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INVESTIGATION OF A CHINESE INK RUBBING BY ^{14}C AMS ANALYSIS

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ABSTRACT. The date of a Chinese ink rubbing was determined using radiocarbon accelerator mass spectrometry (AMS) to be in the range from AD 1480 to AD 1670 (95.4% confidence limit). Together with a scanning electron microscope (SEM) analysis of the ink and a comparative study of the Chinese characters, it was determined that the ink rubbing must have been performed before Emperor Kang Hsi (AD 1662–1722), who ruled at the beginning of the Chin Dynasty. On the other hand, the stone stele, from which the ink rubbing was produced, was carved in AD 531, which is consistent with an analysis of some erased characters. Such analysis seems to be useful to help clarify possible forgeries of these art objects.

INTRODUCTION

Ink rubbing has been an important technique in Chinese culture. Before the development of modern printing processes with colortype, ink rubbing was a unique tool available to faithfully reproduce original artistic work, in particular, calligraphy. In reality, this technique was closely linked to the progress of various types of Chinese writing, including seal-, official-, running-, regular-, and cursive-script. While the engraving of writing on a stele (engraved stone) bears the significance of conservation of art on perishable paper or silk, ink rubbing favors the access of calligraphy for wider circulation. It has sustained the advance of calligraphy for more than 2000 yr, and prolonged the popularity of invaluable master works, accordingly.

Ink rubbing is similar to the letterpress, for which the original work is carefully duplicated by writing on a polished stone surface, and then, the characters are engraved with a chisel to form a concave inscription. For reproduction, a piece of pre-wetted soft paper is first pressed unto the incised stone to shape the characters. After drying, the paper is pounded with an ink-soaked cotton pad to show the engraved characters in white. In another way, the paper is treated by pre-wetting and pressing as in the first one. After peeling off and drying, a thin layer of Chinese ink of suitable consistency is applied over the stone surface, followed by careful matching the said paper with the inked surface below. A sheet of waxed blanket is placed above. By rubbing the blanket downward with a pad to permeate ink through the paper, the blank characters appear amidst the inked background.

Although the time of preparing the stele may have been recorded, the date of rubbing was not to be written down. This practice has become a chance for forgery. As an art object, ink rubbings have been highly appreciated by scholars and aristocrats. Forgery of master works of ink rubbings has become a serious problem in art conservation. The authenticity of an article can be challenged by a counterfeit of newer ones pretending to be old rubbings, or by imitation of original stele through new stone engravings. In this respect, ^{14}C dating by the AMS technique is a viable approach in determining the time period when the rubbing was performed.

The purpose of this investigation is to apply ^{14}C dating to an ink rubbing from an inscribed gravestone of Chang Hsuan (AD 461–493) from the Northern Wei Dynasty. The stele was laid in AD 531 in the Yunchi area, Shanxi Province, but neither the date when the stele was unearthed nor the date of later disappearance were recorded. In 1825, a calligrapher, Ho Shao Chi, procured the ink rubbing

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of this stele from a book market in Jinan, Shantung Province, and considered it to be the sole article in existence. This ink rubbing, also named the stele of Chang Hei Nue (to be explained later), is now part of the Shanghai Museum collection. However, its context and calligraphy differ from those of the author's (H-C Yuan's) family collection. Several forged errors can be obviously detected in the evaluation of the content (Yuan 2003). Thus, a sample was taken from the Yuan family collection for ^{14}C dating by AMS at the VERA facility to estimate the time period when this rubbing was performed. The nature of the ink used for the rubbing was examined by a scanning electron microscope (SEM) to assist the interpretation of the results.

MATERIALS

Chinese ink used in rubbing is a fine dispersion of carbon black and glue from bone collagen in the form of a viscous paste with suitable consistency. Carbon black can be either from pine soot or as lamp black from Tung oil, the latter being from annual seed production. Pine soot, however, is produced from logged pines with ages ranging from decades to hundreds of years. In addition, the blending of old, well-aged inks into new preparation (probably for viscosity and particle size adjustment) had been a trade secret. Thus, if the dated paper is contaminated with a large amount of ink, a shift toward an older age cannot be excluded. But, although the exact amount of carbon added this way to the paper sample could not be determined, it is estimated to be well below 10% of the total carbon from the paper being dated, resulting in a negligible shift of the age.

