IDENTIFYING SOURCE OF LEAD PARTICLES IN FLOOR DUST USING COMPUTER CONTROLLED SCANNING ELECTRON MICROSCOPE (CCSEM)

by

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Abstract

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Identifying the sources of lead (Pb) in indoor dust by analysis of the contents of the dust provides an opportunity to mitigate the source of contamination. In this study, it is hypothesized that in residential properties where there exist the potential for friction surfaces to contribute old lead-based paint to the dust such material can be identified by microscopic examination of the dust. Although old lead-based paint in such circumstances can be implicated, without studying the dust it is impossible to know whether some other contributing source may be important. Exterior soil and dust that potentially can enter the home may be the source(s) rather than the obvious friction surfaces. Here an electron microscopy based method of dust analysis is used to apportion the sources of the lead in dust. A total of over 10 older homes were selected from urban Syracuse, New York, and the samples collected from those houses were analyzed using

computer controlled scanning electron microscope (CCSEM). Furthermore, to evaluate the reasonableness of this method two other measurement techniques: (i) lead isotope composition (PbIC) determination and (ii) bulk sample element concentration measurements (by X-ray Fluorescence analysis (XRF)) were used to provide comparable source attribution results but by alternative means. A source un-mixing model was used to resolve the PbIC data, while a chemical mass balance model (CMB) was used to apportion the receptor site lead to the potential contributing sources.

A descriptive apportionment was used to assign dust lead particles to possible sources in the CCSEM approach. It was felt that this method provided the best source resolution. Under the best conditions we calculated that ≥ 70% of the lead particles in a dust could be attributed to (what we considered) the actual contributing source. It was also concluded that if one added these unattributed lead particles to the paint source particles, then the accuracy of the descriptive apportionment would be high in most situations like those investigated here.

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Introduction

1.1 Childhood Pb Exposure/Pb Poisoning

Lead poisoning has been recognized as one of this country's most important environmental health problems. After the phase-out of lead in gasoline, old lead-based paint became the primary source of lead exposure, particularly for young children. Lead (Pb) contamination is an increasingly important international public health issue. Childhood (Pb) exposure can cause various adverse health effects at relatively low levels of exposure. Extensive studies have been done on Pb exposure, pathways, adverse health effects typically defined by elevated blood lead levels Blood Pb is routinely measured in children because they are more vulnerable to Pb exposure than adults due to their activity behavior and the greater rates of incidental ingestion (direct contact) of soil or re-suspension of Pb dust (inhalation), and because they are still developing (Abdel *et al.* 2010; Belluck *et al.* 2003, Laidlaw *et al.*, 2005, 2012; Mielke and Reagan, 1998; Mukerjee, 1998, Reagan and Silbergeld, 1990).

A large body of evidence shows that a common source of lead exposure for children today is lead-based paint hazards in older housing and the contaminated dust and soil it generates (Bornschein et al. 1987; Clark et al. 1991; Jacobs 1995; Lanphear et al. 1995, 1998; Lanphear and Roghmann 1997; McElvaine et al. 1992; Rabinowitz et al. 1985; Shannon and Graef 1992), although other sources can be significant. Poisoning from lead-based paint has affected millions of children since this problem was first recognized more than 100 years ago (Gibson 1904; Turner 1897). Interior lead-based paint has been identified as the most common source of childhood lead poisoning in the United States (Lanphear and Roghmann, 1997; Reece et al., 1972; Shannon and Graef, 1992). When such paint is peeling, cracking, or chipping, or when it is abraded to dust by wear or remodeling, it becomes hazardous to young children, who have frequent hand-to-mouth activity (Chisolm et al., 1985). The possible exposure of Pb from paint can cause adverse health effects to children either directly by eating paint chips (McElvaine et al. 1992) or indirectly by ingesting lead-paint contaminated house dust or soil through normal hand-to-mouth contact (Bornschein et al. 1987; Duggan and Inskip 1985; Lanphear and Roghmann 1997).

Based on children's cohort activities which suggest the prediction of children's Pb ingestion is more reasonable by determining the children's life style and activities in home, school, and park (Abel et al. 2012). The prediction of potential toxicity of Pb to children can be estimated by calculating the fraction of soil lead concentration (Schoof et al. 1995).

In the United States, Pb poisoning cases are not equally distributed (Gould 2009). The National Health and Nutrition Examination Surveys (NHANES) published data showed the reduction of 84 % overall prevalence of blood lead levels ≥ 10 µg/dL in U.S. children from 8.6 % in 1988-1991 to 1.4 % in 1999-2004 (Jones *et al.* 2009). This prevalence is much less than previously reported (CDC, 2005); however the prediction of which children are susceptible to Pb exposure between ages 1 to 4 years is challenging due to lack of data (Abdel *et al.* 2010), and disparities still exist. Furthermore, the recent change in CDC's (the Centers for Disease Control) level of concern for pediatric blood Pb has meant that many more children are recognized as having elevated blood Pb levels. Previously, the CDC regarded blood Pb levels tests above 10 µg/dL are requiring intervention. Now, CDC uses a reference level of 5 µg/dL. This level "… is based on the U.S. population of children ages 1-5 years who are in the highest 2.5% of children when tested for lead in their blood. This reference value is based on the 97.5th percentile of the National Health and Nutrition Examination Survey (NHANES)'s blood lead distribution in children …" (CDC, 2016). Because of this regulatory change, the CDC estimates "… there are approximately half a million U.S. children ages 1-5 with blood lead levels above 5 µg/dL, the reference level at which CDC recommends public health actions be initiated …" (CDC, 2016).

1.1.1 Exposure/Health Problems

Lead is an environmental toxicant that has deleterious effects on the nervous, hematopoietic, endocrine, renal and reproductive systems (ATSDR, 1993). Much recent progress has been made on recognizing the adverse health effects of low level Pb exposure on various organ systems in both children and adults. Two important reports have systematically evaluated adverse health points associated with low level Pb exposure. These are: The Integrated Science Assessment (ISA) for Lead (US EPA 2013) and the National Toxicology Program (NTP) Monograph on Health Effects of Low-Level Lead (NTP 2012). The ISA reported on systemic effects where the outcome was deemed to be either “causal,” “suggestive,” or “likely causal” in relation to Pb exposure. The NTP reported similarly on “sufficient evidence of an association” for adverse health outcomes and Pb exposure. While most interest has historically focused on cognitive deficits in pediatric populations resulting from low level Pb exposure, there are demonstrated renal, reproductive and developmental, cardiovascular, immune, and hematologic effects also associated with low-level Pb exposure. These deficits are mostly found in adult populations.

A specific metric for chronic kidney disease is glomerular filtration rate (GFR). GFR estimates how much blood passes through the glomeruli in the kidneys each minute. GFR < 60 mL/min/1.73 m^2 is a sign of chronic kidney disease, while a GFR < 15 mL/min/1.73 m^2 is a sign of renal failure. Studies have found that reduced renal function is associated with blood Pb levels <10 µg/dL (Muntner et al., 2003; Goswami et al., 2005; Hernandez-Serrato et al., 2006; Lai et al., 2008; Navas-Acien et al., 2009). The relationship between blood Pb levels and reduced GFR in the Muntner et al. (2003) and the Navas-Acien et al. (2009)

studies was such that a “suggestive of a causal” relationship was indicated. The Navas-Acien et al. (2009) study with blood Pb and estimated GFR (eGFR) data for 14,778 participants 20 years and older split blood Pb data into quartiles. The fourth quartile blood Pb >2.4 (median: 3.2) µg/dL reported an odds ratio for reduced GFR that was significantly elevated.

In terms of developmental defects, a number of studies have found an association between maternal blood Pb and birth weight (a birth defect). While this relationship is not consistent in the published literature, there is compelling evidence for the relationship in a large retrospective study (Zhu et al., 2010). In this study, data collected between 2003-2005 on 43,288 participants in New York state showed that as maternal blood lead increases infant birth weight decreases. The strengths of this study were that many confounding factors were accounted for, and low blood lead levels (< 10 µg/dL) were used.

The positive relationship between cardiovascular disease mortality (CVDM) and elevated blood Pb levels has been found in a number of studies (Lustberg and Silbergeld, 2002; Schober et al., 2006; Menke et al., 2006; Cocco et al., 2007; Neuberger et al., 2009; Khalil et al., 2009; Lin et al., 2011). The Menke et al. (2006) study is particularly strong because the sample size allowed for a various confounding factors to be controlled for, and examined interaction terms with specific covariates and Pb. The study used blood Pb data from individuals at least 18 years old and a 12 year follow up period was used at which point 1,661 deaths were identified from the National Death Index for the study group. At the commencement of the study, the mean blood Pb was 2.58 μg/dL (80th percentile: 4.9 μg/dL). Participants were categorized into blood lead tertiles ranges for the tertiles: <1.93 μg/dL, 1.94–3.62 μg/dL, and ≥3.63 μg/dL. Hazard ratios (HRs) were calculated by multivariable Cox regression models for all-cause cardiovascular, and myocardial infarction, and stroke, by comparing each tertile with the first (low-lead) tertile (a HR is like an odds ratio as both report on the relative change in the risk of an event and both control for other covariates). In order to account for possible confounders, three separate analyses were undertaken in the study, and in each model blood Pb levels were significantly associated with CVDM.

Lead exposure in young children is a particular hazard because children absorb lead more readily than do adults and because the developing nervous systems of children are more susceptible to the effects of lead (CDC, 1991). The adverse health effects of the pediatric population resulting from lead exposure are substantial and the weakness of neurological development considered to be important (USEPA 2006, CDC 2009, Bellinger 2008, Lanphear *et al.* 2005). Blood lead levels (BLLS) at least as low as 10 μg/dL can adversely affect the behavior and development of children. Several recent studies have documented adverse effects and childhood decrements in Intelligence Quotient (IQ) at blood lead concentrations less than 10 μg/dL (Canfield *et al.*, 2003, Chiodo *et al.*, 2004, Jusko *et al.*, 2008, Lanphear *et al.*, 2005, Miranda *et al.*, 2007, Surkan *et al.*, 2007, Téllez-Rojo *et al.*, 2006). So, there is overwhelming epidemiologic evidence that blood Pb levels measured during various life stages, and as well as averaged over many childhood years are associated with cognitive function deficits (US EPA 2013). A well investigated pooled analysis (of seven international prospective studies) utilized data from 1,333 children aged 4.8–10 years (median blood Pb level: 9.7 μg/dL) and concluded that incremental increases in blood Pb levels (peak and concurrent) were related to a decrease in full-scale intelligence quotient (IQ) (Lanphear et al., 2005). Lanphear et al. (2005) fitted various models to the pooled data, and found that the shape of the concentration-response curve (not dose-response) was best approximated by a log-linear fit. Using the log-linear model, it was estimated that a deficit of 1.9 IQ points accrued with a doubling of concurrent blood Pb levels. In terms of blood Pb ranges, an increase in blood Pb from less than 1 to 10 μg/dL resulted in a 6.2 point IQ decrement while an increase in blood Pb from 10 to 20 μg/dL was associated with a 1.9 point IQ deficit. Budtz-Jørgensen et al. (2013) and Crump et al. (2013) reanalyzed the pooled data of Lanphear et al. (2005), however these reanalysis do not negate the validity of the Lanphear et al. analysis. The data clearly indicates at lower blood Pb levels (and hence exposures), the slope of IQ decrements is steeper at low blood Pb levels than at higher blood Pb levels. This is counterintuitive, as typically in dose-response (concentration-response here) relationships, small increases in dose result in small increases in response. The corollary to this is that no blood Pb level is likely to be safe, and so no exposure to Pb should be tolerated.

1.1.2 Demographic Distribution of Elevated Blood Pb Levels

A study by NHANES data showed there is a relationship between the lead-based paint and elevated blood lead levels in children in U.S. (NHANES, 1991-1994). According to NHANES, a higher blood lead levels were recorded in children aged 1-5 years among those who were non-Hispanic blacks or Mexican Americans, from lower-income families, living in metropolitan areas with a population ≥ 1 million, or living in older housing. The differences in risk for an elevated BLL by race/ethnicity, income, and urban status generally persisted across age of housing categories. Similarly, the higher risk for an elevated BLL associated with older age of housing generally persisted across race/ethnicity, income and urban status categories. Therefore, the risk for an elevated BLL was higher among non-Hispanic black children living in housing built before 1946 (21.9%) or built during 1946-1973 (13.7%), among children in low-income households who lived in housing built before 1946 (16.4%), and among children in areas with populations ≥ 1 million who live in housing built before 1946 (11.5%) when compared with children in other categories.

1.2 Nature of Lead (Pb) Contamination in the Urban Environment

1.2.1 Occurrence

Older urban environments with a long history of residential occupancy and industrial activity are widely contaminated by Pb. Numerous studies have implicated auto exhaust fumes, Pb-containing paint, industrial emissions and fossil fuel burning as the major culprits. Contamination may also arise from tire wear, plastic waste, insecticides, old car batteries (Fleming and Parle, 1977) and from the past use of urban sites for metal works, railways, and salvage yards (Thornton et al., 1985). In the exposure topology (Sexton et al., 1992) for Pb, exposure is controlled by route of intake (ingestion, inhalation, percutaneous transfer), and by exposure medium (air, water, soil, food, paint, indoor dust). Due to the variety of routes of exposure, the Pb exposure topology for children can be extremely complex. Lead in paint, dust and soil can all contribute to the exposure in different ways. There also exist uncertainties relating to the nature of exposure. These include (i) the flux of particulate Pb into the indoor system, (ii) the residence time of such material, (iii) the fate of the particulate Pb (i.e., its removal), and (iv) the transport pattern of particulate matter through the system. Structural equation modeling suggested the pathway **soil Pb →window sill dust Pb →floor dust Pb →blood Pb** can be important. But, surfaces in the home where Pb-containing paint is present constitute a direct exposure threat for the young child. This has been known since at least the mid 1920's. However, it is thought that the threat posed by Pb containing paint for the general pediatric population is through its role as a contaminant of dust. Although, the direct exposure pathways for Pb-containing paint are clearly (i) **Pb paint hazard →blood Pb**, and (ii) **Pb paint hazard - hand Pb →blood Pb**. Over 50 years ago it became apparent that widespread elevated blood Pb levels could not be exclusively the result of paint chip ingestion. The **hand-to-mouth** route of dust Pb ingestion for young children, whereby dust adhering to the hand is ingested after mouthing, is now well described. Dust Pb has been shown to be a contributor to blood Pb from studies which have used dust control measures toreduce high pediatric blood Pb levels. The importance of the pathway: dust Pb (hand Pb) →blood Pb has been demonstrated by investigations which have taken a descriptive cross-sectional model approach to assess the relationship.

1.2.2 Contamination of Dust

The Pb in indoor dust is derived from both external and internal sources (Butte and Heinzow 2002). The quantity of Pb derived from either depends upon the location, age, and condition of the property. Exterior particulate material enters the interior by tracking, or by atmospheric transport. The particulate material in the indoor dust pool will depend not only on inputs from the contributing sources, but also on the dust residence time in the home. The dust residence time in the home is controlled by the frequency of surface cleaning. A period of dust accumulation will exist between cleaning episodes during which the dust pool serves as an exposure source for any contaminants such a Pb in the dust. A growing reservoir of Pb in dust in the home that might not be completely removed by cleansing events, is an ongoing hazard for infants and toddlers whose exploratory mouthing behavior results in inadvertent ingestion of Pb contaminated dust they encounter. Children at an early age mouth their hands and objects in their reach by habit and by sucking reflex (Groot et al. 1998). Lead ingestion can be by (i) mouthing of objects, (ii) unintended transfer through hand-to-mouth activity, or (iii) the intake of food contaminated by hands (Stanek et al. 1998).

1.2.3 Contamination of Soil

The major outdoor source of indoor dust is outdoor soil (Rasmussen et al. 2001). The amount of outdoor soil present in indoor dust is potentially highly variable. Estimates range from, at the high-end, 80–85% (Hawley 1985; Roberts et al. 1991), to 30–45% in the mid-range (Fergusson and Kim 1991; Trowbridge and Burmaster 1997), and low-end estimates in the range 20–30% (Davies et al. 1985; Culbard et al. 1988;Rutz et al. 1997). It has been estimated that the contribution from soil and street dust is in the range 45-50% (Lanphear et al., 1996), but it is likely that large fraction of road dust can be from soil estimates of between 57-90% have been suggested (Farfel and Chisholm, 1990; CDC, 1991; Menton et al., 1995). The soil contribution to dust is important because soil and dust ingestion is common among young children. An intake of 100 mg is likely to be the best estimate of the daily mean soil ingestion for young children; the recommended 95th percentile soil ingestion rate for a child is 400 mg/kg/day (EPA 2006). The demonstration how this ingestion results in increased physiological levels has been shown for many contaminants. An individual's exposure to Pb as a result of the soil-to-indoor dust transport pathway is well known (see Clark et al. 2004). Specifically, the interruption of mass flow along this pathway can lead to lower amounts of floor dust Pb, and subsequently lower children's blood Pb (e.g., Rhoads et al. 1999; Lanphear et al. 2003; von Lindern et al. 2003; Lorenzana et al. 2003).

Undoubtedly, some fraction of lead in soil comes from historic gasoline emissions and a major source of lead in soil is also old lead-based paint once applied to the exterior of houses. Different studies have determined that indoor dust is one of the major exposure sources of lead for infants (Hunt *et al.* 1993; Simon *et al.* 2007) and exposure can be considerable if particle fraction is less than 250 µm that adhere to children's hands (Juhasz *et al.* 2011). Since lead does not dissipate, biodegrade, or decay to any significant degree in the environment, the lead deposited into dust and soil becomes a long-term source of lead exposure for children. For example, although lead emissions from gasoline have largely been eliminated, an estimated 4-5 million metric tons of lead used in gasoline remain in dust and soil, and children continue to be exposed to it (ATSDR, 1988). Lead deposited from the air is generally retained in the upper 2-5 centimeters of undisturbed soil, because lead is immobilized by the organic component of soil (EPA, 1986). As part of normal play and hand-to-mouth exploratory activities, young children may inhale or ingest lead from soil or dust. According to the U.S. Environmental Protection Agency (EPA), ingestion of dust and soil during meals and playtime activity appears to be a more significant pathway than inhalation for young children.

In recent years, many studies have been conducted to assess the distribution of surface soil Pb in New Orleans, LA due to hurricanes Katrina and Rita (Abel *et al.* 2012). Some areas in New Orleans have alarming soil Pb content. The standard for Pb soil content in the yards has been set at 1,200 mg/kg by the Environmental Protection Agency (EPA) and 400 mg/kg for lead in soil in play areas. This level has been determined based on a blood lead level of concern (from Centers for Disease Control and Prevention (CDC)) of 5 µg/dL blood lead.

Significantly, the California Office of Environmental Health Hazard Assessment (OEHHA) has recently developed a 1 µg/dL benchmark for source-specific incremental change in blood lead levels for protection of school children and fetuses (OEHHA, 2007). The resultant revised California human health screening level for lead in soil that has been proposed (OEHHA, 2009), would be 80 mg/kg. In the wake of the California EPA's proposed revision, it has been suggested that the USEPA might revise its hazard standard down to 80 mg/kg also. A revised USEPA hazard standard of 80 mg/kg or even 150 mg/kg would greatly increase the urban land area with soil considered as hazardous in terms of its lead content.

Children can also be exposed to lead in bare soil. Pb contaminated soil poses a hazard to children who play in it. Interior levels of dust lead may increase due to lead in soil that enters into home. According to the U.S. Department of Housing and Urban Development (HUD), almost 5 million housing units have levels of lead in soil that exceed EPA standards (Jacobs, 2002). Typically, the high levels of lead in soil result from deteriorating exterior lead-based paint around the foundation of a house (Ter Harr, 1974; Linton, 1980). Furthermore, Pb from automobile gasoline, lead-based paint and industrial sources also contribute to lead levels in soil (ATSDR, 1988).

1.2.4 Pb in Ambient Air

Early studies of ambient air lead concentrations showed a significant correlation between the combustion of leaded gasoline and soil lead concentrations. The EPA has noted previously that air lead concentration decreases as you travel from the center of a city (when lead was present in gasoline) and that soil lead levels are a direct function of the deposition of ambient air lead (EPA 1986). The contribution of leaded gasoline emissions and soil lead levels to interior house dust is evident in studies showing that lead in house dust is related to exterior lead levels (Chaney, 1989). Following the elimination of lead as an additive to gasoline, the threat of airborne lead for the general population has been drastically reduced. This has been one of the great public health triumphs in the US.

1.2.5 Contamination by Paint

In terms of internal sources, deterioration of interior Pb-based paint can contribute significantly to indoor dust Pb levels. Evidence from the National Survey of Lead-Based Paint in Housing indicates that when there is Pb-based paint on a property it is four (4) times more likely to have dust Pb levels that exceed guideline values than if Pb-based paint were not present (EPA, 1995). Non-intact Pb paint covered surfaces around the home pose a health threat to the young child either as direct exposure sources, or as sources of dust and soil Pb contamination. The presence of Pb-containing paint on window components is thought to be of special concern because repeated opening and closing of the window reduces the paint to fine particles. The Lead-Based Paint Hazard Reduction and Financing Task Force, as part of its recommendations concerning research initiatives, has highlighted the need for more information relating to the contributions of dust from friction and impact surfaces to childhood Pb exposure (HUD, 1995). The Task Force noted "Friction and impact surfaces, particularly windows and doors, are included in Title X's definition of lead-based paint hazards. However, little is known about the amount of dust generated by such surfaces." In the Baltimore Repair and Maintenance Study (Lim, 1997), it was found that substantial reductions in dust Pb loadings could be achieved if hazard control interventions included treatment of friction points. But, unsupervised removal of such interior Pb paint can result in dangerous levels of indoor dust Pb contamination when remodeling activities involve such practices as paint sanding. Spatial variations in dust Pb levels often exist within the home. Generally, the quantity of Pb in dust decreases in the locational order **window wells > window sills > floor dust**. The initial guidelines (for clearance, not exposure purposes) for Pb levels on interior surfaces set by HUD were 200 $\mu g/ft^2$ for floors (now 100 $\mu g/ft^2$), 500 ppm for window sills, and 800 $\mu g/ft^2$ for window wells. Around 17%, or 13 million, private homes have interior dust Pb levels which likely exceed these guidelines.

1.2.5.1 Paint Used in US Housing Stock

Pb-based paint has been used in paint principally as a pigment since ancient times. As a pigment, lead carbonate (white lead) is the most common form although there are others (e.g., lead sulfate, lead chromate). Historically lead was present in paint primarily because of its hiding power and was also used to speed up drying, increase durability, maintain a fresh appearance and resist moisture that causes corrosion. Lead- based paint can be found in buildings, in the city, country, apartments or single family homes and inside or outside of homes. Approximately three-quarters of the homes built before 1978 contain some lead-based paint. It may be found on any surface but is most commonly found on exterior painted surfaces, interior woodwork, doors and windows. Heavily-leaded paint was used in most homes built before the 1950s, with lower levels of lead used until 1977 (Tremblay Jr. 2012). Lead paint is still present in millions of homes, sometimes under layers of newer paint. If the paint is in good shape, the lead paint is usually not a problem. Deteriorating lead-based paint (peeling, chipping, chalking, cracking, damaged or dump) is a hazard and needs attention. It may also be a hazard when found on surfaces that children can chew or that get a lot of wear, such as: 1) Windows and window sills, 2) Doors and door frames, 3) Floors, stairs, railings, banisters and porches.

Lead pigment used in paint was first manufactured in the US at the beginning of the nineteenth century. By the start of the twentieth century Pb paint was widely promoted as an exterior and interior house paint (Gooch, J.W. 1993). Despite claims of discontinued use after 1940, Pb-based paint for interior use continued to be sold in significant quantities until as late as 1971 (Rabin, R. 1989). In all, some 7 million tons of white Pb have been used in paint production (U.S. Bureau of Mines 1989). As a consequence, the National Survey of Lead-Based Paint in Housing estimates that 83%, or 64 million, of the private homes in the US built prior to 1980 have Pb-containing paint is not equal across the housing stock (Figure 2-1). For example, housing units built before 1940 have, roughly, three times as much Pb-based paint on the property as units built from 1960 to 1979 (EPA 1995). The National Survey also found that the federal standard of 1.0 mg cm^{-2}, which defines the presence of Pb in paint, is exceeded in

12 million homes occupied by families with children under 7 years. Furthermore, in the pre-1980 housing stock, there are 14 million homes that have non-intact Pb-based paint that covers an area in excess of 5 square feet.

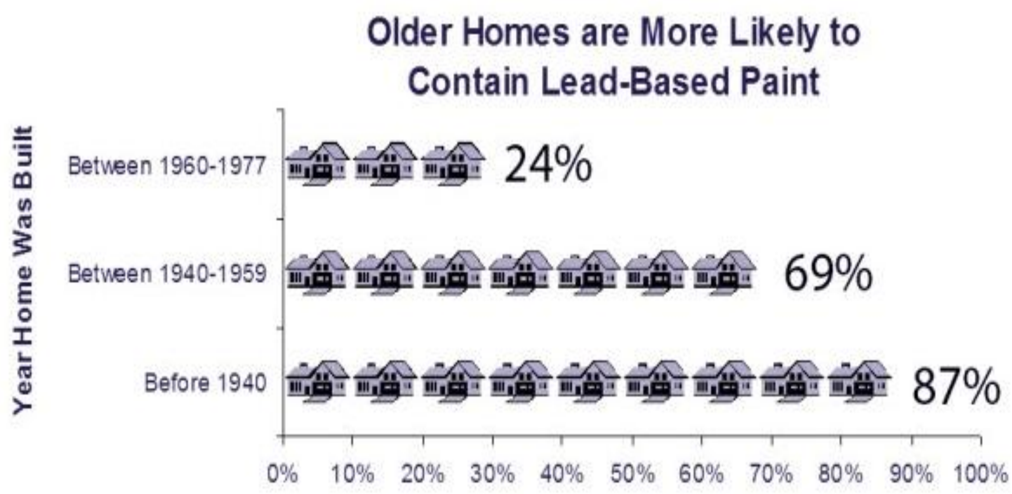


Figure 1-1 Older Homes are More Likely to Contain Pb-Based Paint

In the United States, the main cause of childhood lead poisoning is lead-based paint and the accompanying contaminated soil as well as dust found in older houses (CDC, 991b; Rabinowitz, 1985b; Jacobs, 1994). Lead-based paint was identified as a cause of childhood lead poisoning in as early as 1897 (Turner, 1897; Reich, 1992; Markowitz, 2000; Warren, 2002; Bellinger, 2006). Furthermore, many countries prohibited the use of lead in residential paints as far back as 1922 (Rabin, 1989). By the early 1950s, while other ingredients became more popular, some lead pigments, drying agents, corrosion inhibitors were still in use. It was, in fact, in 1972 when lead was first regulated in residential paint at 0.5 percent. It was “banned” in 1978, meaning that paint could contain no more than 0.06 percent (600 parts per million) lead by dry weight (Rabin, 1989; Reich, 1992). The Consumer Product Safety Improvement Act of 2008 (Public Law 110-314) reduced the threshold further to 0.009 percent (90 parts per million) lead by dry weight (CPSC, 2008). According to HUD, 38 million housing units have lead-based paint (Jacobs, 2002). The extent, likelihood and concentration of lead-based paint increase with the age of the building. It is noted that houses built before 1950 pose the greatest risk of paint deterioration and, therefore, older housing generally commands a higher priority for lead hazard controls (Table 1-1 and Table 1-2).

Table 1-1 Percentage of Housing units with Significant Pb-Based Paint Hazards and Percentage with Bare Soil Lead Levels in Yard ≥ 1200 ppm, United States 2005-2006*

Hazard	**Year of Construction**			
	1978-2005	**1960-1977**	**1940-1959**	**Before 1940**
Significant Pb-Based Paint Hazards**	3%	11%	39%	67%
Bare Soil in Yard Equal to or Exceeding 1,200 PPM***	0.3%	0.3%	4%	14%

*after HUD, 2011

**A "significant" lead-based paint hazard is any paint-lead, dust-lead or soil-lead hazard above de minimis levels in HUD's Lead Safe Housing Rule (24 CFR 35.1320(b)(2)(ii)(B) or 35.1350(d), as applicable).

*** Measured when total amount of bare soil in yard exceeded 9 square feet.

Table 1-2 Percentage of Component Types Coated with Lead-Based Paint, by Year of Construction and by Interior or Exterior Location, United States, 2000*

Component Type	Year of Construction			
	1978-1998	1960-1977	1940-1959	Before 1940
Interior	(%)	(%)	(%)	(%)
Walls, Floors, Ceilings	0	1	2	7
Windows	1	2	6	21
Doors	0	1	7	22
Trim	0	2	4	15
Other	0	1	2	12
Exterior				
Walls	0	9	18	34
Windows	0	12	30	41
Doors	2	5	29	33
Trim	3	8	16	24
Porch	1	7	25	28
Other	0	8	37	37

*Source: Jacobs, 2002. (Lead-based paint is defined as 1.0 mg/cm^2 or 5,000 ppm lead, in accordance with the Federal standard).

1.2.5.2 Pb Paint Composition

At different times of production, lead-bearing paint was composed of Pb in different forms mixed to varying degrees with other inorganic components. Lead, when used in paint, functioned primarily as a hiding pigment. At a fundamental level, paint is a mix of pigment and vehicle. Vehicle consists of binder and thinner, the function of binder is to adhere the pigment to the painted surface, and following paint application the thinner will evaporate to leave the paint film (driers may also be present). In general, paint durability is determined by the resistance of the binder to the exposure conditions. A typical vehicle in Pb-containing paint would be linseed oil (Tome, 1968; Schurr, 1975).

Hiding power of paint is controlled by the pigment content (pigment composition(s), and particle size determining its refractive index) and pigments with a higher refractive index will have a greater hiding power (Radcliffe, 1968). The supplemental pigments have low refractive index and have been used to give the paint other specific properties. Lead and zinc compounds are the oldest of the white pigments, and dominated before the 1920s (Stieg, 1968). At that time, supplemental pigments were considered adulterants and frowned on for use in quality paints (Radcliffe 1968).

White-Pb (lead carbonate) and linseed oil combined as a paint had good hiding power, was easily applied, did not readily crack as a painted surface, and also chalked. Chalking is the breakdown of the binder causing the surface paint to “chalk” off. Not always seen as a desirable property of the paint if excessive (Holley, 1909), a degree of chalking of Pb-paint covered exterior surfaces was considered a useful property. Chalking is the formation of a fine white powder on the paint surface as it ages/weathers. Chalking can aid subsequent repainting, and it can expose cleaner paint underneath as the chalk is removed. Exterior surface chalking will inevitably lead to the deposition of the chalking paint on to the ground outdoors, although the significance of chalking has been down-played in some quarters (Weaver, 1989).

Early white Pb pigments were composed of Pb-carbonate either as normal Pb-carbonate ($PbCO_3$), or as basic Pb-carbonate ($2PbCO_3 \bullet Pb(OH)_2$ and $4PbCO_3 \bullet 2Pb(OH)_2 \bullet PbO$). Normal Pb-carbonate pigment was produced in the form of large prismatic (chunky) particles and as such it was not a useful pigment and was only produced in the early part of the twentieth century (Dunn, 1975). The basic Pb-carbonates were marketed in different grades resulting from the mode of production.

1.2.5.3 Timeline of Pb Paint

1887 – US medical authorities diagnose childhood lead poisoning

1904 – Child lead poisoning linked to lead-based paints

1909 – France, Belgium and Austria ban white-lead interior paint

1914 – Pediatric lead-paint poisoning death from eating crib paint is described

1921 – National Lead Company admits lead is a poison

1922 – League of Nations bans white-lead interior paint; US declines to adopt

1943 – Report concludes eating lead paint chips causes physical and neurological disorders, behavior, learning and intelligence problems in children

1971 – Lead-Based Paint Poisoning Prevention Act (LBPPPA) passed

1971 – The CDC lowered the limit of lead poisoning to 40 µg/dL

1975 – The CDC again lowers the limit of lead poisoning to 30 µg /dL

1976 –The Toxic Substances Control Act was signed into law

1978 – Lead-based house paint banned

1985 – The CDC dropped the limit of lead poisoning to 25 µg /dL

1991 – The CDC again drops the limit of lead poisoning to 10 µg /dL

1992 – The Residential Lead Based Paint Hazard Reduction Act, better known as Title X (ten) was enacted. Where the LBPPPA reacted to lead based paint, Title X emphasized prevention of lead poisoning via lead based paint

1999-2002 to 2007-2010 - CDC analyzed data from NHANES to determine the 97.5th percentile of blood lead distribution in children and determine the reference value (currently 5 µg/dL).

1.2.5.4 First Pb Paint Manufacture

The old Dutch process by which lead in the form of straps was subjected to the action of air, moisture, carbon dioxide and acetic acid in large stacks, and in which the carbon dioxide was derived from the fermentation of tan bar, has now been superseded all over the world by quicker and cleaner processes. A number of the other processes (the Chamber process, Carter process and Electrolytic processes) are now more and less obsolescent. There are isolated examples of these processes still in existence, but practically all white lead is now made in the United States, the Commonwealth and Europe by variations of the two methods which can be historically described as the French process and the Bischof process. Therefore, the description of the manufacture of white lead will be confined to these processes.

French Process: In common with all the other processes for the manufacture of white lead, this process depends on the fact that lead oxide (or hydroxide) is very soluble in a solution of lead acetate, and white lead is insoluble in this solution. A series of basic acetates of lead is formed, some of which are even more soluble in water than the normal acetate. The reactions involved can be expressed simply as follows:

1) Lead is oxidized by air, forming lead oxide

   $Pb + 1/2O_2 = PbO$

2) Normal lead acetate is formed by the action of acetic acid on the oxide

$PbO + 2CH_3COOH = Pb(C_2H\ _3O_2\ ) + H_2O$

3) Normal lead acetate is converted into basic lead acetate by further reaction with lead monoxide and water

$Pb(C_2H\ _3O_2\ ) + 2PbO + 2\ H_2O = Pb(C_2H\ _3O_2\ )\ 2Pb(OH)_2$

4) Basic lead acetate reacts with carbon dioxide to form basic lead carbonate and normal lead acetate is released to be used again to react with more lead oxide

$3(Pb(C_2H\ _3O_2\ )\ .\ 2Pb(OH)_2) + 4CO_2 = 2(2PbCO_3\ .\ Pb(OH)_{22} +$

$3Pb(C)H_3O_2)_2 + 4\ H_2O$

It will be noted that although the acetate radical takes part in the reaction, it is not consumed.While the main reactions involved are indicated by the above equations, they are in practice more complex. The pigmentary characteristics of the precipitate can be controlled and a wide range of products obtained, not merely the product $2PbCO_3\ .\ Pb(OH)_2$ given in the equation.

Bischof Process: This process is basically the same as the French process, the main difference being that the lead is converted to lead oxide as a separate process. The original Bischof process was complicated by the traces of red lead in the oxides produced at that time; this process also used pure carbon dioxide. The modifications now employed use dilute carbon dioxide from flue gases or lime kilns, and by improved methods of making the oxide avoid the complications of the Bischof process associated with the presence of traces of red lead.

The first stage is the production of lead oxide, which is then suspended in water and a small amount of acetic acid added as a catalyst. Dilute carbon dioxide (e.g. scrubbed flue gas) is then passed through the suspension or slurry, until the required degree of carbonation is obtained for the product being manufactured.

The reactions taking place are substantially the same as the French processes. A difference between this process and the French process is that the lead oxide is in suspension in the same liquor in which the white lead is precipitated, and in this case the process is more similar to the old stack corrosion process. The carbon dioxide reacts with the basic lead acetate in solution to form white lead and normal lead acetate. This normal acetate immediately takes up more oxide from the slurry to again form basic acetate, and so the process goes on until all the oxide is converted to white lead.

1.2.5.5 Pb Phase Out

Paint and gasoline additives were the two major high-volume products containing Pb; about the same quantity of Pb, 5 to 6 million metric tons, was used to manufacture each (Mielke and Reagan 1998). Lead-based house paint sales were phased out in 1978 in response to the Lead Paint Poison Prevention Act (Tong 1990). The EPA reported that there was a relationship between leaded gasoline and blood levels and blood levels declined by 37% in association with a 50% drop in the use of leaded gasoline between 1976 and 1980. Subsequent studies showed a correlation between the increase in gasoline use during the summer and a rise in blood lead levels. By 1986 the primary phase-out of lead from gasoline was completed but in some areas of the country, such as Washington State, leaded gasoline was available until 1991. The World Bank called for a ban on leaded gasoline in 1996 and the European Union banned leaded gasoline in 2000.

Chapter 2

Objectives and Aims of the Study

2.1 Primary Objective and Hypothesis Testing

The primary objective of this study was to show that particulate lead-based paint (LBP) in indoor dust could be matched to the painted surface(s) from which it was derived. In so doing, an improved understanding would be gained of the situations in which friction surfaces significantly contribute to leaded dust that accumulates on accessible surfaces within a home. This was presumed possible because the primary objective of this investigation was to be met through the analysis of dusts on surfaces in homes where different types of friction surfaces (in various states of repair) are probable significant sources of dust lead. By investigating situations where different types of friction surface are likely dust Pb contributors, we anticipated that valuable data could be obtained on the relative importance of each surface type, and on the factors which control the production of Pb from them (e.g., condition of the paintwork, and the level of particulate-producing activity).

To date, source specific contributions to dust from painted surfaces remain incompletely understood. Here, the plan was to show that source contributions could be resolved by performing a series of comparison analyses which would aim to match floor dust Pb-containing particles to paint samples collected from each possible contributing indoor source. It was expected that the significance of each of the sources would be demonstrated and the possible existence of a source-specific Pb particle size dependence would be clarified. The anticipated outcome of this study was a hierarchical classification of contributing source types based on the quantity and exposure significance of the material released from each source. It was envisioned that at one end of such a classification would be sources which are repetitive and frequent producers of particulate Pb (i.e., friction surfaces), while at the other end would be sources which episodically release paint particles as a result of non-repetitive fragmentation processes (e.g., flaking wall paint).

