BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Domestic Aluminum Resources: Dilemmas Of Development

Volume II, Appendixes II-VII--Detailed Agency Comments And GAO Response

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PREFACE

This is volume II of the report, which includes the comments from Federal agencies, aluminum companies, and academic advisers for the technical appendix contained in volume I, together with our response to the agency comments. The comments, as well as the report, concern major policy questions about U.S. resource development and industrial policy. The comments are frequently long and reflect a great deal of informed, deliberate thought. They also illustrate how technical data are influenced by subjective judgment and particular organizational perspective.

A great many people from industry, Government, and academia have been involved in development and review of this report. They did not all reach the same conclusions or share all our judgments. The reasoning process was frequently different for almost every participant.

This second volume illustrates that abstracted technical judgments may mask other considerations; that there is not one potential solution but numerous ones, depending on the definition of the research objective; and that the research objective for the miniplant program was changed to develop a nonbauxitic alumina technology rather than a process information matrix.

The way in which the Bureau of Mines program evolved--emphasizing nonproprietary processes, developing an economically noncompetitive process, and focusing research on alumina rather than aluminum--actually has retarded achieving increased future primary aluminum capacity in this country through the use of domestic resources. For these reasons, and because inertia--more than anything else, in the absence of a counterforce--is likely to determine the future of the Bureau's miniplant program, we believe the material in this second volume should be part of the public record.

A general and perhaps tenuous consensus does seem to emerge on two points of difference with our draft report in these comments. The first is that we were "unfair" to the Bureau of Mines in applying a commercial criterion to the miniplant program. The second is that nonbauxitic alumina development is important for the U.S., irrespective of where new primary aluminum capacity is located.

With respect to the latter, we persist in our view that domestic nonbauxitic aluminum resources can be developed only if they can be used in some energy and capital conserving way to make competitively priced aluminum; that competitively

priced new aluminum capacity is not likely to be created from nonbauxitic alumina as an intermediate product; and that the initiative for altering industry's passive response to other governments' economic development efforts and market tempering lies with Government, not industry.

As far as fairness goes, our perception of the Bureau of Mines program was shaped by its potential for increasing major public expenditures on the one hand, and by its seemingly lost sense of strategic significance and economic opportunity for developing new primary aluminum capacity using an indigenous, nonbauxitic resources on the other. If this is "unfair," our unfairness is rooted in these twin perceptions of a pointless program and squandered potential.

Our program review developed information on seven different issue areas. As our scoping comments in chapter 1 (vol. 1) indicate, it was an extensive review conducted on a relatively small program. But the review was designed to assess program management and research responsiveness to wide-ranging major policy issues.

DEPARTMENT OF INTERIOR

The facts of the Bureau's program management are undisputed by the Department of Interior. Some minor changes of technical details were made in this report in response to detailed Bureau criticisms contained in appendix III, but the facts alone, apart from any technical judgments about processes and resource potential, merit a conclusion of administrative misdirection.

Although the Department of Interior's comments took strong exception to the report, as evidenced in appendix II, the issues Interior raised are matters of conclusion and interpretation rather than matters of fact. We have responded in some detail, generally trying to present the facts that prompted our interpretation or conclusion, or to refute allegations expressed by the Department. In one case, concerning the relationship between the Bureau and Toth Aluminum Company, the allegations and response are extraneous to volume I but provide further insights of potentially significant informal understandings between Government and industry, shaping research and development efforts.

BUREAU OF MINES

In addition to its letter, the Department of Interior provided us with a Bureau of Mines document entitled: "Bureau of Mines Review of GAO Draft Report, Domestic Alumina

Resources: Dilemmas of Development." Because of its length, we present only the table of contents and the Bureau's summary in appendix III, together with our response to Section D entitled, "Errors of Fact in GAO Report."

The reader should note that in its specific "errors or clarifications" the Bureau does not present facts to contest any of the five salient themes central to our interpretation of the major points at issue: the concentration on nonbauxitic alumina rather than aluminum development; the failure to consider proprietary processes or other nonproprietary ones; the future economic environment of aluminum production and location; the relative economics of one proprietary and six nonproprietary processes, compared to those of Bayer bauxite alumina; and, the need for review of other policy measures and further nonbauxitic aluminum research before building a pilot plant.

Role and competency issues

The Department of Interior also raised a competency issue regarding the authors of the technical appendix to volume 1, and the advisers who reviewed it. The Bureau's detailed comments supporting this contention, taken from Section I of the previously cited Bureau document, and our response suggesting anomalies in the Bureau's position, are presented in appendix VI, along with the letters of advisers who reviewed the appendix and offered written comments.

OFFICE OF SCIENCE AND TECHNOLOGY POLICY

The Office of Science and Technology Policy (OSTP) is assigned a potentially decisive role in our recommendations for coordinating alumina and aluminum research in the Departments of Energy and Interior. It is a role which the Office does not appear eager to accept. The Office believed the proper time for it to consider the issues raised by our report is during the budget cycle review of the Bureau's program. Its response is considered in appendix IV.

We disagree. It seems unlikely that a subject so influenced by differing judgments about the proper research approach, so involved with differing departmental policies regarding proprietary and nonproprietary research support, and so dependent on an integral understanding of the aluminum industry's role in the economy, can be adequately addressed in a portion of a bureau-level budget review. Our report points to the need for a basic definition of research objectives and their relationship to Federal policies and resulting departmental programs.

DEPARTMENT OF ENERGY

The Department of Energy's comments are contained in appendix V of this volume. The Department did not comment on either the substantive material or the recommendations of our report, even though the Department's sponsorship of proprietary aluminum research was contrasted to the Bureau of Mines' nonproprietary alumina research in our report.

There are major unjoined issues between the two departmental approaches both as to substance and policy. There may also be a coordination problem integrating nonproprietary alumina and proprietary aluminum research findings in a materials research and development program.

ALUMINUM INDUSTRY

Finally, the comments of five aluminum companies who reviewed the draft report are presented without our response in appendix VII. These comments represent the most valuable and instructive criticism the report received. The comments deserve notice both as to their tenor and their technical judgments. They make a substantial contribution to the public record of nonbauxitic alumina research and development. They are also suggestive of the origins of the Bureau's dilemma.

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APPENDIX

I "An Analysis of the Competitive Position of Alternative Processes for Converting Domestic Aluminum Bearing Resources to Alumina," Joel P. Clark and George B. Kenney, Massachusetts Institute of Technology 82

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ABBREVIATIONS

DOE	Department of Energy
GAO	General Accounting Office
EPA	Environmental Protection Agency
IBA	International Bauxite Association
NMAB	National Materials Advisory Board
OMB	Office of Management and Budget
OPEC	Organization of Petroleum Exporting Countries
OSTP	Office of Science and Technology Policy

APPENDIX II

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

Mr. J. Dexter Peach
Director, Energy and
Minerals Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to comment on the GAO draft report, "Domestic Alumina Resources: Dilemmas of Development," (008250), EMD-79-66.

The bulk of the comments we have to provide are attached to this letter as "Bureau of Mines Review of GAO Draft Report, Domestic Alumina Resources: Dilemmas of Development. Summary and Supporting Materials."

The Department of the Interior is quite disturbed by two facets of this report:

1. The report second-guesses policy that was recommended by agencies other than the Bureau of Mines, yet the Bureau is singled out for all of GAO's criticism. In addition, GAO presents a position of advocacy for a single proprietary technology, and we feel strongly that this approach is misdirected.

2. Mr. A.A. Shantz of the GAO is scheduled to present a paper at the forthcoming National Meeting of the American Institute of Chemical Engineers in which he will repeat the criticism stated in the GAO draft report. The Chairman of the Session is J. Szekely -- a member of the Alumina Technical Advisory Board empaneled by GAO to review a report used by them to support their position. We feel very strongly that technical society meetings are not a proper forum for the airing of potentially damaging criticism of one Government agency against another -- and certainly not before review of the draft report is finished. This action can only add support to the opinions of those who believe that the Government lacks cohesiveness and is working at cross-purposes.

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The GAO says that the Bureau's program of nonbauxitic alumina research is fundamentally misdirected. The first reason given for this statement is that the program attempts to produce alumina as an immediate product from nonbauxitic ores and that there is little evidence that such alumina is likely to be competitive with conventional nonbauxitic alumina. The Bureau's objective for our program is to see that there is technology for producing alumina from abundant domestic resources such as clay and anorthosite. We hope that the best technology will be competitive with the conventional Bayer/bauxite route, but strategic and national interest considerations have overshadowed economic ones except as the guide toward the least expensive technology.

The GAO report also says that the second factor in the misdirection of the Bureau's alumina research program is that we have ignored radical technology to make aluminum without first making alumina. The Bureau of Mines has conducted research on a number of such approaches to make aluminum without making alumina first. However, this part of the program is and has been separate from the miniplant project. The approach pursued by the Bureau in its miniplant project was recommended by the National Materials Advisory Board, accelerated by the Secretary of the Interior, and accepted by the alumina-consuming industries. Its objective was to test and develop the most promising technologies on a small scale for recovering alumina from domestic resources. These were technologies for which enough was known, based on prior research, to have confidence that larger-scale testing would be warranted. The miniplant project has always featured all new improvements and approaches developed by industries and Government for recovering alumina from clay, anorthosite, and other raw materials. These improvements and approaches were to be tested and evaluated in order to obtain enough information to form a sound judgment regarding the best processes. Research on smelting and chlorination approaches to produce aluminum was not part of the program. It is worth noting that the GAO criticizes the Bureau for not working on the clay/carbo-chlorination process, and then admits (p. 75) that "...the clay/carbo-chlorination process requires a great deal more development before it can be considered a prime candidate for a large-scale pilot plant."

The final factor contributing to the fundamental misdirection of the Bureau's program according to GAO, is that the Bureau's program ignores proprietary processes. There is a fundamental problem--far more serious in the eyes of the industrial sector than in the Department of the Interior's--based on the present Departmental patent policy for new technology developed in a cooperative effort between industry and Government. Any patents that result are usually assigned to the Secretary of the Interior and would become available for licensing without royalty. Further, pre-existing or background patents concerning the technology come under the jurisdiction of the Secretary when the cooperative work begins. In essence the Secretary may be called upon to determine the royalties that can be collected on the background patents that were the

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basis of the cooperative technological effort. These rules are often the deciding factor in keeping industrial firms out of cooperative efforts with the Bureau of Mines. Further, the GAO should certainly be aware that agencies such as the Bureau of Mines cannot spend Government funds to develop privately-owned processes. Equally important, the Bureau has an obligation to make public results of all its investigations. This fact, too, militates against proprietary interests.

The GAO report has a number of errors of fact. For instance, GAO reports (pp.22-23) that aluminum constituted the most significant commodity in the Bureau's Metallurgical research program and that it averaged 55 percent of the expenditures over 5 years. This is a gross error. Alumina and aluminum research accounted for about 5 percent of the research program. Other errors are cited in the enclosed summary review and supporting materials.

The GAO report includes a section on definitions. These are scientifically inaccurate and specifically biased toward the conclusions that GAO drew. A complete analysis of the definitions is enclosed with our review of the report.

We feel the GAO report is unwarrantedly biased and unduly optimistic about the Toth alumina or clay/carbo-chlorination process. Further, GAO appears to have ignored cautionary comments in the "Summary and Conclusions" section of the report to GAO by Clark and Kenney of MIT. The Bureau of Mines has done a significant amount of research in the chlorination area and has had contact with the Toth firm for more than 10 years. A report on this background and a thorough analysis of the Pullman Kellogg report is included in our enclosed materials. (We appreciate GAO lending us for our review of the draft report the confidential Pullman Kellogg material that Clark and Kenney used.) It is of interest to note that as late as 1976 the process in question was called the Toth Aluminum Process. It was not until 1977 that it was called the Toth Alumina Process. It should also interest you to note that early in the miniplant project Toth was invited by the Bureau of Mines and by some of the cooperators to join the venture, and that almost 10 years ago, the Bureau was prepared to enter into an agreement with Toth to test key aspects of his process.

GAO empaneled an Alumina Technical Advisory Board to review the Clark-Kenney MIT report. This Board is almost exclusively made up from the academic world. Further, it appears that none of the members of this Board has experience in the extractive metallurgy of either alumina and aluminum or chlorination technology which is directly related to the emphasis of the GAO report.

GAO cites low cost estimates by the Bureau of Mines and suggests they represent substantial ignorance. There have been significant past reviews of the Bureau's cost estimation techniques and of the cost estimates produced. There has never before been a question that they

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did not serve the purpose for which they were made. In suggesting substantial ignorance GAO cites an example of a $60-million cost estimate for a major pilot plant and its operation and noted that the data were compiled in May 1977. GAO assumes that the same costs would be closer to $100 million today because of inflation. With this we agree, but the effects of inflation on estimates should hardly call for the term "substantial ignorance."

GAO reports that the miniplant program is centered on a single process--clay/hydrochloric acid-gas precipitation. The Bureau of Mines has not retreated from the idea of completing its technology matrix on the applicability of various processes to domestic resources. At the hearings on the Bureau of Mines appropriations for fiscal year 1979 before the Subcommittee on the Department of the Interior and Related Agencies of the Committee on Appropriations of the House of Representatives (March 16, 1978; printed in Part IV, pp. 936-940), the Acting Director of the Bureau of Mines covered the matrix approach of the alumina research. This approach was confirmed by the Assistant Director--Metallurgy at the 1980 hearings before the same Subcommittee (March 7, 1979; printed in Part III, pp. 1018-1030). As was noted in the Bureau's fiscal year 1980 budget justifications, "The Bureau will continue to evaluate technologies to recover alumina from domestic mineral resources. Private companies are participating in this evaluation by sharing the research costs involved with the operation of the Bureau's alumina miniplant project." This year the four private companies have renewed their participation and a new one, Billiton International Metals, will soon join. At the suggestion of the cooperators only the key or troublesome operations of the various processes will be studied in detail. The current emphasis of the miniplant on the HCl approach reported by GAO is consonant with the advice of the industrial cooperators and our own judgment. $1 million will have been spent shortly for the non-site-specific design of a 25-ton-per-day alumina pilot plant. Current miniplant studies will confirm the accuracy of that design and assure that it could be operated effectively if a decision were ever made to build it. However, even if it were not built, the design plus miniplant data will assure a complete technology package. Testing of each process technology on a continuous basis in the miniplant has been judged unsound with respect to the results that could be expected. Miniplant support research, for instance on the clay/sulfurous acid process on the bench-scale proved that it was not technically feasible to carry the work further. The steering committee concurred with this decision. Work on dawsonite is planned and in fact 100 tons of dawsonitic oil shale have been obtained recently from the Bureau's experimental shaft in the Piceance Basin of Colorado. Work on anorthosite and alunite has also been done concurrent with the miniplant program.

With regard to GAO's recommendations, we have no problem with "Matters for Consideration by the Congress."

With regard to "Recommendations to Secretary of the Interior," under Recommendation No. 1, we question the availability of proprietary data because the results will have to be made known to the public.

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Recommendation No. 2 is being taken care of partially by the Alumina Miniplant Technical Audit Committee that assesses the technological adequacy of the data from the miniplant operations as well as that used by Kaiser Engineers.

On Recommendation No. 3, we think the alumina portion of the program should remain as it is until the technology matrix on alumina processes and resources is completed. The aluminum portion of our program is now, as it has been in the past, considering to a lesser degree direct reduction technologies. As a final point, we feel the Department of the Interior is proscribed from spending public money to develop proprietary technology for the benefit of the owners of the technology.

Our comment on Recommendation No. 4 is essentially the same as that for Recommendation No. 1 because proprietary information will have to be used. In addition, determination of the economic viability of by-products and co-products can produce results from which erroneous conclusions can be drawn if the results are not used with the utmost discretion.

We agree with Recommendation No. 5, that a benefit/cost analysis is needed.

"Recommendations to the Director of Office of Science and Technology Policy."

Recommendations No. 1 and 2, we have no comment.

Recommendation No. 3, how does this recommendation differ from Recommendations No. 2 and No. 4 to the Secretary of the Interior?

Recommendation No. 4, we have no comment.

Recommendation No. 5, would place an inordinate amount of laboratory and/or miniplant work on the Bureau of Mines.

As previously noted, the detailed Bureau of Mines comments are enclosed.

If we can be of any further assistance, please let us know.

Sincerely,

William L. Kendig
Acting Deputy Assistant Secretary - Policy
Budget and Administration

Enclosure

GAO COMMENTS ON DEPARTMENT OF INTERIOR LETTER

PARAGRAPH 3, PART 1, ISSUE A

The report second-guesses policy that was recommended by agencies other than the Bureau of Mines, yet criticizes only the Bureau.

GAO RESPONSE

The Council on International Economic Policy (CIEP) "Special Report on Critical Imported Materials" (December 1974), based on an interagency study sponsored by CIEP and the National Security Council, said that given the high capital cost of creating nonbauxitic alumina capacity, the U.S. could press forward with R&D efforts while awaiting future developments effecting foreign bauxite prices (p. 28). While suggesting that nonbauxitic alumina resources might become competitive if bauxite prices were double their 1974 levels, the report avoided any discussion of the efficiency of Government-supported alumina pilot plants as recommended by the National Materials Advisory Board's report in 1970.

In a memorandum to the Under Secretary of Interior in early 1974, the Acting Director of the Bureau of Mines opposed suggestions of a White House adviser that the Interior Department fund nonbauxitic alumina pilot plants. The Director argued that more technical information was needed before the Government could make a decision about whether or not to support development of a particular proprietary or nonproprietary process. At his urging the Secretary of Interior expanded the Bureau's existing miniplant program to involve private companies in a cooperative effort to develop a technical process information matrix for nonproprietary processes from a series of jointly funded miniplants.

