GEOPHOTOGRAPHY, PART 1: RATIONALE, CURRICULAR IMPLEMENTATION, AND DIGITAL CAMERA OPTIONS

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ABSTRACT

Geoscientists do a wide variety of photographic activities as a routine part of teaching, research, and other scientific activities, but there has been virtually no systematic discussion of these activities collectively, and almost no consideration of the role of geophotography in, for example, geoscience education. Given that photographic imagery is one of the most important and objective ways that geoscientists archive and convey information, this omission is perplexing. As normal photography is now completely digital from acquisition to presentation and publication, and simple digital cameras very inexpensive, there are no significant hurdles to including photography, and introducing successively more challenging photographic skills, at many stages in the geoscience undergraduate curriculum.

In this paper, I review the rationale for recognizing and systematically addressing geophotography as a subfield or aspect of the geosciences. Suggestions are offered on where geophotography can be taught within common courses in the undergraduate curriculum, and skills to be fostered. A major goal is to help bring a new focus on this important skill, and prompt geoeducators to incorporate basic skills into courses and develop and share course materials. Finally, to address the most common initial question from geoscientists, whether student or professional, who are either seeking to begin geophotography or seeking to become better geophotographers, a compact review of the current tiers of digital cameras is presented.

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INTRODUCTION

The term 'geophotography' has been proposed as a subfield or aspect of the geosciences, in recognition of the vital and varied role photography plays, and to serve as an umbrella or rubric under which many different techniques and associated photographic knowledge could be collected (Magloughlin, 2010, 2011, in review). A tentative definition has been proposed to clarify what ought to be included, to illustrate the breadth of the field, and to separate geophotography especially from non-scientific exercises: "Geophotography normally involves realistic recording (commonly using visible, UV, or IR light) and processing of images of scientifically chosen natural features and processes, or the experimental equivalents of natural features and processes, motivated by a scientific understanding or question, and with a specific, useful goal in mind, including research, education, and illustration." (Magloughlin, in review). There is a close analogy to the long-recognized and long-named field of astrophotography, which perhaps received its moniker much sooner and is more obviously a subfield of astronomy because of the extremely common use of a telescope and motor drive for long-exposure images, and, during the film era, of the many specialized techniques for dealing with reciprocity failure.

By the above definition, geoscientists are doing geophotography when they record images with an understanding of (or question about) the geologic features and processes they are recording, when they have specific purposes in mind for the image, and when they preserve the veracity of the subject throughout the process. They thus must understand the science as well as have technical expertise (Goetz, 2009). These criteria thus exclude casual snapshots, landscape photography, and artistic photography. Included in geophotography are many methods and subjects, involving natural and artificial geologic features and processes, indoor and outdoor activities, virtual field trips (Schott, 2009; Piatek, 2010), IR and UV photography (e.g., Aber et al., 2009; Furukawa, 2010; Tamburello et al., 2011), return photography (or Rephotography, e.g., Munroe, 2003; Thornbush, 2010), and both still and video photography (Baldock and Hughes, 2006; Major et al., 2009). An important set of exercises opening up field geology to mobility-impaired individuals are virtual field trips (Atchison and Feig, 2011), especially with the use of virtual mobility and virtual specimens (De Paor and others 2010).

As fundamental as photography is in many different ways and in many different subdisciplines of the geosciences, and especially considering geoscientists have the pleasant task of studying the most spectacular corners of the Earth, it is nonetheless obvious that most geoscientists are not good photographers. This is understandable in that consistently excellent photography is a technical skill requiring much practice. In short, geoscientists are usually quite busy doing geoscience rather than keeping up with the latest camera and lens models, learning about photographic software, and practicing composition and photograph editing.

However, most geoscientists can be *better* photographers without having to become professional photographers on the side, and the whole of the geosciences would benefit from better photography, whether the purpose behind the images is research, classroom instruction, illustration of non-research publications, or recruitment of the next generation of geoscientists. On this last point, I suspect many geoscientists can recall the powerful effect that photographs played in their enthusiasm for and learning within the geosciences, and many instructors can testify to captivating power of excellent images over lecture halls of students. Hoisch and Bowie (2010, p.166), in assessing factors that likely influenced recruitment into the geology major from the ranks of large introductory geology courses, state that influential factors included "…opportunities for working outdoors, field work, observing nature, travel, and environmentally friendly employment", and clearly photo-illustration of these aspects of the geosciences could be influential.

