The Lingering Legacy of Kodachrome

The first color reversal film—invented by two accomplished musicians—brought stunning, velvety colors to family snapshots, famous portraits and world-shaking events alike.
Two unopened boxes of vintage Kodachrome 64 35-mm film.
If I remembered correctly, my father left a half-used roll of Kodachrome slide film in his old 35-mm camera when he switched to Kodak Instamatic cameras and their plastic print-film cartridges a half-century ago.

This belief lingered without much urgency for years. Even in the burst of publicity when the last remaining processor of Kodachrome film shut down in 2010, I hadn’t hastened to get that old roll developed. After many more years of writing about imaging and other optical technologies, however, I wondered about that undeveloped Kodachrome. Not only did I yearn to see what snapshots my father might have captured before he abandoned his rangefinder camera, but I also was curious to see why Kodachrome carried such a powerful mystique in the photography community.

When the Eastman Kodak Company of Rochester, NY, USA, debuted Kodachrome in 1935 as a movie film and in 1936 as a still film, it was the first true-color film on the market, one that ordinary people could use. In an era mostly recorded in shades of gray, Kodachrome stood out for its saturated reds and blues. Over 75 years, the slide film underwent several major changes to its speed and complex development capability, and it ended its commercial run in a blaze of publicity.

Inside the film

“Kodachrome is unusual in that it’s a multi-layered black-and-white film,” says Todd Gustavson, a curator of the technology collection at the George Eastman Museum in Rochester, NY, USA. Unlike virtually every other color film, Kodachrome contains no dyes or dye couplers—organic compounds that react with light-exposed silver halide crystals inside a film’s emulsion to create the dyes. Processing adds the couplers in, one layer at a time.

A cross-section of undeveloped Kodachrome would resemble a tiny, precise sandwich. From top to bottom, the film contained the following layers: blue-sensitive emulsion, a yellow filter, blue/green-sensitive emulsion, a gelatin interlayer, blue/red-sensitive emulsion, an acetate base and an anti-halation coating. The anti-halation layer, sometimes called remjet for “removable jet black,” guards against light rays passing all the way through the film stock and reflecting back into the light-sensitive layers at a different angle, creating a halo effect.

Typically, the acetate substrate would be between 100 and 125 μm thick, while the light-sensitive layers (for color negative film) add up to 15 to 20 μm, says Terry Taber, Kodak’s chief technical officer.

The most recent version of the Kodachrome development method, called the K-14 process, went into use in 1974 and lasted until the film’s discontinuance. The processing cycle began with softening and removal of the remjet with a spray wash. The first round of developer, containing phenidone and hydroquinone, turned all the silver halide crystals into metallic silver and made the yellow filter opaque. After the negative developer, the film would go through a series of cyan, yellow and magenta developers, interspersed with brief selective re-exposures to red and blue light, to generate the dyes that created the image. Bleach, fix, wash, rinse and dry steps finished the cycle.

Kodachrome’s roots:
Early color photography

Attempts to reproduce the range of colors a human eye sees go back to British electromagnetism pioneer James Clerk Maxwell (1831–1879), who in 1861 photographed a tartan ribbon three times, each with a different filter—red, green and blue-violet—over the lens. He printed the images on three photographic glass plates, then projected them through the three colored filters to generate a faintly multi-hued image.

The idea behind Maxwell’s work—separating the visible spectrum into colors and recombining them—underlies all subsequent types of color photography, from early filtering schemes to today’s digital cameras. The namesake of Optica’s highest award, Frederic Ives (1856–1937), devised a color system that required three separate images that had to be viewed through red, green and blue filters. Other scientists inside and outside Kodak had chased the dream of full-color photography.
for decades, but their methods were cumbersome and expensive and produced poor results.

The slide film beloved by so many 20th-century photographers wasn’t even Kodak’s first product named “Kodachrome.” In 1913, a Kodak scientist named John Capstaff invented a two-color subtractive method that required the creation of two positive-dye images, which were then stacked emulsion to emulsion to make a reasonably accurate “color” photograph or movie frame. A few moving test shots with Capstaff’s creation still exist, but the process was never commercialized.

