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Development of Latent Fingerprints on Paper Using Magnetic Flakes

REFERENCE: Wilshire, B. and Hurley, N., **"Development of Latent Fingerprints on Paper Using Magnetic Flakes,"** *Journal of Forensic Sciences*, JFSCA, Vol. 40, No. 5, September 1995, pp. 838–842.

ABSTRACT: For various types of paper differing in color and surface texture, a study has been made of the factors governing the developed print qualities achieved using a magnetic applicator to apply fine iron flake powders and the subsequent retrieval of the magnetic flake from the papers using a rare-earth permanent magnet.

KEYWORDS: criminalistics, fingerprints, magnetic flake powders

For development of latent fingerprints on rough or porous surfaces, impressive results have been reported using a "magna-brush" to apply "magna-powders" [*1–4*]. Conventional magna-powders consist of equiaxed iron particles (approximately 50 μm diameter), mixed with a small amount of fine powder, such as aluminium flake (about 10 μm average diameter and 0.5 μm thickness). On being picked up with an applicator, the coarse iron powder acts as a magnetic carrier for the fine non-magnetic flake, with only the fine particles adhering to the fingerprint residue to reveal the ridge pattern.

A recent innovation in the use of magnetic applicators has been the replacement of conventional magna-powders with fine magnetic flake, obviating the need for a coarse carrier medium [*5*]. Two magnetic flake products have proved particularly suitable, namely, pure iron and austenitic stainless steel [*6*]. Each of these materials can be manufactured either

(a) as uneven-surfaced flake with jagged outlines, giving a poorly-reflecting powder for dark print development on light backgrounds, or
(b) as smooth-surfaced flake with rounded outlines, giving a highly-reflective product for bright print development on dark backgrounds.

For bright print development on non-porous surfaces such as glass, the highly-reflective flake proved superior to commercial bright magna-powders and comparable to those developed with commercial aluminium fingerprint powders, while the dark print qualities achieved with the poorly-reflective flake easily surpassed those obtained using commercially-available dark powders. Moreover, for bright and dark print development on a variety of rough or porous surfaces, the magnetic flake products were superior to all of the commercial fingerprint powders evaluated [*6*].

The magnetic flake fingerprint technology offers a range of advantages, [*7,8*]. For instance, the magnetic flake allows rapid print development, being particularly effective for revealing faint prints. Since the latent fingerprint is contacted only by fine flake capable of adhering to the fingerprint residue, with no brush or coarse carrier particles involved, the risk of ridge smearing or print obliteration during development is negligible. In addition, when magnetic flake is used with new applicator designs incorporating powerful rare-earth permanent magnets, the airborne particle cloud generated during conventional brush application of standard powders is virtually non-existent, eliminating any potential long-term respirable health risk to scene-of-crime officers. Furthermore, one special advantage is offered by the magnetic flake technology. In contrast to all other fingerprint powders in common use, the magnetic flake particles can be removed from many types of surfaces simply by touching the developed print with a rare-earth permanent magnet.

The ability to remove magnetic flake after print development may be important in the case of fingerprints deposited on paper. In general, paper and paper products are excellent receiving surfaces for latent fingerprints. However, except for specially-treated papers, the fingerprint residue becomes absorbed into the paper after a relatively short period of time, usually a day or so after deposition [*2*]. The present program was therefore designed

(i) to optimize the magnetic flake dimensions for development of latent fingerprints deposited on various types of paper,
(ii) to assess the influence of variations in surface texture of the paper on the relative ease of removing magnetic flake after print development, and
(iii) to study the variations in print qualities and the comparative ease of magnetic flake removal as a function of the age of prints deposited on different grades of paper.