Our report points out how the Bureau departed from this information matrix objective in 1975-76 and end ed development of one nonproprietary technology, clay/hydrochloric acid, gas-induced crystallization, for an alumina pilot plant. Proprietary processes were never reconsidered when the program's objective was changed. Other nonproprietary processes were not adequately reviewed or modified in miniplants.

No credible negotiating leverage with foreign bauxite producers could possibly result from public demonstration of a flawed or nonmarketable technology. We cannot believe

other agencies directed the Department of Interior to develop a nonproprietary technology unless they were seriously misinformed about its prospects for success. The Department of Interior's response suggests that the process selected, the manner in which it was developed, and the exclusion of other processes from consideration were all results of extra-departmental policy considerations. We think not. Such determinations seem more likely to have been within the purview of technical program managers. If they were not Bureau decisions, there was never any indication of Bureau dissent.

At the time the research objective was changed, the Bureau possessed enough technical information to know of other, potentially more promising proprietary processes. It also knew a nonproprietary process was unlikely to be commercially competitive. However, major aluminum companies involved in the miniplant program had been unable to agree on which, if any, proprietary processes should be assisted by the Government since 1970. The cooperative Government-industry miniplant accord rested on their shared concern about Jamaican bauxite negotiations, and the conviction that no company would be penalized by Government-assisted non-proprietary research. Rather than jeopardize this industry miniplant cooperator accord, the Department attempted to develop a nonproprietary process technology demonstration it knew would be noncompetitive.

PARAGRAPH 3, PART 1, ISSUE B

GAO presents a position of advocacy for a single proprietary process, which approach, the Department feels, is misdirected.

GAO RESPONSE

Our report focuses attention on alumina as an intermediate product. We emphasize that (a) it is the total competitiveness of U.S. primary aluminum capacity, far more than alumina, that provides the market for domestic alumina resource development; (b) the nonbauxitic alumina technology developed by the Bureau of Mines is not even economically competitive with conventional Bayer bauxite alumina, much less substantially cheaper to use making primary aluminum in the U.S.; and, (c) new U.S. primary aluminum capacity is not being created, but rather is shifting offshore due to more attractive capital arrangements and energy availability.

We identify several proprietary processes that might offset capital and operating costs with mineral coproducts from the production of alumina. We also identify proprietary,

direct-reduction research, supported by the Department of Energy under the Federal Energy Research Development Act of 1974, as another possible answer to reducing the capital and energy costs of primary aluminum production. Finally, in the context of reviewing the capital and operating costs of the nonbauxitic alumina processes examined by the Bureau of Mines to determine the most promising processes, we cite two independent engineering studies and our own analysis which show that the most economically promising approach to producing nonbauxitic alumina was not even considered by the Bureau because it was proprietary. This approach involves the carbo-chlorination of kaolin clays.

By combining this proprietary carbo-chlorination process to make aluminum chloride with a proprietary aluminum chloride reduction process for making aluminum, we concluded that it might even be possible to achieve sufficient energy and capital cost savings to create new, competitive primary aluminum capacity in the U.S. using domestic resources.

Our analysis demonstrated the six other nonproprietary alumina processes reviewed by the Bureau were not even economically competitive with the conventional Bayer process as they are presently conceived. There is, therefore, no reason to believe any of these processes will yield sufficient capital and energy savings to attract new primary aluminum capacity investment.

GAO feels strongly that the Bureau's funding of a single, nonproprietary, alumina technology is misdirected. It is not likely to result in a commercially viable process. We are indeed advocates, but of a sound resource development strategy, not any given technology. We advocate research policies and priorities that offer some realistic promise of addressing our future aluminum needs, and very probable supply shortfalls.

PARAGRAPH 3, PART 2

A GAO staff member scheduled a paper at the American Institute of Chemical Engineers annual meeting which would have repeated criticisms contained in the GAO report draft. Moreoever, the co-chairman of the panel was a member of the alumina technical advisory board empaneled by GAO to review the draft report's technical appendix. The Department of Interior felt this premature disclosure of a draft report was improper.

GAO RESPONSE

It is not GAO policy to present draft reports to public fora, however appropriate they appear. Rather than permit the inference that this policy had been breached or abandoned, the paper in question was withdrawn and the Department immediately notified, prior to Interior's response to GAO. Nevertheless, the Department chose to ignore this fact. The necessity of providing an abstract in advance of our final report led to an unfortunate and distracting accusation by the Department of Interior, despite our best intentioned supervisory review. This, and any related papers by GAO staff familiar with the subject report, will not be presented until after the final report is released.

The co-chairman's role is discussed in context of possible conflicts of interest in chapter 12.

Paragraph 4

National security considerations over-shadow economic feasibility except as a guide to selecting the least expensive strategic technology. The report's contention that non-bauxitic alumina is unlikely to be economically competitive with conventional alumina, and that the program is therefore misdirected, applies the wrong criterion for judgment.

GAO RESPONSE

We carefully considered the probability, magnitude, and characteristics of future supply interruptions as part of our review. We concluded that a technology demonstration program insensitive to competitive cost criteria was also counterproductive on national security grounds.

Our report cites a study showing that real bauxite prices would have to more than double (assuming present technology cost estimates) before the Bureau's preferred process could become economically competitive with imported bauxite conventionally used to make alumina. Because the real cost of bauxite has been declining since 1975, price increases of this magnitude in the next decade are most unlikely. There is not a price problem.

The price of bauxite is a reflection of its availability. Short of general warfare, the most likely supply interruptions will be sporadic, partial, and relatively short term. There will be no massive, long-term withholding of bauxite supplies to achieve higher producer prices. Economic effects from partial interruptions could be substantial, but too temporary

and easily remedied to justify costly, autarchical substitution of an uneconomic resource. Industry's reluctance to share the costs of even a greatly reduced, demonstration-scale pilot plant is compelling testimony of its own estimate of the likelihood that a major supply interruption would prompt a massive shift to more expensive domestic alumina. There is not an availability problem.

Even if there were price or availability problems, the Bureau's lack of support for patentable research may have prevented consideration of the most economic technology. We understand that in exceptional circumstances the Department of Interior policy would allow the Bureau to grant a private party exclusive rights to any invention made under a research contract or cooperative agreement. (See the discussion on p. 75, vol. I.) The Department could have considered the appropriateness of invoking the national security justification to support a superior proprietary technology.

PARAGRAPH 5, ISSUE A

GAO's criticism of the Bureau's alumina research program for not concentrating on nonbauxitic aluminum technologies which skip the intermediate alumina stage, fails to recognize this part of the Bureau's program is separate from the miniplant project.

GAO RESPONSE

We found this separation lamentable in our report and criticized the Bureau for it. Moreover, the aluminum metallurgy program was only about 5 percent of the Bureau's metallurgy program budget, and funding for aluminum reduction technologies virtually ceased once the Bureau decided to develop the clay/hydrochloric acid, gas-induced crystallization technology for an alumina pilot plant.

PARAGRAPH 5, ISSUE B

The approach followed by the Bureau of Mines in its miniplant program is that recommended by the National Materials Advisory Board (NMAB), accelerated by the Secretary of Interior, and accepted by the aluminum companies.

GAO RESPONSE

The approach followed by the Bureau of Mines in its development of clay/hydrochloric acid process technology

is not the one recommended by NMAB. In 1970, NMAB recommended that the Federal Government finance construction and operation of two clay/acid alumina pilot plants using different proprietary technologies and run by private contractors. Although the Department of Interior endorsed this approach, the aluminum industry could not agree on the two proprietary processes to be supported, nor resolve the potential antitrust implications of a cooperative, industry effort aided by Government funds. 1/

The Secretary of Interior, supported by the Bureau of Mines, resisted White House efforts to create a large pilot-plant project without seeking additional congressional appropriations. This, more than anything else, suggested considerable Bureau skepticism about the technology claims for nonbauxitic alumina pilot plants resulting from its wartime experience. Instead, the Secretary publicly called for a rapid acceleration of the existing miniplant process research information matrix in December, 1973. This was hardly an acceleration of the NMAB program.

A White House memorandum to the Under Secretary of Interior in April 1974 was more reflective of at least one major aluminum company's concerns. It said the expanded miniplant program was an inadequate solution to the need to demonstrate a pilot plant capability. The memorandum urged the Department to do more to meet the threat of bauxite producer cartels. Other major aluminum companies opposed Government assistance of a competitor's proprietary processes.

The Department was reluctant to launch a pilot-plant program without new appropriations because of the program's potential cost, technical skepticism about what could be accomplished, and aluminum industry opposition to selective proprietary process research assistance. The original information matrix approach of the Bureau's expanded miniplant cooperator program met these concerns. It was relatively cheap, focused on process steps for nonproprietary technologies, postponed any decisions on a pilot-plant process until the process information matrix was completed, and emphasized individual memoranda of agreements with each cooperating company to develop nonproprietary research.

1/The Office of Management and Budget subsequently disapproved of a proposed Interior funding request for $12 million appropriation to create a single alumina pilot plant.

However, alteration of this program under White House pressure in 1975-76 resulted in a bureau decision to develop a single nonproprietary technology for a pilot plant. This decision sacrificed a meaningful research demonstration in order to continue industry's support for the miniplant program. The point is not the origin of the policy change, but that the Bureau maintained the nonproprietary character of miniplant research in the face of the White House policy directive to develop a demonstrable nonbauxitic alumina technology. Implicitly, such a demonstration would have to be economically feasible. Half the industry cooperators left the program when these limitations on successful development of a pilot plant became apparent.

PARAGRAPH 5, ISSUE C

The Bureau's objective was to test and develop the most promising technologies on a small scale. These were technologies about which enough was known, based on prior research, to suggest larger scale testing was warranted. The miniplant program has always featured all new improvements and approaches developed by industries and Government. These improvements and approaches were to be tested and evaluated to obtain enough information to determine the best processes.

GAO RESPONSE

The objective cited by the Department for the Bureau's program is taken from language in the Bureau-industry cooperative memoranda of agreements signed in July 1974, before the policy change affecting research objectives occurred. In fact, the program initially considered only nonproprietary technologies, not the most promising ones. While the agreements pledged that new improvements and approaches developed by industry for recovering alumina from clay, anorthosite, alunite and dawsonite will be tested and evaluated in miniplants, compulsory, contractual provisions for disclosure of industry research related to the cooperative undertaking were specifically removed from the final draft documents of agreement. Second, only two miniplants were ever constructed, and one of these was discontinued. Only one nonproprietary process yielded new technical information developed in the miniplant from cooperative research. The Bureau proposes only to summarily review the other nonproprietary processes.

Contrary to the department assertion, miniplant cooperators refused to consider dawsonite, and the Bureau refused to even endorse the feasibility of developing aluminum chloride from kaolin clays. The program has featured new improvements and approaches to only one technology.

PARAGRAPH 5, ISSUE D

Research on smelting and carbo-chlorination approaches to produce aluminum and alumina was not part of the mini-plant program. Moreoever, while GAO criticizes the Bureau for not working on the clay/carbo-chlorination process, it admits in its report that the process needs a great deal more work before it can be considered for a pilot plant.

GAO RESPONSE

The inference of the Department's comment is that research on smelting and carbo-chlorination approaches to produce aluminum and alumina are occurring elsewhere in the Bureau of Mines. This was not true until the Bureau authorized resumption of clay/carbo-chlorination research at the Albany Metallurgical Laboratory for fiscal year 1980. As late as 1979 the Assistant Director for Metallurgy still said he envisioned no clay/aluminum chloride research by the Bureau.

We fail to see how criticizing the Bureau for not doing clay/carbo-chlorination research is inconsistent with our conclusion that this potentially promising process needs more development work before it can be considered a prime candidate for a pilot plant.

PARAGRAPH 6

GAO says the final factor contributing to the misdirection of the Bureau's alumina research program is its failure to review proprietary processes. However, it is departmental policy regarding assignment of patent rights and royalties that often deters industrial firms from participating in cooperative proprietary research, not the Bureau of Mines. GAO also should be aware that the Bureau cannot spend Government funds to develop privately owned processes, and that the Bureau must make the results of its investigations public.

GAO RESPONSE

Our report said that the Department of Interior needs to reexamine the benefits of proprietary research in addressing alumina metallurgy program objectives. We believe the public benefits of the Bureau's assistance of nonproprietary research must be related to DOE's proprietary aluminum research program. There is no dispute here as to fact or consequence.

The Department's letter acknowledges the chilling effects of departmental policy interpretations regarding assistance for proprietary research. It incorrectly suggests this situation is not responsive to Bureau wishes, but is imposed by the Department policy.

The Bureau has not supported proprietary alumina research but may be able to do so. The Department of Interior follows the patent provisions of the Federal procurement regulations which would allow the Secretary of Interior under exceptional circumstances to certify that permitting a contractor to obtain exclusive rights to an invention is in the public interest. Also, the Bureau's policy for cooperative arrangements, we understand, would permit private parties to have greater right in analogous circumstances.

Our report suggests that the Department of Interior's general policy orientation--that benefits from inventions resulting from federally funded research should accrue only to the Government--may be counterproductive and unresponsive to its own justification for assisting nonbauxitic alumina research. It contrasted the Bureau's nonproprietary, alumina research with the Department of Energy's support of proprietary aluminum research conducted under the Federal Energy Research and Development Act of 1974.

The Bureau may be financing the development of a costly nonbauxitic alumina process that has only very limited application, and very little relationship to DOE's proprietary aluminum research. The two must go together if a coherent effort to reduce domestic aluminum cost with indigenous materials is to be accomplished. Since the costs of developing the Bureau's nonproprietary alumina process, even if never used, could be very high, the public interest dictates a review of potentially more applicable proprietary processes, as well as compatible alumina/aluminum research.

Government patent policy and innovation have been the subject of extensive congressional hearings and other GAO reports. They have been called "the paramount flaw in Federal R&D policy." 2/

2/William D. Carey, Executive Officer, American Association for the Advancement of Science, Hearings, Senate Commerce Committee, Science Technology, and Space Subcommittee, and Senate Committee on Banking, Housing and Urban Affairs Subcommittee on International Finance, April 26, 1978, Volume II, p. 188.

GAO is aware that the Bureau of Mines has and is presently supporting proprietary and potentially patentable research. There is considerable departmental latitude in this area. Moreover, the present contracted design for an alumina pilot plant, based on nonproprietary miniplant research, depends on process equipment patented by a foreign manufacturer.

GAO is also aware that the Mining and Minerals Policy Act of 1970 charges the Department of Interior with principal responsibility for implementing policies to maintain a strong domestic mining and minerals processing industry. Our report discussed the mineral resource potential of nonbauxitic alumina and focused attention on the aluminum production mechanism. We identified potential economic gains through the use of domestic ores and technologies which reduce energy capital costs sufficiently to create domestic primary aluminum capacity in a free market.

We also expressed some reservations whether or not R&D policies were the most cost effective means of realizing this mineral policy aim, apart from other policy measures.

PARAGRAPH 7

The GAO report contains a number of errors of fact, including a gross error that 55 percent of the Bureau's metallurgical research program expenditures over 5 years were for aluminum research. Other errors are cited in the enclosed specific comments of the Bureau of Mines.

GAO RESPONSE

The Department of Interior is correct in the example cited. A transposing error in Table I-1 (chapter 1) moved the decimal point one space to the right. This table has been corrected, along with supporting text. The correct figure is 5.5 percent, not 55 percent as stated in our draft report. This figure is supportive of our judgment that the Bureau showed little interest in aluminum metallurgy in the past, and should place more emphasis on aluminum reduction technologies using domestic ores in the future.

Other specific clarifications and error corrections suggested by the Bureau of Mines are discussed in detail in chapter 9.

PARAGRAPH 8

The report's section on definitions is scientifically inaccurate, and specifically biased toward the report's conclusion.

GAO RESPONSE

The report's definitions were preceded by a statement that the terms were defined as they were used in the report rather than as technical definitions. Apparently the Department perceives this as an effort to influence the reader.

Our comparison of the first five definitions used by GAO in the report and the corrections and clarifications offered by the Bureau of Mines suggested this claim is distracting. Nevertheless, in order to remove any grounds for frivolous charges, we have rewritten our descriptions to conform with technical definitions in a new glossary of terms.

PARAGRAPH 9, ISSUE A

The GAO report is unwarrantedly biased and unduly optimistic about the Toth Alumina Process. Furthermore, the report ignores the cautionary comments in the "Summary and Conclusion" section of its own technical appendix.

GAO RESPONSE

There is adequate justification for believing that the carbo-chlorination of clays represents the least-cost domestic alternative to conventional Bayer-bauxite alumina. Our report cites two studies confirming this finding, in addition to the uniform assumption cost estimates of Clark and Kenney developed for our report appendix. It could have cited more. Four of the five aluminum companies commenting on our report (chapter 13) cited carbo-chlorination as either the most promising nonbauxitic technology, or as a promising technology which they would like to see included as part of the Bureau's program. The fifth company claimed the Bureau's process appeared to be as good as the carbo-chlorination process.

The Department has chosen Clark and Kenney's cautionary data statements that they could identify "no single alternative alumina production process as superior to others and competitive with the Bayer process, based on the data or lack thereof," while ignoring the context of the statement.

The quoted statement is accompanied with the assertion that the relative ranking of the six processes in the Bureau's feasibility study could not be confirmed or compared to the Bayer or clay carbo-chlorination process as presented.