Development of modern Kodachrome film

The two men credited with inventing the consumer-product Kodachrome, Leopold Mannes (1899–1964) and Leopold Godowsky Jr. (1900–1983), had an unusual path to photographic history. As boyhood friends from musical families, they attended a motion picture, Our Navy, made in 1917 with an early additive color system called Prizma. The system involved taking alternating black-and-white frames through two filters, then playing the images back through a rotating filter wheel. Mannes and Godowsky were so unimpressed that they started working on their own system for making color movies. Their version of projection through color filters earned them a patent but failed to make a splash in the marketplace.

The pair migrated to opposite coasts of the United States: Mannes to piano studies at Harvard University on the East Coast, Godowsky to violin studies at the University of California, Los Angeles, on the West Coast. They also took physics classes and planned more experiments in photography. After a few years, Godowsky moved back East, and the musicians pursued their art and their research simultaneously.

By chance, Mannes became acquainted with a senior partner in a New York investment firm. After discussions, the firm provided a US$20,000 loan to him and Godowsky, which enabled them to obtain their own laboratory for more intensive work. In the mid-1920s, the pair had acquired another patent or two and had even met George Eastman (1854–1932), Kodak’s founder, who offered the duo some materials but failed to follow through, according to Robert L. Shanebrook, a retired Kodak engineer and product manager.

Conscious of the commercial potential of full-color cinematography, the musicians also contacted Optica Honorary Member C.E. Kenneth Mees (1882–1960), a

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Roger Hayward’s simplified illustration of the original Kodachrome process, published in College Chemistry by Linus Pauling, 1950.
British-born scientist who served as the first director of the Kodak Research Laboratories. Mees, whose company had introduced the first 16-mm movie camera, Ciner-Kodak, in 1923, gave the young musicians some experimental coatings developed in his laboratory.

By 1930, the Great Depression was bearing down and Kodak leaders were under pressure to develop a color process that would generate a good cash flow. So in 1931, Mees invited Mannes and Godowsky to move to Rochester and embark on full-time product development. The lab director gave the two young men US$30,000 to pay off their debts and US$7,500 in annual salary.

“What they were bringing was a different view of how to make color film,” Shanebrook says of the pair. “And what Kodak was bringing to the party was the expertise of being able to make more sophisticated emulsions.”

Unlike many employees, whose patents belonged to their employer, Godowsky and Mannes were bringing several of their own patents into the color-film development—and, according to Shanebrook, they made sure that anything they worked on was partially dependent on one or more of their previous patents. Once Kodachrome became a success, the duo earned hundreds of thousands of dollars a year in royalties.

Since the musicians shared the same first name, laboratory staff waggishly dubbed them “Leo the Man” and “Leo the God,” or just “Man” and “God.” In a memoir of Mees’s life, biochemist Hans T. Clarke wrote that the development of Kodachrome “supplies a typical instance of Mees’s courage and readiness to proceed along unusual lines.”

At first, the two Leopolds thought they had lots of time, but around 1933, Mees and other managers pressured them to develop a working product, even if it was only a two-color film, Shanebrook says. Godowsky and Mannes went into overdrive and finally came up with the first iteration of Kodachrome, the three-color reversal film—which, as opposed to negative film, portrays the lightest areas of a photographed subject as the lightest and the darkest areas as the darkest, producing a “positive” image on film.

Kodak first released Kodachrome as a 16-mm movie film in 1935, then as a 35-mm film for still cameras in 1936. However, the first iteration of the film turned out to have relatively unstable color tones, which tended to fade quickly. Gustavson says the few remaining images from the early Kodachrome days are either clear or reddish-brown mush.

Kodak’s laboratory completely redesigned the process to reduce the color shift, according to Gustavson and Shanebrook, and the new version debuted around 1938. A Kodak chemist named Wesley T. “Bunny” Hanson Jr. (1912–1987) led the development of the color coupler masking system. The change also reduced the number of steps in Kodachrome film processing from 28 to 18, Taber says.

Even though the industrial laboratory had turned the fledgling film into a consumer product, Mannes and Godowsky still received the historical credit and compensation for their patents. “It was probably a good marketing thing that two musicians invented color film,” Gustavson says.

For the first two decades of Kodachrome’s existence, Kodak included development in the cost of the product. Purchasers received a prepaid envelope addressed to one of a handful of Kodak processing sites that handled the complex chemistry. In 1954, however, the company lost an antitrust suit and was prohibited from bundling the photofinishing with the film in the United States. Independent processing labs then could acquire Kodak’s machines and chemicals.

