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ANSWERS TO QUESTIONS ON NOTICE
Industry, Innovation, Science, Research and Tertiary Education Portfolio
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AGENCY/DEPARTMENT: COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION

TOPIC: Minerals Down Under Flagship

REFERENCE: Written Question –Senator Bushby

QUESTION No.: AI-102

What does CSIRO consider have been the most tangible, practical achievements of the Minerals Down Under Flagship over the course of its existence?

ANSWER

There have been numerous achievements and impacts from the work of the Minerals Down Under Flagship. The following are a small number of selected highlights.

Increasing access to mineral resources

- Seamless access to Australia's geoscience data wherever it is stored - AuScope Grid provides tools to seamlessly access Australia's pre-competitive geoscience data through the web to ensure that exploration decisions are informed by the latest information.
- Hyperspectral mapping of the Australian continent - the largest Advanced Spaceborne Thermal Emission and Reflection radiometer (ASTER) geoscience map in the world shows the abundance and composition of major mineral groups on the surface for Western Australia. Eventually the entire continent will be mapped to provide explorers with important information on the most prospective areas.
- HyLogging™ automated core logging system provides valuable information for explorers. Instruments have been delivered to all state geological surveys to allow them to digitize their huge stores of cores.
- Next generation detection tools developed for exploration of the Australian continent - New tools have been developed to allow exploration in technically challenging parts of Australia. The research delivers this knowledge through an extensive suite of collaborative projects with Australian explorers:
  - Geochemical tools: A new hydro-geochemical exploration method uses the chemical analysis of groundwater to find mineral deposits. It is ideally suited to Australia since much of the regional areas are dotted with windmills and bores. Through partnerships with industry and state surveys, this information has been compiled for prospective regions in Australia. The impact of the data to identify new exploration areas is clearly reflected in tenement applications over geochemical targets. Similarly, regional laterite (weathered bedrock) sampling in regional Australia provides a regional understanding of the hidden mineral potential with specific target areas. The immediate result in WA was a tripling of tenement uptake in the Yilgarn Craton. These geochemical tools have also been linked to process modelling to understand the geological processes forming mineral deposits.

- Maia is a detector able to produce high-definition, quantitative elemental images with microscopic or nanoscopic detail in real time. This allows samples to be scanned up to 1000 times faster and in much greater detail than previous methods and has revolutionised the way researchers map trace elements in a range of mineral exploration ore samples. For instance, for the first time it has allowed researchers to see the distribution of trace gold in samples where gold has never been detected before. The system has won the prestigious R&D 100 Award convened by the US-based R&D Magazine.
- SiroSOM (Self Organising Maps) is an exploratory data-mining technology that identifies patterns and relationships for geophysical data in exploration. Critically, SiroSOM can help find valuable minerals using only existing data.
- Effective airborne magnetic surveys are an important part of mineral exploration, but those conducted with conventional total magnetic intensity (TMI) sensors present a limited, distorted and fuzzy view of geology, especially for strongly magnetic deposits.
    - One of the world's most advanced airborne systems was developed by CSIRO scientists working through the CRC for Australian Mineral Exploration (CRC AMET). TEMPEST produces three-dimensional images which help geologists map sub-surface geology and determine the best locations to drill. TEMPEST, commercialised for some time, has become a proven system for industry and governments to explore for uranium, gold, base metals, diamonds and even water.
    - CSIRO's tested GETMAG™ system enables users to visualise the depth, size and shape of a deposit with only a few stations needed to extract the same information as a whole TMI survey.
- LANDTEM™ is helping to unearth large deposits of nickel sulfide and silver worth hundreds of millions of dollars. It has found several previously undetected large nickel sulfide deposits in WA and cut exploration costs by 30% for a company working in difficult terrain in northern Quebec. With the mining industry now looking for deeply buried minerals, conventional magnetic sensors, particularly in Australia's conditions, are not sufficient. CSIRO's LANDTEM™, licensed to an Australian startup company, is a highly portable exploration tool that can spot the difference between ore and conductive overburden, even when the ore is deeply buried.
- The research to improve diamond exploration strategies is leading to a new and valuable greenfields exploration tool for diamonds in Australia. Traditional diamond exploration strategies include the search for kimberlite indicator minerals (KIMs). However, KIMs are prone to chemical dissolution in tropical weathering conditions. CSIRO's approach is to use helium thermochronology to detect 'hot zircon' originating from deep crustal regions in the same type of eruption that brings diamonds to the surface. The ratio between 'hot' and 'cold' zircons that originated near the surface can then be used to guide exploration efforts. The method is most valuable in places where KIMs are often not preserved and where the kimberlite has been buried by geological processes.

