Cave Photography with Digital Cameras

Garry K. Smith

Newcastle & Hunter Valley Speleological Society

Abstract

Taking photographs in the damp and confined spaces of a totally dark cave is not everyone's idea of fun. A caver can take 'happy snappy' shots with a point and shoot Compact camera using only light from the camera's inbuilt flash, but the images achieved from this type of photography can be very flat and lifeless. To achieve a more in-depth photo with plenty of contrast (Fig.1), a cave photographer needs to become more dedicated to the art of flash illumination in order to capture that 'wow' factor image.

This paper describes in simple terms the fundamentals of digital cameras and main distinguishing features between the three broad classifications: Compact, Prosumer and DSLR. Also discussed is equipment suitable for cave photography and what to look for when purchasing a camera and flash unit.

Other topics covered include choosing the photo subject, composition, lighting, framing the subject, taking the picture and general flash photography tips.

Figure 1: *Caver admires the Ice Cream Cake in Croesus Cave Tasmania.*

Camera fundamentals

A digital camera is basically a box holding a lens which directs light onto a photosensor element which captures the image, then stores it on a memory card as a digital file.

There are two main types of photosensor element; Charge-Coupled Device (CCD) and Complementary Metal–Oxide–Semiconductor (CMOS), which for the purpose of this paper will be collectively referred to as a 'sensor array'.

A camera has basically three adjustable control elements which the operator can play around with if the automatic setting is not used: aperture, shutter and ISO.

The aperture is the variable opening (hole) through which the light passes before reaching the light sensor array. The aperture is defined by numbers such as f/1.2 which is generally the largest opening, and get progressively smaller down to, f/6.4, f/7.1 and f/8. Some cameras may have apertures as small as f/22. Besides controlling the amount of light which reaches the sensor array, the aperture controls the 'depth of field' in the picture, allowing the photographer to determine how much of the image is in or out of focus.

The second adjustable element is the shutter speed which relates to the length of time the sensor is exposed to the light. This is measured in fractions of a second such as 1/60th of a second. For flash photography, most cameras will not synchronise with a flash unit if set faster than around 1/100th of a second. Setting a fast shutter speed (e.g. 1/250) is handy if taking photos of fast-moving objects above ground in bright sunlight. However, to photograph in low light conditions of a cave entrance without using a flash, may require a slow shutter speed (e.g.1/60) to compensate for the lack of light.

The third element is the International Standard Organization (ISO) sensitivity to light number, which is basically how fast the sensor array reacts to the light. A sensitivity of 80 ISO, or 100 ISO is generally the slowest on most cameras and will produce the best quality image. Turning the camera's ISO up to say 1200 ISO in low light conditions will easily capture an image which looks fine on the cameras small Liquid Crystal Display (LCD) screen, however the resulting image will be of poor quality. The reduced quality will become apparent when the image is enlarged on a computer screen as a considerable variation in coloured dots (pixels) particularly within dark patches. This is referred to as electronic 'noise' and can be observed in areas of an image which should be the same colour but are made up of various coloured pixels. Therefore if the subject can be well lit with plenty of flash power, use a low ISO setting such as 80 or 100.

Very few manufacturers currently offer models with less than 5 Megapixels and most have some video capability. Camera memory cards are getting larger and less expensive, thus allowing users to take more photographs and at no additional cost after the initial equipment outlay. Rechargeable digital camera batteries are getting better and lasting longer.

In many respects the technology of digital cameras has surpassed the capabilities of film cameras. The one big advantage is 'instant gratification', that is the ability to instantly review an image which has just been captured and to delete it and take another if the first is not to the photographer's liking.

Digital Cameras

There are three broad categories of digital camera. They are the Compact, Prosumer and Digital Single Lens Reflex (DSLR).

Compact Digital cameras are also known as 'point and shoot' or 'consumer cameras' (Fig. 2). These cameras are the cheapest and most popular with people who don't consider themselves a photographer. The distin-

Figure 2: *Examples of Compact Digital Cameras Note that the camera on the far left does not have a viewfinder – it has been totally replaced with an LCD screen on the back to make the camera smaller.*

guishing feature is that the optical viewfinder consists of a simple optical system which zooms at the same time as the main lens and has an optical path parallel to the camera's main lens (Fig. 3). The biggest problem is framing inaccuracy as the viewfinder is positioned above the actual lens (often there is also a horizontal offset known as parallex error), so that what is seen through the optical viewfinder is different from what the lens projects onto the sensor (Fig. 4). Increasingly, manufacturers are producing these cameras with LCD screens at the back of the camera which reproduce in real time what the camera lens is seeing. Hence the LCD on the back of the camera is often used to replace the optical viewfinder. Typically the Compact cameras are small and easy to carry but have limitations for the more experienced photographer who wants to be a bit creative. For example most compact cameras do not allow the operator to directly control exposure settings.