Hypotheses to be tested: It was posited that, under the appropriate conditions, it was possible to identify each of the Pb particle contributions made to indoor dusts by lead-based paint (LBP) present on friction, impact, and other painted surfaces. Therefore, it was further suggested that it is possible to identify the circumstances under which friction surfaces generate significant amounts of Pb dust within a dwelling. It was our contention that friction and impact surfaces can generate substantial quantities of Pb dust if the painted surface is degraded and is frequently abraded. We considered it likely that there commonly exists a (disintegration) continuum of Pb dust generating surfaces. At one end of this continuum would be the never abraded friction surface with completely intact paint (e.g., a permanently closed window with a pristine paint covering), while at the other was the constantly abraded surface with many coats of LBP in an advanced state of decay (e.g., an original window in an old, poorly maintained property, which was repetitively opened exposing the paint to frictional wear and changing atmospheric conditions. We hypothesized that by attributing the Pb in settled dust to the disintegrating friction surface from where it came, it should be possible to correlate variations in Pb dust production with degree of surface decay.

The homes selected for participation in this study were drawn from a larger pool of properties which had been recruited by the City of Syracuse Lead Abatement Program. Prior to the start of this investigation, select properties scheduled for abatement (typically window removal) were sampled based on the data from the Lead Abatement Program's risk assessment, this risk assessment involved measuring in situ the amount of Pb in paints on all painted surfaces in the residence using a portable X-ray fluorescence spectrometer (XRF). In the targeted homes samples were collected at receptor sites (floor dusts), point sources (Pb paint covered surfaces), and at storage points within the system (yard soils). The selection of the study homes was to be based on whether they had one, two, or three important friction surfaces. Establishing the contributions from different types of surface was dependent upon the presence of different paints (with the potential to produce leaded dust) on each.

To evaluate contributions from different types of friction surface, it was our intention to compare several analytical approaches, each of which has been used previously (as the sole technique) in dust Pb source attribution studies. In order to have a high confidence in the final apportionment it seemed appropriate to use several complementary techniques (each with different strengths) to address the source identification problem. In addition, by employing several techniques it was felt that it is possible, by comparing the results obtained by each, to assess the cost effectiveness of the different approaches. The work presented here was concerned with individual Pb particle analysis by computer controlled scanning electron microscopy and energy dispersive x-ray analysis (CCSEM). Two other analytical techniques were used to investigate the Pb in the samples from each home. *The data acquired by these methods was NOT acquired as part of this dissertation research, neither was the data analysis and interpretation part of this research. However, the results of these analyses have never been published and for purposes of comparison, information on these other analyses were included here*. To gain an understanding of the relative advantages of CCSEM it was deemed useful to include the results of these other techniques in order to evaluate if the method used here could be considered the "technique of choice" for the type of Pb source attribution investigation undertaken here. In summary, the techniques that have been employed were:

(I) **Individual Particle Analysis By Computer Controlled Scanning Electron Microscopy And Energy Dispersive X-Ray Analysis (CCSEM).** CCSEM which was the principal analytical tool used in this investigation, was employed to compare Pb particles in (receptor) settled dusts with those from painted surfaces (release sources) on the basis of individual particle size, shape, surface morphology, and chemical composition. In each sampled dust the Pb particle content was attributed to its appropriate source using descriptive and statistical apportionment procedures. The importance of each of the sources was judged on the quantity of dust Pb (both in terms of numbers of particles and the quantity of the particles) which it generated.

(II) **Total Sample Analysis By X-Ray Florescence (XRF)**. Multi-element concentrations for bulk samples of source and receptor dusts were determined by XRF. Apportionment of the Pb in the indoor dust was based on the source profiles from each property and utilized the traditional chemical mass balance (CMB) approach.

(III) **Lead Isotopic Composition (IC) Determinations**. Stable lead isotopic analysis was used to assess the contributions to settled dust from sources for which the isotopic ratios (206Pb/ 204Pb, 206Pb/ 204Pb, and 207Pb/ 206Pb) were sufficiently different. A mixing model type of approach were used to evaluate the relative source contributions.

2.2 Specific Aims

The main aims of this project were met, and the proposed hypotheses were tested, by addressing a series of specific objectives. These were:

(1) To apportion the sources of Pb in settled indoor dust from dwellings with friction surfaces in different states of repair. In the first instance, this was undertaken in homes where there was only one (obvious) friction surface. This allowed for the disintegration state of the friction surface to be controlled for. The three types of friction surface investigated were LBP covered windows, doors, and floors. Homes where these friction surfaces were increasingly decaying (ranging from intact to poor condition) provided the study samples. These dwellings were regarded as a 1-friction surface source component system, because the possibility of an external soil/dust contribution to floor dusts could not be excluded, such dwellings were probably 2-component source systems.

(2) To apportion the sources of Pb in settled indoor dust from dwellings with more than one non-intact friction surface. This allowed the effectiveness of the different analysis techniques evaluated under multi-source component conditions. Both 2- and 3-component friction surface source systems were investigated. These were situations where non-intact LBP contributions were from a window and door, from a window and floor, and from a window, door and floor.

Chapter 3

Materials and Methods

The focus of this study was the attribution of lead in dust to indoor friction surfaces. In accordance with EPA regulations, a friction surface is defined as a surface that is subject to friction or abrasion (40 CFR 745.63). Lead-based paint is likely to generate lead-contaminated dust due to the friction and, as a result, friction surfaces are given special attention. EPA regulations further state that any lead-based paint on a friction surface is a lead-based paint hazard if the surface is subject to abrasion and where the lead-dust on the nearest horizontal surface underneath the friction surface (e.g., the window sill, or floor) equals or exceeds applicable dust-lead standards (40 CFR 745.65(a)(1).

EPA also states that friction surfaces can be further defined as surfaces that are being worn down due to surface scratching or rubbing. The most common examples of painted friction surfaces are:

1. painted floors and painted stair treads
2. a double-hung window sash rubbing against a window channel, with one or both of the surfaces painted
3. painted kitchen counters and shelves on which there is abrasive contact by objects used for cooking or eating, painted drawers slides and doors.

These are friction-surface hazards only if the paint is lead-based paint and accordingly the dust underneath the surface (or on it, in the case of floors and stair treads) is a lead-dust hazard.

3.1 Study Design

The first important feature of the original study design was the selection of the residential properties that would allow the contribution to indoor dust from friction surfaces with different surface conditions to be assessed. The initial approach was to select three properties in which one type of prominent friction surface was the only, or the predominant Pb hazard. The three types of friction surface that were to be selected would be **window frames**, **doors**, and **floors**. Three properties to be selected for each surface would be obvious variations in the level of deterioration of the paint on that surface. So, the first set of study homes would include nine dwellings in which either the window (three homes), the door (three homes) or the floor (three homes) had identifiable Pb. For each set of three homes the condition of the specific friction surface of interest, it was anticipated, would range from intact, or almost intact (no, or minimal signs of wear), to very poor condition (large areas of the painted surface damaged). The midpoint sampling location would be a home where the damage to the friction surface was, by visual inspection, intermediate between the other extremes. By selecting samples in this way, we aim to let only the deterioration status of the friction surface vary, while controlling for all other inputs. While each of these homes should be a 1-paint component system, it was quite likely that each would also be a 2-source component system, it would be unlikely that there would be no contribution to the indoor dust from outdoor soil. We contend that these 2-source component systems would provide the best conditions to test the relative merits of the analytical techniques to be employed in the study. Also, the resultant apportionment data would indicate how the deterioration status of the friction surface affects the Pb levels in the dust. In the second set of homes in the study group, two types of friction surface would have been identified as the Pb hazards. A total of four properties would be selected, two of which would have LBP on windows and doors, and the other two would have LBP on windows and floors. For this second set of homes no effort would be made to select dwellings in which the condition of one surface was obviously worse than the other. The aim of this part of the study, which involves 2-paint component (3-source component) homes, was to determine whether it was possible to simply apportion the contributions from two painted friction surfaces, either be using the techniques in combination or alone. The relative effectiveness of each technique could also be compared. The third set of homes selected for the study group would be dwellings with LBP on each of the friction surfaces (window frame, door and floor). Two of these 3-paint houses would be investigated. This probable 4-source component scenario presents the investigator with a very complex indoor dust Pb source apportionment problem. However, 4-source component situations were not uncommon in actual exposure situations. Consequently, the objective here was to assess how effective each of the apportionment techniques could be.

Several changes were made to the original study design when the project was finally implemented. Floor dust sampling was modified to maximize the amount of sample available for analysis. It was found during initial sampling that in order to collect a suitable amount of floor dust from a target room in each home that it was necessary to collect dust from the total open floor space in that room . Most of the dwellings initially sampled had hard-wood floors and the level of dust accumulation proved to be minimal. Therefore, it was decided that the sampling strategy should be modified in a way that would provide the maximum sample available (i.e., vacuum sample material from all open floor space). This was deemed to be an appropriate modification for two reasons. Firstly, it is likely that a young child was exposed to dust that had accumulated on all the open floor space. Secondly, as the study progressed, it was found that there were insufficient instances of the desired Pb-paint coated friction surfaces. Consequently, the number of dwellings sampled was less than anticipated. The actual number of homes that were sampled is discussed below (Table 3.1).

Table 3-1 Sample Code for Single and Double Friction Source Homes

No	House Code	Friction Surface Type
1	A	Window Source
2	B	Window Source
3	C	Window Source
4	E	Window Source
5	J	Floor Source
6	K	Floor Source
7	L	Floor Source
8	O	Window and Floor
9	P	Door and Floor

The sampling sites (residences) for this study were identified by the city of Syracuse Lead Hazard Control program. The Syracuse Lead Program is a long-term federally funded program through HUD. The program has been funded to reduce lead hazards for qualifying homes in the City of Syracuse. Residences where the proposed friction surfaces as contributing sources (of lead) to the dust were present in the home, were identified by the Syracuse Lead program inspector. As part of the program, detailed testing of paint surfaces (for lead) by hand held X-ray Fluorescence Spectroscopy (XRF) was conducted by the program inspector. From a database of homes tested (that were designated for hazard intervention) the homes evaluated in this study were identified.

The initial approach was to select 3 properties in which one type of prominent friction surface is the only, or the predominant Pb hazard. The 3 types of friction surface to be selected would be window frames, doors, and floors. The three properties which would be selected for each surface would have obvious variations in the level of deterioration of the paint on that surface. So, the first set of study homes would include 9 dwellings in which it is the window (three homes), the door (three homes) or the floor (three homes) which would be the identified Pb hazard. For each set of three homes the condition of the specific friction surface of interest would range from intact, or almost intact (no, or minimal signs of wear), to very poor condition (large areas of the painted surface damaged). The midpoint sampling location would be a home where the damage to the friction surface is, by visual inspection, intermediate between the other extremes. By selecting samples in this way, the aim was to let only the deterioration status of the friction surface vary, while controlling for all other inputs. While each of the homes would be a 1-paint component system, it was thought quite likely that each would also be a 2-source component system, it would be unlikely that there would be no contribution to the indoor dust from outdoor soil. It was reasoned that these 2-source component systems would provide the best conditions to test the relative merits of the analytical techniques to be employed in the study. Also, the resultant apportionment data would indicate how the deterioration status of the friction surface affects the Pb levels in the dust. In the second set of homes in the study group, two types of friction surface would have been identified as the Pb hazards. A total of four properties would be selected, two of which would have LBP on windows and doors, and the other two would have LBP on windows and floors. For this second set of homes no effort would be made to select dwellings in which the condition of one surface is obviously worse than the other. The aim of this part of the study, which involves 2-paint component (3-source component) homes, was to determine whether it is possible to simply apportion the contributions from two painted friction surfaces, either be using the techniques in combination or alone. The relative effectiveness of each technique could also be compared. The third set of homes selected for the study group would be dwellings with LBP on each of the friction surfaces (window frame, door and floor). Two of these 3-paint houses would be investigated. This probable 4-source component scenario presents the investigator with a very complex indoor dust Pb source attribution problem. And, 4-source component situations are not common in actual exposure situations. The condition of the friction surfaces, the nature of the friction surfaces, and the types of friction surface present in each of the projected analyses are summarized below (Figure 3-1 and Figure 3-2).

SURFACE CONDITION	FRICTION SURFACE TYPE: Window Source	Door Source	Floor Source
Intact / Minimal Damage	✔	✔	✔
Moderate Damage	✔	✔	✔
Poor Condition	✔	✔	✔
Nine Homes in Total plus One Control Home (*n* = 10)			

Figure 3-1 Coditions for Sampling Homes Where a Single Friction Surface Dominates

TYPE OF SAMPLE	FRICTION SURFACE TYPES: Window (*n* = 3)	Door (*n* = 3)	Floor (*n* = 3)	Window & Door Sources (*n* = 2)	Window & Floor Source (*n* = 2)	Window, Door, & Floor Sources (*n* = 2)
Floor Dust	✔	✔	✔	✔	✔	✔
Window Paint	✔			✔	✔	✔
Window Well Dust	✔			✔	✔	✔
Window Sill Dust	✔			✔	✔	✔
Door Paint		✔		✔		✔
Floor Paint			✔		✔	✔
Other Paint* (e.g., external siding, internal non-friction, other internal friction)	✔	✔	✔	✔	✔	✔
Building Line Soil	✔	✔	✔	✔	✔	✔
Mid Yard Soil	✔	✔	✔	✔	✔	✔

Figure 3-2 Number of Homes to be Sampled and Sample Types to be Collected When One or More Friction Surfaces are Present.

3.2 Sampling

The floor dusts were collected by a BRM cyclone vacuum sampler (Figure 3-3). The BRM cyclone vacuum sampler consists of four major parts: (i) Head (ii) Case (iii) Teflon ring (iv) Clamp. The head of the cyclone has an output nozzle located on the top that is connected to a vacuum source and an inlet located tangentially on the side that is connected to a pick-up tube. The conical shaped bottom half of the cyclone vacuum is the case. Internal threads are located at the narrow end of the case. The dust catch container is screwed tightly into these threads. A Teflon sealing ring is located between the head and case of the cyclone. The clamp holds the head and case together. For friction surfaces (and other surfaces) paint was sampled down to the original surface using a scalpel and forceps. Soils were collected by bagging surface scrapings at the building line and mid-yard. Curbside road dust was collected by brushing and bagging dust in the road.

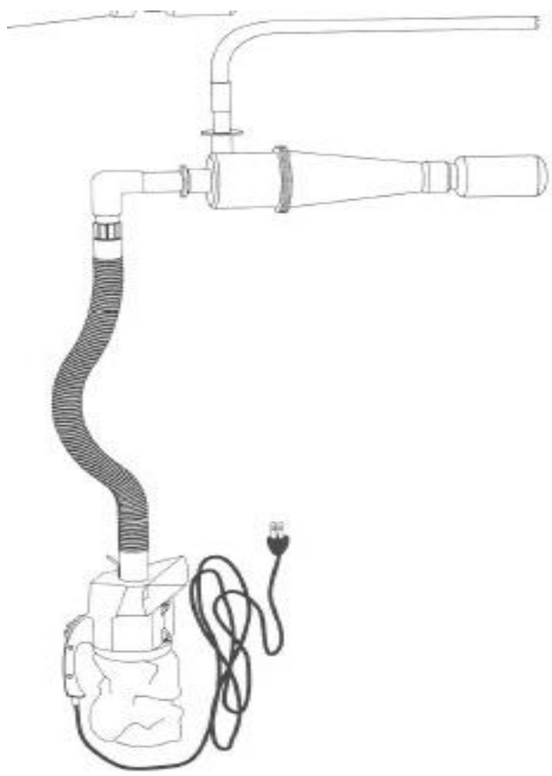


Figure 3-3 BRM Cyclone Vacuum Samper (side view)

In terms of sample preparation, prior to analysis, each of the sampled paints were ground and dry sieved though a 180 µm nylon mesh. The soils samples and road dusts, following air drying, were also dry sieved a 180 µm nylon mesh. Floor dust sub-samples were initially suspended in 50 mL of distilled water and ultrasonically dispersed for 2 minutes. The floor dust suspension was then wet sieved through a 180 µm nylon mesh. The < 180 µm fraction of the dust was then filtered onto 3 separate filter media for three different types of analyses. As noted previously, three different types of analyses were performed on the samples from each home. Three different source attribution methodologies were investigated requiring three different sample analysis techniques. This work focuses on individual Pb-particle characterization by scanning electron microscopy (SEM) and Energy-Dispersive X-ray Microanalysis (EDX). The other two methodologies involved (i) total sample element analysis by X-ray Fluorescence (XRF) for chemical mass balance apportionment; and (ii) Pb-isotope composition (PbIC) determination by mass spectroscopy for three-source unmixing modeling. These other two analyses were conducted by Drs. Mike Rabinowitz and Philip Hopke. The data interpretation provided by them was wholly their own. Their data was included for comparative purposes Loadings were varied in accordance with the type of analysis to be undertaken. For XRF analysis the dust was deposited from a DIW suspension onto a pre weighed Teflon filter. For CCSEM analysis the dust was deposited from a DIW suspension onto a series (generally between 3 and 5) of 0.4 µm pore size 25 mm diameter polycarbonate filters each with a different loading. The remainder of the dust was deposited onto a 42 mm 0.4 µm pore size polycarbonate filter and submitted for PbIC analysis.

3.3 Principal Method of Pb-particle Source Attribution

The samples were characterized at the individual particle level using a combination of scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS) (Figure 3-4). Imaging of particles by collecting sample secondary electrons (SE) provided morphological information, while primary beam backscattered electron (BE) collection provided relative particle composition data. The measurement of sample characteristic X-rays provided element composition information for each particle. The SEM/EDX analysis employed an ASPEX Personal Scanning Electron Microscope (PSEM). Particle imaging was conducted primarily in the BE imaging mode. Backscattered electrons were collected by a four-quadrant detector located at the base of the SEM column. Variations in BE yield strongly correlate with particle average atomic number composition (essentially the BE gray-scale image reports on variation in particle density). Particle element composition was determined by collecting characteristic X-rays using an OmegaMax EDX system with a silicon drift detector with a 10 mm^2 active area and ultra-thin window for detection of elements from Carbon to Uranium. Individual particle analysis (IPA) involving the collection of size, shape, and element composition data involved BE collection operating in tandem with X-ray data collection under computer control. Obtaining statistically significant IPA data sets, in a time efficient manner involved automated particle (in the SEM referred to as a feature) analysis with the primary SEM electron beam and the sample stage moved under computer control (Computer Controlled SEM – CCSEM) guided by the resident automated feature analysis (AFA) software. The AFA software operated sequentially in a feature search mode and then in feature measurement mode. The feature search required initially setting an imaging threshold (in BE imaging mode), whereby the sample particles were isolated/separated from the polycarbonate membrane filter on which the particles were collected for CCSEM analysis (optimally separated from each other by at least one particle diameter). As the substrate (the polycarbonate filter) had a low average atomic number (being composed of carbon) all particles with an average atomic number greater than carbon were separated in the BE image from the substrate by a greater BE yield thus allowing a recognition threshold to be set permitting the AFA software to distinguish the particles from the substrate. This is basically a binary image separation. Once the threshold had been set a search magnification was set (500x), each SEM stage field defined for searching was divided into a 5x5 grid of electronic- fields (increasing the efficiency of the AFA analysis by reducing stage travel time). A search grid size, this is the grid of points where the primary electron beam interacted with the substrate at each point. If the beam interacted with a particle on the substrate at a designated point position that point would be recognized as being on-point (the BE yield would be above the threshold indicating a particle had been found) as opposed to an off-point location where the beam is interacting with the substrate with a BE yield below the set threshold. The field search grid size was set at 1024x1024 pixels, which meant that only a particle less than 0.3 μm in diameter that might fall exactly between the search grid points would be missed during the search. When an on-point pixel was encountered the beam point separation was reduced as the particle was scanned. The AFA software then went into the analysis mode. During the feature scan process, the size was measured using a rotating chord algorithm, shape determined (e.g., the aspect ratio) and X-ray data was collected as the beam rastered along chords across the particle (this provided an average particle composition), a minimum dwell time for X-ray collection on the particle was set at 10 seconds, or a minimum of 5,000 X-ray counts acquired. For each particle X-rays counts were measured for an element list that included: O, Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ba, Sn and Pb. Relative X-ray concentrations (recorded as normalized k-ratios) for these elements and size information were recorded in a particle-by-particle database. While a fixed element list was used at this stage, the software actually stored complete X-ray spectrum data allowing subsequent reprocessing of data if needed (e.g., removing and/or adding element(s) from the element list). The standard operating conditions for each analysis were: a primary beam current of 1 nA, an accelerating voltage of 25 kV, and a working distance of approximately 16 mm. The duration of AFA was set at either the collection of data on 6,000 particles, or a total analysis time (for search and measure) of 600 minutes. The goal of CCSEM is to generate statistically significant individual particle data sets that can be used to define the compositionally different particle types that comprise the media sample of interest.

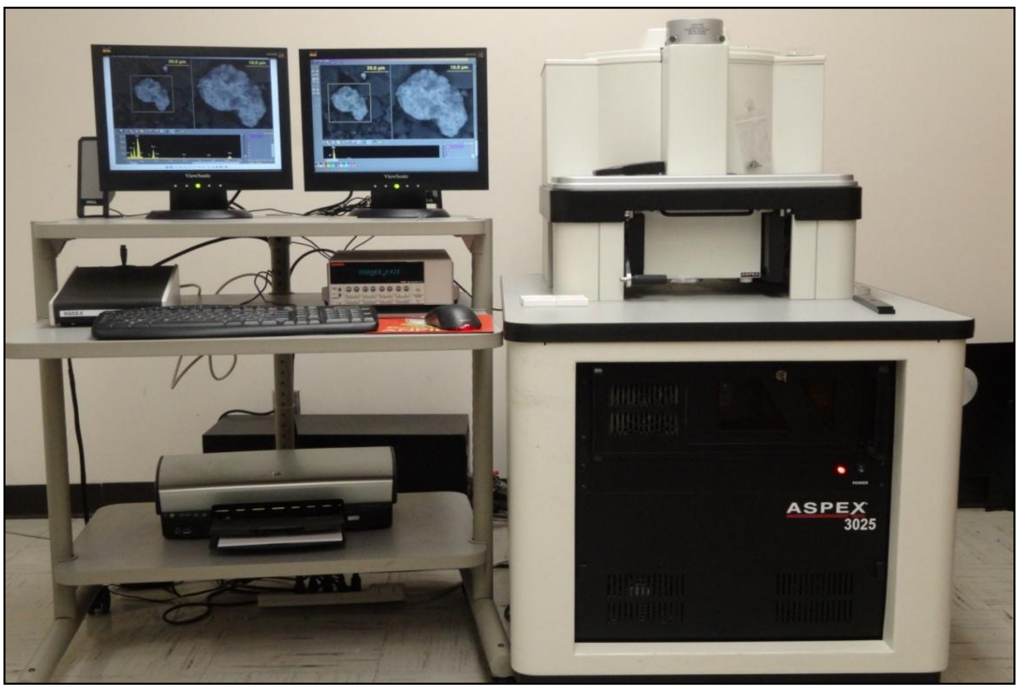


Figure 3-4 ASPEX@ SEM-EDS

3.4 Ancillary analytical methods

As noted previously, two additional source attribution methodologies in addition to CCEM were used with the dust samples collected here. These analyses were not undertaken as part of this study. However, the data from these ancillary analyses have never been published, and it was deemed appropriate to include the data from these studies for purposes of comparison with the CCSEM analysis used here.

3.4.1 Procedure for Common Pb Isotopic Composition (PbIC) Analysis of Paints, Soils and Dust

Sam Bowerings laboratory at MIT was selected for PbIC analysis because of its international reputation. Depending on sample size and type, between 0.5 and 5 g of each sample was weighed into Teflon beakers. The samples were leached in weak HNO_3+ HCI at room temperature for approximately 30 minutes. After leaching, the acid was removed by pipette into acid washed tubes and centrifuged to remove any particulate matter. The clear leachate was then pipetted into acid cleaned beakers and dried on a hotplate at 350°F. Approximately 2 ml of concentrated HNO_3 was then added to the leachate, and it was again dried at 350°F. Then, 2-5 ml of 6N HCI was added to the leachate and was refluxed for several hours at 250°F in a capped Teflon beaker. This solution was then dried on a hotplate at 350°F, and 1.1 N HBr was added in preparation for Pb column. Paint samples were weighed into Teflon beakers, and the samples were then leached in approximately 1 ml of 7N HNO_3 on a hotplate at 250° F for approximately 30 minutes. After leaching, the acid was transferred by pipette into clean tubes and centrifuged to remove any particulate matter. The clear leachate was then transferred to clean beakers and dried on a hotplate at 350 °F. Approximately 2 ml of concentrated HNO_3 was then added to the leachate and it was dried again 350 °F. Next, 2-5ml of 6N HCI was added to the leachate and it was refluxed for several hours at 250 °F in a capped Teflon beaker. Finally, the solution was dried once more on a hotplate at 350 °F, and 1.1 N HBr was added in preparation for Pb column chemistry. For all types of media, Pb was separated using HBr-based chemistry on anion exchange resin in Teflon micro columns. All reagents were distilled to reach ultrahigh purity for trace metals. Pb isotopic compositions were measured on a VG sector-54 mass spectrometer at MlT. PblC was determined in static multi collector mode. The ratios 206Pb/204Pb 203Pb/ 204Pb and 207Pb/ 206Pb was determined.

3.4.2 Procedure for X-ray Fluorescence (XRF) Analysis

XRF analysis for this study was performed at the Desert Research Institute (DRI), Particulate samples were prepared for X-ray fluorescence (XRF) analysis in the same manner as for CCSEM. Once the material was size fractionated it was deposited on membrane filters. Efforts were made to analyze the same material submitted for XRF as has been analyzed by CCSEM. It was hoped that the results from each type of analysis could be correlated for exactly the same material. XRF was performed on the membrane filtered samples for the following elements: Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Y, Zr, Mo, Pd, Ag, C, In, Sn, Sb, Ba, La, Au, Hg, Tl, Pb, and U using an energy dispersive x-ray fluorescence (EDXRF) analyzer. XRF analyses was performed on a Kevex Corporation Model 0700/8000 or a Kevex 0700/IXRF energy dispersive x-ray fluorescence (EDXRF) analyzer using a side-window, liquid-cooled, 60 keV, 3.3 milliamp rhodium anode x-ray tube and secondary fluorescence. The x-ray output stability was within 0.25% for any 8-hour period within a 21 hour duration. The silicon detector has an active area of 30 mm^2, with a system resolution better than 165 eV. The analysis was controlled, spectra were acquired, and elemental concentrations were calculated by software implemented on an LSI 11/23 microcomputer (0700/8000 model) or a Pentium PC (0700/IXRF model).

3.5 Analysis of Data

3.5.1 CCSEM data analysis

CCSEM analysis is capable of partitioning the information space formed by the data from the particles into its basic particulate components. While bulk sample analysis techniques will provide data of the total amount of an element in a sample, CCSEM analysis provides information on the quantity of that element in the different particle types within that sample. Consequently, if different particle types from different sources are present in a dust sample, using CCSEM analysis it is possible to identify those particle types and quantify the amount of each particle type present in the sample. Hence, the first stage in CCSEM data analysis is to identify homogenous groups of particle types in the data set. For this purpose, we used a pattern recognition approach that was a supervised divisive hierarchical cluster analysis. Identification of homogenous classes of particles was based on intra-particle similarities in composition and form. A descriptive apportionment was used to assign Pb-particles to the possible sources. In the descriptive apportionment source calsses were defind from CCSEM analysis of lead particles in the indoor paint(s) in the soils and in the road dusts. This was the major task of the study. CCSEM data was collected from the samples and particles containing lead as identified in the AFA process were relocated in the SEM for additional data collection. During the AFA analysis an image of the particle analyzed was collected, as was the coordinates on the SEM stage of the particle. By having the SEM "drive" back to particle it was possible with the particle image information to relocate the AFA recorded lead-bearing particle.Upon relocation each particle was re-analysed for its element composition (longer electron beam dwell time) and morphological form. In terms of morphology we used specific pigment crysal habit and crystal abundance to facilitate LBP attribution. So, lead-carbonate pigment historically took the form of hexagonal platy crystals, this is a defining characteristic of LBP. Small Pb particlesclumped together in aggregates is also a defining feature of LBP as only aggregates such as this come from LBP. Therefore a basic classification scheme was devised (on a property-by-property basis), a floor dust Pb particle would be classified as a "paint," "soil," or "road dust" particle if it had the same, or orobviously very similar element composition as the source "particle types". If particles were relocated that were composed solely of lead they were classified as paint. Also multivariate statistics in the form of discriminant function analysis were used to aid in source attribution.

3.5.2 XRF Data Analysis

XRF analysis results would be used to apportion sources of the Pb in the indoor receptor dust through the application of the Chemical Mass Balance Receptor Model (CMB). The XRF results give the total quantity of an element present in either the source or the receptor dust sample. Therefore, compared to CCSEM analysis, the XRF data reports were on a different aspect of the sample. The CMB8 receptor model assumes that the mass of Pb in the receptor dust is the sum of the mass contributions from all the sources. The EPA-authorized implementation of the CMB8 will be used to model the XRF results. The model employs a least squares solution to a set of linear equations (for each element) of the form:

$$DUST_i = F_{1i}S_1 + F2_iS_2 + \ldots\ldots F_{iJ}S_j \ldots\ldots + F_{lj}S_j \quad \text{for } l=1, \ldots., l,\ j=1, \ldots.., j$$

Where $DUST_i$, is the concentration of element i in the dust, F_{ij} is the fraction of element i in the dust from source j, and S_j is the fraction of the mass contributed from source j. The equations are solved for the source strength term (S). They are solved by an effective variance least squares estimate from the measured uncertainties in the source and receptor concentrations.

3.5.3 PbIC Data Analysis

PbIC analysis results (in the form of the ratios 207Pb/204Pb, and 206Pb/204Pb) were interpreted using an end-member mixing model approach. If an indoor dust under investigation is derived from two contributing sources with different isotopic signatures (e.g., a LBP source and a background soil source), then this two component system can be represented on a mixing plot, and if the receptor dust is a linear combination of contributions from the end-member sources the contributions from each can be calculated.

Chapter 4

Results

During the sampling period it was found that it was impossible to comply with the study design for the project. Homes with the proposed variety of indoor friction surfaces were not readily identifiable by the lead inspector in a timely manner. Specifically, properties with multiple friction surfaces were rarely recruited to the Lead Abatement Program. To maintain the project schedule homes that met the requirements of the study design were sampled and the collected media were analyzed. The study collected samples from 15 residences with a subset of material being analyzed by some methods.

4.1 CCSEM for Floor Dust Lead Source Attribution

Here we report on the CCSEM analysis results on a property-by-property basis, and the type of friction surface(s) under consideration as potential contribing source(s) are set out with the residence information below.

House A *(Projected Window Paint Source, poor condition)*

Results are presented for the descriptive apportionments and the discriminant analysis in Table 4-1. The Pb content of the target and other paints from the property are set out in Appendix A. Here the source attribution investigates the the target paint, the soil and the road dust as the projected contributing sources of particulate lead to the indoor floor dust. The target paint had a Pb content of 127,633 ppm, the soil had a Pb content of 199 ppm, and the road dust 9 ppm. In the descriptive apportionment based on elements associations from the operator analyzed particles various “types” of lead-bearing particles were recorded. Image and Xray element data from these particles are set out in Appendix A. The analyzed particles from the target paint produced19 groups, or classes, of lead particles “types” (in each class the particle compositions were unique and/or similar) (Table 4-2). In the soil 21 classes of lead particles were identified (Table 4-3), and in the road dust material 10 classes were defined (Table 4-4). An additional class called here “unattributed Pb” was also used specifically for particles consisting of only lead and with no morphological habit suggesting a possible source. These were, therefore, unattributable lead particles. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-1. In the the class assignments of the operator analyzed particles the greatest percentage of lead particles were assigned to the unattributed Pb class. This is a problem with this type of analysis and source attribution. These unattributed particles could be derived from the paint source (in in all likelihood were) however when individual lead pigment particles are liberated from the paint and incorporated into the dust it is not possible to assign them to the paint source when they are composed solely of Pb and are irregularly shaped. In the discriminant analysis the floor dust lead particle assignments were different. The individual lead particle information for the first two discriminant functions (which carry most of the information on the particles) is set out in Figure 4-1. This shows where the CCSEM analyzed lead particles plot in the discriminant space defined by the first two dicriminant functions. The graph shows much overlap between groups. The paint particles do form a homogenous group on the positive side of the first function axis. We posit that the separation of groups is hampered by the results from the road dust samples. Because of the lack of identifiable lead-bearing particles in the road dust samples it was felt necessary to aggregate all the road dust CCSEM analyses. So, the road dust Pb particles used in the discriminant analysis were not site specific and possibly as a result of that showed a wide variety of compositions in the particles derived from unknown sources. In the discriminant analysis, when the floor dust lead particles were not coded as a group, the individual particles were assigned to the nearest other group (paint, soil, road dust) by shortest Euclidean distance in the information space between the particle and the centroid of each other group. The percentage number assignments for the floor dust particles are also set out in Table 4-1. The floor dust particles were primarily classed as having a paint origin, but with almost 30% having a road dust origin. In a second analysis with the road dust code eliminated the floor dust lead particles were almost exclusively classified as lead paint particles.It should be noted that there is no unattributed Pb group in these discriminant analysis runs. Undoubtedly such particles are present in the source samples and will impact the classification, so in one sense the discriminant classification does not have the resolution of the operator, classified particles in the descriptive apportionment.

Table 4-1 House A Descriptive Apportionment and DiscriminantAnalysis Data

	Window Paint	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	17%	8%	0%	75%
Dust Discrim classification	60%	11%	29%	NA
Dust Discrim Classification without Road	88%	12%	-	NA

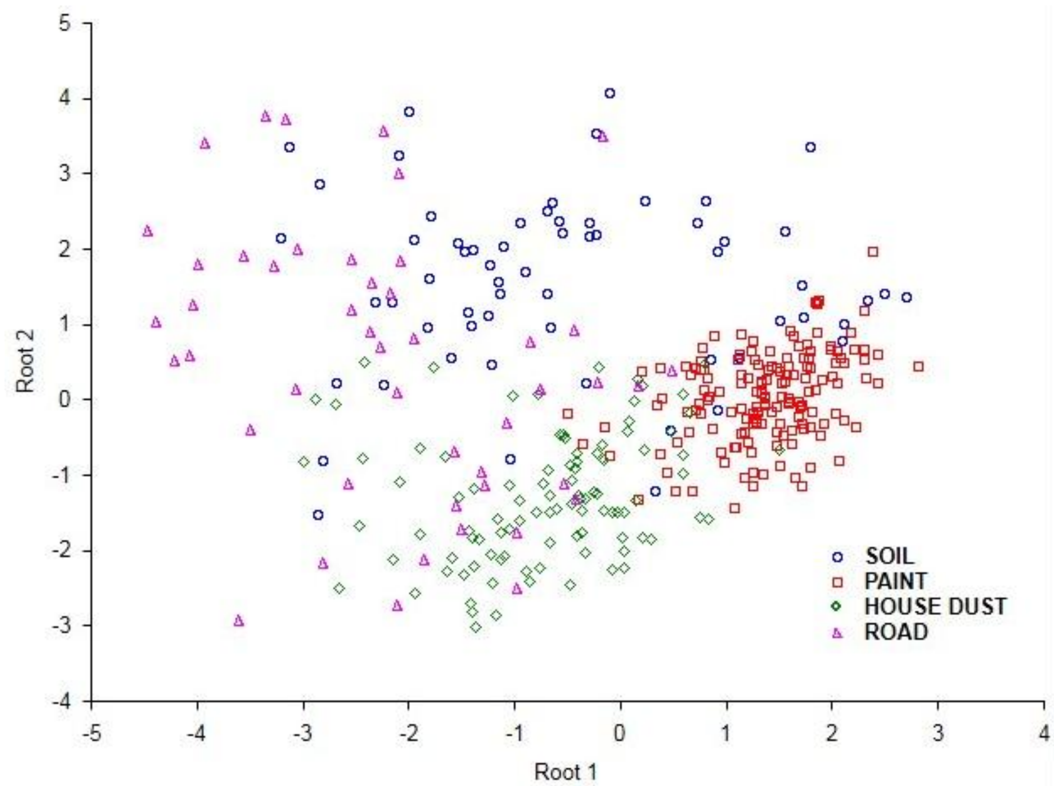


Figure 4-1 House A CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-2 House A Paint Pb Particle Class

Class Name	Pb Particle Class	No
PbTi + Other Class	PbTi	1
	PbTiCa	1
PbZn + Other Class	PbZn	11
	PbZnCa	2
	PbZnSi	1
	PbZnCaSi	1
	PbZnSiAlFe	1
	PbZnCaSiMgFe	1

Table 4-2 - *Continued*

Pb + Others Class	PbCa	3
	PbCaSiAlFe	1
PbZnTi + Others Class	PbZnTi	1
	PbZnTiCa	3
	PbZnTiSi	3
	PbZnTiCaSi	2
	PbZnTiSiFe	1
	PbZnTiSiMg	1
	PbZnTiCaSiFe	1
	PbZnTiCaSiMg	2
PbZnBa + Others Class	PbZnBaCaSiMg	4

Table 4-3 House A Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbTi + Others Class	PbTi	16
	PbTiSi	2
	PbTiCa	2
	PbTiFe	1
	PbTiSiAl	3
	PbTiSiAlFe	1
	PbTiSiAlK	1
	PbTiCaKFe	2
	PbTiSiAlMgFe	1
	PbTiCaKFePSiAl	1
	PbTiCaSiAlMgNa	1
PbZn + Others Class	PbZnCaKFe	1
	PbZnCaSiAlPMnFeCl	1
Pb + Others Class	PbCa	1
	PbCaP	1
	PbCaFe	1
	PbPSiFe	1

Table 4-3 -*Continued*

	PbCaSiAlK	1
	PbCaSiAlKP	1
	PbPSiAlCaFeNa	1
Pb + Others Class	PbCaSiAlKPMgNaFe	1

Table 4-4 House A Road Dust Pb Particle Class

Class Name	Pb Particle Class	No
	PbTi	5
	PbTiSi	2
	PbTiSiMg	5
	PbTiCaSiMgFe	4
PbTi + Others Class	PbTiCaSiAlKPNaFe	1
	PbCl	1
	PbClCa	1
	PbSiAl	1
Pb + Others Class	PbCaSiAl	1
PbZn + Others Class	PbZnCaSiAlKPMgFe	1

House B *(Projected Window Paint Source, poor condition)*

Results for the House B media for the descriptive apportionments and the discriminant analysis are set out in Table 4-5. The Pb content of the target and other paints from the property are set out in Appendix B. Here the source attribution investigates the the target paint, the soil and the road dust as the projected contributing sources of particulate lead to the indoor floor dust. The target paint had a Pb content of 59,950 ppm, the soil had a Pb content of 1,466 ppm, and no road dust was collected at this location. Operator collected data in the form of images and Xray element data from the particles analysed in the media from this location are set out in Appendix B. The analyzed particles from the target paint produced 52 groups, or classes, of lead particles "types" (in each class the particle compositions were unique and/or similar) (Table 4-6). In the soil 22 classes of lead particles were identified (Table 4-7). There were no road dust classes from this location. The additional class called "unattributed Pb" was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-5. In the class assignments of the operator analyzed particles the greatest percentage of lead particles were assigned to the paint class and the unattributed Pb class. These unattributed particles could be derived from the paint source. In the discriminant analysis the floor dust lead particle assignments were different. The individual lead particle information for the first two discriminant functions (which carry most of the information on the particles) is set out in Figure 4.2. The graph shows some overlap between groups. But, the paint particles do form a homogenous group quite separate from the soil particle group. Again, road dust Pb particles used in the discriminant analysis were not site specific but were the aggregate data from all the analyzed road dusts. In the discriminant analysis, when the floor dust lead particles were not coded as a group, the individual particles were assigned to the nearest other group. The percentage number assignments for the floor dust particles are also set out in Table 4-5. The floor dust particles were primarily classed as mostly having a paint origin, and the rest having a road dust origin. In a second analysis with the road dust code eliminated the floor dust lead particles were largely classified as lead paint particles, with a small percentage classified as soil.