<u>New discoveries to enhance exploration</u>

- Understanding ore formation to progress and optimise ore discovery:
    - CSIRO scientists have discovered the presence of a natural deep earth pump that is a crucial element in the formation of ore deposits and earthquakes. This is the first direct observation of fluids moving through the mid-crustal shear zone. It is direct evidence for one of the processes whereby forming fluids moved up from the mantle to the shallow crust and form the ore deposits that we mine today. The evidence is described in a paper published in the prestigious journal *Nature.*

  - How gold nuggets form has been a mystery. In the past it has often been assumed that gold nuggets formed in place, where they were found, either precipitated from fluids or grown from microbial action. However, CSIRO researchers have revealed that nuggets form deep underground at high temperature. Their presence near the surface is the result of geological process and weathering over vast periods of time. If the nuggets are not formed where they are found but weathered from gold-rich ore, the original source may still be nearby – essential information for explorers.
- Nanoparticles of gold too small to be seen with the naked eye have never before been seen in nature but CSIRO researchers have discovered the gold in clay from southern WA where groundwater is both salty and acidic. This is also the first observation of the nanoscale mobility of gold during weathering. The gold had not been identified earlier because it was transparent to electron beams but the new analysis showed 59 parts-per-million. CSIRO believes that this form of gold is probably common in the natural environment where saline water interacts with gold deposits. With gold over A$1600 an ounce, this research is good news for Australia's gold explorers.

<u>Expanding ore reserves by transforming mining and processing methods</u>

- Processes for Australia's nickel laterite reserves - Australia has enormous nickel laterite reserves (~$350 billion value), but processing is challenging and expensive. A new process under development enables a major reduction in capital and operating costs, reduces waste, and minimises transport of hazardous chemicals.
- Automated mining for productivity and safety - New automation technologies for deployment on Australian mine sites including 3D mapping, location tracking, intelligent control of drilling and tele-robotic systems.
- Non-cyanide leaching of gold ore – A new process that has similar extraction rates to the use of cyanide but without the use of such hazardous chemicals. The process could unlock hundreds of millions of dollars of value from gold deposits where cyanide use in inappropriate or ineffective.
- Positioning Australia's iron ore exports - Australia's reserves of the traditional high grade Brockman ores that have fuelled iron ore exports since the industry's birth are steadily declining. More complex lower grade ores are therefore being developed both to replace the high grade ores that are being depleted and to provide the resources for the massive expansion of the iron ore industry currently taking place. These new ores need to be carefully characterised to understand their downstream performance in beneficiation plants, sinter plants and blast furnaces. CSIRO has developed a suite of technologies that position Australia's iron ores in the global market including:
  - A new process to remove phosphorus and alumina contaminents from Australia's large resources of high phosphorus ores (~8 billion tonnes) with an in-situ value exceeding $760 billion.
  - Demonstrating the viability of hydrated and friable Marra Mamba ores for export and processing. Marra Mamba ores now enjoy wide market acceptance and constitute a major proportion of Australia's current iron ore exports currently worth more than $60 billion per annum in 2011/2012.
  - An automated optical image analysis system called *Recognition* which is now being used in the evaluation of new iron ore prospects by the larger iron ore companies in Australia.

  In addition, **an easy to understand, up to date, interoperable iron ore database** has been created to help focus research on reducing the phosphorus content of Australian high-phosphorus iron ores. It is also useful for understanding the nature and extent of high alumina

iron ores in Australia, which has been nominated by industry as a long-term issue in need of an economic solution.