This concluding caveat paragraph about the absence of Bureau data is preceded by two paragraphs of conclusion the Department apparently chose to ignore. In the first, the judgment is expressed that even doubling certain of the carbo-chlorination process operating costs does not detract from its commercial potential. "The carbo-chlorination operating cost adjustments are presented to highlight the competitiveness of this process." Similar adjustments in the operating costs of the six processes reviewed by the Bureau's feasibility study could not be attempted because of the lack of data.

The paragraph immediately preceding the cautionary remarks the Department apparently refers to states: "the potential benefits of incorporating the Toth process with the Alcoa chloride (smelting) process offer potentially large enough cost savings to make the Toth process an economically attractive alternative in the mid to late 1980's."

This is the basis for our urging additional Federal assistance for research and development on this process.

PARAGRAPH 9, ISSUE B

The Department chronicled certain aspects of its previous dealings with Toth Aluminum Company, set forth briefly below, apparently to refute any inference of unfairness on the part of the Bureau of Mines.

(a) the Bureau has done a lot of research on carbo-chlorination;

(b) the Bureau has had contracts with Toth Aluminum Company for more than 10 years;

(c) as late as 1976 the process in question was called the Toth aluminum process;

(d) Toth was invited to join the miniplant program; and

(e) 10 years ago the Bureau was prepared to test key aspects of the Toth process.

GAO RESPONSE

Although our report did not discuss these points, the public record should be clear on them.

(a) In 1975 the Bureau opposed further funding of clay/ carbo-chlorination research at its Albany Metallurgical Laboratory because of three specific research problems. In February 1976, senior officials of the Toth Aluminum Company briefed both the Assistant Director for Metallurgy and the Associate Director for Mining and Metallurgy Research of the Bureau, using process flow sheets and other experimentally derived data showing research results which successfully surmounted the Bureau's three technical objections to the technique. Despite this information, these officials neither authorized further clay/ carbo-chlorination research, nor endorsed the process to ERDA officials as important or technically feasible.

(b) The Bureau appears to have been very skeptical of Toth Aluminum Company's ability to fulfill research claims. In the past its relationship with Toth has sometimes been contentious and uncomfortable. Sometimes it was called upon to publicly refute or confirm Toth's research claims to other agencies and branches of the Government.

For example, in 1976 the Bureau refused to endorse the technical principles of the Toth carbo-chlorination process on which it had been briefed. As a result, the company believed it did not get DOE funding for proprietary research similar to funds subsequently granted by DOE to Alcoa, or Kaiser aluminum company.

(c) Whether the process was called an alumina or an aluminum chloride process depends on whether or not the end product is alumina, aluminum chloride, or aluminum. The latter would require a fully integrated three phase--clay, aluminum-chloride, aluminum--facility. The variety of Alcoa patents, together with its demonstration plant operation focused on smelting aluminum from aluminum chloride, may have convinced Toth to concentrate its resources and appeals for assistance on the clay/aluminum chloride phase by the mid-1970s. It does not

necessarily suggest the company did not know what it was doing.

(d) The Bureau's invitation to Toth to participate in its nonproprietary miniplant research was destined to fail. The company could afford neither to fund nonproprietary research, nor disclose its proprietary research position. Toth could not afford the Bureau's miniplant program. It concluded it needed financial assistance for its process research experiments.

(e) The Bureau's willingness to test "key aspects" of Toth's process 10 years ago was actually a challenge to the company. At that time, Toth persisted in making public claims for a process the Bureau believed technically deficient, in order to attract Government research funds. The Bureau planned to demonstrate that certain critical pathways of this claimed process were not technically feasible.

PARAGRAPH 10

GAO empaneled a group of technical advisers to review the work of Clark and Kenney, used as a technical appendix to the report. All of these advisers were academicians, and they were inexperienced in extractive metallurgy of either alumina and aluminum or chlorination technology.

GAO RESPONSE

The Department's assertion that the individuals reviewing Clark and Kenney's work were lacking in business experience and technically unsuited is untrue. One was the former Director of the Bureau of Mines. One is the principal subcontractor of Alcoa, performing under the company's aluminum direct reduction research for the Department of Energy. Another is the Dean of a large mining college, and a consultant for Toth Alumninum Company. Still two more are chairmen of large Materials Science and Metallurgical Engineering Departments. All these advisers have extensively consulted with Government and industry, served on Government panels, and published extensively. Many have been Bureau grantees.

It is simply unfair to question the qualifications of these individuals based on citations in chemical abstracts as the Bureau did. In addition, practically all of these men limited their endorsement to Clark and Kenney's paper. They were acutely aware of their professional and institutional responsibilities and reputations, and have no desire

to become involved in a dispute with the Bureau of Mines--a point we discuss in appendix VI.

Finally, for GAO to use technical advisers from the aluminum industry to review a paper whose subject bears on conflicting proprietary industry interests and resultant judgments of the Bureau's program for Government assisted research seemed inappropriate. Instead, we discussed the Bureau's program with major aluminum producers at great length, gave them an opportunity to review and comment on our draft report, and have printed their comments in appendix VII.

PARAGRAPH 11

The GAO report says that cost estimates by the Bureau represent ignorance. These estimates were good enough for the purposes for which they were made. In addition, the example of current $100 million pilot plant cost represents inflation, not technical ignorance about process engineering.

GAO RESPONSE

The basic purpose for which process costs were made in the past was to identify the most economically attractive, nonproprietary process of the six reviewed in the Bureau's feasibility study. Because only one of these processes was reviewed and modified in a miniplant, we did not find those process cost comparisons very meaningful.

Industry participants told us they believed these cost data were probably adequate for ordinal ranking. Our own study suggested potential process modifications sufficient to affect the relative ordinal ranking of the six nonproprietary processes the Bureau reviewed. The Bureau contractor made no attempt to optimize all processes, nor examine alternative pathways.

Another purpose of process cost estimating was to compare operating and capital cost requirements of the best nonproprietary process with those of conventional alumina technology. In this regard, process costs have been so consistently understated in the past that the Bureau must have been ignorant of subsequent process steps and equipment required to solve technical problems associated with continuous scale production. As the Bureau's contractor told the miniplant steering committee, "* * * the more you know about a process and the more effort you put into discovery, the higher the process costs will be."

We discussed the program cost implications for the Bureau of solving these engineering unknowns rather than assuming solutions. The Bureau's experience estimating these program costs is relevant to its present estimates of future pilot-plant costs. The major program elements we reviewed, for example, have already cost more than $15 million through fiscal year 1979, and the Bureau estimates another $10 million will be needed. They were originally estimated to cost $1.6 million.

Finally, our report cites Bureau data which suggests that a commercial scale alumina plant, using an experimental and unscaled nonbauxitic process, can produce alumina for approximately the same operating cost per ton as a new conventional Bayer alumina plant of comparable size. If this were true, there would be no reason for Government assisted research.

We have attempted to clarify the language of our report dealing with pilot-plant cost estimates and inflation. The principal cost element responsible for scaling the proposed pilot plant down from the original 50 tons per day to 25 tons per day was not inflation, however. The critical step in the clay/HCL gas sparging process developed by the Bureau's miniplant requires equipment larger than any presently available. Therefore, the design was scaled down in order to use patented, commercially available equipment.

PARAGRAPH 12

The Bureau of Mines has not retreated from its technical information matrix objective, reaffirmed in recent congressional testimony. At the suggestion of industry cooperators, it will examine only "key or troublesome" operations of the five other nonproprietary processes not yet examined. Testing of each of these technologies on a continuous basis in a miniplant has been judged unnecessary in light of probable results and concurrent laboratory research, although dawsonite research will continue. The Bureau's emphasis on hydrochloric acid, gas-induced crystallization is consonant with this approach. Current miniplant work is to confirm the accuracy of a 25-ton-per-day pilot-plant design which, even if unbuilt, will assure a complete technology package.

GAO RESPONSE

We do not agree that concentrating on developing a nonproprietary clay/hydrochloric acid pilot-plant technology is the same objective as developing a technical information matrix to select the best process, congressional testimony notwithstanding. Examining "key or troublesome" steps in the

other processes is a way of confirming rather than solving problems with these approaches, as was done with the preferred process.

According to the response of Reynolds Metals Company, each of these processes has varying degrees of potential for modification and refinement. Reynolds estimated it would cost $10 to $15 million per process to examine innovations for each of the six in a miniplant. The letter suggests that each of these processes may be capable of significant innovation over the ones which were compared to the preferred process in the feasibility study.

At least its own nitric acid process, Reynolds felt, rather than the one compared, was economically competitive with the preferred miniplant process. Alcoa Aluminum Company claimed its anorthosite process, rather than the one reviewed in the feasibility study, was economically competitive with the preferred miniplant process. Our study cites differing basic assumptions used for each of the two hydrochloric acid processes in the feasibility study which, if uniform, would drastically improve the relative economic position of the evaporative hydrochloric acid process compared to the preferred one.

We, therefore, differ with the Department's determination that further research is not needed to pick the best nonproprietary process of the six the Bureau set out to review.

With respect to the larger question of whether these are even the right six processes, given the Department's stated "off-the-shelf," technology package objective, the Department is silent. Why should such technology be public, rather than economically feasible?

Dawsonite research is being conducted by a grantee rather than as part of the miniplant program. It is unlikely that a cooperative program with the major aluminum companies will ever discharge the Bureau's responsibility to examine dawsonite alumina technology in a miniplant. Basically, the companies are not interested in capital intensive technologies which might produce alumina as a coproduct of oil.

The unanswered questions about the program's "technology package" for national security-related supply interruptions are:

--What is its purpose and likely utility?

APPENDIX II

--Where does it go from here, and at what additional costs and probable uses?

--Are there other more productive avenues of research?

BUREAU OF MINES COMMENTS

AND OUR RESPONSE

We present below a facsimile of the table of contents of the Bureau's report review document, in order to show the full range of the Bureau's comments. On the following pages we focus on "tab D" of the document, which contains specific comments on our report. In appendix VI we present issues relating to "tab I."

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GAO COMMENTS ON THE BUREAU'S "ERRORS OF FACT IN GAO REPORT" (TAB D)

The following are all the specific comments detailing specific Bureau of Mines suggestions "to correct errors of fact, or for purposes of clarification" contained in section D, and GAO's responses to them. About 18 of the Bureau's 31 comments were matters of clarification while the balance were largely factual interpretations. The Bureau identified five errors of specific fact in our report and one typographical error. Conversely, we identified four errors in facts asserted by the Bureau in its detailed comments. Page numbers correspond to the draft report and do not always coincide with those of the final report.

1. Page i: Paragraph 2, Line 9: Rather than say " * * * if properly addressed by research * * *" we suggest saying, "* * * if successfully addressed * * *."
GAO: Agreed, text modified.

2. Page i: Paragraph 2, Line 3: New alumina capacity, in addition to new aluminum capacity cited by GAO, is shifting to foreign locations.

   GAO: Agreed, text modified.

3. Page ii: Paragraph 1, Line 4-6: "There is little evidence that such alumina is likely to be competitive with conventional alumina." This was known from the start. The objective was assuring strategic supply capability from domestic resources. A secondary objective was to try and put a ceiling on imported bauxite prices.

   GAO: A "technology package" consisting of a technically feasible process and a pilot-plant engineering design does not enhance availability of domestic alumina supplies if it is not implemented. Unless the Government underwrites the costs, economic feasibility will determine whether or not domestic, nonbauxitic alumina resources will be developed in a pilot plant.

   The price ceiling imposed on bauxite, based on the Bureau's nonbauxitic process, is about three times as much as the present cost of bauxite. Moreoever, the real cost of bauxite has been declining since 1975.

4. Page ii: Paragraph 2, Lines 4-6: Regarding processes that might produce much of their own energy. This pertains to the recovery of waste heat and could be realized by all alumina processes. However, energy savings might be negligible compared to the capital costs of recovery.

   GAO: This language pertains to oil shales and fly ash containing alumina. The additional costs of alumina recovery appear relatively small, given the initial capital investments to recover energy. According to Superior Oil Company, its oil shale process could produce up to 280,000 tons of alumina per year, based on production of 350,000 to 525,000 barrels of oil. Fly ash recovery of alumina from lignite coals in power stations might be equally impressive.

5. Page iii: Paragraph 1, Sentence 3: In the refining process the alumina is also separated from impurities.

   GAO: Agreed, text modified.

6. Page iii: Paragraph 1, Sentence 4: Aluminum metal is produced by electrically reducing the alumina, not by electrically charging it.

   GAO: Agreed, text modified.

7. Page iii: Paragraph 2: The U.S. is cited as a major market for aluminum. We suggest the report state that the United States is the market for about 30 percent of the world's aluminum.

   GAO: Agreed, text modified.

8. Page iv: " * * * the aluminum industry urged the Government to research and develop nonbauxitic alumina process technology." This wording implies that the BOM had not previously addressed this subject.

   GAO: We disagree with the Bureau's interpretation. The history of the Bureau's involvement is fully discussed in chapter 1, as outlined in the table of contents. We did not feel the subject was suitable for inclusion in a digest.

9. Page iv: "The industry's concern about nationalizations in the Caribbean region in 1970, and emerging Jamaican efforts to renegotiate higher bauxite export levies in

1974--uniformly applied by all bauxite exporting countries through the International Bauxite Association--forced the Bureau of Mines to formulate a research program." The Bureau cited this passage saying its interest was longstanding and not precipitated by these events, and that higher export levies were not uniformly applied by IBA.

GAO: Our description of the Bureau's previous involvement with alumina research is a major part of chapter 1 (pp. 6, 12-16). The precipitating events creating Bureau funding proposals for alumina pilot plants in 1970 discussed on page 14, and increased miniplant appropriations in 1974 discussed on page 33, were threatened nationalizations in the Caribbean and Jamaican levy negotiations. Finally, language cited by the Bureau was qualified with "industry's concern about" these things. We changed "all bauxite" to "most bauxite."

10. Page v: Line 1: The Bureau has four, not three, program elements in its alumina/aluminum R&D effort

--metallurgical base program,

--miniplant cooperative program,

--miniplant supporting research at the regional metallurgy labs, and

--pilot plant studies.

GAO: Generalizing from program accounting codes going back to fiscal year 1974, there are only three consistent program elements. Miniplant supporting research at the eight regional metallurgical research centers was not added as a separate code until the transition quarter of fiscal year 1976.

11. Page vi: "The GAO report is not unique in saying that nonbauxitic alumina processes are more expensive than the Bayer process. The Bureau of Mines has said the same thing. And the situation will remain the same, provided that no improvement in the nonbauxitic process is made."

GAO: High-level officials of the Bureau of Mines have also been quoted saying: "We think we now have the

technology to do it, [make nonbauxitic alumina] * * * and the cost begins to look competitive with bauxite." 3/

12. Page vi: Lines 18-22: Regarding the statement "Because there is little chance that the real cost of bauxite will double in the next decade * * *," the Bureau said the price of bauxite will always be subject to taxes of foreign governments. Therefore, GAO cannot say what actions will be taken, or what prices will be.

GAO: The quoted sentence also noted the real cost of bauxite has declined since 1975. It says there is little chance that the real cost of bauxite will double in the next decade. It might happen, it simply is not likely. In our judgment, the greatly expanded capacity in Guinea, Australia, and Brazil will not allow major producing countries to increase prices before the end of the next decade.

13. Page x: Lines 1-4: The Bureau said: (a) it is not clear what direct reduction process GAO is discussing; and, (b) it is not correct to say the Bureau has ignored energy co-production processes, especially dawsonite.

GAO: We have modified our language to read: "The Bureau has ignored both direct reduction of aluminum from smelting constituent ore bodies and the possibility of energy co-production processes as a means of developing nonbauxitic alumina resources."

Placing dawsonite "last on the list" does not resolve whether it is part of the alumina miniplant cooperative program or not. It was not one of the processes reviewed in the process feasibility study, nor in cooperative miniplants. Bureau officials have indicated the aluminum industry has no interest in sharing funding for this process.

3/Assistant Director, Metallurgy, U.S. Bureau of Mines, quoted by T. Y. Canby, in "Aluminum the Magic Metal," National Geographic, August 1978, p. 201; and "the [Bureau] process is economically competitive with a grassroots Bayer plant built in the U.S. . . ." Bureau Spokesman, quoted by David J. Deutsch and Gerald Parkinson, "Alumina Minerals--Still Overshadowed by Bauxite," Chemical Engineering, December 3, 1979, p. 58.

14. Page x: Paragraph 3: While it is true that at least for the present U.S. aluminum firms will build new smelters abroad, present U.S. smelters will still need an assured supply of alumina. They will continue to be renovated, improved, and expanded.

GAO: Does "assured supply" mean domestic, or does it imply some special Government commitment to support the aluminum industry? As economic enterprises, aluminum companies will no doubt consider ways to maintain and extend the productive life of existing domestic aluminum smelters. The Bureau, however, has never examined the trade-offs associated with encouraging domestic alumina supplies to support U.S. smelters, and the added costs to taxpayers or aluminum consumers.

The Bureau's comment emphasizes the confusion about the miniplant program's research objective. Earlier, the Bureau characterized this technology as uneconomic, but for strategic purposes. Is "assured supply" a strategic purpose of the Government, or the aluminum industry? If uneconomic alumina plants were built to supply domestic aluminum smelters in times of emergency, would the alumina produced at other times, or the plant, belong to the Government? How would these costs compare with conventional stockpile operations, and to what extent would they actually contribute to domestic resource development? None of these questions have been meaningfully analyzed by the Bureau.

15. Page 1: It should be noted that the IBA was formed in 1974. The Bureau's original miniplant program started in 1973.

GAO: The formation of the IBA in 1974, and the first miniplant program in 1973, as well as the rationale for expanding it rather than supporting a proprietary pilot-plant technology, are discussed in our report.