The famous, the mundane, the infamous

When Kodak introduced Kodachrome, the United States and other countries were mired in the Great Depression. US President Franklin D. Roosevelt started the Farm Security Administration (FSA) to combat poverty in rural areas. As part of the effort, the FSA
hired 11 photographers to document the struggles of farm families. Most worked in monochrome, but several photographers used Kodachrome to record migrant workers in the fields, agricultural products and farm buildings. Many of their chosen Kodachrome subjects wore drab clothing on a brown or gray background—but the photographers were probably more concerned with conveying the FSA’s preferred messages than with making artistic impressions.

Fortunately for Kodak, the 1939–40 World’s Fair in New York, USA, provided Kodachrome’s manufacturer with ample opportunities to market amateur photography to the masses. The Kodak Pavilion was situated at a prime location at one end of Rainbow Avenue; the building’s highlight was the Cavalcade of Color, a 10-minute show of 2,112 Kodachrome slides that 11 custom-built projectors beamed onto a large semicircular screen. The scenes ranged from flowers to families to a roaring circus tiger. “The slide show subtly interwove aspiration and accessibility,” wrote Swiss art historian Ariane Pollet. “The visitors found themselves torn between a fascination with the cutting-edge technology of the shifting panoramas and the familiarity of portraits of newlyweds and animals.” Kodak also printed pamphlets titled “Make Your Own Cavalcade of Color” and built “photo opportunity” sets for visitors to create their own snapshot souvenirs (one featured artwork by Salvador Dalí).

For less than a decade after World War II, Kodak offered to reprint Kodachrome slides onto tiny sheets of a plastic material, according to Shanebrook. These prints, just 8.3 cm by 5.7 cm in size, were technically complicated to make because the dynamic range of the print material was about 10 times less than that of the original slides.

Typing “Kodachrome photos” into any search engine yields a dazzling array of bright, nostalgic images of parents and children posing in front of Christmas trees, fireplaces and bicycles. In the 1950s and 1960s, newly prosperous Americans, weary of two decades of economic depression and war, wanted to photograph their families and vacations in full color, and during those years Kodachrome was the most widely available color film.

While newspapers would stick to black-and-white photography until the early 1980s, magazines such as National Geographic, Look and Life took advantage of Kodachrome to bring full color to their readers. In the mid-1980s, a frequent contributor to National Geographic, American photographer Steve McCurry, captured one of the magazine’s most memorable cover photos when he imaged a 12-year-old Pashtun girl living in a refugee camp in Pakistan. The intense stare of her green eyes, with her face framed by a red scarf, stuck in readers’ minds as the “Afghan Girl,” sparking a documentary search for her in 2002. Because of her high profile, she gained refugee status in Italy in 2021.

By far the most devastating event captured on Kodachrome was filmed by Abraham Zapruder (1905–1970), a clothing manufacturer and home-movie buff
in Dallas, USA. The first half of the 8-mm silent reel shows an unidentified woman donning a vest and answering a phone; the second half depicts President John F. Kennedy’s motorcade on 22 November 1963 and caught the most complete footage of his assassination. Later in the day, Zapruder, a newspaper reporter and a US Secret Service agent brought the film to Kodak’s Dallas processing facility for rushed development.

Decline and fall of Kodachrome

In the early 1960s, Kodak began selling its line of Instamatic cameras, which used film that came in an easy-to-load drop-in plastic cartridge. The company manufactured Kodachrome in these cartridge formats from 1963 to 1974, but color negative film such as Kodacolor benefited from the growing consumer demand for color prints instead of slides. The ability to make reprints and enlargements from Kodacolor boosted the negative film’s profitability.

For photographers who still preferred color reversal film, Kodak also competed against its own Kodachrome with Ektachrome, a product with a much simpler development process than its older cousin, enabling small outside photo labs to get into the processing business. Beginning in 1959 and continuing for the rest of the 20th century, Kodak boosted the speed of Ektachrome well past that of Kodachrome, making Ektachrome the preference of photographers who needed a faster film.

Both Kodacolor and Ektachrome also benefited from a simplified development process because the dye couplers are included in the film during the manufacturing process. The US military had wanted the ability to process film in the field, and NASA’s Apollo crews took Ektachrome to the moon because it would have a shorter turnaround time than Kodachrome upon the return home. Even advanced amateur photographers could process Ektachrome in their home darkrooms.

