PARENT COMPANY AND EMPLOYER IDENTIFICATION NUMBER

Each proposer shall furnish the following information by filling in the appropriate blocks:

a. Is the proposer owned or controlled by a parent company as described below? ( ) Yes (X) No. (For the purpose of this proposal, a parent company is defined as one which either owns or controls the activities and basic business policies of the proposer. To own another company means the parent company must own at least a majority (more than 50 percent) of the voting rights in that company. To control another company, such ownership is not required; if another company

is able to formulate, determine or veto basic business policy decisions of the proposer, such other company is considered the parent company of the proposer. This control may be exercised through the use of dominant minority voting rights, use of proxy voting, contractual arrangements, or otherwise.)

b. If the answer to a. above is "Yes", proposer shall insert in the space below the name and main office address of the parent company.

Name of Parent Company: _____

Main Office Address (No., Street, City, State and Zip Code)

c. Proposer shall insert in the applicable space below, if it has no parent company, its own Employer's Identification Number (E.I. No.) (Federal Social Security Number used on Employer's Quarterly Federal Tax Return, U. S. Treasury Department Form 941), or if it has a parent company, the E.I. No. of its parent company.

Employer Identification Number of Parent Company: 94-1156365

8. CLEAN AIR AND WATER CERTIFICATION

(Applicable if the bid or offer exceeds $100,000, or the Contracting Officer has determined that orders under an indefinite quantity contract in any year will exceed $100,000, or a facility to be used has been the subject of a conviction under the Clean Air Act (42 U.S.C. 1857c-8(c)(1)) or the Federal Water Pollution Control Act (33 U.S.C. 1319(c)) and is listed by EPA, or is not otherwise exempt.)

The bidder or offeror certifies as follows:

(a) Any facility to be utilized in the performance of this proposed contract has ( ), has not (X), been listed on the Environmental Protection Agency List of Violating Facilities.

(b) It will promptly notify the Contracting Officer, prior to award, of the receipt of any communication from the Director, Office of

6. CERTIFICATION OF NONSEGREGATED FACILITIES

By the submission of this proposal, the offeror, applicant, or subcontractor certifies that it does not maintain or provide for its employees any segregated facilities at any of its establishments, and that it does not permit its employees to perform their services at any location, under its control, where segregated facilities are maintained. It certifies further that it will not maintain or provide for its employees any segregated facilities at any of its establishments, and that it will not permit its employees to perform their services at any location, under its control, where segregated facilities are maintained. The offeror, applicant, or subcontractor agrees that a breach of this certification is a violation of the Equal Opportunity clause in this contract. As used in this certification, the term "segregated facilities" means any waiting rooms, work areas, rest rooms and wash rooms, restaurants and other eating areas, time clocks, locker rooms and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive or are in fact segregated on the basis of race, creed, color, or national origin, because of habit, local custom, or otherwise. It further agrees that (except where it has obtained identical certifications from proposed subcontractors for specific time periods) it will obtain identical certifications from proposed subcontractors prior to the award of subcontracts exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause; that it will retain such certifications in its files; and that it will forward the following notice to such proposed subcontractors (except where the proposed subcontractors have submitted identical certifications for specific time periods):

NOTICE TO PROSPECTIVE SUBCONTRACTORS OF REQUIREMENT FOR CERTIFICATION OF NONSEGREGATED FACILITIES

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a. Is the proposer owned or controlled by a parent company as described below? ( ) Yes (X) No. (For the purpose of this proposal, a parent company is defined as one which either owns or controls the activities and basic business policies of the proposer. To own another company means the parent company must own at least a majority (more than 50 percent) of the voting rights in that company. To control another company, such ownership is not required; if another company

is able to formulate, determine or veto basic business policy decisions of the proposer, such other company is considered the parent company of the proposer. This control may be exercised through the use of dominant minority voting rights, use of proxy voting, contractual arrangements, or otherwise.)

b. If the answer to a. above is "Yes", proposer shall insert in the space below the name and main office address of the parent company.

Name of Parent Company: _____

Main Office Address (No., Street, City, State and Zip Code)

c. Proposer shall insert in the applicable space below, if it has no parent company, its own Employer's Identification Number (E.I. No.) (Federal Social Security Number used on Employer's Quarterly Federal Tax Return, U. S. Treasury Department Form 941), or if it has a parent company, the E.I. No. of its parent company.

Employer Identification Number of Parent Company: 94-1156365

8. CLEAN AIR AND WATER CERTIFICATION

(Applicable if the bid or offer exceeds $100,000, or the Contracting Officer has determined that orders under an indefinite quantity contract in any year will exceed $100,000, or a facility to be used has been the subject of a conviction under the Clean Air Act (42 U.S.C. 1857c-8(c)(1)) or the Federal Water Pollution Control Act (33 U.S.C. 1319(c)) and is listed by EPA, or is not otherwise exempt.)

The bidder or offeror certifies as follows:

(a) Any facility to be utilized in the performance of this proposed contract has ( ), has not (X), been listed on the Environmental Protection Agency List of Violating Facilities.