Experimental Procedures

Paper Textures

A wide range of different papers was generously made available by Sappi Graphics, offering a variety of surface textures and colors. Although trials were undertaken with all grades of paper supplied, four types were selected for detailed investigation, namely,

Received for publication 27 Dec. 1994; revised manuscript received 28 Feb. 1995; accepted for publication 1 March 1995.
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(i) Savannah Natural Art (white, produced with either a gloss or matte finish) and
(ii) Croxley Signature paper (white or blue, both manufactured to give a fine fibrous surface appearance).

The surface textures of these papers are evident from the scanning electron micrographs presented as Fig. 1. The white Savannah Natural Art papers had smooth surfaces, with the gloss version having relatively few surface holes (Fig. 1*a*) compared with the large number of holes distributed randomly across the surfaces of the matte grade, (Fig. 1*b*). In contrast, the Croxley Signature papers were characterized by a highly fibrous appearance, (Fig. 1*c*) with no discernible textural differences between the white and blue papers because the color was imparted simply by absorption of an appropriate dye into the fibers during manufacture.

Trial Magnetic Flake Powders

In general, latent fingerprints deposited on the three different types of white paper were developed with the poorly-reflecting "dark" iron flake, whereas prints deposited on the blue paper were developed with the highly-reflective "bright" iron flake.

The ball-milling procedures used to produce the iron powders [*6*] resulted in flake diameters ranging from ~3 μm to ~60 μm, with a mean flake diameter of ~20 μm and an average flake thickness of ~0.5 μm. However, with the numbers, sizes and types of surface crevice differing significantly for the various papers studied, (Fig. 1), it was anticipated that fine flake particles could become lodged irretrievably in the small surface holes of the papers. So, while the majority of the present trials were performed using the as-milled products, additional studies were completed using flake powders sieved to obtain samples with restricted ranges