16. Page 8: Lines 1-6: Estimates of recoverable alumina from these deposits is 3.8 billion tons, not 3.8 million.

GAO: The Bureau is correct, and the typographical error has been corrected.

17. Page 9 and 88: In regard to dawsonite and multiple-mineral development, the report states that only one oil company is seriously pursuing a multiple mineral

development approach to alumina contained in oil shale. It is assumed that GAO is referring to Superior Oil. If limited only to a consideration of oil companies, the statement is true. However, it should be noted that the Multi Mineral Corporation of Houston, Texas, has prepared a proposal for multiple mineral development in the Piceance Creek Basin of Colorado. Based on this proposal, Multi Mineral has entered into a contract with the Bureau of Mines and BLM to use the 2,300 ft. shaft recently sunk by the Bureau of Mines in the heart of the Dawsonite-nahcolite area of mineralization in the Piceance Basin. The Multi Mineral Corp. is presently in possession of the shaft, and to this extent is farther advanced in its predevelopment activities than is Superior Oil, which, as is correctly stated by GAO, is still awaiting consummation of a land exchange agreement.

GAO: The founder and President of Multi Mineral Corporation is the former Director of the Shale Oil Division of Superior Oil Company. He still actively consults for Superior Oil Corporation. A Superior Oil refinery using a Superior Oil process will use nahcolite from the ore mined by Multi Mineral, a wholly owned subsidiary of Charter Corporation. It is possible that this company may provide a means of continuing Superior Oil's process development, despite impediments to its proposed land exchange in the Department of Interior.

18. Page 12: Last Paragraph: The Bureau asserts that Arthur D. Little is the sole owner of a proprietary nitric acid process.

GAO: We believe that the Bureau is incorrect. The Bureau was informed by letter by the company in 1974 that it has sold its proprietary interest in nitric acid research.

19. Page 23, Table 1: Funding shown for Total Aluminum Program is in error by a factor of 10.

GAO: The Bureau is correct. A transcription error resulted in a significant misstatement. We have corrected the table and made the required changes in the text.

The data now demonstrates that aluminum research has never been a very significant part of the metallurgical base program.

20. Page 24, Table 2: The report gives the misleading impression that the funds shown were for the direct

support of the miniplant. This is not true. None of the money was for this purpose.

GAO: We believe the Bureau is wrong. According to Bureau directives from the Assistant Director for Metallurgy to the Directors of the Regional Metallurgical Centers, in June 1976 transition Quarter expenditures--some on specified existing program accounting codes and others reprogrammed to new accounting codes--were to be spent in supporting miniplant research. The Assistant Director specified the type of research and its authorized costs. A memorandum from the Associate Director for Mining and Metallurgy Research to the Director of the Bureau in February 1976 briefly summarized how the Metallurgical Research Centers' research would be reorganized during the transition quarter to support the miniplant program.

We believe Table 2 (p. 24) is substantially correct. The text explicitly says: "Aluminum research expenditures between fiscal years 1974 and 1978 totaled just over $6 million, excluding the $538,000 in the transition quarter of fiscal year 1976, spent exclusively on alumina research to support the miniplant (table 2)."

21. Page 25: Table 3: The Bureau says Tuscaloosa had only one (rather than three) alumina research projects in fiscal years 1978-1979, and that the fluidized bed research of Albany Metallurgical Research Center was not equally applicable to hydrochloric and nitric acid processes as our notation asserted.

GAO: The original data were drawn from Bureau records. They have been corrected.

22. Page 28: Paragraph 2: The Bureau said Kaiser Engineers, its contractor, did not propose the six processes that were reviewed in the feasibility study. These processes were proposed for review in the Bureau's Request for Proposal as recommended by the miniplant steering committee.

GAO: The report's language has been clarified to reflect the fact that the six processes originally proposed by the Bureau to miniplant cooperators were not accepted by the miniplant steering committee. The six processes proposed for the feasibility study by the miniplant steering committee included two hydrochloric acid processes and excluded dawsonite. These were the six processes in the Bureau's RFP.

23. Page 38: The GAO report discussed Alcoa's reasons for dropping out of the miniplant and implies that the miniplant and supporting research were not supplying adequate data for a pilot-plant design. The miniplant technical audit committee was formed in December 1977, in order to define all the process information that was known, being obtained, or was still needed in order to design a pilot plant, using clay/hydrochloric acid, gas-induced crystallization. This information audit was "well underway" when Kaiser Engineers began its pilot-plant design in February 1978.

GAO: Alcoa said it dropped out of the miniplant program because it opposed the Bureau's abandonment of a technical information matrix, in favor of using the miniplant to develop a single pilot-plant technology. The company argued that no judgment could be made of the most economical, nonproprietary process based on only one miniplant process review. To link a pilot-plant's design to the most economic nonproprietary process, when only one process had been reviewed in the miniplant, meant that only this process would be generating new research information. It would be the obvious candidate for a pilot plant.

As to what the Bureau believes our language implies, the steering committee's technical audit committee was created in December 1977, only 2 months before the contractor's postponed pilot-plant design work was rescheduled to begin (February 1978). The technical audit committee was created out of a realization that even the miniplant-generated cost estimates, which were used by the contractor as the base case process for comparing the other five unreviewed processes in feasibility study, were incomplete. They rested on costs derived from technical assumptions about how the process would theoretically operate.. The absence of empirical data necessitated these assumptions.

Two months before pilot-plant design work was scheduled to begin, the steering committee created a special group to identify the still missing engineering information that the miniplant would have to produce in order to design a pilot plant. This engineering information had a direct impact on process operating and capital costs. It was not available for the contractor's economic comparisons of the six processes in the feasibility study. The pilot-plant design was subsequently halved because of unavailable data for a 50 ton per day plant.

Alcoa dropped out of the miniplant program 1-1/2 years before the technical audit committee was created. Nevertheless, its basic objection that a comparison of these processes without new data from miniplant examination of each was premature, proved to be correct.

24. Page 54: Paragraph 1: In discussing table 1, the text should read "* * * in 1977 required 17 million tons of aluminum recoverable from bauxite."

GAO: The Bureau's language using the aluminum content of bauxite is confusing because the Bureau does not publish the tonnage of bauxite mined at each of these locations, only aluminum contained in the bauxite.

25. Page 56: The discussion of alumina imports should note that increases have come from Australia rather than countries which imposed bauxite levies.

GAO: It does. See pages 57-58.

26. Page 62: Footnote 2: This definition is not correct.

GAO: Agreed, footnote definition modified to read: "An annual ton consists of all capital costs in the production of aluminum divided by the total tonnage of capacity."

27. Page 68: Paragraph 2: The first sentence discusses aluminum prices and the second one cites demand. Sentence one should use the word "demand" rather than "price." Further, what is the source of the figure attributed to the Bureau of Mines.

GAO: Sentence one now reads: "There seem to be quite different implicit assumptions about domestic aluminum prices, judging from differing import demand estimates by the Bureau of Mines and the aluminum industry."

Source for the Bureau figure is now cited in a footnote as used in a Federal Preparedness Agency report.

28. Page 69: Table 6: Footnote 1 should read "Aluminum contained in bauxite and alumina which is used for abrasives, refractories, and chemicals."

GAO: Agreed, text modified.

29. Page 79: The report says clay/carbo-chlorination needs more research yet the process was not assigned as high an uncertainty factor for cost estimating as clay/ hydrochloric acid, gas-induced crystallization which is based on confirmed miniplant research.

GAO: Contingency funding adjustments, referred to by the Bureau as the uncertainty factor, reflect the amount of capital necessary to assure a confidence interval of plus or minus 20 percent of the estimated capital and construction costs. It was the judgment of Clark and Kenney that doubling the Pullman-Kellogg study's contingency funding allowance would achieve the study's stated 20 percent confidence level for the clay/carbo-chlorination process. Conversely, by reducing the Bureau contractor's unstated but implicit confidence level in the feasibility study from plus or minus 30 percent to plus or minus 20 percent, resulting contingency funding requirements had to be significantly increased.

30. Page 95: Paragraph 2: The GAO report does not cite the concerns of Section 7(a) of the Strategic and Critical Materials Stockpile Act, nor acknowledge that none of the 11.5 million tons of the alumina stockpile objective are presently on hand. The value of this shortfall after crediting bauxite offsets is about $640 million.

GAO: We have reported on the reasonableness of commodity objectives and strategic stockpile management problems elsewhere (see: "The Strategic And Critical Materials Stockpile Will Be Deficient For Many Years," (EMD 78-82). We fail to see how a $100 million pilot plant producing 50 tons per day (37,500 tons per year), or a cheaper plant producing half as much, is going to reduce a 5.5 million ton alumina shortfall in the strategic stockpile, after crediting existing bauxite stockpiles for their alumina content. The issue is least cost procurement of alumina from either additional commercial size plants using proven design, or a new technology.

Our judgment is that the proposed process is not economically competitive. Thus, only very large Government subsidies for plant construction and operation, or for the alumina produced from them, would produce commercial-scale plants. For example, the Government would have to build one or more demonstration plants of about 100,000 tons annual capacity using the new technology if its commercial advantages were not apparent. Depending on site-specific factors, these demonstration-scale plants could cost from $150 million to $250 million each.

If the process still did not appear economically attractive, demonstration plants alone would contribute only 100,000 tons per year to strategic stockpiles, and additional Federal incentives would be needed to stimulate more private capacity construction.

Rather than open-ended technology investment, the costs of various public policy options necessary to produce nonbauxitic alumina or aluminum technologies should first be estimated and compared to other policy options. Unless the technology objective is defined as a commercially competitive system, the costs of the technology options will never be less than those of other options.

31. Page 95: Paragraph 2: The Bureau believes Caribbean bauxite and alumina producers could cause considerable damage to our economy in the short term, if they perceived it to be in their interests.

GAO: We agree. We do not agree with the inference that it is likely to be in their interests to do so during the next decade.

APPENDIX IV

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20500
September 7, 1979

Mr. Harry S. Havens
Director
Program Analysis Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Havens:

Dr. Press has forwarded me a copy of your draft report entitled "Domestic Alumina Resources: Dilemmas of Development." I am happy to give you a few comments based on my brief review.

The tone of the report is quite strong, and yet much of the back-up material in the report and the appendices seem to indicate more ambiguity and uncertainty than was reflected in the report. Perhaps the clearest example of this is favoring of the clay/carbo-chlorination process over various alternatives. Your particular choice does not seem to be in accord with the Clark/Kenney appendix, which indicated that several approaches have similar probabilities for success. Another example appears on page ix of the digest. It hardly seems fair to criticize BOM by pointing out that inflation has made May 1977 cost estimates inaccurate.

Another area of concern to me is the recommendation that the Office of Science and Technology Policy conduct a study reviewing nonbauxitic alumina resource development. The choice among various nonbauxitic processes lies, quite properly, with the Bureau of Mines. Of course, during the forthcoming budget cycle, our office will consider your concerns in evaluating the BOM proposals. I am sure many of the issues in the report will surface at that time. In our view, the normal budget process, rather than a special study, is the appropriate forum for resolution of the issues discussed in the report.

We appreciate your insights in these areas. If I am able to assist you further, please feel free to contact me.

Sincerely,

John C. Houghton
Senior Policy Analyst

GAO RESPONSE TO THE OSTP COMMENTS

PARAGRAPH 1

The Office of Science and Technology Policy (OSTP) believed the tone of our report was too strong for the supporting data presented. The OSTP felt these data suggested more uncertainty and ambiguity than was reflected in the draft report.

GAO RESPONSE

In general, some of the more declarative language of the draft was modified to reflect statements of opinion. However, the OSTP's response is disturbing with respect to the two examples cited to support the observation. The technical appendix data and Clark and Kenney's conclusions definitely do support the report's position on clay/carbo-chlorination technology and the need for more research. The OSTP's conclusion that it did not, could only have come from either a very superficial reading of the appendix, or a profound conclusion that Clark and Kenney's work was wrong. The letter suggests the former.

As a second example, the OSTP says it hardly seems fair to criticize the Bureau by pointing out in the digest that inflation has made their cost estimates inaccurate. This language in the digest has been modified to resemble the language in the text which points out three reasons why pilot-plant cost estimates for appropriations purposes are premature. First, substantial ignorance of the process R&D requirements necessary for innovations to save energy. Design size in relation to available equipment costs is critical. Moreover, the Bureau estimates of process costs are totally unrealistic for purposes of comparison with conventional technology, or other nonbauxitic processes. Second, capital equipment estimates made in 1979 have suffered from inflation, irrespective of design size and cost assumptions. For example, pilot-plant cost estimates have increased at least 40 percent since they were made. Finally, the miniplant program costs themselves have been underestimated in the past by an order of magnitude, suggesting officials did not know what needed to be done. A $1.6 million program has cost $15 million through fiscal year 1979, and another $10 million has been proposed through fiscal year 1983 to complete the original objective.

We do not criticize the Bureau for not knowing what the research objective would cost before the program was started. We criticize them for misdirecting the research

effort, altering the original objective to develop a nonbauxitic technology without changing the nonproprietary requirement, and then trying to demonstrate why this preferred technology was the best choice of the original candidates for review. When better research options are known to exist, this is not good management of the public's resources. Our report demonstrates not only that there are better options but also that even the options the Bureau set out to examine were not adequately reviewed.

PARAGRAPH 2

The OSTP believed the choice of various nonbauxitic processes lies with the Bureau of Mines. The OSTP will only be involved with considering the Bureau's proposals during the budget cycle. At that time it will consider our concerns in evaluating the Bureau's proposals.

GAO RESPONSE

The OSTP contends that the normal budget cycle, rather than a special study, is the appropriate forum for resolution of issues discussed in our report. The OSTP response is not clear on which issues in our report the OSTP will recognize as appropriate. How will the OSTP manage to incorporate the relative responsibilities for proprietary and nonproprietary research and development, conducted in two separate executive department efforts for alumina and aluminum, and involving supply availability and energy conservation objectives as well as the legitimate concerns of several other Federal agencies, in one bureau level budget review?

We believe the OSTP approach is too likely to be entirely inconsequential to the kinds of fundamental policy issues related to R&D raised in our report. In testimony before the Subcommittee on Science, Research, and Technology, of the House Committee on Science and Technology, and in a letter report to Chairman Fuqua of the House Committee on Science and Technology, GAO has specifically called attention to the need for greater OSTP involvement coordinating alumina-aluminum and phosphate research.

We believe the OSTP response is superficial, incomplete, and disappointing. The two paragraphs of discussion written by a senior policy analyst indicate an abdication of responsibility to adequately address an important issue.

APPENDIX V

Department of Energy
Washington, D.C. 20585

AUG 15 1979

Mr. J. Dexter Peach, Director
Energy and Minerals Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

We appreciate the opportunity to review and comment on the GAO draft report entitled "Domestic Alumina Resources: Dilemmas Of Development."

The report is directed towards the Bureau of Mines program for developing nonbauxitic domestic alumina resources and the DOE's supportive R&D efforts in proprietary process areas. Because aluminum is one of the most energy intensive commodities and its use continues to increase, we believe the report is timely and focuses on important issues relating to areas for potential development.

We will be pleased to provide a more in depth review of the work being performed by DOE or any other additional information you may desire.

Sincerely,

for M. Ray

Jack E. Hobbs
Controller

F A C S I M I L E

BUREAU OF MINES COMMENTS ON THE TECHNICAL BACKGROUND AND COMPETENCY OF THE AUTHORS OF THE MIT REPORT AND THOSE REVIEWING THE REPORT (FROM SECTION I OF THE BUREAU REVIEW DOCUMENT)

In January, 1979, the Massachusetts Institute of Technology released a draft report to the GAO entitled, "An Analysis of The Competitive Position of Alternative Processes for Converting Domestic Aluminum Bearing Resources to Alumina." The report was authored by Joel P. Clark and George B. Kenney, and presents findings that are supportive of the Toth Clay/carbo-chlorination process. We have determined that neither of these gentlemen has had any recent literature citations in alumina/aluminum research. Nor do they have citations on process evaluation or cost estimation. This is based on the Chemical Abstracts listing of publications and patents from 1972 to present, as shown below.

	Citations	Research Activity(ies)
G. B. Kenney	1	Strain-rate-dependent effect of specimen volume on strength of brittle materials.
J. P. Clark	3	Martensitic alloys, magnesium-cadmium alloy deformation.

Because of lack of involvement in research on alumina or aluminum, we question whether the authors are enough in tune with the issues to properly analyze the technologies discussed in their report.

In addition, we are puzzled by the nature of the technical advisory board empaneled by GAO to review the Clark-Kenney report. We believe that all of the members are men or reasonable integrity, and no doubt have considerable scientific acumen. It is surprising to us, however, that GAO would select an advisory group for this purpose comprised almost entirely of individuals from academe, and having little or perhaps no recent association with research activities relevant to the major issue areas discussed in the report; i.e., alumina production and aluminum reduction, processing, and chlorination chemistry. In this regard, we offer the following information which lists the number and area of relevance of the Chemical Abstracts citations for each of the board members for the period 1972-1976:

Board Member	Citations	Research Activity(ies)
J. C. Agarwal	11	Copper, desulfurization of coal, smelting iron ore.
W. H. Dresher 1/*	2	Chemical processing, recovery of vanadium.
M. C. Flemings	45	Alloys, casting technology (including aluminum alloys) copper review (1975)).
W. R. Hibbard, Jr.	0	None.
R. D. Pehlke	26	Iron and steelmaking; Book: "Unit Processed of Extractive Metallurgy."
J. Szekely	45	Steelmaking, process optimization, gas-solid reactions.
M. E. Wadsworth	22	Copper extractive hydrometallurgy.

