

PROJECT ADMINISTRATION DATA SHEET

ORIGINAL REVISION NO. _____

Project No. E-19-545 (05489-0A0) ~~GTRC~~/GIT DATE 6 / 28 / 85

Project Director: Dr. Eric Clayfield School/~~ENR~~ Chemical Engineering

Sponsor: U. S. Department of the Interior, Bureau of Mines

Type Agreement: Grant No. G1154113

Award Period: From 7/1/85 To 9/30/86 (Performance) 9/30/86 (Reports)

Sponsor Amount:	<u>This Change</u>	<u>Total to Date</u>
Estimated: \$	<u>147,000</u>	\$ <u>147,000</u>
Funded: \$	<u>147,000</u>	\$ <u>147,000</u>

Cost Sharing Amount: \$ 220,500 Cost Sharing No: E-19-214 (B5489-0A0)

Title: Allotment Grant to the Georgia Mining and Mineral Resources Institute for the period 1 July 1985 through 30 June 1986.

ADMINISTRATIVE DATA OCA Contact Brian J. Lindberg X4820

1) Sponsor Technical Contact:	2) Sponsor Admin/Contractual Matters:
<u>Dr. Ronald A. Munson</u>	<u>Oliver H. Snyder III</u>
<u>U. S. Dept. of the Interior</u>	<u>Grants Management Office</u>
<u>Office of Mineral Institutes</u>	<u>U. S. Dept. of the Interior</u>
<u>Bureau of Mines, MS 1020</u>	<u>Bureau of Mines</u>
<u>2401 E. Street, NW</u>	<u>2401 E. Street, NW</u>
<u>Washington, DC 20241</u>	<u>Washington, DC 20241</u>

Defense Priority Rating: N/A Military Security Classification: N/A
(or) Company/Industrial Proprietary: N/A

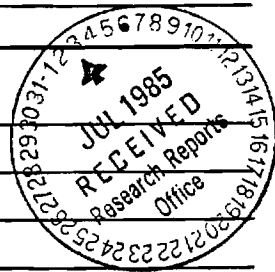
RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval - Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of \$500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT. However, purchase of additional items of equipment having an acquisition cost of \$1,000 or more must be requested in writing.

COMMENTS:



COPIES TO: SPONSOR'S I. D. NO. 02.111.000.85.004

Project Director	Procurement/EES Supply Services	GTRC
Research Administrative Network	Research Security Services	Library
Research Property Management	Reports Coordinator (OCA)	Project File
Accounting	Research Communications (2)	Other <u>Jones</u>

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date December 10, 1986

Project No. E-19-545

School/~~KA~~ ChE

Includes Subproject No.(s) N/A

Project Director(s) E. Clayfield

~~GTRC~~ / GIT

Sponsor U. S. Department of Interior

Title Allotment Grant to the Georgia Mining and Mineral Resources

Institute for the period 1 July 1985 through 30 June 1986

Effective Completion Date: 9/30/86

(Performance) 12/31/86

(Reports)

Grant/Contract Closeout Actions Remaining:

- None
- Final Invoice or Final Fiscal Report
- Closing Documents
- Final Report of Inventions
- Govt. Property Inventory & Related Certificate
- Classified Material Certificate
- Other _____

Continues Project No. E-19-533

Continued by Project No. E-19-515

COPIES TO:

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 Other I. Lashley
A. Jones
R. Embry

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PERFORMANCE REPORT

"The Paperwork Reduction Act of 1980 (44 U.S.C. 35) requires us to inform you that: The information is being collected to monitor a Federal grant program. This information will be used to ensure grantee compliance with the governing provisions of OMB Circular A-110, Treasury Circular 1075 and policies and procedures of 30 CFR Part 890. The obligation to respond is required to obtain a benefit."

1. Grant Recipient	Type of Report	Reporting Period	Grant Number:
Georgia Institute of Technology Atlanta, GA 30332	<input checked="" type="checkbox"/> Quarterly <input type="checkbox"/> Final	<input checked="" type="checkbox"/> July 1-Sept. 30 <input type="checkbox"/> Oct. 1-Dec. 31 <input type="checkbox"/> Jan. 1-March 31 <input type="checkbox"/> April 1-June 30	G 1154113 Date Report Prepared: 12/9/85

2. Grant Title:
Allotment Grant for State Mining and Mineral Resources Institute

3. Principal Investigator:	Address:	Telephone No.
Professor Eric J. Clayfield	Georgia Mining & Mineral Resources Institute Georgia Institute of Technology Atlanta, GA 30332-0101	404 894-2893

4. Summary:
This period the education, technical advisory and research development activities of Professor Eric Clayfield as Director of GMMRI, materially aided by GMMRI part-time administrative secretary Jane Wilkes, included the following:-

Obtained encouraging appreciation, from involved students and Georgia mineral industry contacts, of the added value imparted to the multidisciplinary Mineral Engineering Certificate Program by the inclusion of advanced geotechnology courses, GEOS 4600 and GEOS 6100, as core courses directed towards the specialized training requirements of modern mineral industry.

Continued the development of increased industrial interest in the present and potential relevance of GMMRI research activities and expertise, particularly the applicability to solid/liquid separation problem areas. Provided technical advisory assistance to a wide range of companies requesting guidance in mineral processing and required product development problems, primarily involving Georgia mineral operations; the major companies included Freeport Kaolin/Engelhard Corpn, J.M. Huber Corpn, Billiton Metals BV, Shell Mining Co. Initiated and directed exploratory experimental work in the GMMRI Mineral Processing Laboratory arising from such industrial interactions.