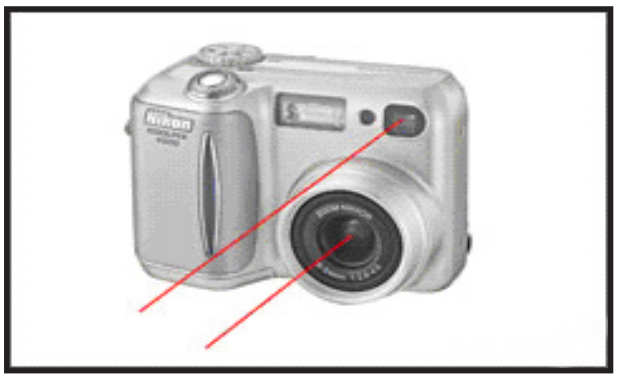

Figure 3: *Typical Compact Digital camera. As the optical path of the viewfinder runs parallel to the camera's main lens, what the photographer sees is different from what the lens projects onto the sensor.*

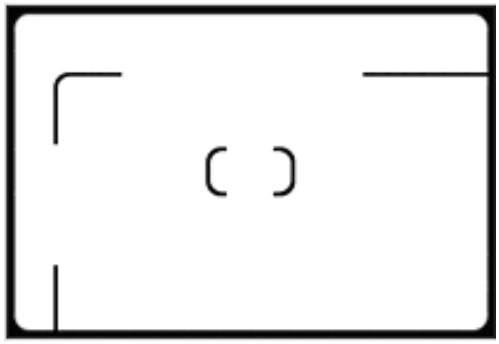

Figure 4: *Sometimes optical viewfinders have parallax error lines on them to indicate what the sensor will see at relatively small subject distances (e.g. below 1.5 metre or 5 feet).*

Compact digital cameras tend to have very poor optical zoom qualities compared to the better cameras.

Prosumer or Bridge Digital cameras are closely related to high end 'compacts', but they are often confused with Digital Single-Lens Reflex (DSLR) cameras due to their similar body shape and large zoom lenses (Figs 6 & 7). Prosumer cameras fill the niche between the Compact and DSLR. The word Prosumer is derived from a combination of the words professional (SLR cameras) and consumer (compact cameras).

They are comparable in size and weight to the smallest DSLR cameras, but lack the removable lenses, larger sensors, mirror, and reflex system which characterize DSLRs.

Prosumer cameras have a non-removeable zoom lens which is reasonably sealed against dust ingress. Hence there is reduced possibility of dust being deposited on the sensor array, compared to DSLR Cameras with removeable zoom lenses which can act as an air pump and suck dust into the camera body. Any dust on the sensor will significantly reduce image quality

Many Prosumer cameras have LCDs which can be flipped out from the body or angled up or down to make it easier to view while taking low or high angle shots (Fig. 5).

Figure 5: *Digital Prosumer camera with a flip and twist LCD.*

For those who wear corrective glasses, it is worth checking to see if the viewfinder has a diopter adjustment. This may negate the need to wear glasses while photographing.

Figure 6: *Typical style of camera at the low end of the Prosumer Camera range*

The fact that the camera is totally self-contained (lens, flash, etc) is a big selling point. As there are many features crammed into the average Prosumer camera, it gives plenty of room for the enthusiast photographer to experiment well beyond the auto 'point and shoot'.

Figure 7: *Typical style of camera in the high end of the Prosumer Camera range.*

Digital Single Lens Reflex (DSLR) cameras are generally used by professionals and serious photo enthusiasts (Figs 8, 9 & 10). The cameras basically use a mirror and pentaprism or pentamirror system to direct light from the lens to the viewfinder eyepiece. When the photo is taken, the shutter mirror flips out of the way to allow the light from the lens to hit the sensor array and capture the image. This through-the-lens viewfinder system ensures that what is seen through the eyepiece is captured by the light sensor array.

Heavier than both compact and prosumer cameras, DSLRs give photographers the ultimate in quality, control and creativity. The combination of high quality optics and large sensor arrays (typically 6 to 12 million pixels) provides excellent image definition when the subject matter is correctly exposed and in focus.

Figure 8: *Fixed LCD on a digital SLR - used to view images only after they are saved to memory.*

These cameras can be used in the automatic mode, however using some of the excellent manual features can certainly allow the photographer to be very creative.