Finally, digital photography took its toll on Kodak’s film business—even though a Kodak scientist, Steven J. Sasson, invented the first self-contained digital camera in 1975. Digital imaging’s capabilities rapidly eclipsed Sasson’s 3.6-kg, 0.01-megapixel device, and during the first decade of the new millennium, Kodak and other film manufacturers heavily trimmed their product lines. Shanebrook says that when he retired from Kodak in 2003, the company had plans for discontinuing Kodachrome at a future date.

Though Kodak was investing in digital technology, financially it was in a downhill slide that would culminate in a 2012 bankruptcy reorganization. Its analog films were falling by the wayside. In June 2009, Kodak officials announced that the company would stop manufacturing all versions of Kodachrome. With the demise of the film stock, the cessation of the specialized K-14 processing would inevitably follow, as Kodak ended production of the K-14 chemicals.

By then, the only company running the specialized K-14 equipment was Dwayne’s Photo in Parsons, KS, USA. As Gustavson remembers it, Kodachrome’s demise was little noticed until Dwayne’s announced a hard deadline for the film’s development: 30 December 2010. The unassuming photofinishing lab in a small-town corrugated-metal building was suddenly inundated with thousands of exposed Kodachrome canisters flown in from six continents.

The last two rolls of Kodachrome went to McCurry, the “Afghan Girl” photographer, and to Dwayne Steinle, the eponymous proprietor of Dwayne’s Photo. McCurry traveled with his 36-exposure roll over six carefully planned weeks taking pictures ranging from New York icons like Robert De Niro and Grand Central Terminal to remote, colorful corners of India. McCurry admitted to a Seattle Times reporter that he felt a sense of nostalgia and asked, “I thought, what better way to honor the memory of the film than to try and photograph iconic places and people?” But he reserved the last three frames for scenes of ordinary life in Parsons.
Legacy and memories

People who have old boxes of developed and mounted Kodachrome slides need not worry that their precious images will fade anytime soon. As long as processed Kodachrome is stored in the dark, it has the best image stability of all color films. Image preservation scientist Henry Wilhelm has written that its yellow dye will fade less than 20 percent over 185 years in optimal dark storage. However, when exposed to light regularly or projected on a screen, Kodachrome is actually less stable than its in-house rival, Ektachrome.

In 2018, Kodak and its spinoff company, Kodak Alaris, released new versions of Ektachrome for 16-mm and Super 8-mm movies and still photography. That revival sparked rumors among photography enthusiasts that Kodachrome might be the next extinct film to be resurrected. Insiders, though, say that renaissance will never happen because the cost of reconstructing the dyes and the now-scrapped processing equipment would be prohibitive. “It has nothing to do with the complexity of the film,” Gustavson says.

Probably because of its association with holidays and family, Kodachrome became a pop culture icon. American singer-songwriter Paul Simon scored a top-10 hit with a cheerful 1973 song named after the product. The US state of Utah has a state park named Kodachrome Basin, home of colorful sandstone spires; a National Geographic writer/photographer dubbed the rugged area “Kodachrome Flat” while exploring it for the magazine’s September 1949 issue. In 2017, a comedy-drama movie named after the film told the fictional story of a son (played by Jason Sudeikis) road-tripping his dying photographer father (played by Ed Harris) to Dwayne’s Photo to deliver his last rolls of Kodachrome for processing.

Kodachrome lives on in other small ways, though K-14 chemistry no longer exists. Fans can find unexposed rolls of Kodachrome and mounted Kodachrome slides on online shopping sites. Dwayne’s Photo is still operating, despite Steinle’s death in 2020, and the shop will develop other types of vintage film. Digital photographers share “recipes” for tweaking images to make them look more like vintage Kodachromes.

To determine my own place in Kodachrome history, I rewound the mystery film inside my father’s Argus C3 camera and opened the back. Sure enough, the camera had contained a 20-exposure roll of Kodachrome II, probably manufactured 50 years ago, and requiring the earlier K-12 development process. I could mail it to a lab that might be able to give me black-and-white prints sometime in 2023. Maybe I’ll add one last monochrome chapter to the Kodachrome story.

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For references and resources, go online: optica-opn.org/link/kodachrome.
Article References and Resources

- Nat Geo’s Most Amazing Photos, Final Exposure, National Geographic TV, 17 September 2010.

If the author gets any usable photographs from her Kodachrome roll, she will post them online at http://photonicpat.wordpress.com.