Co-ordinated, or directed, the development and appropriate reporting of fellowship research projects at Georgia Tech, funded by earned GMMRI awards:-

"Mineral Tailings: Dewatering/Consolidation Behavior of Crushed Stone Pond Screenings", Ms. Cynthia Hall, Civil Engineering, Master's work; this project on the geotechnical properties and resultant potential uses of such 'pond screenings' ultrafines has been successfully completed, with material co-operative assistance from Vulcan Materials Co, GA. A comprehensive report of this research has been now approved and published.

contd

(Attach additional sheets if necessary)

"Phase Equilibria in Baria-Lime-Corundum Systems", Mr. Raiford Hann, Ceramic Engineering, Ph.D. work; the second stage of this work, involving characterization of the heterogeneous phase equilibria in this ternary system which critically govern its applicational performance as a high-value cement, has been successfully completed, with final report publication to be effected shortly. An external paper on the first stage of his research has been accepted for publication in the J. Am. Ceramic Soc.

"Group Contribution Equation of State for Polar Fluids", Mr. Gus Georgetown, Chemical Engineering, Ph.D. work; following completion, and external presentation as a paper at the ACS National Meeting, of the first stage of this work, the second stage is progressing to the development of modified equation forms enabling better prediction of the physical properties of coal-derived fluids.

"Developments in Metallurgical Extraction of Complex Sulfide Ores", Mr. Peter Northcutt, Geophysical Sciences, Master's work; this critical evaluation of technology developments and economics analysis has been completed, with a comprehensive report of this research study approved and in the course of publication.

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1. Grant Recipient Georgia Institute of Technology Atlanta, GA 30332	Type of Report	Reporting Period	Grant Number:
	<input checked="" type="checkbox"/> Quarterly	<input type="checkbox"/> July 1-Sept. 30	G1154113
	<input type="checkbox"/> Final	<input checked="" type="checkbox"/> Oct. 1-Dec. 31	Date Report Prepared:
		<input type="checkbox"/> Jan. 1-March 31	4/3/86
		<input type="checkbox"/> April 1-June 30	

2. Grant Title:
 Allotment Grant for State Mining and Mineral Resources Institute

3. Principal Investigator:	Address:	Telephone No.
Professor Eric J. Clayfield	Georgia Mining & Mineral Resources Institute Georgia Institute of Technology Atlanta, GA 30332-0101	404 894-2893

4. Summary:

During this period the technical advisory, education and research development activities of Professor Eric Clayfield as Director of GMMRI, effectively aided by GMMRI part-time administrative secretary Jane Wilkes, included the following:-

Presented a two-day lecture/interactive case study course "Surface Science Concepts--Applicability to Solid/Liquid Separation Problems", involving critical mineral processing problem areas, at Westhollow Research Center, Shell Development Co. Houston.

Gave technical advisory assistance to a wide variety of companies requesting guidance in mineral processing and mineral product development problems, mainly involving Georgia mineral source operations. Initiated and directed exploratory experimental work in the GMMRI Mineral Processing Laboratory arising from such industrial interactions.

Directed or co-ordinated the development and appropriate reporting of the following fellowship research projects at Georgia Tech, funded by earned GMMRI awards with complementary industrial support:-

"Developments in Metallurgical Extraction of Complex Sulfide Ores", Mr. Peter Northcutt, Geophysical Sciences, Master's work; following completion, a comprehensive report of this critical evaluation research study published this Fall Quarter.

"Surfactant Effects on Comminution/Separation of Complex Sulfide Ores", Mr. Peter Northcutt, Geophysical Sciences, PhD work; initiated and directed this ultrafines-oriented research project.

contd.

"Enhanced Electro-osmotic Dewatering of Mineral Ultrafines", Ms. Christine Grant, Chemical Engineering, Master's work; direction of this project progressing satisfactorily, enabling planned emphasis on the innovative use of surfactant effects, with Interim Progress Report presented.

"Crystal Structure of Zirconia Composites", Mr. Raiford Hann, Ceramic Engineering, PhD work; this first-stage doctoral research published as a paper 'Monoclinic Crystal Structures of Zirconium Dioxide and Hafnium Dioxide by X-ray Powder Diffraction,' J. Am. Ceramic Soc., October 1985.

"High Temperature Phase Equilibria in Baria-Lime-Corundum Systems, Mr. Raiford Hann, Ceramic Engineering, second-stage PhD work; progressing satisfactorily, with planned presentation of the ternary phase diagram work at the national meeting of the American Ceramic Society.

"Group Contribution Equation of State for Polar Fluids", Mr. Gus Georgetown, Chemical Engineering, PhD work; this research aimed at better prediction of the physical properties of coal-derived fluids progressed to the second phase involving detailed examination of applicable mixing rules.