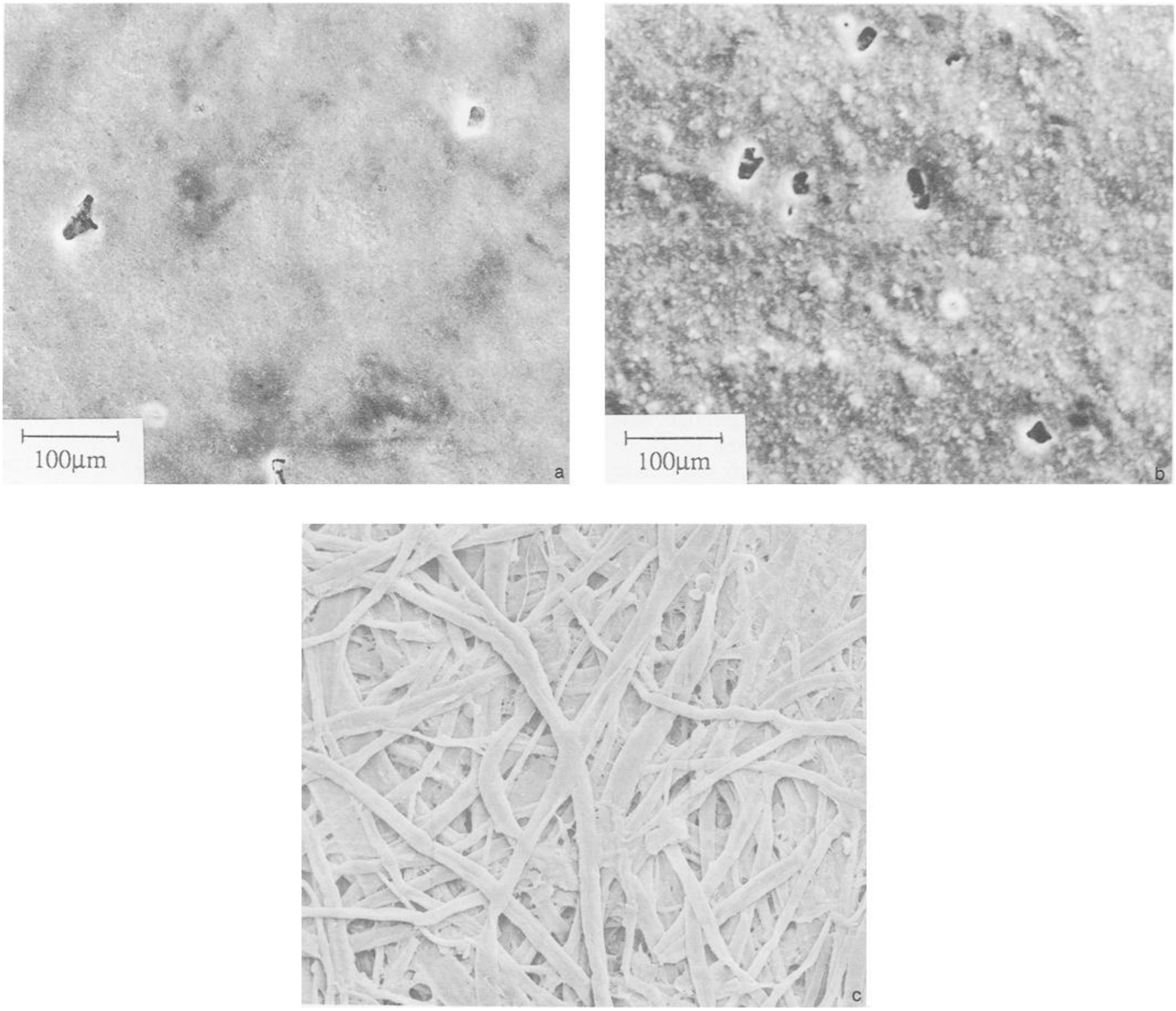

FIG. 1—*Scanning electron micrographs showing the surface appearance of the Savannah Natural Art white paper produced with* (a) *gloss and* (b) *a matte finish, compared with* (c) *the fibrous surface texture of the Croxley Signature paper.*

of particle diameter. Thus, for both the smooth-surfaced and uneven-surfaced iron powders, samples were produced with flake diameters of >20 μm, 20–32 μm, 32–38 μm and >38 μm.

Fingerprint Development Procedures

The various magnetic flake powder samples were used to develop sets of identical latent fingerprints deposited on the different types of paper by several different donors [6]. For each of the paper types considered, one print from each identical set was developed with one of the magnetic flake powder samples, which was applied using a standard commercial magnetic applicator. In cases where excess flake adhered to a print, the excess could be removed easily by passing a rare-earth permanent magnet over the developed print, without touching the surface of the paper. Each developed print was then photographed, using reflected light techniques. In order to assess the print qualities achieved using the various magnetic flake products, comparisons were made with the results obtained for identical print sets developed with commercial bright or dark magna-powders, which were also applied using a standard magnetic wand.

A series of preliminary trials established that, irrespective of the types of powder or paper considered, the print development procedures adopted gave consistent results. Even so, as a precaution since only a qualitative assessment could be made of the print qualities achieved, all experiments were performed in duplicate. Moreover, as an additional safeguard against subjectivity, several key experiments were repeated independently by different experienced investigators.

Results and Discussion

Optimization of Magnetic Flake Sizes

For all types of paper studied (Fig. 1), using either the "bright" or "dark" magnetic powders, similar patterns of results were recorded when identical sets of newly-deposited latent fingerprints were developed with flake samples differing in particle size. The effects of variations in particle dimensions on print quality can then be inferred from Figure 2, which shows photographs of prints on the white matte paper developed with a commercial dark magna-powder (Fig. 2*a*), with as-milled dark iron flake (Fig. 2*b*) and with dark magnetic flake sieved to give particle diameters of 20–32 μm and >38 μm, (Figs. 2*c* and *d*, respectively). Clearly, the results recorded using the commercial dark magna-powder (Fig. 2*a*) were inferior to those attainable with the as-milled dark iron flake (Fig. 2*b*). In fact, the as-milled flake revealed not only the detailed ridge pattern but even the locations of the pores along the individual ridges, (Fig. 2*b*). However, the clearest prints were achieved with the dark magnetic flake sieved to restrict particle diameters to within the range 20–32 μm (Fig. 2*c*), with the poorest qualities found with samples sieved to ensure that all flake diameters were in excess of 38 μm (Fig. 2*d*).

