Cold Storage Freezes Time for Photographic Film and Prints

Images on Ice

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Early in the 20th century, attorney, writer, and philosopher W.H. Coin Harvey envisioned the archival documentation of what he considered a rapidly self-destructing civilization—humanity. He drew up plans and began to build a concrete pyramid in Monte Ne, Arkansas, to house historical documents, books, and papers. These would be protected by glass and transparent paper that Harvey believed would preserve them for thousands of years. He predicted that as time passed, earth would settle around the structure, leaving only the shaft leading down into the pyramid and its contents. Attached to the shaft would be a plaque inscribed, "When this can be read, go below and find the cause of the death of a former civilization."

As fate would have it, civilization survived and the pyramid was never built. With the onset of the Great Depression, there was no money to fund this massive project. The pyramid's foundation now lies at the bottom of a lake. Occasionally, when the water level is very low, you can see parts of the amphitheater that was to surround the pyramid. Harvey's legacy serves as a reminder that we all must make a concerted effort to preserve the things we value.

It is this concern for historical documentation that has driven the photographic industry to search for archival materials and processes to preserve creative works. To the digital world, archiving means saving data to CD, DAT tape, or a computer hard drive. In general, the data is intended to last for a period of six to 12 months, or perhaps several years. History, however, requires a permanent record, with no time limits.

In historical terms then, what must we do to protect our film, prints, digital data, and other precious materials for future generations? How do we prevent a color photograph from fading, or film from decomposing? What if the images we store in a digital format are unreadable and unrecoverable in the years to come?

Jim Wallace, director of the Office of Printing and Photography Services of the Smithsonian Institution, addresses yet another archival issue: Will we be able to translate a digital image file 100 years from now? There is no imaging equivalent to the ASCII code. "You have to commit to a particular file format today, and build the cost of future file conversions into your budget months or years down the road," he said. And once you've chosen the file format, where do you store the data?

The most trusted and popular digital archiving media so far is the compact disc. In fact, the CD, in every application-specific permutation, plays a leading role in a number of industries. Audio CDs are the backbone of the recording industry. Software companies have chosen CD-ROM as the vehicle for shipping their technology. Businesses use CD-Recordable (CD-R) and CD-Rewritable (CD-RW) discs to store and distribute everything from invoices to document archives. Virtually all personal computers ship with CD-ROM drives, and CD recorders promise to be the next must-have peripheral.

While CDs are more rugged and less finicky than other removable storage devices, they are not infallible. In response, data recovery specialists have sprung up throughout the digital community. A CD data recovery store in Phoenix reported