Table 4-5 House B Descriptive Apportionment and Discriminant Analysis Data

	Window Paint	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	49%	2%	0%	49%
Dust Discrim classification	54%	1%	45%	NA
Dust Discrim Classification without Road	93%	7%	-	NA

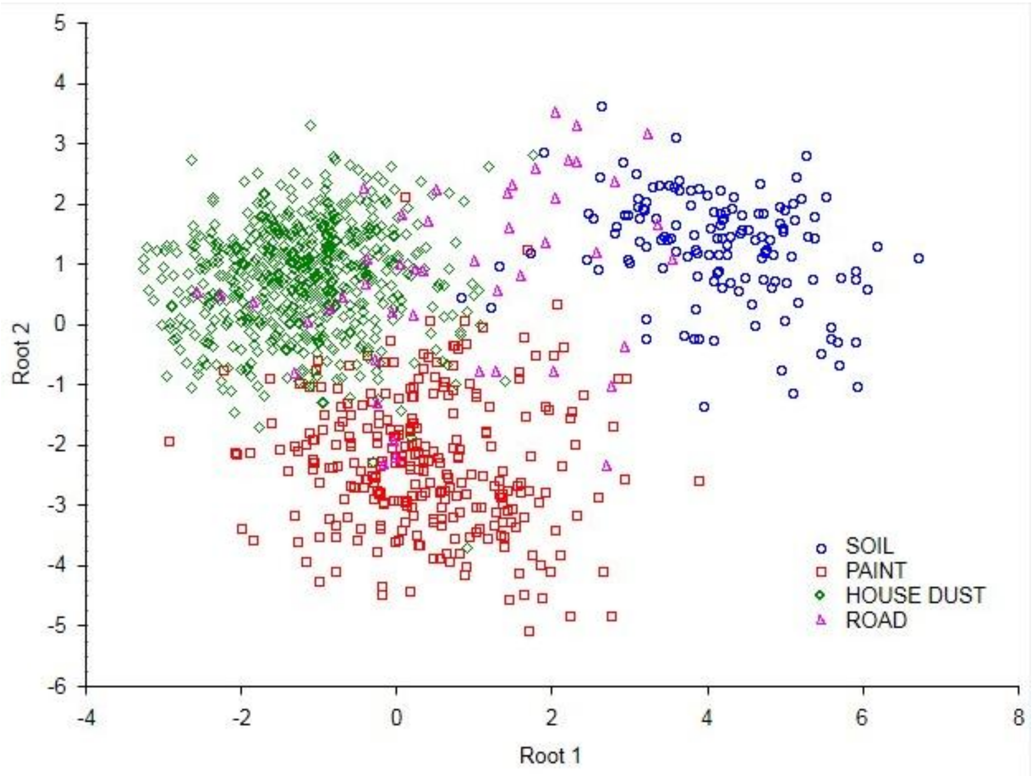


Figure 4-2 House B CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-6 House B Paint Pb Particle Class

Class Name	Pb Particle Class	No
Pb + Others Class	PbNa	2
	PbSi	2
	PbSiFe	1
	PbSiMg	1
PbTi + Others Class	PbTi	2
	PbTiSi	1
PbZnBa + Others Class	PbZnBa	1
	PbZnBaSi	1

Table 4-6 -*Continued*

	PbZn	49
	PbZnCa	1
	PbZnCl	15
	PbZnFe	2
	PbZnSi	15
	PbZnSiAl	3
	PbZnCaCl	1
	PbZnClFe	1
	PbZnClSi	7
	PbZnSiMg	5
	PbZnSiMgFe	1
	PbZnSiMgP	1
	PbZnSiAlMg	1
	PbZnSiClFe	1
	PbZnCaClSi	1
	PbZnClCaFe	1
	PbZnClSiFe	2
	PbZnClSiMg	2
	PbZnSiAlFe	2
	PbZnSiAlK	1
	PbZnSiMgCaFe	1
	PbZnSiAlClFe	1
	PbZnCaClKFe	1
	PbZnCaSiClMg	1
	PbZnCaSiAlClMgFe	1
PbZn + Others Class	PbZnCaSiAlKClMgFe	1
	PbZnCrSi	1
	PbZnCrSiCl	1
PbZnCr + Others Class	PbZnCrCaSiMgFe	1

Table 4-6 - *Continued*

PbZnTi + Others Class	PbZnTi	6
	PbZnTiFe	1
	PbZnTiSi	7
	PbZnTiSiAl	1
	PbZnTiCaSi	2
	PbZnTiSiMg	2
	PbZnTiSiMgFe	2
	PbZnTiSiAlMg	1
	PbZnTiCaSiMg	3
	PbZnTiSiAlMgFe	1
	PbZnTiCaSiAlMgFe	1
	PbZnTiCaSiAlKMgP	1
PbZnTiCr + Others Class	PbZnTiCrSiClMg	1
	PbZnTiCrCaSiMgFe	1
	PbZnTiCrCaSiClMg	2

Table 4-7 House B Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbTi + Others Class	PbTi Only	23
	PbTiSi	6
	PbTiFe	2
	PbTiSiAl	2
	PbTiSiFe	3
	PbTiSiMg	21
	PbTiSiCa	1
	PbTiSiMgFe	24
	PbTiSiMgAl	2
	PbTiSiMgCa	4
	PbTiSiAlK	1
	PbTiFeSiCa	1
	PbTiSiCaMgFe	19

Table 4-7 - *Continued*

PbTi + Others Class	PbTiSiAlMgFe	6
	PbTiSiAlMgCa	1
	PbTiSiMgFeCaAl	3
	PbTiCaSiAlMgKFe	2
	PbTiCaSiAlMgFeZn	1
Pb + Others Class	PbCl	1
	PbCaPSiAlFe	1
	PbCaPSiAlK	1
	PbCaPSiAlMgFe	1

House C *(Projected Window Paint Source, moderate- condition)*

Results for the House C media for the descriptive apportionments and the discriminant analysis are set out in Table 4-8. The Pb content of the target and other paints from the property are set out in Appendix C. Here the source attribution investigates the the target paint, the soil and the road dust as the projected contributing sources of particulate lead to the indoor floor dust. The target paint had a Pb content of 24,599 ppm, the soil had a Pb content of 460 ppm, and no road dust was collected at this location. Operator collected data in the form of images and X-ray element data from the particles analysed in the media from this location are set out in Appendix C. The analyzed particles from the target paint produced 45 groups, or classes, of lead particles "types" (in each class the particle compositions were unique and/or similar) (Table 4-9). In the soil 22 classes of lead particles were identified (Table 4-10). There were no road dust classes from this location. The additional class called "unattributed Pb" was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-8. In the class assignments of the operator analyzed particles the greatest percentage of lead particles by far were assigned to the paint class and under 20% were assigned to the unattributed Pb class. These unattributed particles could be derived from the paint source. In the discriminant analysis the floor dust lead particle assignments were different. The individual lead particle information for the first two discriminant functions is set out in Figure 4-3. The graph shows overlap between groups. But, the paint particles do form a separate group. Again, road dust Pb particles used in the discriminant analysis were not site specific but were the aggregate data from all the analyzed roaddusts. In the discriminant analysis, when the floor dust lead particles were not coded as a group, the individual particles were assigned to the nearest other group. The percentage number assignments for the floor dust particles are also set out in Table 4-8. The floor dust particles were primarily classed as mostly having a paint origin, and the rest having a road dust or soil origin. In a second analysis with the road dust code eliminated the floor dust lead particles were largely classified as lead paint particles, with a smaller percentage classified as soil. Interestingly in this classification the paint attribution was not much greater while the soil classification increased three-fold.

Table 4-8 House C Descriptive Apportionment and Discriminant Analysis Data

	Window Paint	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	77%	5%	0%	18%
Dust Discrim classification	62%	12%	26%	NA
Dust Discrim Classification without Road	64%	36%	-	NA

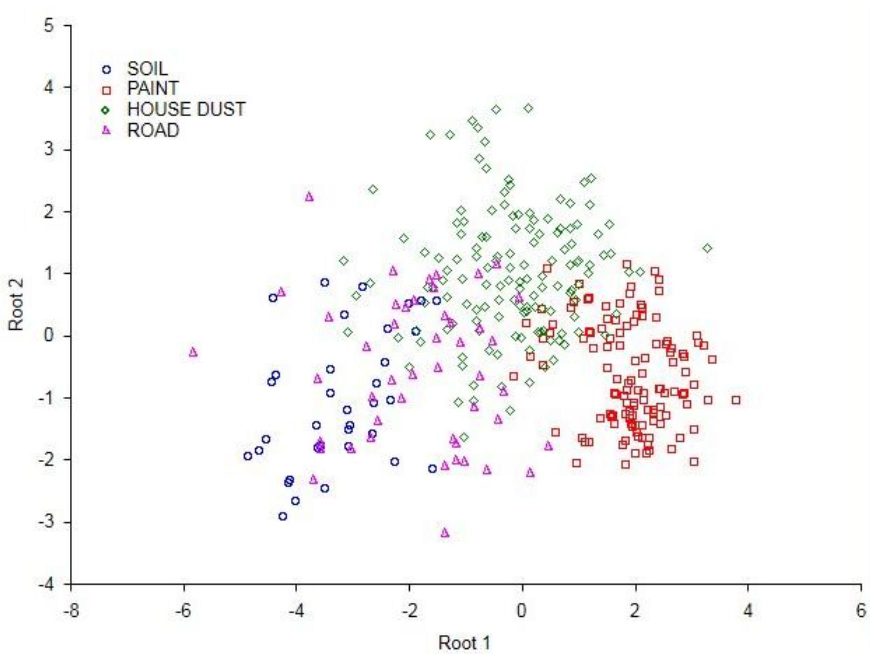


Figure 4-3 House C CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-9 House C Paint Pb Particle Class

Class Name	**Pb Particle Class**	**No**
	PbCrCaSi	1
	PbCrSiFe	1
PbCr + Other Class	PbCrSiAlMgNa	1
	PbZn Only	5
	PbZnCa	1
PbZn + Other Class	PbZnSiMg	1
	PbTi	3
	PbTiCa	1
	PbTiSiMg	3
	PbTiSiNa	1
	PbTiCaSiMg	2
	PbTiSiMgNa	1
	PbTiCaSiMgNa	3
PbTi + Other Class	PbTiCaSiMgPNa	1

Table 4-9 - *Continued*

PbZnTi + Other Class	PbZnTi Only	11
	PbZnTiSi	2
	PbZnTiCaSi	1
	PbZnTiSiMg	7
	PbZnTiCaSiMg	13
	PbTiZnSiP	1
	PbZnTiSiAlMg	1
PbCrTi + Other Class	PbCrTiCaSi	2
	PbCrTiSiMg	1
	PbCrTiCaSiMg	2
	PbCrTiCaSiAlMg	1
	PbCrTiCaSiAlMgNa	1
	PbCrTiCaSiAlMgFe	2
	PbCrTiCaSiAlMgNaFe	2
	PbCrTiCaSiAlKMgFeNa	1
PbCrBa + Other Class	PbCrBaCaSi	4
	PbCrBaCaSiMg	1
	PbCrBaSiAl	1
	PbCrBaMgSi	3
	PbCrBaCaSiAlFe	1
	PbCrBaCaSiAlMg	1
	PbCrBaCaSiFeMg	1
	PbCrBaSiAlMgFe	1
	PbCrBaCaSiAlMgFe	5
	PbCrBaCaSiMgNaP	1
PbZnBa + Other Class	PbZnBa	1
	PbBaZnCaSi	1
	PbZnBaCaSiMg	1
	PbZnBaCrCaSiAlMgFe	1
Pb + Other Class	PbFe	1
	PbBaCa	1

Table 4-10 House C Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbCaP + Other Class	PbCaP	5
	PbCaPSi	1
	PbCaPNa	1
	PbCaPSiAl	1
	PbCaPSiFe	1
	PbCaPSiAlNa	1
	PbCaPSiAlMn	1
	PbCaPSiAlFe	1
	PbCaPSiAlKFe	2
	PbCaPSiAlFeMn	1
	PbCaPSiAlKFeMg	3
	PbCaPSiAlKFeNa	1
	PbCaPSiAlClMgFe	1
PbTi + Other Class	PbTiSi	2
	PbTiCaPSiAlMgFeNa	1
PbZnCaP + Other Class	PbZnCaPAl	1
	PbZnCaPSiAlFe	1
	PbZnCaPSiAlMgFe	1
	PbZnCaPSiAlKMgFe	1
	PbZnCaPSiAlKMgFeMn	3
PbCr + Other Class	PbCrCaP	1
Pb + Other Class	PbSiAlKFeMg	1

House E *(Projected Window Paint Source, intact- condition)*

Results for the House E media for the descriptive apportionments and the discriminant analysis are set out in Table 4-11. The Pb content of the target and other paints from the property are set out in Appendix D. Here the source attribution investigates the the target paint, the soil and the road dust as the projected contributing sources of particulate lead to the indoor floor dust. The target paint had a Pb content of 95,690 ppm, the soil had a Pb content of 2,602 ppm, and the road dust 275 ppm. Operator collected data in the form of images and X-ray element data from the particles analysed in the media from this location are set out in Appendix D. The analyzed particles from the target paint produced 21 groups, or classes, of lead particles "types" (Table 4-12). In the soil 42 classes of lead particles were identified (Table 4-13) and in the road dust material 2 classes were defined (Table 4-14). The "unattributed Pb" was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-11 In the class assignments of the operator analyzed particles, just under three quarters of the floor dust lead particles were assigned to the paint class and just over 20% were assigned to the unattributed Pb class. These unattributed particles could be derived from the paint source. Soil class assignments accounted for less than 5%. In the discriminant analysis the floor dust lead particle assignments were different. The individual lead particle information for the first two discriminant functions is set out in Figure 4-4. The graph shows some overlap between groups, but there was a clear separation between some groups. Again, road dust Pb particles used in the discriminant analysis were not site specific but were the aggregate data from all the analyzed road dusts. At House E, the discriminant classification has similar numbers of house dust lead particles assigned to the soil and paint classes, but road dust classes dominated with almost70% of the floor dust particles be assigned as such. In the discriminant analysis, when the floor dust lead particles were not coded as a group, the percentage number assignments for the floor dust particles (Table 4-11) was a large increase in floor dust lead particles assigned to the soil lead particle classes.

Table 4-11 House E Descriptive Apportionment and Discriminant Analysis Data

	Window Paint	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	73%	4%	0%	23%
Dust Discrim classification	18%	14%	68%	NA
Dust Discrim Classification without Road	33%	67%	-	NA

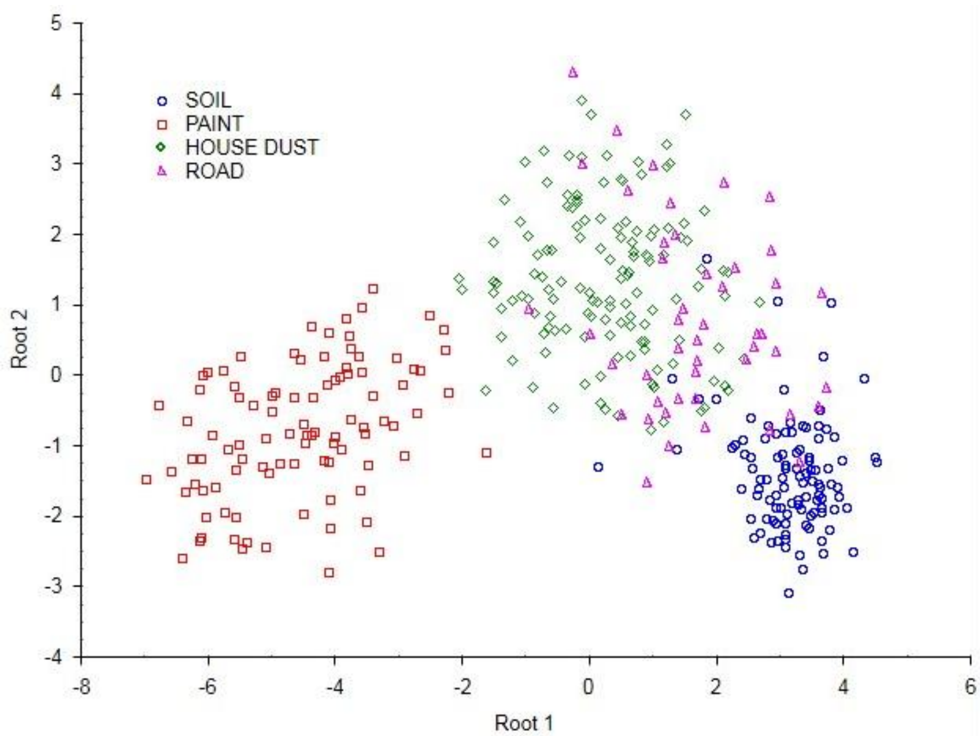


Figure 4-4 House E CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-12 House E Paint Pb Particle Class

Class Name	Pb Particle Class	No
	PbZn	25
	PbZnCa	6
	PbZnCl	12
	PbZnSiCa	1
	PbZnSiAlCl	5
PbZn + Other Class	PbZnSiClMg	1
	PbTi	1
	PbTiCa	3
PbTi + Other Class	PbZnBa	3
	PbZnBaSi	1
	PbZnBaCaSi	1
PbZnBa + Other Class	PbZnBaCaSiMg	1

Table 4-12 – *Continued*

PbZnTi + Other Class	PbZnTi	3
	PbZnTiCa	8
	PbZnTiCaCl	1
	PbZnTiCaSi	1
	PbZnTiSiAl	1
	PbZnTiSiCl	1
	PbZnTiCaSiAl	3
Pb + Other Class	PbCa	1
	PbCaSiAl	1

Table 4-13 House E Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbCaP + Other Class	PbCaP	4
	PbCaPSi	1
	PbCaPCl	1
	PbCaPSiAl	4
	PbCaPSiAlMg	1
	PbCaPSiAlFe	3
	PbCaPSiAlNa	1
	PbCaPSiAlK	2
	PbCaPSiAlKFe	3
	PbCaPSiAlMnCl	1
	PbCaPSiAlFeNa	1
	PbCaPSiAlKFeMg	1
	PbCaPSiAlNaFeCl	1
	PbCaPSiAlKMgFe	1
	PbCaPSiAlKFeMgNa	2
	PbCaPSiAlKMgFeCl	1
Pb + Other Class	PbPSiAlFe	1
	PbCaMnCl	1
	PbCaSiFe	1
	PbCaAlZnMg	1

Table 4-13 –*Continued*

Pb + Other Class	PbCaSiAlZnMg	1
	PbCaSiAlFeZnCl	1
	PbCaSiAlKZnFeMg	1
PbZnCaP + Other Class	PbCaPSiAlZn	5
	PbCaPAlFeZn	1
	PbCaPSiAlKZn	1
	PbCaPSiAlFeZn	11
	PbCaPSiAlKZn	1
	PbCaPSiAlMnZnFe	4
	PbCaPSiAlKZnFe	1
	PbCaPSiAlZnFeMg	2
	PbCaPSiAlZnFeCl	1
	PbCaPSiAlKFeMnZn	13
	PbCaPSiAlFeMnZnCl	1
	PbCaPSiAlFeMgZnMn	1
	PbCaPSiAlKFeMnZn	1
	PbCaPSiAlKMnZnMg	1
	PbCaPSiAlKMnZnMgFe	4
	PbCaPSiAlKZnMgFeCl	2
	PbCaPSiAlKZnFeMnCl	1
PbTiCaP + Other Class	PbCaPSiAlKFeMgTi	1
	PbCaPSiAlKZnMgFeTi	6

Table 4-14 House E Road Dust Pb Particle Class

Class Name	Pb Particle Class	No
Pb + Other Class	PbCa	1
	PbSiCaPAl	1

House J *(Projected Floor Paint Source, poor condition)*

Results for the House J media for the descriptive apportionments and the discriminant analysis are set out in Table 4-15. The Pb content of the target and other paints from the property are set out in Appendix E. The target paint had a Pb content of 31,088 ppm, the soil had a Pb content of 325 ppm, and the road dust 597 ppm. Operator collected data in the form of images and X-ray element data from the particles analysed in the media from this location are set out in Appendix E. The analyzed particles from the target paint produced 27groups, or classes, of lead particle “types” (Table 4-16). In the soil 27 classes of lead particles were identified (Table 4-17) and in the road dust material 8 classes were defined (Table 4-18). The additional class called “unattributed Pb” was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-15. In the class assignments of the operator analyzed particles (descriptive apportionment) the majority of the lead particles were assigned to the paint classes and the soil classes. Unlike the other homes, house J had an insignificant percentage unattributed Pb particles like the plots for the other houses shows a separation of soil and paint group, with the house dust and road dust falling between the soil and paint groups in the discriminant space. Not surprisingly the closeness of the road dust and floor dust Pb-particles resulted in the floor dust lead particles (when not group coded) being classified mostly as road dust (Figure 4-5). A significant fraction of the floor dust lead particles were also classified as paint, while less than 10% were classified as soil. Interestingly, removing the road dust code resulted in more floor dust particles being assigned to the soil group than the paint group.

Table 4-15 House J Descriptive Apportionment and Discriminant Analysis Data

	Floor Paint	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	70%	27%	0%	3%
Dust Discrim classification	39%	8%	53%	NA
Dust Discrim Classification without Road	47%	53%	-	NA

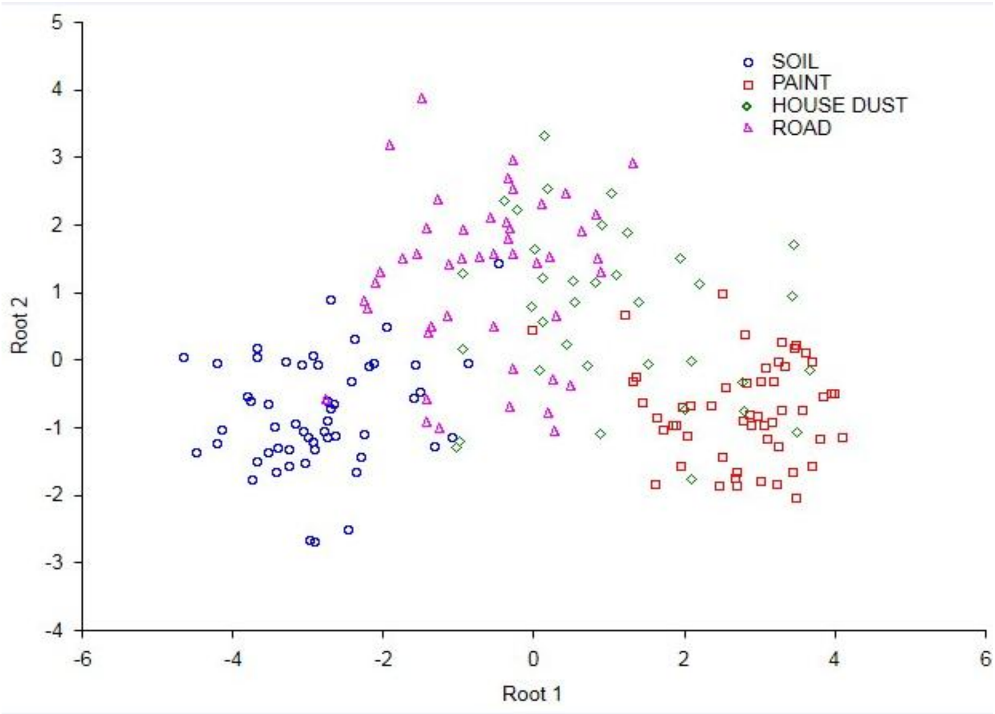


Figure 4-5 House J CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-16 House J Paint Pb Particle Class

Class Name	Pb Particle Class	No
PbCr + Other Class	PbCr	1
	PbCaCrFe	6
	PbCrCaFeNa	1
	PbCrSiAlKMgFeNa	1
PbZnCr + Other Class	PbZnCr	1
	PbZnCrCa	1
PbZn + Other Class	PbZnCl	1
	PbZnSi	1
	PbZnCaMg	1
	PbZnSiAl	1
	PbZnCaSiMg	1

Table 4-16 - *Continued*

PbZnTi + Other Class	PbZnTi	2
	PbZnTiCaSiMg	1
	PbZnTiSiAlCl	1
PbTiCr + Other Class	PbCaCrTi	1
	PbCaTiCrFe	22
	PbTiCrCaFeNa	1
	PbTiCrCaFeCl	2
	PbTiCrCaFeSi	1
	PbTiCrCaFeMgNa	1
	PbTiCrCaSiMgFe	1
	PbTiCrCaSiAlFeMgNa	1
	PbTiCrCaSiAlKFeMgNa	1
PbZnTiCr + Other Class	PbZnTiCrSi	1
	PbZnTiCrCaFe	3
	PbZnTiCrCaFeSi	2
	PbZnTiCrCaSiMgFe	1

Table 4-17 House J Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbCl + Other Class	PbCl	1
	PbClMn	1
	PbClSiMn	1
	PbClCaSiMgFe	1
	PbClMnSiAlKMg	1
	PbClCaMnSiAlNa	1
	PbClCaMnSiAlKMg	2
	PbClCaMnSiAlKMgFe	8
	PbClCaMnSiAlKMgFeP	4
	PbClCaMnSiAlKMgFeNa	1
	PbClCaMnSiAlKMgFePNa	2

Table 4-17 - *Continued*

PbCaP + Other Class	PbCaSiAlFeP	1
	PbCaSiAlNaFeP	1
	PbCaSiAlMgFeP	1
	PbCaSiAlMgNaP	2
	PbCaSiAlKMgFeNaP	4
	PbCaSiAlKMgFeP	2
	PbCaSiAlMgFeNaP	2
	PbCaMnSiAlKMgFeP	1
	PbCaMnSiAlKMgFeNaP	4
PbTi + Other Class	PbSiMgFeTi	1
	PbCaSiAlMgFeNaTiP	1
	PbClCaMnSiAlKMgTiP	1
	PbClCaMnSiAlKMgFeTi	1
PbZnCaP + Other Class	PbCaSiAlKMgFeZnP	2
	PbClCaSiAlFeZnP	1
	PbClCaMnSiAlMgFeZnP	1

Table 4-18 House J Road Dust Pb Particle Class

Class Name	Pb Particle Class	No
PbCl + Other Class	PbCl	2
	PbClCaK	1
	PbClSiSn	1
	PbClSiCaAl	1
	PbClSiCaAlMgFe	2
	PbClSiAlMgFeKMn	1
Pb + Other Class	PbSiCaAlMgFeK	2
	PbSiCaAlMgFeKNa	1

House K *(Projected Floor Paint Source, moderate condition)*

Results for the House K media for the descriptive apportionments and the discriminant analysis are set out in Table 4-19. The Pb content of the target and other paints from the property are set out in Appendix F. The target paint had a Pb content of 37,680 ppm, the soil had a Pb content of 310 ppm, and the road dust 478 ppm. Operator collected data in the form of images and X-ray element data from the particles analysed in the media from this location are set out in Appendix F. Here the source attribution investigates the target paint and the soil as the projected contributing sources of particulate lead to the indoor floor dust. The analyzed particles from the target paint produced 28 classes of lead particles "types" plus 2 classes of lead particles from the analysis of the soil (Table 4-20 and Table 4-21), and there were no road dust classes from this location. The additional class called "unattributed Pb" was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-19. In the supervised descriptive apportionment over 95% of the floor dust lead particles were assigned to the paint class. As this was a floor dust sample from a floor with a coat of lead based paint this perhaps not surprising. The discriminant plot for the media sampled for house K is set out in Figure 4.6. Here, because of the lack of Pb particles found in the CCSEM analysis of House K soil, it was decided that all CCSEM characterized soil lead particles from this study would be included in this discriminant analysis. The group separation is striking, but perhaps the discriminant classification was (possibly) less successful than the descriptive apportionment with just 75% and 24% of the floor dust Pb particles being classified as paint-lead and soil-lead respectively (Table 4-19). Removing the road dust lead coding resulted in the discriminant classification assigning more of the House K floor dust Pb particles to the soils group than the target paint group. This is a somewhat suspect outcome.

Table 4-19 House K Descriptive Apportionment and Discriminant Analysis Data

	Floor Paint	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	96%	2%	0%	2%
Dust Discrim classification	75%	24%	1%	NA
Dust Discrim Classification without Road	59%	41%	-	NA

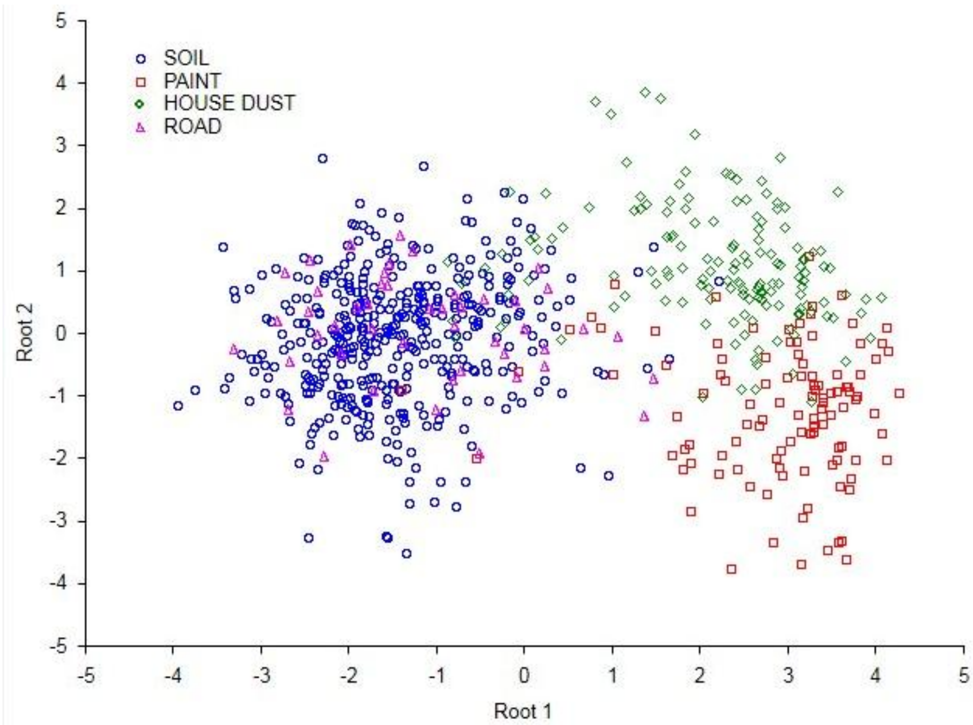


Figure 4-6 House K CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-20 House K Paint Pb Particle Class

Class Name	Pb Particle Class	No
PbCr + Other Class	PbCr	8
	PbCrFe	2
	PbCrAl	1
	PbCrCaFe	2
	PbCrSiAlCl	1
PbZn + Other Class	PbZn	2
	PbZnSiAl	2
	PbZnFe	1
	PbZnCaSiAlFe	1
	PbZnCaSiAlKFe	1
PbBaCr +Other Class	PbBaCr	1
	PbBaCrFeNa	1

Table 4-20 - *Continued*

PbCrZn + Other Class	PbCrZn	10
	PbCrZnFe	5
	PbCrZnSi	1
	PbCrZnSiFe	1
	PbCrZnCaSiAlFeMg	1
PbZnBa + Other Class	PbZnBa	2
	PbZnBaSiFe	1
PbZnBaCr + Other Class	PbZnBaCr	3
	PbZnBaCrFe	24
	PbZnBaCrSiFe	18
	PbZnBaCrCaFe	6
	PbZnBaCrSiAl	2
	PbZnBaCrSiAlFe	5
	PbZnBaCrCaSiAlFe	2
PbZnTiCr + Other Class	PbZnTiCrFe	1

Table 4-21 House K Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbClCaP + Other Class	PbCaPSiAlClMgFe	1
PbCaP + Other Class	PbCaPSiAlKMgFe	1

House L *(Projected Floor Paint Source, intact condition)*

Results for the House L media for the descriptive apportionments and the discriminant analysis are set out in Table 4-22. The Pb content of the target and other paints from the property are set out in Appendix G. The target paint had a Pb content of 322,565 ppm, the soil had a Pb content of 2,292 ppm, and the road dust 206 ppm. Operator collected particle data in the form of images and X-ray element data in the media from this location are set out in Appendix G. Here the source attribution investigates the target paint, and the soil as the projected contributing sources of particulate lead to the indoor floor dust. The analyzed particles from the target paint produced 53 classes of lead particles "types" plus 1 class of lead particles from the analysis of the soil (Table 4-23 and Table 4-24), and there were no road dust classes from this location. The additional class called "unattributed Pb" was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-22. In the supervised descriptive apportionment 75% of the floor dust lead particles were assigned to the paint class, and 24% was assigned to the "unattributed Pb" class. As this was a floor dust sample from a floor with a coat of lead based paint this perhaps assignment of floor dust lead particles to paint and "unattributed Pb"might be expected. The discriminant plot for the media sampled for House L is set out in Figure 4.7. Here, because of the lack of Pb particles found in the CCSEM analysis of House L soil, it was decided that all CCSEM characterized soil lead particles from this study would be included in this discriminant analysis. The group separations are not major but they do occupy separate areas on the discriminant plot. The discriminant classification was very different from the descriptive apportionments. Only just over 10% of the floor dust particles were classified as paint and the majority was classified as soil (Table 4-22).Removing the road dust lead coding resulted in almost no change in the classifications.