Factors Affecting Print Quality

For newly deposited prints on the various types of papers, the magnetic flake particles adhered strongly to the fingerprint residue, so that particles decorating the ridges could not be removed either by passing a rare-earth magnet over a developed print or even by contacting the paper surface with the magnet immediately after development. In contrast, any magnetic flake particles located in the furrows between the ridges could be recovered relatively easily just by moving the magnet over the developed prints without touching the paper surfaces, although the proportion of flake removed was found to depend on the type of paper considered. The magnetic flake could be retrieved most easily from the furrows of prints deposited on the gloss paper (Fig. 1*a*), with increasing difficulty experienced with the matte variety (Fig. 1*b*) and particularly with the fibrous paper (Fig. 1*c*). The extent of powder retrieval from the furrows therefore varied with the numbers, sizes and types of holes on the paper surfaces. However, the ease with which the magnetic particles could be removed from between the ridges also depended on the flake size and morphology,

(a) with finer flake particles tending to lodge more firmly in the surface holes (Fig. 3) and
(b) with the jagged-edged dark flake being more difficult to retrieve than equivalent-sized bright flake having smooth surfaces and rounded outlines.

The ease with which the iron flake could be removed magnetically from the furrows markedly affected print quality, as can be deduced from the photographs presented as Figure 2. Thus, with standard magna-powders, any non-magnetic particles deposited between the ridges during print development could not be removed, resulting in a high "background" which impaired print clarity, (Fig. 2*a*). With the as-milled magnetic flake having particles varying in diameter from less than 3 μm to over 60 μm, it proved relatively easy to retrieve flake with diameters above ~20μm, whereas the finer particles which tended to lodge firmly in the surface holes were more difficult to recover (Fig. 3). Hence, the contrast between the ridges and furrows of prints developed with as-milled flake (Fig. 2*b*) was not as high as the level achieved with magnetic flake sieved to restrict the particle diameters to 20–32 μm (Fig. 2*c*). Yet, on increasing the mean flake diameter to above ~38 μm, the print qualities decreased significantly, (Fig. 2*d*). This effect can be explained on the basis that with large flake diameters, part of a flake can adhere firmly to the fingerprint residue of one ridge, with the rest of the flake particle overlapping into the adjacent furrow. Consequently, the boundaries between the ridges and furrows become progressively less distinct as the mean flake diameter increased above ~38 μm, resulting in poor print qualities (Fig. 2*d*).

Effects of Print Age

For all types of paper studied, while impressive print qualities could be achieved when newly-deposited fingerprints were developed with either the as-milled magnetic flake (Fig. 2*b*) or with the 20–32 μm iron flake (Fig. 2*c*), the print qualities decreased with increasing print age as the fingerprint residue became absorbed into the paper. For example, using the as-milled dark iron flake, ordinary sweat prints developed within a few hours of deposition were of excellent quality, but were faint after one day and irresolvable after two days. Similarly, sebum-rich prints were extremely faint after two days and unidentifiable after longer times.

The ease with which the magnetic flake particles could be retrieved from developed prints by contacting the paper surfaces with a magnet was also found to depend on the total print age, defined as the time between deposition and development plus the time between development and attempted retrieval. This fact was established by developing sets of identical prints of different ages on various types of paper and then, after varying periods of time, contacting the developed prints with a powerful rare-earth magnet. For all paper types and magnetic flake products considered, all or

