Free Lead Particles Associated with Keys

The defendant was accused of the shooting death of his wife. Police administered gunshot residue samplers to the defendant's hands and objects that he likely came into contact during the interval from the shooting to his arrest. The examination of the samplers by scanning electron microscopy/energy dispersive X-ray spectroscopy (SEM/EDS) showed no particles of potential gunshot residue, except the sampler of a set of keys from the defendant picked up lead-containing particles. The criminalist called these particles “consistent with gunshot residue.” There were no control examinations (i.e., testing other sets of keys) made. As will be seen below, it is unlikely that the source of the lead particles found by the criminalist originated from a firearm.

In 1999 the California State Attorney General's Office filed a complaint against thirteen lock and key manufacturers under California's Proposition 65 due to lead (Pb) in their keys. The basis for this lawsuit was that the brass keys manufactured by these firms have from 1.5 to 2.5% lead (Pb) content [1]. An agreement was reached with the defendants in 2001 [2]. “Most common keys are made from brass that contain 1.5 to 2.5% lead, but the defendants agreed to no longer make keys with more than 1.5% lead. ... Some keys, including many car keys, are steel and contain only trace amounts of lead. Other keys are made from nickel-silver, or plated with nickel-silver, and do not give off significant amounts of lead” [2].

By the manufacturers apparently saying that the lead is “alloyed” with the brass (copper (Cu) + zinc (Zn)) of the keys implies that the lead is homogeneously distributed throughout the brass. An internet search has failed to uncover any information as to the nature of the lead association with the key brass. Why is this determination important? If the lead component of keys is heterogeneously distributed (i.e., there are areas on key surfaces that have concentrations of lead), normal key wear might expose high-percentage composition lead particles to the handler.

Not only may lead in keys expose the handler to this toxic metal, but also the locksmith/key makers are exposed. Indeed, key grinders may have a health risk many times that of the key user due to continuous lead exposure from the grinding of keys. Kondrashov et al. [3] tested six professional locksmiths and six control volunteers for bone and blood lead and concluded that “locksmiths are chronically exposed to lead.” Therefore lead, either homogeneously alloyed with brass or as concentrated particles (heterogeneously distributed) are being respired and likely imbibed by locksmiths.

Another issue perhaps even more serious is the propensity of parents to give babies and toddlers rings of keys as toys. Some children become so enamored with keys that parents request used keys from lock and key stores [4].

Methods

Instrumentation. The samples were examined by an ETEC scanning electron microscope (SEM) equipped with an IXRF Systems imaging and X-ray analysis system. The X-ray analysis system (energy dispersive X-ray analysis, EDS) was used to identify the elemental compositions of the material being examined. Backscatter electron imaging was used to identify lead concentrations (by object average atomic number or density) on the key brass fragments and dust surrounding key grinding machines.

The key grinding environment. Samples were taken of dust and metal debris around three key grinding machines with the standard adhesive samplers used for gunshot residue sampling..

Old house key. A house key, in continuous use for approximately 25 years, was examined in the SEM and lead deposits on the key were found by backscatter electron imaging and identified by EDS.

Results and Discussion

Key grinding environment. Concentrations of lead associated with keygrinding debris was easily found by backscatter electron imaging and identified as lead by EDS. The lead that is "alloyed" with key brass has a heterogeneous distribution. It is apparent that in many spots on a key surface, concentrations of lead are found (Fig. 1). The concentrations of lead with the brass can be quite high (Fig. 2 at spectrum location 2). A typical lead EDS spectrum from key lead is shown (Fig. 2, Spectrum 1).

Many of the brass key shavings from the key grinding machines have a "coating" of lead. This lead appeared to have been molten at the time of deposition (Fig. 3). The friction of the grinding wheel against the key brass generates enough heat on the brass to cause the key lead to become molten. A portion of this molten lead likely becomes an aerosol during grinding to be respired by the locksmith/key maker. The observation of previously molten lead on the key brass debris suggests this is likely a significant mode of contamination for the locksmith/ key maker. Another is imbibing lead via contaminated hands.