(b) It will promptly notify the Contracting Officer, prior to award, of the receipt of any communication from the Director, Office of

Federal Activities, Environmental Protection Agency, indicating that any facility which it proposes to use for the performance of the contract is under consideration to be listed on the EPA List of Violating Facilities.

(c) It will include substantially this certification, including this paragraph (c), in every nonexempt subcontract.

9. WOMAN-OWNED BUSINESS

Concern is ( ) is not (X) a woman-owned business.

A woman-owned business is a business which is, at least, 51 percent owned, controlled, and operated by a woman or women. Controlled is defined as exercising the power to make policy decisions. Operated is defined as actively involved in the day-to-day management.

For the purposes of this definition, businesses which are publicly owned, joint stock associations, and business trusts are exempted. Exempted businesses may voluntarily represent that they are, or are not, woman-owned if this information is available.

10. PERCENT OF FOREIGN CONTENT

The offeror/contractor will represent (as an estimate), immediately after the award of a contract, the percent of the foreign content of the item or service being procured expressed as a percent of the contract award price (accuracy within plus or minus 5 percent is acceptable).

Signed by _____

Edward C. Barrera, Staff Associate
(Title)

Note: No solicitation may be properly considered without this certification and no award may be made without it being executed.

APPENDIX H

U. S. DEPARTMENT OF ENERGY

REPORTING REQUIREMENTS CHECKLIST

DOE Form CR-537 (1-78)

(See Instructions on Reverse)

FORM APPROVED OMB NO. 38R-0190

1. IDENTIFICATION	2. OBLIGATION INSTRUMENT:

3. REPORTING REQUIREMENTS

A. PROJECT MANAGEMENT	Frequency	B. TECHNICAL INFORMATION REPORTING	Frequency
1. ☐ Management Plan		1. ☒ Notice of Energy RD&D Project (SSIE)	O
2. ☐ Milestone Schedule & Status Report		2. ☒ Technical Progress Report	Q
3. ☐ Cost Plan		3. ☒ Topical Report	Y
4. ☐ Manpower Plan		4. ☒ Final Technical Report	F
5. ☒ Contract Management Summary Report	M		
6. ☒ Project Status Report	M	C. PMS/MINI-PMS	
7. ☐ Cost Management Report		1. Cost Performance Report	
8. ☐ Manpower Management Report		☐ Format 1 WBS	
9. ☒ Conference Record	A	☐ Format 2 Functional	
10. ☒ Hot Line Report	A	☐ Format 3 Baseline	
		☐ Format 5 Problem Analysis	
		2. ☐ Cost/Schedule Status Report	
		3. ☐ Management Control System Description	
		4. ☐ Summary System Description	
		5. ☐ WBS Dictionary	

FREQUENCY CODES:

A – As Required
C – Contract Change
F – Final (End of Contract)
M – Monthly
O – One Time (Soon After Contract Award)
Q – Quarterly
S – Semi-Annually
X – Mandatory for Delivery with Proposals/Bid
Y – Yearly or Upon Contract Renewal

4. SPECIAL INSTRUCTIONS

Submit all reports to the DOE Program Officer at Idaho Operations Office (ID) as indicated below:

A.5 and 6 - Six copies are due at ID within fifteen days after end of the calendar month.

B.1 - Two copies are due at ID within fifteen days after Cooperative Agreement Award.

B.2 - Six copies are due at ID within fifteen days after end of the calendar quarter.

B.3 - Six copies are due not less than forty-five days prior to completion of the yearly term.

B.4 - Submit in draft forty-five days prior to completion date of Cooperative Agreement. After thirty days for DOE review, submit eleven copies including one camera-ready copy.

5. ATTACHED HEREWITH:

☐ Report Distribution List ☐
☐ WBS/Reporting Category ☐

6. PREPARED BY (Signature and date):	7. REVIEWED BY (Signature and date):

Appendix I

NON-EQUILIBRIUM WATER/ROCK INTERACTIONS

Walter Earl Dibble, Jr., Ph.D.
Stanford University, 1980

The results of established crystal growth theory and silicate dissolution experiments are combined in developing a new model for mineral/water reactions controlled by surface processes. The overall reaction rate at steady-state is determined by coupling equations for the velocities of mass transport and interface detachment processes. Non-steady state processes can be successfully treated when interface reactions control the rate. For most sparingly soluble minerals, diffusion through the solution can be neglected as a rate-determining factor.

Many surface processes are driven by the total interface undersaturation, but only processes facilitating detachment contribute to dissolution. Other, non-detachment related, surface reactions result in lower dissolution rates. Slow rates of many mineral/solution reactions are attributed to the surface processes which consume the energy that would otherwise drive detachment.

An analysis of the time dependence of interface reaction velocities indicates that linear rate laws apply when uniform detachment or layer-source generation mechanisms such as screw dislocations control the dissolution rate. At low interfacial undersaturations, first-order, logarithmic rate laws prevail. A parabolic time dependence occurs if surface detachment parameters vary as a function of $(\text{time})^{1/2}$.