In contrast, the raw material for Chinese paper were fibers from Broussonetia trees or bamboo, both being fast-growing species. Thus, the problem of old paper material discussed in Burleigh and Baynes-Cope (1983) can be excluded.

METHODS

Sample Preparation

A strip (1 × 26.7 cm) was cut from the edge of the ink rubbing paper without touching the character part (Figure 1). Approximately one-half of this sample was taken from the strip and processed further for the ^{14}C age determination (VERA laboratory number V-2268). The material was first cleaned ultrasonically, followed by a standard Acid-Base-Acid (ABA) treatment at 60 °C using 1M HCl–0.1M NaOH–1M HCl in sequence, and rinsing with bi-distilled water between the change of the reagent. Ten mg of the pretreated and dried material was transferred into a quartz tube together with 1 g CuO and some silver wire, then evacuated and sealed with a torch. The sample was combusted in a muffle furnace for 4 hr at a temperature of 900 °C. The evolved CO_2 was reduced to carbon with hydrogen in the presence of an Fe catalyst at 580 °C. The resulting graphite-catalyst mixture was pressed into an Al target holder for AMS analysis.

For reference, targets were prepared from the IAEA standards C-3 (cellulose), C-5 (subfossil wood) and C-6 (ANU-sucrose), while dead carbon from a graphite rod was used as machine and chemistry blanks (Wild et al. 1998). As far as possible, the standards and the blank material was treated in the same way as the sample. The $^{14}C/^{12}C$ ratio of the chemistry blank was subtracted from the $^{14}C/^{12}C$ ratios of both the standards and the sample for background correction.

AMS Measurements

The VERA AMS system is based on a 3-MV Pelletron tandem accelerator (Kutschera et al. l997; Priller et al. 1997). Procedures for ^{14}C and $\delta^{13}C$ measurements have been described previously (e.g., Rom et al. 1998). The ^{14}C measurements are now performed in a fully automated way (Steier et al.

Figure 1 Sample taken from the edge of the ink rubbing (see text for details)

2000; Puchegger et al. 2000). Recently, VERA has been upgraded to accommodate isotope ratio measurements across the nuclear chart (Vockenhuber et al. 2003). This now allows one to switch quickly between high-precision “routine” ^{14}C measurements (e.g., Wild et al. 2001) and more elaborate AMS measurements up to ^{244}Pu (Steier et al. 2003; Winkler et al. 2003).

In the present investigation, the accelerator was operated at a terminal voltage of 2.7 MV. Typically, ^{12}C currents from the MC-SNICS cesium beam sputter source were in the range of 28 to 42 μA. For fast switching between carbon isotope measurements, the beam-sequencing method was used (Priller et al. 1997), with sequential time periods for isotope injection of 213 ms for ^{14}C, 1.15 ms for ^{13}C, and 0.15 ms for ^{12}C. The sample target was measured 6 times with each measuring period lasting about 5 minutes.

Age Determinations

The ^{14}C content in percent Modern Carbon (pMC) and the ^{14}C ages of the ink rubbing sample were calculated according to Stuiver and Polach (1977) from the $^{14}C/^{12}C$ and the $^{13}C/^{12}C$ ($\delta^{13}C$) ratios, both measured at VERA. The ^{14}C age of the rubbing sample was converted by the OxCal software version 3.5 (Bronk Ramsey 2000, 2001) with atmospheric calibration data from Stuiver et al. (1998) into a calibrated age.