Free lead particles were noted in the dust associated with the key grinding machines (Fig. 2). Many of these were spherical (i.e., were likely created by heat). Thus, these particles were likely formed during the grinding process.

Remnants of lead on the keys after grinding likely remain on the key surfaces after delivery to the customer by the key grinder. Such lead debris exposes the handler to lead.

Old house key. The 25-year old house key showed deposits of lead throughout the brass surface (Fig. 4). Many of these lead deposits showed gaps around the embedded lead (Fig. 4). The appearance of these defects in the brass of the key suggest an erosion of either the lead or brass from the interface area. Free lead particles are likely formed in this manner. It appears that a tape lift sampling of keys for gunshot residue analysis would dislodge some of these embedded lead particles from the small pits on the key surface. This observation suggests that old brass keys are a continuous sources of lead particles on the user.

Chlorine is sometimes observed with lead on the grinder shavings (Fig. 3, spectrum 1) and on the old key (Fig. 4, spectrum). For the latter, all of the spectra with prominent lead peaks showed associated chlorine.

Conclusion.

A health risk exists for the entire population, not only for locksmiths/key makers. Small children who are allowed by their parents to play with keys may have significant lead exposure, especially for those children that put keys in their mouths. Long term sucking on keys may be a source of lead that health officials have failed to consider with children who have been found to have elevated blood lead. The consequence of lead in small children is well known – brain growth retardation and other health issues.

Gunshot residue samplers from suspects in shooting cases should not be reported as having particles "consistent" with gunshot residue when the only particles found are lead. It is likely that lead particles from keys are ubiquitous in our environment, especially on hands.

In 2001, the California State Attorney General came to a settlement with the manufacturers regarding key lead. The key manufacturers "…will pay $30,000 to the Public Health Institute to advise pediatricians, child care providers and others about the importance of not letting children play with keys, because of the lead hazard they pose" [2]. This either did not happen, or the $30,000 was woefully inadequate to counter this problem. I have observed small children playing with keys. Parents of these children are usually shocked when informed of the lead hazard associated with keys.

References

1. Anonymous. 1999. Attorney General Lockyer sues key manufacturers over failure to warn consumers about exposure to lead from keys in violation of Proposition 65. Cautions against using keys as toys with small children. News Release, Office of the Attorney General, State of California, Department of Justice. October 12, 1999.

2. Anonymous. 2001. Major manufacturers agree to reduce amount of lead in door keys under settlement of Proposition 65 lawsuit. News release, Office of the Attorney General, State of California, Derpartment of Justice. April 27, 2001.

3. Kondrashov, V.S., S.J. Rothenberg, J.S.Jahr, J.L.McQuirter and S.N.Steen. 2004. Are locksmiths at risk from anesthesia? An assessment of lead exposure. Anesthesiology 2004; 101:A1396

4. Personal communication, proprietor of local key shop in Encinitas, California, November 22, 2005

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COMMENTS APPRECIATED!