- Automated mining for productivity and safety - A wide range of technologies need to come together to make full automation possible at mine sites to lower the cost of mining and make previously uneconomic ore bodies viable and to remove workers from potentially hazardous locations. CSIRO has developed and delivered important new technologies to industry and commercial manufacturers for deployment on Australian minesites including:
  - 3D Laser SLAM (Simultaneous Location and Mapping). CSIRO can now generate accurate 3D maps of the environment around a vehicle using a spinning laser mounted on a continuously moving vehicle without the need for additional sensors. Previous approaches to localisation and mapping required the vehicle to stop frequently, an impractical requirement in the real world and no longer necessary using CSIRO's technology. This is a critical step in the drive towards full automation.
  - Underground location tracking using WASP (Wireless Ad hoc System for Positioning). This recently commercialised technology allows real-time accurate production tracking, control and scheduling within mines.
  - Telerobotic control systems. CSIRO has augmented traditional 3D visualisation technologies with other technologies such as stereoscopy, streaming video, haptics and motion to deliver more 'life-like' and immersive (therefore more accurate) virtual environments. Telerobotic control systems have been developed for and initially applied for remote operation of shiploaders and rockbreakers.
- **Advances in drilling, excavation and analysis -** Even small improvements in drilling and excavation technology can achieve significant cost savings and efficiency improvements for exploration and mining. Drilling currently contributes approximately 20 per cent of exploration costs and 10 per cent of mining costs. In addition to productivity gains, improved excavation techniques also address the vital issues of safety.
  - Sweetspot intelligent control for drilling. This patented system uses feedback to vary the weight on a drill bit and torque to provide optimum drilling penetration for any rock conditions without the intervention of a human operator. Sweetspot automation can be used to improve production rates through increased penetration and longer bit life.
  - **Patented steerable bit for percussive drilling.** Gravity and ground conditions can cause deviations when drilling long and up-holes in hard rock mines which can result in large, oversize rock fragments being produced by drill and blast operations. The method to avoid deviation from the drilling line will also be useful when drilling deep holes where a large diameter drill bit is used to maintain a drilling line. This method may decrease the required size of drill bit, increasing drill rates and making significant energy and cost savings.
  - Super Abrasive Resistant Tools, or SMART*CUT technology provides a critical, reliable technology to bond diamond composite material to cutting tools for mining, civil construction and manufacturing. The thermally stable diamond composite material is more than 1000 times more resistant to abrasive wear than tungsten carbide, so drill bits made from the material will last very much longer. They can also can operate at higher temperatures, virtually eliminate the need for environmentally damaging cooling fluids and enable faster operations. Prototype drill bits have demonstrated twice the penetration rate and expend half the energy of traditional rock coring bits.
  - **SIROVISION® is an efficient and cost-effective commercialised solution to rock mass structure mapping and** analysis. This advanced photogrammetric technology quickly, cheaply and safely captures data and generates useful information. There is no other product that provides integrated structural measurement and analysis.

- With the support of 12 of the world's largest mining companies, CSIRO coordinated the first new set of guidelines for open pit slope design for more than 30 years. It outlines what works best in different situations and why, what doesn't work and why not and what is the best approach to satisfy best practice in a range of situations. The guidelines are now cited regularly in technical and conference publications and a number of mines have now adopted the guidelines as their global company design standards. An extension to the work is planned for publication in 2012 and additional sponsors have already indicated their intention to join the project that will expand the scope of the original work.
- Laser Induced Breakdown Spectroscopy (LIBS) down hole elemental analysis - LIBS uses a pulsed laser to initiate a plasma spark on the surface of material and the light emitted from the plasma spark is analysed using a spectrometer. A LIBS down hole analyser has been developed and integrated with a 4WD platform for use in blast holes and, for the first time, geologists have access to on-the-spot elemental analysis. Mining companies process many thousands of samples a year so the time savings from LIBS will be of great benefit. The technology has been developed as a collaborative partnership with BHP Billiton Iron Ore.

Reducing environmental footprint and improving productivity of existing mining and processing

- Integrated steelmaking process - This process is being evaluated for potential pilot operation and. if widely adopted, could more than halve greenhouse gas emissions from iron and steel production. There is no competing technology which will be market ready before 2040. The estimated value of the integrated steelmaking process over the next twenty years is $42 billion.
- Large scale ore sensing for process efficiency - smart sensors to monitor ore through the mining and processing cycle and optimise efficiency through suitable control strategies. These technologies together will fundamentally change the real time control and efficiency of ore processing and are currently being commercialised and deployed by industry.
- Ionic liquids for aluminium production - This is a novel low-energy method for producing aluminium using ionic liquids. The current method for producing aluminium requires molten cryolite to be heated to 1000 degrees Celsius. Ionic liquids can operate electrolytically at only 80 degrees Celsius, offering potential energy savings of 30 per cent.
- Magnesium production at the speed of sound - Traditional techniques to produce magnesium are environmentally burdensome and/or extremely labour intensive. CSIRO's novel technology called MagSonic is cost effective, energy efficient and environmentally friendly. The new process uses the carbothermal route, heating magnesia (MgO) with carbon to around 1700°C to produce magnesium and carbon monoxide. To cool this quickly to prevent the hot mixture reverting to its original components the MagSonic technology uses a Laval nozzle – a rocket – to cool the gases in milliseconds. CSIRO is working with industry partners to take MagSonic to the pilot scale.
- Use of seawater in mineral processing - Through a series of bench-scale tests, CSIRO researchers have demonstrated that the use of fresh water in flotation, grinding and gravity separation could be dramatically reduced by using either seawater or even hypersaline groundwater as a replacement. The change of water type can be achieved without a loss of efficiency or grade. Significant reductions in the use of valuable fresh water could be achieved through this process, particularly in remote areas where fresh water is scarce and in demand for human and stock use.

In addition, as part of a review of CSIRO's impact in 2010 ACIL Tasman undertook an analysis of the National Research Flagship program. A copy of the full ACIL Tasman report is available on the CSIRO website at: <http://www.csiro.au/en/Portals/About-CSIRO/How-we-work/Budget--Performance/Performance-reviews/Impact-and-Value-2010.aspx>.