



Puzzle masters

Researchers piece together early Buddhist manuscripts using Adobe® Photoshop® CS2 software



In 1994, the British Library Oriental and India Office of Collections acquired 29 fragments of manuscripts written on birch bark scrolls in Gāndhārī, a dialect of the Prakrit language. The scrolls were inside a clay pot, bearing an inscription in the same language, in which they had been buried in antiquity. Preliminary analysis of these documents indicated that they dated from about the first century A.D., making them the oldest surviving substantial collection of Buddhist manuscripts, as well as the oldest collection of any kind of Indian manuscripts.

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Researchers involved in what is now the Early Buddhist Manuscripts Project desperately wanted to unlock the secrets contained on the bark scrolls, yet the badly fragmented and fragile scrolls could not be repeatedly touched without damaging them. To address this problem, in 1994 a team at the University of Washington (UW) began using digital imaging tools, including Adobe Photoshop software, to study, translate, and preserve the manuscripts. Instead of touching the actual scrolls, the team used Adobe Photoshop on photographs of the scrolls to get information that couldn't be extracted from the originals.

An expanded team of researchers is still working today to translate and study the entire collection. “Thanks to digital technologies, including Adobe Photoshop CS2, scholars are learning more than they had imagined possible from these scrolls,” says Richard Salomon, director of the Early Buddhist Manuscripts Project and professor of Asian languages and literature at UW. “Adobe Photoshop has enabled us to work on this material in a way that nobody in our field had ever done before with manuscripts in terms of being able to see the manuscript in greater depth and creating charts of the ancient letters.”

Searching for significance

Gandhāra has long been known as one of the main centers of Buddhist art and culture during the early part of the Christian era, as attested by its abundant archaeological, art, historical, and inscriptional remains. But until the 1994 discovery, only one specimen of a Gandhāran Buddhist text—the famous Gāndhāri Dharmapada, edited by John Brough in 1962—was known. The new manuscripts therefore are unearthing unprecedented insights into the scope and composition of the long-hypothesized, and now actually discovered, body of Gandhāran Buddhist literature. The scripts are also providing researchers with the earliest documentary evidence of the contents of any of the Buddhist canons.

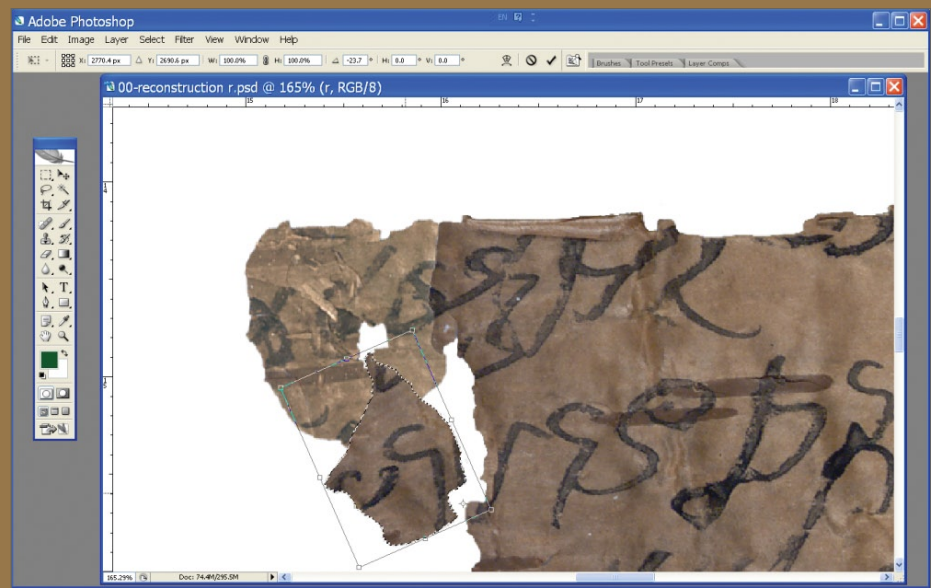
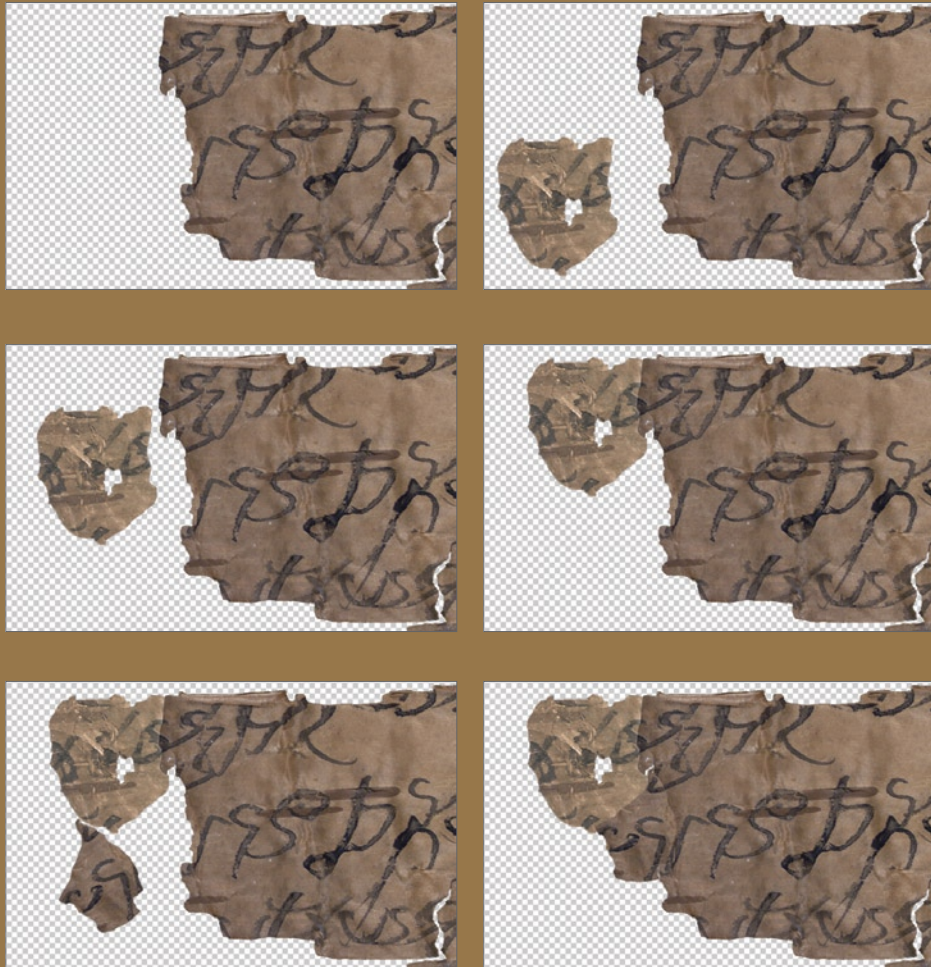
The search for the significance of the scrolls, officially named the Early Buddhist Manuscripts Project, began as a collaboration between the UW and the British Library in 1996. Dr. Andrew Glass—now at Bukkyo University in Japan but part of the original UW team—is among the primary researchers working on the project. The first fruit of the scholars' labor, *Ancient Buddhist Scrolls from Gandhāra*, an overview of the manuscripts and their significance, was published in summer 1996. Thereafter the researchers published three additional volumes at the rate of one every year.

