

Australian Magnesium Corporation's deposit of magnesite at Kunwarara, Queensland, provides ore for refining to magnesium metal. Photo: AMC



## FLAGSHIPS SET SAIL

Peter Pockley seeks signs that CSIRO's vaunted Flagships are really sailing.

Nearly 2 years after CSIRO's then-new Chief Executive, Geoff Garrett, announced that the organisation would shift focus to a few "Big Hairy Audacious Goals", the plan has been officially "launched" by Prime Minister, John Howard.

CSIRO's media statement led with the claim that Dr Garrett's six "Flagships" comprise "one of the largest targeted scientific research programs in Australia's history". Science Minister, Peter McGauran, later extended the superlative to "the largest scientific program in our Nation's history".

Admitted by officials as an exercise in getting a political "blessing", the "launch" was covered only barely in the media.

Since CSIRO presented its plan for seven Flagships to the government's National Research Priorities exercise last August, one on information technology has been dropped. In order of their announcement, the list is now:

- Preventative Health;
- Light Metals;
- Healthy Country;
- Agrifood Top 5;
- Ocean Wealth; and
- Energy Transformed.

Their preliminary status at the time of the launch was emphasised in the description of each Flagship with up to five generalised dot points. CSIRO's statement said they "will be unveiled in more detail in the coming months".

An air of hope pervaded the proceedings. Garrett has declared goals of making billions of dollars in 10 years from new science arising from the Flagships (e.g. \$10 billion in light metals; \$3 billion in agrifoods) and extending the lifespan of Australians by 10 years. These figures are not as "big, hairy and audacious" as last August's submission, when CSIRO claimed the total benefits from the Flagships would be \$125 billion. No documentation has been released to support either estimate.

Howard said nothing about funding in his off-the-cuff speech. CSIRO's announcement to the media, too, avoided the crucial issue of finance, despite well-documented turmoil as Garrett massively reshapes the organisation to create the six Flagships announced (room was left open for more), which are extracting 10% of CSIRO's appropriation funding from each of its 20 existing Divisions for 4 years.

The ultimate budget for the Flagships appears to be in the range of \$300–400 million annually, coming from government support for CSIRO generally (\$639 million in 2002–03) plus an indeterminate amount of "external earnings" (\$267 million in 2001–02). Garrett has set a "stretch goal" of a total annual budget (government plus external) of \$1.3 billion by 2006–07. This will require more than \$400 million extra from government and/or industry.

### WHAT'S NEW?

As the research "programs" are being built on research and researchers within the Divisions, the scheme essentially re-badges and extends existing projects.

The CSIRO Staff Association reacted sharply. "Launching a grand new initiative without adequate funding is courting disaster," said its President, Dr Michael Borgas. Pointing to hundreds of staff lost following government cuts of "\$100 million in real terms over the last 10 years", Borgas forecast: "We are likely to see a lot of important CSIRO research terminated to pay for the Flagships".

Since his appointment in January 2001, Garrett has not personally explained the Flagships through the media, even following the "launch". Clearly, however, his thrust is to "evolve" research institutes in the public domain into essentially commercial research "enterprises" through a "systems-level" approach.

These terms come from an unpublished document (11 February 2003) where the Chair of the Flagship Program, Dr Graham Harris, says the "process [is] delivering outcomes in an emerging network culture". Harris envisages CSIRO "responding to external drivers" by acting as "honest broker", playing "a catalytic role" in "complex systems" and stimulating "innovation strategies" that will "place CSIRO in a position of cognitive advantage". No practical examples are

provided.

Directors, separate in line from Divisional Chiefs, have recently been appointed for three Flagships (Preventative Health, Light Metals, and Energy Transformed). One Director (Ocean Wealth) is doubling as a Chief (Dr Tony Haymet of Marine Research).

*Australasian Science* pressed "CSIRO Corporate" for sufficient information on the unique science that is meant to underlie the Flagships that would allow some comprehension of the scheme. We settled on first covering Light Metals, as it seems the most coherent to date, has a firm link with industry and has started first.

## METALS MATTER

The Brisbane-based Director of Light Metals, Tony Filmer, says Australia is well-endowed with minerals of the three metals that his Flagship has selected for more intense R&D – magnesium (Mg), titanium (Ti) and aluminium (Al). The purifying and refining processes require high inputs of energy, and a grand aim is to reduce the amount of energy that industry requires by one-third.