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	<input checked="" type="checkbox"/> Quarterly	<input type="checkbox"/> July 1-Sept. 30	G1154113
	<input type="checkbox"/> Final	<input type="checkbox"/> Oct. 1-Dec. 31	Date Report Prepared:
		<input checked="" type="checkbox"/> Jan. 1-March 31	4/7/86
		<input type="checkbox"/> April 1-June 30	

2. Grant Title:
Allotment Grant for State Mining and Mineral Resources Institute

3. Principal Investigator:	Address:	Telephone No.
Professor Eric J. Clayfield	Georgia Mining & Mineral Resources Institute Georgia Institute of Technology Atlanta, GA 30332-0101	404 894-2893

4. Summary:

During this reporting period the education and research development activities of Professor Eric Clayfield as Director of GMMRI, assisted by GMMRI part-time administrative secretary Jane Wilkes, included the following:-

Taught a new version of the Mineral Engineering Certificate core course MET 4116 (Separation Technology), which further emphasized surface-governed mechanisms of developing application in the required advanced technology for effective processing of mineral ultrafines material.

Gave technical advice to Georgia mineral companies requesting guidance in mineral processing and premium product development problems.

Directed or co-ordinated the development and progressive reporting of the following fellowship research projects at Georgia Tech, funded by earned GMMRI awards and complementary industrial support:-

"Enhanced Electro-osmotic Dewatering of Mineral Ultrafines", Ms. Christine Grant, Chemical Engineering, Master's work; initial paper on this research, 'An Innovative Approach to the Dewatering of Mineral Ultrafines', accepted for presentation at the National Organization of Black Chemists and Chemical Engineers Symposium, Atlanta, April 22-25, 1986, with subsequent publication in the symposium proceedings.

"Surfactant Effects on Comminution/Separation of Complex Sulfide Ores", Mr. Peter Northcutt, Geophysical Sciences, PhD work; this research project, initiated last quarter, is progressing well, with the state-of-the-art technology review and concurrent experimental work development effectively expedited by industry provision of process information and appropriate fine-grained ore material.

Continued

"Potential Health Effects from the Uranium Content in Georgia Phosphate Deposits", previous completed project; a paper on this research work-- 'Evaluation of potential radon exposure from development of Georgia phosphate deposits', by G.C. Eichholz, J.P. Ambrose and M.G. Skowroski, Nuclear Engineering and Health Physica, was published in Mining Engineering, Vol. 38, No. 3, 195, March 1986.

"High-Temperature Phase Equilibria in Baria-Lime-Corundum Systems", Mr. Raiford Hann, Ceramic Engineering, PhD work; progressing successfully, with a paper on recent research findings prepared for submission for publication in Acta Crystallographica.

"Group Contribution Equation of State for Polar Fluids", Mr. Gus Georgeton, Chemical Engineering, PhD work; initiated its third phase, involving the derivation of the mathematical forms to be used in the required equation of state development.

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1. Grant Recipient Georgia Institute of Technology Atlanta, GA 30332	Type of Report	Reporting Period	Grant Number:
	<input checked="" type="checkbox"/> Quarterly <input type="checkbox"/> Final	<input type="checkbox"/> July 1-Sept. 30 <input type="checkbox"/> Oct. 1-Dec. 31 <input type="checkbox"/> Jan. 1-March 31 <input checked="" type="checkbox"/> April 1-June 30	<u>G1154113</u> Date Report Prepared: <u>8/14/86</u>

2. Grant Title:
Allotment Grant for State Mining and Mineral Resources Institute

3. Principal Investigator: Professor Eric J. Clayfield	Address: Georgia Mining & Mineral Resources Institute Georgia Institute of Technology Atlanta, GA 30332-0101	Telephone No. <u>404 894-2893</u>
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4. Summary:

During this reporting period the education and research development activities of Professor Eric Clayfield as Director of GMMRI, effectively aided by GMMRI part-time administrative secretary Jane Wilkes, included the following:-

Continued the development of industrial awareness and interest in GMMRI research projects primarily aimed at solid/liquid separation problem areas. As such, gave a review presentation "GMMRI Mineral Engineering Research Developments" to Georgia mineral companies management, and technical advice to several such companies requesting guidance in mineral processing problems.

Participated in the First International Conference on Separations Science and Technology, New York, April 1986.

Organized and presided as Chairman the technical session on Solid-Liquid Separation Processes for Ultrafines Suspensions at the 60th Colloid and Surface Science Symposium, Atlanta, June 15-18, 1986. Co-author of two papers presented at this symposium:- "Electrostatic Enhancement of Liquid-Liquid Extractions", F. Watts, M.J. Matteson and E.J. Clayfield, Proc. 60th Coll. and Surf. Sci. Symp. Atlanta, 150, (1986), and "Electrokinetic Dewatering of Mineral Ultrafines", E.J. Clayfield and C.S. Grant, Proc. 60th Coll. and Surf. Sci. Symp. Atlanta, 76, (1986).

Directed or co-ordinated the on-going development and progressive reporting of the following fellowship research projects at Georgia Tech, funded by earned GMMRI awards and complementary industrial support:-

"Surfactant-Enhanced Electro-osmotic Dewatering of Mineral Ultrafines", Ms. Christine Grant, Chemical Engineering, Ph.D. work: this further project stage was initiated following successful completion with M.S. thesis publication May 1986 of

Continued

the initial research work. Ms. Grant presented a paper on this work, "An Innovative Approach to the Dewatering of Mineral Ultrafines", C.S. Grant and E.J. Clayfield, Proc. 13th Annual Meeting of National Organization of Black Chemists and Chemical Engineers, Atlanta, April 1986, and May 1986 received the prestigious Society of Women Engineers Outstanding Graduate Engineering Award. She also presented the paper on her research, referred to above, at the 60th Colloid and Surface Science Symposium.