The first goal herein is to provide information to encourage geoscience educators to make training in geophotography a routine part of geoscience courses and develop discipline-specific exercises, and to provide both basic information and a few suggestions on where and how to begin to accomplish this. The second goal of this and follow-up papers is to compactly provide information to current geoscientists in order to foster their growth as geophotographers, which, just like athletic pursuits, involves a combination of improving skills and reducing errors. In this paper, the discussion will be confined to an overview of the current categories of cameras. A third goal, not discussed beyond this point, is to encourage experts, especially in new and 'niche' versions of geophotography, to contribute their expertise in order to help build a collection of resources and flesh out the diversity of geophotographic pursuits.

A primary focus here is on general outdoor or *field geophotography*—the most obvious and commonly practiced subcategory of geophotography—from macrophotography (close-up to extreme close-up photography) to wide-angle, panoramic, 360°, and gigapixel photography. This subfield involves the most general--and usually initial--choices of equipment, techniques, and, at an intermediate to advanced level, can involve the widest array of equipment.

The process of geophotography can be divided into four parts: choice of equipment, planning for a particular outing, composition and all factors manipulated on-site, and post-production. This paper addresses the most fundamental part of the first of these, camera options, as a guide for those who have no photographic equipment and those who have some photographic equipment and want to improve their potential for taking better photographs. Such decisions are obviously driven by present and future time commitments, finances, and the most common anticipated photographic needs. With the extremely rapid pace of technological change in photography, the approach here is generic and applies to current, common camera options.

Once the choice of equipment is made, the approach advocated here is dominantly pragmatic. That is, with the available equipment, what can the geophotographer do to get the best possible image under the circumstances dealt? Some photographers advise not bothering to put camera to eye if the lighting conditions are not optimal. However, most geoscientists, most of the time, have limited control over *when* they are able to take their photographs of a particular outdoor subject. Geoscientists participate in pre-planned field trips, are obligated to do a hike on a particular day, happen to be driving by when a roadcut attracts their attention, or happen across a geologic process already in progress. The point is that very commonly, geoscientists have good reason to photograph some feature, but little control over *when* they photograph it, and therefore little control over the environmental conditions. Advance planning for outings is advantageous, and, when possible, can improve the odds of being in the right place under optimal (not merely lighting) conditions. But unlike the photographic greats such as Ansel Adams, who returned to particular locations dozens of times in the pursuit of optimal conditions, a more pragmatic approach is to prepare the geophotographer to capture the best possible image under whatever conditions happen to exist. Like the practitioners of any outdoor sport, the outdoor/field geophotographer needs to cope with and succeed whether the conditions prove bright or dim, wet or dry, windy or calm, cold or hot, dusty or clear. Naturally, later advice pertaining to on-site procedures may or may not apply depending on whether or not the requisite equipment and capabilities are available; the corollary is that with more options come more capabilities and a greater likelihood of obtaining high quality photographs.

TEACHING GEOPHOTOGRAPHY IN THE GEOSCIENCE CURRICULUM

Circumspect geoscience educators need to weigh many factors in tailoring courses for majors within a geoscience curriculum, relative to their particular population of students. One unarguable goal is the conveyance, based on the mission of preparing students for careers within the geosciences, of skills they will actually use. The vast majority of geoscientists acquire, use, and learn from a wide variety of photographs as a routine part of their work. It seems likely that those who are better at acquiring, using, and interpreting photographs are likely to be more successful geoscientists. Yet textbooks on geological field methods (Compton, 1985; Assaad et al., 2004; Maley, 2005) offer little or no instruction on geologic photography, and I am not aware of *any* available instructional resources devoted to geophotography. A webinar on Geophotography is to be offered by SERC (SERC, 2013) and materials will remain available thereafter.

What can be suggested at this early stage is that various kinds of geophotography be integrated into courses taken more-or-less in succession within a typical geosciences degree. Today, digital photography has virtually completely replaced film photography with only a few specialist and niche applications remaining for film; thus, there are no significant barriers to implementing photography within the curriculum anywhere desired. This is because even simple point-and-shoot cameras are adequate (in some situations and in some respects preferred) for most applications, and the very low-end of such cameras currently cost roughly one quarter to one half of the price of an average college textbook. Software for basic manipulation and annotation of images is included with most computer systems, is present within word processing software to which students routinely have access, and more sophisticated image editing programs are, at a minimum, available as freeware (Chastain, 2011; Viescas, 2011). These latter types of programs are sophisticated enough and contain sufficient editing options that many students of geophotography will never need to go further.

