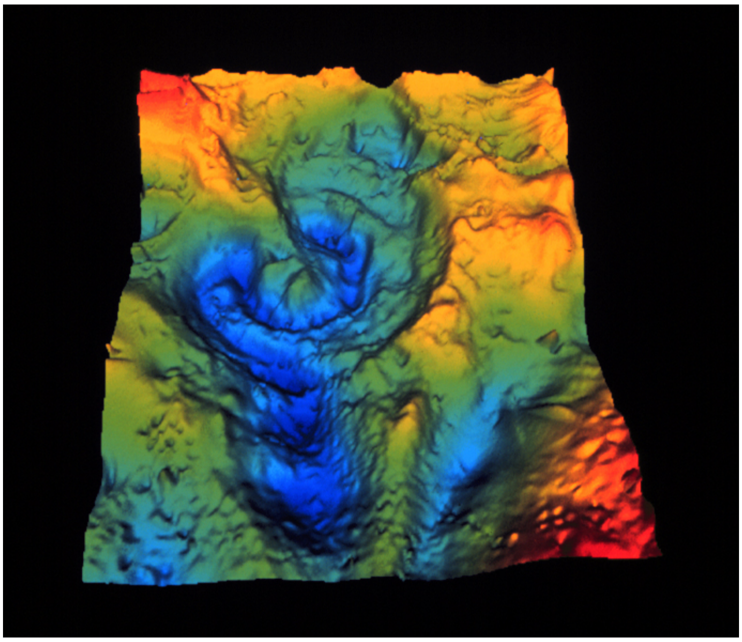
Miscellaneous commentary

Shock and Er … wait a minute (*October 2017*)



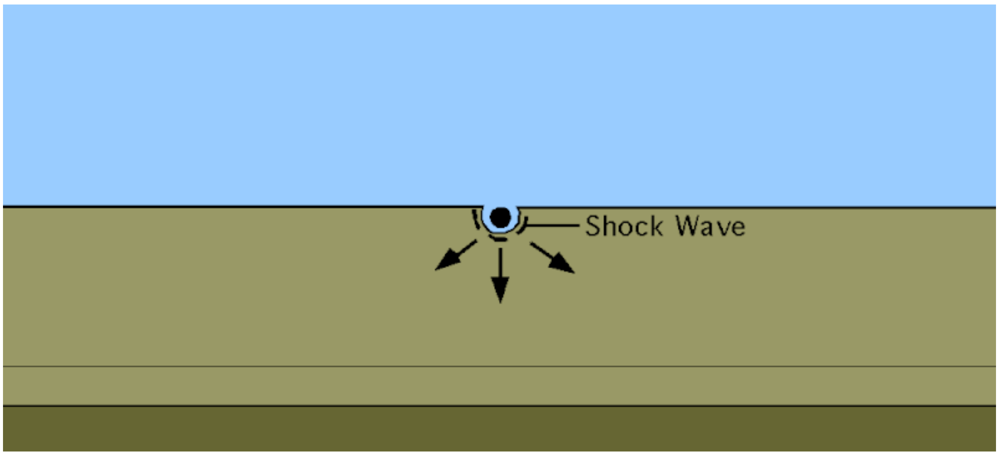
Enhanced gravity map of the Chicxulub crater (Credit: NASA)

Michael Rampino has produced a new book (Rampino, M.R. 2017. *Cataclysms: A New Geology for the Twenty-First Century*. Columbia University Press; New York). As the title subtly hints, Rampino is interested in mass extinctions and impacts; indeed quite a lot more, as he lays out a hypothesis that major terrestrial upheavals may stem from gravitational changes during the Solar System's progress around the Milky Way galaxy. Astronomers reckon that this 250 Ma orbit involves wobbling through the galactic plane and possibly varying distributions of mass – stars, gas, dust and maybe dark matter – in a 33 Ma cycle. Changing gravitational forces affecting the Solar System may possibly fling small objects such as comets and asteroids towards the Earth on a regular basis. In the 1980s and 90s Rampino and others linked mass extinctions, flood-basalt outpourings and cratering events, with a 27 Ma periodicity. So the book isn't entirely new, though it reads pretty well.