"Surfactant Effects on Comminution/Separation of Complex Sulfide Ores", Mr. Peter Northcutt, Geophysical Sciences, Ph.D. work; this research project is progressing well, significantly aided by further industry provision of materials and complementary student support funding.

"Electrocapillary Enhancement of Liquid-Liquid Extractions", Mr. Frank Watts, Chemical Engineering, Ph.D. work; in its initial stage, with detailed thesis proposal approved, and a paper on the preliminary experimental work presented by Mr. Watts at the 60th Colloid and Surface Science Symposium, referred to above.

"Novel Silica-Based Ceramic Fibers for Composites", Ms. Theresa Long, Chemical Engineering, M.S. work; in its initial stage, essentially involving this quarter an appropriately extensive literature review and project planning development.

"Particle Deposition on Charged Collector Arrays", Mr. Dan Jacober, Chemical Engineering, Ph.D. work; experimental determinations of aerosol particle mixing and diffusivity characteristics progressing well, with initial results presented by Mr. Jacober as a paper at the 60th Colloid and Surface Science Symposium, referred to above.

"High-Temperature Phase Equilibria in Baria-Lime-Corundum Systems", Mr. Raiford Hann, Ceramic Engineering/Materials Engineering, Ph.D. work; progressing successfully into its final stages, with a paper on this research presented at the 88th Annual Meeting of the American Ceramic Society, May 1986.

"Group Contribution Equation of State for Polar Fluids", Mr. Gus Georgeton, Chemical Engineering, Ph.D. work; entering the final phase, involving detailed evaluation of experimental data to define constants for the developed equation of state enabling prediction of physical properties of polar fluids, such as coal-derived liquids.

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**REPORT OF FUNDED
SCHOLARSHIPS AND FELLOWSHIPS**

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Name of Institute	Georgia Mining and Mineral Resources Institute	Grant Number: <u>G1154113</u>
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Reporting period: October 1—March 31 April 1—September 30

DEGREE FIELDS	ACADEMIC LEVELS					
	Undergraduate		Graduate		Post-Doctoral	
	No. of Recipients	Total Amount	No. of Recipients	Total Amount	No. of Recipients	Total Amount
1. Mining Engineering						
2. Extractive Metallurgy						
3. Ceramic (Process) Engineering						
4. Mineral Processing						
5. Petroleum & N.G. Eng.						
6. Mineral Economics						
7. Fuel Science						
8. Please List Other Fields						
9. Total receiving support this reporting period.						
10. Total scholarships and fellowships awarded to date from this Grant.			4	30,277		

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PERFORMANCE REPORT

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1. Grant Recipient	Type of Report	Reporting Period	Grant Number:
Georgia Institute of Technology Atlanta, GA 30332-0101	<input type="checkbox"/> Quarterly <input checked="" type="checkbox"/> Final	<input type="checkbox"/> July 1-Sept. 30 <input type="checkbox"/> Oct. 1-Dec. 31 <input type="checkbox"/> Jan. 1-March 31 <input type="checkbox"/> April 1-June 30	G 1154113 Date Report Prepared: 9/29/86

2. Grant Title:
Allotment Grant for State Mining and Mineral

3. Principal Investigator:	Address:	Telephone No.
<u>Professor Eric J. Clayfield</u>	<u>Georgia Mining & Mineral Resources Institute</u> <u>Georgia Institute of Technology</u> Atlanta, GA 30332-0101	<u>404/894-2893</u>

4. Summary:
See attached.

THE GEORGIA MINING AND MINERAL RESOURCES INSTITUTE
GEORGIA INSTITUTE OF TECHNOLOGY

FINAL AND ANNUAL STATUS REPORT 1985/1986
Grant No. G 1154113

Eric J. Clayfield, Director, GMMRI
Professor, Chemical Engineering
Chairman, Multidisciplinary
Mineral Engineering Program

ORGANIZATION

The Georgia Mining and Mineral Resources Institute (GMMRI) is an integral part of the College of Engineering at Georgia Tech. Designated by the U.S. Department of the Interior, Office of Surface Mining, it was activated April 1980 when OSM funding became available, at an allocation rate of \$150,000 per year plus required matching funding. In 1982 administration of the developing GMMRI program was transferred from the Office of Surface Mining to the Bureau of Mines.

The Board of Directors of GMMRI, the external advisory board, consists of mineral industry representatives of whom

- (a) three are appointed by the Georgia Mining Association, three by the President of Georgia Tech; these six members serve on a staggered rotational basis,
- and (b) two serve as permanent members--the Executive Vice President of the Georgia Mining Association and the Executive Secretary of the Georgia Crushed Stone Association.

Ex-officio members involved are one representative each from the Georgia Geological Survey, the University of Georgia, the U.S. Bureau of Mines, and Georgia Institute of Technology.

An internal guidance committee consists of one representative each from the following degree program at Georgia Tech--Ceramic Engineering, Chemical Engineering, Civil Engineering, Geophysical Sciences, Metallurgy and Nuclear Engineering, plus a minority representative.