The LCD screen at the back of a DSLR camera is used to display the image directly after taking the shot, or viewing images previously saved on the memory card. For this reason it is more difficult to compose a photo with an SLR in very dark caves using a torch to locate the boundaries of the scene as well as looking through the viewfinder (Fig. 8).

Figure 9: *Typical Digital SLR (DSLR).*

Figure 10: *Top View of DSLR.*

Choosing a Digital Camera

Now that the basics of a digital camera operation are explained, one must really take some time to identify what type of digital camera to purchase for underground photography. There are so many makes and models on the market these days. A novice can gain good advice by talking to a professional photographer or fellow cavers who have achieved good photographic results.

A range of issues involving choice of camera and associated equipment, choice of subject, structure of the picture composition and some general points on taking photos in caves need to be considered. These are:

1. Choosing the right camera
2. Choosing flash and slave equipment
3. Pre-checking camera equipment
4. Co-operative models and helpers
5. Subject and composition tips
6. Framing the picture
7. Lighting the subject
8. Taking the picture
9. General tips
10. Tips for composing a photo
11. Pixels, Megapixels and DPI explained

1. Choosing the right camera

It is impossible to list the large number of variables involved, but here are a few simple aspects to consider.

a. Choose a camera which can be operated in a full manual mode if required. This will give full flexibility in overriding the aperture, speed and ISO to allow more creative photography.

b. A camera with low light capability will work better in dim light situations.

c. Make sure the camera has a lens which will cover the full 'field of view' which you are expecting to be captured in the image. A lens covering a range from 28mm to 200mm or more is preferable for those wide angle shots in small chambers, as well as zooming into those further away subjects. Fig. 11 is an example of where the zoom lens was set at 28 mm to capture the full scene in a confined chamber.

d. The Macro focus distance may be important if considering close up photography of cave invertebrates. Many cameras only allow the macro setting when the lens is at its widest angle of view, for example 28 or 35mm. Bear in mind that the functionality of a zoom lens will mean the minimum focus distance from camera to subject increases as the lens is zoomed toward the telephoto end of the lens' range.

e. There must be the option to turn off the camera's double flash related to the "red eye reduction" or additional flashes which may be used by the camera to determine white balance or exposure settings. The camera's multiple flashes will prematurely set off the slave flash units and can result in under exposed images.

2. Choosing flash and slave equipment

Many digital cameras have inadequate inbuilt flash systems and lack a connector for use with an external flash unit. Basic slave units will not synchronise with many digital cameras which use a very rapid series of pre-flashes to perform various functions, such as: red eye reduction, white balance settings, flash power/ duration determination or the camera aperture and ISO settings.

Most cameras will allow the operator to turn off the red-eye reduction flash, however there are many cameras which do not have the option to turn off the pre-flash which sets the camera's white balance or aperture and

Figure 11: *A waterfall when illuminated by several synchronised electronic flash units, appears to be frozen. To get the blurred movement of water, strobe flashes or a constant light source is required.*

ISO. This pre-flash typically fires 100ms (100 milliseconds, or 1/10th second) before the camera captures the image on the second flash. Most slave units will fire on the pre-flash and cannot cycle quickly enough to fire again when the picture is taken 100 ms later. Thus, the extra light from the slave flash does not show up in the digital camera photo. The pre-flash and second flash may be so close together that the photographer only sees the one flash. The camera manual is a good place to find out how to turn off extra flashes.

Some advanced slave units feature a switch, which allows the user to select between several triggering modes used by different digital camera models. This allows them to be used with any camera on the market.

There are a number of slave units commercially available, which connect directly onto the hot-shoe of the electronic flash unit. These work extremely well in caves, out of the camera's line of sight, as they are triggered from the reflected visible light from another camera flash. The Firefly brand slave units are triggered by a pulse of Infra Red (IR) or visible light, but are not set off by torchlight (Fig. 12). As such they are well

Figure 12: *Firefly 2 and 3 – slave units are triggered by IR & visible light.*

Figure 13: *Flash Unit with light sensing eye in base of hot shoe. This determines required flash duration to illuminate subject.*

suited for cave photography and will work in dark areas up to 500 m away from the camera.

It is worth investing in at least one or more good quality slave units to put on electronic flash units. A second hand flash unit from a pawn broker or *Cash Converter* is probably the cheapest way to get started and it is easier on the bank account if the flash gets destroyed in the harsh cave environment.

It is worth paying a little more to get an electronic flash unit with a couple of settings and the smart technology of a light sensor which can cut off the flash when the subject is exposed correctly (Fig. 13).

Another alternative to the visible light or IR triggered slave units is the Radio Frequency slave units which are now available in selected outlets.

