ALUMINIUM VIA THE CHLORINATION OF AUSTRALIAN BAUXITES

PART 1: A PROPOSED PROCESS

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SUMMARY

Background

The development of a chloride based technology for producing aluminium has reached an advanced stage in a major company (Alcoa)\(^*\), and alternative processes involving aluminium chloride are being studied in other laboratories. Therefore, companies involved in the mining, refining, and smelting of aluminous materials must give serious consideration to the chloride metallurgy of aluminium.

Beyond the great amount of information available in the literature, there is a large amount of Australian expertise in this area. Before the preparation of the present report, however, this information had never been collated or assessed in detail in terms of the unique Australian environment.

Objective

Following a 1974 tour of several overseas aluminium laboratories by one of the authors (H.J.C.), the survey reported here was begun to determine the feasibility of applying all, or part, of the new Alcoa chloride-route technology to Australian bauxites.

At that time, several contradictory estimates were abroad concerning the cost and energy consumption of the chloride route, and plant data are still unavailable.

The present report was designed to compare several feasible routes to aluminium chloride and evaluate the energy consumption, and cost of aluminium ingot produced by electroreduction of aluminium chloride.

Summary of Technical Content

The current knowledge in the field of aluminium production via the chloride route has been extensively reviewed. New technology for several potentially attractive processes for producing cell grade aluminium.

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*Names of companies and organizations are generally given in shortened form in this report. The "Key" (following this Summary) will provide unambiguous identification. The "Key" and the entire report are presented in the microfiche contained in the back pocket.
FIGURE S1. FLOWSHEET FOR BCR PROCESS FOR MANUFACTURE OF ALUMINIUM VIA PRODUCTION OF ANYHYDROUS ALUMINIUM CHLORIDE
chloride has been examined. Figure S1 presents a flowsheet for the process most likely to be both technologically and economically successful. This process involves the chlorination of calcined bauxite (with an optional beneficiation stage) and is referred to here as the "bauxite chlorination route" (BCR) process. Most of the stages in this BCR process have been proven on the laboratory scale, but considerable work is required for development via pilot plant units through to a fully integrated industrial process.

A comparison of cost estimates and fossil fuel consumptions for the conventional Bayer-Hall (Heroult) and chloride-route processes is given in Table S1.

The $\text{Al}_2\text{O}_3 + \text{C} + \text{Cl}_2$ process, within the Australian context, offers only small cost savings over the conventional Bayer-Hall (Heroult) process, but there are other advantages. In particular, the energy saving is impressive.

The BCR process, using a high proportion of known technology (i.e. in a reliable form), is cheaper than the $\text{Al}_2\text{O}_3 + \text{C} + \text{Cl}_2$ process but is intermediate in energy consumption to the Bayer-Hall (Heroult) and $\text{Al}_2\text{O}_3 + \text{C} + \text{Cl}_2$ processes. However, if specified technological advances are assumed to occur during development, the BCR offers potentially much greater cost savings than $\text{Al}_2\text{O}_3 + \text{C} + \text{Cl}_2$ process. The BCR also offers, potentially, a similar energy saving to the $\text{Al}_2\text{O}_3 + \text{C} + \text{Cl}_2$ process, and is more suited to Australian conditions by virtue of its acceptance of Australian coal as an energy source in most stages of the process.

**Major Conclusions**

(1) Under present circumstances and by utilizing known technology, the cost savings for chloride processes are insufficient to justify large investment. There are, however, potential technological improvements, as yet unproven, which warrant small scale developmental work on the bauxite chlorination route (BCR process).

(2) Australian bauxites are well suited to chloride technology by virtue of their high gibbsite content. This enables the BCR process to be designed around the use of relatively cheap Australian coal. Australia is therefore a logical location for a chloride-based process.
### TABLE S1  COMPARISON OF EXISTING BAYER-HALL (HEROUlt) PROCESS WITH SOME CHLORIDE PROCESSES

<table>
<thead>
<tr>
<th>Bayer-Hall (Heroult) process</th>
<th>( \text{Al}_2\text{O}_3 + \text{C} + \text{Cl}_2 ) process</th>
<th>Unmodified BCR process</th>
<th>Possible improved BCR together with credits for by-products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated capital cost in 1975 (per annual tonne Al)</td>
<td>$2300</td>
<td>$2300</td>
<td>$1800</td>
</tr>
<tr>
<td>Estimated manufacturing cost in 1975 (per tonne Al)</td>
<td>$670</td>
<td>$630</td>
<td>$600</td>
</tr>
<tr>
<td>Increased profitability w.r.t. Bayer-Hall (Heroult) process</td>
<td>Zero %</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Fossil fuel energy consumption (GJ per tonne Al)</td>
<td>252</td>
<td>182</td>
<td>208</td>
</tr>
</tbody>
</table>

* The costs are calculated for aluminium that is to be manufactured by hypothetical new plant at Gladstone, Qld, under the particular conditions specified in the report.