Table 4-22 House L Descriptive Apportionment and Discriminant Analysis Data

	Floor Paint	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	75%	1%	0%	24%
Dust Discrim classification	11%	88%	1%	NA
Dust Discrim Classification without Road	12%	88%	-	NA

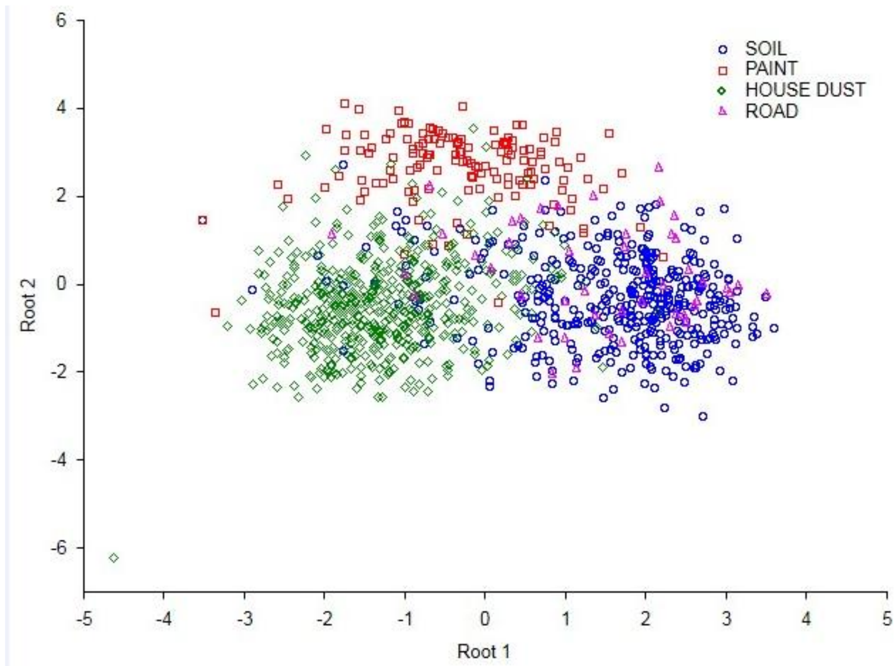


Figure 4-7 House L CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-23 House L Paint Pb Particle Class

Class Name	Pb Particle Class	No
PbTi + Others	PbTi	3
	PbTiNa	1
	PbTiCa	1
	PbTiCaFe	1
	PbTiCaSiAlNa	1
PbZn + Others	PbZn	4
	PbZnCa	3
	PbZnP	5
	PbZnSiP	1
	PbZnSiAl	2
	PbZnCaMg	1
	PbZnCaP	2
	PbZnCaPCl	1
	PbZnCaPFe	2
	PbZnCaSiAlKPCl	1

Table 4-23 – *Continued*

PbZnTi + Other Class	PbZnTi	10
	PbZnTiCa	4
	PbZnTiCl	10
	PbZnTiP	1
	PbZnTiSi	1
	PbZnTiFe	1
	PbZnTiSiMg	2
	PbZnTiCaSi	3
	PbZnTiCaCl	3
	PbZnTiSiCl	1
	PbZnTiCaK	1
	PbZnTiClFe	1
	PbZnTiCaP	2
	PbZnTiCaSiAl	1
	PbZnTiCaSiMg	3
	PbZnTiSiClFe	1
	PbZnTiClSiMg	1
	PbZnTiCaClP	1
	PbZnTiCaPFe	1
	PbZnTiCaSiAlP	1
	PbZnTiCrCaSiMg	1
	PbZnTiCaSiPFe	1
	PbZnTiCaSiAlKP	1
	PbZnTiCaSiAlMgPFe	1
PbZnBa + Other Class	PbZnBa	3
	PbZnBaCa	3
	PbZnBaSi	1
	PbZnBaSiCa	2
	PbZnBaCaFe	1
	PbZnBaSiFe	1
	PbZnBaSiP	1
	PbZnBaCaSiPCl	1
Pb + Other Class	PbCa	3
	PbSi	3
	PbSiP	1

Table 4-23 – *Continued*

Pb + Other Class	PbCaSiAl	1
	PbSiAlK	1
	PbCaClPFeNa	1

Table 4-24 House L Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbCaP + Other Class	PbCaPSiAlKCaFe	1

House O *(Projected Window and Floor Paint Sources)*

Results for the House O media for the descriptive apportionments and the discriminant analysis are set out in Table 4-25. In this home there were two target paints, one was a window frame paint, the other was a floor paint. The Pb content of the target and other paints from the property are set out in Appendix H. The target paint1 (porch Window) had a Pb content of 25,934 ppm and paint 2 (floor) had a Pb content of 163,111ppm. There was no soil on this property, and the road dust had 400 ppm lead. Operator collected data are set out in Appendix H. The analyzed particles from the target paint1 and paint2 produced 24 groups and53 groups respectively of lead particles (Table 4-26 and Table 4-28). In the road 3 classes of lead particles were identified (Table 4-27) and there were no soil classes from this location. The additional class called “unattributed Pb” was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-25. In the class assignments of the operator analyzed particles the greatest percentage of lead bearing particles were assigned to floor paint classes. While only 1% of the lead-bearing particles were assigned to the window paint classes, 9% of particles had compositions that matched classes that overlapped the two paints. The dominance of the floor paint is highlighted in the picture below (Figure 4-9) where it is obvious that the paint on the floor is in a poor state of repair. In the discriminant analysis, only the two paints, the floor dust and the road dust were included. No soil data was included in this analysis. The source groups and the receptor group on the two major discriminant functions are set out in Figure 4-8. The plot shows minor overlap between the paint groups, but obvious overlap with the floor dust and road dust groups (road dust Pb particles were not site specific). In the discriminant analysis, when the floor dust lead particles were not coded as a group, the individual particles were assigned to the nearest other group. The percentage number assignments for the floor dust particles are also set out in Table 4-25. The discriminant classification was very similar to the descriptive apportionments

Table 4-25 House O Descriptive Apportionment and Discriminant Analysis Data

	Paint 1 Window	Paint 2 Floor	Paint 1 or Paint 2	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	1%	75%	9%	NA	0%	15%
Dust Discrim classification	5%	90%		NA	5%	NA

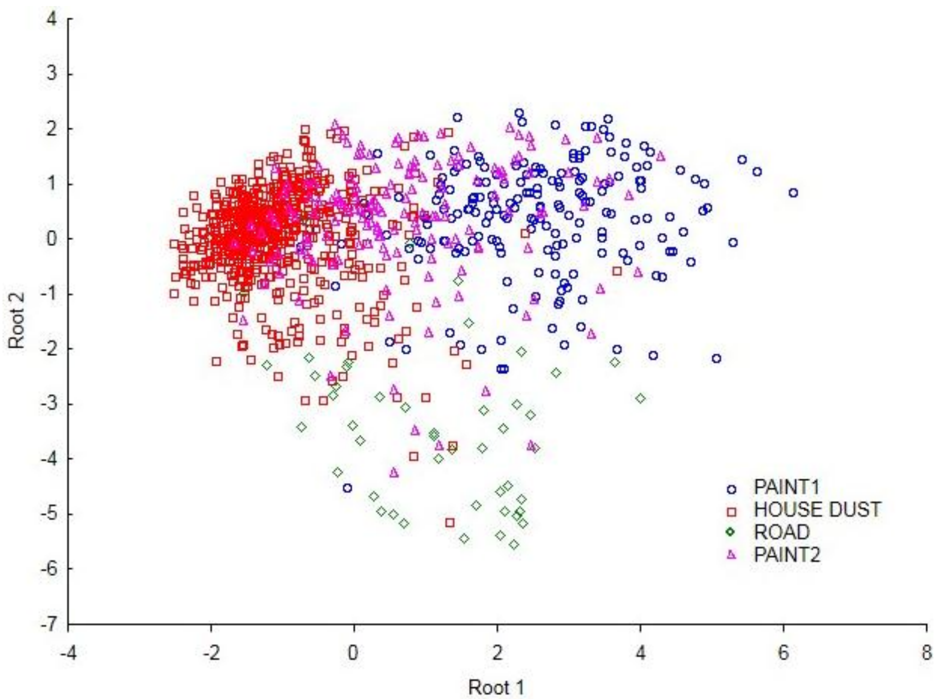


Figure 4-8 House O CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-26 House O Paint1 Pb Particle Class

Class Name	Pb Particle Class	No
PbTi + Other Class	PbTi	18
	PbTiNa	1
	PbTiSiMg	3
	PbTiSiAlMg	1
	PbTiSiMgNa	1
PbZn + Other Class	PbZn	3
	PbZnCl	1
	PbZnMg	1
	PbZnSiAlP	1
PbTiZn + Other Class	PbTiZn	30
	PbTiZnSi	3
	PbTiZnCaSi	2
	PbTiZnSiMg	35
	PbTiZnSiAl	1
	PbTiZnCaSiMg	19
	PbTiZnSiAlMg	3
	PbTiZnCaSiAlMg	1
	PbTiZnCaSiAlMgFe	2
PbZnBa + Other Class	PbZnBaSi	1
Pb + Other Class	PbP	1
	PbPNa	1
	PbSiMg	1
	PbCaSiMg	1
	PbCaSiAlKPMgFeNa	1

Table 4-27 House O Road Dust Pb Particle Class

Class Name	Pb Particle Class	No
PbZn + Other Class	PbZnSiCl	1
	PbZnSiAlFe	1
Pb + Other Class	PbCaSiAlKCl	1

Table 4-28 House O Paint2 Pb Particle Class

Class Name	Pb Particle Class	No
PbBa + Other Class	PbBa	3
	PbBaNaP	2
	PbBaSiMgNaP	1
PbTi + Other Class	PbTi	3
	PbTiSi	1
	PbTiCaP	1
	PbTiSiP	1
	PbTiCaNaP	1
	PbTiSiMgNa	1
	PbTiCaSiNaP	1
	PbTiCaSiAlNaP	1
	PbTiCaSiMgNaP	1
PbZn + Other Class	PbZn	18
	PbZnP	6
	PbZnSiP	2
	PbZnCaP	6
	PbZnClP	6
	PbZnSiAl	1
	PbZnSiMg	5
	PbZnSiMgP	3
	PbZnCaClP	2
	PbZnCaSiMg	1
	PbZnCaSiClP	1
	PbZnSiClMgP	1
	PbZnCaSiMgP	2
	PbZnCaSiAlFeP	1
	PbZnCaSiAlClFeP	1
PbZnBa + Other Class	PbZnBa	4
	PbZnBaSi	3
	PbZnBaCaP	1
	PbZnBaSiP	1
	PbZnBaSiMg	2
	PbZnBaSiAlP	1
	PbZnBaCaClP	2

Table 4-28 – *Continued*

PbZnBa + Other Class	PbZnBaCaSiP	1
	PbZnBaSiMgFe	1
	PbZnBaCaSiMgP	3
	PbZnBaCaSiAlMgP	1
PbZnTi + Other Class	PbZnTiCaP	1
	PbZnTiSiAlP	1
	PbZnTiCaClP	3
	PbZnTiCaSiP	1
	PbZnTiCaSiMgP	3
	PbZnTiCaSiClMgP	1
	PbZnTiCaSiAlKFeP	1
Pb + Other Class	PbNaP	5
	PbSiMg	1
	PbSiP	1
	PbCaNaP	3
	PbNaClP	2
	PbNaSiP	3
	PbCaNaClP	1
	PbSiAlKNaP	1

Figure 4-9 House O Poor Condition of Floor Paint

House P *(Projected Door and Floor Paint Sources)*

Results for the House P media for the descriptive apportionments and the discriminant analysis are set out in Table 4-29. In this house there were two target paints, one was a door frame paint (paint 1), the other was a floor paint (paint 2). The Pb content of the target and other paints from the property are set out in Appendix I. The target paint1 had a Pb content of 50,687 ppm and paint 2 had a Pb content of 6,240ppm. The soil had a Pb content of 1,340 ppm, and the road dust 210 ppm. Operator collected individual particle data from media from this location are set out in Appendix I. The analyzed particles from the target paint1 and paint2 produced 27 groups and 46 groups respectively (Table 4-30 and Table 4-31). In the soil 17 classes of lead particles were identified (Table 4-32) and there were no road classes from this location. The additional class called “unattributed Pb” was also used. The percentage of the lead particles in the floor dust matching the classes types are set out in Table 4-29. In the class assignments of the operator analyzed particles, percentages in the paint classes were not significant, the largest percentage assignment was in the “unattributed Pb” class. We posit that in all likelihood these indistinguishable lead particles were likely to be paint pigment from one of the paint sources. Surprisingly, a higher percentage of lead bearing particles were assigned to the door paint classes compared to the floor paint classes, as one might imagine the floor to be a higher impact surface.

In the discriminant analysis the individual lead particle information for the first two discriminant functions is set out in Figure 4.10. The plot shows overlap for all groups, although it is less for the (all particle) soil group. In the analysis, when the floor dust lead particles were not coded as a group, the individual particles were assigned to the nearest other group (Table 4-29). Unlike the descriptive apportionment a greater percentage of the floor dust Pb was classified as floor paint. Nevertheless, the soil and road dust classes recorded higher percentages. This seems to be a problematic result given that there are two indoor lead-paint sources in the home. Then the road dust code was removed from the analysis and the resulting classification was dominated by soil (Table 4-29).

Table 4-29 House P Descriptive Apportionment and Discriminant Analysis Data

	Paint 1 Door	Paint 2 Floor	Paint 1 or Paint 2	Yard Soil	Road Dust	Unattributed Pb
Descriptive Apportionment	19%	5%	3%	25	0%	48%
Dust Discrim classification	13%	23%	NA	34%	30%	NA
Dust Discrim classification	24%	21%	NA	55%	NA	NA

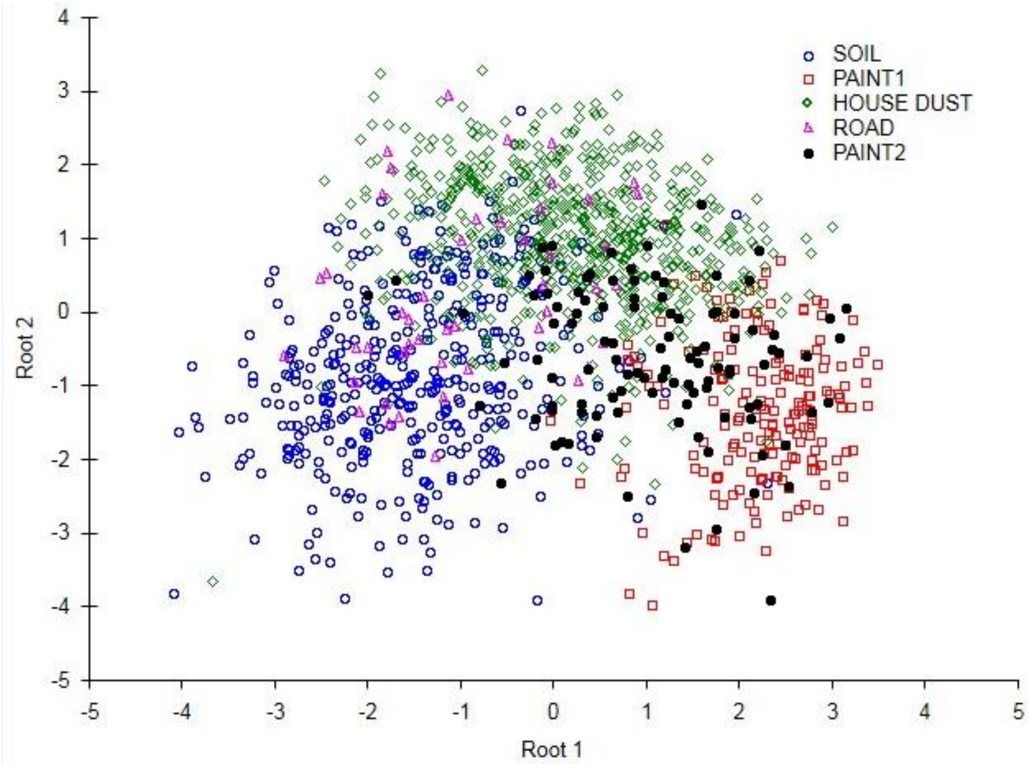


Figure 4-10 House P CCSEM Data Plotted on the Principal Discriminant Functions

Table 4-30 House P Paint1 Pb Particle Class

Class Name	Pb Particle Class	No
PbZn + Other Class	PbZn	87
	PbZnCa	5
	PbZnP	1
	PbZnSi	9
	PbZnCaSi	1
	PbZnSiAl	2
	PbZnSiMg	13
	PbZnSiPMg	2
	PbZnCaAlP	1
	PbZnCaSiMg	10
	PbZnCaSiMgP	2

Table 4-30 - *Continued*

PbZn + Other Class	PbZnCaSiMgCl	1
	PbZnCaSiMgKP	1
	PbZnCaSiAlKP	1
PbZnBa + Other Class	PbZnBa	4
	PbZnBaSi	2
	PbZnBaCa	2
	PbZnBaCaP	1
	PbZnBaCaSi	3
	PbZnBaSiMg	1
	PbZnBaCaSiMg	2
	PbZnBaCaSiPMg	2
PbZnTi + Other Class	PbZnTiCa	8
	PbZnTiCaSi	2
	PbZnTiCaSiAl	2
	PbZnTiCaSiAlMg	2
	PbZnTiCaSiMg	4

Table 4-31 House P Paint2 Pb Particle Class

Class Name	**Pb Particle Class**	**No**
PbZn + Other Class	PbZn	20
	PbZnMg	1
	PbZnSiMg	4
	PbZnCaP	2
	PbZnCaCl	1
	PbZnCaSiP	2
	PbZnCaPCl	4
	PbZnCaSiPCl	1
	PbZnCaSiAlMg	1
	PbZnCaSiClMgFe	1
	PbZnCaSiMgFe	2
	PbZnCaSiKPMg	1
	PbZnCaSiPMgCl	1
	PbZnCaSiAlKMgFe	1

Table 4-31 - *Continued*

Pb + Other Class	PbPNa	4
	PbCaPNa	4
	PbClPNa	1
	PbSiPNa	1
	PbCakClNa	1
	PbCaPClNa	2
	PbCaSiKNaCl	1
PbTi + Other Class	PbTiCa	2
	PbTiCaNaP	1
	PbTiCaSiAl	1
PbTiCr + Other Class	PbTiCrCa	3
	PbTiCrCaNa	1
PbZnTiCr + Other Class	PbZnCrTiCa	1
	PbZnTiCrCaSi	2
	PbZnTiCrCaSiAlFe	1
PbZnBa + Other Class	PbZnBa	1
	PbZnBaCa	1
	PbZnBaSiMg	1
PbZnTi + Other Class	PbZnTi	1
	PbZnTiSi	2
	PbZnTiCa	1
	PbZnTiCaK	1
	PbZnTiCaSiMg	2
	PbZnTiCaSiPMg	1
	PbZnTiCaSiAlPCl	1
	PbZnTiCaSiAlPMg	1
	PbZnTiCaSiAlFeMg	1
	PbZnTiCaSiAlKMgFeCl	1
	PbZnTiCaSiAlPMgFeCl	1
PbCr + Other Class	PbCrCa	1
PbBa + Other Class	PbBaCaSiPNa	1

Table 4-32 House P Soil Pb Particle Class

Class Name	Pb Particle Class	No
PbTi + Others	PbTi	1
	PbTiCaSiAlPMgFe	1
PbCaP + Others	PbCa	1
	PbCaP	1
	PbCaClPSi	1
	PbCaPClNa	1
	PbCaPSiAl	1
	PbCaClPSiAl	3
	PbCaPClSiAlNa	1
	PbCaPSiAlKNa	1
	PbCaPClSiAlMgNa	1
	PbCaSiAlKPClMgFeNa	1
	PbCaSiAlKPClMgFeNa	1
PbZn + Other Class	PbZnClKSi	1
	PbZnSnSiAlPCuClFe	1
	PbZnCaSiAlKPClMgFe	1
PbCr + Others	PbCrCaSiAlKMgFe	1

4.2 Ancillary Sample Analyses Results

4.2.1 PbIC Floor Dust Lead Source Attribution

Since there are four isotopes, only six possible combinations of these four exist. Of these six, three can be calculated from knowing the other two, for example 207/204 ratio is the 206/204 divided by the 206/207. So, measuring and reporting only three ratios (for example the 206/204, 206/207 and 206/208 ratios) would have as much information as reporting.every one of the six possible ratios. The 206 and 207 isotopes are the accumulated result of the radioactive decay of uranium over geological time, and 208 comes from thorium decay, but 204 has no radiogenic precursor. For this reason, and considering all of the world's lead ores and the wide range of their geological ages, substantial variations in the isotope ratios exist. Furthermore, many of the ratios strongly co-vary. It was determined that ratios to be used would be: 206/207, 206/204 and 206/208. There is a very high inter-correlation among these three ratios. For that reason, often only one value is reported, since the others could be easily inferred and would offer only confirmatory information.

Mixing Model Calculations

The isotope ratios were used to determine the relative importance of each of the proposed sources to a sample, usually an indoor dust sample. This was done by a simple mixing model. The two proposed sources are considered as end-members on a mixing line. If the value for the sample falls on the value for one end-member, then that end-member supplied 100 percent of the lead to that sample. If the sample value falls half way between the two end-members, then the sample is composed of equal parts of each of the end -members.

In geometric terms, the end-members occupy points in three-dimensional space, each axis being a ratio; the x, y and z axis corresponding to the three isotope ratios. The mixing line runs between the two potential sources, and the sample's place on that line is determined by the relative importance of each end-member. Distances are calculated by the Pythagorean formula.

Although knowing only one ratio might be enough to resolve the importance of a source, here we use the data from all the ratios in calculating the mixing model. Each of the three ratios was examined separately, and for each ratio the relative importance of the potential sources was calculated. Thus three answers were obtained. They usually agreed very well, and the final result for that comparison would be the average of those three estimates. In geometric terms that would be the three-dimensional distance, each ratio being a dimension, between the two end-members and the sample lying between them. The detailed comparisons of the samples from each house were presented.

House A (Projected Window Paint Source, poor condition)

The three paint samples are all very similar, all much lower than the ambient average. The mid-yard and road samples resemble the ambient value. The building line soil is predominantly 69% house paint A2, only 31 ±2% resembles ambient outdoor lead. The uncertainties quoted in this section are the standard deviation of the three estimates. The dust is not like any potential source. Indeed it is outside the range of the other samples from this house. It likely reflects some lower, un-sampled value.

House B *(Projected Window Paint Source, poor condition)*

The two paint samples differ from each other, and both are below the ambient average, although the range is small. The mid-yard sample B5, taken by the road does not look like the ambient average but, like the building line soil B4, have some paint component. Because B4 is lower than any of the other samples here, there must have been some other, un-sampled source of lead with an even lower value, deflecting it downward.

The dust Bl from room 3's floor looks nearly identical with the target paint B2 the poor window sill. It could be 100 percent from that source B2. Alternatively, but perhaps less likely because of the distances, the dust could be made from a mixture of 67% exterior foundation paint B7 and 33±7% from ambient sources. Or the dust could be a mixture of the 53% building line soil B4 and 47± 11% from an ambient component. Whatever the case, the dust was not just from the ambient sources, rather it was all, directly, or indirectly through the soil, from the house's paint.

House C *(Projected Window Paint Source, moderate condition)*

The three paint sample C2, C7 and C8, vary among themselves, not over a wide range, but all are below the ambient value. The lead likely contains some Idaho, Bunker Hill, lead. There was no road dust, but the yard sample C5 was from near the street. It fell near the building line soil sample C4. Both of these fell near paint C7, the moderate target paint from room 3's exterior window frame. The yard sample C5 could be resolved into a mixture of mostly 89% paint C7 and 11 ± 6 % ambient lead, while C4 would be 69 % C7 and 31±5 % ambient lead.

The other paints, C2 and C8, if they were involved in the soil contamination of sample C5, instead of C7, would have been less significant. If it were paint C2, then it would be 47%, and 53 ±4% ambient lead. If it were paint C8, then it would be 41 and 59±5% ambient lead. The indoor dust sample Cl from the floor of room 3 appears to be more influenced by paints C2 and /or C8 than was the outdoor soil contamination. If it were only paint C2 then it would require 77% of C2 and 23±5% ambient lead, and if it were only paint C8, then it would be 67% C8 and 33±7% ambient lead. If paints were the only source of lead to the dust, and that can not be excluded from the isotopic data, then wide range of combinations of paints would account for the lead in the dust, but paint C7 would certainly be involved. The ambient sources, if they play any role at all, are secondary. Again there are ambiguities, because the dust appears to be a mixture.

House E *(Projected Window Paint Source, intact condition)*

The three paint samples vary considerably and all are different from the ambient value. The three outdoor samples are all very similar and resemble the ambient value. The dust value is closest to paint E8, living room (damaged baseboard), the competing paint, but it is not close enough for that paint to be the sole source. Also, the dust resembles a nearly equal mixture of the 2 target paints from the *room* (E2 and E7), 49 ±4% from E7. Or, it could be an equal mixture of all 3 paints with no input from the outside. Alternatively, the dust could be a mixture of paint E2 only and 30±6 %the outside source, but not E7 or E8 with the ambient lead. Isotopes alone can not distinguish among these possibilities. Perhaps field conditions suggest there relative plau sibility.

In any case paint E2, the intact window frame, must play a role, and E7 can not be sole source, even if mixed with the ambient source.

House J *(Projected Floor Paint Source, poor condition)*

Only one paint sample measured, but it is different from the ambient value. The indoor dust could be a mixture of 28 ± 13% ambient lead with the majority 72% from paint J2.

House K *(Projected Floor Paint Source, moderate condition)*

Here the three paint samples, K2, K7 and K8, varied considerably, and none fell near the ambient average value. The mid yard K5 and building line K4 soil samples are very close to the ambient value. The indoor dust Kl from the living room floor looks like a mixture of 46 % the moderate target paint from the living room floor K2 and 54±9% from ambient sources, which here resembles the yard soil. Alternatively it could be a mixture of 62% paint K2 and 38±8 % K7. Or the dust could be a mixture of 76% K2 and 24% K8 Indeed, any combination of those two mixtures, which exclude the ambient input could match the dust. In any case, paint K2 is a major contributor, from 46 to 76 %.

House L *(Projected Floor Paint Source, intact condition)*

The two paint samples, L2 and L7, are different from each other, and both differ from the ambient value, which falls close by the mid yard and road samples from this house. The building line sample L4, from the rear porch entrance, falls close to paint L7, intact front porch upper trim. The soil does not look like paint L2, the intact porch floor. Perhaps the same trim paint, L4, was also applied around the house and present in the rear porch area as well.

Here the indoor dust from the porch floor is a mixture of 77 percent L2, the target porch floor paint, and 23± 1 percent input from ambient sources. Or is could be a nearly equal mixture of 56 % L2 and 44 ±9 % paint L4, or it could be a combination of these. Certainly not only L2, but L2 is a major input, contributing no less than 56 and as much as 77%.

House O *(Projected Window and Floor Paint Sources)*

The three paint samples, O3, O2 and O7, all vary, and all are above the ambient value. They appear to be Missouri or Tri-State lead. The mid yard O5 and road dust O6 samples are very close, and both are very close to the ambient value. There was no building line sample. The indoor dust O1the front porch floor appears to be a mixture of predominantly 56 ± 1% of paints O2, target paint from front porch floor, and 44% O7, the competing paint from the front porch door. Or it could be a mixture of 86 % O7 and 14± 1%

O3, the target window sill paint. Indeed, the dust could be a combination of these mixtures. Alternatively, if sample O7 is excluded for some reason, the dust could be a mixture of the 77% ambient lead and 23% O2, or it could be 70% ambient lead and 30% O3, or some combination of these.

Overall, although the situation is somewhat ambiguous, the dust sample has a major paint component. It could be made only from paints, and if that were case, then it is not only sample O7, but a combination of paints.

<u>House P *(Projected Door and Floor Paint Sources)*</u>

The two paint samples, P3 and P2, vary from each other and from ambient value. No combination of only these two, or these two paints plus the ambient lead could yield this dust value. The indoor dust is similar to P4, the building line soil, with only 6 ±5% additional ambient lead. The soil P4 may reflect some other heretofore unmeasured paint, which would be unlike the two paints collected here, with a much lower ratio. Paint P2, the target paint, had very little, less than 1 percent, impact.

4.2.2 Chemical Mass Balance (CMB) Model Calculations for Floor Dust Lead Source Attribution

The fundamental principle of receptor modeling is that mass conservation can be assumed and a mass balance analysis can be used to identify and apportion sources of airborne particulate matter in the atmosphere. This methodology has generally been referred to within the air pollution research community as *receptor modeling.*The approach to obtaining a data set for receptor modeling is to determine a large number of chemical constituents such as elemental concentrations in a number of samples. Alternatively, automated electron microscopy can be used to characterize the composition and shape of particles in a series of particle samples. In either case, a mass balance equation can be written to account for all m chemical species in the n samples as contributions from p independent sources

$$X_{ij} = \sum_{k=1}^{p} C_{ik}\, k \qquad (1)$$

Where X_{ij} is the ith elemental concentration measured in the jth sample, C_{ik} is the gravimetric concentration of the ith element in material from the kth source, and ski is the airborne mass concentration of material from the kth source contributing to the jth sample.

There exist a set of natural physical constraints on the system that must be considered in developing any model for identifying and apportioning the sources of airborne particle mass (Henry, 1991). The fundamental, natural physical constraints that must be obeyed are:

- The original data must be reproduced by the model; the model must explain the observations.

- The predicted source compositions must be non-negative; a source cannot have a negative percentage of an element.
- The predicted source contributions to the aerosol must all be non-negative ; a source cannot emit negative mass.
- The sum of the predicted elemental mass contributions for each source must be less than or equal to total measured mass for each element; the whole is greater than or equal to the sum of its parts.

While developing and applying these models, it is necessary to keep these constraints in mind in order to be certain of obtaining physically realistic solutions.

Models

There are a variety of ways to solve equation 2 depending on what information is available. If the number and nature of the sources in the region are known (i.e., p and a_{ik} 's), then the only unknown is the mass contribution of each source to each sample, f_{kj} . This approach was first independently suggested by Winchester and Nifong (1971). Miller el al (1972) modified equation 2 to explicitly include changes in composition of the source material while in transit to the receptor

$$X_{ij} = \sum_{k=1}^{p} C_{ik} \alpha_{ik}\, k \qquad (2)$$

Where αik is the coefficient of fractionation so that if ai'k were the composition of the particles as emitted by the source, aik is the composition of the particles at the receptor site ($C_{ik} = \alpha_{ik}\ C_{ik}$). In practice, it is generally impossible to determine the αik values and they are assumed to be unity ($C_{ik} = C'_{ik}$). The collection of p source profile vectors forms a source profile matrix, C. Thus the problem can be written as

$$X = C \qquad (3)$$

The problem was solved using a least-squares fitting method. Initially ordinary least-squares were employed (Friedlander, 1973). Since different elements have quite different scales for their values (major elements at µg m^{-3}·concentrations, minor elements at concentrations of hundreds of ng m^{-3} and trace elements at ng m^{-3} values), Kowalczyk et al. (1978) used a weighted least-squares regression analysis to fit six sources with eight elements for ten ambient samples. In these analyses, the ambient elemental concentrations are weighted by the inverse of the square of the analytical uncertainty in that measurement. Thus, the ordinary weighted least squares solution is given by

$$S = (C^T WC)^{-1} C^T W \qquad (4)$$

Where

$$W = \begin{vmatrix} 1/\sigma_1^2 & 0 & \cdots & \\ 0 & 1/\sigma_2^2 & \cdots & \\ \cdots & \cdots & \cdots & \\ 0 & 0 & \cdots & 1/ \end{vmatrix}$$

It was recognized that there is uncertainty in the source profile values. The inclusion of this error is the statistical "error in x" problem that has been examined by a large number of investigators. In 1979, Watson (1979) and Dunker (1979) independently suggested a mathematical formulation called effective variance weighting that included the uncertainty in the measurement of the source composition profiles as well as the uncertainties in the ambient concentrations. As part of this analysis, a method was also developed to permit the calculation of the uncertainties in the mass contributions. The effective variance weights are given by

$$(w_e)_{ii} = \frac{1}{\sigma_i^2 + \sum_{k=1}^{p} \sigma_{ik}^2}$$

Where α_i is the measured uncertainty in the ambient concentration, x, and α is the measured uncertainty for element I emitted by source k. Thus, the weights are dependent of the values of the regression coefficients, and an iterative algorithm is used to solve the problem. The solution is found using the following steps:

1. Set $S_k = 0$ for j=1,…,p for first iteration
2. Calculate the s vector for the (1+1)th iteration using effective variance weights.
3. Test for convergence of the solutions. If any of (1+1) S_k values differs by more than 1% from 1th iteration, go to step 2; Otherwise step 4.
4. Errors in S_k values can be directly estimated.

The approach has been described by Cooper et al. (1984) and Watson et al. (1991). Effective variance least squares (EVLS) has been incorporated into the standard personal computer software (CMB 7.0) developed by the U.S. EPA for receptor modeling by Watson et al. (1990). A new beta test version for Windows 32-bit operating systems was used for making the analyses presented below.

Data Description

House vacuum dust and source samples were collected at 15 residence locations in Syracuse. The samples were analyzed for multiple elements using X-ray fluorescence (XRF). Each sample was characterized by the following 38 elements: Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Y, Zr, Mo, Pd, Ag, Cd, In, Sn, Sb, Ba, La, Au, Hg, Tl, Pb, and

U. At each house, one vacuum dust sample and several (3 to 6) house specific source samples (paints and soils) were obtained. The goal of the present study was to apportion the source contributions of the sources to the dust sample.

Data analysis and Results

The EPA Chemical Mass Balance (CMB) receptor model version 8.2 was used. Initial efforts were made to apportion the contributions of all the possible sources to the dust sample at each house, but they were unsuccessful because of the severe collinearities among different paint sources and among different soil sources. In the end, based on the trial results of different combinations of paints and soils for a better fit, only one paint and one soil source were found to fit the dust sample well for most of the houses. At two houses, only one source was found to be the reasonable contributing source in terms of fitting, and adding a second source would result in well above 100% of the total mass explained. The results are shown in Table 4-33. Since the source samples and the dust samples had the same unit, µgig, the source contribution estimates were actually the contributing mixing fractions of the sources.

It can be seen that the soil source (Mid-yard soil, Road dust, or Building line soil) contributed much more to the house dust than the paint source (Target paint). However, from house to house the contributions of the soil and paint varied considerably, depending on the sample collection locations (living room, bathroom, bedroom, or porch) and paint conditions.

Table 4-33 CMB Results for the Pb for the Pb in the House Dust Samples

House	Contributing Sources	Source Contribution Estimate (Mixing fraction)	Pb Fractional Contribution
A (A1)	A5, Mid-yard soil	0.7889 ± 0.0013	0.022
	A2, Target paint	0.0602 ± 0.0001	1.031
B (B1)	B1, Target paint	0.1879 ± 0.0006	0.93
	B5 Mid-yard soil	0.6041 ± 0.0021	0.027
C (C1)	C2, Target paint	0.1191 ± 0.0008	*
	C5, Mid-yard soil	0.4730 ± 0.0018	
E (E1)	E7, Target paint	0.0571 ± 0.0002	0.932
	E6, Road dust	0.6091 ± 0.0017	0.037
J (J1)	J5, Road dust	0.3898 ± 0.0012	0.033
	J2, Target paint	0.2085 ± 0.0005	0.916
K (K1)	K6, Road dust	0.8039 ± 0.0039	0.111
	K2, Target paint	0.0871 ± 0.0010	0.952
L (L1)	L2, Target paint	0.0272 ± 0.0002	1.034
	L5, Building line soil	0.6508 ± 0.0024	0.175
O (O1)	O2, Target paint 2	0.2398 ± 0.0004	*
P (P1)	P5, Mid-yard soil	0.8733 ± 0.0018	0.039
	P2, Target paint	0.0708 ± 0.0002	0.918

***** The Pb mass was overestimated by more than 50%, and the Pb fractional contribution from the paint was over 1.5, the fractional contribution from the soil was below 0.1. Thus, for these houses the Target paint source can be considered to have contributed to all of the Pb mass in the house dust sample.

From the Pb and fractional mass contributions for the resol ved sources (Table 4-33) it is apparent that for somer houses the Target paint source contributed much more to the Pb mass in the house dust than the soil source did. While for other houses the Pb mass was too much overestimated (by more than 50%), and the Pb fractional contribution from the paint source was over 1.5. Thus, for these houses the paint source can be considered to have contributed to all of the Pb mass in the house dust.

Chapter 5

Discussion

At the start of this study it was proposed that it should be possible to recognize the contribution to indoor dust from friction surfaces that had a coating of lead based paint. The principal means used to address this proposal was individual particle analysis of lead bearing particles by SEM and EDX. This was subsequently compared to two other source attribution methods. Namely, chemical mass balance (CMB) modeling using bulk chemical analysis (by XRF), and lead isotope composition (PbIC) mixing model using Pb isotopic ratios. This type of particle lead is, as it turned out, extremely challenging.

The combination of SEM/EDX under computer control (CCSEM) permitted a (operator) supervised descriptive source attribution of lead bearing particles in target floor dust. The CCSEM particle element data was also used for source classification of lead bearing particles in target floor dust using discriminant analysis. What initially seemed a fairly tractable problem was made difficult by the fact that lead paints can breakdown into their individual pigments particles? The lead pigment particles may have no “fingerprint”. These particles may be composed only of lead and may not have a characteristic morphology “unidentifiable Pb”. These particles could be characteristic of some other source. When there is no defining characteristic to a particle it may be impossible attribute a source to it. Of course, if a residence has indoor lead based paint that is in less than perfect condition, it might not be unreasonable to assume that any substantial quantities of these lead-only particles are derived from the paint. But it is impossible to say this without absolute certainty. For example, Houses A and B in this study in the descriptive apportionment have highest percentage lead particle contribution from a paint friction surface. But, in both instances the percentage of particles designated as "unidentifiable Pb" was high. If it could be concluded that these particles originated from the lead based paint, then over 90% of the floor dust could be considered to have come from the friction surface. Nevertheless, this assumption did not help in situations like House P where there were two lead particles sources potentially contributing to the dust. In this instance, almost 50% of the floor dust lead particles were designated as "unidentifiable Pb" and as such it was not possible to say which paint source they originated from. But, in dust samples where the frequency of occurrence of "unidentifiable Pb" was less, the descriptive apportionment did better at assigning dust lead particles to a friction surface. For Houses C, E, J, and O, the descriptive apportionments assigned ≥ 70% of floor dust lead particles to a friction surface source. The discriminant analysis source classification appeared less reliable than the descriptive apportionment. In many residences a significant contribution to the floor dust seemed to be originating from road dust. Realistically, the transport path from road to indoor dust seems unlikely to provide equal or greater percentages of lead particles than the indoor friction surface. In some instances the discriminant analysis did produce findings similar to the descriptive apportionment (e.g., House O). However the analysis itself had some data problems. For many particles the element concentration was zero, so a low replacement concentration value was set to allow the analysis to be undertaken. Also the particle element data was skewed and a log normal transformation was employed. However, the resulting distribution did not always approach normality. Finally, for some residences, non-site-specific aggregates of data had to be used. Here such aggregate data was used to define a road dust source of lead particles. It is likely that the variations in the compositions of the road dust particles from across the city are unlikely to make a homogenous group.

In the case of the isotope mixing the method frequently resulted in ambiguous situations, where three or more possible sources exist. All of their ratios essentially fall on a line. The isotope ratio of the dust could be decomposed into several possible mixtures depending on which pairs of available sources are considered. For example, in House C, several possible interpretations are equally plausible based only on the isotope ratios. Any blend of paints C2 and C8 mixed with paint C7, or the building line soilC4, or with enough of the ambient outdoor lead, would be consistent with the single dust value C1. A wide range of these mixtures could account for the dust value, because the dust is not overwhelmingly from only one source. It may be that other information, such as about the amounts of lead, their concentrations in each possible source, or the proximity of some painted surfaces, or some other chemical clue such as colored paint fragments, when used in conjunction with the isotope data, would limit the range of practical possibilities. These other types of information could exclude possibilities. Relying solely on the isotopic data can result in these ambiguous interpretations. It works best when only two potential sources are possible

The CMB method suffered from collinearity problems between sources. The fact that paint contains many of the element constituents present in media such as soil and dust, made apportionment modeling among multiple sources difficult. The collinear relationships between elements in the sampled media provide an intractable problem for the CMB method. The problem also frequently resulted in overestimation of source contributions. In some instances source contributions to the receptor dust exceeded 100%. Clearly this is an impossible result. CMB when applied in the circumstance of this investigation could not resolve more than two sources.

When there is a need to resolve the contributions of particle lead from several sources it seems like the CMB and the PbIC approaches are consistently hampered unless only two contributing sources are present. The CCSEM based methodology seems to be a potentially more useful technique where multiple sources are contributing Pb bearing particles to a receptor site. The descriptive apportionment method seems the least problematic as the various uncertainties associated with the discriminant analysis classification render it unreliable as a source attribution technique. The greater accuracy of the descriptive apportionment method does come at a considerable cost however. Machine, and machine operator time is a major investment, and this lead particle source attribution method may likely only be worthwhile in a research setting similar to the source attribution exercise undertaken in this study.