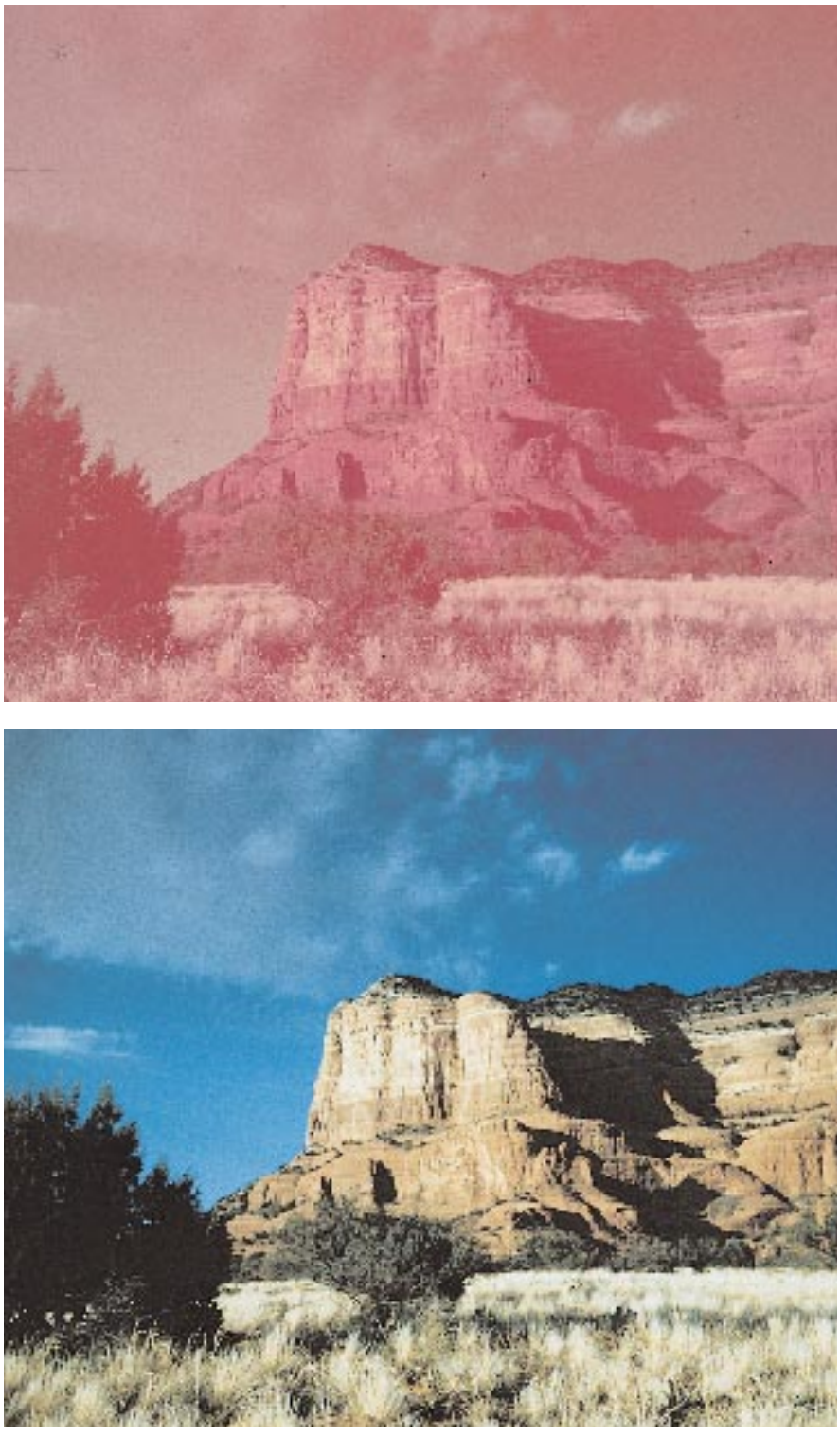
that in the first month after installing disc repair equipment, they fixed approximately 300 CDs. Because CDs are inexpensive and easily duplicated, it makes sense to keep several copies of your vital files stored on CDs in various locations.

"The compact disc is here to stay for the foreseeable future," agreed Cheryl Bianchi, worldwide category manager of the Eastman Kodak Company Digital and Applied Imaging division. "According to the Santa Clara Consulting Group, 650 million CD-Recordable discs were sold worldwide last year. And that number could go as high as 2 billion by the year 2000. It's an incredibly strong market. Users can feel confident that the media will continue to be supported."

The CD base is so strong, in fact, that backward compatibility has become a key objective in the storage industry for the latest storage format, DVD (digital versatile discs). That's good news for anyone considering CD media for archiving digital image files. If you decide to switch to DVD, you won't have to transfer your entire collection at the same time, because the DVD format also reads CD-based formats.

Bianchi says information stored on CD will last at least a century, and that's probably a conservative estimate. This is due in part to the metallic coating that reflects the laser as it reads the data. Experts say the better the metal, the more stable the data. Most discs are coated with gold instead of aluminum, and a CD's lifetime can be placed—at the minimum—in the same range as properly preserved photographic film and prints.

Henry Wilhelm and Carol Brower of Wilhelm Imaging Research, in Grinnell, Iowa, were awarded a three-year research contract by the Smithsonian Institution. They are leading a team that is investigating how to



The image (top) was captured in 1959 on Ektachrome 120 transparency film and stored at room temperature for 40 years. "Had the transparency been stored at 0˚F, it would be in pristine condition today," said photographic preservation expert Henry Wilhelm. "It would look similar to this Kodachrome duplicate (above) that was made from the original."

Henry Wilhelm (left) and Mark McCormick-Goodhart stand in the cold storage vault at Wilhelm Imaging Research Inc., in Grinnell, Iowa. The vault is part of a three-year research project in preservation for the Smithsonian Institution in Washington, D.C. The doors of the cabinets that line the walls are fitted with sealing gaskets that protect the negatives, film, and prints stored within the freezer units.

package and store photographs and motion picture film in non-humidity-controlled freezer units that are commercially available and moderately priced. Mark McCormick-Goodhart, vice president of Old Town Editions Inc. and former Smithsonian senior research photographic scientist, is a principal researcher with the project. Wilhelm and McCormick-Goodhart are testing the longevity of photographs stored at -20°C (-4°F) in sealed cabinets where moisture is controlled passively, rather than actively with dehumidified systems.