Such ideas have been around for decades, but it all kicked off in 1980 when Luis and Walter Alvarez and co-workers published their findings of iridium anomalies at the K-Pg boundary and suggested that this could only have arisen from a major asteroid impact. Since it coincided with the mass extinction of dinosaurs and much else besides at the end of the Cretaceous it could hardly be ignored. Indeed their chance discovery launched quite a bandwagon. The iridium-rich layer also included glass spherules, shocked mineral grains, soot and other carbon molecules –nano-scale diamonds, nanotubes and fullerenes whose structure is akin to a geodesic dome – and other geochemical anomalies. Because the Chicxulub crater off the Yucatán Peninsula of Mexico is exactly the right age and big enough to warrant a role in the K-Pg extinction, these lines of evidence have been widely adopted as the forensic smoking gun for other impacts. In the last 37 years every extinction event horizon has been scrutinized to seek such an extraterrestrial connection, with some success, except for exactly coincident big craters.

The K-Pg event is the only one that shows a clear temporal connection with a small mountain falling out of the sky, most of the others seeming to link with flood basalt events and their roughly cyclical frequency – but hence Rampino's Shiva hypothesis that impacts may have caused the launch of mantle plumes from the core-mantle boundary. Others have used the 'smoking gun' components to link lesser events to a cosmic cause, the most notorious being the 2007 connection to the extinction of the North American Pleistocene megafauna and the start of the Younger Dryas return of glacial conditions (see *Impact cause for Younger Dryas draws flak* Palaeoclimatology May 2008). Since 1980, alternative mechanisms for producing most of the impact-connected materials have been demonstrated. It emerged in 2011 that nano-diamonds and fullerenes may even form in a candle flame (Su, Z. *et al*. 2011. New insight into the soot nanoparticles in a candle flame. *Chemical Communications*, v. **47**, p. 4700-4702; DOI: 10.1039/C0CC05785A) and their global distribution could be due to forest fires. And now it seems that shocked mineral grains can form during a lightning strike (Chen, J. *et al*. 2017. Generation of shock lamellae and melting in rocks by lightning-induced shock waves and electrical heating. *Geophysical Research Letters*, v. **44**, p. 8757-8768; doi:10.1002/2017GL073843). Shocked or not, quartz and feldspar grains are resistant enough to be redistributed into sediments. Although platinum-group metals, such as iridium, are likely to be mainly locked away in Earth's core, some volcanic exhalations and many flood basalts – especially those with high titanium contents – are significantly enriched in them. So even the Alvarez's evidence for a K-Pg impact has an alternative explanation. Rampino is to be credited for acknowledging that in his book.

An awful lot of ideas about rare yet dreadful events in the biosphere depend, like many criminal cases, on the 'weight of evidence' and defy absolute proof. The evidence generally permits alternatives, such as the cunning, but perhaps playful, Verneshot hypothesis for the extinction-flood basalt connection (see *Mass extinctions and internal catastrophes* May 2004, *Verneshots: huge volcanic gas blasts ten years on* January 2015). As regards The K-Pg extinction, it is certain that a very large mass did fall on Chicxulub at the time of the mass extinction, whereas the Deccan flood basalts span a million years or so either side. But the jury is out on whether either or both did the deed. For other events of this scale and larger ones the money is on internal origins. As for Rampino's galactic hypothesis, the statistics are decidedly dodgy, but chasing down more forensics is definitely on the cards.