3. Pre-Checking Camera Equipment (before going underground)

One of the biggest mistakes is to go caving and clamber all the way in lugging lots of camera gear, only to find the batteries are flat or something has been left behind.

Check that all equipment works before leaving home by setting up a mock photo at night in the back yard or indoors. This can be as simple as checking that the slave flash is firing syncronously (in sync.) with the camera flash and the correct exposure can be achieved. As previously discussed, many Compact digital cameras will not allow the photographer to turn off the automatic double flash setting. An easy test is to take a photo of the electronic slave flash unit set up on the other side of the room. If the photo shows the slave flash firing with a bright light, then the camera and slave are in sync. The next step is to work out what aperture to use in order to achieve a good exposure. Using the flash guide settings is the best place to start, however the final setting can only be fine-tuned in the cave when a photo is being set up.

When purchasing camera equipment, try and stick to equipment which uses the same type of battery, eg. rechargeable AA. This way you don't need to carry as many spare batteries and rationalisation of equipment can help to reduce weight (Fig. 14).

A good battery tester is worth having at hand to do a final check on all camera and flash batteries. Remember

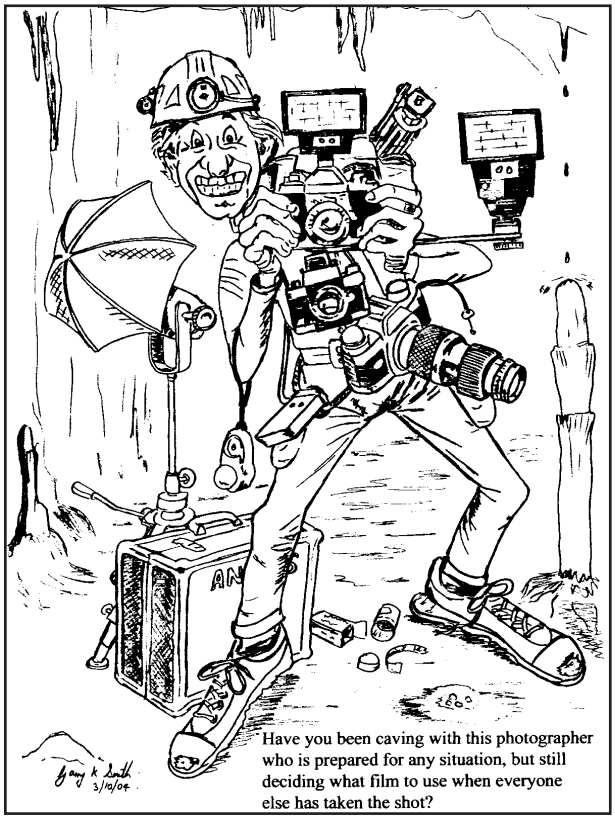

Figure 14: *How much gear do you really need?*

to check the small batteries hidden in the slave units.

4. Co-operative models and helpers

Cave models can make or break a photograph. They need to be co-operative and have plenty of patience to stay in the same position for whatever time it takes to capture the perfect image. This may be while the slave flashes are adjusted or moved and it may involve the model changing positions to suit the composition which the photographer is aiming to portray. A cave model standing in an awkward position or with an un-natural facial expression can be very detrimental to the overall image. Hence, the cave model must be relaxed and comfortable with the reality that they may be in the same place for a period of time.

In some circumstances it may be an advantage to have helpers holding slave flash units at the correct angle and position. This can be a tedious task as the photographer may need the angle or position changed several times during the shoot.

Make sure that all members in your party know the planned trip is a photographic trip if some serious photography is to be undertaken. These trips can yield the best results when time is taken to set up each shot, as opposed to the happy snappy trip where everyone is constantly on the move.

Cave photographers don't particularly have a good reputation with other cavers because of the time it takes to set up and take the desired shot. Hence, it is a good idea while the rest of the party is exploring possible leads in the vicinity, the photographer should use the opportunity to size up the photo subject, get the gear ready with flashes and camera in position. Take a few test shots to check lighting without any cave model in the picture. When all is set, ask the model to step into the

picture and take the shot (Fig. 15). Above all, know how all the equipment functions.

Even groups of photographers can work together provided only one person sets off the slave flashes. Once a few test shots are taken to determine optimum aperture with a known ISO (e.g. 100), other photographers are informed of the settings. Everyone focuses their camera on the subject and holds their camera focused (or use manual focus) and framed on the subject. The coordinating photographer counts to 3 before taking the photo to trigger off the slave flashes. At 2 the other photographers take the photo with their cameras set on a 4 or 5 second exposure without a flash from their camera. That way everyone is able to capture the image, possibly from slightly different angles.

