

## **BRIEF SUMMARY OF TEPO RESEARCH PROJECT**

An international team of scientists led by Distinguished Professor Ross Large, University of Tasmania, has made a stunning discovery, which extends Darwin's Theory of evolution. Research on the common sulfide mineral pyrite, formed on the seafloor over the last 3.5 billion years, has shown how chemical changes in the ocean, related to collision of tectonic plates, has been a driver of evolution and extinction of life. They propose a new theory that "Man evolved from the mountains, i.e., without plate tectonics and mega-mountains, man, the pinnacle of evolution, would not exist."

## **COMMENTS ON THE TEPO RESEARCH BY OTHER INTERNATIONAL EXPERTS**

*By Professor Peter Cawood, St Andrews University*

"To say I was impressed and excited by this body of work would be an understatement. I think the colloquial phrase "blown-away" is more appropriate"

"I truly believe that the research undertaken by Large and his team is defining the way forward in unravelling how the Earth works. The phrase "leading-edge science" is much overused but the research by the Tasmanian group is leading and not just following in the footsteps of others."

"Importantly, the research undertaken by Professor Large and co-workers is not the end of the journey but rather a remarkable beginning that provides a new way to view and ultimately understand the evolution of the oceans, atmosphere, and the life they harbor."

*By Professor David Rickard, Cardiff University*

"The work of Large's team has set off a wholly new area of enquiry."

*By Professor Nicholas Arndt, Institute des Sciences de la Terre, Grenoble.*

"A remarkable aspect of the research is that it touches on literally earth-changing events during both the formative part of our planet and in more modern times."

## **Laser Time Machine Provides New Twist to Darwin's Theory**

Don't you wish you could go back in time to observe the surge and decline of life that makes-up Darwin's evolutionary theory. This means going back to when the Earth was 3.6 billion years old and then progressing forward every 100 million years, making 36 stops along the way.

This, in effect, is what a team of international scientists, from Tasmania, South Australia, USA and Russia have done – collecting a 2016 Eureka Prize along the way.

The team led by Distinguished Professor Ross Large, from the University of Tasmania, developed their time machine by measuring over 5000 crystals of pyrite (iron sulfide or fools gold) using a laser beam attached to a super sensitive chemical analyser.

Professor Large described the results as “absolutely revolutionary”

The pyrite crystals they analysed, recorded the changes in chemistry of ancient oceans, so that the team was able to determine how evolution of bacteria and higher life forms was affected (some scientists say controlled) by ocean trace elements.

They showed that the earliest oceans, over 2 billion years old, contained high levels of nickel, cobalt, iron, arsenic and gold, much higher than the modern ocean. They were able to observe the beginnings of life in the oceans; bacteria called prokaryotes, whose evolution depended on the high levels of nickel and cobalt at this time.

Over the next billion years, known amongst geologists as the boring billion, the time machine indicated that the chemistry of the oceans became more alkaline and many trace elements critical for life dropped to very low levels. At this time, life slowed to a virtual standstill, and other metals such as zinc and copper replaced nickel and cobalt as the controls on evolutionary pathways.

Between time machine landings at 600 million and 500 million years ago, a dramatic change was observed by the scientific team. Trace elements critical for life, particularly molybdenum (Mo), selenium (Se), nickel (Ni) and manganese (Mn), increased dramatically in the ocean, creating a massive increase in bacterial blooms leading to the Cambrian explosion of life. This event was accompanied by a dynamic flux in oxygen in the atmosphere to levels similar to that required to sustain complex life.

The next five landings (500 million years to the present) turned out to be the most exciting for the team, with such rapid evolutionary change, that extra landings were required to enable the scientists to join the dots.

### ***Scientists Connect the Dots of Life over last 500 Million Years***

The last 500 million years of Earth history was eagerly anticipated to provide the time-team with the key to Darwin’s theory of evolution. However the ultimate result from the laser analysis of pyrite crystals was totally unexpected.

“Our dataset of over 3500 pyrite crystal laser analyses for the last 500 million years showed that the nutrient elements critical for life; Se, Mo and Cd had a cyclic pattern of variation”.