We suggest that an advisory panel similar to those utilized by the Office of Technology Assessment, in which the members have a good understanding of the issues, and represent a cross reaction of interest groups would have served as a better review medium for the Clark-Kenney report.

OTA is of course not unique in empaneling advisory committees in which the representation is based on knowledge of the issue areas, and with concern for appropriate balance. For example, the National Research Council, Commission on Material Resources convened several committees, boards, and panels to assist in the preparation of a 1979 report on the Redistribution of Accessory Elements and Compounds. One of the panels was concerned specifically with alumina, and had the following membership:

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*Bureau footnote follows on pp. 42-43.

ALUMINA PANEL

Chairman, John A. Apps
Lawrence Berkeley Laboratory
Berkeley, California

John R. Dyni
U.S. Geological Survey
Denver, Colorado

Frank J. Laird, Jr.
The Anaconda Company
Tucson, Arizona

Haydn H. Murray
Indiana University
Bloomington, Indiana

William W. Walker
Earth Sciences, Inc.
Golden, Colorado

Edward A. Worthington.
Kaiser Aluminum & Chemical Corporation
Pleasanton, California

1/It is worth noting that W. H. Dresher accepted a job as a consultant to look into the Toth Process after he had been asked by Joel Clark to review the MIT report to GAO. This borders on conflict of interest, and causes some concern as to Dresher's objectivity in his review of the Clark-Kenney report. A brief review of Dresher's activities in regard to MIT, GAO, and Toth is as follows:

1. Dresher was asked by Clark (MIT) to review the latter's report to GAO, "An Engineering/Economic Analysis of Proposed Processes for Converting Domestic Aluminum Bearing Resources to Alumina," probably early in 1978.

2. Meanwhile, Dresher accepted a job as consultant to look into the Toth process. He visited Toth laboratories July 31 - August 3, 1978, and advised his client on August 8, 1978 that the Toth process looked promising.

3. After this report went out, Dresher received Clark and Kenney's draft report to GAO, and reviewed it. His August 24, 1978, letter to Shantz said he generally supported Clark and Kenney's analyses, but pointed out that they evidently were not aware of the Toth process ("It would seem that this process has more to offer than any of the six processes discussed by Drs. Clark and Kenney"). He also recommended that Clark and Kenney include depreciation and return on investment in their operation costs.

4. Shantz evidently then wrote Chaplin at Toth, asking for information (no copy of that letter available). Chaplin responded September 18, 1978, sending an abbreviated version of Toth's pamphlet, "Data and Information on the Toth Alumina Process," and promising to send the Pullman-Kellogg evaluation later (with some confidential materials removed).

5. Clark then sent Dresher by letter dated November 22, 1978, a final draft report to GAO, incorporating a new section on clay-chlorination.

6. Dresher reviewed that report and wrote Shantz on December 4, 1978, making the following major points:

   (a) New title "An Analysis of the Competitive Position of Alternative Processes for Converting Domestic Aluminum Bearing Resources to Alumina" is an improvement.

   (b) Addition of clay carbo-chlorination broadens the report to include all processes available today (not really true, of course).

   (c) Inclusion of indirect costs (specifically depreciation and return on investment) in the operating costs is a valuable addition.

Other quotations from Dresher's letter:

"The report is adequate, in my opinion, to make R&D decisions as to which process (or processes) should be carried forward into larger scale process development but should not be considered as the last word in choice of processes."

"...seems to be a great deal of confidence on the part of major aluminum producers in their foreign sources where they have heavy investments."

"The heavy investment of the industry into Australia certainly will have a moderating influence on the International Bauxite Association which will preclude an OPEC-type political and/or economic action."

"My feeling at this time is that a major aluminum producer will not be inclined to alter its present practice and move to domestic alumina production in any significant way."

Bureau of Mines
7/18/79

GAO COMMENTS ON COMPETENCY AND DISCLAIMERS

We attempted to deal with the technical competency issue raised by the Bureau in three ways. First, the text of the draft report was altered to indicate that the advisers' responsibilities were limited to commenting only on the technical appendix. Second, we answered the charge that these academicians reviewing this work were not technically or characteristically equipped to publish or comment on the subject, in our response to the Department of Interior's comments. Third, the authors of the technical appendix invited the reviewers to sign or write disclaimers for the draft report, which contained the appendix they reviewed.

The rationale for the disclaimer was to permit individuals to disassociate themselves from the report's criticism of the Bureau of Mines. Most of the advisers who reviewed the authors' work signed the disclaimer. A few also denounced the draft report, or objected to associating their names with it.

One of the technical advisers did not confine himself to reviewing the technical appendix but wrote commending the draft report. It is his conduct which is described in the preceding Bureau documents as bordering on a conflict of interest. This allegation, and a supporting chronology of purported travel and correspondence, was contained in materials widely circulated in the Department of Interior and shown by Bureau officials to an individual listed in the draft report as a technical adviser who was present for the purpose of discussing future contracts with the Bureau of Mines. It was also seen by the authors of the technical appendix, and by other individuals listed in the draft as technical advisers.

The Bureau of Mines did not make allegations of conflicts of interest about another technical adviser, also known to be a subcontractor for an aluminum company conducting proprietary, direct reduction research for the Department of Energy. Although this individual was indirectly accused in the Department's comments (paragraph 3, part 2) as being both co-chairman of a professional panel hearing a GAO staff paper critical of the Bureau of Mines, and a member of GAO's technical advisory panel associated with the paper, he sent a copy of a strongly worded letter de-

nouncing the report to the Bureau of Mines. His principal contractor endorsed the same draft report.

Generally, we have tried to be sympathetic to the institutional as well as personal interests the technical advisers are trying to protect. The disclaimer offered by the appendix authors to their peers represents a substantial restriction on any endorsement of report findings by the technical advisers to the appendix. The order of appendices in the draft report, referred to in the Clark memo, has been altered. Technical advisers' names now appear following Clark and Kenney's paper (appendix I, volume I) rather than as a separate appendix.

On succeeding pages in this appendix we reproduce a memo and several letters written by technical consultants, all related to the matter of disclaimer.

APPENDIX VI

MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASSACHUSETTS 02139

July 27, 1979

M E M O

TO: Members of the
Alumina Technology Advisory Board
For U.S. General Accounting Office Study

After reviewing the complete draft of the proposed U.S. General Accounting Office study entitled "Domestic Alumina Resources: Dilemmas of Development" I am concerned that there are several ambiguities that may lead to misconceptions on the part of readers of the report: First , it may appear from the sequence of the Appendices to the report that the Technology Advisory Committee reviewed and concurred with the entire GAO report. This is not true. You were only asked to review the technical report written by Dr. Kenney and myself. Further, while you have had adequate time to review the technical report, you have only received the entire GAO report in the recent mail and thus may not have had time to review it in detail. Second, the conclusions drawn by the GAO based on the technical report (Appendix II) are likely to be extremely controversial. Some or all of you may not wish to be associated with them.

As a result of these problems, I feel that it is necessary to circulate a statement, which you have the option to sign, disclaiming any association of the Technology Adivsory Committee with the main body of the GAO report. If you agree with the enclosed statement please sign and forward it to: Dr. Arthur Shantz, U.S. General Accounting Office, 2401 E Street, N.W., Columbia Plaza Office Building, Rm. 675, Washington, D.C. 20241.

I sincerely hope that your involvement with this study will not cause you any hardship and I thank you again for your participation as a member of the advisory committee.

Sincerely,

Joel P. Clark

Joel P. Clark
Associate Professor of
Materials Systems
Department of Materials Science
and Engineering
M.I.T.

JPC/cp

APPENDIX VI

STATEMENT OF THE TECHNOLOGY ADVISORY BOARD

FOR THE UNITED STATES GENERAL ACCOUNTING OFFICE REPORT

ENTITLED:

"Domestic Alumina Resources:

Dilemmas of Development"

Members of the Technology Advisory Board for the U.S. General Accounting Office (GAO) report entitled: "Domestic Alumina Resources: Dilemmas of Development" were asked to review a technical analysis of the competitive position of alternative processes for converting domestic aluminum bearing resources to alumina. This analysis, written by Prof. Joel P. Clark and Dr. George B. Kenney appears as Appendix II to the GAO report. Members of the Technical Advisory Board have not agreed to review or comment on the main body of the report and the inclusion of their names in Appendix I should not be construed to mean that any one or all of these persons are in agreement with the conclusions of the main GAO report.

APPENDIX VI

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

COLLEGE OF MINES

OFFICE OF THE DEAN

TELEPHONE: (602) 626-1401

July 16, 1979

C-1876-WHD

J. Dexter Peach
Director
Energy and Minerals Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Peach:

I am very pleased to be given the opportunity to review and comment on proposed GAO report, "Domestic Alumina Resources: Dilemmas of Development", EMD-79-66. I am in complete concurrance of the GAO's analysis of the domestic alumina/aluminum situation and with the conclusions and recommendations of the report. The GAO's analysis of the future trend of alumina and aluminum products in the United States, in fact, is excellent. I am also in agreement with certain aspects of the GAO's analysis of the Bureau of Mines domestic aluminum program. There have been sufficient changes in the alumina supply and aluminum metal production situations since the program was initiated to warrant that this is, indeed, a proper time to stop and rethink the purpose and objectives of the program.

I am not in concurrence, however, with the GAO's analysis of what might be described as the motivations of the Bureau in its conduct of the domestic alumina program. The Bureau, as the proposed report's title suggests, is in a dilemma. This dilemma is caused, in my opinion, by the inability of the United States to come to grips with the present and potential problems in mineral raw material supply. I think it only fair that the report acknowledge the Bureau's (and for that matter the Federal government's) dilemma rather than charging that agency with a totally misdirected program. Thus, instead of inferring an inept Bureau of Mines as the cause of the dilemma, the report should emphasize the need for the establishment of a national purpose and direction with regard to the domestic production of mineral raw materials, in this case aluminum. These and other points will be discussed in more detail in the following text.

I have attached copies of the report pages on which I have made notations and suggestions for changes. If I can be of further assistance to you in this matter, please call upon me.

Sincerely yours,

William H. Dresher
Dean

WHD:mw
Attachments

APPENDIX VI

MERTON C. FLEMINGS
ROOM 8-407
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS. 02139

FORD PROFESSOR OF ENGINEERING
DEPARTMENT OF
MATERIALS SCIENCE AND ENGINEERING

TELEPHONE: (617) 253-3233

July 30, 1979

Mr. J. Dexter Peach
Director
Energy and Minerals Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach,

In answer to your letter of June 27, I have reviewed the draft of the proposed report, "Domestic Alumina Resources: Dilemmas of Development" (008250) and recommend that this report not be published without careful thought and redrafting.

It was my understanding that I was serving as a member of the advisory committee for the analysis in Appendix II, written by Prof. Joel P. Clark and Dr. George B. Kenney. This appendix is excellent. I approve it as written.

If, however, the main report is published in its present form, please make it clear that my name as advisor is to be connected with this appendix alone. See also the attached signed statement to this effect, which I am forwarding also to Dr. Arthur Shantz.

Sincerely yours,

Merton C. Flemings

MCF:ar.
Encl.

cc: Dr. Arthur Shantz

APPENDIX VI

STATEMENT OF THE TECHNOLOGY ADVISORY BOARD

FOR THE UNITED STATES GENERAL ACCOUNTING OFFICE REPORT

ENTITLED:

"Domestic Alumina Resources:

Dilemmas of Development"

Members of the Technology Advisory Board for the U.S. General Accounting Office (GAO) report entitled: "Domestic Alumina Resources: Dilemmas of Development" were asked to review a technical analysis of the competitive position of alternative processes for converting domestic aluminum bearing resources to alumina. This analysis, written by Prof. Joel P. Clark and Dr. George B. Kenney appears as Appendix II to the GAO report. Members of the Technical Advisory Board have not agreed to review or comment on the main body of the report and the inclusion of their names in Appendix I should not be construed to mean that any one or all of these persons are in agreement with the conclusions of the main GAO report.

APPENDIX VI

COLLEGE OF ENGINEERING

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Blacksburg, Virginia 24061

UNIVERSITY DISTINGUISHED PROFESSOR OF ENGINEERING (703) 961-6473

September 6, 1979

Mr. J. D. Peach
Director, Energy and Materials Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

My reply to your letter of June 27, 1979 has been delayed due to summer activities away from the university and the need to carefully analyze the report.

Appendix II which is the Analysis by Clark and Kennedy is reasonable and describes the limitations related to cost estimates. I find it appropriate.

I disagree with the conclusions and implications of the report. In my opinion the Bureau's program of nonbauxitic alumina research was not misdirected and at the time it was initiated and until the recent energy crunch of 1979, it did not ignore the reasons for overseas shifts. In my opinion the proprietary process is based on such preliminary bench scale work that it can't be evaluated and its development is being pursued by the proprietary owners.

While it is possible that the Bureau's nonbauxite process may not be competitive with overseas bauxite, it is a desirable technology to have available in case the supply of bauxite or alumina is cut off.

On the basis of these comments it would be inappropriate to identify me with the main body of the report as it is now written. I was Director of the Bureau during the early days of the program.

Sincerely,

Walter R. Hibbard, Jr.
University Distinguished Professor
of Engineering

WRH/bj

APPENDIX VI

THE UNIVERSITY OF MICHIGAN
MATERIALS AND METALLURGICAL ENGINEERING
ANN ARBOR, MICHIGAN 48109

August 30, 1979

Dr. Arthur Shantz
U.S. General Accounting Office
Room 5142
441 G Street, N.W.
Washington, D.C. 20548

Dear Dr. Shantz:

In response to the June 27, 1979 request from J. Dexter Peach, Energy and Minerals Division Director, I have reviewed the draft of the proposed report, "Domestic Alumina Resources: Dilemmas of Development" (008250) and the attached Appendix II, "An Analysis of the Competitive Position of Alternate Processes for Converting Domestic Aluminum Bearing Resources to Alumina" prepared by J.P. Clark and G.B. Kenny.

As a member of the advisory committee for the analysis presented as Appendix II, I wish to express my approval and endorsement of the Appendix as written.

However, with regard to the report draft itself, I wish to withhold judgment and offer no comment. I am enclosing a signed copy of the disclaimer statement prepared by Professor Clark.

Sincerely,

Robert D. Pehlke

Robert D. Pehlke
Professor and Chairman

Encl.
cc: J.D. Peach
J.P. Clark
J.C. Agarwal
W. Dresher
M.C. Flemings
M. Fuerstenau
J. Szekely
M.E. Wadsworth
W. Hibbard

APPENDIX VI

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE MASSACHUSETTS 02139

JULIAN SZEKELY
PROFESSOR OF MATERIALS ENGINEERING

ROOM 4-117
(617)-253-3236

July 27, 1979

Dr. Arthur Shantz
U.S. General Accounting Office
2401 E Street, N.W.
Columbia Plaza Office Building, Rm. 675
Washington, D.C. 20241

Dear Dr. Shantz:

I am writing to say that I was somewhat surprised both by the overall conclusions and the tone of your report, "Domestic Alumina Resources: Dilemmas of Development". Having served on the advisory board for the preparation of Appendix II, I found that document a reasonably well balanced statement of the current status of technologies that may be used for the production of alumina. The main thrust of Appendix II was that at present there is a great deal of uncertainty (viz the confidence limits in Table 4) regarding the relative merits of the competing processes. However, neither the Toth Process nor the HCl Sparge System can be discounted at this stage.

To my mind Appendix II, prepared by Drs. Clark and Kenney, is a carefully written, well balanced document, where a great deal of care has been taken to qualify the conclusions and inferences that may be drawn from essentially insufficient information.

Whether the data available at present would warrant major expenditures involved in the construction of pilot scale facilities or as the report suggested, further laboratory scale efforts and economic evaluations would be needed before the committment of major funds is made, is a topic on which reasonable people may disagree.

To my mind there is nothing in the technical report that would justify the clearcut statements and the sensational language used in your report (viz "The Bureau's program of nonbauxitic alumina research is fundamentally misdirected" [p. ii]; "...the Bureau's program ignores proprietary processes in favor of developing an unpromising public technology" [p. ii]; "Alumina Research and Development Focus is wrong" [p.V]). You should perhaps be reminded, Sir, that your task is to prepare a well reasoned document rather than to supply headlines for some of the less reputable newspapers.

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In all, while I am in general agreement with Appendix II of your report, I would like to disassociate myself formally from the conclusions that you have drawn from it. To my mind a substantial re-drafting of your report would be warranted in the light of these comments and of the other comments that you will no doubt receive.

You may even wish to arrange a meeting of all the key personnel to discuss with them whether their perception of this problem agrees with yours.

Yours sincerely,

Julian Szekely

cc. Dr. Ralph Kirby
U.S. Bureau of Mines

APPENDIX VI

THE UNIVERSITY OF UTAH
SALT LAKE CITY, UTAH 84112

COLLEGE OF
MINES AND MINERAL INDUSTRIES
OFFICE OF THE DEAN
209 W. C. BROWNING BUILDING
801 — 581-8767

January 29, 1979

Dr. Arthur A. Shantz
U. S. General Accounting Office
441 G Street N.W.
Washington D.C. 20548

Dear Dr. Shantz:

Attached you will find the draft report entitled, "An Analysis of the Competitive Position of Alternative Processes for Converting Domestic Aluminum Bearing Resources to Alumina," prepared by Joel P. Clark and George B. Kenney. I apologize for responding at such a late date but I spent one full month away from the campus during which time the report arrived on my desk. I have had difficulty in keeping up with my correspondence. I have read the report with great interest and I trust that my comments will be useful in your review procedures. My comments are summarized on the attached sheet.