Experimental rate data for quartz dissolution are used to define molecular activation mechanisms based on the kink-site detachment model. The quartz dissolution mechanism involves binding of ionic species to surface detachment sites. Surface binding reactions are controlled mainly

by the sign and magnitude of the surface electrostatic potential. Because the interface electric field strength determines the activated kink-site density, the dissolution rate increases exponentially with ion concentrations in the bulk solution, and rates are minimized at the pH at which the surface charge is zero. Rate equations for quartz dissolution are developed assuming surface charging and complexation reactions are much more rapid than the overall dissolution rate.

Different layer-edge detachment processes occur for quartz dissolution depending on the absolute rate. At low rates, linear rate laws indicate layer-edge generation and/or motion control the rate. At high velocities, the motion of kinks on layer edges may limit rates; but exponential time dependences suggest that the driving force for detachment is greatly reduced by non-detachment related surface processes. In the intermediate rate region, surface diffusion processes may control rates and result in parabolic time dependences if surface reconstruction becomes the slow rate step.

The dissolution of silicates is more complex than quartz dissolution because most silicates dissolve incongruently. For any solution composition, an equilibrium surface state must exist with a specific chemical configuration, structure, and electrical charge. For silicates, both the interface electric field and variation in surface chemical composition control rates.

To characterize a solid that varies significantly in composition at a solid/fluid interface, it is necessary to define a new thermodynamic intensive variable for the surface. The interface chemical potential is defined by the variation in the surface composition from bulk solid

stoichiometry. The results of this treatment yield a method for determining the chemical configuration of a surface from changes in the surface tension and bulk solution composition.

To determine variations in interface composition as a result of incongruent dissolution, values of the chemical potentials of components in the bulk solid phase must be known. These values are determined for phyllosilicates using an extension of the method of Tardy and Garrels (1974). They can also be combined to estimate values of Gibbs free energies of formation for many sheet silicates for which no thermochemical data are available. The results are used to predict chemical potential values for F- and Li-bearing components and for components in the exchange position of smectites. They show that small amounts of fluorine in a sheet silicate significantly affect the Gibbs energy of formation.

MAY 07 1982

Stanford University
Sponsored Projects Office
320 Galvery Street
Stanford, California 94305

ATTENTION: Carol J. Goodman

SUBJECT: MODIFICATION NO. M002 TO COOPERATIVE AGREEMENT NO. DE-FC07-80ID12147

Gentlemen:

Enclosed for your files is a fully executed copy of a modification to the agreement which extends the term. Article V - Term of the Agreement provides for extension as mutually agreed in writing; your letter constitutes your agreement and the modification need not be signed by you. If you have any questions, please call me on (208) 526-1510.

Very truly yours,

Original Signed By:
Kent R. Hastings

Kent R. Hastings
Contracting Officer
R&D Contracts Branch
Contracts Management Division

Enclosure

bcc: Dean Thompson, FMD, w/enc.
S. M. Prestwich, w/enc.
Janet Crofts, w/enc.
Dennis Nellson, UURI, W/enc.
~~BWXKXWX~~

R&DCB
KRHastings:db
5/7/82

U.S. DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE

COOPERATIVE AGREEMENT

ID FORM-182
(Rev. 05-80)
Ref: CMD

PURSUANT TO AUTHORITY OF PL 93-410, PL 93-438, PL 93-473, PL 93-577, and PL 95-91

1.a. Agreement No.: DE-FC07-80ID12147

1.b. Modification No.: M002

2. Agreement Period
From: 9-30-80 To: 6-30-82

3. Participant Name and Address
Stanford University
Sponsored Projects Office
320 Galvery Street
Stanford, California 94305

4. Participant Type
[X] Educational
[ ] State or Local Government
[ ] Nonprofit
[ ] Profit

5. Project Title
A Theoretical and Experimental Evaluation of the Na-K-Ca Geothermometer.

6. Project Will be Conducted per
See Article _____

7. Technical Reports Are Required
See Article _____

8. Principal Investigator(s) or Program Director(s) Name and Address
Amos Nur/George Parks
Stanford University
Stanford, California 94305

9. DOE Program Officer (Name and Address)
S. M. Prestwich, Energy & Technology Div.
U.S. Department of Energy
550 Second St., Idaho Falls, ID 83401
Telephone No. (208) 526-1147

10. Accounting and Appropriation Data

11. Method of Payment
[ ] % At Award, % When Requested, 5% Upon Letter of Credit Receipt of Final Report
[ ] Reimbursement
[ ] Other (specify) See Article _____

12. Submit Vouchers to

13. Funding Sources

Source	Amount
DOE:	$
Participant:	$
Total Funding:	$

14. Remarks:
Changes are as follows:

In accordance with a May 4, 1982 request from Stanford University the term of the agreement is extended through June 30, 1982.

15. Amount Obligated By This Action: $

16. DOE Issuing Office (Name and Address)
Idaho Operations Office
550 Second Street
Idaho Falls, Idaho 83401

17. DOE Contracting Officer
Kent R Hastings 5/7/82
Signature of Contracting Officer (Date)
Name (typed) Kent R. Hastings
Telephone No. (208) 526-1510

18. Participant Acceptance
By _____ _____
Signature of Authorized Official (Date)
Name (typed) _____
Title _____

(Replaces ID F-182 (11-79))