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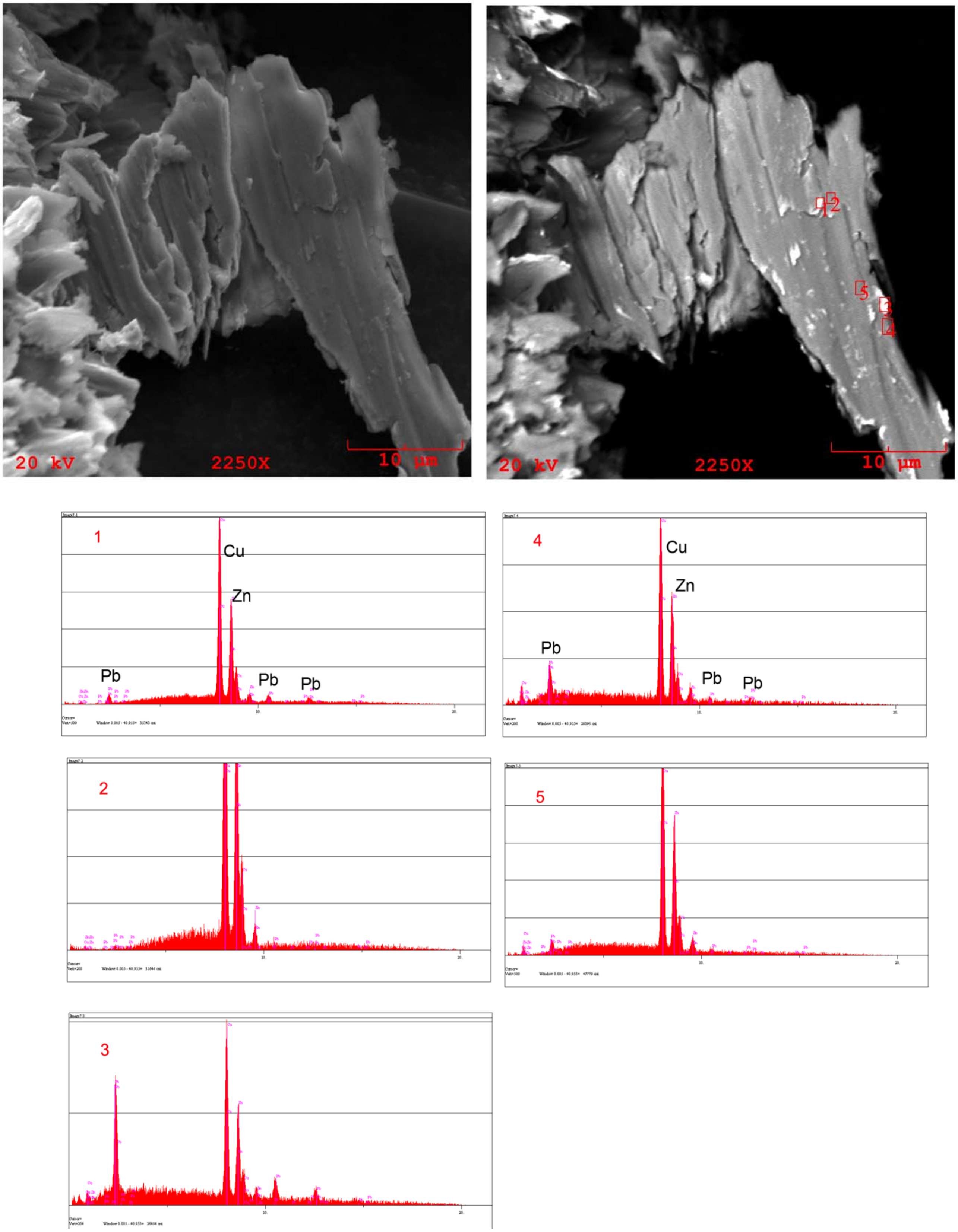

Figure 1. *Brass shavings from a key grinding machine. Top left: Secondary electron image. Top right: Backscatter image. White areas are lead-containing concentrations. The red-border boxes are analysis areas with analysis numbers. The spectra 1 through 5 correspond to the areas outlined in the backscatter image. Pb = lead, Cu = copper, Zn = zinc.*