Rediscovering history letter by letter

Reconstructing the texts is a laborious process because some of the fragile bark scrolls are badly fragmented. Initially, the British Library mounted the fragments, which range in length from just a few



Centuries ago, Buddhist monks rolled up these scrolls, flattened them, folded them in half, and placed them in this clay pot. What are left today are small, fragmented panels of text that researchers are reconstructing digitally using Adobe Photoshop CS2.



Andrew Glass of the Early Buddhist Manuscripts Project separates images of the scroll fragments before beginning the process of digitally piecing them back together. Using Adobe Photoshop CS2, he drags the pieces into the proper position; if necessary, he uses the Transform command on the edge of a fragment so that it aligns perfectly with the edge of its neighboring fragment.

words to several hundred lines of text, in 57 glass frames and provided UW with black-and-white photos of the frames. Although photographs are the traditional medium that the scholars use to study ancient texts, the set from the British Library wasn't sufficiently legible, reports Glass, so the library and the university began to consider how digital tools might improve their access to the material.

First the library tried taking color photographs and scanning them; however, the resolution wasn't high enough and the colors shifted. Scanning the fragments themselves wasn't a viable option, because the laser light might damage them. Finally the library captured the framed fragments using a 4x5 camera fitted with a digital back and provided Glass and his colleagues with 100MB TIFF files on CD-ROM.

Piecing together a giant jigsaw puzzle

The team's first task was to piece the fragments together. The scrolls had been rolled up, flattened, and then folded in half, and over time the sides had disintegrated, leaving small, fragmented panels of text. "When these packages are unraveled, it's extremely difficult to know how the pieces fit together," Glass says. "Many of them are in a jumble, so we separate the pieces and put them back together."

To piece together the puzzle, Glass places each fragment of a scroll on a separate layer in Adobe Photoshop CS2 and drags the pieces into the proper position, zooming in on the join lines to make sure they fit precisely. Sometimes Glass uses the Transform command on part of a fragment—if, for instance, it's been warped or distorted—so that it aligns perfectly with the edge of its neighboring fragment.

Next Glass manipulates the lightness and color balance to improve legibility. If the ink is faded in a particular area, he might also use Photoshop CS2 to increase the contrast locally.

Glass also creates a font set for each scribe's handwriting, which helps in dating the manuscripts. He makes a list of each of the 200 to 300 syllabic forms used in each text, then chooses an archetypal form for each and saves it in its own file.