"Cold storage wins hands down compared to any other method," said McCormick-Goodhart, "and it always comes up cheaper. The archivist at motorcycle manufacturer Harley-Davidson, for example, entertained bids on duplicating their photographic collection of approximately 40,000 sheets of 8x10-inch film, both digitally and conventionally. The work dates from the company's founding in 1903. Some of the film was nitrate, some acetate-based black-and-white negative film, and some Ektachrome transparencies.

"The estimates came in at more than $4 million because there were so many images. Whether you scan the images, or dupe them conventionally on film, that figure seems just about right to me," said McCormick-Goodhart. "When they finally decided to invest in a cold storage system to preserve the images, the cold vault cost about $20,000, and the storage packages approximately $15,000. So for less than $40,000, the collection is preserved in a state of near suspended animation.

"Taking into consideration the electricity needed to run the vault, and the cost of maintenance over 100 years, each image will cost about $10 to preserve. But by that point, all those duplicates that you would have spent over $100 per image to make would have to be reworked, too. And they'd be second generation, rather than originals."

McCormick-Goodhart researched low temperature storage for 10 years at the Smithsonian under a mandate to preserve the Institute's photographic collections indefinitely. "The first cold storage vaults were used for color collections around 1975. The idea of cold storage for processed materials gained

credibility with a 1971 article by Adelstein, Graham, and West published in the *Journal of Photographic Science*. They showed that low temperatures could significantly reduce dye fading and other problems.

"The original cold storage vaults were custom-built with dehumidifiers," said McCormick-Goodhart. "These early vaults demanded serious commitment. They were complex to engineer and required specialized staff to build and maintain them."

Wilhelm and McCormick-Goodhart met in 1991 through membership in the Film Preservation committee of the American National Standards Institute. Their association led to a joint investigation of cold storage preservation using commercial refrigeration products. Anyone, they felt, should be able to purchase a standard cold storage vault normally used to store food, and let it do the work of the more expensive, complex systems.

"The downside of this setup is that curators can't access their collections without allowing warm-up time," said McCormick-Goodhart. "They have to bring a cold object out slowly, which can take minutes or hours." At this point they realized the importance of digital archiving, that digital reproduction would make the images more accessible. The museum curator could examine digital reproductions without disturbing the originals, which could, if necessary, be brought out again to make fresh files. Computers and cold storage are a match made in heaven.

One of McCormick-Goodhart's early projects was to develop a packaging system that professional and amateur photographers could use in their studios or homes. One kit holds materials equivalent in volume to 2,000 35mm slides and costs around $60. Photographic materials are placed in a polyethylene bag inside an acid-free box. Inside, the box contains buffers of ordinary photo mount board on the top and bottom. On the outside, two small patches of paper impregnated with cobalt chloride serve as humidity indicators. They are visible through the final packaging layer, a second polyethylene bag.

At a safe humidity, the indicators are blue. As moisture slowly passes through the polyethylene bag, shifts in humidity change the color of the patch to lavender. The permeation rate of moisture through the polyethylene bag is a direct function of temperature. The process does not work nearly as well at 35°F and higher. If the moisture increases, you must remove the materials from the freezer and replace the dry mount board inside the box. The material is protected from water, the prevailing cause of damage to photographs.

An archivist on a budget can create a cold storage vault by using the Metal Edge Inc., in Commerce California, archival packaging, and a typical domestic freezer. "For about $700, you can buy one with

*Hollywood Vaults cold storage (*www.hollywoodvaults.com*) in Hollywood, California, was founded by David Wexler to preserve many valuable materials, including motion picture film, photographs, audio recordings, and computer data. The vaults are equipped with state-of-the-art temperature and humidity controls.*

auto-defrost," said McCormick-Goodhart. "I have two in my basement where I store some 30,000 images."

A typical freezer runs at 0°F for common food storage, an optimum temperature for preservation. Like food, little aging happens as long as the material is frozen. However, when it is removed from the freezer, it picks up the aging process where it left off. If the strategy works for food, then it will work for photographic materials, newspapers, magazines, books, almost any organic material that has poor stability at room temperature.

"To any photographer who is serious about handing down his work as a legacy, I would also emphasize hard copy prints," said McCormick-Goodhart. "Prints are easily read and their value can be quickly assessed. If I had to bet on an archiving strategy, I would bet that 50 years from now, more digital prints will be made from hard copy prints from this era than will be made by calling up a digital file. A prime example is the remastering of old motion pictures."

"Temperature is key," said Wilhelm. "If you store a substrate like Ektacolor 74 color printing paper, commonly used for color prints in the '70s and '80s, at room temperature (75°F), there is noticeable fading (10 percent loss) over approximately eight years. Naturally, this loss might occur faster, depending on the adequacy of processing and washing.