Appendix A

Raw data, SEM images and X-Ray Spectra of House A

House A

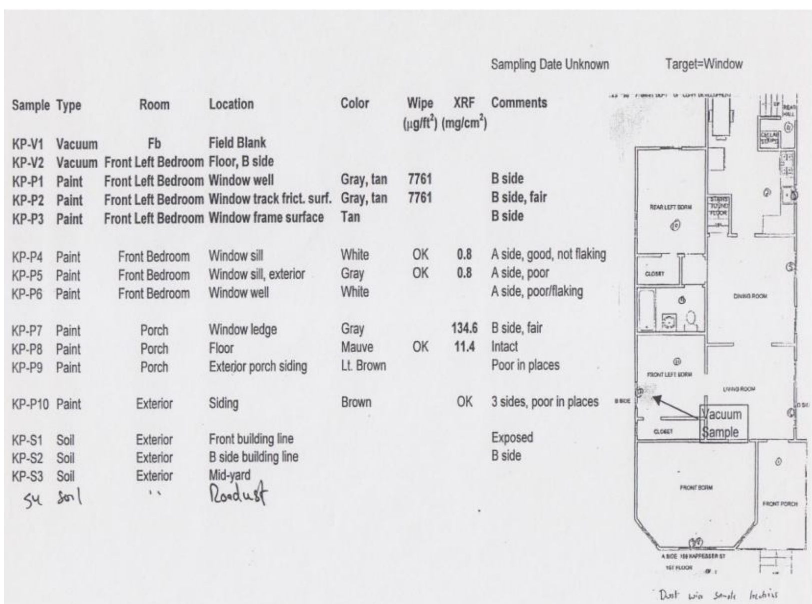
Single Implicated Window Friction Source

Window Paint in Poor Condition

Single Story Family Home

Sampling Location:	**Front Left Bedroom 1st Floor**
Collected Samples:	
Dust	**1. Front Left Bedroom Floor Dust [A1]**
Implicated Friction Surface	**2. Front Left Bedroom Window Well Paint [A2]** **3. Front Left Bedroom Window Track Paint** **4. Front Left Bedroom Window Frame Surface**
Other LBP Window Surfaces	**5. Front Bedroom Sill Interior Paint** **6. Front Bedroom Sill Exterior Paint [A7]** **7. Front Bedroom Well Paint**
Other LBP Surface	**8. Exterior Porch Window Ledge Paint** **9. Exterior Porch Floor Paint [A8]** **10. Exterior Porch Siding Paint** **11. Siding Paint**
Soil	**12. Building Line Exterior Front [A4]** **13. Building Line Exterior "B" Side House** **14. Midyard [A5]** **15. Road Dust [A6]**

Figure A 1 House A General View



Sampling Date Unknown Target=Window

Sample	Type	Room	Location	Color	Wipe (µg/ft²)	XRF (mg/cm²)	Comments
KP-V1	Vacuum	Fb	Field Blank				
KP-V2	Vacuum	Front Left Bedroom	Floor, B side				
KP-P1	Paint	Front Left Bedroom	Window well	Gray, tan	7761		B side
KP-P2	Paint	Front Left Bedroom	Window track frict. surf.	Gray, tan	7761		B side, fair
KP-P3	Paint	Front Left Bedroom	Window frame surface	Tan			B side
KP-P4	Paint	Front Bedroom	Window sill	White	OK	0.8	A side, good, not flaking
KP-P5	Paint	Front Bedroom	Window sill, exterior	Gray	OK	0.8	A side, poor
KP-P6	Paint	Front Bedroom	Window well	White			A side, poor/flaking
KP-P7	Paint	Porch	Window ledge	Gray		134.6	B side, fair
KP-P8	Paint	Porch	Floor	Mauve	OK	11.4	Intact
KP-P9	Paint	Porch	Exterior porch siding	Lt. Brown			Poor in places
KP-P10	Paint	Exterior	Siding	Brown		OK	3 sides, poor in places
KP-S1	Soil	Exterior	Front building line				Exposed
KP-S2	Soil	Exterior	B side building line				B side
KP-S3	Soil	Exterior	Mid-yard				
S4	Soil	"	Roadust				

Figure A 2 House A Floor Plan

Table A 1 House A lead concentration data by XRF

Analysis Number	House Code	Sample Description	Pb Conc (µg/g)	Error (µg/g)
HUD 001-1	**A4**	House A - Building Line Soil: Front fo house	199	10.8
HUD 002-1	**A5**	House A - Mid-Yard Soil	204.3	9.6
HUD 003-1	**NONE**			
HUD 004-1	**A1**	House A - Cyclone Vacuum Dust Sample: Front, left bedroom floor	7481.2	21.9
HUD 005-1	**A2**	House A - Target Paint: Front, left bedroom window well, poor condition	127632.6	107.6
HUD 006-1	**A7**	House A - Competing Paint: Front bedroom window sill exterior, poor condition	189588.1	146.7
HUD 007-1	**A8**	House A - Competing Paint: Front porch floor, intact condition	38666.5	61.3
HUD 007-1	**A6**	House A - Rpad Dust: Front of house	8.3	24.5

Table A.2 House A Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	**House Code**	**Description**	**206/204**	**207/204**	**208/204**	**207/206**	**208/206**	**207/208**
HUD1	**A4**	House A - Building Line Soil: Front of House	17.933	15.558	37.606	0.86754	2.09703	0.4137
HUD2	**A5**	House A - Mid-Yard Soil	18.874	15.709	38.689	0.83235	2.04993	0.40604
HUD4	**A1**	House A - Cyclone Vacuum Dust Sample: Front, left bedroom floor	17.062	15.43	36.748	0.90436	2.15385	0.41988
HUD5	**A2**	House A - Target Paint: Front, left bedroom window well, poor condition	17.567	15.491	37.214	0.88183	2.11838	0.41628
HUD6	**A7**	House A - Competing Paint: Front bedroom window sill exterior, poor condition	17.505	15.496	37.198	0.88521	2.125	0.41657
HUD7	**A8**	House A - Competing Paint: Front porch floor, intact condition	17.698	15.547	37.434	0.87846	2.11519	0.41531
HUD8	**A6**	House A - Road Dust: Front of house	18.755	15.623	38.412	0.83297	2.04806	0.40671

Table A 2 House A Pb bearing particles found in floor dust sample

Chemical Composition	Morphology	Size
Pb	Irregular	1.3
Pb	Irregular	1.2
Pb	Irregular	1.4
Pb	Irregular	0.9
Pb	Blocky	2.7
Pb	Irregular	0.75
Pb	Irregular	0.6
Pb	Aggregate	12.75
Pb	Rounded	0.9
Pb	Irregular	1.35
Pb	Irregular	0.8
Pb	Irregular	1.5
Pb	Irregular	2.06
Pb	Irregular	1.16
Pb	Irregular	1
Pb	Irregular	0.63
Pb	Irregular	0.84
Pb	Irregular	0.9
Pb	Irregular	7.5
Pb	Irregular	1.625
Pb	Rounded	0.625
Pb	Irregular	1.44
Pb	Irregular	0.94
Pb	Irregular	0.51
Pb	Irregular	1.45
Pb	Irregular	1.25
Pb	Irregular	0.85
Pb	Hexagonal	3
Pb	Irregular	1.63
Pb	Irregular	5.53
Pb	Irregular	1.56

Table A 3 – *Continued*

Pb	Irregular	1.28
Pb	Irregular	2
Pb	Irregular	1.05
Pb	Irregular	1.43
Pb	Irregular	1.3
Pb	Irregular	1.25
Pb	Hexagonal	1.63
Pb	Irregular	1.95
Pb	Irregular	0.813
Pb	Irregular	1.78
Pb	Irregular	3.6
Pb	Irregular	1.88
Pb	Irregular	0.68
Pb	Irregular	1.3
Pb	Aggregate	1.75
Pb	Irregular	0.75
Pb	Irregular	2.47
Pb	Irregular	1.95
Pb	Irregular	1.56
Pb	Rounded	1.56
Pb	Irregular	8.8
Pb	Aggregate	5.6
PbSi	Irregular	1.05
PbCa	Irregular	1
PbCl	Irregular	2.5
PbCl	Aggregate	7.75
PbCl	Irregular	1.35
PbP	Irregular	1.3
PbZnP	Irregular	1.63
PbClP	Irregular	1.05
PbClCa	Irregular	2.01
PbZnCaPFe	Aggregate	5.14
PbZnCaSiAlKPFe	Irregular	46.75
PbPCaNa	Irregular	0.78

Table A 4 House A Pb bearing particles found in paint sample

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	3.57
Pb	Irregular	3.11
Pb	Aggregate	9.28
Pb	Aggregate	15.4
Pb	Irregular	2.72/4.64
Pb	Blocky	9.5
Pb	Irregular	4.03
Pb	Irregular	3.5
Pb	Blocky	5.57
Pb	Irregular	3
Pb	Aggregate	4.64
Pb	Irregular	3.25
Pb	Paint Pigment	5.35
Pb	Irregular	4.22
Pb	Blocky	4.16
pb	Irregular	3.92
Pb	Irregular	4
Pb	Aggregate	2.62
Pb	Irregular	6
Pb	Irregular	3.77
Pb	Rounded	2.44
Pb	Irregular	6.11
Pb	Irregular	3.71
Pb	Paint Pigment	5.4
Pb	Irregular	1.33
Pb	Aggregate	8.33
Pb	Irregular	2
Pb	Irregular	3
Pb	Paint Pigment	4.28
Pb	Irregular	2.5
Pb	Irregular	5.8
Pb	Blocky	3.12
Pb	Irregular	3.1
Pb	Aggregate	6

Table A 4 - *Continued*

Pb	Aggregate	2.5
Pb	Irregular	1.95
Pb	Irregular	2.7
Pb	Irregular	1.54
Pb	Rounded	1.3
Pb	Irregular	1.54
Pb	Irregular	3
Pb	Aggregate	2.77
Pb	Irregular	2.82
Pb	Irregular	2.22
Pb	Irregular	1.77
Pb	Irregular	2
Pb	Aggregate	4.22
Pb	platy aggregate	2.2
Pb	platy aggregate	4
Pb	Irregular	2.82
Pb	Irregular	1.8
Pb	Aggregate	2.6
Pb	Irregular	1.9
Pb	Irregular	0.5
Pb	Irregular	3
Pb	Aggregate	5
Pb	Irregular	0.88
Pb	Aggregate	5.95
Pb	Platy-Aggregate	4.8
Pb	Platy-Aggregate	5
Pb	Matrix-bound aggregate	5
Pb	Aggregate	15
Pb	Irregular	4.65
PbZn	platy aggregate	15.79
PbZn	Platy-Aggregate	10
PbZn	Matrix-bound aggregate	3.85
PbZn	Irregular	6.66
PbZn	Irregular	3.8
PbZn	Aggregate	6.85

Table A 4 - *Continued*

PbZn	Aggregate	10.5
PbZn	Irregular	1.28
PbZn	Aggregate	4.29
PbZn	Aggregate	5.62
PbZn	Aggregate	2.5
PbCa	Aggregate	2.57
PbCa	Irregular	1.65
PbCa	Aggregate	5
PbTi	Aggregate	6.25
PbZnTi	Aggregate	2.52
PbZnCa	Aggregate	5.2
PbZnCa	Aggregate	10.71
PbTiCa	Aggregate	3.75
PbZnSi	Aggregate	5.71
PbZnTiCa	Aggregate	3.2
PbZnTiCa	Aggregate	7.22
PbZnTiSi	Platy Aggregate	22.5
PbZnTiSi	Aggregate	5.35
PbZnTiSi	Aggregate	3
PbZnTiCa	Aggregate	8.23
PbZnCaSi	Aggregate	9.2
PbZnTiCaSi	Aggregate	13.5
PbZnTiSiFe	Irregular	3
PbZnTiCaSi	Aggregate	4
PbZnSiAlFe	Aggregate	5.14
PbCaSiAlFe	Irregular	2.5
PbZnTiSiMg	Aggregate	16.25
PbZnTiCaSiFe	Aggregate	9.33
PbZnTiCaSiMg	Aggregate	10
PbZnBaCaSiMg	Aggregate	4
PbZnBaCaSiMg	Aggregate	7
PbZnBaCaSiMg	Aggregate	3.33
PbZnBaCaSiMg	Aggregate	13.5
PbZnCaSiMgFe	Aggregate	3.43
PbZnTiCaSiMg	Aggregate	12.25

Table A 5 House A Pb bearing particles found in building line soil sample

Chemical Composition	**Morphology**	**Size**
Pb	Aggregate	7
Pb	Crystaline	7
Pb	Angular	1
Pb	Irregular	3
Pb	Irregular	1.5
Pb	Irregular	2
Pb	Elongated	1.4
Pb	Irregular	1
Pb	Irregular	3
PbTi	Rounded	0.6
PbTi	Irregular	0.5
PbTi	Irregular	1
PbTi	Irregular	1.7
PbTi	Irregular	1
PbTi	Irregular	1
PbTi	Irregular	0.5
PbTi	Irregular	1.2
PbTi	Aggregate	4
PbTi	Aggregate	8.5
PbTi	Irregular	2
PbTi	Aggregate	4
PbTi	Angular	1
PbTi	Irregular	1
PbTi	Irregular	3
PbTi	Aggregate	5
PbCa	Irregular	0.8
PbTiSi	Angular	1
PbTiCa	Elongated	1
PbTiCa	Irregular	0.5
PbTiFe	Irregular	6
PbCaP	Irregular	1.5
PbCaFe	Aggregate	4

Table A 5 - *Continued*

PbTiSi	Irregular	8
PbTiSiAl	Irregular	2.4
PbTiSiAl	Rounded	0.8
PbPSiFe	Irregular	4
PbTiCaKFe	Irregular	2
PbTiSiAlFe	Irregular	0.5
PbZnCaKFe	Aggregate	6
PbCaSiAlK	Irregular	15
PbTiSiAlK	Irregular	0.8
PbTiCaKFe	Aggregate	25
PbTiSiAlMgFe	Irregular	2
PbCaSiAlKP	Irregular	6
PbPSiAlCaFeNa	Irregular	3
PbTiCaSiAlMgNa	Irregular	0.3
PbTiCaKFePSiAl	Irregular	20
PbCaSiAlKPMgNaFe	Irregular	5.5
PbZnCaSiAlPMnFeCl	Blocky	12

Table A 6 House A Pb bearing particles found in road dust sample

Chemical Composition	Morphology	Size
PbTi	Irregular	1
PbTi	Irregular	1.2
PbTi	Aggregate	3
PbTi	Irregular	1.15
PbTi	Aggregate	2
PbCl	Irregular	1.3
PbSiAl	Irregular	6.5
PbTiSi	Aggregate	2.5
PbTiSi	Irregular	0.7
PbClCa	Aggregate	3
PbCaSiAl	Irregular	2
PbTiSiMg	Aggregate	5.7
PbTiSiMg	Aggregate	3.5
PbTiSiMg	Aggregate	2.5
PbTiSiMg	Aggregate	2.5
PbTiSiMg	Aggregate	4.5
PbTiCaSiMgFe	Aggregate	14
PbTiCaSiMgFe	Aggregate	3.2
PbTiCaSiMgFe	Aggregate	8
PbTiCaSiMgFe	Aggregate	11
PbZnCaSiAlKPMgFe	Irregular	3.5
PbTiCaSiAlKPNaFe	Irregular	3

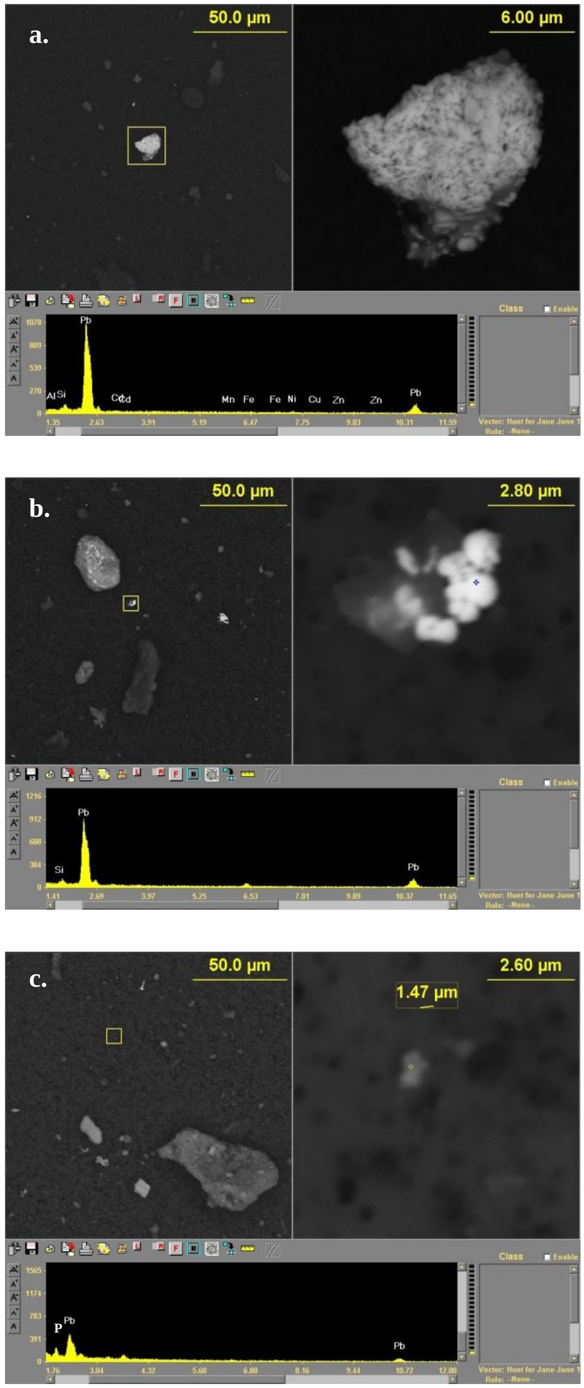


Figure A 3 House A floor dust particle with Pb pigment particles (a, b) and P (c) in matrix

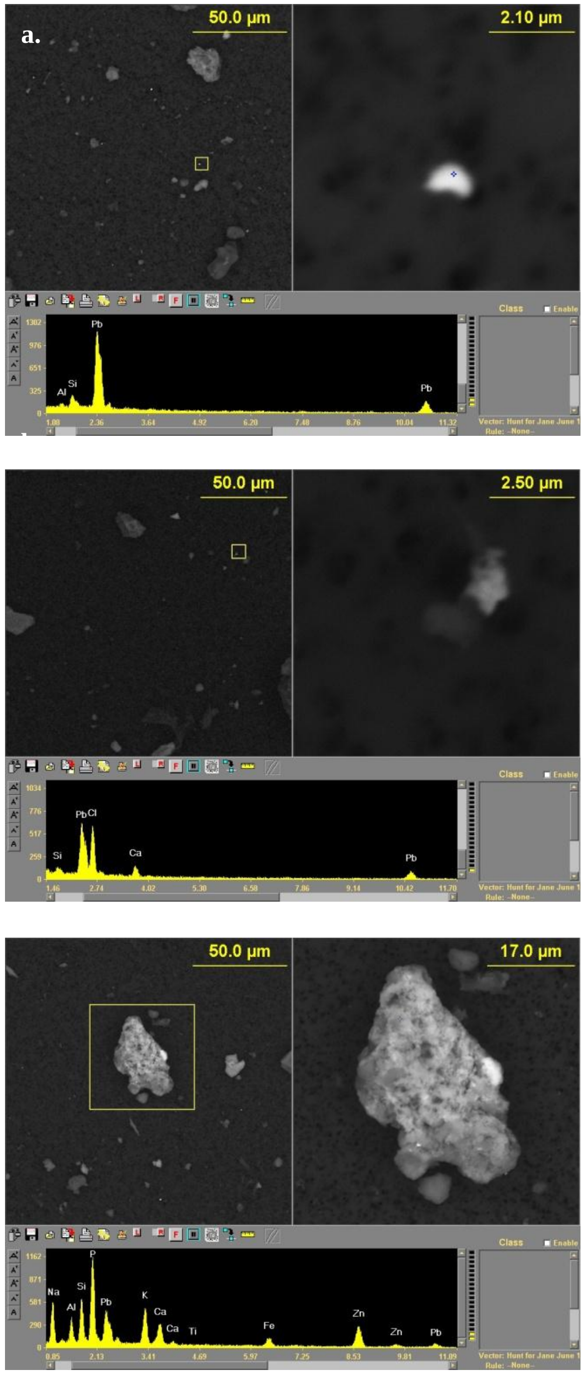


Figure A 4 House A floor dust particle with Pb pigment and Si (a), Ca, Cl (b), Zn Si, P, Al, Fe, K, Ca (c) matrix

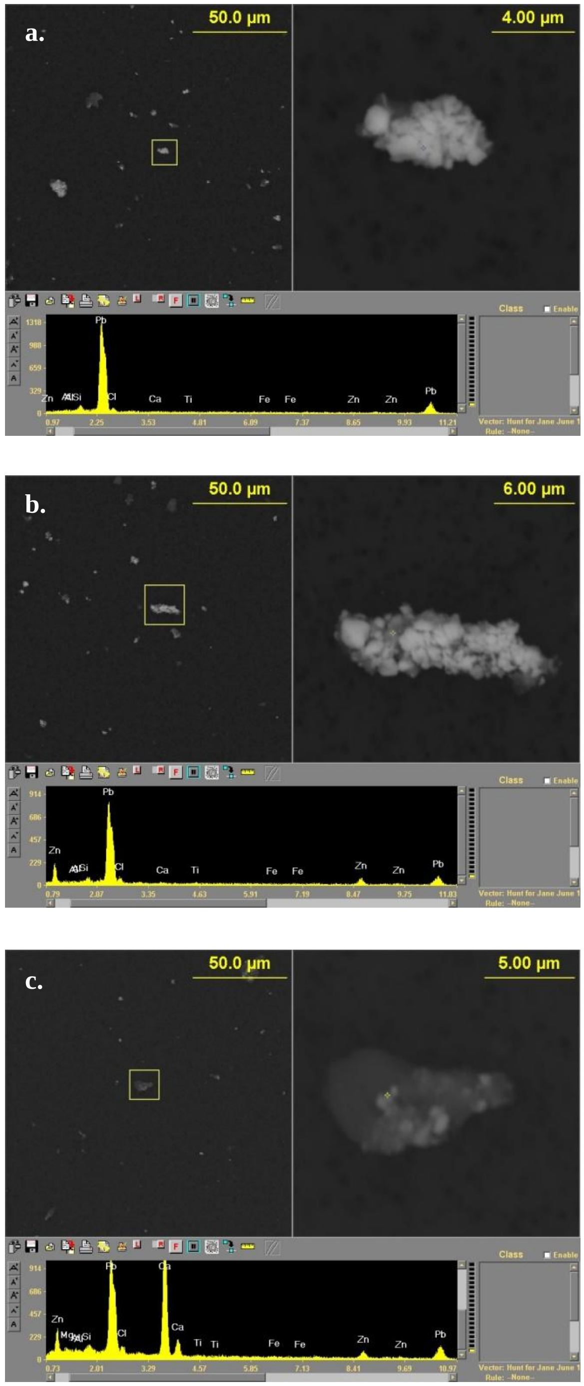


Figure A 5 House A window frame paint particle with Pb pigment particles (a) and Zn (b), Zn, Ca (c) in matrix

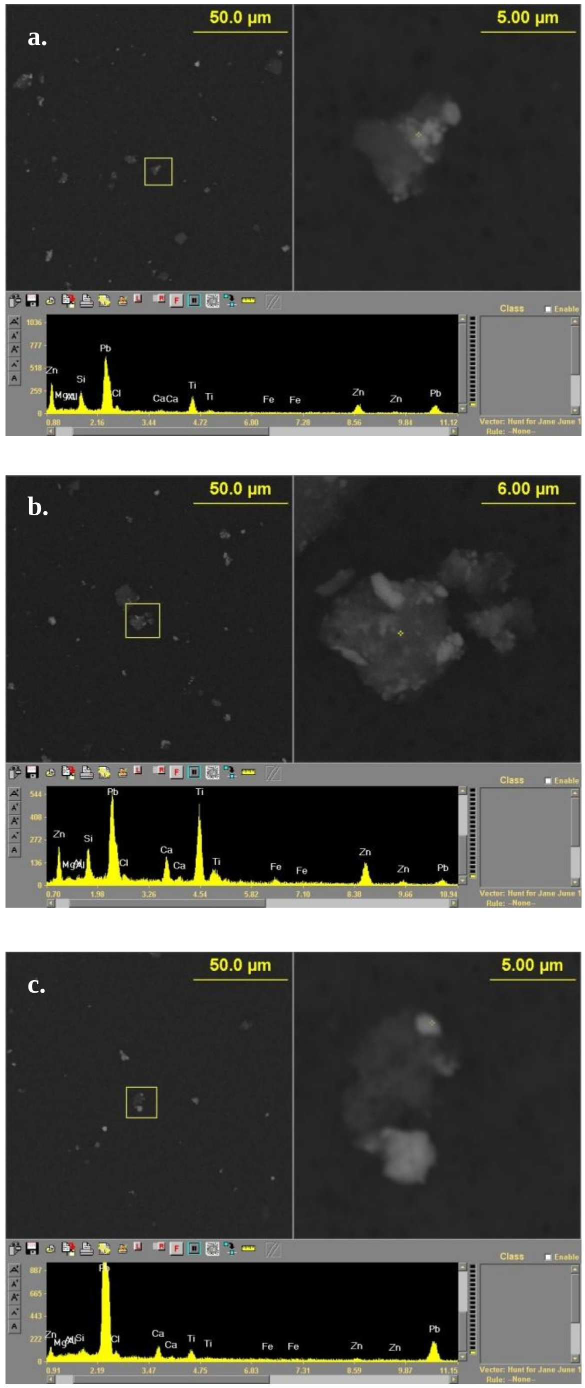


Figure A 6 House A window frame paint particle with Pb pigment and Zn Ti, Si (a), Zn, Si, Ca, Ti, Fe (b), Zn, Ca, Ti (c) in matrix

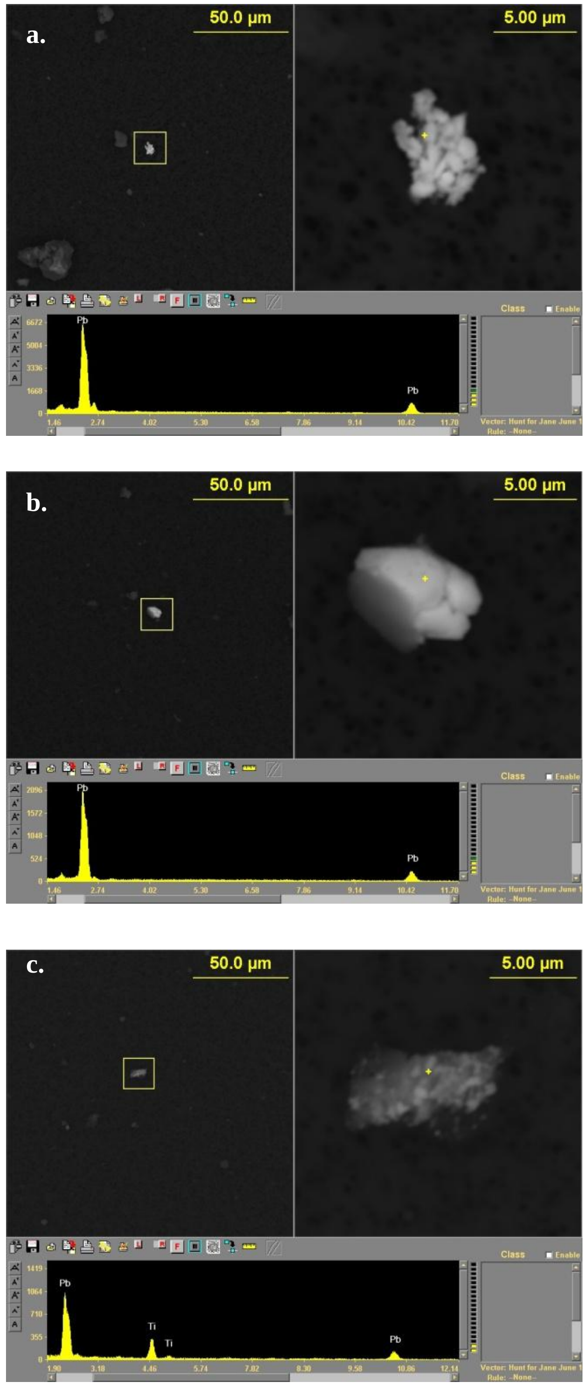


Figure A 7 House A building line soil particle with Pb pigment particles (a,b), and Ti in matrix (c)

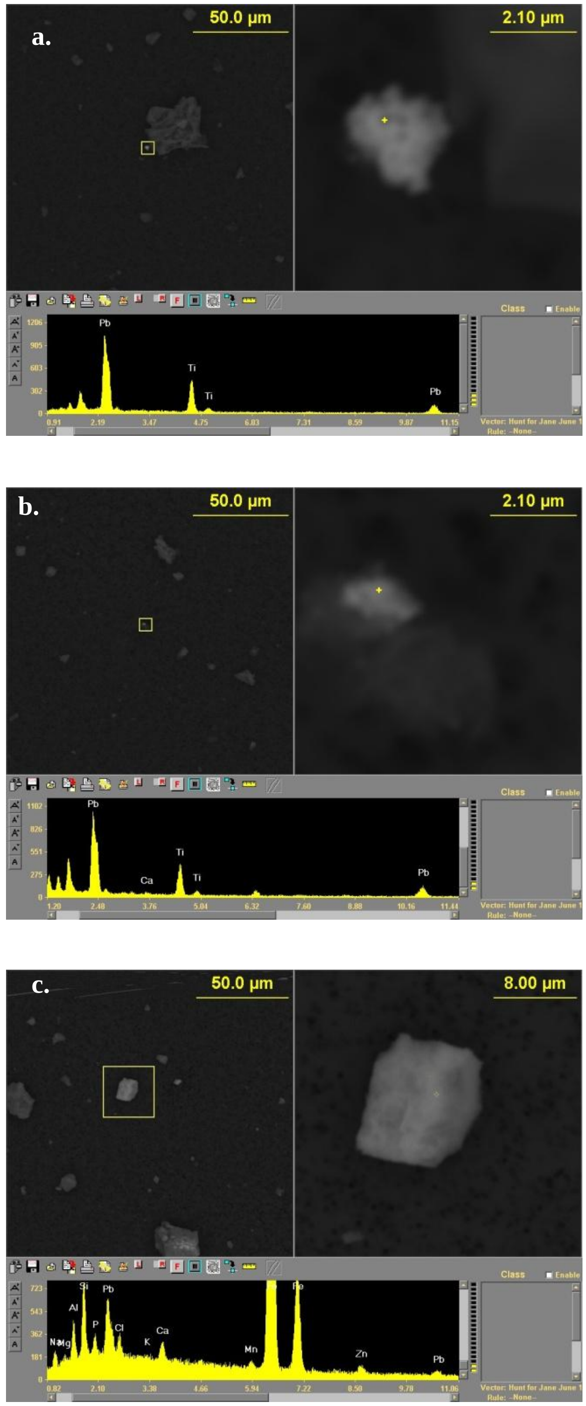


Figure A 8 House A building line soil Particle with Pb pigment and Ti, Si (a), Ti, Si, Al, Mg, Fe (b), Si, Al, P, Zn, Cl, Ca, Mn, Fe (c) in matrix

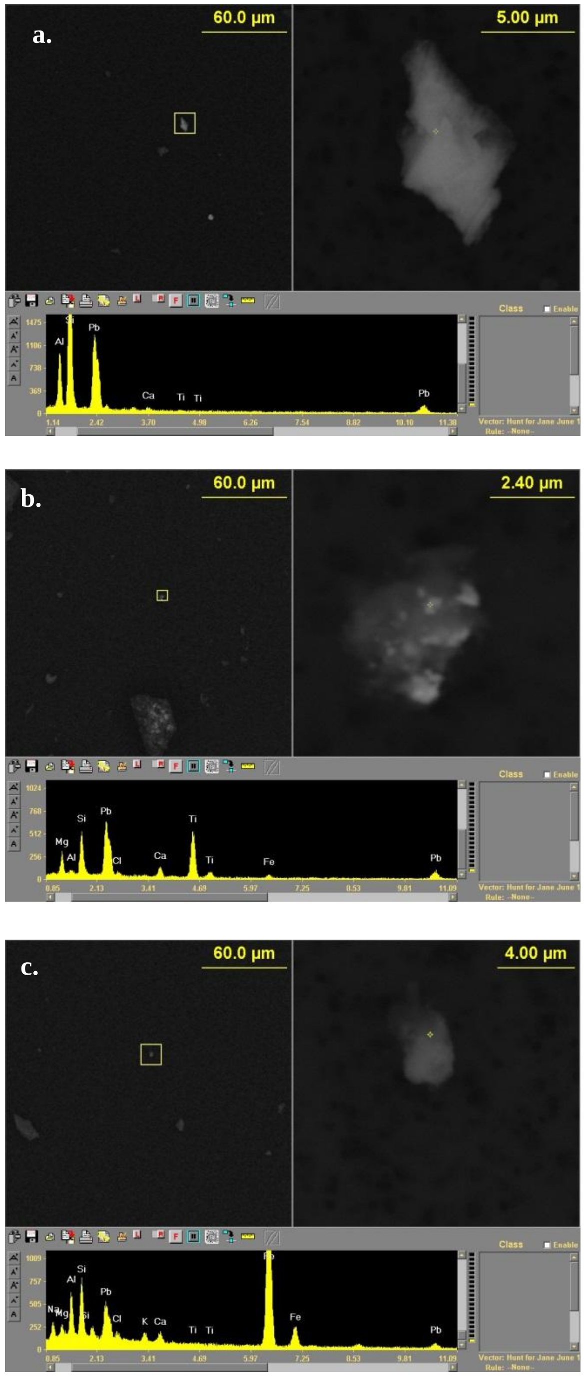


Figure A 9 House A building line soil Particle with Pb pigment and Al, Si (a), Ti, Si, Ca, Mg, Fe (b), Si, Al, P, Zn, K, Ca, Fe, Mg (c) in matrix

Appendix B

Raw data, SEM images and X-Ray Spectra of House B

House B

Single Implicated Window Friction Source

Window Paint in Poor Condition

Multi Story Family Home

Sampling Location: **Room 3**

Collected Samples:

Dust	**1. Room 3 Floor Dust [B1]**
Implicated Friction Surface	**2. Room 3 Window Sill Paint [B2]**
	3. Room 3 Window Frame Inside
Other LBP Window Surfaces	**4. Room 3 Door Paint**
	5. Room 3 Closet Door Paint
	6. Room 2 Window Paint
	7. Room 5 Door Paint
	9. Room 5 Window Paint
Other LBP Surface	**10. Exterior Building Foundation Paint [B7]**
Soil	**11. Building Line Exterior Side House [B4]**
	12. Yard by Road [B5]

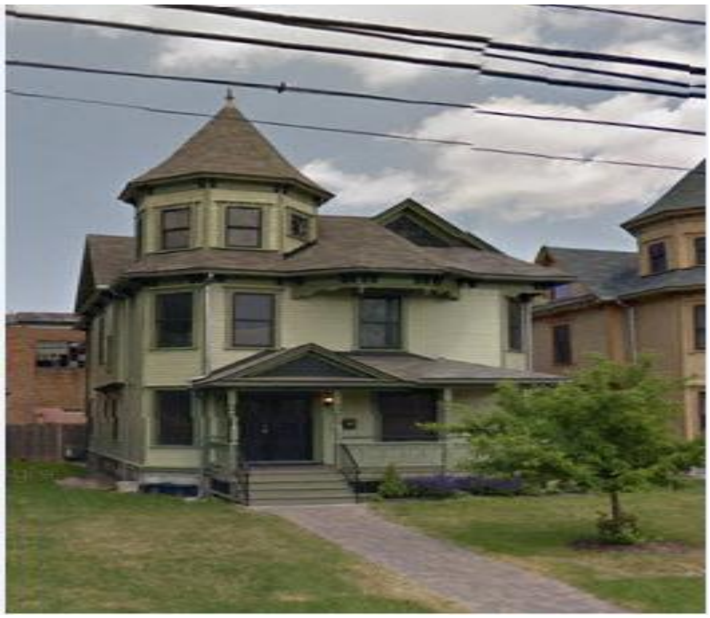
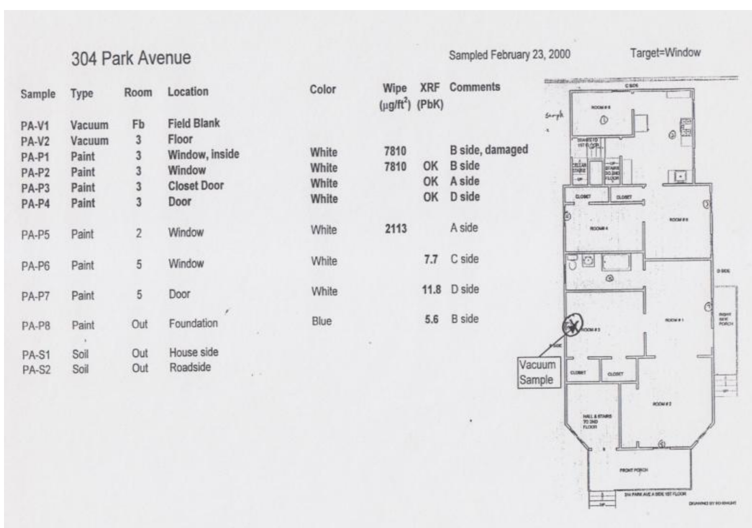


Figure B 2 House B General View



304 Park Avenue

Sampled February 23, 2000 Target=Window

Sample	Type	Room	Location	Color	Wipe ($\mu g/ft^2$)	XRF (PbK)	Comments
PA-V1	Vacuum	Fb	Field Blank				
PA-V2	Vacuum	3	Floor				
PA-P1	Paint	3	Window, inside	White	7810		B side, damaged
PA-P2	Paint	3	Window	White	7810	OK	B side
PA-P3	Paint	3	Closet Door	White		OK	A side
PA-P4	Paint	3	Door	White		OK	D side
PA-P5	Paint	2	Window	White	2113		A side
PA-P6	Paint	5	Window	White		7.7	C side
PA-P7	Paint	5	Door	White		11.8	D side
PA-P8	Paint	Out	Foundation	Blue		5.6	B side
PA-S1	Soil	Out	House side				
PA-S2	Soil	Out	Roadside				