Clearly, the specifics can vary vastly depending on the nature of the curriculum, class size, and so forth, but the purpose here is promoting planning and improvement. Drummond and Markin (2008) surveyed institutions with geology degrees and found, among others, the following courses, in rough order of a normal curricular treatment, with occurrence within the curriculum ranging from 76 to 99.3%: Introductory/Physical Geology, Historical Geology, Mineralogy, Petrology, Structural Geology, and Field Camp. There are natural opportunities within each of these (and other) courses, and specific and increasingly challenging skills could be incorporated (Table 1) with careful planning. Geophotography can be a skill developed over the course of the curriculum analogous to writing, map interpretation and generation, computer skills, and petrography. Where well-integrated and executed, geophotography could be a line-item on a geoscience graduate's resume.

CHOICE OF CAMERA

Four categories of cameras will be addressed here, with the provisos that there are significant differences in cameras within a given category across brands, and that both technology and terminology are changing rapidly. The four types are compact or 'point and shoot' (P&S) cameras, bridge cameras, mirrorless interchangeable-lens cameras (MILC), and digital single-lens reflex (DSLR) cameras. Both the initial price and potential long-term price (how much one *could* spend, over time, on accessories) increase across the four types. While most users will pick one of the four, there are good reasons to own and carry two or even three of the types.

Beyond financial considerations, how and where the camera is used (particularly the conditions), the most common use of the images (research, teaching, non-research related publications, temporary images), and the user's level of photographic expertise are the most important factors to consider. Across the camera spectrum are numerous trade-offs: less versus more required expertise, lower quality versus higher quality images, less weight versus more weight, ceding control to the camera versus having manual controls, convenient access to the camera and quick acquisition of photographs versus less convenient access and more time to acquire an image, having less or more confidence on-site that an excellent photograph was acquired, and many others.

Currently, an interesting technological-societal-generational photography phenomenon has become evident to geoscience educators: use of the do-everything (poorly) smart phone. Students who just a few years ago invariably carried at least a P&S camera on field trips or used one in the teaching lab setting now attempt to do their photography with a smart phone or even tablet computer. After a recent field trip to Yellowstone National Park, arguable one of the world's most varied and photographable geologic landscapes, with a large number of geoscience students, I received photographs from students and attempted to compile a photographic presentation. Compared to just a few years ago, photographic skills of the students had taken a decided step *backwards*, making the following discussion all the more timely. As the goal here is to increase the *quality* of geophotography, low-pixel, low-quality, and ultracompact camera-oids, particularly those embedded in electronics designed for other purposes, are not included in the discussion.

P&S (compact) cameras

P&S or compact cameras are the smallest, lightest, and most automated cameras (Fig. 1). They are ideal if the user's level of expertise is low, i.e., one is content to let the camera to make most of the decisions, if easy availability (e.g., mounting the case on a day-pack's shoulder strap) is important, if low weight is important, and if low to moderate-quality images are acceptable. As desirable as high quality images are, these cameras are nonetheless good choices for wet or dusty conditions, as they are much easier to protect--quick to access, quick to obtain a picture, and quick to return to a protective case. A high quality lens for a DSLR can cost twenty times the price of a single P&S, and thus the latter can be good choices for working around volcanic, wet, and otherwise hazardous-to-equipment environments.

If the absolute lightest possible camera is critical, a P&S is ideal; a good DSLR with one lens can weigh over 2 kg, which can be prohibitively heavy for some types of field geology.

The major downside of P&S cameras is that it is difficult to get excellent quality images, mainly due to modest lens and sensor qualities, simpler image processing software (not surprisingly, camera manufacturers save their best on-board software for their best cameras), and less manual control over camera functions. Also, the viewfinder does not show exactly what the camera ‘sees’. Thus, it is more difficult to see exactly what one is photographing, and viewing the digital monitor in bright sunlight makes it more difficult to ensure one has acquired a good image. But these cameras can produce adequate images for a wide variety of applications, however, significant enlargement of the images make the limitations obvious.