"Stored at 45°F, it would take 75 years for a loss of 10 percent to occur. Drop the temperature to 35°F and 'just noticeable' fading won't occur in an estimated 160 years. By bringing the temperature down to 0°F, that figure shoots up to as long as 2,700 years. Kodachrome transparency film, known to be highly stable, will last a predicted 32,000 years at 0°F before noticeable fading occurs."

"Cold storage wins hands down compared to any other method," said McCormick-Goodhart, "and it always comes up cheaper."

For those who have neither the funds nor the inclination to build a cold storage vault, Hollywood Vaults provides secure, 24-hour access to refrigerated space on a rental basis. Founded in 1985 by David Wexler, a former filmmaker, the company provides self-service protection for a variety of precious items, including motion picture film, video tape, computer data, and photographs. Wexler offers storage chambers in 11 sizes, plus a cryogenic freezer. Recently upgraded and expanded, Hollywood Vaults supports stringent, state-of-the-art temperature and humidity control, fire protection, and air filtration. Rental space costs between $65 and $1,350 monthly.

"My clients read like a Who's Who of the entertainment industry," said Wexler. "From film to television, music, museums, and archives. The names are kept confidential for security reasons." Maintained at 25 percent humidity, photographs often curl at the edges. But once the print is removed from storage and has a chance to rehydrate, it flattens out again at about 50 percent humidity.

The Kennedy Library in Boston was the first historical institution to initiate 0°F storage. This is significant, because John F. Kennedy was the first United States president to be photographed predominantly in color. White House photographers used color negative film that was, for the most part, very unstable. In fact, by the time the library construction was completed, the negative film had already faded more than 10 percent. Today this collection is better preserved primarily because the library's audiovisual curator, Alan Goodrich, has placed the historical still photographs, plus 6,000 reels of motion picture film, in cold-vault storage.

NASA stores space flight films in 0°F vaults, including the footage from the Apollo missions. Determined to preserve these films forever, NASA used a "classic dehumidified" vault with 20 percent humidity. While a dehumidified vault is an excellent environment for large collections, Wilhelm pointed to several disadvantages. The design requires the expertise of specialized engineering firms, and construction is costly. Maintenance must be supplied by a company that specializes in dehumidified vaults, and the cost of energy is much higher than a normal vault.

The Smithsonian maintains a number of humidity-controlled vaults. They have many dispersed collections that ideally should be kept in cold storage. The goal of the Smithsonian-funded project is to design a system that costs less to maintain and can be built rapidly and inexpensively. What they will gain from this will benefit all.

Two years ago, a large stash of motion picture films was discovered buried in the ground

under the Yukon permafrost. Back when those movies were passed along the theater circuit, shipping them back to the studio from Alaska was way too expensive. Instead, theater owners decided to dispose of them right there, tossing them into an abandoned swimming pool, which they covered with dirt. There beneath the permafrost, the films were well preserved, in spite of the lack of protection from moisture. In some cases, these became the only surviving copies.

The temperature in the new research vault at Wilhem Imaging Research is kept at 0˚F. Monitors continuously record temperature and humidity. A chilled mirror hygrometer inside the vault double-checks the accuracy of the relative humidity readings. The data can be accessed either on premises or remotely, via Windows-based software made by Pace Scientific Inc., Charlotte, North Carolina. Once the project is in full swing, the modem access telephone number will be published so that interested parties may also download the software and view the vault settings.

One concern about any cold storage vault is what happens in the event of power failure or compressor failure, or if the door is left open. The new vault design "fails safely," so the collection is not harmed physically. However, the normal chemical deterioration rate resumes. "We don't consider this particularly consequential, as long as the vault is brought back online in a timely manner," said McCormick-Goodhart.

The Smithsonian project uses pre-fabricated vaults originally intended for the food industry. They are cheaper than custom-made vaults with compressors and dehumidifying systems. Special storage cabinets house the collection inside the vault. With soft rubber gaskets surrounding the door, these units are reasonably air tight and vapor tight. The cabinets were donated to the project by three manufacturers: Delta Designs Inc., Topeka, Kansas; Viking Metal Cabinet Company, Chicago, Illinois; and the Steel Fixture Manufacturing Company, Topeka, Kansas. "The contents are well protected from a broken pipe or a leaky roof. In the event of fire, the most likely hazard would be the water sprayed from fire hoses and sprinkler systems, which can drip down from floor to floor. But these cabinets provide excellent protection against water."