ACTIVITIES 1985/1986

Education Program

The multidisciplinary scope and expertise resources, at Georgia Institute of Technology, of the mineral engineering education program effectively enables the selective emphasis of appropriate technology development areas in the course study program; for example, mining for civil engineers, mineral processing for chemical engineers, mining and processing of non-metallic minerals for ceramic engineers, extractive/chemical metallurgy for metallurgists, and exploration for geophysical scientists. A student in the Schools of Civil Engineering, Chemical Engineering and Ceramic Engineering may obtain a Mineral Engineering Certificate at the bachelor's, master's, or doctoral level; in Metallurgy and Geophysical Sciences a certificate may be obtained at the master's or doctoral level. Each certificate is in addition to a degree in a particular discipline. Certificate requirements include a minimum total of 18 hours in mineral engineering approved courses which must include core courses in mining and mineralogy, mineral processing, and extractive metallurgy. At the graduate level, research for a degree must be in an appropriately relevant area of mineral engineering, and a minimum grade of "B" is required of all courses counting toward the certificate. A student must also meet all degree requirements of the School's degree programs where he is enrolled. Appropriate GMERI scholarships and/or

graduate fellowships are awarded to particularly well-qualified students.

In 1985/86, activity of this mineral engineering education program at Georgia Tech was progressively maintained with further encouraging appreciation obtained, from student evaluations and Georgia mineral industry contacts, of the added value imparted to the multidisciplinary Mineral Engineering Certificate Program by the inclusion of advanced geotechnology core courses, and by the further development of the separation technology core course which emphasized interfacial concepts of growing importance and application in the required innovative development of improved technology for effective ultrafines processing. Realistically commensurate with industry needs, high quality students, of "3.5 plus" grade level have been attracted to this interdisciplinary study area to gain approved mineral engineering certification.

The Mineral Engineering Certificate Program is not ABET-evaluated as such, but comprises Georgia Tech engineering schools courses satisfying ABET requirements in their evaluation and accreditation of these schools' degree program. For example, in the Fall Quarter 1985 the Certificate core courses MET 4114 (mining), MET 4116 (mineral separation), MET 4411 (extractive metallurgy) were evaluated in the ABET report on the ChE Program, resulting in re-accreditation for three years.

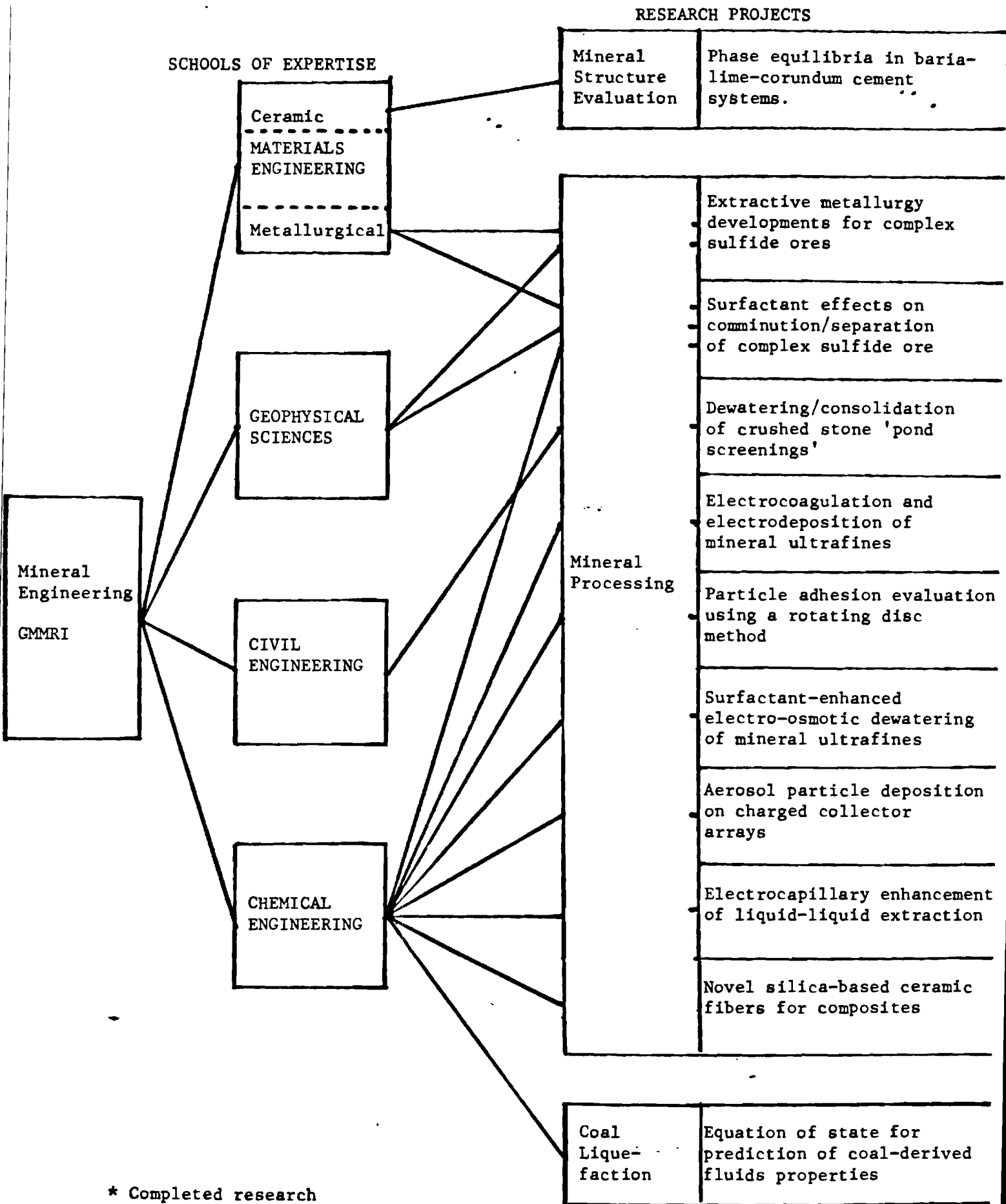
An educational activity, in a wider informatory sense, was the appreciable, and appreciated, number of invited presentations

(12) given on GMMRI research developments and student training opportunities, at local state, national and international meetings and symposia.