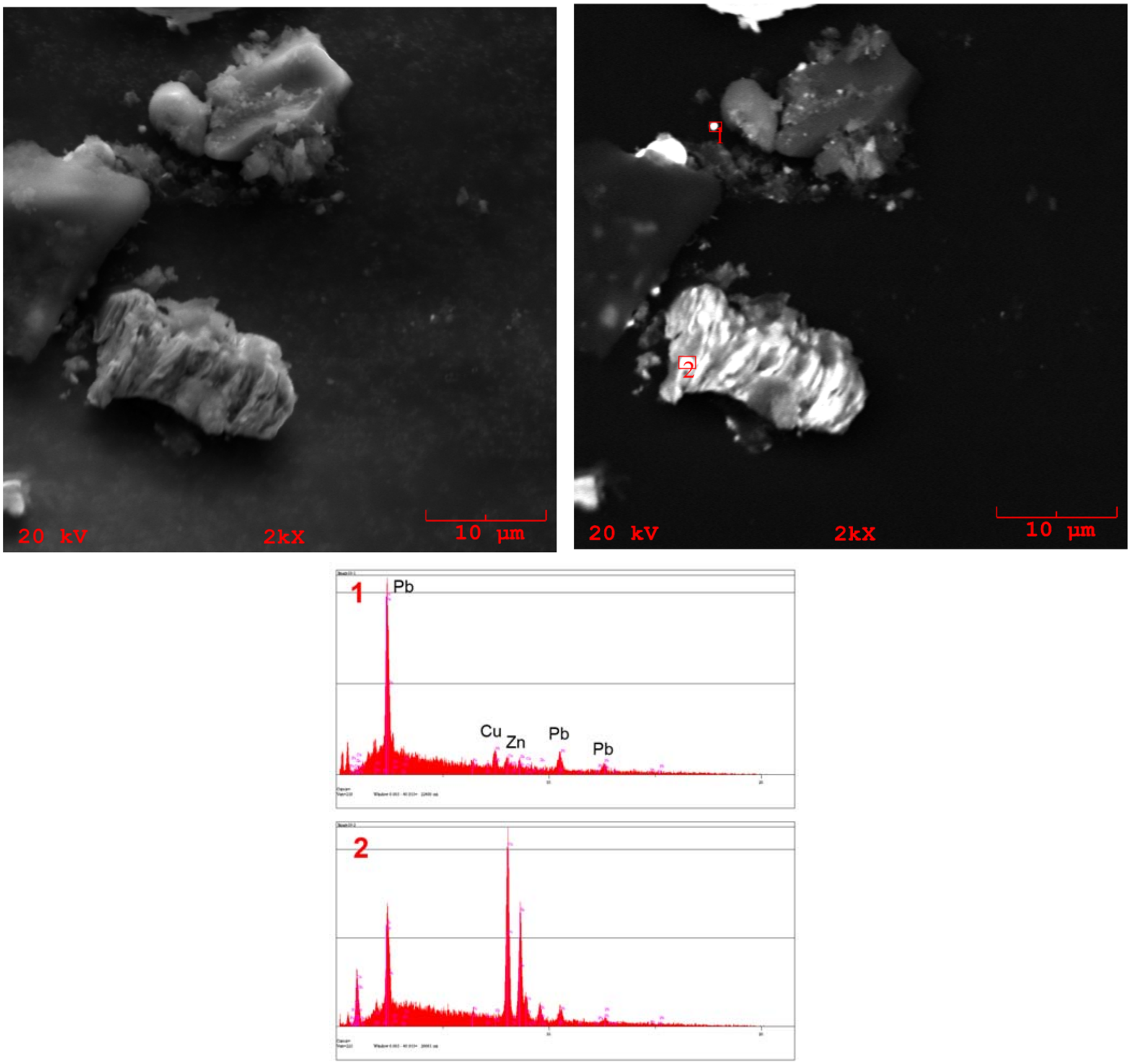

Figure 2. *Smaller debris from a key grinding machine. Top left: Secondary electron image of key grinding debris. Top right: Backscatter image of same area. White objects and parts of shavings are lead. Spectra are from within the red-border areas in the backscatter image.*