A final issue is that the exposed part of the lens on P&S cameras is very small. While this presents a smaller target for raindrops or sharp objects, it also means a single scratch on the lens will likely ruin the camera. On the other hand, P&S cameras can be the most damage-resistant, and shock- and water-proof versions (Fig. 1) are available.

Bridge cameras

The term ‘bridge camera’ has been around since the 1980s, and such intermediate-caliber cameras are intended to fill the gap between P&S and DSLRs. There are many different versions, but they are generally lightweight and not much bigger than P&S cameras, and they have a single fixed lens and relatively small sensor (Fig. 2). Many are capable of zooming to the equivalent of a long telephoto and thus some are called superzoom cameras. Some accept filters, which owing to their small size, are much cheaper than those for MILC and DSLR cameras. These cameras preserve most of the compact nature and low weight of P&Ss while offering more manual controls, and some are optically excellent.

For geophotographers, bridge cameras can often be a good choice. Destroying one in a field accident, as with P&S cameras, is relatively non-tragic. They are hardier than higher end cameras since they have a single fixed lens, and their small size makes them easier to protect in adverse conditions. For those of advanced beginner to intermediate abilities, they allow filter use and manipulation of numerous shooting options. If telephoto capabilities are important, they are a good choice. However, their image quality is still inferior to DSLRs, and have the same viewfinder drawbacks as P&S cameras.

MILC cameras

MILCs (many other terms are in use, including ‘hybrid cameras’) are a recent design (Fig. 3), first introduced by Sigma with its DP1 in 2008. These serve as a step beyond bridge cameras, whose functionalities have been largely usurped by P&S cameras. MILCs may have small or large sensors and bodies similar either to P&S or DSLR cameras; thus they can provide image quality of P&S or DSLR caliber. Some MILCs use ‘pancake’ type lenses, which are very thin, in order to achieve compactness. The large sensors of some MILCs perform better than small sensors, especially those in P&S and bridge cameras, in low-light situations, and these cameras can be a good choice for geophotography in commonly dim conditions or a gloomy climate (where close-up photography exacerbates the problem). A major distinction between bridge cameras and MILCs is that the latter have interchangeable lenses, which adds versatility, but increases the overall price and weight if a full set of lenses from wide angle to telephoto is needed. However, the lenses are commonly much smaller than those for DSLRs, so coupled with the smaller camera bodies, this accomplishes a large weight reduction.

MILCs have fewer parts and thus can be smaller and may be more durable than DSLRs. They may or may not have optical viewfinders, and they lack the flip-up mirror of DSLRs and thus do not have the through-the-lens (TTL) capability of DSLRs, which is a major distinction and significant disadvantage. As a result, composing and focusing is commonly done with the LCD screen—something familiar to P&S camera users but unfamiliar to DSLR users—and this can be a disadvantage in bright sunlight. At present, at least one brand has a 24.3 megapixel sensor—more than adequate for almost any application. Because the LCD screen is always needed while the camera is on, and the batteries are smaller to help make the camera body smaller, such cameras typically have a much shorter battery life than DSLRs. Another consideration is the crop factor or focal length multiplier, meaning the magnification achieved when the sensor is smaller than traditional 35 mm film size or an equivalent-sized sensor. This turns a wide-angle lens into a neutral-magnification lens, and a telephoto into a longer focal length telephoto. Crop factors currently range from approximately 1.5x to 5.5x—an important consideration both for the purchase of the camera and lenses. Some systems have adapters that allow the use of DSLR lenses. At present, MILCs lack the wide range of accessories of DSLRs, but flash units, GPS-tagging units, and microphones are available. Because of the (in many cases) good image quality and much-reduced weight, MILC cameras may decrease the demand for DSLRs in the future.

DSLR cameras

DSLR cameras (Fig. 4) allow maximum control, have the largest number of accessories, are capable of the highest quality images (excluding the much higher-priced professional medium-format cameras, such as Mamiya, Leica, and Hasselblad), are the heaviest of the cameras, and have the highest initial and potential costs (given the large number of accessories). These are the cameras for those who want the very best quality images, have the expertise to take manual control, and have the time on-site to spend in order to obtain high quality images. In recent years, video (including HD) has been added to most new DSLR systems, and sensors with extreme low-light sensitivity and at least 32 megapixels are available.