A recalculation in 1978 showed that costs have increased as follows:

- Capital costs - approximately 50%
- Manufacturing costs - approximately 44%
(3) A comprehensive knowledge of the technology of the chloride route is necessary to protect the market for our vast reserves of bauxite. This is particularly true if a chloride-route process designed around the use of Georgia clay is developed in the USA. The bauxite technology could be a marketable commodity for customers purchasing Australian bauxite.

(4) The probably energy saving for a chloride process directly treating bauxite will be as much as 30% (includes all stages of the integrated process, not only the electrolysis stage). This forms a powerful incentive for continuing developmental work.

(5) The BCR process would permit the entire ore-body to be utilized instead of rejecting a proportion of alumina which may amount to 25% in some operations.

(6) Additional advantages that would flow from adoption of the chloride route include (a) establishment of a caustic industry, (b) decrease in the need for petroleum coke imports, (c) production of valuable by-products, (d) reduction in the level of pollutants, particularly red mud and fluorine-containing compounds.

(7) The BCR process is capital intensive and requires development at the kilogram scale to increase the precision of the estimates. The technological improvements required are extremely complex and require several years research and development.

(8) Further information on Alcoa technology, particularly in the electrolysis plant, is necessary before proceeding beyond the kilogram scale.
KEY TO NAMES OF COMPANIES AND ORGANIZATIONS

Alcan -- Alcan Aluminium Ltd., Montreal, Canada
       Alcan Australia Ltd., Sydney, Australia
Alcoa of Australia Ltd., Melbourne, Australia
Alcoa -- Aluminium Company of America, Pittsburgh, USA
Alusuisse -- Schweizerische Aluminium AG (Alusuisse), Neuhausen, Switzerland
Amdel -- Australian Mineral Development Laboratories, Frewville, SA, Australia
BASF -- Badische Anilin-und-Soda Fabrik AG, Ludwigshafen, W. Germany
British Aluminium Co. Ltd., London, United Kingdom
British Titan Products Co. Ltd., London, United Kingdom
Chlorine Technology (Aust.) Ltd., Australia
CIG -- Commonwealth Industrial Gases Ltd., Melbourne, Australia
Comalco -- Comalco Ltd., Melbourne, Australia
CRA -- Conzinc Riotinto of Australia Ltd., Melbourne, Australia
Du Pont -- E.I. Du Pont de Nemours & Co., Inc., Wilmington, Delaware, USA
Gulf -- Gulf Refining Co., Port Arthur, Texas, USA
ICI -- ICI Australia Ltd., Melbourne, Australia
Kellogg -- M.W. Kellogg Co., Houston, Texas, USA
Laporte -- Laporte Titanium Ltd., London, United Kingdom
Lurgi -- Lurgi (Australia) Pty Ltd., Melbourne, Australia
Mitsubishi Metal Corporation, Japan
Morganite -- Morganite Australia Pty Ltd., Melbourne, Australia
Nabalco -- Nabalco Pty Ltd., Nhulunbuy, NT, Australia
Norton Co., Inc., Worcester, Mass., USA
Pechiney -- Pechiney Ugine Kuhlmann, Paris, France
QAL -- Queensland Alumina Ltd., Brisbane, Australia
Tenneco -- Tenneco Chemicals Inc., Houston, Texas, USA
Sumitomo -- Sumitomo Chemical Co. Ltd., Tokyo, Japan
Toth -- Toth Aluminium Corporation, New Orleans, LA, USA
USBM -- United States Bureau of Mines, Albany, Oregon, USA
Woodall-Duckham -- Woodall-Duckham Pacific Ltd., Melbourne, Australia
New Zealand Aluminium Smelters Ltd., Invercargill, New Zealand