Sincerely yours,

M. Milton Wadsworth

MILTON E. WADSWORTH
Professor of Metallurgy
and Associate Dean

MEW:d

att.

APPENDIX VI

Comments of the draft report "An Analysis of the Competitive Position of Alternative Processes for Converting Domestic Aluminum Bearing Resources to Alumina," by Joel P. Clark and George B. Kenny. I found the report to be very informative both regarding the highlights of the technical concepts and in regard to the economic analysis. In general the conclusions arrived at seem well justified. This is based upon the data and analysis presented in the report and not upon any external survey which I as a reviewer have done on my own. It seems appropriate nevertheless offer some comment regarding what I think is a lack of uniformity in the depth of coverage.

COMMENTS:

1. In regard to the nitric acid process the analysis seems to avoid addressing difficulties associated with the formation of nitrogen/oxygen intermediates. Based upon problems associated with nitric acid in other processes it would seem that a more detailed analysis of the formation and handling of nitrogen/oxgyen intermediates should receive some greater attention. The authors correctly point to potential loss of nitrate but somewhere in such an analysis the feasibility of nitrate recovery and the intrinsic problems associated with nitrate recovery could have been addressed.

2. The write up on the Anorthosite via The Lime Sinter Process appears to be essentially dismissed out of hand in the first part of the write up and then takes a turn with rather strong support based upon the fact that ALCOA currently holds two patents. This latter point is significant and should have resulted in a more detailed analysis of the patent literature. Superficially it appears that the Anorthosite process may have a more favorable prognosis for successful application than might be concluded from the report itself.

3. The sulfurous acid process is treated superficially in the report. This of course may stem from the fact that the Kaiser Engineers estimate the process has essentially attained its maximum state of development. The general conclusion however, that controlling SO_2 is a problem of major impact does not account accurately for recent developments in the handling of SO_2 emissions particularly where high strength gases may be maintained by close process control. The problem of handling SO_2 in terms of its enviromental impact was not treated with sufficient detail to reflect current technology in the field. The report would have been strengthened somewhat had this problem been addressed in some greater detail. In short the conclusions may be totally correct regarding SO_2 but the correctness of the conclusion is really not clear in the analysis itself.

4. In regard to the Carbo-Chlorination Process (page 32) the authors discussed the fact that fused solutions of aluminum and iron chloride are rectified under pressure. This comment is not clear to this reviewer and perhaps should be clarified. The authors seem quite obviously favorable towards the Carbo-Chlorination Process and from the data presented justifiably so. They also suggest the feasibility of coupling the carbo-chlorination process with the newly proposed ALCOA aluminum chloride smelting process. This is of course an intriguing thought expanded upon to some degree by the authors. It appears to this

APPENDIX VI

reviewer that coupling the new ALCOA process with any of the processes which can produce aluminum chloride is an end product represent interesting combinations. It would seem that the logic of combining the carbothermic with the ALCOA is clear but similarly it seems the hydrochloric acid sparging process and the hydrochloric acid extraction evaporation crystallization process coupled with the ALCOA process should receive some attention for the sake of consistency. Coupling other chloride processes may have some obvious drawbacks but these reasons should have been addressed.

The report is a very interesting report undoubtedly representing a detailed and significant compilation of information on the feasibility of treating potential alumina sources. The continuity of the report and the ease of reading would have been materially helped had the conclusions and problems been summarized in each section. The report is a valuable and significant compilation of the available information in the field.

LETTERS FROM ALUMINUM COMPANIES CONTRIBUTING TO REPORT

In the course of our review, we discussed the Bureau's nonbauxitic alumina research program with all companies participating in the miniplant program, as well as former participants. Most of these companies completed answers to prepared questions regarding their participation. A few companies agreed to more detailed interviews regarding the status of nonbauxitic aluminum research, their research activities, the outlook for domestic aluminum production, and their experiences with the Bureau of Mines research support. These latter companies were invited to comment, for the record, on our draft report.

The comments of the aluminum companies differed in tone and content. The Aluminum Company of America agreed with the overall conclusions of the referenced draft. Reynolds Aluminum agreed with our recommendations, but took issue with the underlying conclusions and data. Alcan Aluminum Corporation opposed our conclusion that the Bureau's research was misdirected, but supported many of our related judgements and recommendations regarding aluminum research. Kaiser Aluminum and Chemical Corporation believed our technical data were correct, but that our judgment and conclusions were biased. Toth Aluminum Company, toward whom the Department of Interior accused us of favoritism, hoped the report would lead to a reexamination of the Bureau's research priorities, but disagreed with our assessment of the domestic alumina extraction market.

The aluminum company letters are presented in the following sequence:

--Aluminum Company of America

--Reynolds Aluminum

--Alcan Aluminum Corporation

--Kaiser Aluminum and Chemical Corporation

--Toth Aluminum Corporation

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ALUMINUM COMPANY OF AMERICA
1200 RING BLDG. WASHINGTON, D. C. 20036

1979 August 17

Mr. J. Dexter Peach
Director/Energy and Minerals Division
United States General Accounting Office
Washington, D.C. 20548

Re: Proposed Draft Report/"Domestic Alumina Resources: Dilemmas of Development"

Dear Mr. Peach:

In general, Alcoa is in agreement with the overall conclusions of the referenced GAO draft. We have reviewed the three major concepts of the draft. The first, which is made very often, is that the Bureau of Mines program departed from the stated objective of investigating six processes in the mini-plant scale, so that the effort in economic evaluation and demonstration plant design was based on insufficient data and was therefore premature. Alcoa's position, which is essentially the same, is stated quite accurately on pages 37 and 38 of the report. The second major concept is that emphasis should be put on finding an aluminum process that would use a domestic ore and reduce the amount of energy required to make aluminum. Finally, the GAO and their technical advisors think that direct chlorination of clay, followed by smelting in the Alcoa Smelting Process, is the method having the best chance of economic success.

Specific comments and corrections are as follows:

1) Alcoa objects to the proposals concerning Government acquisition of information regarding proprietary processes. (Page 102-103) We question the ability of the government to safeguard information in light of the recent Freedom of Information Act decision. We question the need for in-house government experimentation in this area, and believe the DOE policy is superior to the Bureau of Mines policy, as stated on page 92 of the draft.

2) On page iv the summary states that industry urged the Government to develop a nonbauxitic alumina process. If this is so, the pressure came from companies other than Alcoa. We felt considerable pressure to join the Bureau of Mines' cooperative program.

3) Alcoa cannot verify assumptions underlying the GAO forecast of the use of aluminum in automobiles. (Page 65-66) If car manufacturers, for example, would alter their current mix and make a major shift to the production of small cars, aluminum penetration could be delayed.

4) In general, we agree with the assessment that primary expansion is taking place outside the United States. However, energy availability is equal in importance to energy cost. Also, the capital cost of new non-U.S. capacity can be greater than domestic cost, depending on specific location.

5) The economically competitive production of alumina by a chlorination process remains to be demonstrated.

6) Alcoa has been and is continuing to investigate a variety of domestic feed materials for aluminum chloride production.

7) We disagree with the statement on page 41 of the main report -- that dawsonite and alunite proprietary processes have fewer technological uncertainties than the clay/acid processes. This concept is unsupported.

8) We also disagree with the thought expressed on page 56, that higher bauxite prices create an incentive to transport alumina rather than bauxite. This overlooks the demands of the bauxite-producing countries for industrialization by construction of refining plants.

9) On page iv of the Digest, line 10, the word "all" should be replaced by the word "most".

10) On page 4, third line of the draft, we object to the statement that Alcoa and Pechiney "comprised an international cartel," since the word "cartel" implies active efforts to regulate markets. Also the statement ignores other major aluminum producers such as Alcoa, Alusuisse and British Aluminum.

11) In paragraph 3 on page 4, the DPC smelters and refineries were both built and managed by Alcoa. The proprietary technology installed in these plants was given by Alcoa to Kaiser and Reynolds without charge. This should be stated in that section.

12) In paragraph 3 on page 4, the separation of Alcoa and Alcan was made years earlier. I believe Alcan was never a subsidiary of Alcoa, but was controlled by some of the same individuals who controlled Alcoa. The courts ruled that those holding dual ownership had to choose one or the other and dispose of

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the appropriate shares. The entire section on the history of the industry could be improved.

13) Page 5, the first entire paragraph should be changed to read -- aluminum is the most abundant metal... In the following paragraph, the sentence should read -- dissolves the bauxite under heat and pressure, and precipitates alumina from a caustic...

14) On page 10 in the first paragraph under the heading "Aluminum Industry Pilot Plants," we object to the sentence that characterizes the aluminum industry as being influenced more by the prospects of avoiding R&D expenditures than by... This is gratuitous and certainly does not apply to Alcoa.

We wish to thank you for giving us the opportunity to review this draft report. We will be most happy to discuss the comments listed or answer any questions you or others might have dealing with the comments we have made.

Sincerely,

Gregory B. Barthold
Manager, Technical Programs

GBB:psp

REYNOLDS ALUMINUM
REYNOLDS METALS COMPANY · RICHMOND, VIRGINIA 23261

August 9, 1979

Mr. J. Dexter Peach
Director
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Peach:

We have reviewed a draft of a proposed GAO report entitled, "Domestic Alumina Resources: Dilemmas of Development (008250)." We find ourselves in the position of agreeing with most of the recommendations of this report and disagreeing with many of the underlying arguments and conclusions.

It is suggested that the best interest of all concerned would be served if the draft were rewritten to: (1) tone down the attack on the Bureau of Mines, (2) define specifically and accurately the original objective and commitment of the Bureau of Mines in its miniplant program for alumina from domestic resources, (3) recognize the fidelity of the Bureau to this commitment, (4) recognize the fact that the concentration of the Bureau on the HCl process means only that any one of the process options selected for examination will require an expenditure of $10-15 million in order to exploit the innovative concepts that are needed to develop an energy conserving process, (5) reexamine the arguments and conclusions regarding the viability of new U. S. capacity with the Hall Process cells in the light of (a) balance of trade consideration, (b) the projected value of the U. S. dollar if all expansion in U. S. consumption is met from foreign sources, and (c) the effect of this change in the value of the dollar on the cost to keep our existing domestic alumina plants operating, and (6) support the arguments with references to definitive analyses.

We believe that the original matrix concept of the miniplant program has not been abandoned. Statements to this effect have been made by Bureau of Mines officials in recent meetings of the Industrial Cooperators Steering Committee. What should now be clear is that each process examined via miniplant operations will probably cost from $10-15 million. The reason lies in an understanding of the nature of the process development job before us. To merely assemble an aggregate of proven process equipment and conduct generally accepted unit operations is to fail. Conventional approaches to acid processes for extracting alumina from clay, for example, consume around 50 million Btu/ton of alumina, when the energy equivalent of plant electrical power is added. This figure can be reduced to the range 30-35 million Btu/ton by innovative and imaginative process concepts. The Bureau of Mines has done this, at least in principle, with the HCl-gas sparging process. Reynolds Metals had done it, at least in principle, with a proprietary process employing nitric acid.

APPENDIX VII

To prove such innovations to a level of confidence meriting demonstration plant investment will probably require in the neighborhood of $10-15 million in miniplant expenses for each principal process option tested. Reynolds Metals Company spent almost a fourth as much proving the most critical of seven stages of its proprietary process. If carbochlorination is to be examined in the miniplant - as we feel it should be - we should expect to spend at least $10 million for miniplant studies of that process.

No such innovations were introduced and no such expenses were incurred in the miniplant work with the nitric acid process. This is why this process has not looked as good as the HCl-gas sparging process on subsequent economic evaluations.

In the absence of definitive analyses, or references thereto, we are unable to accept the conclusions to the effect that future capacity expansion to meet U. S. needs for aluminum must be outside the United States, unless the Hall-Heroult process is replaced with processes such as the Alcoa chloride process. Modern Hall-Heroult cells can produce aluminum for 6 kwh/lb. We understand that the claim for aluminum chloride electrolysis is in the range 4.2 to 4.5 kwh/lb. It needs to be established that such a difference is sufficient to drive new capacity abroad where the wealth would then be created to be sold in the U. S., contributing to our balance of trade deficits and relative devaluation of our currencies. The probable effect of such devaluations on the cost to produce alumina in our existing plants needs to be shown. Whereas we commend efforts to develop processes requiring less energy than the Hall-Heroult process, we feel that technology should be made available to economically produce alumina from domestic non-bauxitic sources, for use in Hall-Heroult cells.

We do not use or agree with the definition of annual ton given at the bottom of page 62.

A comment we wish to make concerns remarks made in the first full paragraph of page 67. The entire auto analysis is suspect, and conclusions have been drawn about the entire aluminum industry after having looked in detail only at the automotive market. But it is a major error to compare the forecasts for aluminum usage in autos in 1985 to present domestic primary capacity and draw conclusions about tightness in the markets.

First, the best available evidence, (Aluminum Association survey) shows domestic capacity in 1985 will be above present primary capacity. Second, secondary recovery constitutes about 25% of total supply which has been ignored in the mentioned paragraph. The resulting number of 52% of domestic primary capacity devoted to transportation needs is both high and misleading. Our own forecasts of essentially that same number show it to be well under 30% when the correct supply total is used.

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Turning now to the economic estimates given in the draft report, we believe that, although the Kaiser Engineers' estimate for the nitric acid process probably represents a fair estimate for the design studied briefly and inconclusively in the miniplant program, estimates we have made on a different process configuration are about the same as for the HCl-gas sparging process. By the time a 30% R.O.I. is added to the large investments forecast for the acid processes, the figures for product cost get so high that it is easy to see why a cursory study would lead to the conclusions reached in this draft report. However, it should be pointed out that plants large enough to be competitive by any process would be financed largely by loan, perhaps as much as 75%. The product costs arising from adding 30% of the investment to plant level costs reflect an effort to make substantial profits on money borrowed. This distorts the true competitive situation. A discounted cash flow analysis, wherein the product cost reflects the price one would have to get to repay the loan with interest and return 15% after tax on outstanding equity would be substantially lower and would not penalize the fledgling processes as much as the 30% of R.O.I. method does. We find that the discounted cash flow method places the acid processes within 25% of a modern Bayer facility operating in the U. S. on Australian bauxite, in terms of the present value of cost over a project life of 30 years. No extraordinary contingency allowances are embedded in these figures to account for the current technological uncertainties of the unproven acid processes. The purpose of miniplant and pilot plant work is to reduce such uncertainties to commercially acceptable levels in the most economical manner.

Upon completion of the miniplant work on the HCl-gas sparging process, the industry should be in a position to go forward rapidly with the development of commercial plant designs whenever they appear to be necessary. Until such necessities arise, the miniplant could be used to develop the same kind of information for the other principal processes, one of which might turn out to be better than the HCl-gas sparging process.

The miniplant matrix concept is intact, but somewhat altered as to the contestants. We would agree with the GAO report recommendation that carbochlorination be included in that matrix and suggested in a communication dated April 23, 1979, to the Director of the Bureau of Mines that it be considered. However, we are not recommending that any particular proprietary process be the subject of miniplant tests. We believe the nitric acid process should be kept in the matrix with the objective of testing new process steps to overcome the difficulties found in the first set of miniplant runs. However, we would recommend that miniplant studies on carbochlorination precede those on the nitric acid process.

We agree with the recommendations to the Congress and the Secretary of the Interior.

We agree to the need for coordination of Department of Interior and Department of Energy programs relating to aluminum technology. We reserve judgment as to the specific recommendations for the Office of Science and Technology Policy until more information is available as to the methodology and

APPENDIX VII

qualifications of personnel to be used for such studies. Specifically, with respect to Item 5 of the recommendation respecting the Office of Science and Technology Policy, we believe the rules of creditability for all processes considered should be the same. It is not clear whether or not these recommendations regarding the Office of Science and Technology involve the elimination of the Industry Cooperators' role in guiding the work of the Bureau of Mines on alumina from domestic resources.

Our position is summarized by responding statement by statement to the "Digest" provided with the draft report. This is attached.

We appreciate the opportunity that has been given to us to review this draft report, and hope that our comments will be of service to the General Accounting Office.

Very truly yours,

R. M. Kibby
Coordinator
Research and Development
Primary Metals Division

RMK/msc

Attach.

cc: Mr. R. H. Featherston

APPENDIX VII

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

DOMESTIC ALUMINA RESOURCES:
DILEMMAS OF DEVELOPMENT

D I G E S T

ALUMINUM RESEARCH
AND ALUMINA RESOURCES

Page ii - "The Bureau's program of nonbauxitic alumina research is fundamentally misdirected."

Not necessarily - would be better to say "may be misidrected, needing careful re-examination in view of disclosures since 1974 of technologies not on the original list of projects to be examined in the miniplant program."

"There is little evidence that such alumina is likely to be competitive with conventional bauxitic alumina."

The evidence supplied by the Kaiser Engineers' report seems to support the expectation that the hydrochloric acid process could be sufficiently economical to serve as insurance against disruption of foreign supply of alumina. This was the original intent of the program.

"Second, the program ignores the major capital and energy-related cost factors that are shifting new primary aluminum capacity overseas."

We understand the reason for this may be political. The program was designed in 1973 to fulfill a commitment to certain political figures. Energy was not the issue then as now. Perhaps faithfullness to this commitment, in view of present circumstances, is unsupportable and the objective of the program should be restated.

"Only radical changes in the conventional production process, such as skipping the alumina phase entirely or dramatically reducing the costs of the energy-intensive smelting stage, can make new U. S. aluminum capacity globally competitive."

