From deep space to deeper Earth

World-leading EarthByte Group forging new frontiers in mining insights.

University of Sydney researchers are going back two billion years to understand the formation of the Earth's mineral deposits, find the next great undiscovered orebody, and help cut exploration costs through better use of available data.

Twelve years in the making, the project is being led by the EarthByte Group, a world-class research group in global and regional plate tectonics and geodynamics, and an e-geoscience pioneer. EarthByte was formed out of the University of Sydney's School of Geosciences in 2002.

A current $12-million Science Infrastructure Endowment Fund (SIEF) Big Data Knowledge Discovery research project is among the most important in Australia's resources sector.

Through this project, EarthByte and its partners NICTA and Sirca, bring giant, multidimensional data sets and cloud computing together to create a knowledge-rich 4D data and software environment in which data mining and machine-learning tools are being linked to a plate tectonic framework over geological timescales. The resulting 4D model of the dynamic Earth will give energy and mining companies new insights forged through space and time.

EarthByte is forming an industry consortium to allow companies to take advantage of this emerging technology, and is seeking partnerships and collaborations in the resources sector to further develop its breakthrough research.

'EarthByte started with a view that geoscience is drowning in too much data, and that existing geological data is not being analysed as well as it should,' says Dietmar Müller, Professor of Geophysics at the School of Geosciences.

'The emergence of e-research and e-geoscience is enabling much deeper analysis of existing geological and geophysical data, rather than having to go into the field and collect costly new data for greenfields exploration sites.'

EarthByte's research has two key implications for the resources sector. First, with most of Australia's significant near-surface orebodies thought to have been discovered, mining companies will increasingly need to find ore deposits deeper beneath the surface.

Müller says: 'There are still many rich deposits lurking in the 80 per cent of the Australian continent that is covered by a thick layer of weathered rocks, and there is currently no exploration model to find them, driving exploration companies offshore. To discover deeper mineral deposits, companies need extra intelligence on understanding Australia's deep structure and evolution.

'The premise is to develop an understanding of Australia's geology beyond the present day setting, trying to reconstruct the original tectonic setting in which particular geological provinces were formed. Spatial-temporal data mining has never been applied to Australian geology, but that is changing, as recently pointed out by the UNCOVER Group of the Australian Academy of Science, which has developed a strategic framework for better understanding Australia's metallogenic evolution (www.science.org.au/policy/uncover.html).

'It seeks to understand how a number of continents, volcanic arcs and plate boundaries evolved through time, because we know that many rich ore deposits form along tectonic plate boundaries and continental sutures.'

Müller notes that: 'In Australia, most mineral deposits are very old – up to nearly two billion years ago in the Proterozoic period. We need to understand what the Australian continent looked like through deep time, when it did not look like the Australia we know today; 1.5 billion years ago, it consisted of at least five

different continents separated by ocean basins, chains of active volcanoes and subduction zones.'

This can now be achieved by the emerging technology of a cloud-based virtual geological observatory, the GPlates Portal. A prototype of this portal was released in early October 2014 (portal.gplates.org) – it allows users to interactively reconstruct the most detailed global gravity map to date, which was published simultaneously in the journal *Science*, revealing buried tectonic structures in unprecedented detail. The portal had over 40,000 views during its first three days of existence, highlighting the enormous interest in this technology.

A major implication of a geological observatory is cost. Falling commodity prices and less available capital for emerging mining companies are necessitating lower-cost exploration techniques. 'We can reduce the cost of greenfield exploration through much more comprehensive analysis of combined geological and geophysical information,' Müller says.

Mining companies have lagged behind energy companies in their adoption of e-geoscience technologies, he says. 'Mining companies have not had the need to employ this level of research before. We have only recently got to the point of running out of easier-to-find ore deposits in Australia. There wasn't as pressing a need to get more information out of the existing data when companies could pay to get fresh data through exploration programs for near-surface deposits.'

Difficult industry conditions have also increased the need to embrace e-geoscience. 'Larger mining companies are understandably focused on cutting costs and exploiting existing deposits. Our research can help mining companies continue to find new, hidden resources, at much lower cost compared to traditional exploration,' Müller says.

Inconsistent geological data has made it harder to get the most out of publicly available information, he says. 'Companies sometimes struggle to get hold of the data they need. It might not be in the one place, or in the right format, or location. We do a lot of global and local analysis, and are able to analyse disparate pieces of data coherently.'

Professor Müller and Associate Professor Patrice Rey lead EarthByte. It has over 30 full-time academics, Postgraduate, Honours students and software developers researching the interplay between the deep earth and surface processes. Its diverse research covers basin evolution, geodynamic controls on ore deposit formation, continental deformation, formation of the Australian opal, causes of long-term sea level change and Phanerozoic and Proterozoic plate tectonic reconstructions.

EarthByte also drives the development of its industry-standard, open-source plate reconstruction software, GPlates, which enables the interactive manipulation of plate tectonic reconstructions and the visualisation of geodata through geological time. It is upgrading the GPlates software interface to cloud-computing, making it easier and more convenient to access.

Müller is passionate about the untapped potential to understand ancient geological history. 'Mining companies usually spend a lot of energy looking at how the Earth is today, to determine where to look for ore deposits. But to find greater resources that are buried deeper, we need to think about how the Earth evolved through space and time, as far back as two billion years.'

Understanding the break-up of the supercontinents of Pangaea, Rodinia and Columbia (Nuna), and how they generated ore deposits, is crucial for the mining industry, Müller says. 'We know some supercontinents had more resources than others.' EarthByte's GPlates system uses a diversity of geodata to restore the Earth's tectonic plates and their boundaries to their original positions.

Müller, Rey and Dr Adriana Dutkiewicz, also of the University of Sydney, collaborated on an Australian Research Council Discovery Project to create the first opal prospectivity map in Australia, using geological and geophysical data, locations of known deposits and paleogeographic reconstructions. A new opal field discovered in 2012 (75 kilometres from Lightning Ridge in New South Wales) was precisely in an area suggested by the prospectivity map. Although the opal find and team's research were independent of each other, it reinforced the map's potential.

Another prospectivity map has been developed for parts of the famed Pilbara and Yilgarn cratons in Western Australia, through PhD research conducted by EarthByte's Andrew Merdith. Rio Tinto has favourably reviewed the iron ore map, and a research paper on it will be presented at the Australian Society of Exploration Geophysicists and the Petroleum Exploration Society of Australia's 24th International Geophysical Conference and Exhibition in Perth in February 2015.

The new geological observatory will allow users to categorise, cluster and extract features from large data sets using 'visual knowledge discovery'. This large-scale data analysis coupled with rich interactive visualisation, will let mining companies quickly digest data and build understanding in ways previously impossible, says Müller. The web portal will also provide specific 'knowledge exploration' pathways for policy and decision-makers, educators and students, while delivering useful geoscience knowledge to users across the spectrum of expertise.

Müller says the virtual observatory will drive novel and creative world-class research to underpin innovations towards a sustainable supply of energy and deep Earth resources. 'The EarthByte group is leading the world in the understanding of geodata through spatial temporal relationships. It's important research for the Australian resources industry and we are now at a stage where we can encourage more mining companies to get involved, through industry collaboration and partnerships.'

For more information the EarthByte Group, visit www.earthbyte.org.

To learn more about GPlates, visit www.gplates.org

For more information on the University of Sydney's School of Geosciences, visit www.geosci.usyd.edu.au