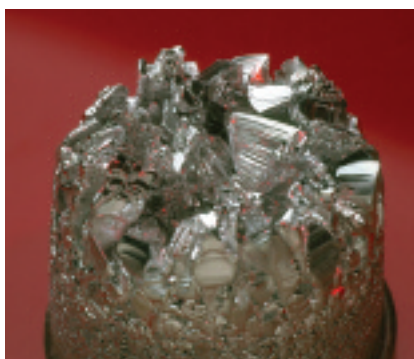
There is an economic incentive for establishing and maintaining the full range of processing – from extraction to refining and manufacture – within Australia rather than merely shipping ores overseas. This has largely been achieved for aluminium, but magnesium and titanium are in their infancies and CSIRO aims to place them ahead of international competition.

"Initially, CSIRO money will be put into high-risk projects with potentially high rewards," Dr Filmer declares while admitting: "There is not a lot of published background information".

This seems likely to continue as the scientists consulted by *Australasian Science* say that any significant discoveries will not be published in the scientific literature until patents are obtained to protect them. This concern about "intellectual property", however, can



**Magnesite nodules from the Kunwarara mine in Queensland.** Photo: CSIRO Minerals



**Magnesium crystals made in CSIRO Minerals' laboratories illustrate the resistance to corrosion of the high purity metal.**

Photo: CSIRO Minerals

become a messy issue for CSIRO, as evidenced by current disputes over ownership of CSIRO's work in gene silencing and aspects of forestry.

Filmer speaks the same technical language as Garrett, as both are metallurgists. He came to CSIRO in January from a lifetime of work in industry, notably in CRA Research and, most recently, as Managing Director of Comalco Smelting. He nominates his top achievement as being in the team that developed the "carbon-in-pulp electrowinning" process that extracts gold more efficiently from ores. Developed in South Africa, the process is now used worldwide.

He says that "mature" industries like

aluminium refining have to concentrate on "achieving incremental improvements, leaving them little opportunity to think of next-generation stuff. We have to step back from day-to-day work and ask how processes should be and how we can get there."

The three metals are categorised as "light" because of their low densities and melting points compared with iron and its common steel alloys. If magnesium is successfully applied in motor vehicles, for example, the saving in weight would lead to less fuel for propulsion, thus also reducing emissions of greenhouse gases (*AS*, April 2003, p.6.).

Asked why his view of the Flagships as collaborative ventures with industry and universities could not have been achieved easier through a Cooperative Research Centre (CSIRO is partner in 46 CRCs), Filmer sees the schemes as distinct: "Unlike CRCs, our form of partnership will cover the whole spectrum of science, engineering, finance and outcome delivery".

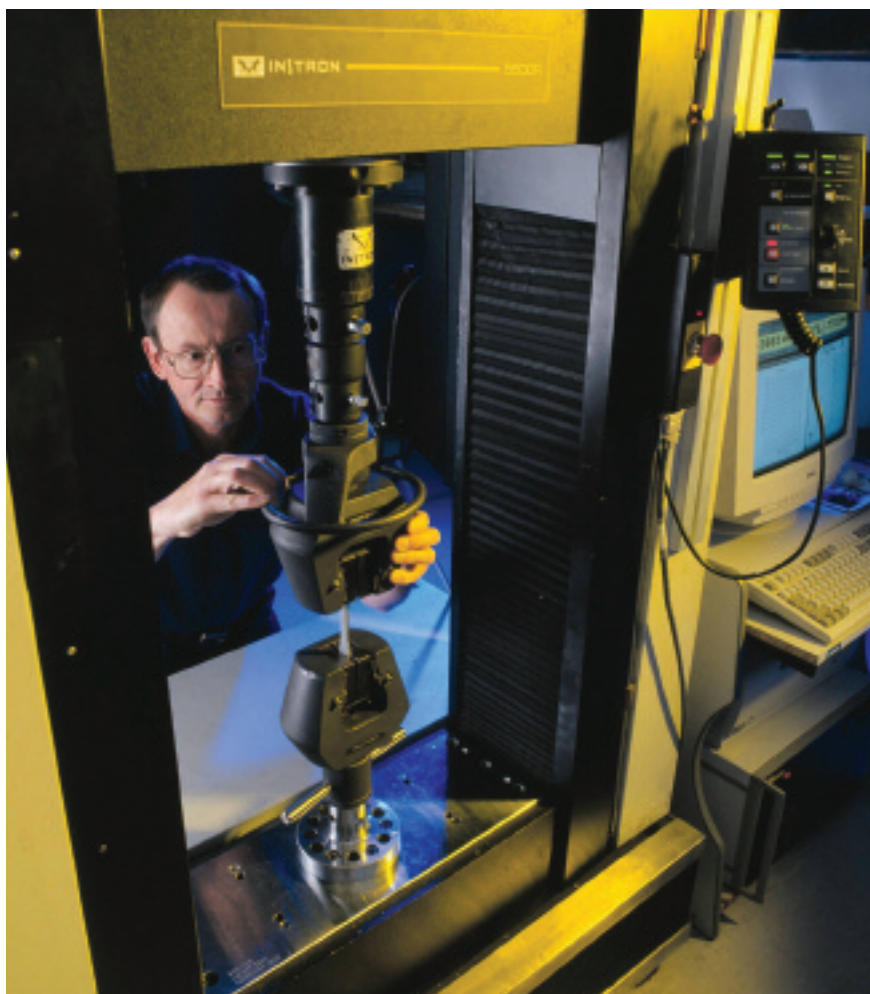
Light Metals is being run by a central group of only four: Filmer and an assistant, technical director and business analyst. Filmer explains: "There will be no hierarchy among the 150 staff we shall coordinate in the first year [drawn in full or part from Divisions plus some new posts]. For 2003–04, we have about \$10 million from government appropriations [taken from Divisions] plus about \$17 million from other sources."