Figure 15: *A photographer lines up his subject and checks exposure and flash angles.*

5. Subject and Composition Tips

A good subject is best described as something which is of interest to the photographer and the target audience. There is no real benefit having a well exposed shot of something of little interest. A photo of an often-photographed icon really needs to be an outstanding photograph from a different angle or different lighting conditions to set it apart from the rest.

Incorporating as many of the following elements will increase the chance of making a photo more interesting to the viewer.

a. Include both near and far objects. This will require a good depth of field.

b. Include some aspect which will give a comparison of scale.

c. A dominant feature in a photo should catch the observer's eye and lead it toward the rest of the photo. An example is a person looking toward the rest of the scene or at a dominant feature. Definitely avoid having a cave model looking out of the picture.

d. The 'thirds principal' is a good rule of thumb to use. e.g. a person 1/3 of the way across the photo. However there are sometimes exceptions to this rule of thumb.

e. Don't cut a person off at the knees, ankles or neck; either include a person's head and shoulders to mid chest level, or the whole person.

g. Make sure the model has an acceptable facial expression and is positioned in a good pose. An awkward expression or posture can ruin an otherwise good photo.

h. Get the exposure correct by adjusting the flash units or camera aperture.

i. Make sure there are no reflective tapes or stickers on the model's clothing or equipment.

6. Framing the picture

Using the suggestions mentioned under the heading 'Subject and Composition Tips', set your camera on a tripod so that the required field of view is framed. This may require the zoom lens to be adjusted, the camera tilted on the tripod, or even repositioning the tripod to a new location.

In total darkness it is difficult to see on the LCD screen what the camera actually has in the 'field of view'. To overcome this problem it is a good idea to shine your torch around the intended subject and at the same time watch on the LCD screen where the torch beam spot is. When your torch beam is on the far left of the intended photo, then it should just be seen on the far left of the LCD screen. In this way the beam of the torch can be used to run around the intended boundaries of the photo and the camera 'field of view' adjusted accordingly.

Using this technique is easier if the camera has a flip up or flip out LCD so that the photographer does not have to crouch awkwardly behind the camera or have their eye up to the viewfinder of a DSLR camera. Bear in mind that in caves the conditions for photography are often cramped and just trying to get an eye behind the camera may be very uncomfortable. This is where the prosumer cameras with flip out screens have it over the other cameras.

Figure 16: *Back lighting illumination gives a aura around the subject and provides contrast with reflection off the running water.*

7. Lighting the subject

Despite having superb subject material to photograph, bad lighting can severely diminish the visual impact (wow factor) of a photo.

The complexity of photographing in total darkness is often not appreciated by daylight photographers. The time required to produce a quality flash photo and the effort involved in achieving this can best be understood by a cave photographer or the model who has patiently posed for a photo in cramped, wet and cold conditions for an extended period of time.

So what are some good rules of thumb?

a. Expose the subject well.

b. Have a few dark areas within the frame to give contrast to the subject.

c. Provide side light to give some degree of contrast/ shadow to the objects of interest. This will help give a better depth to the final image.

d. Back lighting can greatly enhance the photo by giving the subject an aura and provide reflections from pools of water (Fig. 16). Avoid flare from a flash unit which is pointing back toward the camera.

e. Make sure that a torch beam is not illuminating any part of the subject in the field of view. A torch beam will produce a spot which is over exposed and will most likely have a colour shift toward the orange if from an incandescent globe or blue if from a LED torch. Compare the difference in images with and without a torch spot (Figs 17 and 18).

f. Avoid harsh shadows which may be prominent in the field of view. The exception is when the shadow is to be a feature of the final image (refer to item 'j'). An example of a bad shadow is shown in Fig.19.

g. Experiment with lighting on one side of the subject and again with lighting both sides of the subject (Figs 21 and 22). Subjects which cast a prominent shadow may require lighting on both sides.

h. Moving the flash angle so that the background wall of the cave remains unlit, will highlight the subject against a black background (Figs 23 and 24).

i. Using a light source at a critical angle to a subject can accentuate features of the subject with shadows (Figs 25 and 26).

j. Shadows cast by the subject can be used to dramatise or enhance the photo (Figs 27 and 28).

k. Getting the lighting angle correct can produce some excellent results. For example a refracted image of stalagmites will appear inverted in the water drop on a straw (Fig. 29). Note the calcite crystal growing in the water drop. When undertaking macro photography it is often best to use the smallest aperture possible with plenty of flash power.

l. There are many variations of lighting which can be achieved by moving the flash from the obvious position

Figure 17: *The bright orange spot from the photographer's incandescent headlight beam has reduce the quality of the photo.*

Figure 18: *This time the photographer's torch beam has been turned away from the field of view when the photo was taken.*