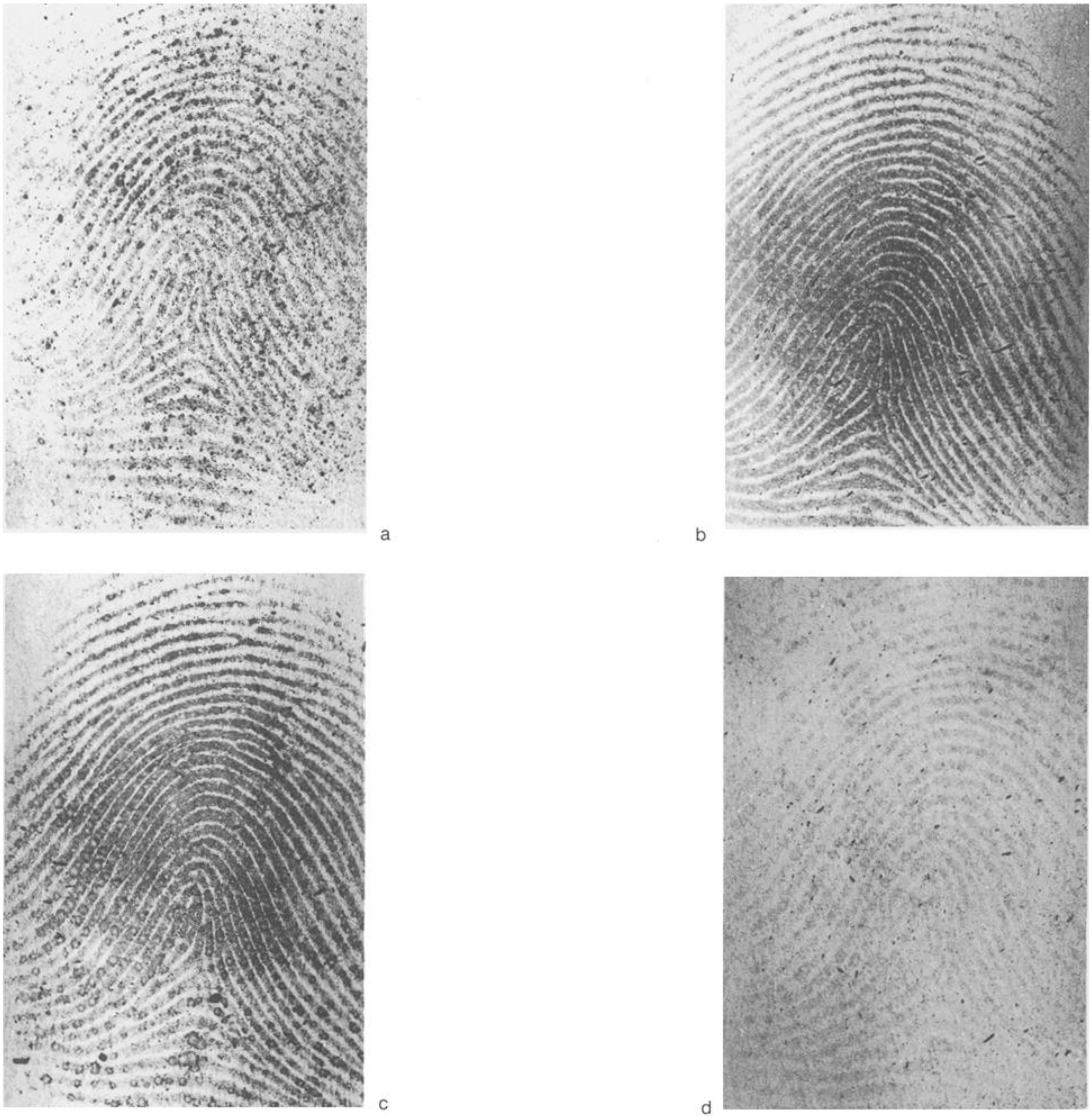

FIG. 2—*Reflected-light photographs of identical fingerprints deposited on the white matte paper which were developed immediately after deposition using a standard commercial magna-brush to apply* (a) *a commercial dark magna-powder,* (b) *the as-milled dark iron flake,* (c) *the dark iron flake sieved to restrict particle diameters to within the range 20–32 μm and* (d) *the dark iron flake sieved to ensure all flake diameters were in excess of 38 μm.*