Scanning Electron Microscope (SEM) Investigations

A tiny fragment of the ink rubbing paper was gold-plated for examination by SEM, using a 15 kV Norton S-4200 SEM. For identifying the origin of carbon in ink, photos were taken at 10k, 20k, and 50k magnifications with operating voltage of 10 kV. These photomicrographs were compared with those from paper bearing inks from either pine soot or lamp black.

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RESULTS AND DISCUSSION

The result of the OxCal calibration of the measured ^{14}C age is shown in Figure 2 and the results are summarized in Table 1.

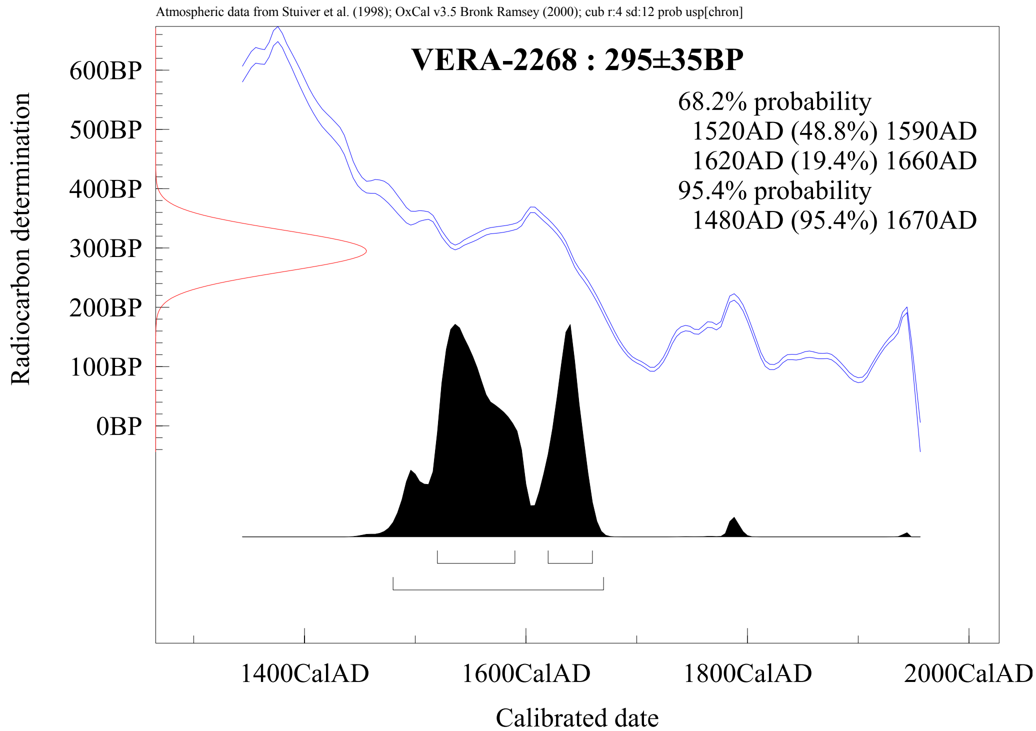

Figure 2 Plot of ^{14}C age versus calibrated date for Sample V-2268 determined with the Oxcal calibration program

Table 1 ^{13}C and ^{14}C results of the ink rubbing sample

Laboratory number	$\delta^{13}C$[a] (‰)	^{14}C content[a] (pMC)	^{14}C age[a] (yr BP)	Calibrated date[b]
VERA-2268	–26.2 ± 0.6	96.4 ± 0.4	295 ± 35	AD 1480 (95.4%) AD 1670

[a] 1σ uncertainty
[b] Calibrated range for the 95.4% confidence (2 σ) limit determined with the OxCal calibration program (see Figure 2)

