2nd John de Laeter Memorial Lecture

7.00 pm , Monday 19th March, 2012

Bankwest Theatre, Building 200A, Curtin University, Bentley

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Volcanoes, Asteroid Impacts and Mass Extinctions

FRED JOURDAN

The history of life on Earth is punctuated by large mass extinction events. The cause of these mass extinctions remains unknown and controversial. Isotopic and elemental Chemistry is a tool of choice that helps us understand why these extinctions occurred. In particular, chemical data shows that the extinctions are linked somehow to drastic climate changes at this time. What caused these dramatic changes? Various geochemical tools are used to establish the ages and characteristics of major events in Earth's history such as large volcanic eruptions and massive asteroid impacts. In this talk, we will investigate the possible causes of past climate changes and mass extinctions and, the past

Fred Jourdan is a Senior Research Fellow at the John de Laeter Centre of Mass Spectrometry & Department of Applied Geology, Curtin University. He is director of the Western Australian Argon Isotope Facility dedicated to research in argon geochronology, the science of dating Earth processes. He obtained his PhD at Nice University, France in 2005. His research focuses on isotopic and chemical study of timescales and processes recorded in terrestrial and extraterrestrial materials, with a special focus on large volcanic provinces and impact events and their relationship with mass extinctions.

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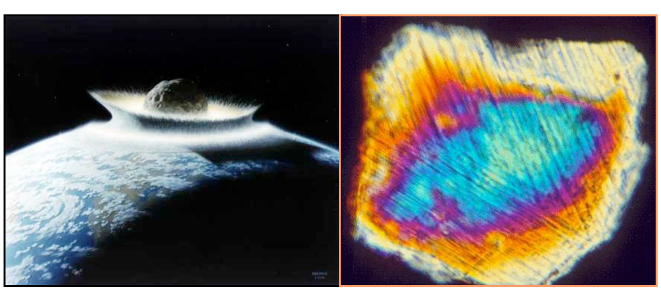
Held in the Bankwest Theatre at Curtin on Monday 19th March, the 2nd John de Laeter Memorial Lecture was attended by more than 60 people, with many remaining after the excellent presentation by Fred Jourdan to mingle and enjoy refreshments in the courtyard. Fred is a Senior Research Fellow in the John de Laeter Centre of Mass Spectrometry and Dept of Applied Geology at Curtin, and Director of the Western Australian Argon Isotope Facility dedicated to research in argon geochronology, the science of dating Earth processes. His research focuses on the isotopic and chemical study of timescales and processes recorded in terrestrial and extraterrestrial materials, with a special focus on large volcanic provinces and impact events and their relationship to mass extinctions.

The history of life on Earth is punctuated by large mass extinction events, with five large ones occurring in the Phanerozoic and many minor ones occurring between them. The cause of these mass extinctions remains unknown and controversial, in particular that of the end Mesozoic extinction. Isotopic and elemental chemistry shows that the extinctions are somehow linked to drastic climate changes. Various geochemical tools are used to establish the ages and characteristics of major events in Earth's history such as large volcanic eruptions and massive asteroid impacts. Fred's talk, summarised below, investigated the possible causes of past dramatic climate changes and related major mass extinctions.

The Cretaceous-Palaeogene (K-T) extinction event is well-documented, but controversy as to whether this was caused by an asteroid impact or the flood basalts of the Deccan Traps has raged for many years. The asteroid impact that created the Chicxulub crater in Mexico (66.04 $\pm$ 0.05 Ma), and the related razor sharp Cretaceous-Tertiary (K-T) boundary and its fine layer of shocked quartz, iridium and tectite spherites, has long been the popular culprit of the dinosaur's demise.



Asteroid impact and shocked quartz

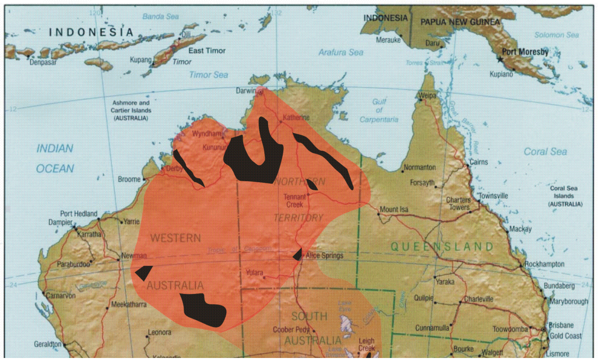
However, about the same time (66.5-65.5 Ma) the Deccan Traps in India were emplaced. So which one was the culprit? How did they affect the Earth's climate?

Impacts see an increase in soot, SO_2 and CO_2, which initially causes global cooling but ultimately leads to global warming, then to global circulation decrease/anoxia and marine and land extinction. Similarly, volcanism in the form of LIPs (large igneous provinces) and CFBPs (continental flood basalt provinces) sees an increase in ash, SO_2, CO_2, and CH_4 with similar global results. The question is, were other large extinction events caused by impact or volcanism? To determine this, the impact and/or volcanic eruptions must be exactly synchronous with a mass extinction.