## MAGNIFICENT MAGNESIUM

Most schoolchildren know magnesium for its brilliant flame in the chemistry lab, but it has more substantial uses. Increasingly its lightness leads to applications of its alloys (which are more fire-resistant than pure magnesium) in motor vehicles and aircraft, and in casing for computers and mobile phones.

Extractive metallurgist in CSIRO Minerals, Raj Rajakumar, who is Technical Director of the Flagship, says the





**Fred Polivka of CSIRO tests a patented diecast magnesium alloy (high-temperature) that has been cast into an engine block under trial for use by the automotive industry.**

Photo: Mark Fergus, CSIRO

grand aim of the project is to reduce the energy required to produce magnesium metal by 30% and to cut the capital investment required by half. "This demands a radical new technology, not some simple fixes," he says.

He says that the dominant local company, Australian Magnesium Corporation, has been applying CSIRO developments for 12 years. AMC has a 3-year "research alliance" with CSIRO. At the applications end, CSIRO Manufacturing and Infrastructure Technology has a similar alliance with the CRC for Alloys.

At the Flagships launch AMC's CEO, Rod Sharp, outlined the potential of research to support a full suite of magnesium processing in Australia. "The export value of a tonne of raw

magnesite is around \$50," he began. "The export of magnesium oxide (magnesia) commands between \$400 and \$800 a tonne. Magnesium alloy will be exported at around \$5000 per tonne. The next challenge is a diecasting industry where formed or diecast magnesium could be exported for around \$15,000 per tonne."

Unlike aluminium, which relies on one process to convert ore to alumina (the oxide) and electrolyse that to make metal, magnesium needs a diversity of processes for different starting materials: the ores magnesite (magnesium carbonate) and dolomite (calcium and magnesium oxides), seawater, tailings from other processes and flyash from power stations.

Dr Rajakumar explains that, in

general, starting materials have to be converted by different chemical processes to magnesium chloride prior to electrolysis to form the metal. The major Australian ore, magnesite, is reacted with hydrochloric acid, but the resulting magnesium chloride molecule contains 6–10 molecules of water in the form of hydrates. Driving this out (e.g. by first complexing it with ammonia) requires much energy. Another process, for dolomite, reduces the oxide to metal by fusing with silicon.

Solving the multidisciplinary problems will be "high risk, but will bring high rewards if we succeed," says Rajakumar. But the risk is also financial, which could affect CSIRO.

AMC has a demonstration plant in Gladstone producing 1500 tonnes of metal annually. Debate continues over government support, private investment and a timetable for the company's plan to build a full-scale \$1.4 billion plant at Stanwell to produce 97,000 tonnes of magnesium metal per year, the world's largest.