Two sizes of sensors predominate at present. The Advanced Photo System type-C (APS-C) sensors range from approximately 14x21 to 19x29 mm, and produce a crop factor of approximately 1.5x. Such sensors are cheaper and allow a more compact camera. The ‘full frame’ sensor is approximately the same size as traditional 35 mm film, at approximately 24 x 36 mm. Larger sensors make cameras more expensive, but may have more light sensitivity and less digital noise (manifesting as pixels in the final image showing anomalous colors or brightness). Such sensors have a crop factor of 1x, meaning those familiar with lenses used with 35 mm SLR (film) cameras will see the same magnification and field of view in a full frame DSLR.

Again, such cameras allow the maximum flexibility and creativity and, in the right hands, produce the highest quality images. But understanding and mastering all of the capabilities of such cameras, and the additional time spent on-site to utilize such capabilities, may exceed the patience of many users. The additional weight of such systems (roughly ten times that of a P&S camera), and the initial and eventual price tags, should give many users pause.

Additional camera considerations

The choice of a camera for the beginner is a bit of a catch-22. Purchasing an advanced camera with capabilities one does not understand allows for growth in expertise, but if one fails to master these capabilities, one can be handicapped and obtain worse results than if a simpler, more automated camera were used. In public places, those using tripods and long (telephoto) lenses tend to attract "how-do-I" interruptions, that is, requests for help from individuals using more camera than they understand, and in some public places, tripods are prohibited. Before purchasing a camera, it is useful to examine the owner's manual; one recent popular Nikon DSLR manual is 452 pages long, compared to a popular P&S manual's 212 pages. Another option is to borrow or rent a camera and lens. Many on-line companies are available for camera and lens rental, including LensGiant (2012).

Geophotographers planning long backpacking trips or photography in cold conditions might consider a camera that uses standard (disposable) batteries rather than a camera-specific battery pack. The latter are usually much more expensive and if one is away from a power source for an extended period, charging may be a problem, whereas a large supply of the former weigh little and can be kept warm, if necessary, in a pocket.

Image stabilization refers to a group of methods designed to compensate for camera movements during exposure. What this process is called and how it is implemented varies by manufacturer (e.g., built into the camera versus the lens), but it has become extremely common. One of the most important criteria for an excellent image, especially for scientific purposes, is the sharpness of the image, and one of the main ways sharpness is lost is through movement of the camera during exposure. Image stabilization helps preserve sharpness, especially in dim light when a slow shutter speed is necessary. This technology is effective, and benefits geophotographers working in dim light and conditions (cliff-clinging, for example) where holding the camera steady is problematic.

The pixel count is a primary specification of a camera; currently 12-18 megapixels is common. While technological advances undoubtedly will allow, and certain needs will require, higher pixel counts, for the vast majority of applications, current capabilities are adequate, and higher pixel counts come with various *disadvantages* both while shooting and for later post-processing and storage. In the near-term, pixel counts higher than 12-15 megapixels should not necessarily be seen as a large advantage. Indeed, professional photographers consider that with a high pixel count, use of a tripod becomes essentially mandatory—a major consideration if hiking and back-country use are an important application.

Returning to the issue of how one's images are to be used, and under what circumstances they will typically be obtained, the novice camera buyer ought to think carefully. For example, if geophotography is normally done in the vicinity of a vehicle and the highest quality images is required, the choice of a DSLR is clear. However, if one's geophotography is commonly to be done in the back country, cutting weight by choosing one of the lighter types of cameras may be best. In addition, having a camera compact enough to fit in a shirt pocket or stored in a case on one's backpack strap and thus almost instantaneously available can result in a more complete photographic record and more successes if dealing with transient or sudden geologic phenomena. In conditions highly dangerous to the equipment (volcanic settings with blowing ash, for example), using a camera that can be relatively cheaply replaced may be preferred.

Immediately essential additional equipment

Particularly for MILCs and DSLR cameras, lenses should always be protected with high-quality UV filters. Flying rock chips, outcrops, blowing dust, steam from fumaroles, and many other natural hazards can destroy a lens, and filters are much cheaper to replace. Since the light used in every photograph passes through the filter before passing through the (potentially very expensive) lens, high quality filters are worth the extra expense. Their superior coatings make them easier to clean thoroughly and more resistant to degradation from scratches.