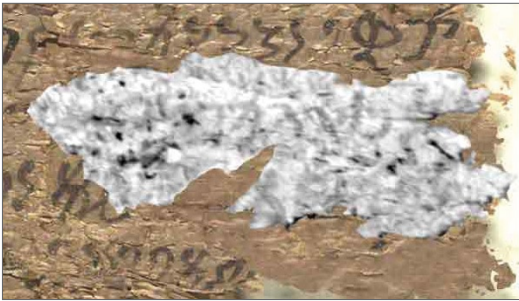
Harnessing technology to open new horizons

The processes and technologies used in the Early Buddhist Manuscripts Project continue to advance and change. In December 2000, Glass began filming the manuscripts in infrared. Initially he worked with NASA scientist Greg Bearman; later the British Library invested in the technology, having seen the results from the initial work with NASA.

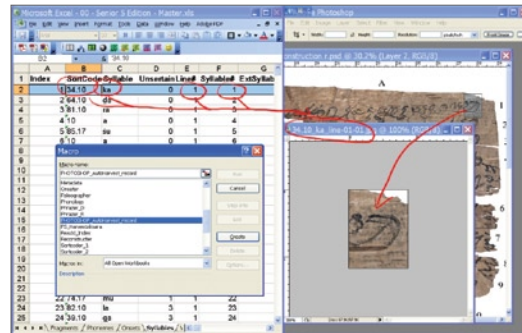
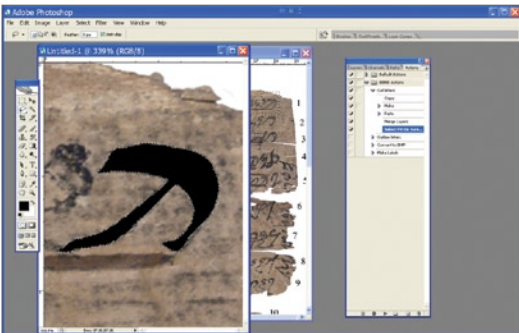
Glass has also upgraded to subsequent versions of Photoshop over the years, which has continually streamlined his workflow and enhanced his

“Adobe continues to improve the way Photoshop CS2 handles RAW images, so that processing is getting faster and faster.”

Andrew Glass, researcher, Early Buddhist Manuscripts Project



Since the Early Buddhist Manuscripts Project began in 1994, researchers' efforts have improved with advances in technology. They now photograph the scroll fragments in infrared to enhance their resolution, and use actions and scripting in Adobe Photoshop CS2 to automate repetitive tasks.



research efforts. For instance, he's now able to work with large numbers of RAW image files and automate many time-consuming research processes to reach insights faster. “The infrared camera produces RAW image files, and so I manipulate these in Photoshop CS2 to obtain a format we can use,” says Glass. “Adobe continues to improve the way Photoshop CS2 handles RAW images, so that processing is getting faster and faster.”

Automating tedious research tasks

Glass has become a master at using Actions in Photoshop CS2 to automate many of his more tedious research processes. He has shared actions and techniques he devised for the font work with colleagues in Norway, Germany, Australia, New Zealand, and Japan. He's also been using the scripting feature in Photoshop CS2.

“One of the slowest parts of cutting out the letters for the font before was giving each letter the correct label so I could find it again,” Glass says. “Now I have linked a Microsoft Excel spreadsheet containing the text of the manuscript to Adobe Photoshop CS2. I simply point to a letter, and a macro in Excel captures the selected letter in Photoshop CS2 and saves it with the proper name generated by Excel.”

This process has dramatically increased his speed at collecting letters. He now collects every letter and then sorts them alphabetically so he can look at every example of a given letter in the manuscript. Having this collection of letters has proved useful not only when Glass is confronted with badly damaged letters, but also in other aspects of his studies.

For the next book in the research team's series, slated for 2006, Glass reconstructed a six-foot scroll by combining both the color and infrared images. The final image is a single Photoshop CS2 file, almost 600MB, and every fragment in the file is on a separate layer. The fragments that make up the scroll are now preserved under five separate glass frames.

“We were able to reconstruct the texts in a large, high-resolution way that enables people to appreciate what these scrolls would have looked like. They are also much easier to read,” says Glass. “Adobe Photoshop CS2 has not only revolutionized the way we are able to study these texts, but also provides a wonderful way to bring them to life.”

Organization

Early Buddhist Manuscripts Project

Seattle, Washington

<http://depts.washington.edu/ebmp/index.php>

Challenges

- Find powerful new ways to decipher ancient scrolls without touching or damaging them
- Piece together fragments of scrolls
- Build on the world's knowledge of early Buddhist canons
- Sort, analyze, and catalog syllabic forms to help with dating
- Accelerate mundane image processing and analysis tasks
- Bring scrolls to life for people

Solution

- Use infrared and large-format photography and Adobe Photoshop CS2 to piece together and enhance images from ancient scrolls
- Automate tedious processes using Actions and scripting in Adobe Photoshop CS2

Benefits

- Researchers can see manuscripts in greater depth
- Scholars can create charts of ancient letters
- Ancient texts can be deciphered faster
- Researchers' and laypeople have improved access to historically important material

Toolkit

- Adobe Photoshop CS2
- Dell Inspiron 8500 PC running Microsoft® Windows® XP Professional
- PhotoPhase camera
- PowerPhase camera