This suggested to the team that during high concentration levels of nutrient elements the oceans were ideal for life and evolutionary change, whereas at low levels, stagnation of evolutionary change was likely. Thus the team could explain why bursts of evolution were interspersed with periods of little evolution.

“Interestingly we are currently in a period of high nutrient levels, ideal for life in the oceans – in contrast to the dramatic scenarios of our oceans portrayed by many today.”

However what totally surprised the scientists was that three of the periods of extremely low nutrient elements corresponded precisely with three of the five major mass extinction events in the oceans.

The team determined to set their time machine precisely on these three mass extinction events at 450 million years ago, 375 million years ago and 200 million years ago, by laser analyzing hundreds of pyrite crystals of these three ages.

### ***The chemical window of life unlocked by a mix and match of expertise***

At this stage of the research, the matching of geology and ocean chemistry expertise with palaeontology, evolutionary biology and toxicology expertise was required by the team to solve the next big question. “What precisely caused the mass extinction events”?

Professor John Long, Flinders University, invited a new group of international scientists to join the team and targeted the element selenium as the devil in the detail.

“Selenium is a unique element, with a critically small concentration window for life; too much is toxic, but too little cannot sustain life.”

“Selenium is also strongly held in the structure of pyrite crystals and is accurately determined by the laser analysis method developed for our time machine.”

Soon it became obvious to the team, that extreme deficiency in the little known element, SELENIUM, may have been the cause of the global mass extinction events, hundreds of millions of years ago.

“We need further research to prove the selenium theory of mass extinction events, however there is no doubt at this stage that it is a very exciting possibility”.

## ***Did Man Evolve from the Mountains?***

A major feature of the Earth's surface that would be obvious to time travellers stopping every 100 million years would be the slow rearrangement of the continents, commonly known as continental drift or plate tectonics.

A theory previously proposed by a team of scientists from the Australian National University is that the Cambrian explosion of life, 540 million years ago, was ultimately driven by the collision of supercontinents during plate tectonics.

As the theory goes, elements critical for life in the oceans principally come from weathering and erosion of rocks on the continents. Weathering breaks down the minerals in the rocks and releases the nutrient trace elements, which are the key to life and evolutionary change.

Thus, as erosion rates increase for extended periods, more life-supporting elements are supplied to the oceans. In the long term of geological history, erosion rates rise dramatically during mountain-building events, and these major events are caused by the collision of tectonic plates.

Geologists have known since the 1960s that collisions of tectonic plates lead to the formation of continent-scale mountain ranges. "Our research team has provided for the first time, strong evidence, through our newly established laser pyrite crystal analysis program, to link plate tectonics, evolutionary patterns of life and mass extinction events".

This provides a twist to Darwin's theory; "geological processes on Planet Earth have been the driver of evolution".

"This is an exciting possibility to emerge from our ride in the Laser Time Machine" says Professor Large: "Did Man evolve from the Mountains?"

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## **TEPO Research Team**

*University of Tasmania:* Distinguished Professor Ross Large, Professor Leonid Danyushevsky, Dr Jacqueline Halpin, Dr Daniel Gregory\*, Dr Jeffrey Steadman, Associate Professor Sebastien Meffre. PhD Students; Elena Lounejeva, Sean Johnson, Indrani Mukherjee.

*Flinders University:* Strategic Professor John Long

*Russian Academy of Science:* Professor Valeriy Maslennikov

*University of California, Riverside:* Dr. Daniel Gregory\*

## **Key Publications from the TEPO Research Program (2014-2016)**

Gregory DD, Meffre S and Large R., 2014, Comparison of metal enrichment in pyrite framboids from a metal-enriched and metal-poor estuary: *American Mineralogist*, 99, 633-644.

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Large RR., Halpin, JA., Danyushevsky. LV., Maslennikov. VV., Bull SW., Long, JA., Gregory, DD., Lounejeva, E, Lyons, TW., Sack, PJ., McGoldrick, PJ. and Calver, CR., 2014, Trace element content of sedimentary pyrite as a new proxy for deep-time ocean-atmosphere evolution: *Earth and Planetary Science Letters*, v. 389, p. 209-220.

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