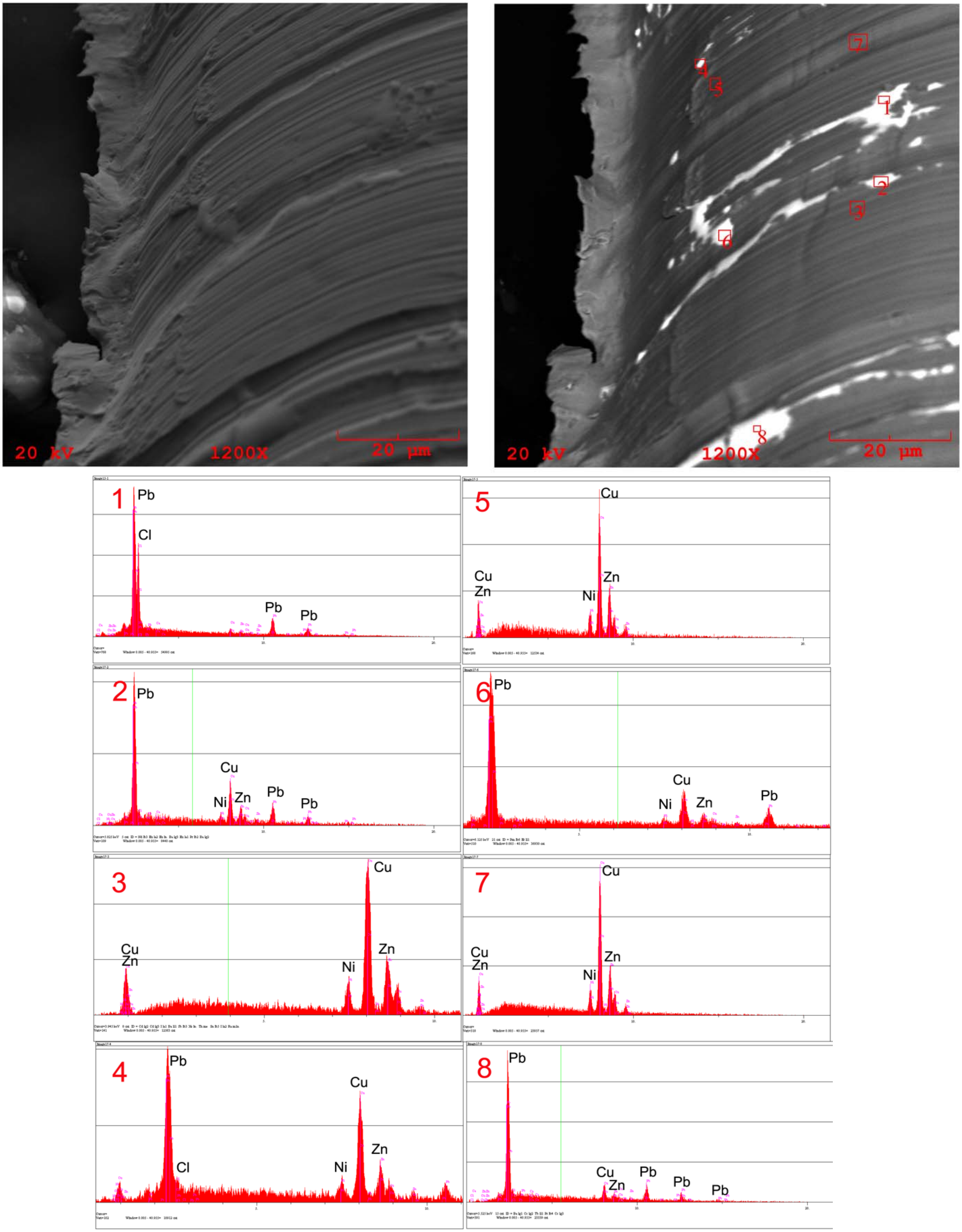

Figure 3. *Shaving from a key grinding machine. Top left: Secondary image. Top right: Backscatter image showing concentrations of lead (white) over the surface of the shaving. Spectra are from the areas indicated by number on the backscatter image (top right). The form of these lead aggregations indicate that the lead was molten when deposited.*