Animation showing the Chicxulub Crater impact. (credit: University of Arizona, Space Imagery Center)

Field studies – real or virtual? (*October 2017*)

Every evening's TV schedules include either an ad for some kind of 'virtual reality' (VR) device or a 'techie' programme in which one appears. As well as massively multiplayer online role-playing games, commercial VR offers 3-D encounters with charging rhinoceroses, surfing, wingsuit flying and other 'experiences' that are either life threatening or viciously expensive. Second Life, the online virtual world (but not yet compatible with VR goggles), appeared as long ago as 2003 and at present has about a million regular users and many more have passed through its portal, eventually to tire of its cheesiness. Yet, Second Life no longer seems to be a topic of normal conversation; maybe aficionados don't go out very often. The development software, the speed and resolution of computers, the peripheral technologies and the visual quality of immersive VR seem to be following something like Moore's law – the observation that the number of transistors in a dense integrated circuit doubles approximately every two years. And VR gaming is clearly very profitable with revenues likely to rise from about US$17 million in 2014 to over US$ 20 billion by 2020.

Douglas McCauley writes in *Science* (Insights 20 October 2017) about the potential of digital games and simulation for expanding the reach of STEM education, particularly in his own field of ecology (McCauley, D.J. 2017. [Digital nature: Are field trips a thing of the past?](#) *Science*, v. **359**, p. 298-300; doi: 10.1126/science.aao1919). His view is partly positive, as they match the thirst for armchair experiences and the growing digital expertise of the billion or more gamers and many more whose culture is dominated by electronic media, skewed strongly to the under-24s. For instance, children in the US spend on average 7 hours per day online, but only 4 to 7 minutes of unstructured outdoor play. There are obvious opportunities to familiarise and enthuse young people with the staggering richness of the natural world, which none of us will ever be able to witness first hand. At a time when the UK National Trust reports, for instance, that only a third of British children can recognise a magpie (a distinctive and common European member of the crow family) whereas 9 out of 10 easily recognise a Dalek alien cyborg, there is clearly a need. Sixty years ago David Attenborough's early monochrome Zoo Quest series on BBC TV definitely drew me into natural science as it did millions of others, and I for one am deeply grateful for his then somewhat awkward efforts. So it would be stupid to condemn the potential of VR and more plain-vanilla gaming methods, as they could do much the same and probably a great deal more. But can it really teach the field skills needed by any potential observational scientist rather than just make people more interested?

McCauley is less certain on that front, and so am I. Studies have shown that virtual field trip participants perform no better than their peers who engaged only in conventional illustrated lectures. 'Immersive' experiences can simulate some, but not all aspects of real terrain, ecosystems and geological features. My own geological ventures have involved a 'virtual' aspect provided by remote sensing and image interpretation. Those now pretty aged technologies show 'the big picture' – with some zoom-in capacity – and provide insights into regional and, with Google Earth, local geological structures and relationships. By capturing imagery outside the humanly visible wavelength range they add a great deal about rock composition that would otherwise require large sample collections, petrographic interpretation of thin sections and some basic geochemistry. A stereoscopic 3-D view and the use of terrain in creating perspective oblique images also permit estimates of dip and strike of strata. But it is all a bit inhuman and alien, much the same as 'doing' geology on Mars without the opportunity to behave as a curious being would if actually on the surface.

Any field scientist has real experience imprinted for years in much the same way as would her hunter-gatherer forbears, while it has been shown that virtual experiences may persist for a mere few weeks. My view is that often uncomfortable total immersion in field reality, literally step-by-step and day after day, fosters continual reflection during and for a long time after the experience. Much of science in general is about 'mulling over' observations at every level of detail; the more detail and the more repetition the deeper the insight and the more profound the breaks through.

As higher education continues along its path of commodification the more supposedly 'immersive' virtual experiences are likely to supplant field work, largely for cost reasons – both for students and institutions. In my former institution, to which I am still tenuously attached, a decision was taken 17 years ago to make residential field studies optional, and in 2011 to abandon them almost entirely in favour of 'virtual' experiences of one kind or another. The results have been dramatic: enrolment in geoscientific courses has fallen to a third of the pre-2000 level; retention has declined by up to 10% and pass rates have dropped significantly (see *The production of geoscientists: a cautionary tale from the Open University* February 2013). The bottom line is that what we used to call Earth sciences has become increasingly marginalised as regards the range of courses on offer at the British Open University.