Figure 19: *A flash position can be very crucial. Note, shadow across cavers face.*

Figure 20: *Flash position has been changed slightly and resulted in better photo.*

Figure 21: *Stalagmite with flash lighting on one side.*

Figure 22: *Stalagmite with flash lighting on both sides.*

Figure 23: *The subject may be perfectly exposed and in focus but the lighting on the wall behind is detracting from the main subject.*

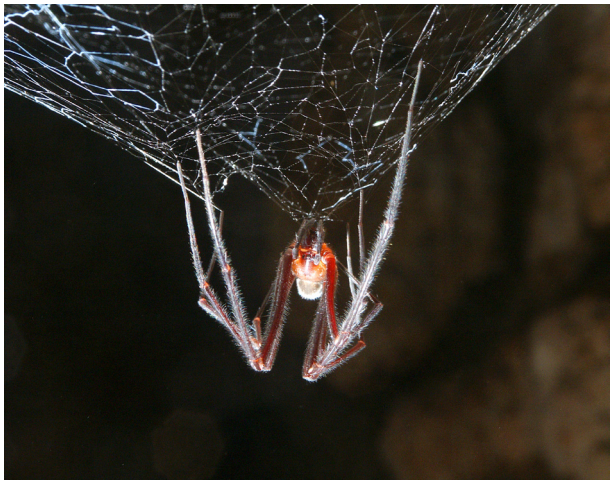

Figure 24: *With the cave wall not lit and flash to the side, a whole new dimension can be observed with some light passing through the spider's body. A small flash on the camera is used to just illuminate the front of spider.*

Figure 25: *Without much shadow the dog skull looks flat.*

Figure 26: *Here the shadow on the dog skull accentuates the facial feature.*

in front of the subject. Figures 30, 31 and 32 depict how the final result can be dramatically changed by moving the slave flash units.

8. Taking the Picture

Assuming the photographer has identified the subject and camera position, consider the following steps when taking the photo:

a. Identify the 'field of view' around the subject for the desired picture.

b. Place the camera on a tripod. The camera can also be hand held if more convenient.

c. Place the electronic flash slave units in appropriate positions to allow for desired lighting effect & exposure.

d. Take a few test shots to check the camera exposure and lighting effect of the slave flashes. Adjust camera

Figure 27: *Stalactites cast good shadows on the ceiling when lit from behind.*

Figure 29*: Stalactites on ceiling above can be seen in water drop with correct flash lighting.*

'aperture' settings if required. The electronic flash units may be strategically placed on rock ledges, fitted to tripods or just hand held by someone.

e. Have the 'cave model' (caver who is posing for the photo) positioned in the desired location. Make sure there are no reflective strips on their clothing or equipment. Bright coloured clothing looks better than dark colours.

f. If the pose of the cave model is looking toward the camera, shine your head lamp at their eyes for a couple of seconds. This will dilate their pupils and eliminate 'red eye'. It may also be better to have the cave model's head lamp turned off.

g. The camera may have to be set to a single spot focus mode for cave photos. The photographer shines their head lamp at the main focus point in the field of view and half presses the shutter button down to allow the camera to focus easily on the main subject. The photographer may have to momentarily swivel the camera slightly to focus on an object just off centre of view. Continue to

Figure 28: *The placement of a flash to give a shadow can add to the effect.*

Figure 30: *Lighting only from front, but off centre to allow shadow behind straws to make them stand out.*

hold the camera shutter button at the halfway point to maintain focus. Using manual focus is an alternative to the auto focus.

h. The photographer turns off their head torch or points their torch beam out of the picture. This will eliminate the torch spot from the final photo (Fig. 17). It may be more convenient for a photographer's helper to shine their torch for camera focusing and reducing cave model red eye.

Figure 31: *Lighting only from behind subject, which almost blends straws into background wall.*

Figure 32: *Main lighting from behind and small amount of light from the front.*

i. The photographer is still holding the camera shutter button half depressed to maintain the camera in the focused position. If the cave model is ready, push the shutter button all the way down to take the photo. The small inbuilt camera flash will set off all the slave flash units.

j. Check the stored image to verify that the field of view, exposure, model's position and expression is satisfactory.

This all sounds like a long winded process, however once everything is set up, it only takes a few seconds to

Figure 33: *Using a small aperture will produce photos with the greatest 'depth of field'. Note the rimstone dams in the foreground are in focus as well as the cave model further away. This is not possible if a large aperture size is used.*

take extra photos to improve on the original, particularly if the cave model has blinked or a slave unit has failed to fire.