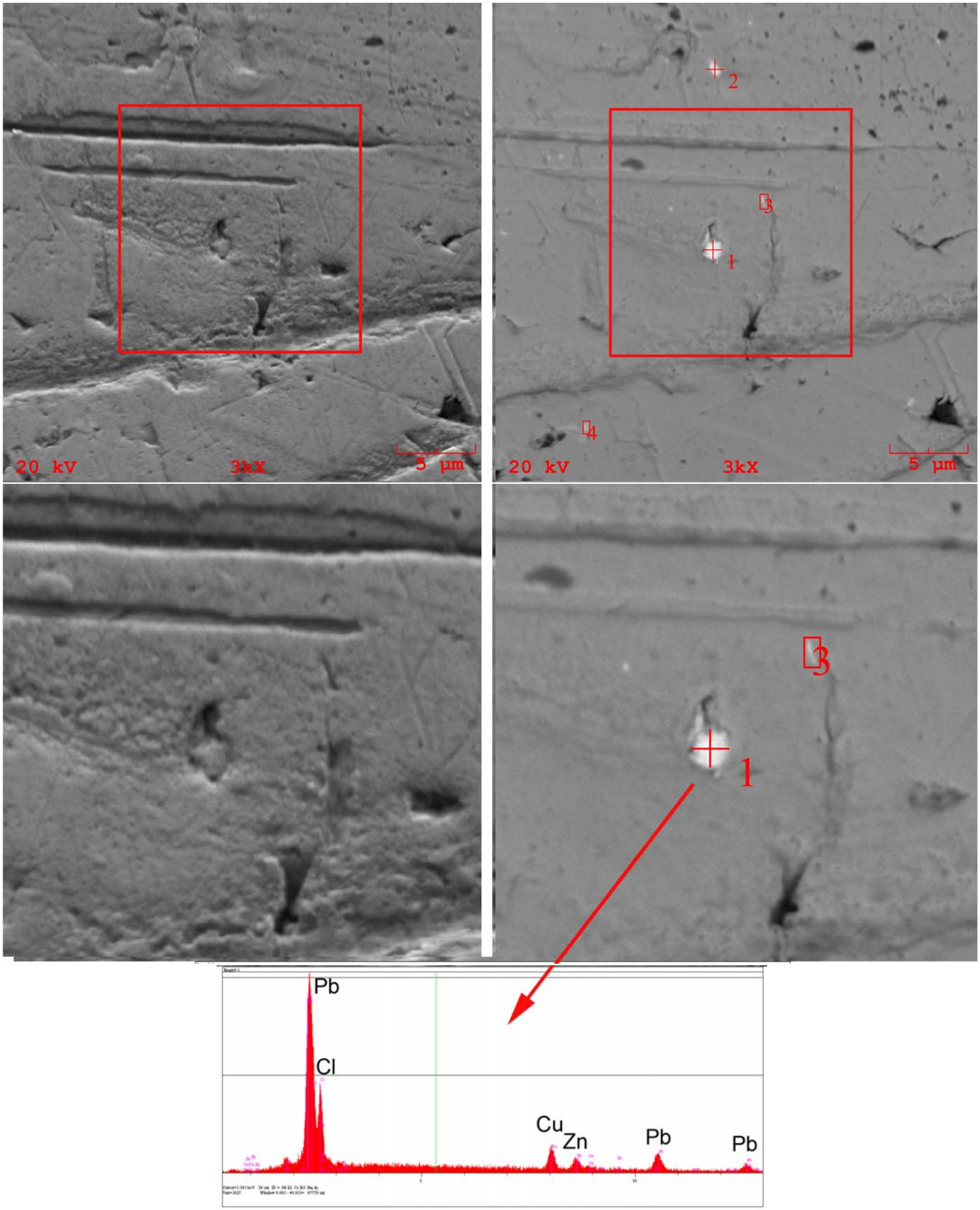

Figure 4. *The surface of a well-used 25 year old key. Left images: Secondary electron images. Right images: Backscatter electron images. The middle images are enlargements of the top images. The middle images show a lead particle in a pocket in the brass of the key.*