Figure B 3 House B Floor Plan

Table B 1 House B Lead Concentration Data by XRF

Analysis Number	**House Code**	**Sample Description**	**Pb Conc (µg/g)**	**Error (µg/g)**
HUD 084-1	**B2**	House B - Target Paint: Room 3 window sill, poor condition	59949.9	76.5
HUD 085-1	**B7**	House B - Competing Paint: Exterior foundation	176412.1	153.2
HUD 086-1	**B4**	House B - Building Line Soil	1466.8	12.5
HUD 087-1	**B5**	House B - Mid-Yard Soil: By road	548.1	11
HUD 088-1	**B1**	House B - Cyclone Vacuum Dust Sample: Room 3 floor	12052.2	55.7

Table B 2 House B Lead Isotopic Ration Data by Mass Spectroscopy

Analysis #	**House Code**	**Description**	**206/204**	**207/204**	**208/204**	**207/206**	**208/206**	**207/208**
HUD84	**B2**	House B - Target Paint: Room 3 window sill, poor condition	18.447	15.6	38.166	0.8457	2.06897	0.409
HUD85	**B7**	House B - Competing Paint: Exterior foundation	18.288	15.542	38.081	0.8499	2.08228	0.408
HUD86	**B4**	House B - Building Line Soil	18.253	15.619	38.154	0.8557	2.09024	0.409
HUD87	**B5**	House B - Mid-Yard Soil: By road	18.504	15.633	38.281	0.8449	2.06881	0.408
HUD88	**B1**	House B - Cyclone Vacuum Dust Sample: Room 3 floor	18.454	15.632	38.23	0.8471	2.07178	0.409

Table B 3 House B Pb bearing particles found in floor dust sample

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	9.52
Pb	Irregular	4.19
Pb	Irregular	3.81
Pb	Irregular	5.03
Pb	Irregular	4.3
Pb	Irregular	3.25
Pb	Irregular	2.43
Pb	Irregular	2.32
Pb	Irregular	3.39
Pb	Irregular	2.1
Pb	Irregular	2.81
Pb	Irregular	2.79
Pb	Irregular	1.98
Pb	Irregular	2.08
Pb	Irregular	6.65
Pb	Irregular	2.19
Pb	Irregular	2.16
Pb	Irregular	9.15
Pb	Irregular	6.83
Pb	Irregular	2.03
Pb	Irregular	1.91
Pb	Irregular	2.69
Pb	Irregular	2.25
Pb	Irregular	2.34
Pb	Irregular	1.61
Pb	Irregular	2.06
Pb	Irregular	2.77
Pb	Irregular	2.27
Pb	Irregular	4.4
Pb	Irregular	2.8
Pb	Irregular	1.6
Pb	Irregular	1.4
Pb	Irregular	3.2
Pb	Irregular	4

Table B 3 - *Continued*

Pb	Irregular	1
Pb	Irregular	1.8
Pb	Irregular	1.5
Pb	Irregular	1
Pb	Irregular	2.8
Pb	Irregular	1.8
Pb	Irregular	1.3
Pb	Irregular	3.7
Pb	Irregular	4.77
Pb	Irregular	1.3
Pb	Irregular	3.8
Pb	Irregular	1
Pb	Irregular	1.4
Pb	Irregular	1.1
Pb	Irregular	1.5
Pb	Irregular	1.5
Pb	Irregular	1.4
Pb	Irregular	1.5
Pb	Irregular	3.73
Pb	Irregular	2.12
Pb	Irregular	1.8
Pb	Irregular	1.79
Pb	Irregular	1.25
Pb	Irregular	1.54
Pb	Irregular	2.22
Pb	Irregular	2.2
Pb	Irregular	1.83
Pb	Irregular	1.79
Pb	Irregular	1.64
Pb	Irregular	2.38
Pb	Irregular	3.26
Pb	Irregular	1.81
Pb	Irregular	1.41
Pb	Irregular	4.69
Pb	Irregular	1.93

Table B 3.- *Continued*

Pb	Irregular	2.02
Pb	Irregular	1.72
Pb	Irregular	5.46
Pb	Irregular	2.5
Pb	Irregular	1.47
Pb	Irregular	1.38
Pb	Irregular	4.25
Pb	Irregular	1.78
Pb	Irregular	2.56
Pb	Irregular	2.49
Pb	Irregular	2.8
Pb	Irregular	1.67
Pb	Irregular	1.39
Pb	Irregular	1.79
Pb	Irregular	2.06
Pb	Irregular	2.44
Pb	Irregular	1.62
Pb	Irregular	2.79
Pb	Irregular	1.75
Pb	Irregular	1.95
Pb	Irregular	8.13
Pb	Irregular	7.32
Pb	Irregular	2.74
Pb	Irregular	4.41
Pb	Irregular	2.44
Pb	Irregular	1.66
Pb	Irregular	2.37
Pb	Irregular	3.27
Pb	Irregular	1.98
Pb	Irregular	3.06
Pb	Irregular	1.53
Pb	Irregular	2.38
Pb	Irregular	2.13
Pb	Irregular	1.92
Pb	Irregular	1.61

Table B 3 - *Continued*

Pb	Irregular	1.65
Pb	Aggregate	4
Pb	Irregular	1.9
Pb	Irregular	1.5
Pb	Aggregate	3.1
Pb	Irregular	1.87
Pb	Irregular	1.68
Pb	Irregular	1
Pb	Irregular	1.89
Pb	Irregular	1.9
Pb	Irregular	1
Pb	Irregular	1
Pb	Irregular	0.83
Pb	Irregular	1.88
Pb	Irregular	1.13
Pb	Irregular	1
Pb	Irregular	0.9
Pb	Irregular	1.87
Pb	Irregular	1.05
Pb	Irregular	1.25
Pb	Irregular	2
Pb	Irregular	1
Pb	Irregular	0.68
Pb	Irregular	1.5
Pb	Irregular	1
Pb	Irregular	0.85
Pb	Irregular	2.2
Pb	Irregular	1
Pb	Irregular	0.85
Pb	Irregular	0.85
Pb	Irregular	0.94
Pb	Aggregate	1.95
Pb	Rounded	0.92
Pb	Aggregate	2.4
Pb	Irregular	1.7

Table B 3 - *Continued*

Pb	Irregular	1.1
Pb	Irregular	1.5
Pb	Irregular	1.1
Pb	Irregular	1
Pb	Irregular	3.37
Pb	Irregular	1.25
Pb	Irregular	9
Pb	Aggregate	1.5
Pb	Irregular	1.24
Pb	Irregular	1.82
Pb	Irregular	1
Pb	Irregular	0.72
Pb	Irregular	0.6
Pb	Irregular	1
Pb	Irregular	1.2
Pb	Irregular	1
Pb	Irregular	1
Pb	Irregular	0.6
Pb	Irregular	1
Pb	Irregular	0.5
Pb	Irregular	2.8
Pb	Irregular	1.8
Pb	Irregular	1.28
Pb	Irregular	1.41
Pb	Irregular	4.4
Pb	Rounded	2.08
Pb	Irregular	1.68
Pb	Irregular	2.2
Pb	Irregular	12.3
Pb	Irregular	1.49
Pb	Irregular	3.6
Pb	Irregular	3
Pb	Irregular	4.24
Pb	Irregular	3.41

Table B 3 - *Continued*

Pb	Irregular	1.79
Pb	Irregular	1.25
Pb	Irregular	1.87
Pb	Irregular	0.99
Pb	Irregular	0.48
Pb	Irregular	1.6
Pb	Irregular	1.06
Pb	Irregular	1.3
Pb	Aggregate	4
Pb	Aggregate	2.2
Pb	Irregular	1.33
Pb	Irregular	1
Pb	Elongated	1.33
Pb	Aggregate	5.55
Pb	Aggregate	2
Pb	Irregular	0.85
Pb	Irregular	1.25
Pb	Irregular	1.6
Pb	Irregular	1.5
Pb	Irregular	0.533
Pb	Irregular	0.8
Pb	Irregular	2.4
Pb	Irregular	0.73
Pb	Irregular	0.75
Pb	Irregular	1.5
Pb	Irregular	1.07
Pb	Irregular	1.06
Pb	Irregular	1.8
Pb	Irregular	1.3
PbCa	Irregular	4.26
PbCa	Aggregate	12.8
PbCa	Irregular	1.61
PbCa	Irregular	2.05
PbCa	Irregular	2.33

Table B 3 - *Continued*

PbCa	Irregular	2.14
PbCa	Aggregate	4.37
PbCa	Irregular	2.37
PbCa	Irregular	1.25
PbCa	Irregular	1.96
PbCa	Aggregate	1.66
PbCa	Irregular	2
PbCa	Aggregate	1.35
PbCa	Irregular	1.11
PbCa	Irregular	1.33
PbCa	Aggregate	1.33
PbCa	Aggregate	7.6
PbTi	Irregular	3.02
PbTi	Irregular	8.64
PbTi	Rounded	1.84
PbTi	Irregular	2.46
PbTi	Irregular	2.84
PbTi	Irregular	1.2
PbTi	Irregular	1.56
PbZn	Aggregate	8.54
PbZn	Irregular	12.4
PbZn	Irregular	5.54
PbZn	Aggregate	5.22
PbZn	Aggregate	5.2
PbZn	Aggregate	6.11
PbZn	Aggregate	8.4
PbZn	Irregular	1.9
PbZn	Irregular	2.34
PbZn	Aggregate	5.09
PbZn	Aggregate	5.22
PbZn	Irregular	3.29
PbTi	Aggregate	10
PbTi	Aggregate	2.2
PbCr	Irregular	2.13

Table B 3 - *Continued*

PbCr	Irregular	2.2
PbCr	Irregular	1
PbCr	Irregular	1.67
PbCr	Irregular	0.9
PbCr	Irregular	3.33
PbCr	Irregular	2
PbCr	Irregular	2.67
PbCr	Irregular	2.16
PbCr	Elongated	3.6
PbCr	Irregular	1.06
PbCr	Irregular	2
PbCl	Irregular	1.6
PbCl	Irregular	4.22
PbCl	Irregular	1.71
PbCl	Irregular	2.32
PbCl	Irregular	2.53
PbCl	Irregular	3.33
PbCl	Irregular	1.33
PbAl	Irregular	2.64
PbSi	Irregular	2
PbSi	Irregular	1
PbFe	Aggregate	6
PbSi	Irregular	2
PbCaCl	Irregular	4.2
PbCaMg	Aggregate	1.6
PbCaSi	Aggregate	2.26
PbCaK	Irregular	2.4
PbCaCl	Aggregate	4.28
PbTiZn	Irregular	8.9
PbTiCa	Irregular	3.75
PbTiCa	Irregular	2.28
PbTiCa	Irregular	1.1
PbTiCa	Irregular	1.6
PbTiCa	Irregular	2

Table B 3 - *Continued*

PbTiCa	Irregular	2.34
PbTiCa	Aggregate	5.55
PbTiCa	Irregular	2.57
PbTiCa	aggregate	13.33
PbTiSi	Aggregate	8.33
PbTiCr	Angular	1.17
PbSiMg	Irregular	3.19
PbSiAl	Irregular	1.83
PbSiAl	Irregular	2
PbZnCa	Irregular	1.66
PbZnCa	Aggregate	4.5
PbZnCa	Aggregate	3.33
PbZnCa	Aggregate	3.46
PbZnCa	Aggregate	4.33
PbZnCa	Aggregate	4.44
PbZnCl	Aggregate	4.93
PbZnCl	Aggregate	3.33
PbZnCl	Aggregate	6.25
PbZnCl	Aggregate	3.2
PbZnSi	Aggregate	4.33
PbZnSi	Aggregate	6
PbZnSi	Aggregate	12.85
PbZnSi	Aggregate	5.55
PbZnSi	Aggregate	6
PbZnCl	Aggregate	6
PbCrCa	Irregular	1.5
PbClK	Irregular	3.46
PbCaP	Irregular	2.5
PbCaSiAl	Aggregate	2.53
PbCaSiAl	Irregular	4.61
PbCaKCl	Irregular	2
PbTiCaCl	Irregular	2.75
PbTiCa	Irregular	2
PbTiClNa	Irregular	3.69

Table B 3 - *Continued*

PbTiCaK	Irregular	1.8
PbZnTiCa	Irregular	2
PbZnTiCl	Aggregate	25.5
PbZnTiCa	Aggregate	3.33
PbZnTiSi	Aggregate	2.56
PbZnTiSi	Aggregate	4.67
PbZnTiSi	Aggregate	2.6
PbZnTiCl	Aggregate	8.53
PbZnSiAl	Irregular	4
PbZnSiCa	Irregular	6
PbZnSiCaAlFe	Aggregate	11.66
PbZnSiCa	Aggregate	6.66
PbZnSiCa	Aggregate	2.77
PbZnSiCa	Irregular	3
PbZnSiCa	Aggregate	1.98
PbZnSiCa	Aggregate	7.85
PbZnSiCa	Aggregate	5.75
PbZnSiCl	Aggregate	6.66
PbZnSiCl	Aggregate	20
PbZnSiMg	Aggregate	2.4
PbTiCrCa	Angular	2
PbTiCrCa	Irregular	2
PbTiCrCa	Irregular	5.2
PbTiCrCa	Irregular	1.89
PbTiCrCa	Aggregate	2
PbTiCrCa	Aggregate	4.44
PbTiCrCa	Irregular	1.5
PbTiSiAl	Aggregate	3
PbZnBaCa	Irregular	4.89
PbZnBaSi	Aggregate	4
PbTiCaSiAl	Irregular	2
PbZnTiCaSi	Angular	4.33
PbZnCaSiAl	Irregular	4.29
PbZnCaSiAl	Aggregate	6

Table B 3 - *Continued*

PbZnCaSiMg	Aggregate	6.66
PbZnCaSiMg	Aggregate	3.92
PbZnCaSiFe	Aggregate	4.13
PbZnTiCaSi	Aggregate	3.66
PbZnTiCaSi	Aggregate	5.55
PbZnCaFe	Aggregate	3.33
PbZnTiSiMg	Aggregate	16.33
PbCaSiClNa	Aggregate	5.33
PbZnCaSiFe	Aggregate	4.1
PbZnSiClMg	Aggregate	4.04
PbZnSiClMg	Aggregate	18.66
PbZnSiAlFe	Aggregate	18
PbTiCaPCl	Irregular	2.66
PbZnBaCaSi	Irregular	5.85
PbCaSiCl	Aggregate	3.46
PbTiCaSiAl	Irregular	3.75
PbTiCaSi	angular	1.66
PbTiCaSiAl	Irregular	3.46
PbTiCaSiAl	Irregular	1.55
PbCaPAlFe	Irregular	5.94
PbZnCaSiAlCl	Aggregate	5.2
PbZnCaSiMgCl	Aggregate	8
PbZnTiCaSiFe	Aggregate	3.03
PbZnTiCaSiMg	Aggregate	6
PbZnTiCaSiCl	Aggregate	43.33
PbZnCaSiCl	Aggregate	9.06
PbZnTiCaSiCl	Aggregate	7.14
PbZnSiCl	Aggregate	4.61
PbZnTiCaSiAl	Aggregate	8
PbZnTiCaSiFe	Aggregate	4.07
PbZnTiSiAlCl	Irregular	6.43
PbZnCaSiMgFe	Aggregate	6.25
PbZnCrCaSiAl	Aggregate	3.46
PbZnCrCaSiCl	Aggregate	4

Table B 3 - *Continued*

PbZnCaSiKFe	Aggregate	9.26
PbZnCaSiMgFe	Aggregate	5.2
PbZnCaSiMgCl	Aggregate	7
PbZnSiAlMgCl	Aggregate	17.4
PbZnSiAlClFe	Aggregate	16.33
PbZnBaCaSiCl	Aggregate	9.38
PbZnSiAlClKFe	Aggregate	8.6
PbZnCaSiMgP	Aggregate	6.5
PbZnTiCaSiMgFe	Angular	7
PbCaSiAlPFeNa	Irregular	5.83
PbZnCrCaSiAlMgFe	Aggregate	4.61
PbZnCrTiCaSiAlMg	Aggregate	3.92
PbZnTiCaSiAlKFe	Irregular	5.15
PbZnCaSiAlMgFe	Aggregate	16
PbZnCaSiAlKPFe	Aggregate	6.66
PbZnTiCaSiAlKMgFe	Aggregate	4.44

Table B 4 House B Pb bearing particles found in window paint sample

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	3.85
Pb	Aggregate	6.19
Pb	Aggregate	8.85
Pb	Aggregate	8.1
Pb	Irregular	4.02
Pb	Aggregate	6.27
Pb	Aggregate	6.28
Pb	Irregular	1.39
Pb	Aggregate	7.37
Pb	Irregular	5.06
Pb	Irregular	1.56
Pb	Irregular	1.28
Pb	Irregular	2.93
Pb	Irregular	2.61
Pb	Irregular	3.05
Pb	Irregular	2.33
Pb	Aggregate	2.38
Pb	Irregular	2.91
Pb	Aggregate	11.4
Pb	Aggregate	3.57
Pb	Aggregate	3.63
Pb	Irregular	3.5
Pb	Aggregate	8.87
Pb	Aggregate	14.4
Pb	Irregular	1.29
Pb	Irregular	3.79
Pb	Aggregate	6.78
Pb	Irregular	3.4
Pb	Irregular	1.86
Pb	Irregular	1.57
Pb	Irregular	1.7
Pb	Elongated	1.25
Pb	Aggregate	3.24

Table B 4 - *Continued*

Pb	Irregular	259
Pb	Irregular	4.63
Pb	Irregular	1.9
Pb	Aggregate	4.96
Pb	Aggregate	3.61
Pb	Aggregate	4.01
Pb	Aggregate	2.85
Pb	Irregular	1.71
Pb	Aggregate	2.99
Pb	Aggregate	5.05
Pb	Irregular	4.15
Pb	Aggregate	2.86
Pb	Irregular	1.85
Pb	Irregular	4.03
Pb	Irregular	2.94
Pb	Irregular	1.64
Pb	Aggregate	4.31
Pb	Irregular	1.7
Pb	Aggregate	7.09
Pb	Aggregate	2.47
Pb	Irregular	2.75
Pb	Aggregate	3.44
Pb	Irregular	1.47
Pb	Aggregate	4.02
Pb	Aggregate	3.04
Pb	Irregular	1.82
Pb	Aggregate	4.77
Pb	Aggregate	3.7
Pb	Irregular	3.67
Pb	Irregular	1.52
Pb	Irregular	1.04
Pb	Irregular	0.946
Pb	Aggregate	4.55
Pb	Aggregate	5.77

Table B 4 - *Continued*

Pb	Aggregate	3
Pb	Irregular	1.11
Pb	Aggregate	3.97
Pb	Irregular	1.71
Pb	Irregular	1.75
Pb	Irregular	2.62
Pb	Aggregate	1.99
Pb	Aggregate	4.26/2.05
PbZn	Aggregate	5.44
PbZn	Aggregate	5.71
PbZn	Aggregate	4.19
PbZn	Aggregate	5.14
PbZn	Aggregate	3.5
PbZn	Aggregate	8.13
PbZn	Aggregate	1.56
PbZn	Aggregate	2.51/1.34
PbZn	Aggregate	4.01
PbZn	Aggregate	6.62
PbZn	Aggregate	13.2
PbZn	Aggregate	5.14
PbZn	Aggregate	3.98
PbZn	Aggregate	4.57
PbZn	Aggregate	5.01
PbZn	Irregular	3.46
PbZn	Aggregate	9.23
PbZn	Aggregate	8.38
PbZn	Aggregate	1.85
PbZn	Aggregate	8.03
PbZn	Aggregate	4.12
PbZn	Aggregate	4.5
PbZn	Aggregate	5.72
PbZn	Irregular	1.12
PbZn	Irregular	2.4
PbZn	Irregular	4.31

Table B 4 - *Continued*

PbZn	Aggregate	3.33
PbZn	Aggregate	3.54
PbZn	Irregular	3.16
PbZn	Aggregate	3.05
PbZn	Irregular	1.76
PbZn	Aggregate	2.83
PbZn	Aggregate	5.23
PbZn	Aggregate	3.42
PbZn	Aggregate	2.78
PbZn	Aggregate	3.25
PbZn	Irregular	2.67
PbZn	Aggregate	8.79
PbSi	Irregular	3.44
PbTi	Irregular	2.49
PbTi	Aggregate	4.72
PbNa	Irregular	2.95
PbNa	Irregular	1.86
PbZn	Aggregate	3.81/1.22
PbZn	Aggregate	8.38/2
PbZn	Aggregate	2.56
PbZn	Aggregate	4.73
PbZn	Aggregate	9.14
PbSi	Irregular	2.51
PbZn	Aggregate	6.4
PbZn	Aggregate	4.25
PbZn	Aggregate	7.06
PbZn	Aggregate	11
PbZn	Aggregate	6.06
PbZn	Aggregate	24.9
PbZnSi	Aggregate	5.77
PbZnSi	Aggregate	8.35
PbSiMg	Irregular	4.29
PbZnSi	Aggregate	8.87
PbZnSi	Aggregate	12.5

Table B 4 - *Continued*

PbZnSi	Aggregate	7.1
PbSiFe	Aggregate	5.21
PbZnSi	Aggregate	4.06
PbZnSi	Aggregate	8.55
PbZnSi	Aggregate	3.38
PbZnSi	Aggregate	4.01
PbZnSi	Aggregate	14.2
PbZnSi	Aggregate	11.6
PbZnSi	Aggregate	4.48
PbZnSi	Aggregate	43
PbZnSi	Irregular	3.76
PbZnTi	Aggregate	3.6
PbZnTi	Aggregate	8.27
PbZnTi	Aggregate	3.49
PbZnCl	Aggregate	3.7
PbZnCl	Aggregate	4.43
PbZnCl	Irregular	2.37
PbZnCl	Irregular	2.2
PbZnCl	Irregular	1.57
PbZnCl	Aggregate	4.28/2.31
PbZnCl	Aggregate	5.96
PbZnCl	Aggregate	9.66
PbZnCl	Aggregate	4.05
PbZnCl	Irregular	1.79
PbZnCl	Irregular	2.04
PbZnCl	Irregular	1.65
PbZnCl	Irregular	1.72
PbZnCl	Irregular	0.955
PbZnCl	Aggregate	5.26
PbZnFe	Aggregate	7.83
PbZnFe	Aggregate	8.06
PbZnCa	Irregular	9.97
PbTiSi	Aggregate	2.91
PbZnTi	Aggregate	3.98

Table B 4 - *Continued*

PbZnTi	Aggregate	3.93
PbZnSi	Aggregate	9.16
PbZnTi	Aggregate	3.5
PbZnBa	Aggregate	6.37
PbZnTiSi	Aggregate	5.25
PbZnTiSi	Aggregate	39.1
PbZnTiSi	Aggregate	9.1
PbZnTiSi	Aggregate	4.82
PbZnTiSi	Aggregate	2.5
PbZnTiSi	Aggregate	10.2
PbZnTiFe	Irregular	3.13
PbZnClSi	Aggregate	18.6
PbZnClSi	Aggregate	17.5
PbZnClSi	Aggregate	20.4
PbZnClSi	Aggregate	4.45
PbZnClSi	Aggregate	21.9
PbZnSiMg	Aggregate	5.34
PbZnCaCl	Aggregate	6.35
PbZnSiAl	Aggregate	6.68
PbZnClSi	Aggregate	4.18
PbZnBaSi	Aggregate	30.6
PbZnSiMg	Aggregate	8.22
PbZnSiMg	Aggregate	5.17
PbZnSiAl	Aggregate	6.16
PbZnSiAl	Aggregate	8.06
PbZnClFe	Aggregate	24.5
PbZnTiSi	Aggregate	14.4
PbZnSiMg	Aggregate	12.2
PbZnSiMg	Aggregate	20
PbZnCrSi	Aggregate	4.15
PbZnClSi	Aggregate	9.14
PbZnClSiMg	Aggregate	5.79
PbZnClSiMg	Aggregate	3.75
PbZnClSiFe	Aggregate	7.41

Table B 4 - *Continued*

PbZnClSiFe	Aggregate	6.4
PbZnTiCasi	Aggregate	9.69
PbZnTiSiAl	Aggregate	7.47
PbZnSiMgFe	Aggregate	6.65
PbZnCrSiCl	Aggregate	17.4
PbZnSiAlK	Aggregate	6.9
PbZnCaSiClMg	Aggregate	26.7
PbZnTiCaSiMg	Aggregate	7.36
PbZnTiCaSiMg	Aggregate	9.16
PbZnTiSiMg	Aggregate	6.55
PbZnTiCrSiClMg	Aggregate	12.4
PbZnSiMgP	Aggregate	4.65
PbZnSiMgCaFe	Aggregate	6.79
PbZnSiAlFe	Aggregate	3.17
PbZnSiAlFe	Aggregate	10.4
PbZnCaClKFe	Aggregate	13
PbZnCaClSi	Irregular	4.6
PbZnSiAlMg	Aggregate	4.04
PbZnTiCaSiMg	Aggregate	10.1
PbZnSiAlClFe	Aggregate	6.89
PbZnCrCaSiMgFe	Aggregate	9.74
PbZnTiSiAlMg	Aggregate	9.41
PbZnTiSiMgFe	Aggregate	7.69
PbZnSiClFe	Aggregate	26.4
PbZnTiSiMgFe	Aggregate	8.96
PbZnTiSiAlMgFe	Aggregate	11.6
PbZnTiSiMg	Aggregate	58.3
PbZnTiCaSi	Aggregate	17.3
PbZnTiCrCaSiClMg	Aggregate	8.43
PbZnTiCrCaSiClMg	Aggregate	35.2/18.6
PbZnCaSiAlClMgFe	Aggregate	14.6
PbZnTiCrCaSiMgFe	Aggregate	7.89
PbZnTiCaSiAlMgFe	Aggregate	3.55
PbZnCaSiAlKClMgFe	Aggregate	25.8
PbZnTiCaSiAlKMgP	Aggregate	13.1

Table B 5 House B Pb bearing particles found in building line soil sample

Chemical Composition	Morphology	Size
PbTi	Irregular	0.992
PbTi	Irregular	0.876
PbTi	Irregular	1.32
PbTi	Irregular	1.65
PbTi	Irregular	1.23
PbTi	Irregular	1.21
PbTi	Aggregate	1.59
PbTi	Irregular	1.27
PbTi	Irregular	0.951
PbTi	Irregular	1.68
PbTi	Aggregate	1.03
PbTi	Irregular	0.857
PbTi	Aggregate	1.3
PbTi	Aggregate	5.7
PbTi	Aggregate(Tiny Pb Inclusion)	7.48/.828
PbTi	Irregular	0.757
PbTi	Irregular	1.08
PbTi	Aggregate	3.01
PbTi	Irregular	1.96
PbTi	Aggregate	2.09
PbTi	Aggregate	7.28
PbTi	Aggregate	1.69
PbTi	Aggregate	1.83
PbCl	Irregular	1.57
PbTiSi	Irregular	0.835
PbTiSi	Aggregate	2.6
PbTiSi	Aggregate	2.8
PbTiSi	Aggregate	3.41
PbTiSi	Aggregate	1.97
PbTiSi	Aggregate	2.36
PbTiFe	Aggregate	4.75
PbTiFe	Irregular	0.979
PbTiSiAl	Irregular	2.24

Table B 5 - *Continued*

PbTiSiAl	Irregular (Tiny Pb Inclusion)	3.13/.738
PbTiSiFe	Aggregate	3.76
PbTiSiMg	Aggregate	2.41
PbTiSiMg	Aggregate	2.62
PbTiSiMg	Aggregate	2.08
PbTiSiMg	Aggregate	1.58
PbTiSiMg	Aggregate	3.99
PbTiSiMg	Aggregate	3.1
PbTiSiMg	Aggregate	3.64
PbTiSiMg	Aggregate	4.42
PbTiSiMg	Aggregate	2.07
PbTiSiMg	Irregular	1.21
PbTiSiMg	Irregular	0.845
PbTiSiMg	Aggregate	4.23
PbTiSiMg	Irregular	3.49
PbTiSiMg	Aggregate	1
PbTiSiMg	Aggregate	10.1
PbTiSiMg	Aggregate	11.6
PbTiSiCa	Irregular	1.66
PbTiSiMg	Aggregate	7.56
PbTiSiFe	Aggregate	2.62
PbTiSiFe	Aggregate	1.8
PbTiSiMg	Aggregate	3.65
PbTiSiMg	Aggregate	4.56
PbTiSiMg	Aggregate	2.44
PbTiSiMg	Aggregate	2.26
PbTiSiMgFe	Aggregate	5.17
PbTiSiMgFe	Irregular	1.92
PbTiSiMgFe	Aggregate	10.6
PbTiSiMgFe	Aggregate	10
PbTiSiMgFe	Aggregate	2.21
PbTiSiMgFe	Aggregate	8.98
PbTiSiMgFe	Aggregate	18.8
PbTiSiMgFe	Aggregate	3.93

Table B 5 - *Continued*

PbTiSiMgFe	Aggregate	14.9
PbTiSiMgFe	Aggregate	3.25
PbTiSiMgFe	Aggregate	2.17
PbTiSiMgFe	Aggregate	2.46
PbTiSiMgFe	Aggregate	3.51
PbTiSiMgFe	Aggregate	2
PbTiSiMgFe	Aggregate	2.58
PbTiSiMgFe	Aggregate	3.56
PbTiSiMgFe	Aggregate	9.86
PbTiSiMgFe	Aggregate	7.64
PbTiSiMgFe	Aggregate	8.26
PbTiSiMgFe	Aggregate	14.1
PbTiSiMgFe	Aggregate	4.14
PbTiSiMgAl	Aggregate	3.67
PbTiSiMgAl	Aggregate	7.52
PbTiSiMgFe	Aggregate	6.86
PbTiSiMgCa	Aggregate	3.31
PbTiSiMgCa	Aggregate	10.7
PbTiSiMgCa	Aggregate	1.94
PbTiSiMgCa	Aggregate	5.55
PbTiSiMgFe	Aggregate	7.68
PbTiSiMgFe	Aggregate	6.31
PbTiSiAlK	Aggregate	2.74
PbTiFeSiCa	Aggregate	2.02
PbTiCaSiMgFe	Aggregate	4.61
PbTiSiCaMgFe	Aggregate	1.96
PbTiSiCaMgFe	Aggregate	3.4
PbTiSiCaMgFe	Aggregate	2.58
PbTiSiCaMgFe	Aggregate	3.45
PbTiSiCaMgFe	Aggregate	20
PbTiSiCaMgFe	Aggregate	13.1
PbTiSiCaMgFe	Aggregate	4.02
PbTiSiCaMgFe	Aggregate	3.72
PbTiSiCaMgFe	Aggregate	18.5

Table B 5 - *Continued*

PbTiSiCaMgFe	Aggregate	2.23
PbTiSiCaMgFe	Aggregate	3.68
PbTiSiCaMgFe	Aggregate	13.8
PbTiSiCaMgFe	Aggregate	2.58
PbTiSiCaMgFe	Aggregate	3.67
PbTiSiCaMgFe	Aggregate	3.25
PbTiSiCaMgFe	Aggregate	6.81
PbTiSiAlMgFe	Aggregate	14.1
PbTiSiAlMgFe	Aggregate	1.69
PbTiSiAlMgFe	Aggregate	19
PbTiSiAlMgFe	Aggregate	15
PbTiSiAlMgFe	Aggregate	2
PbTiSiAlMgCa	Aggregate	7
PbTiSiMgCaFe	Aggregate	7.65
PbCaPSiAlFe	Irregular	2.45
PbCaPSiAlK	Aggregate	2.08
PbTiSiMgFeCaAl	Aggregate	10.6
PbTiSiMgFeAl	Aggregate	9.77
PbTiSiMgFeCa	Aggregate	3.69
PbTiSiMgFeCaAl	Aggregate	16.3
PbTiSiMgFeCaAl	Aggregate	7.65
PbCaPSiAlMgFe	Aggregate	2.49
PbTiCaSiAlMgKFe	Aggregate	2.98
PbTiCaSiAlMgKFe	Aggregate	7.03
PbTiCaSiAlMgFeZn	Aggregate	2.42

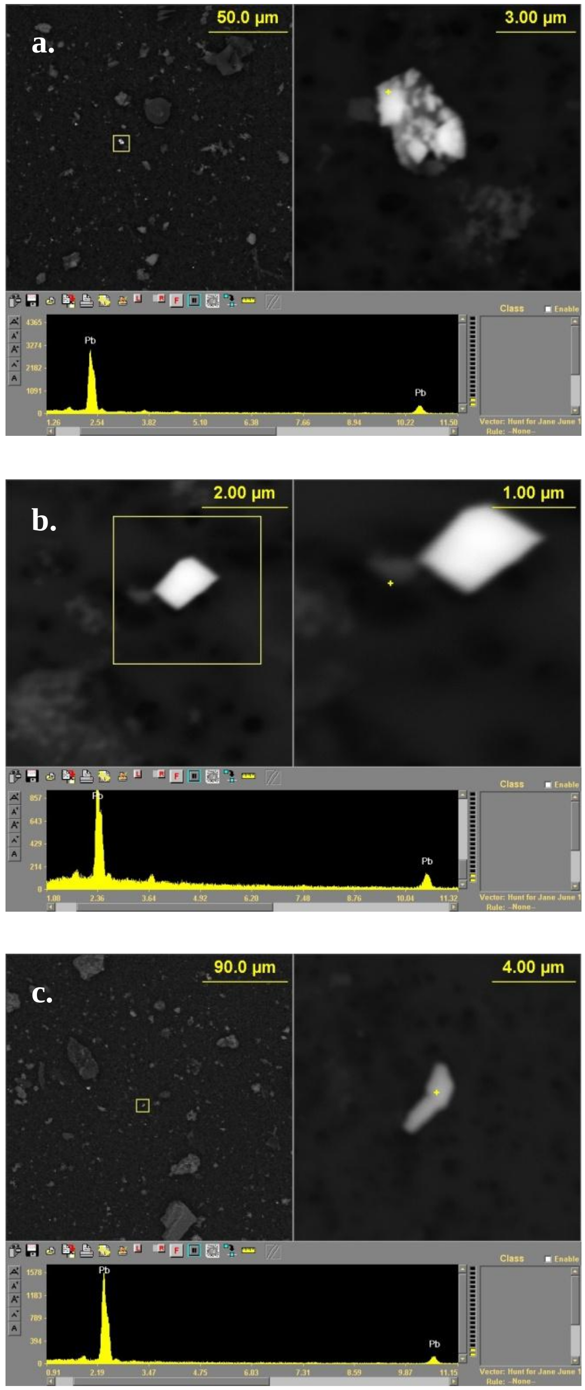


Figure B 3 House B floor dust particle with Pb pigment particles (a, b and c)

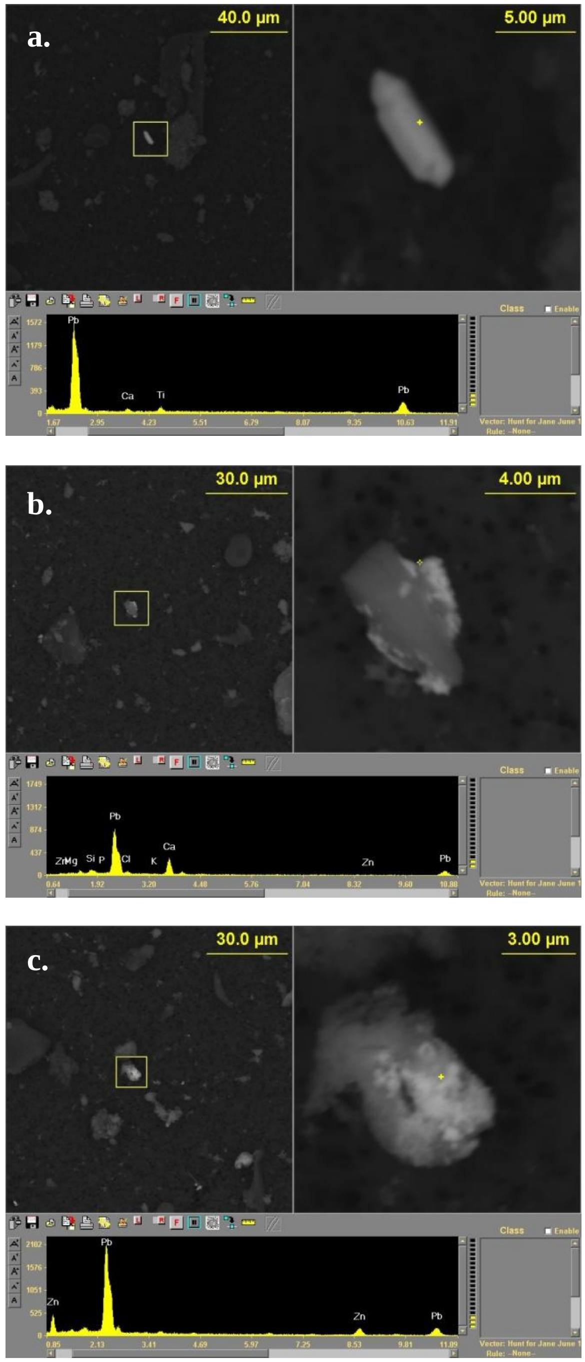


Figure B 4 House B floor dust particle with Pb pigment particles and Ti (a), Ca(b), Zn (c) in matrix

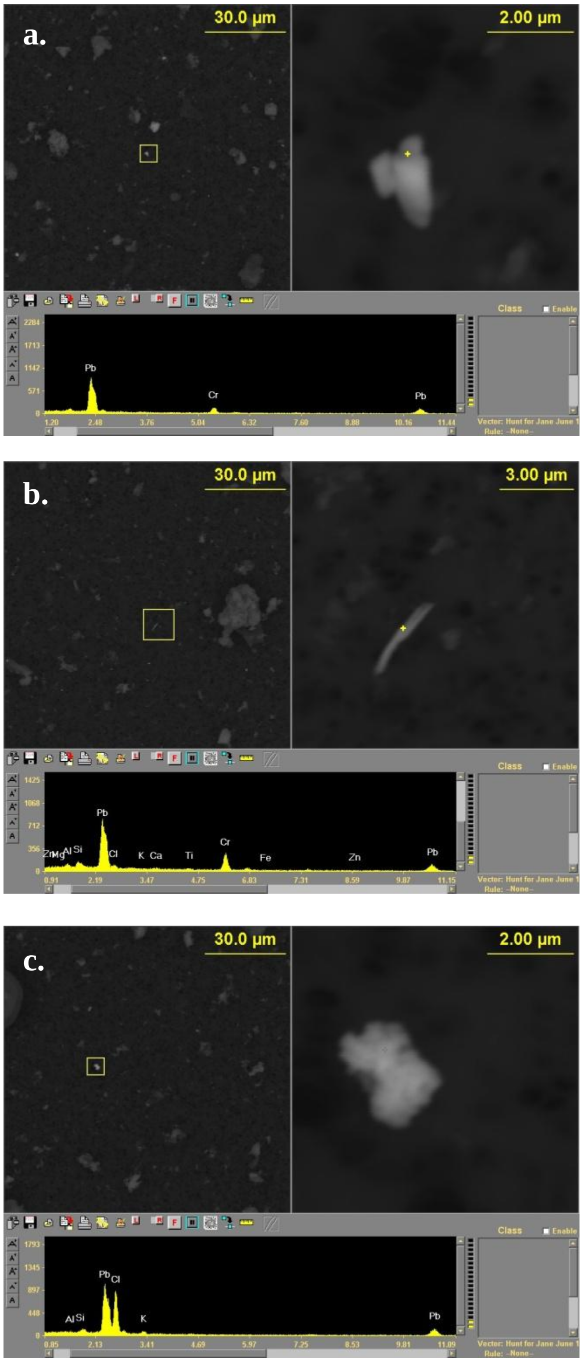


Figure B 5 House B floor dust particle with Pb pigment particles and Cr (a, b), Cl(c), in matrix