The security in the system is very high—more so than a dehumidified vault in which objects often lie unprotected on shelves. "Most collections store well at zero degrees," said McCormick-Goodhart. "You can't exactly go in and browse at that temperature, so what most people will do is accumulate requests for materials during the day, then take out those items at night to warm up for viewing the next morning." McCormick-Goodhart envisions having a digital or visual database, so that you can see images of everything the vault contains. "This would be applicable to any cold storage vault. Most people who would implement a system like this would at the same time start to scan everything at low-resolution and build a visual database with search capabilities."

"Someone might look at this and say, 'My color prints don't really need to last 2,700 years,'" said Wilhelm. "The reality is that if they had an Ektacolor 74 print from the '70s or '80s, and this work had been kept at room temperature in the intervening years, it would have already lost way more than 10 percent, and the yellowish staining would already be there. The real justification for zero-degree storage is to stop everything where it is, so it can be accessed in 10, 20, 30, or even 3,000 or 32,000 years from now." Ultra low-temperature storage also enables passive humidity control, so it becomes less expensive than

Archiving Your Images

So what does one do? Here are *PEI*'s recommendations for archiving your images:

1. When making digital copies, scan or create images at high resolution, higher than you'll ever need. Tomorrow's equipment may take advantage of this.
2. Save files in uncompressed file formats. Compression can strip out data and deteriorate image quality.
3. Make several backup copies—film, paper, and digital.
4. Print to high-quality photorealistic output. Today's rule is that often, the more photorealistic, the less archival output is, but this will change with newer paper and ink formulations. If you're going to drop it into cold storage, why not use the best looking output available?
5. Freeze your output/film using one of the cold storage solutions mentioned in this article.
6. Occasionally back up your digitally stored data to ensure compatibility with newer equipment.
7. Take nothing for granted. In technology, anything can happen—remember SyQuest? When portable storage took off, their 44MB cartridge was the industry standard. No longer.

Digital image access and cold storage of originals go hand-in-hand. McCormick-Goodhart's advice is to first put your money into cold storage to halt deterioration, then plan for digital access to the archive.

dehumidified vaults running at higher temperatures. "This is a win-win situation that is not intuitive," said McCormick-Goodhart.

The team believes the biggest application for this procedure will be for smaller collections, historical societies, and corporate archives, which every company has. The duo plans to store a variety of material inside the vault. There will be output from various digital print systems, including Iris and Epson, made with different ink sets and substrates. "When we retire or depart from this Earth," said Wilhelm, "we will be passing down an important part of history."

If you expect your digitized collection to be archivable, there will be serious problems. Digital image archiving is viable for storing your pictures, but take it from the experts, there's still an important place for film, and as McCormick-Goodhart noted, "Originals are critical to authentication."

An artist's original intent is best served by the final print he makes, not by a digital file that won't print or display the same way on future output devices, even if the file is readable. To some extent, this argument is also true for photographic negatives, but we preserve film negatives as important source material. "I think digital files will also become important source material, worthy of long-term preservation," said McCormick-Goodhart. "But no one has yet worked out a proven strategy for their survival."

At the Smithsonian, Jim Wallace believes conventional and digital archives have complementary roles. "Digital archives make our collections more accessible," he says. "When someone calls for a print, it is easy to scan it onto a CD-ROM and send them the scan." In handling several such requests daily, the digital image archive is flexible and efficient.

The Smithsonian is building a database that will provide access to images of the museum's collection of objects. The Institution's vast store of object-related photographs is being scanned to Photo CDs, or in the case of large originals such as 8x10 glass plates, directly to 2Kx3K TIFF files. The Photo CD image pack, containing various resolutions of image data or TIFFs, will be stored in a digital archive. The public will be able to view smaller versions of the image files on the Web. Museum staff will be able to access the full-size file for downloading and printing.

Even in a digital world, Wilhelm expects cold storage to be implemented worldwide. This is our opportunity to save the remainder of the traditional photographic legacy of silver halide. "Sara Lee takes better care of her cakes," said Wilhelm, "than the motion picture industry in this country cares for its multi-million dollar motion pictures. But, this is reality." ◀

The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures, *a book by Henry Wilhelm and contributing author Carol Brower, with technical editor John Wolf, was more than 20 years in the making (ISBN 0-911515-00-3, $39.95). It has become the standard reference on preserving fading color photographs. In this fully illustrated work, Wilhelm and Brower evaluate hundreds of color photographic materials and reveal which color print and film materials last longer than others. It is available from Light Impressions at* www.lightimpressionsdirect.com, amazon.com, *and* barnesandnoble.com. *Wilhelm and McCormick-Goodhart are planning a book on cold storage for still photographs, motion picture collections, and paper books. For information, visit their Web site at* www.wilhelm-research.com.

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