Research Program

The expeditious establishment of a substantial GMMRI research program, involving a wide range to mining and mineral technology problem areas of specific concern of Georgia mineral industries operations, was achieved by making appropriate use of the extensive multidisciplinary expertise and facilities existing throughout the College of Engineering at Georgia Tech. Subsequent program development places a particular emphasis on applying and exploiting our acquired capability strengths in the area of mineral processing R&D as exemplified in the attached program chart.

This selective focussing of our research activities is appropriately based on demonstrated expertise in the innovative application of surface science concepts to critical S/L separation processes involving ultrafines material. Research in this problem area is of major importance to our mineral industries in view of the growing need to develop cost-effective processes for dealing with the finer particle-size material inevitably involved as domestic ore grade decreases, and for premium ultrafine products developments in Georgia kaolin and industrial minerals operations. This GMMRI program is



* Completed research

stimulating new industry interest in co-operative research involvements, with complementary support including research students funding assistance and new equipment donation.

Outline summaries of research projects in this program, directed or coordinated by GMMRI and supported by GMMRI fellowship, state and industrial funding, are as follows:

MINERAL STRUCTURE EVALUATION

"Phase Equilibria in Baria-Lime-Corundum Cement Systems"

This work, essentially involving characterization of the high-temperature phase equilibria in this ternary system which critically govern its applicational performance as a premium-value cement, progressed well into its final stages. A phase diagram for the high-baria region of the $BaO-CaO-Al_2O_3$ system was constructed that contained the location of four invariant points. Crystallization paths and primary phase fields were also identified. Two vertical sections representing isoplethal planes of 25 and 33 mole percent corundum with variable Ba/Ca ratios were constructed from the solidus and liquidus data. These sections describe the solid-liquid equilibrium relationships along those isoplethal planes.

The crystal systems for the high and low temperature forms of the $Ba_4Al_2O_7-CaO$ solid solutions were identified for the first time and the nature of the polymorphic inversion was determined. The results of the above mentioned work were presented at the 88th annual meeting of the American Ceramic Society on May 8,

1986, with a paper in press to the Journal of the American Ceramic Society. A manuscript on the BaO-Al₂O₃ binary system, to be submitted to this journal, contains new information on the crystallography of the compound Ba₃Al₂O₆ and its CaO solid solutions, and a section describing a novel method for determining the melting point of pure BaO.

PhD work, Mr. Raiford Hann, Ceramic Engineering.

MINERAL PROCESSING

"Developments in Metallurgical Extraction of Complex Sulfide Ores"

Complex sulfides are now being recognized as a major source for non-ferrous base metals, i.e., copper, lead, zinc, nickel, cobalt and their associated trace metals (an economically significant amount of precious metals is known to be associated with most deposits of complex sulfides). Such polymetallic mineral deposits are readily found worldwide, but often the fine dissemination of the ore minerals presents many difficulties in the production of high grade concentrates and in the separation of the metal value(s) at high recoverable rates. In the past few years, there has been much research and development in the chemistry and extractive metallurgy involving the treatment of complex sulfide ores. This research exploits the thermal and chemical mechanisms which are characteristic of complex sulfides and has developed into treatment methods proposed, piloted, and, in a few cases, used commercially. Thus despite the current

economic and environmental legislation difficulties faced by the non-ferrous metallurgical industry, new and emerging technologies for the recovery of the metal value(s) contained in complex sulfides are beginning to develop at a greater pace. This growth has resulted in many complexities in the field of extractive metallurgy, which must adapt principles and techniques from the fields of chemical engineering, chemistry, geology, computer science, and many other allied areas in order to achieve the effectiveness and efficiency that the industry requires. With emerging technology stressed, and with an emphasis on polymetallic smelting processes, this completed work study critically reviews such metallurgical extraction technology--essentially a desk-top research study but realistically augmented by operational site visits with industry co-operation.

MS work, Mr. Peter Northcutt, Geophysical Sciences. Completed August 1985.

"Mineral Tailings: Dewatering/Consolidation Behavior Of Crushed Stone Pond Screenings"

To process stone to the correct gradations, crushed aggregate producers crush, sieve, and wash rock excavated from quarries. The crushing and sieving processes produce not only the desired size of crushed stone, but also undesirable fine material. To remove this fine material, the crushed aggregate producers wash the crushed stone. The wash water then carries the ultrafines away to a settling pond. Periodically these

producers dredge up the settled fine material, termed "pond screenings," and stockpile it next to the pond. With Georgia producing over 38 million tons of crushed stone each year, their crushed aggregate producers generate about 2 million tons or more of pond screenings each year. Due to their high water content and fluidity, they are difficult to handle and currently present an appreciable "waste disposal" problem. Potentially, with suitable characterization and control of their properties, they could form a marketable product.