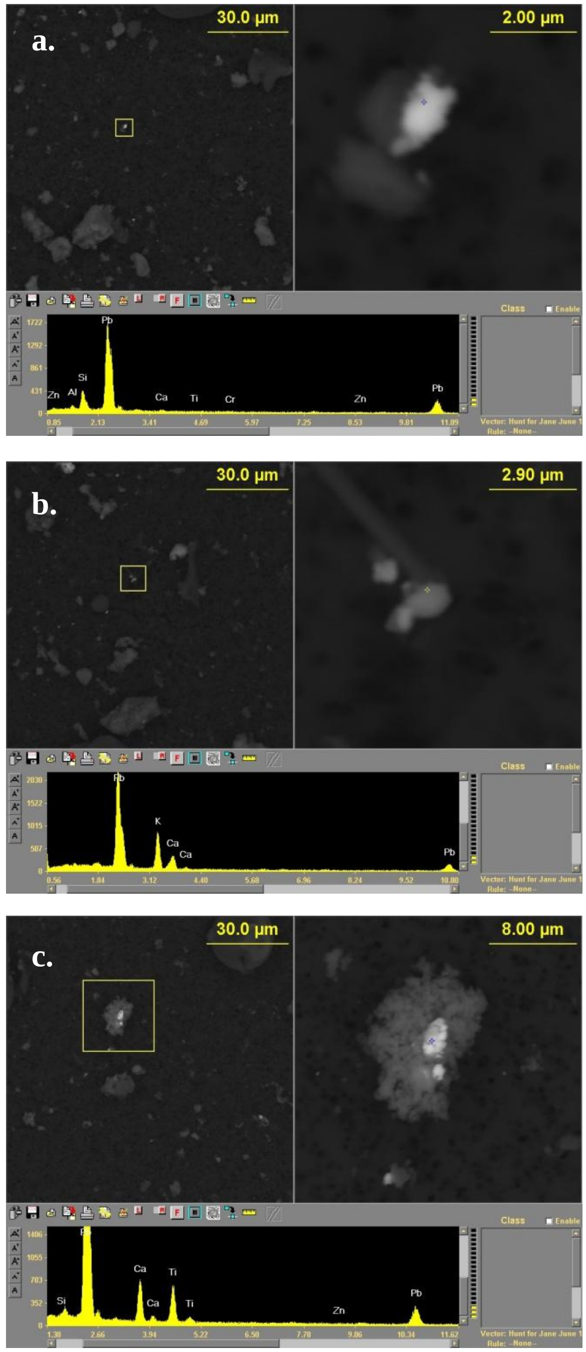


Figure B 6 House B floor dust particle with Pb pigment particles and Si (a) K, Ca (b), Ti, Ca (c) in matrix

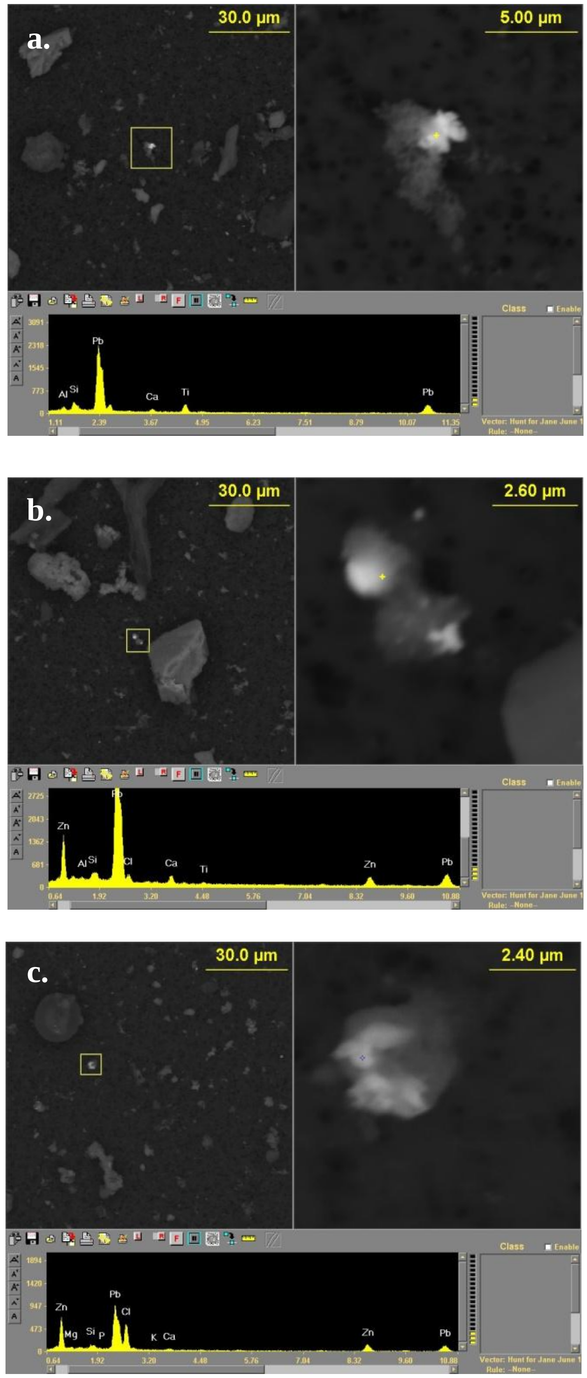


Figure B 7 House B floor dust particle with Pb pigment particles and Ti, Si (a)

Zn, Ca (b), Cl, Zn (c) in matrix

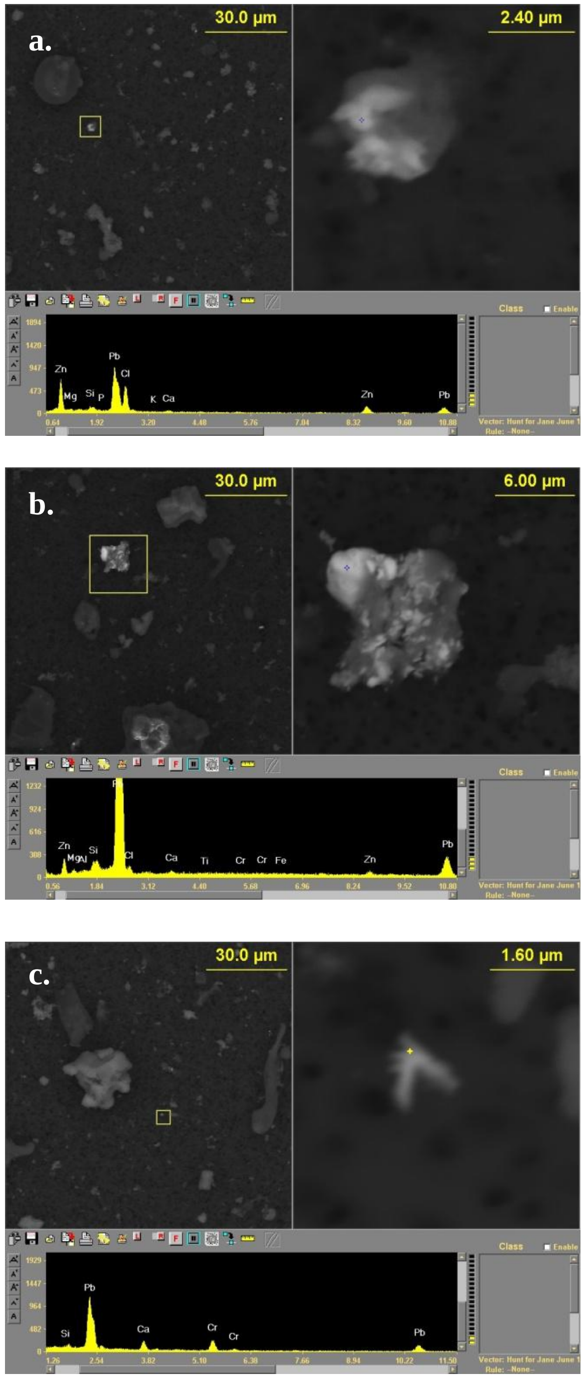


Figure B 8 House B floor dust particle with Pb pigment particles and Zn, Cl (a) Zn, Si (b), Cr, Ca (c) in matrix

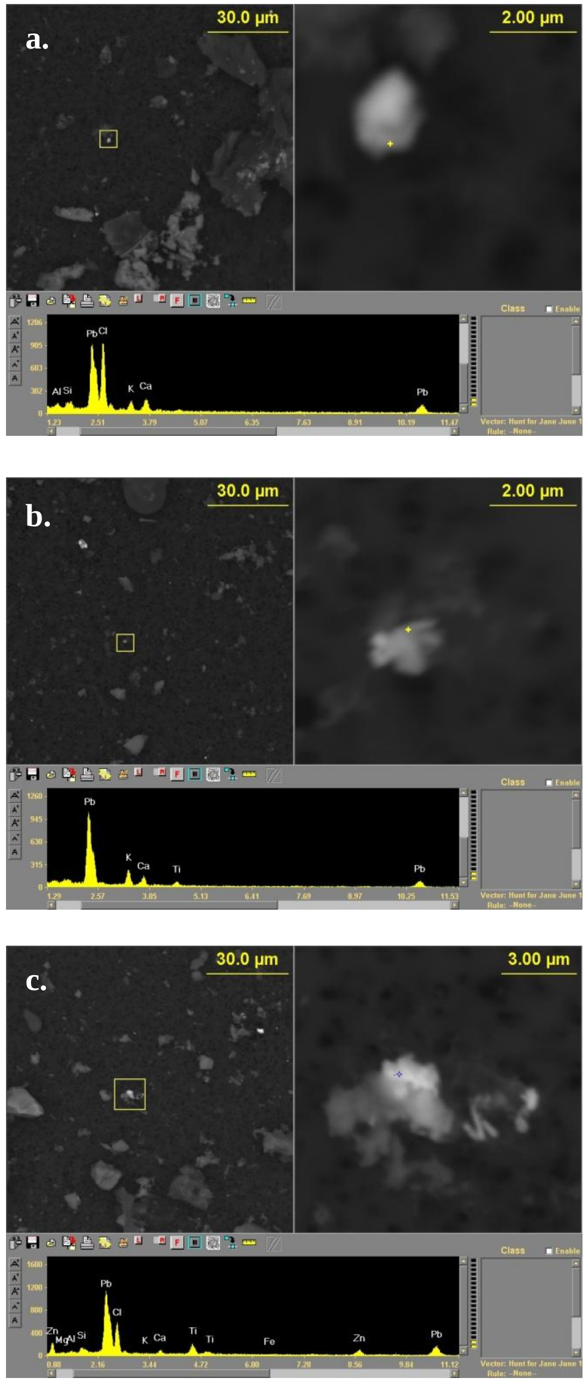


Figure B 9 House B floor dust particle with Pb pigment particles and Cl, Ca, K(a) Ti, Ca, K (b), Cl, Zn, Ti (c) in matrix

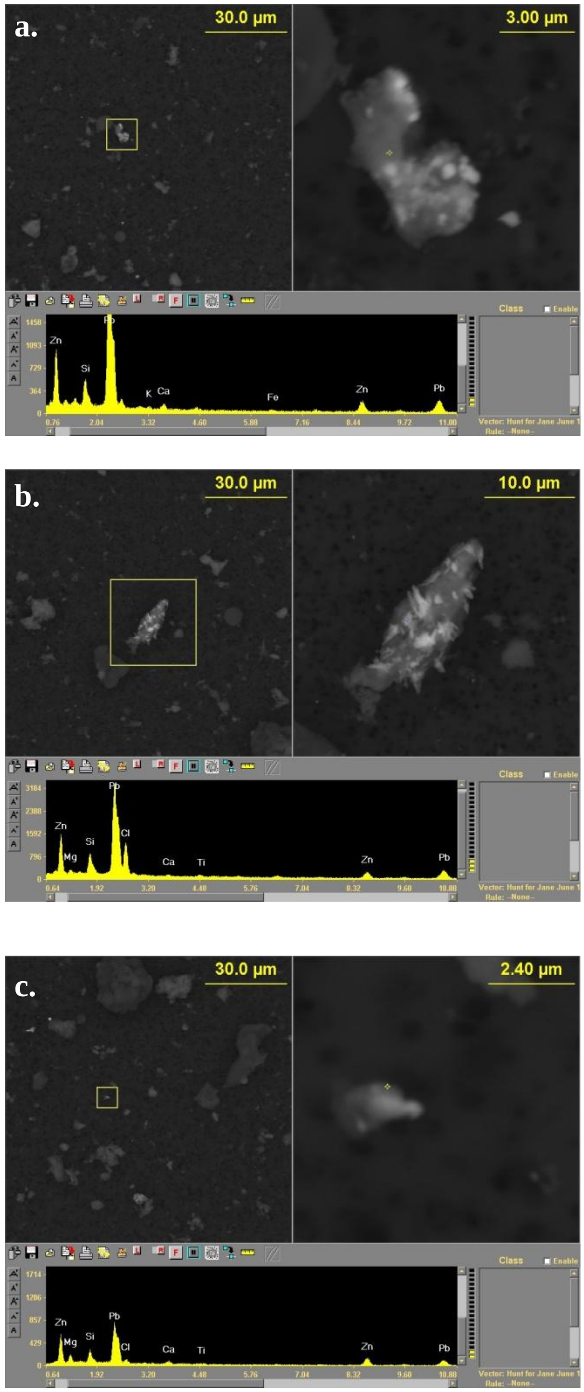


Figure B 10 House B floor dust particle with Pb pigment particles and Zn, Si, Ca, (a) Si, Cl, Zn (b), Si, Zn, Mg (c) in matrix

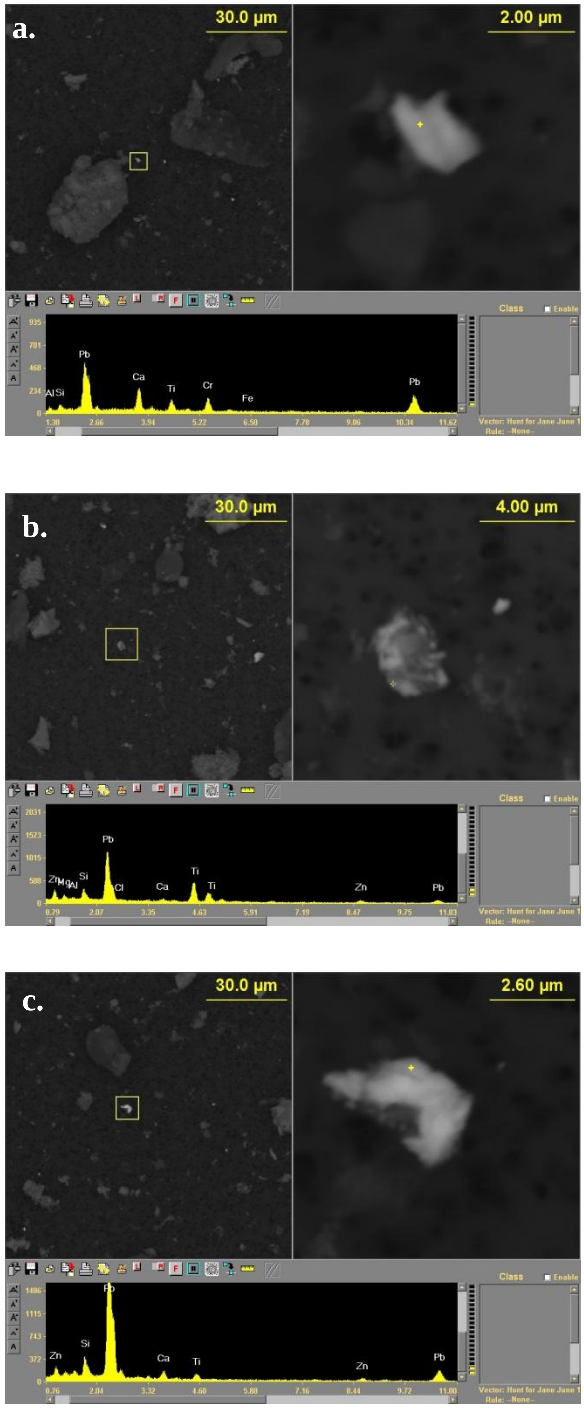


Figure B 11 House B floor dust particle with Pb pigment particles and Ca,Ti, Cr (a) Zn, Si, Ba (b), Si, Zn, Ca, Ti (c) in matrix

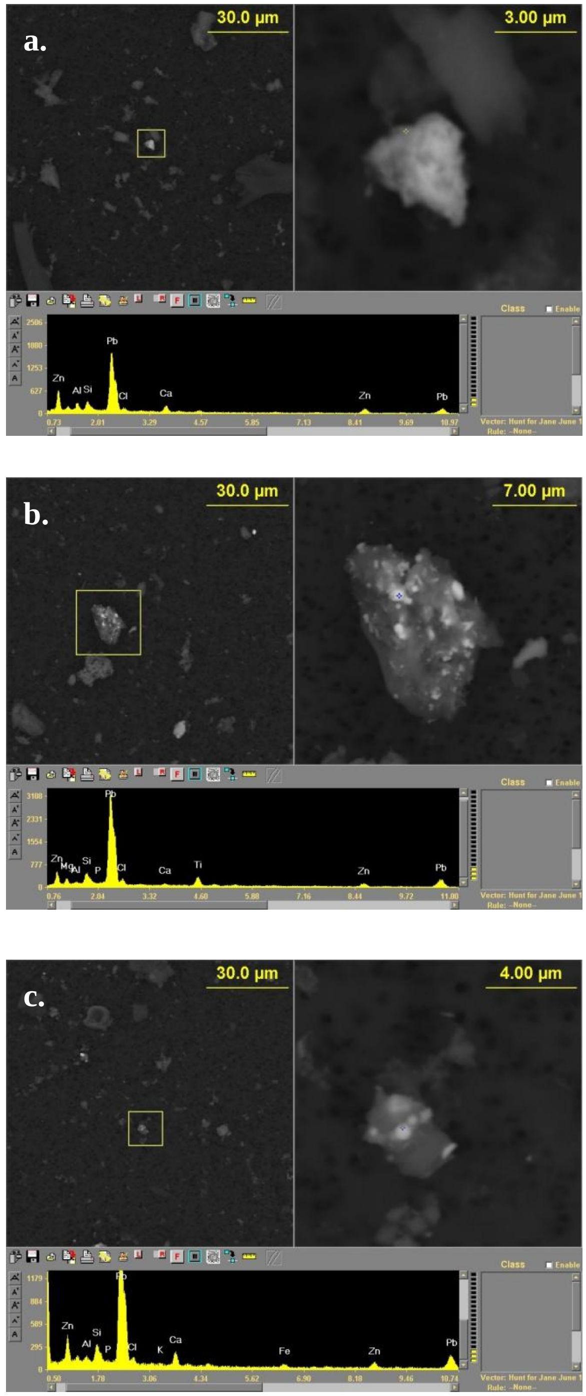


Figure B 12 House B floor dust particle with Pb pigment particles and Zn, Si, Al, Ca (a) Zn, Si, Ti (b), Si, Zn, Ca (c) in matrix

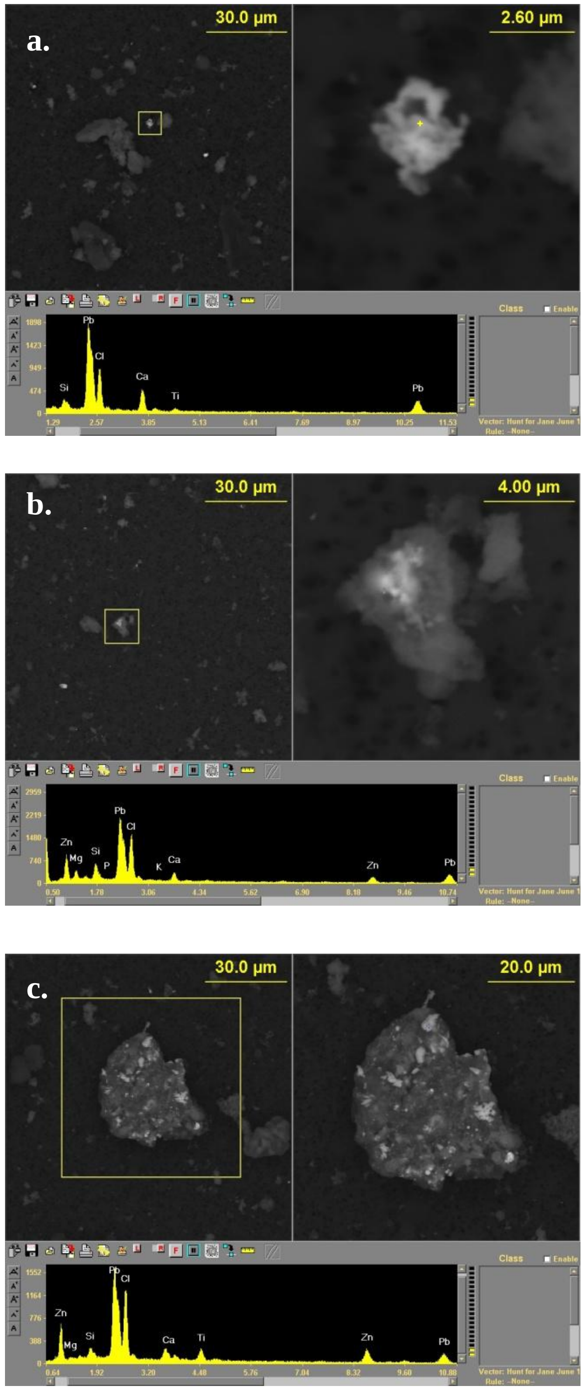


Figure B 13 House B floor dust particle with Pb pigment particles and Cl, Ca, Si (a) Zn, Cl, Si, Ca, Mg (b), Zn, Cl, Si, Ca, Ti (c) in matrix

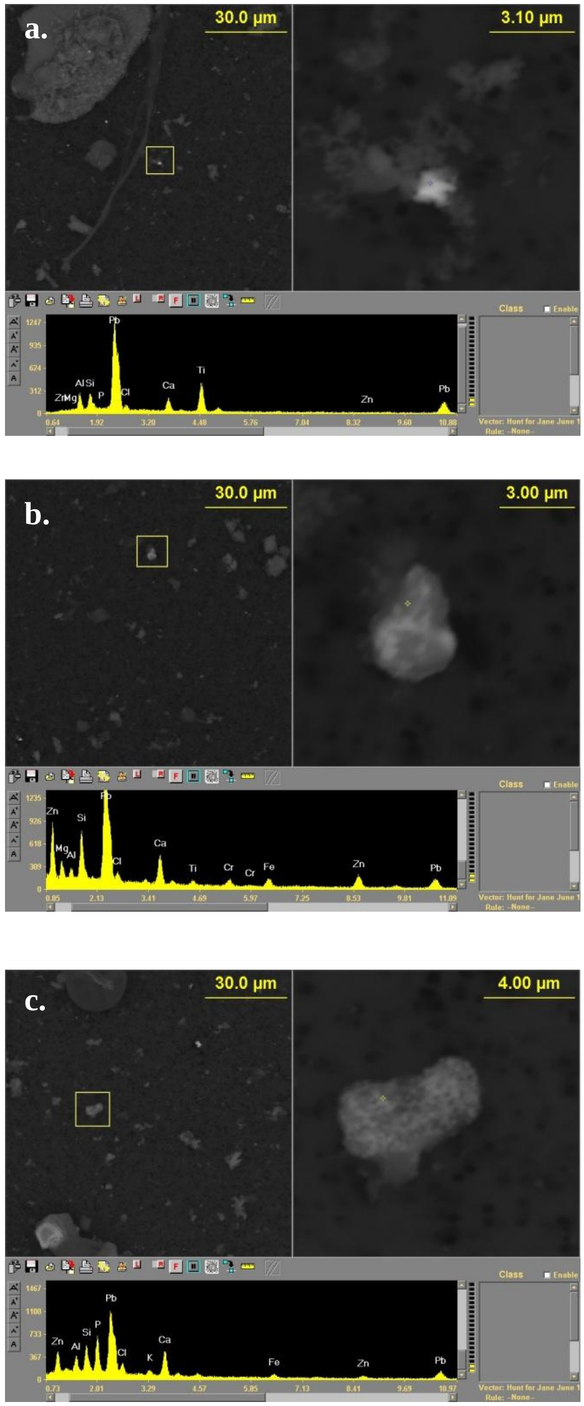


Figure B 14 House B floor dust particle with Pb pigment particles and Ti, Ca, Si, Al (a) Zn, Ca, Si, Al, Mg, Cr, Fe (b), Zn, P, Al Si, Ca, Fe (c) in matrix

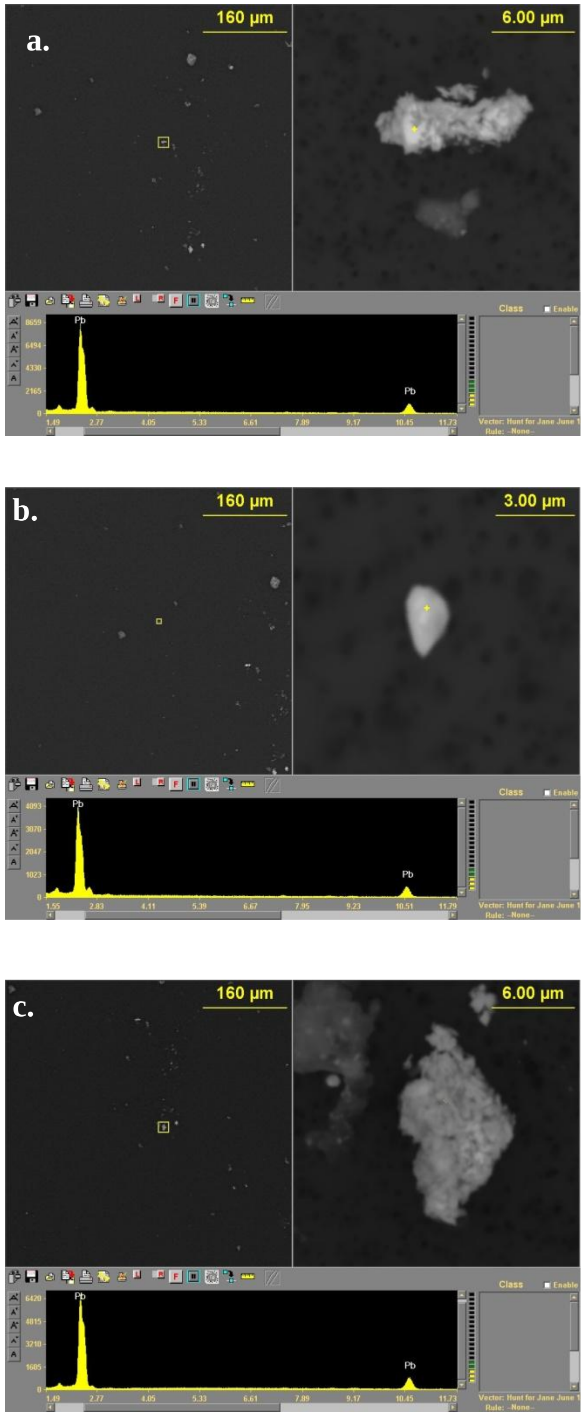


Figure B 15 House B window frame paint particle with Pb pigment particles (a, b and c)

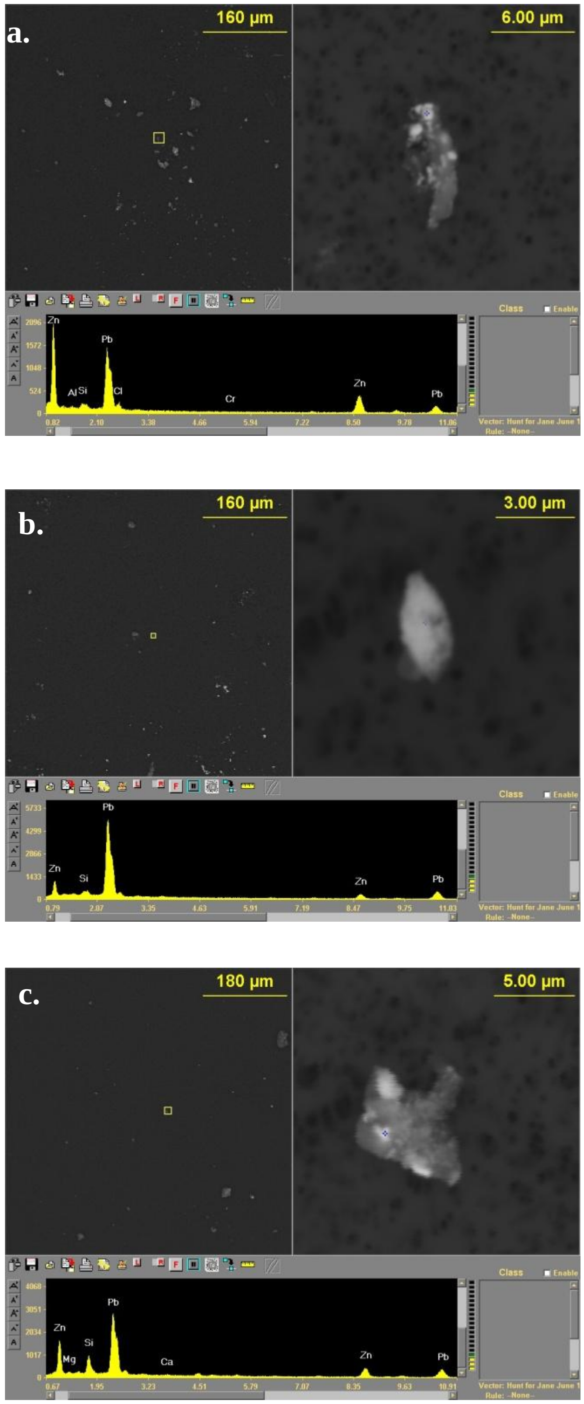


Figure B 16 House B window frame paint particle with Pb pigment particles and Zn (a, b) Zn, Si (c) in matrix

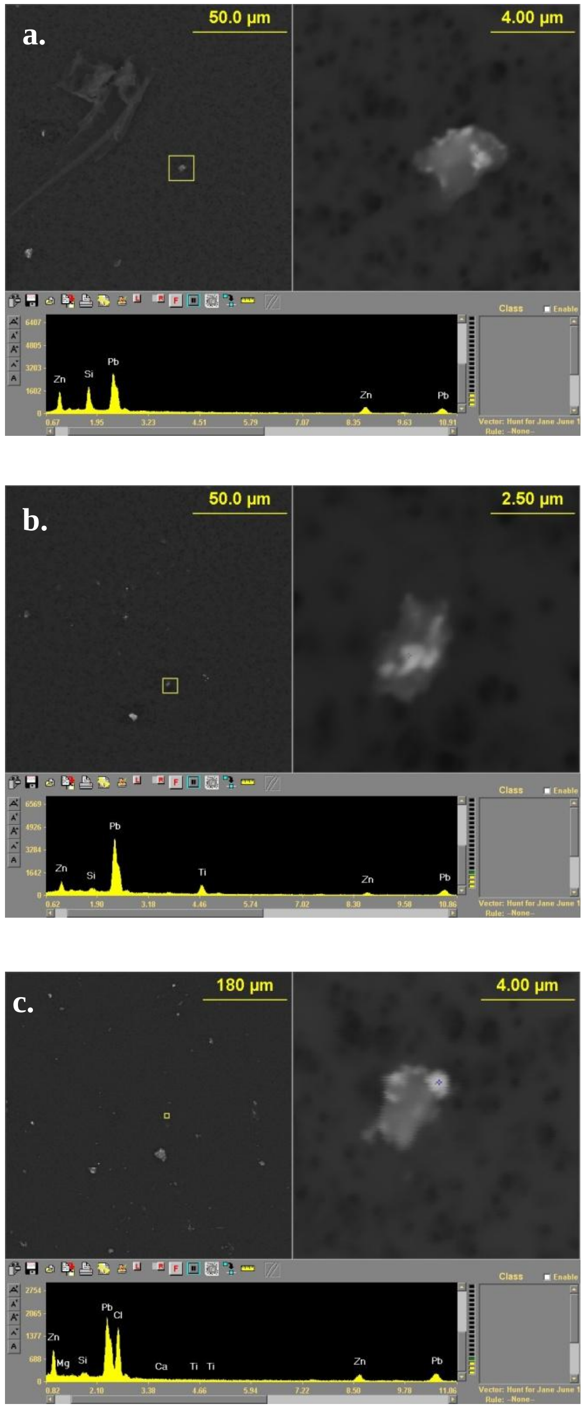


Figure B 17 House B window frame paint particle with Pb pigment particles and Zn, Si (a) Zn, Ti (b) Zn, Cl (c) in matrix

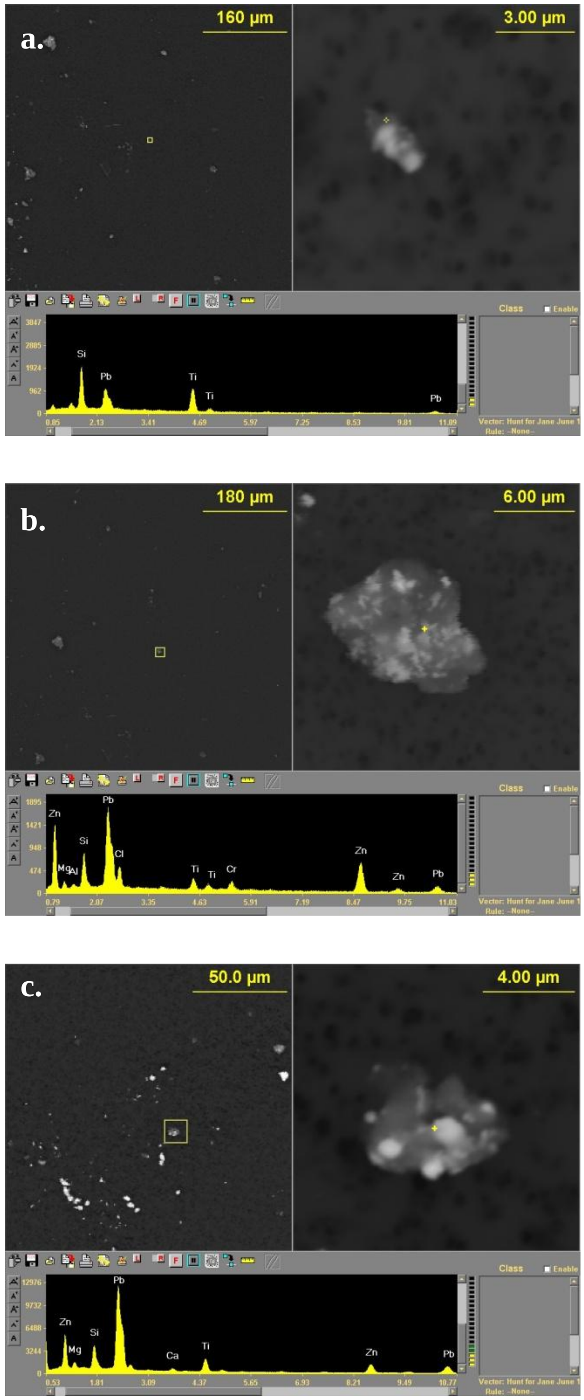


Figure B 18 House B window frame paint particle with Pb pigment particles and Ti, Si (a) Zn, Si, Ti, Cr, Cl (b), Zn Ti, Si (c) in matrix

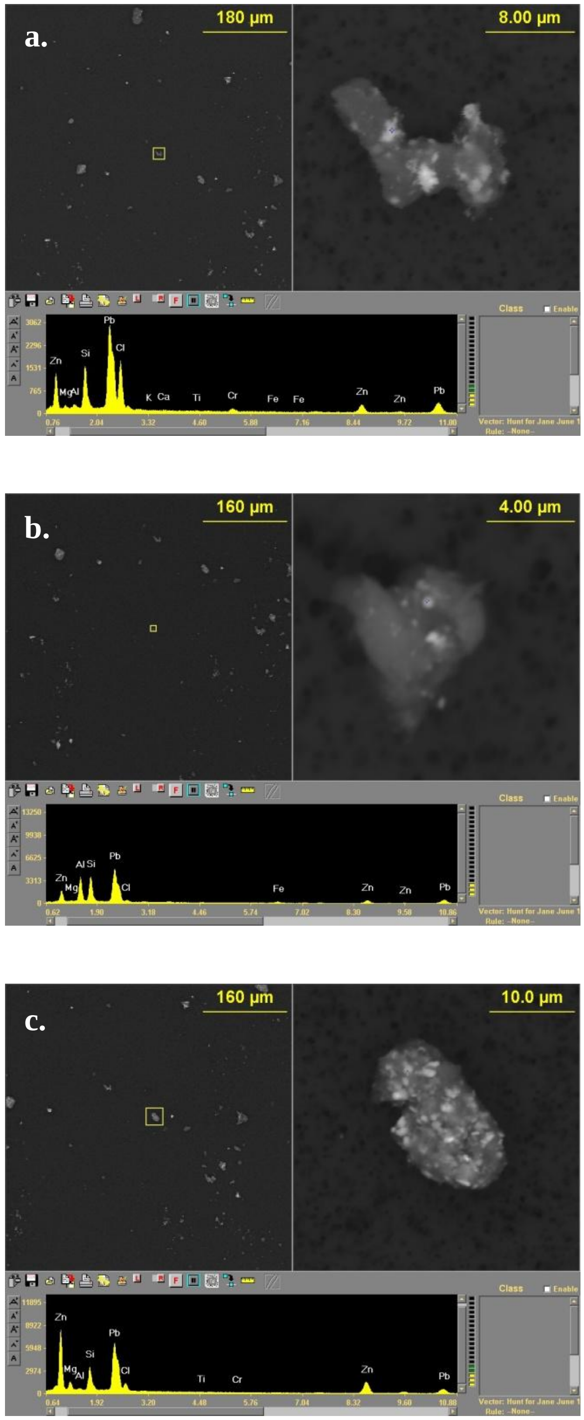


Figure B 19 House B window frame paint particle with Pb pigment particles and Zn, Si, Cl (a) Zn Si, Al (b) Zn, Si, Mg (c) in matrix