9. General Tips

a. A camera with an adjustable diopter in the viewfinder can be very beneficial to photographers who normally wear prescription glasses. When adjusted correctly there is no need to wear glasses while photographing. However with DSLR cameras the only replay for viewing stored images is on the LCD screen at the back of the camera, so the advantage of the adjustable dioptre is lost if prescription glasses are still required to view the LCD screen. On the other hand many Prosumer cameras have the option to view and edit stored images through the viewfinder. Although the internal viewfinder LCD may be small, there is generally plenty of scope for the photographer to determine the quality of images for editing, hence there may be no need to wear glasses at all.

b. Make sure a head lamp beam is not in the field of view when taking the photo. A headlamp with an incandescent globe will create an over exposed spot which is yellow. A white LED will produce a bluish spot.

c. A camera with 5 or 6 megapixels will produce images (if camera is set at its highest resolution), which can be easily printed up to A4 sheet size. If larger high resolution prints are desired, it is worth considering an 8 or 10 megapixel camera. (Table 1)

d. Always have the camera set on the highest resolution to take every photo. It is often impossible to recreate that perfect shot with a person's expression or lighting effect, but it is very easy to delete a photo which did not work out.

e. To produce images with the greatest 'depth of field' or in-focus range (Fig. 33), use the smallest possible aperture setting to suit the highest available electronic flash output (or other light source).

f. When using an electronic flash with a slave unit to remotely trigger it, make sure the flash's light sensor is not obstructed by a nearby object. The use of a very small tripod to support each flash unit can be a big advantage and eliminate the need to directly place them on the ground or a rock ledge. When hand held, the flash's light sensor (Fig. 13), may inadvertently be obstructed by the holder's finger, resulting in overexposure of the image.

g. Carry camera gear in a good quality camera case which is dust and waterproof as well as shock resistant. A favourite with many photographers is the Pelican case which comes in a wide variety of sizes and contain foam which can be cut out to exactly fit around equipment.

h. Where possible, avoid long exposure times and avoid using high ISO settings as the electronic noise will reduce the quality of the final image.

Table 1

Number of Megapixels	Acceptable Print Size (Inches)
2.0	4 x 6 [standard]
3.0	5 x 7
4.0	8 x 10
5.0	9 x 12
6.0	11 x 14
8.0	12 x 16
10.0	16 x 20
12.0	18 x 24

10. Tips for composing a photo

As with all photography, "beauty is in the eye of the beholder". It is a subject which is not an exact science, rather something which appeals to the artist (photographer) and the viewer. Here are a few simple tips which could help an amateur.

a. **Framing the subject (composition).** The images in Figures 34 to 37 are used to highlight what the author considers as simple rules of thumb which can be used to improve the framing of a subject. The fourth image (Fig. 37) represents the best composition in the series of figures.

b. Scale of the subject. In cave photos it can often be very difficult to judge how large or small a decoration is. Therefore it is a good practice to add something to the composition which can be used as a comparison of scale (Figs 38 & 39). In this case a caver gives scale.

c. **Photographing from an unusual angle**, can give a different perspective to that of the standard horizontal. I am talking about lying on your back shooting up or being up high and photographing straight down. There are many interesting effects which can be achieved by this method. (Figs 40, 41, 42 & 43).

11. Pixels, Megapixels and DPI explained

A pixel is basically the smallest single component of an image. This includes printed pixels on a page, pixels carried by electronic signals, represented by digital values, pixels on a display device (e.g. LCD) or pixels in a digital camera (photosensor elements - CCD).

The measures of 'dots per inch' (dpi) and 'pixels per inch' (ppi) are sometimes interchanged, but have distinct meanings especially to the printer, where dpi is a measure of the printer's resolution of dot printing (e.g. ink droplet density). For example, a high-quality inkjet image may be printed with 200 ppi on a printer capable of 720 dpi at its maximum resolution.

A pixel is one dot of information in a digital image which collectively consists of millions of tiny dots (Mega = Million) to make up the overall picture. For instance a 3 megapixel image contains approximately 3 million pixels, while an 8 megapixel image consists of 8 million pixels, e.g. a 3 megapixel photo is 2048 pixels wide X 1536 pixels high = 3,145,728 (3 million pixels or 3 megapixels).

If you are only going to print post card prints from a digital image, there won't be any detectable difference in the print from a 3 megapixel image compared to an 8 megapixel image. The graininess is only visible when a picture is significantly enlarged. This is where the 8 megapixel image can be enlarged much more than the 3 megapixel. A good reference to the maximum enlargement from an image is shown in Table 1.