## TERRIFIC TITANIUM

Titanium has some valuable properties. While it has a higher melting point than iron, it is only 57% as dense and its alloys can be nearly as strong as steel. This suits it for the oil and chemical industries, desalination plants and, as surgical implants, for replacing degenerated bones and joints. Its lightness and bright appearance make it a good



**Nasir Ahmed tests welding of titanium pipe using the Keyhole Gas Tungsten Arc Welding Process at CSIRO, Adelaide.**

Photo: Jeremy Stewart, CSIRO

material for architecture.

Alloys of the metal resist corrosion and oxidation up to 600°C and down to -196°C without losing any of its toughness. They also can survive almost indefinitely in seawater without corrosion.

But, Nasir Ahmed of CSIRO Manufacturing and Infrastructure Technology says working with titanium is not easy as the metal can spring back strongly to its original shape or may crack and tear.

Ahmed is researching novel, efficient ways of forming and welding titanium into tubes, pipes, elbows and tee shapes. "Keyhole welding" seems the most promising method whereby inert gases protect the melt zone from absorbing oxygen and nitrogen in the air, as this makes the metal brittle. The targets are to improve reliability, reduce costs by 30% and enable commercial production in Australia.

While there are abundant resources of titanium-bearing minerals, notably rutile and ilmenite in the mineral sands of Western Australia and the Murray Basin, most of this is exported for processing in the USA, Japan, Europe and Russia (worth \$1.3 billion). Local industry uses the minerals to produce high-grade titanium dioxide for paints, pigments, plastics and ceramics.

Filmer says "a gleam in my eye" is to develop a continuous process to replace the current batch process, which converts titanium from the mineral into titanium tetrachloride and then reacts that with magnesium metal to form a sponge of titanium. It is difficult to go from a sponge to a useable sheet of workable metal.

### ABSOLUTE ALUMINA

Aluminium is well-known for its use in drink cans, kitchen foil and the bases of cooking pots. Because of its lightness and resistance to corrosion, it is popular in all forms of engineering.

Of all Australia's resources, aluminium ranks supreme because the



**Bauxite, the ore for making aluminium, is coloured by iron impurities.**

Photo: CSIRO Minerals

nation's quarries not only supply overseas companies with raw bauxite but, unlike iron ore, the local industry is integrated on a massive scale from mining through to refining ore and producing and manufacturing the metal. Australia's six refineries produce 30% of the world's alumina (aluminium oxide) from bauxite (16.3 million tonnes valued at \$5 billion), with Queensland Alumina at Gladstone and Alcoa at Pinjarra, WA, being the largest in the world.

Domestic R&D has been central to the competitiveness of these operations, but John Farrow, CSIRO's Program Manager for alumina, says the race is on to go beyond making minor improvements to the technology of alumina refining to a genuine breakthrough. A team of 28 scientists in the Minerals Division's laboratories in



**Russell Penniford operates an autoclave at CSIRO, Perth, to determine the performance of bauxite extraction.**

Photo: Brian Richards, Murdoch University

Perth is gearing up for an enhanced assault with \$1 million in extra funding through the Flagship.

To appreciate the strategy it is necessary to understand the underlying chemistry. The current "Bayer Process" starts by digesting the bauxite, which contains iron oxide impurities, in caustic soda (sodium hydroxide). This is precipitated out of solution into aluminium hydroxide, a solid known as gibbsite. This contains water in its structure, which is removed by heating it with natural gas to form alumina.

One-fifth of the energy needed to produce alumina goes into the last step. Dr Farrow's group wants to force the system to precipitate another solid, boehmite, which contains less structural water and would thus need less heat to change it into alumina. If successful, he says, it would reduce the total energy needed by Australia's alumina refineries by 12%, a saving of \$60 million annually.

The team is not starting from scratch, having 15 years of investigation under its belt already. They have a good understanding of how gibbsite precipitates from solution and have obtained boehmite in the laboratory at high temperatures (150–250°C) and concentrations in a pressure vessel. But something keeps stopping the reactions part-way along and the scientists have to find out why.

Farrow's tactic is to use computers to simulate the structure of molecules in the reaction and atomic force microscopy to enable the team to see individual atoms and map how the surface of the solid grows as it precipitates from solution. From this information they may be able to design a process that preferentially produces boehmite.

They will give this project concerted attention for 18 months, when Farrow says: "If we have no signs of success by then, we'll drop the work. This is a long-shot." He puts the odds at one in 100 or 150 at the moment.