A process requiring less energy could be applied worldwide, so the advantage to the U. S. may be limited. The alumina phase can not be skipped entirely; process steps must exist somewhere in the system to separate aluminum from impurities.

Page iii- "Bauxite is a porous, heterogeneous mixture of materials containing alumina."

Bauxite also contains iron, silicon and other oxides which must be separated before commercially pure aluminum can be produced.

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COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

DOMESTIC ALUMINA RESOURCES:
DILEMMAS OF DEVELOPMENT

D I G E S T

ALUMINUM RESEARCH
AND ALUMINA RESOURCES

Page v - "We consider both the creation of a successful nonbauxitic alumina technology, and its presumed result most unlikely."

We do not agree. Process innovation will be required. But such innovations have come forth, and we should expect that others will come forth in the future with a well organized R & D program.

Page vi - "Nonbauxitic alumina resources will not be developed as a result of substitution for bauxitic alumina. They are not price competitive."

It is premature to conclude this.

"The real, constant dollar cost of bauxite would have to more than double before the Bureau's best nonbauxitic process technology can be substituted for bauxite."

Who is ready to guarantee that the real constant dollar cost of bauxite will not double in the next 20 years? Where does this report account for the national interest in terms of balance of trade?

Page vii- "Even if nonbauxitic alumina were cheaper, new conventional, primary aluminum capacity would probably not be built in this country. Energy-related infrastructure costs of new, conventional aluminum smelting capacity are higher here than in some other countries."

Conventional primary capacity most assuredly will be added in North America, if only to add potlines to existing plants.

"Alumina costs constitute only a small portion of the total costs of making aluminum."

Alumina costs in the U. S. account for a large portion of total costs of making aluminum - in some cases well over 30%.

Page viii-"Moreover, these estimates rest on miniplant technology-assessment costs which have been so understated in the past that they suggest substantial ignorance."

A possible reason for understatement of miniplant costs is that early estimates appear to have understated the need for innovative process steps to conserve energy and the R & D requirements to meet those needs.

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COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

DOMESTIC ALUMINA RESOURCES:
DILEMMAS OF DEVELOPMENT

D I G E S T

ALUMINUM RESEARCH
AND ALUMINA RESOURCES

Page ix - "Two proprietary processes, one producing aluminum chloride from kaolin clays and the other reducing aluminum chloride to aluminum, if combined, might offer significant capital and energy cost savings."

We agree with the potential of the carbochlorination processes to challenge foreign Bayer process costs when operating in the U. S. on domestic ores. But it is not at all certain that any currently announced proprietary process will do this.

We agree with the theoretical superiority of chloride cells operating on anhydrous aluminum chloride from domestic resources. Insufficient evidence has been made public to support the belief that any present proprietary process or combination of them will accomplish this.

While it is agreed that proprietary processes should be evaluated, it is just as dangerous to settle on one of them at this time as it is to continue the present course of public R & D on domestic non-bauxitic resources.

Page x - "The Bureau has ignored both direct reduction of aluminum processes and the possibility of energy coproduction processes as means of developing nonbauxitic alumina resources"

As suggested earlier, this may be nothing more than faithfulness to an old political commitment. The Bureau should be given a chance to respond to new directives reflecting the political realities of today.

"Foreign production of aluminum may be so much cheaper than new domestic aluminum capacity that research and development of nonbauxitic alumina resources could be futile."

This conclusion should be made more definitive and the risk of being wrong should be estimated.

Foreign faciliteis are not a panacea. U. S. workers are still much better at getting a complicated job done than workers in many countries with abundant power.

"The benefits and costs to our economy of relying on foreign aluminum supplies should be carefully examined before concluding that changes in the operation of international aluminum markets are necessarily desirable."

We agree.

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COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

DOMESTIC ALUMINA RESOURCES" DILEMMAS OF DEVELOPMENT

D I G E S T

ALUMINUM RESEARCH AND ALUMINA RESOURCES

Page xi - "In the light of our findings in this report, we recommend that the Congress consider the following supportive measures:

"(1) Reject as premature any further requests for pilot-plant appropriations, such as for site selection and procurement, until the Secretary of the Interior publishes in summary form, the essential comparative economic assessment of all public and proprietary nonbauxitic technology processes."

We would agree.

"(2) Appropriate funds for the Office of Science and Technology Policy to conduct a study for the Departments of Energy and Interior reviewing research, both public and private, on nonbauxitic alumina resource development and specifying the major technology options which should be pursued."

We would agree.

Page xii - RECOMMENDATIONS TO THE SECRETARY OF THE INTERIOR

"We recommend that the Secretary of the Interior through the Director of the Bureau of Mines:"

(1) May be worthwhile, but somebody has to make a judgment as to whether the proprietary processes will perform as estimated with the facilities forming the basis of the capital estimate.

(2) We understood that KE was going to do this under the contract with the Bureau.

(3) We agree -- after the preliminary evaluations have been made and if they support a shift in direction.

Page xiii- (4) A reexamination would produce a different set of numbers than those already existing. What basis would one use to say that one set is better than another?

(5) This should include balance of trade considerations.

Page xiv- RECOMMENDATIONS TO THE DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

(1) - (4) Sounds reasonable to coordinate activities of Departments of Energy and Interior.

Page xv - (5) Processes not in the Bureau of Mines program should have the same rules of verification as those applied to the Bureau, or appropriate contingency allowances made.

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Alcan Aluminum Corporation

Suite 800 [illegible] 1701 Pennsylvania Avenue N.W. Washington [illegible]

31 August 1979

General Accounting Office
Room 5144
441 G Street, N.W.
Washington, D. C. 20548

Attention: Dr. Arthur A. Shantz

Dear Dr. Shantz:

We refer to the draft report "Domestic Alumina Resources: Dilemmas of Development" which was forwarded to us with covering letter of 27 June 1979. While we consider the report a valuable contribution to the debate on the materials issue, we do have substantive differences with the report's position on:

I. The H-Plus Process

II. The Bureau of Mines Miniplant Project

We also comment on various technical or typographical errors.

I. The H-Plus Process

On pages 10 and 11 the report includes a number of inaccurate and speculative statements. Since Alcan and Pechiney will have spent in excess of $30 million on the H-Plus process, and Anaconda, Alcoa, Alumet, and others have also spent significant amounts on alternative processes, the statement that the "aluminum industry seems influenced by the prospects of avoiding R&D expenditure" obviously is not correct. We would also dispute that the H-Plus pilot run "offerred less than satisfactory solutions to problems associated with commercial development of nonbauxitic alumina," and we would prefer not to have an uninformed, if not imaginary, "corporate financial officer" expressing opinions on our decision to proceed with the development of the H-Plus process, or the potential for recovery of expenses from sales of technology.

Other statements appearing on pages 10 and 12 seem to imply that closing a pilot plant reflects dissatisfaction with the process. Pilot plants, by definition, are not designed to economy of scale, hence are not viable operating plants. They are designed to run for the minimum time necessary to provide specific information; since they generate no income, one does not keep them running after the information has been obtained. It is, therefore, incorrect to infer that since several pilot plants have been closed down, operating them was a mistake, or that they were unsuccessful.

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II. The Bureau of Mines Miniplant Project

The draft report criticizes the handling of the Alumina Miniplant Project by the Bureau of Mines for the following reasons:

1) The 1974 program called for miniplant testing of six specific processes. After a detailed study (which included miniplant work) the Bureau selected one process for further work and decided not to proceed with miniplant testing of the others at this time. Miniplant and other development work was thereafter mainly concentrated on the selected process, leading to the preliminary design of a pilot plant.

2) The selection of the clay/hydrochloric acid, gas induced crystallization process as the best of the six processes examined is suspect and probably is not the best choice.

3) Proprietary processes were not considered.

4) In its planning the Bureau has not taken into account the possibility that new alumina plants may not be built in the United States, and that the future appears to lie with aluminum chloride coupled with an Alcoa smelting process, or with some as yet unspecified direct-reduction process.

We strongly disagree with the conclusion that the miniplant program has been misdirected by the Bureau of Mines. Alcan joined the program with the primary objective of obtaining cost data for various alumina producing processes, and we consider this objective to have been achieved. The development of the best of the alternatives considered to a pilot plant design stage we also feel is a very worthwhile objective.

Although the emphasis changed from developing an information matrix for all six processes to identifying the best process and developing our knowledge of it, this change appears logical, since there seems to be little benefit in generating information on projects which due to their cost have already been shown to be of academic interest only.

The conclusion in Chapter 6, page 90, and other sections in the report gave the impression that the GAO is surprised that the miniplant program concentrated on one process and did not generate an equal amount of data for other unspecified number of processes. In our view we have neither the time nor the money to generate new data simply for the sake of doing so; according to the GAO report most of the time since 1974 and most of the 9 million dollars spent thus far on the program have been used to generate data for one process only.

We also feel if the most up-to-date information -- including proprietary data if available -- is taken into account, the clay/hydrochloric acid, gas induced crystallization process will continue to show up as the best of the six processes examined by Kaiser Engineers.

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The GAO report attaches too much significance to the probability that alumina from alternate sources will be more expensive than Bayer alumina. We think all suspected this might be the case when the program was initiated. The important thing, in our opinion, however, is to determine how much the difference in cost is.

The fact that proprietary processes were not considered does constitute an important disadvantage, but this is hardly the fault of the Bureau of Mines, since companies are unwilling to supply proprietary data because confidentiality cannot be guaranteed under the present system. We would support a recommendation that companies with proprietary data meet with the Bureau and other involved personnel to examine whether there is some way of allowing the evaluation of their processes while guaranteeing confidentiality of data.

With regard to (4), although the report makes a good case for considering processes other than those which produce alumina, we do not consider that there is sufficient evidence to justify a severe change in direction at this time. North America has about 6.5 million tons of smelter capacity based on alumina which must be protected, and certainly not everyone believes that bauxite prices will decline indefinitely, since apart from IBA generated increases is the simple fact that bauxite quality, accessibility and availability will inevitably deteriorate in time, causing real cost increases. We are, therefore, unwilling to drop the development of alumina processes in favor of pursuing processes which may or may not be technically feasible and which would require the use of an undemonstrated smelting technology, the true worth of which is only known to one company.

We, therefore, do not agree that the Bureau's allocation of its primary effort to alumina production by a credible process constitutes grounds for an allegation of misdirection.

Alcan has made a detailed study of a proprietary clay carbo-chlorination process and has concluded that the chemistry of the process is not adequately developed. Necessary modifications which we consider to be obvious would have a significantly adverse impact on capital and operating costs. In addition, there are steps in the process critical to its success which we feel have not been satisfactorily demonstrated, and while it is not impossible for these to be resolved eventually, it is our opinion that the necessary work might take several years with no guarantee of satisfactory results in the end. In terms of development, we consider the carbo-chlorination of clay to be 5-10 years behind processes which make alumina by an acid route.

We would caution the GAO to differentiate between the technical feasibility of alumina production by the hydrochloric acid gas sparging process, which is certainly possible and has had its major steps checked in the miniplant laboratory or on various pilot plants, and processes which do not have satisfactorily substantiated flowsheets and require very significant development effort before enough information would be available even for the design of a pilot plant.

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Alcan, however, sees merit in examining clay carbo-chlorination and other direct reduction processes provided this is added to the present program and that it does not detract from work in progress on the clay/hydrochloric acid induced crystallization process.

It is necessary to be aware that emphasis on the development of chloride processes may entail restricted commercial application since much of the current technology is proprietary and controlled by one company.

At least two of the recommendations for this involvement of the Office of Science and Technology Policy seem to be duplications of studies proposed elsewhere. It is not clear to us how the overall purpose of the project will be assisted by the involvement of another government agency.

We feel that the Clark and Kenney paper is a competent and objective study, but one which could be improved by the incorporation of information which has become available recently. In this connection, equipment for the indirect decomposition of aluminum chloride hexahydrate has now been satisfactorily demonstrated, indirect decomposition of aluminum chloride can certainly reach the 90%, if not 95% level; two crystallization steps are necessary to reach purity requirements for both the hydrochloric acid processes, sufficient pilot-scale work has been carried out on gas-induced crystallization to permit adequate assessment and design.

III. Technical or Typographical Comments

1) The H-Plus process uses hydrochloric and sulphuric acids, not sulphurous acid.

2) The H-Plus process can use feeds of kaolin, coal shales or coal washings, and non-carboniferous shales, and is not restricted to low grade alumina ores. Brown coal is not a preferred feed.

3) The list of pilot plants given on pages 10-13 omits, among others, the Alumite plant operated by Alumet.

4) Figures quoted on page 86 for the energy requirement for Bayer alumina production are substantially incorrect and misleading, although it is true that energy costs for smelting are more critical to the cost of the finished production. A 1975 Battelle Columbus study estimates that in 1974, the energy required to produce alumina in the U.S. was 47 million BTU per ton of aluminum compared with 196 million BTU per ton for smelting.

IV. Summary

In summary, Alcan's response is as follows:

1) The erroneous references to the H-Plus process should be corrected and the speculative comments on the pilot plant operation deleted;

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2) The Alumina Miniplant Program has not been misdirected by the Bureau of Mines;

3) Work on the design of a pilot plant to produce alumina from kaolin by the hydrochloric acid gas induced crystallization process should be continued at its present priority level;

4) The possible application of proprietary processes should be re-examined;

5) Progress in the development of chloride-producing and direct reduction processes should be monitored.

Yours very truly,

J. P. Monaghan

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KAISER ALUMINUM
& CHEMICAL CORPORATION

July 27, 1979

Mr. J. Dexter Peach
United States General Accounting Office
Washington, D. C. 20006

Dear Sir:

Thank you for the opportunity to comment on the draft report "Domestic Alumina Resources: Dilemmans of Development".

We have studied the 158 pages of the report at great length and in detail and although there are a number of errors in the body of the report, we will restrict ourselves primarily to commenting on the conclusions presented in the "Digest" of the report.

Our comments are attached.

We notice that Arthur Shantz is planning to present this paper at the A.I.Chem. E. meeting in Boston in August. We presume the commitment to this meeting was made several months before you asked for our comments. Nevertheless, we hope that you will take our comments into account when presenting this paper and in the final draft of the report.

Sincerely yours,

W. H. Cundiff
Engineer & Technical Services
Manager - Raw Materials Division

WHC/lsm

Att.

cc: R. Maier

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KACC COMMENTS ON DRAFT REPORT

DOMESTIC ALUMINA RESOURCES: DILEMMAS OF DEVELOPMENT

P ii, line 1, GAO Report

"The Bureau's program of nonbauxitic alumina research is fundamentally misdirected. First, it attempts to produce alumina as an intermediate product from nonbauxitic ores. There is little evidence that such alumina is likely to be competitive with conventional bauxitic alumina."

KACC Comment

We disagree. Recent improvements in Hall cell efficiency will make them competitive for a long time to come. Therefore, R & D work on improving the costs and security of supply of alumina, as a feed to these cells, is important and should not be dismissed as, "misdirected".

We also disagree with the statements as to the competitiveness of alumina produced from nonbauxitic ores. For example, although the report claims, - "the economics of bauxitic alumina are far superior" - p. vi; Table 5 of Appendix 2 of this report shows a total production cost of $331 per ton of alumina from clay versus $310 per ton of alumina from bauxite. Considering the accuracy of the estimates we would define this as competitive.

P ii, line 7, GAO Report

"Second, the program ignores the major capital and energy related cost factors that are shifting new primary aluminum capacity overseas".

KACC Comment

We disagree. Firstly, we know of no capital related cost factor favoring overseas primary aluminum capacity. In most cases they cost more due to the remoteness of the plant site which has to be near a relatively cheap energy source. Secondly, there is no economic reason why an overseas smelter should not be supplied from a U.S. located alumina plant using a domestic ore. KACC ships alumina from the U.S. to overseas smelters today.

P ii, 2nd paragraph, GAO Report

"Finally, and critically related to preceding deficiencies, the Bureau's program ignores proprietary processes in favor of developing an unpromising public technology.

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KACC Comment

Proprietary processes have not been ignored.

Toth was invited to present his process to the miniplant steering committee with no result. Alcoa was asked if it would permit a detailed review of its Anorthosite process and declined.

We would be very surprised if Alcoa would make their $AlCl_3$ cell process available to anyone at this time.

P vii and P viii,
2nd paragraph, GAO Report

Non bauxitic alumina research and development has also been justified as a supply security measure ..... financing a pilot plant would add little to the country's supply security".

KACC Comment

We cannot see the logic in this. If a successful pilot plant is built then we have the basis for producing alumina from U.S. clay. Although this of itself will not make the U.S. independent of foreign bauxite, it would bring us much closer to that goal.

In that the Clay/HCl process is much more developed than the Toth process, for example, we could probably reach this goal of independence several years earlier with the Clay/HCl process.

General Comment

We assume that the economic opinions which are propounded in the main body of the report are based on Appendix 2 written by Clark & Kenney. However, one would not think so in reading the report. Mr. Shantz seems to take the results of Clark & Kenny and color them as necessary to make his point. For example, as already mentioned, on page vi of the digest, Mr. Shantz claims that "the economics of bauxitic alumina are far superior" when in fact they are only 7% better.

Mr. Shantz gives the impression that the work done on the Kaiser Engineers contract was inferior. In contrast, Clark & Kenney say it was "competent".

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TOTH ALUMINUM CORPORATION

September 20, 1979

Mr. J. Dexter Peach, Director
Energy and Minerals Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Peach:

We at Toth Aluminum Corporation (TAC) appreciate the opportunity to review and comment on the draft copy of the proposed General Accounting Office (GAO) report entitled "Domestic Alumina Resources: Dilemmas of Development". The draft report was copied to TAC Directors and copies were circulated internally within TAC for critique and comments, and all parties were requested to treat the draft as the confidential property of the GAO. Although we have referred to this proposed report in discussion with outsiders, all such references have been deliberately general and non-specific.