The case for CFBPs. Major continental flood basalts that have been studied include CAMP in Morocco, KAROO in South Africa, DECCAN in India, and KALKARINDJI in central and northern Australia. The main area of Kalkarindji is approximately 2-3 million km^2 and its mean age, from $^{40}Ar/^{39}Ar$ (plagioclase) and U/Pb (zircon and baddeleyite), is 510.05 $\pm$ 0.6 Ma. There is also a possible intrusion into Proterozoic carbonate, dolomite and anhydrite layers, leading to degassing.

The CAMP (Central Atlantic Magmatic Province) covers 10 x 10^6 km^2 and is the largest CFBP on Earth and was emitted in pulses over 2-3 million years. It

occurs in western South Africa, northern South America, eastern North America and southwestern Europe. Lave flows more than 300 m thick in the Central High Atlas are intercalated with sedimentary deposits. Dated at 201.6 ± 0.2 Ma, it can be aligned with the Triassic/Jurassic boundary, but there has been some controversy suggesting the CAMP postdates the boundary dated at 201.3 ± 0.3. Triassic pollen found in between the lava flows, but not after, suggests that CAMP and the extinction event were synchronous.



Kalkarindji Continental Flood Basalt Province

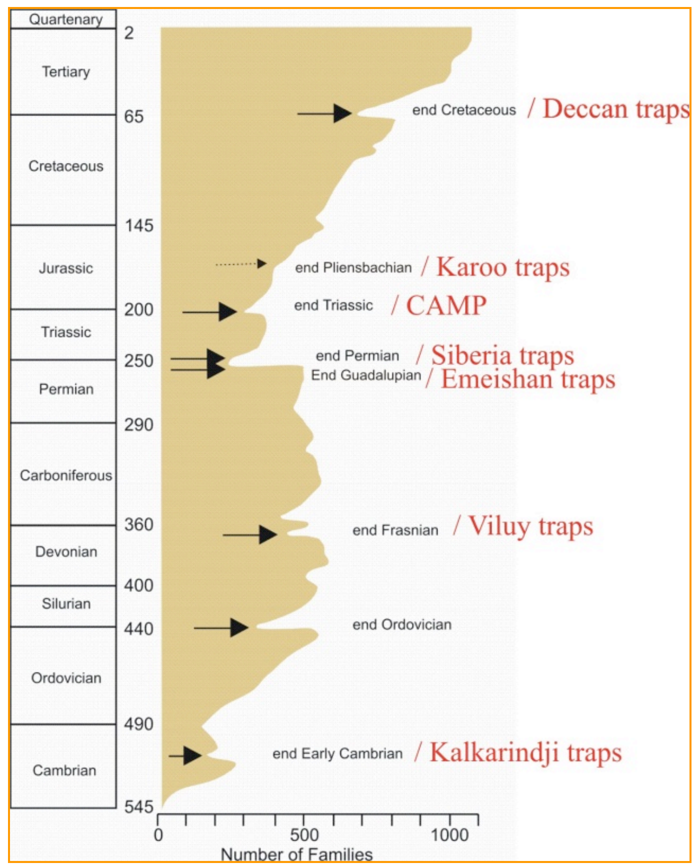
Work done at Curtin on CFBPs indicates that there is a temporal correlation between peak activities of CFBs and most mass extinctions. However, it appears that sluggish provinces like Karoo didn't cause much damage.

Wolfe Creek, WA

The case for impact craters. Currently, the global earth impact crater database includes 179 confirmed impact structures with 26 of these occurring in Australia. None of the Australian ones are well-dated. Like the moon and other celestial bodies, Earth has had many more impact structures than this, but they have either been eroded or subsumed with the oceanic floor turnover, but evidence of their existence is known from ejecta, tecktites, spherules and shocked quartz. Of the impact structures so far studied, only the Chicxulub crater can be aligned with a mass extinction.

***In conclusion*,** volcanism has played a dominant role in mass extinction processes, but the volume and timing of CFBs (= eruption rate) seem to be one of the main factors controlling the impact on the biosphere. Interestingly, 70% of biologists view the present era as part of a mass extinction event - possibly one of the fastest ever.

Footnote: Despite impact crater's fall from grace with regard to causing mass extinctions, they may be linked to other events in Earth's history. Studies by Kath Gray and others on the Acraman impact crater in the Gawler Ranges of South Australia, dated at 580 Ma, have recognised a post impact evolutionary radiation of acritarchs. This increase in algal diversification, the base of the food chain, may have triggered other biotic changes such as the Cambrian Explosion.



Major eruptions linked to mass extinctions