Especially for heavier cameras, a comfortable neck/shoulder strap is essential, and harness systems that keep the camera readily available without flopping around or bouncing are useful. A polarizing filter helps capture a superior image in many situations by darkening a bright sky to a level more comparable with the brightness of the subject, obtaining richer colors, and eliminating reflections off of smooth or wet surfaces.

Memory cards with enormous storage capacity are available, and while generally very stable, can and do fail. Thus, remembering the proverbial eggs-in-one-basket lesson is appropriate. In a similar vein, small image storage units, which are essentially small hard drive or solid-state memory devices, are essential for extended outings. The simplest allow the user to plug any of a variety of memory card types into the device, which then automatically copies all images into storage. Always store such devices separately from camera memory cards and the camera itself to avoid a complete loss in the event of accident or theft. Uploading to on-line utilities or cloud storage provides another level of protection. A cardinal rule of photography is one can never obtain the same image twice, and in geophotography, even trying to do so may cost days and enormous physical effort and expense.

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418 **Table 1. Suggestions on how and where to integrate geophotography skills and exercises in**
419 **an undergraduate geoscience curriculum.**

Course	Geophotographic task	Skills
Introductory Physical Geology (small courses)	Knowledgeably acquiring and illustrating images of any geologic features (campus or city tour, field trips, gem & mineral shows)	Acquiring clear, sharp images; downloading; annotating & cropping using photo imaging software, inserting in a report
Historical Geology	Macrophotography of fossils to illustrate lab reports, including use of a copy stand	Controlling depth of field, manipulating lighting to control shadows, use of small scales in the image, setting white balance
Mineralogy	Macrophotography of mineral specimens	Controlling depth of field; white balance; correcting colors and contrast; labeling mineral features (cleavage, parting, fracture, twinning)
Petrology	Photography of rock types, emphasizing specific structures and textures (crystallinity, vesicles & amygdules, foliation, bedding); obtaining good images whether specimens are light or dark colored or high contrast; setting up a background	Combining photomicrographs, hand sample photographs, and (if available) outcrop photographs to illustrate reports. Taking photomicrographs. Comparing and contrasting PPL and XPL photographs, and obtaining correct exposure in both modes, and annotating the images with labels and scale bars.

Geomorphology	Recording geomorphically illustrative landforms	Wide angle and panoramic photography, use of persons and objects as scales
Structural Geology	Cataloguing structures especially at hand sample to outcrop scale	Zooming with feet & lens; depending on scale and conditions, using fill flash and/or high dynamic range software to minimize high contrast
Introductory Field Geology Course (Field Methods)	Photographing key geologic features and structures at a variety of scales to illustrate geologic arguments in written reports	Dealing with changing directions and lighting in varied conditions; recording directions and matching field book sketches to photographs; show proficiency in photographic editing; scanning and manipulating aerial photos and satellite images
Summer Field Course (Field Camp)	ditto	Demonstrating ability to obtain and then clearly produce (through cropping, editing, etc.) features at all scales that scientifically enhance arguments made in a summary report.

Figure 1. A P&S (point & shoot) camera. This particular model has a fast lens, full 1080p HD video, a 7.62 cm OLED screen, 12.7 megapixels, and weighs 0.221 kg. OLED displays are generally lighter, thinner, and have a higher contrast ratio than LCD displays. Of special interest to geophotographers, it has shock-, water-, freeze-, and crush- (to 100 kg) resistant capabilities, and GPS information is recorded in each image's metadata.

Figure 2. A bridge camera with fixed lens. This particular model has a 12.1 megapixel sensor, a 6.86 cm LCD display, optical image stabilization, and weighs 0.601 kg including battery and memory card.

Figure 3. Example of an increasingly popular type of camera, the mirrorless interchangeable-lens camera (MILC), 0.48 kg. This particular model has 12.1 megapixels, a 7.62 cm LCD display, has a 2x crop factor, and the body weighs 0.265 kg.

Figure 4. Digital single-lens reflex (DSLR) camera. This particular model has a 16.2 megapixel full-format sensor (1x crop factor), 1080 p HD video capabilities, and an 8.13 cm LCD monitor. The ISO's standard range is up to 12,800, but can be 'pushed' to over 200,000, meaning the camera can record images in exceptionally dim light, including moonlit scenes. The camera body weighs 1.34 kg with memory card and battery and without lens. With strap and a typical wide-angle to short telephoto range lens, the total weight of such a system is around 2 kg.