More megapixels is not necessarily better, unless you

Figure 34: *The lighting is good however the caver and decorations of interest are too small in the image.*

Figure 35: *The caver is a better proportion for the image size, but is too central to the overall image.*

Figure 36: *The caver is well framed at 1/3 in from the side of image, but he is looking out of the picture.*

Figure 37: *The caver is well positioned at 1/3 across the image, looking at the most prominent stalagmite which is also 1/3 in from edge of frame. The viewer is first drawn to look at the caver and then to where the caver is looking – toward the prominent white stalagmite.*

Figure 38: *Decoration which is difficult to determine its scale.*

Figure 39: *Adding a caver into the scene gives a much better idea of the scale.*

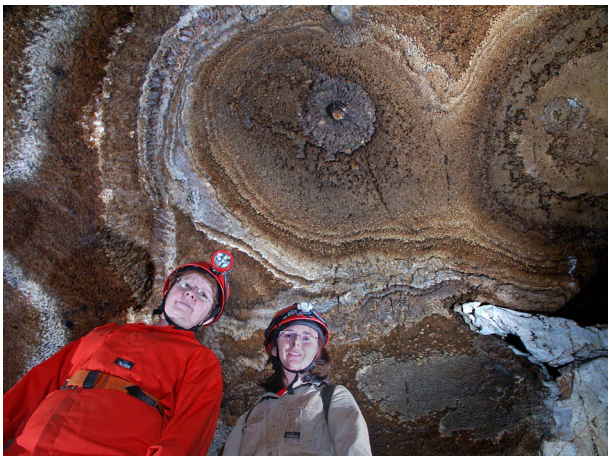

Figure 40: *An ant's eye view of cavers and ceiling decoration.*

Figure 41: *Looking down into an underground stream meander.*

Figure 42: *Looking up from the bottom of an abseil pitch.*

Figure 43*: Looking up into an aven containing shawls and stalagmites*

want to print out large photos. Here are a couple of things to consider before purchasing a digital camera with lots of mega-pixels e.g. 10 or 12 megapixels:

- Images take a longer time to transfer from camera to computer.
- More hard drive space is needed to store images.
- A more powerful computer is needed to view and edit an image.

Conclusion

Cavers who just want to take 'happy snap' photos with the occasional side lit photo can't go past the high-end consumer cameras which have the ability to use some manual modes. Most serious cave photographers would find the prosumer range of camera well suited for almost all conditions, with the flexibility for more creative photography. These cameras have fully manual mode options and often have a fixed zoom lens starting at around 28mm up to 200mm or more. In many respects the modern high end Prosumer digital cameras have features which make them more suited to dusty and cramped cave environments than the professional DSLR.

Photographing a good subject does not necessarily make a good photo. It is essential to pay special attention to the cave model's posture, facial expression and direction they are looking. Equally important is the framing, depth of field and lighting effect on the subject. To achieve good lighting, reliable slave flash units are invaluable to the serious cave photographer.

It is worth making the extra effort to purchase a quality camera and protect it in a strong, water and dust proof case, to take underground. Above all, know intimately how all the camera equipment works and check the operation of everything before going underground.

Acknowledgements

I would especially like to thank photographers, Sonia Taylor-Smith and Murray McKean for their comments and critical reviewing of this paper.

Photos are by the author

Definitions

Aperture An adjustable opening in the lens, through which light passes to reach the light sensor.

Field of view The area covered by a lens; the subject which is included in a photograph.

Depth of field The portion of the image which is considered to be acceptably in focus, extending in front of and behind the position of sharpest focus.

ISO or ASA International Standard Organization (ISO). A rating scale originally used to define film sensitivity, but now is used to rate the sensitivity of the digital camera's light sensor. The higher the number the more sensitive. ISO designation replaces the ASA (American Standards Association), but is numerically identical.

Pixels A pixel is basically the smallest single component of an image. See under heading 'Pixels, Megapixels and DPI explained' for more information.

Further Reading

Howes, C., 1989 *To Photograph Darkness,* Alan Sutton Publishing, Brunswick Road, Gloucester UK.

Howes, C., 1997 *Images Below,* Wild Places Publishing, 51 Timbers Square, Roath, Cardiff CF2 3SH, UK.

Wools-Cobb, D., 2003 Cave Photography – Getting Started, *Proceedings of Under Way 2003,* 24th Biennial Conference of the Australian Speleological Federation Inc. 2-8 Jan 2003 Bunbury, Western Australia:195-198.

Wools-Cobb, D., 2003: Cave Photography – Getting Good Photos, *Proceedings of Under Way 2003*, – 24th Biennial Conference of the Australian Speleological Federation Inc. 2nd - 8th Jan 2003 Bunbury, Western Australia:199-202.

Garry Smith delivering his paper. Photo: D. Carr