Analysis of the results shows that the rubbing was performed before AD 1670, towards the end of the Ming Dynasty in China. This estimate is supported by a clue in the inscription. Although the name of the inscribed stele is in the memory of Chang Hsuan, in the Chin Dynasty it was also called the stele of Chang Hei Nue, as mentioned earlier. The reason was that the Emperor Kang Hsi in the Chin Dynasty had a given name of "Hsuan" Hua. The imperial regulations demanded that no character in the stele should coincide with the given name of any emperor in that dynasty, otherwise, it would become a serious offence. For any existing steles with character(s) in conflict with this regulation, such character(s) should be chiseled off, producing a blank in the corresponding spot of the ink rubbings. Since the given name "Hsuan" in the stele was intact as indicated in this rubbing (Figure 3a), it is certain that the rubbing was done before the Kang Hsi epoch (AD 1662–1722), as confirmed by the AMS measurement results. The above-mentioned practice is supported by the same stele in which the character "Shun" was mostly chiseled off (yet still identifiable as this particular character), it coincided with the given name of Emperor Hsiung-tsung, Li Shun (AD 806–820), in the late Tang Dynasty (Figure 3c). Thus, the original gravestone was unearthed before the end of Tang Dynasty, AD 907. The given name of Chang Hsuan's father was completely carved away in the stele (Figure 3b); therefore, it could not be determined whether this character coincides with that of the ruling monarch.

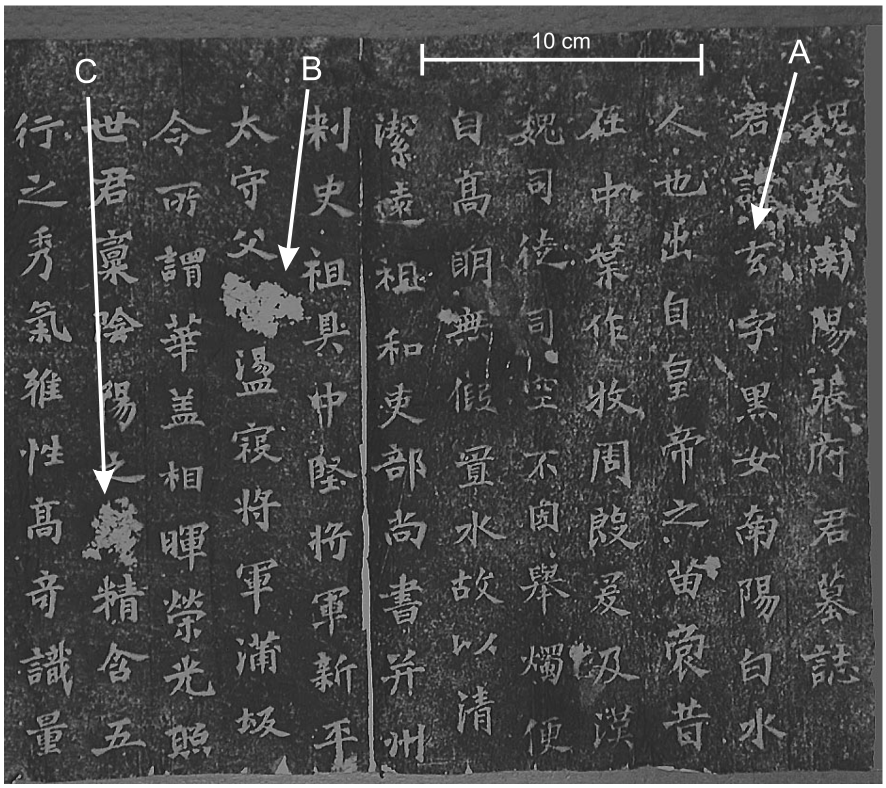

Figure 3 Part of the ink rubbing showing important locations of characters: A–"Hsian" is intact; B–father's name unknown; C–"Shun" is chiseled away

Figures 4A–4C show the SEM photomicrographs of ink particles magnified to 10k, 20k, and 50k, respectively. By comparing the figures from the present ink rubbing with 4D (from pine soot) and 4E (from lamp black), the cloudy appearance of Figures 4A–4C and 4D clearly indicates that the ink used in this rubbing was based on pine soot. As discussed above, the influence of the ink on the date of the paper should be negligible.