It is indeed gratifying to see TAC's clay carbo-chlorination processes receive the serious attention of a United States Government Agency. As outlined in an August 6, 1979 letter from our Senior Vice President, Mr. Alfred Lippman to Mr. John Hadd of your Division, we have contacted the United States Bureau of Mines (USBM) on several occasions without being able to elicit more than cursory interest in our processes. Despite the fact that Mr. Lippman has kept the USBM fully informed of our progress and successes in overcoming their specific objections to clay chlorination, we have remained singularly unsuccessful in convincing the Bureau to modify its stance that "direct chlorination of clay is entirely impractical"(1), and to include clay chlorination in their nonbauxitic alumina investigations.

Having read your draft report and tracing the decision processes culminating in the USBM's choice of the hydrochloric acid leach/gas-induced crystallization process, their reluctance to include clay carbo-chlorination in their miniplant study becomes much more understandable. The USBM had apparently shifted away from their six-process miniplant data development objective to a program in which they were simply developing data for the design of a pilot plant for a single non-proprietary process, selected by consensus as the most economical. Apparently once this commitment was made no other process candidate could or would be considered.

(1) Letter,T.A. Henrie (USBM) to A. Lippman (TAC), May 6, 1975

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APPENDIX VII

Hopefully your thorough impartial review of the nonbauxitic aluminum research and development program will result in a reassessment of the program mission and a reexamination of all potential processes. Under these conditions we have little doubt that clay carbo-chlorination will prove to be highly competitive.

In this regard our assessment of the importance of a domestic alumina extraction industry differs somewhat from that expressed in your draft report. We agree fully, and have so stressed in presentations on the potential of TAC carbo-chlorination processes, that domestic non-bauxite aluminum technology will acquire significance only insofar as it reduces the total energy cost in producing the metal; as by direct Alcoa electrolytic smelting of aluminum chloride produced by TAC carbo-chlorination of domestic clays.

Projected savings of such integrated processing are shown dramatically in Table 2, page 79 of your draft report where projected TAC-Alcoa aluminum plant capital and metal production costs are lower by 32% and 22% respectively than those of a conventional new Bayer-Hall plant. Alcoa's claim of over 30% reduction in electricity consumption in smelting, and TAC energy savings of 10-20% over Bayer (through elimination of the aluminum chloride to alumina oxidation step) plus the TAC process substitution of lignite or low grade coals for high grade Bayer fuels, should provide great incentive to the Department of Energy to fully investigate this integrated TAC-Alcoa aluminum production scheme.

The reduced capital and energy costs of the above scheme, together with possible federal concessions similar to those offered by foreign governments such as tax holidays, credit guarantees, low interest loans and outright grants, waiver of environmental protection regulations,etc might provide sufficient incentive to the aluminum industry to reduce the present shift to offshore plant construction.

However the fact still remains that approximately 13 million tons of bauxite and 3 million tons of refined alumina must be imported each year to feed our domestic primary aluminum industry. This 90+% dependence on imported raw materials and the associated imbalance of trade could be significantly reduced through the establishment of a viable domestic Alumina industry.

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In this regard you might wish to consider rephrasing the summary section on page (vi) of the draft report, where it states that when comparing "the operating and capital costs of seven nonbauxite alumina processes and those of conventional bauxite alumina...the economics of bauxite alumina are far superior". This statement conflicts with the conclusions reached at several points in the draft report; for example page 97 paragraph two states "clay/carbo-chlorination offers very substantial potential energy-and-capital-cost reductions". Projected capital costs for clay carbo-chlorination are shown in Clark and Kenney's report (Table 1, page 4) and mentioned in your draft report on page 89. In both cases costs are projected to be significantly lower than those for Bayer.

Projected production costs for clay carbo-chlorination are shown in your Table 2, page 85, and are very much lower than new Bayer plant costs. The present market price of Bayer alumina is lower than the projected alumina price since the projection reflects the inevitable price rise forced by the construction of much more expensive new Bayer plants built to supply the rising demand for aluminum.

Thus we feel that a strong case exists right now to pursue the development of relatively low cost alumina plants in this country, if only to replace the 3 million tons per year of imported refined alumina. From the energy consumption figures in your Table 3, page 87a, this could result in a saving of 3.3 million barrels per year of fuel oil or 4-5 million barrels a year of imported crude. Of course additional reasons for a domestic alumina industry would be to limit the potential rise in bauxite prices on the world market and to assure availability of alumina to existing U.S. Hall-type smelters against possible interruption of supply by political,military or any other actions.

In this regard it is particularly significant to note that TAC carbo-chlorination technology, despite the relatively young state of its development, appears highly cost competitive with the 100-year old established Bayer technology. TAC technology has been demonstrated fully in bench-scale tests, and TAC miniplant testwork, carried out in four and six inch diameter fluid bed reactors has verified the results of clay carbo-chlorination processing through aluminum chloride production. In addition, although the TAC processes are proprietary in catalytic and other aspects, the overall carbo-chlorination system is closely related in a unit operational sense to well established commercial processes, such as rutile and ilmenite chlorination, mixed chlorides rectification and titanium tetrachloride oxidation operations in the titanium industry. Such considerations should add significantly to confidence levels in projecting operating results and/or cost estimates of TAC clay carbo-chlorination processes, whether the end product be aluminum chloride or alumina.

The above considerations are particularly pertinent in reference to your definition of dawsonite in the section following page (xv). I sincerely question your choice of wording in referring to dawsonite processing as the "most attractive economic alternative to Bayer-bauxite". Your discussion of dawsonite processing on page 88 indicates little to favor it as a viable alternative to bauxite. Furthermore studies on the recovery of alumina from dawsonitic oil-shales have identified several serious economic obstacles including low alumina grade, disposal of co-product Na_2CO_3 and $NaHCO_3$, both low priced chemicals, mining costs etc. These are discussed in a little more detail in Attachment B. On the other hand, your cost data indicate that if any process warrants the "most attractive" description, it is TAC clay carbo-chlorination.

Also under the Definitions section, the clay carbo-chlorination process definition should include reference to alumina production, as for example: "A proprietary process for producing aluminum chloride and/or alumina from kaolin clays and other aluminous materials. a promising option for the production of aluminum domestically". Then under the definition of Pullman Kellogg, the phrase "and alumina" should be added after "aluminum chloride".

In discussions of the HCl-processes for alumina production Clark and Kenney pages 17 and 22 raise concerns about the use of fluid-bed clay calciners that might generate excessive amounts of partially dehydrated fines. Our experience with a six inch diameter fluidized bed calciner operating at 750°C and 1 ft/sec superficial velocity with a 50% minus 50-mesh feed, was that only 15% of the calcined clay reported to dust collectors and this dust was approximately 90-95% dehydrated. Recycle of this amount of dust to remove the remaining water should present few problems in an integrated plant.

Another concern was variation in aluminous ore composition as mentioned on page 48, line 1, of your draft report and pages 2 (last paragraph) and 3 of the Clark and Kenney report. Kaolin clay composition variations (quoted by Clark and Kenney as: Al_2O_3, 36.5%-29.2%; Fe_2O_3, 0.9%-1.7%; "Others", 2.7%-54.%) must have some effect on any process treating the clay to extract alumina. However clay carbo-clhorination is relatively insensitive to feed variations in these ranges. Indeed, taking the worst case figures from the above ranges, projected plant capital costs would increase by only 2.4% and production costs by only 9%--still far below estimated new Bayer plant costs.

Other comments and suggestions are more editorial in nature and are included in Attachment A. Many of these comments stem from the fact that clay carbo-chlorination has projected capital and production costs clearly superior to new Bayer plants, while the six processes reviewed by the USBM and Kaiser Engineers do not. It appears however that this fact was overlooked at times during the report writing so that conflicting statements occur at several places in the draft. Our comments in Attachment A are offered to assist you in eliminating these apparent inconsistencies.

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Your excellent, candid evaluation of the cooperative USBM-Aluminum industry nonbauxite study has revealed several basic flaws in the research and development approach taken. No attention was paid to the very real problem of reducing capital and energy costs in developing a domestic raw material-to-aluminum process. Furthermore the program automatically and somewhat arbitrarily eliminated promising proprietary processes such as clay carbo-chlorination and oil-shale/dawsonite coprocessing from consideration.

Your report recommends that the Office of Science and Technology Policy initiate a review of the alumina/aluminum research and development programs and objectives of the Departments of Energy and the Interior, including an evaluation of promising proprietary processes. After many fruitless expensive years of trying to interest federal bureaus in our technology, we are in full agreement with your recommendation for such a systematic approach to process evaluation. Consistent with our retaining proprietary rights for our clay carbo-chlorination processes, we would be pleased to cooperate with your office, the OSTP, DOE, DOI or any of their divisions in this evaluation work.

We have prepared non-confidential reports that broadly describe the TAC clay carbo-chlorination process and include sufficient technological and forecast data to permit prompt evaluation of process potential. Copies could be made available to those involved in the investigation, and we would be pleased to offer further assistance if such were deemed necessary.

Our intent in offering these comments and suggestions is purely constructive, and hope sincerely that they prove useful to you. Please feel free to call or contact us at any time.

Yours sincerely,

TOTH ALUMINUM CORPORATION

Dr. Gervase M. Chaplin
Vice President
Engineering and Technology

GMC/bf

cc: Dr. Arthur A. Shantz,
Energy and Minerals Division
United States General Accounting Office
Washington, D.C. 20548

Encl: Attachments A, and B

APPENDIX VII

ATTACHMENT A

Editorial Comments: Kindly note that these comments and suggestions are made with the most constructive intent possible--in no way are they intended to slant the thrust of the report. However where conflicting statements appear in the report, factual (per your report) corrections are suggested without reservation or bias.

Page	Par.	Line	Comment
iii	2	4	After "However," add "kaolin clays ," Omit "other." Sentence to read: "However, kaolin clays, alumina - bearing oil shales,..."
vi	2	9	After "far superior" add "to those of all processes except clay carbo-chlorination, which has projected capital and production costs significantly lower than Bayer". Then omit or modify twelve lines "The real,... from bauxite".
vii	1	1	Rewrite line one: "However even if nonbauxite alumina were very much cheaper,"
Definitions: (Rewrite)			Clay/carbo-chlorination process: "A proprietary process of Toth Aluminum Corporation for producing aluminum chloride and/or alumina from kaolin clays, bauxites and other aluminous ores; a promising option for the production of aluminum domestically, but not investigated by the Bureau of Mines."
Definitions: (Rewrite)			Dawsonite: Eliminate " and the most... Bayer-bauxite:
Definitions: (Add)			"Kaolin Clay. A fine white clay containing alumina, silica and water. Vast tonnages are located in Georgia, Arkansas, Oregon, Oklahoma, and Texas and other states."
Definitions:			Miniplant: line 1, omit "metallurgy process models" and insert "metallurgical processing plants"
Definitions: (Rewrite)			Pullman-Kellogg: "Consulting firm that independently analyzed the feasibility of producing aluminum chloride and alumina from domestic kaolin clay using the TAC carbo-chlorination process, in a proprietary 1978 study."

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Page	Par	Line	Comment (Continued)
75	3	3	After "Mines," add "which did not include the clay carbo-chlorination or dawsonite processes,"
78	4	2	Change paragraph "Unfortunately these numbers... inquiry worthwhile." The figures cited in Table I were updated from the 1975 Arthur D. Little report to reflect 2nd quarter 1978 costs using 6.7% per year escalation, or an escalation index of 1.215 for the three year period.
79	Table 1		Add "-* Cost basis second quarter 1978".
79	Last Sentence		Omit "Current...level". Add "The clay carbo-chlorination process steps have been fully demonstrated at the bench scale, and the major three fifths of the process, clay calcination, carbo-chlorination and aluminum chloride condensation have been demonstrated in TAC's miniplant".
80	1	3	After "through the" add "alumina production"
80	1	8	After "chapter 2." add "Development costs for a clay/carbo-chlorination plant producing aluminum chloride for subsequent direct reduction, should be significantly lower due to the elimination of the aluminum chloride oxidation equipment."
89	1	Needed:	Inclusion of a nonbauxitic alumina process capital costs table similar to Table 2, page 85. For example from Table 4, page 41 of the Clark and Kenney report we get:

Alumina Plant Capital Costs
(500,000 TPY plant, 1977 Dollars)

Process	Capital Costs $/Annual Ton
Clay/carbo-chlorination	$429 (1)
Clay/HCl-gas induced	629 (2)
Clay/HCl- evaporative	753 (2)
Clay/HNO_3- evaporative	915 (2)
Bayer-Bauxite Alumina	572 (3)

(1) Pullman Kellogg
(2) Kaiser Engineers
(3) Clark and Kenney

APPENDIX VII

Page	Par.	Line	Comment (Continued)
8	1	4	"3.8 million" should read "3.8 billion"
21	3	1	At this point rather than in chapter 3 it would seem appropriate to identify the processes that were considered for study,and perhaps list reasons for selection and rejection e.g., HCl/evaporation; HCl/gas crystallization; HNO_3; Dawsonite; Alunite; Carbo- chlorination; Anorthosite; Sulfurous Acid; HCl/Sulfurous acid (H+) etc.
41	New Par	last	Since proprietary processes are being introduced and discussed at this point, a brief outline of the TAC clay carbo-chlorination process as described in the 1976 Arthur D. Little report should be included here. For instance, the paragraph might read: "A promising proprietary process called clay carbo-chlorination was reviewed by Arthur D. Little, Inc (ADL) under sponsorship of the US Environmental Protection Agency in 1975. The process involves treating calcined kaolin clay with low grade lignite or sub-bituminous coke and chlorine in the presence of a reaction rate catalyst. ADL estimated that projected carbo-chlorination plant capital and production costs could be considerably less than those for new Bayer plants. This carbo-chlorination process was not reviewed in the Bureau of Mines or Kaiser Engineers feasibility studies".
54	1	1	Guinea aluminum equivalent is quoted as 1,900,000 in USBM MCP-14, May 1978, vs. 1,190,000 in Table 1.
54	1	15	U.S. Mine Capacity and Production figures are confusing and could use clarification.
54	2	2	Change "17 million" to "90 million": According to USBM publication MCP-14, about 80 million long tons of bauxite (90 million short tons) were produced in 1977, not 17 million as stated.
75	2	2	Omit "and there are undoubtedly others" - this is pure conjecture at this point and sounds overly protective.
75	2	6	Replace "coal" with "lignites or low grade coals"
75	2	11	After "plant" add "even though the process is closely related in a unit operational sense to well established commercial processes in the titanium industry".

APPENDIX VII

Page	Par.	Line	Comment (Continued)
90	2	4	After "processes" add "such as clay/carbo-chlorination and dawsonite"
94	3	3	After "technology" add "alone".
95	1	4	After "that the" add "Kaiser Engineers"
95	1	6	After "alumina." add "One possible exception is the clay/carbo-chlorination process with its potentially lower production costs as presented previously in Table 2, page 85."
98	2	3	After "development." add "As noted in Table 3, page 87a, with the exception of the clay/carbo-chlorination process, production of nonbauxitic"
98	2	7	Eliminate "costs of...gained", and replace with "costs of most of these new processes appear to offset any operating cost advantages, except again for the clay/carbo-chlorination process".
98	3	1	After "developing" add "potential"
98	3	3	Eliminate "Data...construction" and replace with "Available data do not justify the immediate construction"
98	3	5	After "requirement of" add "producing"
98	3	6	Eliminate " produced". After "these" add "nonbauxitic"

I sincerely hope that these comments and suggestions are accepted in the same constructive sense in which they are offered, and prove useful.

Sincerely,

Dr. Gervase M. Chaplin

APPENDIX VII

ATTACHMENT B

COMMENTS: ALUMINA FROM DAWSONITIC OIL SHALE

The chemistry apparently has been developed for the extraction of dawsonite from oil shale and for the production of alumina from the dawsonite. However, publications have listed several physical and marketing obstacles to commercial feasibility.

1. Mining. The dawsonitic shale occurs in the Peance River Basin in Colorado at depths of 2000 feet or more and in the presence of large underground lakes. Serious safety problems and high mining costs would exist. Non-dawsonitic shale occurs at 200-400 ft. levels.

2. Nahcolite. There is ususally about 5-7 times more nahcolite ($NaHCO_3$) than alumina in dawsonitic shale. The nahcolite must be extracted first to permit alumina extraction. The profitable sale of the nahcolite is required for economic viability. The contemplated use is as scrub for removal of sulfur dioxide from flue gases. However, two factors militate against that sale: (1) there are huge deposits of nahcolite (70 billion tons) near the surface at Searles Lake, California and at Green River, Wyoming, and (2) a process has been recently announced that scrubs out the SO_2 with soda but recovers the soda so only make-up soda would be required from supply sources.

3. Water. The scarcity of water in Colorado would impose a limit on alumina and nahcolite production. One estimate was for a problematical 1 million TPY alumina maximum.

4. Competitive fuel. Major emphasis for recovery of oil from shale has been directed lately to insitu processing (controlled underground combustion to distill the fuel without mining of solids). Cost for insitu was estimated to be a small fraction of that for mining and surface processing, so a heavy cost penalty would be borne by a mining operation for fuel production from dawsonitic shale. Insitu processing would not recover nahcolite or dawsonite.

It would therefore seem that large scale on-site technology would have to be developed together with assured marketing of products before production of alumina from dawsonitic oil shale could be deemed technologically and economically feasible.

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