almost all of the magnetic flake particles could be removed from the developed prints only for total print ages of two days or so, although complete removal depended on the type of flake used to develop prints on the various papers. Thus, for prints contacted with a rare earth magnet two days after development with the as-milled iron flake, coarse particles could be removed relatively easily but some fine particles were trapped irretrievably in the surface holes, particularly with the matte and fibrous papers (Fig. 3). In contrast, the 20–32 μm magnetic powders not only produced the clearest print qualities (Fig. 2*c*) but also allowed virtually complete retrieval of flake from developed prints once the fingerprint residue had become absorbed into the various types of paper.

As with other powder dusting techniques, for latent fingerprints on paper, the magnetic flake products therefore allowed development only of prints which were little more than about one day old. Even so, the ability to remove the magnetic flake from the paper after print development may offer advantages. For instance, prints could be first developed with the magnetic flake, subsequently removing the flake before chemical reprocessing with reagents such as ninhydrin. Although the results achieved with the magnetic flake did not surpass the print qualities obtained with ninhydrin, the flake method made it easier to distinguish recently-deposited prints from older ones. Thus, dual magnetic flake/chemical processing may be valuable when new prints have been deposited over older ones, as chemical processing would develop both sets, making identification difficult.

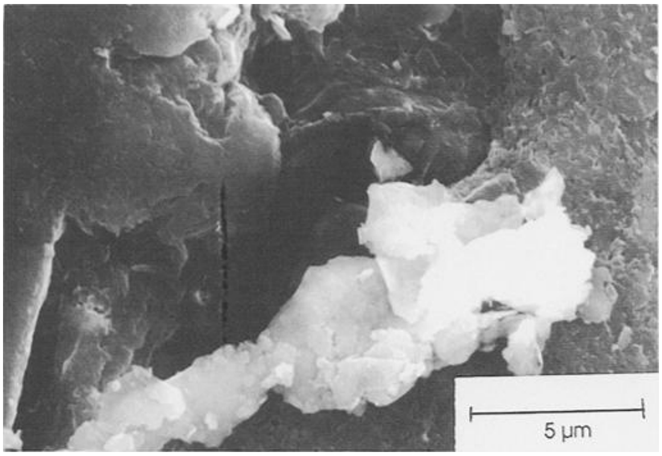

FIG. 3—*Scanning electron micrograph showing an iron flake particle (appearing bright in the figure) lodged irretrievably in one of the surface holes on the matte paper (Fig. 1b).*

Conclusions

For development of latent fingerprints newly deposited on papers differing in surface texture, excellent print qualities were achieved using a magnetic applicator to apply as-milled dark magnetic flake to prints on various white papers, with impressive results also recorded using as-milled bright magnetic flake to develop prints on colored papers. However, prints of even greater clarity could be produced by sieving the as-milled powders to supply powder samples with flake diameters restricted to within the range 20–32 μm.

As the fingerprint residue became absorbed into the various types of paper studied, the print qualities attainable with the magnetic flake products decreased with increasing print age, such that ordinary sweat prints were irresolvable and sebum-rich prints virtually unidentifiable after two days.

The magnetic flake powders could be retrieved by contacting developed prints with a rare-earth permanent magnet, but only when the fingerprint residue had been absorbed into the paper two days or so after deposition. For two-day-old developed prints, while some small particles in the as-milled flake became lodged irretrievably in the holes present on the surfaces, particularly on matte and fibrous papers, virtually all traces of flake could be removed from prints developed with the 20–32 μm flake products. Hence, the 20–32 μm magnetic flake powders produce the clearest print qualities, while also allowing maximum retrieval of flake particles from prints developed on all types of paper.

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