CONCLUSION

The use of AMS for dating the paper of Chinese ink rubbing has been successfully accomplished with good precision. Its result could be assessed with pertinent information of historical events. In the light of wide-spread forgery of classical Chinese paintings and calligraphy works, the use of ^{14}C dating of paper and silk substrates with the AMS technique can help resolve authenticity problems

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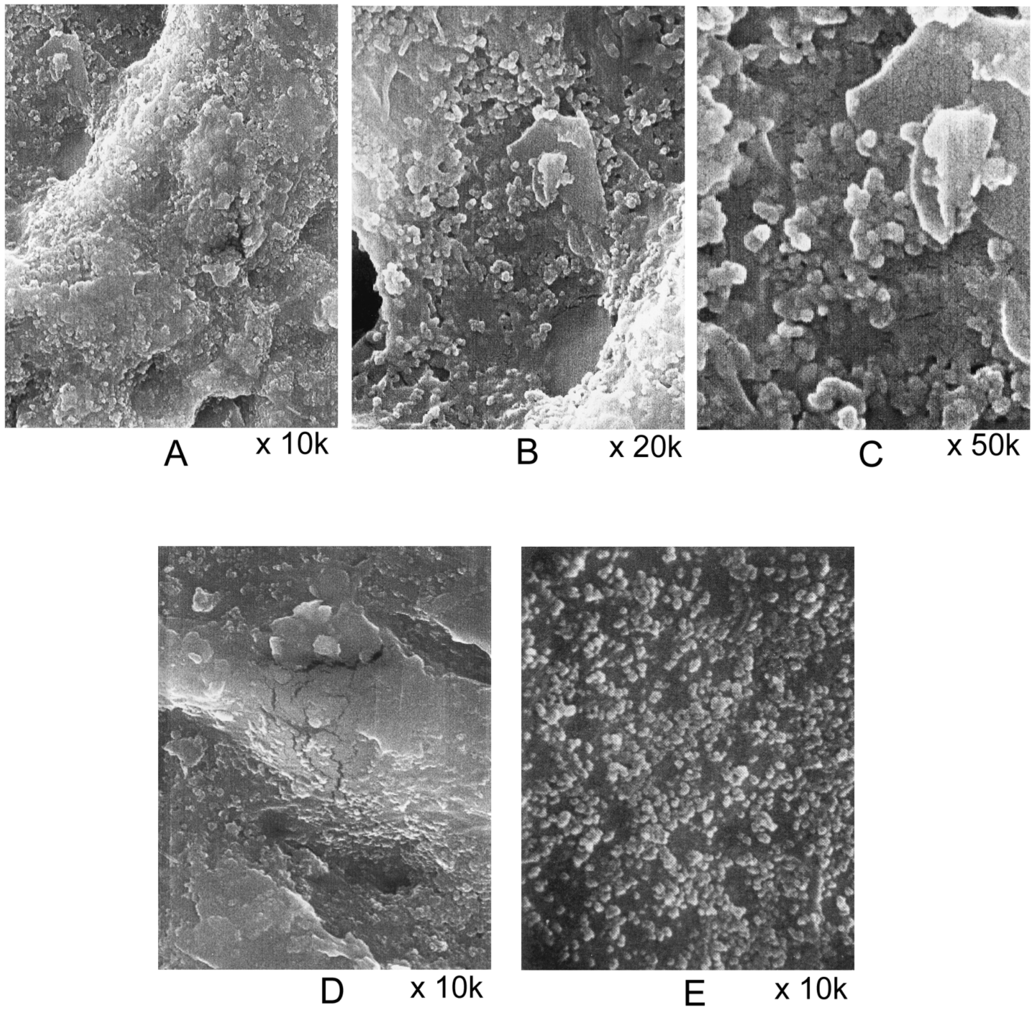

Figure 4 Scanning electron microscope (SEM) photographs of ink particles from the investigated ink rubbing material (A–C), contemporary pine soot (D), and of lamp black from AD 1810 (E)

and aid screening art objects. For the majority of art works, samples can be taken from their edges without touching the colored part.

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