This work evaluated the relevant geotechnical properties of pond screenings, with respect to disposal problems and possible usage; in particular, it evaluates the gradation, dry density-water content relationship, dewatering/consolidation characteristics, and pull-out capacity of such screenings material. It involved essential co-operation from a major Georgia crushed stone producer, Vulcan Materials CO. The conclusions from this lab-scale evaluation were that pond screenings could well make an adequate fill, embankment, or retaining wall backfill material. Recommendations detailed for satisfactory applications of pond screenings involve monitoring criteria, together with the need for additional evaluations including pull-out tests with different reinforcing material and testing of screenings and mixed with sand, lime-fly ash and cement.

MS work, Ms. Cynthia Hall, Civil Engineering, Completed September 1985.

"Particle Adhesion Evaluation Using a Rotating Disc Method"

A fundamental understanding, and effective control of particle adhesion behavior is required for premium ultrafine products developments in surface coatings and pigments applications. This requires a quantitative evaluation of particle adhesion behavior which should preferably involve a system in which the transport of material in a fluid to a surface is known, to enable a direct fundamental study of the effect of dispersants on the adhesion of fine particles arriving at a surface. Such an experimental approach can be developed on the basis of the mass transport theory which has been widely and successfully applied, in the form of the rotating disc method, for the study of electrode processes involving the transport and reaction behavior of ions. This research work demonstrates the development and application of the rotating disc system to characterize the transport and adhesion of colloidal particles to the disc surface. Comparisons of experimental particle adhesion results with that predicted by the theoretical convective diffusion treatments developed for surfactant-free colloidal systems show excellent agreement, providing encouraging support for the validity of this rotating disc approach for an absolute evaluation of particle adhesion behavior.

Completed research, E. J. Clayfield, scientific paper July 1986.

"Surfactant Effects on Comminution/Separation of Complex Sulfide Ore"

A resultant development of the "complex sulfides" MS research completed August 1985, this PhD work is exploring the development and practical application of particular surface science concepts to improve the generation and preferential separation of mineral ultrafines. Specifically, the objective is to evaluate a multipurpose surfactant approach for enhancing the processes of grinding-flotation-leaching of fine-grained complex sulfides, in terms of improved overall recovery and cost-effectiveness. The material is a sulfide ore supplied by Brunswick Mining and Smelting, as representative rod-mill feed, and also flotation feed. An information study report on the mineralogical history and present on-site process design for this ore has been developed, together with an updated literature search on the use of surfactant additives in appropriate mineral processing developments. Preliminary ore characterization testing, including evaluation of grain size, grain boundary nature, particle size, has been carried out. An integrated, continuous-processing unit system has been developed, using established commercial techniques, to enable realistic wet-grinding/size separation/flotation/leaching process evaluation of the conceptual surfactant effects.

PhD work, Mr. Peter Northcutt, Geophysical Sciences

"Surfactant-Enhanced Electro-osmotic Dewatering of Mineral Ultrafines"

The effective dewatering of ultrafines suspensions is of particular and growing importance in mineral processing. With the finer particle-size material inevitably involved as ore grade decreases, the resultant reduction in hydraulic permeability critically limits effective application of conventional dewatering by differential pressure filtration methods. In principle, electrokinetic flow is relatively insensitive to particle size and consequent pore size of packed particle bed. As such, the application of electro-osmosis to improve the dewatering performance of conventional filtration methods for ultrafines is an attractive concept, provided an electro-osmotic effect can be generated and developed to offer a sufficiently cost-effective process. This work investigates such an application of electro-osmotic effects to enhance the dewatering performance of vacuum filtration of iron oxide ultrafines (ochre), with particular emphasis on the use of ionic surfactant adsorption to achieve electro-osmotic flow and the development of a theoretical model treatment of the experimental results obtained. The promising results and process efficiency of this further dewatering work were comprehensively reported May 1986, C. S. Grant, ChE, MS Thesis Report; the concept is being further developed, as PhD project work, to optimize ionogenic surfactant type effect and concentration.

Ms. Christine Grant presented a paper on this work at the National Organization of Black Chemists and Chemical Engineers Symposium, April 1986, with subsequent publication, and May 1986 received the prestigious Society of Women Engineers Outstanding Graduate Engineering Award. She also presented a paper on her research at the 60th Colloid and Surface Science Symposium, June 1986.

MS/PhD work, Ms. Christine Grant, Chemical Engineering.

"Aerosol Particle Deposition on Charged Collector Arrays"

A fundamental study of such ultrafines deposition behavior is of considerable applicational importance, in terms of atmospheric pollution problems from mineral industries operations requiring optimum, cost-effective solutions. In this research work, experimental studies of the removal of entrained aerosol particles from turbulent air streams by a spherical collector have indicated the presence of an area along the wake edge which is concentrated in particles. Dispersion of this concentration wake is important in determining optimum spatial arrangement of spherical collectors for maximum removal of particulates with a minimum number of collectors and a minimum pressure drop across the collection volume. This study has evaluated the characteristics of particle mixing downstream from a sphere based on axial and radial aerosol concentrations. The effects of particle size and free stream velocity variations are considered over a range

of free stream Reynolds Numbers from 2000 - 12000 and Stokes Numbers from 0.001 to 1.5. Mr. Jacober presented a paper on this research at the 60th Colloid and Surface Science Symposium, June 1986.

PhD work, Mr. Dan Jacober, Chemical Engineering.

