ANDYSEZ 43

IS THERE LIGHT?

- Andy Spate

This ANDYSEZ might be seen as a trifle whimsical. But it illustrates, yet again, the breadth (and depth) of karst science. Cave guides may be able to raise this discussion with their clients – not on every tour please! It might provide some additional material when discussing non-light driven energy sources which provide the driving forces that support some extreme ecosystems.

At the Samcheok City, Republic of Korea, 2002 International Cave Expo, I was handed a copy of the *International Journal of Speleology* (29B(1/4) 2000). I visit this Journal occasionally and it often has much of interest (and only costs individuals 16 Euros (~US$15) a year – but isn't that a kind of kangaroo?).

The issue cited above includes a number of interesting papers including:

- *Development, Management and Economy of Show Caves (Arrigo CIGNA & Ezio BURRI)* which lists "*Some important show caves from all over the world*". All Australian show caves are listed courtesy of Ernie Holland. Twenty-one Australian areas out of the 200 listed (of an estimated 800 world-wide!). Only four New Zealand activities.? It presents an excellent discussion of show cave management, economies and the environmental aspects of show cave development. Would that our governments and agencies be so interested…?

Hey Kiwis – could we have a listing of New Zealand show caves in the next Journal?

- *The Influences of Cave Tourism on CO_2 and temperature in Baiyun Cave, Hebel, China (SONG Linhua, WEI Xiaoning & LIANG Fuyuan).*

- A wonderful (and perhaps whimsical) paper by Giovanni BADINO (from Italy) titled "*Is it always dark in caves?*"

The answer to the question posed by Badino is "**No**"! As he says "It is always dark in caves, yes: but not *absolutely* dark…" [emphasis Badino].

I am going to attempt to précis Badino's paper to explain why caves are not dark. Badino's observations and calculations seem to indicate that Andrew Pavey's remark about *f*2.8 for three weeks may be applicable for eyes adjusted to visible light. Using ASA 400 film at *f*1.4 and allowing for reasonable reflectance from the cave walls, ceiling and floor a reasonable picture would seem to require somewhere between 20,000 and 4,000,000,000 years… Even Pavey won't wait around that long!

Read on, dear friends…

You will all have seen photographs of large tanks of water associated with nuclear reactors and other sources of radiation which exhibit a ghostly blue glow. This is light produced by Cerenkov radiation which is defined by the OED as "Light emitted by a charged particle moving in a medium at a speed greater than that of light in the same medium." You all know as well as I do that visible light travels quite slowly through limestone but you might not know that cosmic rays pass through rock.

The Earth is constantly being bombarded by radiation of many forms from outer space – much is dissipated in the atmosphere producing showers of particles of many kinds. At sea level, electrons, gammas, neutrinos and muons make up much of this radiation. At just a few metres below the surface only muons and neutrinos from cosmic rays are present. The muons are absorbed relatively early but the electrically neutral neutrinos can pass right through the Earth without interaction. If interaction does occur a muon might be produced which will travel through rock, water or air (caves) producing Cerenkov radiation.

Other light sources in caves are from secondary processes produced by radioactive minerals within the rock mass or from the luminescence of non-radioactive minerals stimulated by high energy particles from radioactive decay. Badino points out that these natural light fluxes in caves are very easy to detect (using instrumentation) but are not utilised by underground life forms.

As far as we know… There are many places around the world where natural and artificial cavities are being used for the study of cosmic rays and associated radiation and particles.

Badino discusses the processes of vision which are both complex and poorly understood. It would appear that the time resolution of any organism's eyes – that is the duration of Cerenkov and other light release occurs too infrequently for our eyes to respond.

As Badino says "It is not strange that caves appear to us as dark: the general features of cave illumination do not fit with the vision parameters selected outside [caves] by life evolution."

The Grotto Gigante is a very large cavern near Trieste, Italy. It is at a depth of about 100 m and a diameter of about 15 m. In this cave, using the average muon flux and the eye's surface area, we can estimate that within 100 seconds there will be only two muon interaction with the retina.

This will produce about 50,000 photons each minute directly against our retina. This is about the same intensity of a 6th magnitude star which is defined roughly as the absolute limit for visual detection.

As Badino says "…it is difficult, but we may see it! So, it is probable that a part of phosphenes (the luminous impression due to the excitation of the retina by other than the impingement of light) that we may see in cave darkness is the visible part of cave illumination…"

Let's finish by quoting Badino's conclusions verbatim:

> The cosmic radiation and other secondary effects are able to release visible light in underground cavities, mainly by the Cerenkov effect. The illumination increase linearly with the cavity dimensions.
>
> These light emissions are largely used for cosmic rays studies, especially in Underground Neutrino Observatories, and generally speaking are able to give physiological effects, but the need for noise [in a physics sense] reduction forces the brain to disregard suck weak signals in the construction of a visual sensation. This is the reason why caves appear to us as so dark.
>
> It is easy, for us, to design "eyes" able to reconstruct images from light fluxes in caves, but they would be large and energetically expensive devices that could work only in large cavities. The Nature, more cleverly seems to have chosen different and simpler ways to give good detectors of the surrounding world to the underground life."

I would bet that future research in the coming decades will reveal the use of Cerenkov or other light sources by underground life… Stand by!