"Novel Silica-based Ceramic Coated Fibers for Composites"

Initiated this year, this work aims to evaluate the feasibility of producing carbon hybrid fibers involving siloxane coating concepts, potentially applicable as premium performance, premium value "mineral-based" reinforcing agent products for polymer composite systems. Following an extensive literature survey, the resulting experimental program has involved coating carbon fibers with various starting concentrations of tetraethoxysilane (TEOS) and heat-treating the coated fibers. Viscosity measurements of the TEOS solutions have been obtained as a function of time. A number of the coated fibers have been examined with a scanning electron microscope and a qualitative element analysis was performed to determine if silica was present on the fiber surface. Coated fibers from another source have been subjected to single filament testing to determine elongation and modulus. Ms. Theresa Long presented a literature review on sol-gel technology of metal alkoxides to graduate students at Georgia Tech.

MS work, Ms. Theresa Long, Chemical Engineering

"Equation of State for Prediction of Coal-Derived Fluids Properties"

Coal-derived fluids contain a large number of different polarity compounds, and as such accurate prediction of the physical properties of these fluids presents a difficult problem. This research work aims to develop and implement a technique for modeling such complex fluid mixtures, and predict their important physical properties, involving the formulation and application of cubic equations of state. It has completed the first two phases of the required development of a Group Contribution Equation Of State. The first phase involved the evaluation of the Patel-Teja (PT) equation in systems containing polar components. The PT equation led to good results and could thus be extended with confidence to complex systems, including coal derived chemicals. These results, which were presented at the American Chemical Society Spring 1985 Meeting, were also published as "Applications of Cubic Equations of State to Polar Fluids and Fluid Mixtures" in the ACS Symposium Series No. 300

The second stage of the work involved the evaluation of mixing rules for the PT equation in order to gain an understanding of how components would behave in a fluid mixture. Mr. Georgeton is now involved in the final stages of his work. Incorporating the PT equation, he has derived an equation of state based on the idea of group contributions, with experimental data being regressed to obtain equation constants,

and enable the prediction of physical properties of complex fluids.

PhD work, Mr. Gus Georgeton, Chemical Engineering.

A listing of GMMRI Research Publications 1985/1986 is as follows:-

Reports

"Developments in Metallurgical Extraction of Complex Sulfide Ores", P.C.

Northcutt, M.S. Thesis Report, GeoS, August 1985.

"Mineral Tailings: Dewatering/Consolidation Behavior of Crushed Stone Pond Screenings", C. Hall, M.S. Special Research Problem Report, CE, September 1985.

"Electro-osmotic Dewatering of Mineral Ultrafines", C.S. Grant, M.S. Thesis Report, ChE, May 1986.

"Shear Strength of Rock Discontinuities in Georgia", R.D. Barksdale and N. Syriopoulos, CE, Report SCEGIT-121, October 1985.

"Micro-Computer Solutions for Rock Slope Stability", R.D. Barksdale and J.N. Gomez, CE, Report SCEGIT-118, December 1985.

Scientific Papers

"Monoclinic Crystal Structures of Zirconia Composites", J. Pentecost, R.E. Hann and P. Switch, J. Am. Ceram. Soc., October 1985.

"High Temperature Phase Equilibria in Baria-Lime-Corundum Systems", R.E. Hann, Proc. 88th Annual Meeting American Ceramic Soc., May 1986.

"Electrocoagulation and Electrodeposition of Mineral Ultrafines using Rotating Disc Concept", E.J. Clayfield, Proc. 5th International Conference on Surface and Colloid Science, Clarkson University, Potsdam, New York, 475, (1985).

"An Innovative Approach to the Dewatering of Mineral Ultrafines", C.S. Grant and E.J. Clayfield, Proc. 13th Annual Meeting of National Organization of Black Chemists and Chemical Engineers, Atlanta, April 1986.

"Electrokinetic Dewatering of Mineral Ultrafines", E.J. Clayfield and C.S. Grant, Proc. 60th Colloid and Surface Science Symposium, Atlanta, 76, (1986).

"Particle Adhesion Evaluation Using a Rotating Disc Method", E.J. Clayfield, Proc. International Symposium on Particles on Surfaces: Detection, Adhesion and Removal, Fine Particle Soc., San Francisco, 19, (1986).

"Particle Mixing in Turbulent Wake of Spheres", D.E. Jacober and M.J. Matteson, Proc. 60th Colloid and Surface Science Symposium, Atlanta, 193, (1986).

"Electrostatic Enhancement of Liquid-Liquid Extractions", F. Watts, M.J. Matteson and E.J. Clayfield, Proc. 60th Colloid and Surface Science Symposium, Atlanta, 150, (1986).

"Applications of Cubic Equations of State to Polar Fluids and Fluid Mixtures", ACS Symposium Series, No. 300, (1986).

"Evaluation of Potential Radon Exposure from Development of Georgia Phosphate Deposits", G.C. Eichholz, J.P. Ambrose and M.G. Skowroski, Mining Engineering, 33, 195, (March 1986).

In addition, recent Patents from previous mineral processing-related research were:-

"Multiple Emulsions for Mineral Fines Upgrading", Appln. No. K.6310 GBR, E.J. Clayfield.

"Process and Apparatus for the Removal of Oil from an Oil-in-Water Dispersion, and Process for the Manufacture of a Solid Material Suitable for said Process", Appln. No. K.6212 U.S., E.J. Clayfield.

"Method for Separating Coal Particles from an Aqueous Slurry", Appln. No. 8322626, K.6198 GBR, R.J. Clayfield.