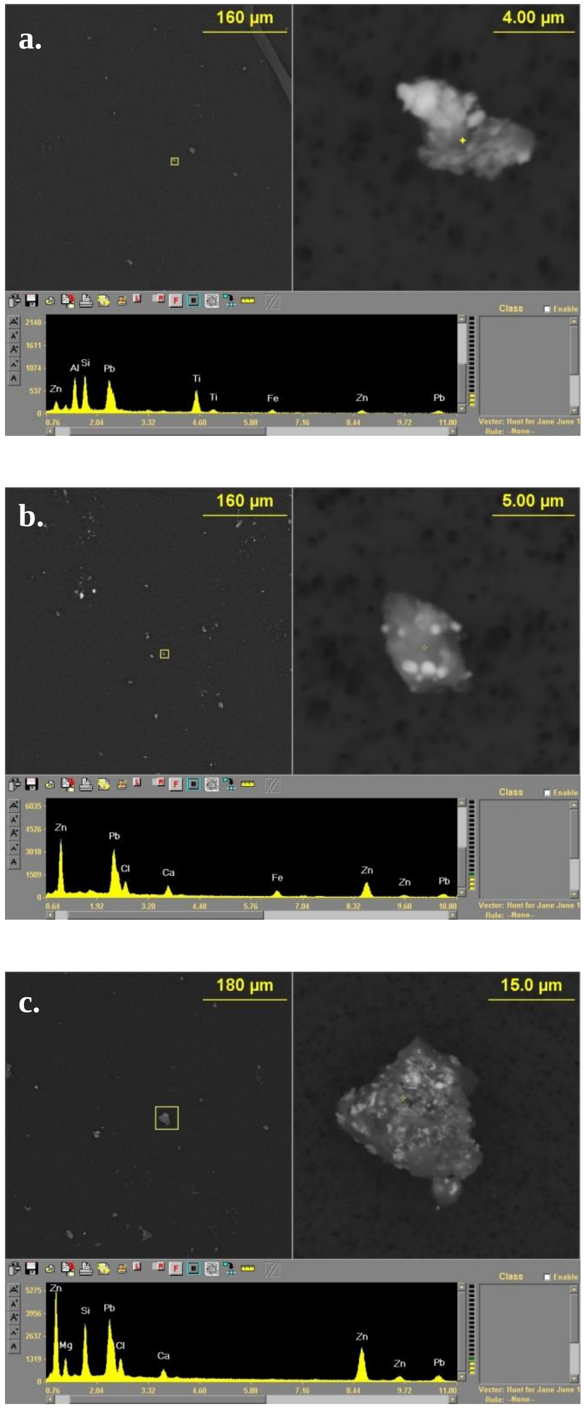


Figure B 20 House B window frame paint particle with Pb pigment particles and Zn, Ti, Si, Al, Fe (a) Zn Cl, Ca, Fe (b) Zn, Si, Mg, Cl, Ca(c) in matrix

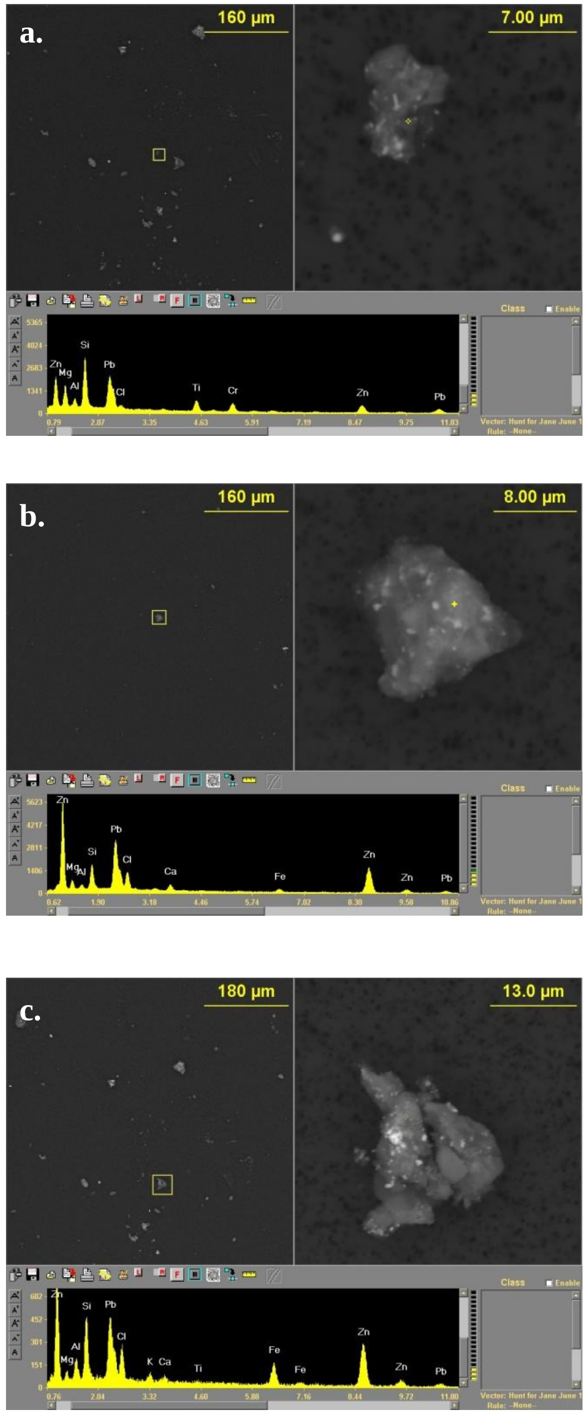


Figure B 20 House B window frame paint particle with Pb pigment particles and Zn, Cr, Ti, Si, Al, Fe (a) Zn Cl, Ca, Fe, Si, Mg (b) Zn, Si, Mg, Cl, K, Al, Fe(c) in matrix

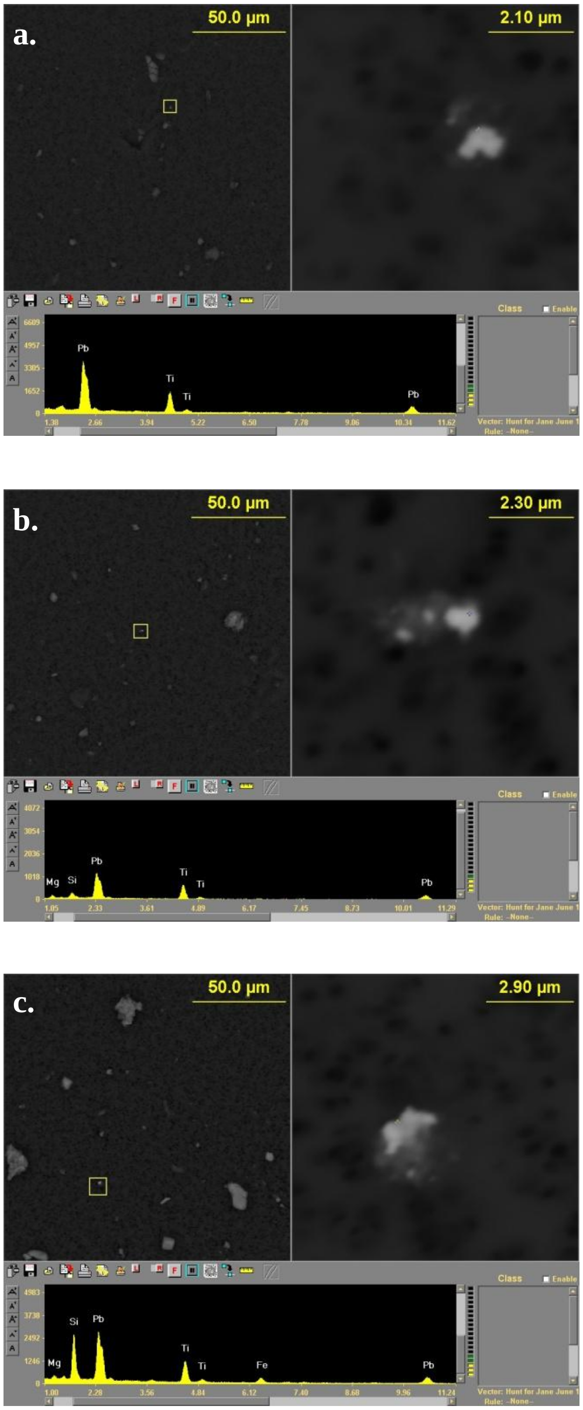


Figure B 21 House B building line soil particle with Pb pigment particles and Ti (a,b) Ti, Si, Fe(c) in matrix

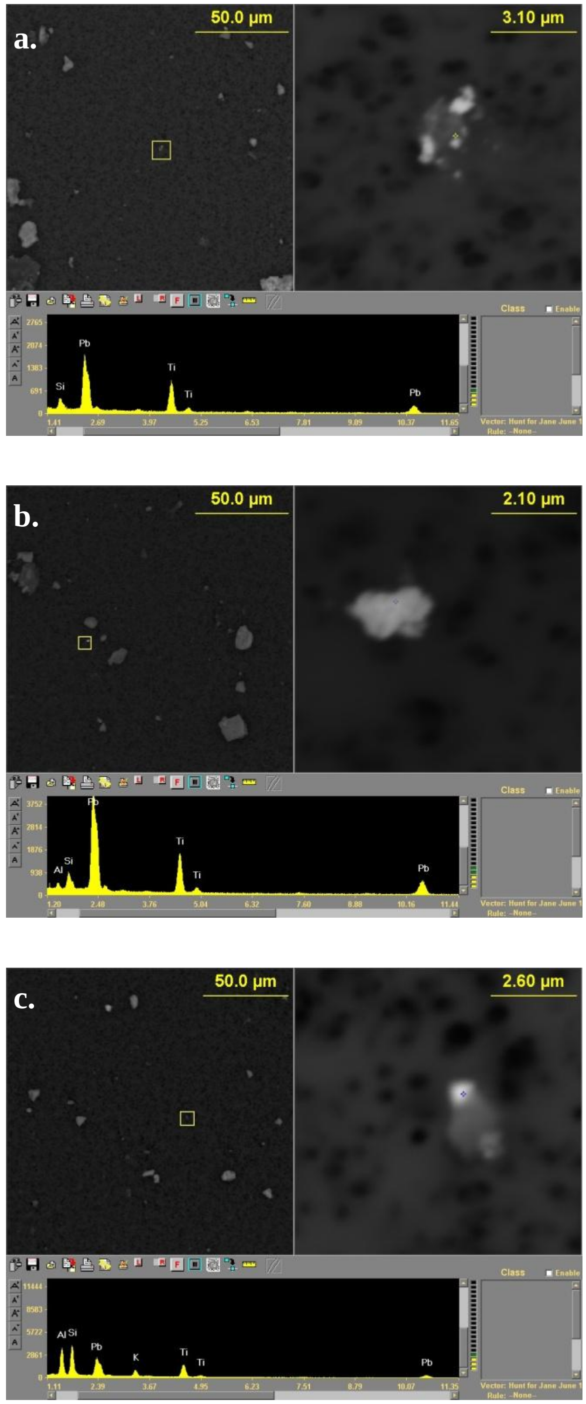


Figure B 22 House B building line soil particle with Pb pigment particles and Ti, Si (a,b) Ti, Si, Al, K (c) in matrix

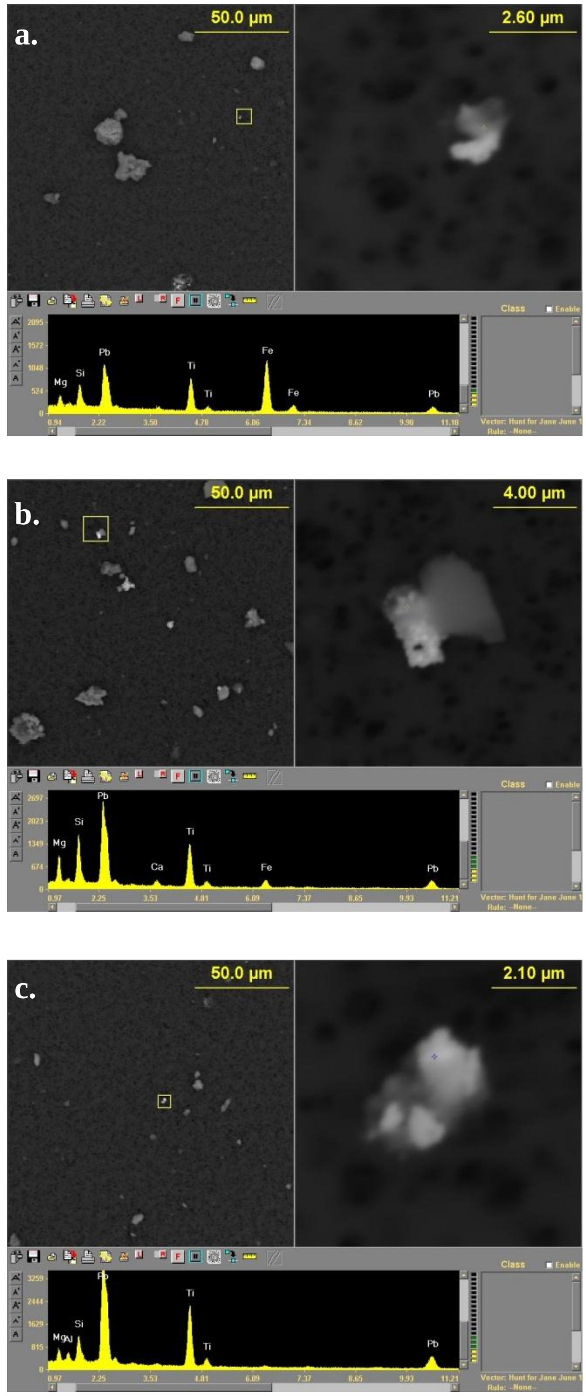


Figure B 23 House B building line soil particle with Pb pigment particles and Ti Si, Mg, Fe (a,b) Ti, Si, Al, Mg(c) in matrix

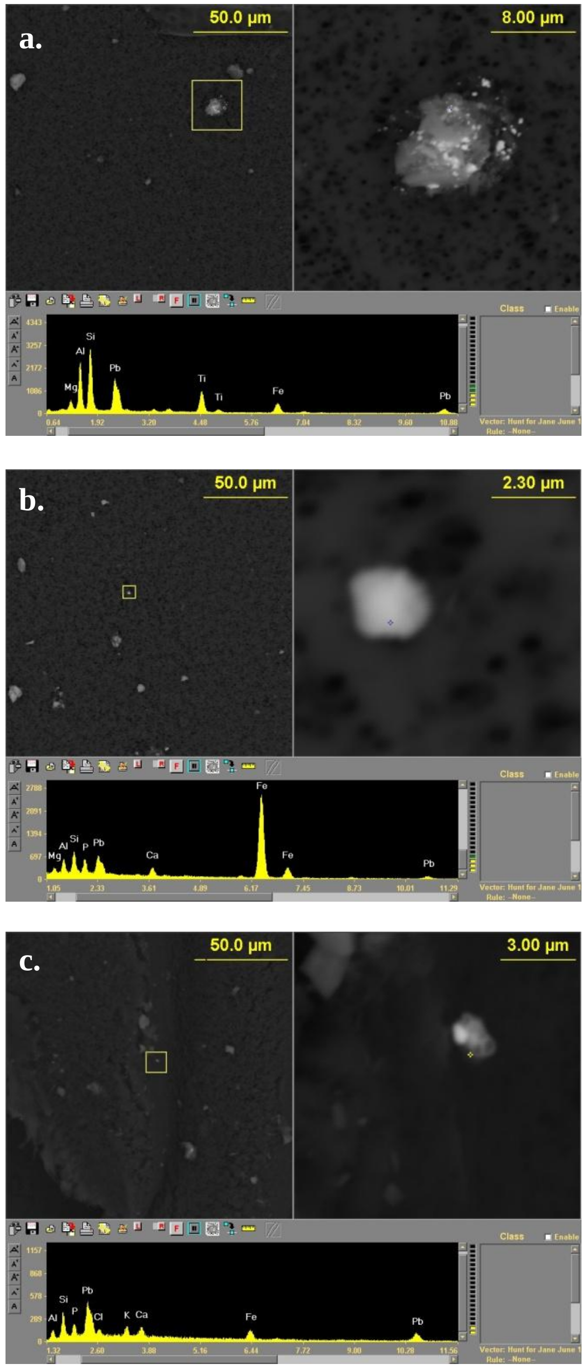


Figure B 25 House B building line soil particle with Pb pigment particles and Ti Si, Mg, Ca (a) Si, Al, P, Ca, Fe (b) Si, Al, P, K, Ca, Fe (c) in matrix

Appendix C

Raw data, SEM images and X-Ray Spectra of House C

House C

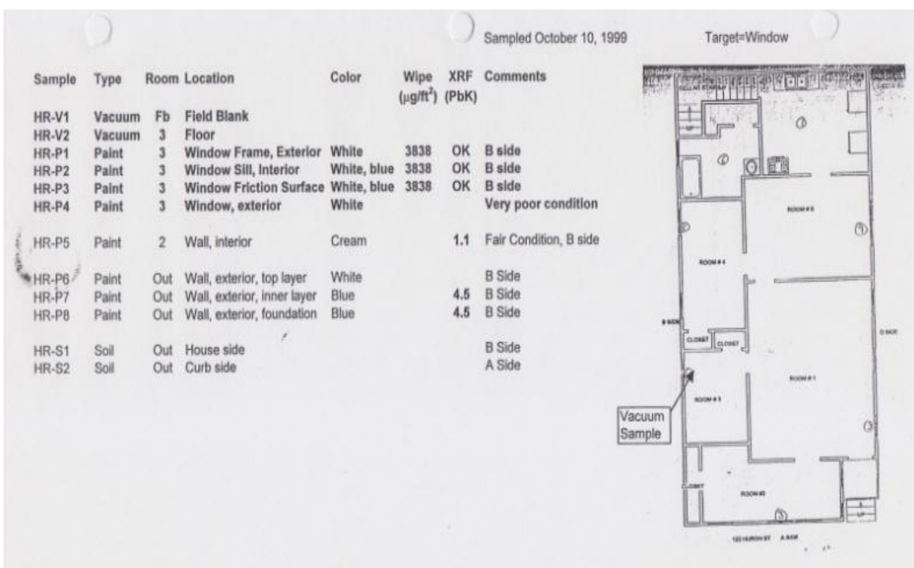
Single Implicated Window Friction Source

Window Paint in Moderate Condition

Single Story Family Home

Sampling Location:	**Left Front Bedroom**
Collected Samples:	
Dust	**1. Left Front Bedroom Floor Dust [C1]**
Implicated Friction Surface	**2. Left Front Bedroom Window Frame Paint [C2]** **3. Left Front Bedroom Window Sill Paint** **4. Left Front Bedroom Friction Surface Paint** **5. Left Front Bedroom Window Outside [C7]**
Other LBP Surfaces	**6. Front Bedroom Wall** **7. Exterior Paint Top Layer** **8. Exterior Paint Under Layer** **9. Exterior Building Foundation Paint [C8]**
Soil	**11. Building Line "B" Side House [C4]** **12. Yard by Road [C5]**

Figure C 1 House C General View



Sampled October 10, 1999 Target=Window

Sample	Type	Room	Location	Color	Wipe ($\mu g/ft^2$)	XRF (PbK)	Comments
HR-V1	Vacuum	Fb	Field Blank				
HR-V2	Vacuum	3	Floor				
HR-P1	Paint	3	Window Frame, Exterior	White	3838	OK	B side
HR-P2	Paint	3	Window Sill, Interior	White, blue	3838	OK	B side
HR-P3	Paint	3	Window Friction Surface	White, blue	3838	OK	B side
HR-P4	Paint	3	Window, exterior	White			Very poor condition
HR-P5	Paint	2	Wall, interior	Cream		1.1	Fair Condition, B side
HR-P6	Paint	Out	Wall, exterior, top layer	White			B Side
HR-P7	Paint	Out	Wall, exterior, inner layer	Blue		4.5	B Side
HR-P8	Paint	Out	Wall, exterior, foundation	Blue		4.5	B Side
HR-S1	Soil	Out	House side				B Side
HR-S2	Soil	Out	Curb side				A Side

Figure C 2 House C Floor Plan

Table C 1 House C Lead Concentration Data by XRF

Analysis Number	House Code	Sample Description	Pb Conc (µg/g)	Error (µg/g)
HUD 073-1	**C2**	House C - Target Paint: Room 3 window frame, moderate damage	24599.3	50
HUD 074-1	**C7**	House C - Target Paint: Room 3 exterior window frame, moderate damage	131163	115.8
HUD 075-1	**C8**	House C - Competing Paint: Exterior foundation	353795.4	228.4
HUD 076-1	**C1**	House C - Cyclone Vacuum Dust Sample: Room 3 floor	1075.8	19.4
HUD 077-1	**C5**	House C - Mib-Yard Soil: By road	523.2	11.3
HUD 078-1	**C4**	House C - Building Line Soil	460.8	10.3

Table C 2 House C Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	**House Code**	**Description**	**206/204**	**207/204**	**208/204**	**207/206**	**208/206**	**207/208**
HUD73	**C2**	House C - Target Paint: Room 3 window frame, moderate damage	18.055	15.548	37.939	0.861	2.101	0.40981
HUD74	**C7**	House C - Target Paint: Room 3 exterior window frame, moderate damage	18.379	15.609	38.233	0.849	2.08	0.40827
HUD75	**C8**	House C - Competing Paint: Exterior foundation	17.964	15.529	37.889	0.864	2.109	0.40985
HUD76	**C1**	House C - Cyclone Vacuum Dust Sample: Room 3 floor	18.204	15.582	37.99	0.856	2.087	0.41017
HUD77	**C5**	House C - Mib-Yard Soil: By road	18.404	15.614	38.185	0.848	2.075	0.4089
HUD78	**C4**	House C - Building Line Soil	18.48	15.631	38.296	0.846	2.072	0.408

Table C 3 Pb bearing particles found in floor dust sample of house C

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	3.87
Pb	Irregular	1.01
Pb	Irregular	2.26
Pb	Aggregate	12.5
Pb	Irregular	1.81
Pb	Irregular	1.49
Pb	Irregular	1.25
Pb	Irregular	1.45
Pb	Irregular	0.794
Pb	Irregular	1.67
Pb	Irregular	1.36
Pb	Irregular	1.3
Pb	Irregular	0.921
Pb	Irregular	1.77
Pb	Irregular	2.9
Pb	Irregular	1.54
Pb	Irregular	1.5
Pb	Irregular	1.03
Pb	Irregular	1.63
Pb	Aggregate	1.96
Pb	Aggregate	1.29
Pb	Aggregate	4.36
Pb	Aggregate	3.27
Pb	Irregular	3.69
Pb	Irregular	2.09
Pb	Irregular	1.19
Pb	Irregular	1.11
Pb	Irregular	1.73
PbCr	Irregular	2.46
PbCr	Aggregate	2.62
PbCr	Irregular	2.06
PbCr	Irregular	1.13
PbCr	Irregular	1.62

Table C 3 - *Continued*

PbCr	Irregular	1.56
PbCr	Irregular	1.56
PbCr	Aggregate	1.77
PbCr	Aggregate	2.88
PbCr	Aggregate	2.1
PbCr	Irregular	1.94
PbCr	Aggregate	2.5
PbCr	Irregular	1.22
PbCr	Elongated	3.41
PbCr	Irregular	1.29
PbCr	Irregular	1.69
PbCr	Aggregate	4.05
PbCr	Elongated	2.33
PbCr	Irregular	1.82
PbCr	Irregular	4.38
PbCr	Irregular	1.29
PbCr	Irregular	1.63
PbZn	Irregular	1.38
PbZn	Aggregate	0.764
PbZn	Aggregate	1.87
PbK	Irregular	2.82
PbCa	Irregular	3.71
PbCa	Aggregate	3.08
PbFe	Aggregate	3.21
PbCrCa	Irregular	2.01
PbCrCa	Irregular	2.86
PbCrCa	Aggregate	3.85
PbCrSi	Aggregate	2.49
PbCrSi	Aggregate	7.67
PbCrSi	Irregular	1.5
PbCrSi	Irregular	2.82
PbCrFe	Aggregate	2.27
PbCrZn	Aggregate	4.54
PbCrBa	Irregular	1.35
PbCrBa	Aggregate	3.73

Table C 3 - *Continued*

Chemical Composition	**Morphology**	**Size**
PbCrSi	Irregular	1.5
PbCrSi	Irregular	2.82
PbCrFe	Aggregate	2.27
PbCrZn	Aggregate	4.54
PbCrBa	Irregular	1.35
PbCrBa	Aggregate	3.73
PbSiAl	Irregular	1.5
PbCaCl	Aggregate	3.78
PbCl	Irregular	1.56
PbCrBaCa	Aggregate	4.27
PbCrBa	Aggregate	4.12
PbCrZnSi	Aggregate	1.55
PbCrSiAl	Aggregate	6.44
PbCrSiAl	Aggregate	2.92
PbCrSiAl	Aggregate	12.3
PbCrSiAl	Aggregate	1.13
PbCrSiAl	Aggregate	4.59
PbCrSiAl	Aggregate	5.48
PbCrSiMg	Irregular	1.81
PbCrSiMg	Aggregate	1.93
PbCrCaSi	Irregular	2.59
PbCrCa	Irregular	3.24
PbCrCa	Elongated	2.47
PbCrSi	Aggregate	2.8
PbCrCa	Aggregate	2.34
PbZnCaP	Aggregate	2.52
PbZnCaCl	Aggregate	6.19
PbTiSiAl	Aggregate	2.93
PbTiCaCl	Irregular	2.85
PbCrBaSi	Aggregate	3.91
PbCrBaCa	Irregular	2.32
PbCrTiCa	Elongated	1.93
PbCrBaCa	Irregular	2.86
PbCrFe	Irregular	2.13

Table C 3 - *Continued*

PbCrCaFeSi	Irregular	1.78
PbCrCaSiAl	Irregular	1.71
PbCrSiAlMg	Aggregate	3.22
PbTiCaSiAl	Aggregate	5.51
PbTiCaSiAl	Irregular	1.6
PbCrTiCaZn	Aggregate	3.3
PbCrCaSiMg	Irregular	3.7
PbCrCaSiMgAl	Irregular	5.5
PbCrCaSiAl	Irregular	1.48
PbCrTiCaSiAl	Aggregate	1.73
PbCrTiCaSiAl	Irregular	2.71
PbCrTiCa	Aggregate	6.51
PbCrTiCaSiAl	Aggregate	9.62
PbCrTiCaSiAl	Irregular	1.74
PbCrTiCaSi	Irregular	3.09
PbCrTiCaSiAl	Aggregate	5.67
PbCrTiCaSiAl	Aggregate	7
PbZnTiCaKP	Aggregate	2.68
PbTiCaSiAlCl	Aggregate	10.8
PbCrCaSiAlMg	Aggregate	5.13
PbCrTiCaSiAlFe	Aggregate	3.27
PbCrCaSiAl	Irregular	3.71
PbTiCaSiKCl	Aggregate	7.45
PbTiCaSiAlKCl	Aggregate	18.3
PbTiCaSiAlKCl	Irregular	8.38
PbTiCaSiAlFeCl	Irregular	1.56
PbCaSiKPNaMg	Aggregate	4.46
PbCrSiMg	Irregular	2.97
PbCrCaSi	Irregular	1.49
PbTiCaSiAlKPMg	Irregular	3.6
PbTiCaSiAlKFeNa	Irregular	13.6
PbCaSiAlKMgPClNa	Aggregate	13.4
PbTiCaZnSiAlMgFe	Irregular	2.91
PbTiCaSiAlKFeMnPCl	Irregular/Tiny Pb Inclusion	2.91

Table C 4 House C Pb bearing particles found in window frame paint sample

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	4.13
Pb	Irregular	3.55
Pb	Hexagonal	2.49
Pb	Irregular	5.73
PbZn	Aggregate	7.42
PbZn	Irregular	4
PbZn	Irregular	3.33
PbZn	Aggregate	14.2
PbZn	Aggregate	3.27
PbTi	Aggregate	3.48
PbTi	Irregular	3.76
PbTi	Aggregate	3.8
PbFe	Irregular	5.92
PbZnTi	Irregular	4.35
PbZnTi	Aggregate	10.8
PbZnTi	Aggregate	5.45
PbZnTi	Aggregate	3.11
PbZnTi	Aggregate	8.3
PbZnTi	Irregular	3.39
PbZnTi	Aggregate	2.57
PbZnTi	Aggregate	6.28
PbZnTi	Aggregate	3.73
PbZnTi	Aggregate	13.8
PbZnTi	Aggregate	7.77
PbTiCa	Aggregate	6.3
PbZnBa	Aggregate	14.5
PbZnCa	Aggregate	6
PbBaCa	Irregular	2.35
PbTiSiMg	Aggregate	4.74
PbTiSiMg	Aggregate	7.35
PbTiSiMg	Aggregate	3.6
PbTiSiNa	Aggregate	8.42
PbZnTiSi	Aggregate	4.17
PbZnTiSi	Aggregate	10.2

Table C 4 - *Continued*

PbZnSiMg	Aggregate	10
PbCrSiFe	Aggregate	10.1
PbCrCaSi	Aggregate	3.72
PbCrBaCaSi	Irregular	3.5
PbCrBaCaSi	Aggregate	7.3
PbCrBaCaSi	Aggregate	8.35
PbCrBaCaSi	Aggregate	12.8
PbCrBaSiMg	Irregular	6.56
PbCrBaSiMg	Irregular	4.52
PbCrBaSiMg	Aggregate	6.75
PbCrBaSiAl	Irregular	5.96
PbTiCaMgSi	Aggregate	17
PbZnTiCaSi	Aggregate	5.38
PbTiZnSiMg	Aggregate	5.91
PbTiZnSiMg	Aggregate	25.3
PbTiZnSiMg	Aggregate	23
PbTiZnSiMg	Aggregate	3.51
PbTiZnSiMg	Aggregate	3.81
PbTiZnSiMg	Aggregate	10.4/1.57
PbTiZnSiMg	Aggregate	26.4
PbTiZnSiMg	Aggregate	9.97
PbTiZnSiMg	Aggregate	4.4
PbTiZnSiP	Aggregate	6.02
PbTiCaSiMg	Aggregate	7.73/2.62
PbTiSiMgNa	Aggregate	9.24
PbTiCrSiMg	Aggregate	4.84
PbTiCrCaSi	Aggregate	3.81
PbTiCrCaSi	Aggregate	8.21
PbBaZnCaSi	Aggregate	7.82
PbTiZnCaSiMg	Aggregate	35.6
PbTiZnCaSiMg	Aggregate	5.04
PbTiZnCaSiMg	Aggregate	8.93
PbTiZnCaSiMg	Aggregate	11
PbTiZnCaSiMg	Aggregate	14.5
PbTiZnCaSiMg	Aggregate	6.65

Table C 4 - *Continued*

PbTiZnCaSiMg	Aggregate	18.4
PbTiZnCaSiMg	Aggregate	8.32
PbTiZnCaSiMg	Aggregate	6.16
PbTiZnCaSiMg	Irregular	27
PbTiZnCaSiMg	Aggregate	17.6
PbTiZnCaSiMg	Aggregate	11.7
PbTiZnCaSiMg	Aggregate	14.3
PbTiZnSiAlMg	Aggregate	30
PbTiCaSiMgNa	Aggregate	4.86
PbTiCaSiMgNa	Aggregate	9.22
PbTiCaSiMgNa	Aggregate	7.52
PbTiCrCaSiMg	Aggregate	6.67
PbCrTiCaSiMg	Aggregate	9.36
PbCrSiAlMgNa	Aggregate	32.6
PbZnBaCaSiMg	Aggregate	4.31
PbCrBaCaSiMg	Aggregate	17
PbTiCaSiMgPNa	Aggregate	1.34/7.83
PbCrTiCaSiAlMg	Irregular	7.6
PbCrBaCaSiAlFe	Aggregate	8.07
PbCrBaCaSiFeMg	Aggregate	13
PbCrBaCaSiAlMg	Aggregate	14.4
PbCrBaSiAlMgFe	Aggregate	6.67
PbCrBaCaSiAlMgFe	Aggregate	20.6
PbCrBaCaSiAlMgFe	Irregular	6.81
PbCrBaCaSiAlMgFe	Aggregate	6.83
PbCrBaCaSiAlMgFe	Aggregate	30
PbCrBaCaSiAlMgFe	Aggregate	14
PbCrTiCaSiAlMgFe	Aggregate	62.5
PbCrTiCaSiAlMgFe	Aggregate	13
PbCrTiCaSiAlMgNa	Aggregate	7.26
PbCrBaCaSiMgNaP	Irregular	6.54
PbCrTiCaSiAlMgFeNa	Aggregate	14.5
PbCrBaZnCaSiAlMgFe	Aggregate	8.13
PbCrTiCaSiAlMgNaFe	Aggregate	12.9
PbCrTiCaSiAlKMgFeNa	Aggregate	7.18

Table C 5 House C Pb bearing particles found in building line soil sample

Chemical Composition	**Morphology**	**Size**
PbCaP	Aggregate	
PbCaP	Aggregate	1.24
PbCaP	Irregular	2.88
PbCaP	Irregular/Little Pb Inclusion	.875/4.55
PbCaP	Irregular	1.66
PbTiSi	Aggregate	2.74
PbTiSi	Irregular	3.18
PbCaP	Irregular	3.93
PbCaP	Irregular	2.25
PbCrCaP	Irregular	1.3
PbCaPZnAl	Irregular	3.67
PbCaPSiAl	Aggregate/Little Pb Inclusion	60.2
PbCaPSiFe	Irregular	3.32
PbSiAlKFeMg	Irregular	4.46
PbCaPSiAlMn	Irregular	4.31
PbCaPSiAlNa	Aggregate	6.9
PbCaPSiAlFe	Aggregate	1.16/4.17
PbCaPSiAlZnFe	Irregular	8.4
PbCaPSiAlkFe	Irregular	4.13
PbCaPSiAlKFe	Aggregate	1.55/6.02
PbCaPSiAlFeMn	Aggregate/Little Pb Inclusion	0.71/5.72
PbCaPSiAlClMgFe	Irregular	1.81
PbCaPSiAlKFeMg	Irregular	5.37
PbCaPSiAlKFeMg	Aggregate	23.6
PbCaPSiAlKFeNa	Aggregate	2.65/11.9
PbZnCaPSiAlMgFe	Irregular	17.2
PbTiCaPSiAlMgFeNa	Irregular	4
PbZnCaPSiAlKMgFe	Irregular	50.7
PbZnCaPSiAlKMgFe	Irregular	6.74/4.83
PbZnCaPSiAlKMgFeMn	Irregular	12.2
PbZnCaPSiAlKMgFeMn	Irregular	11.7
PbZnCaPSiAlKMgFeMn	Irregular	40.3

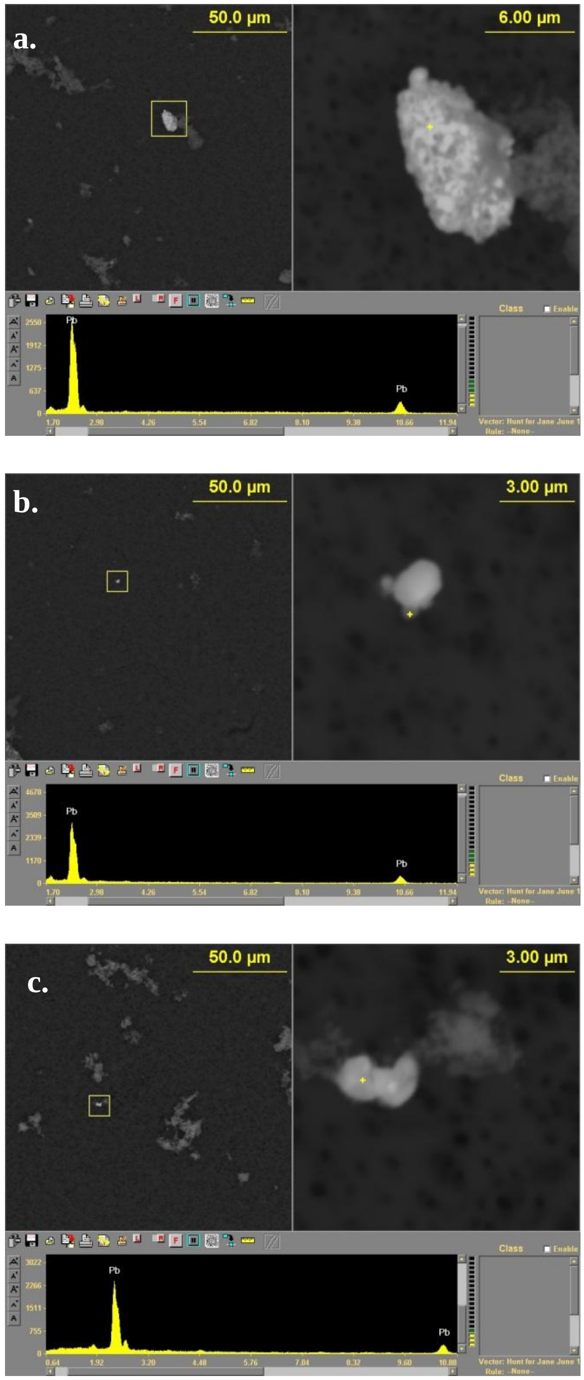


Figure C 1 House C floor dust particle with Pb pigment particles (a, b and c)

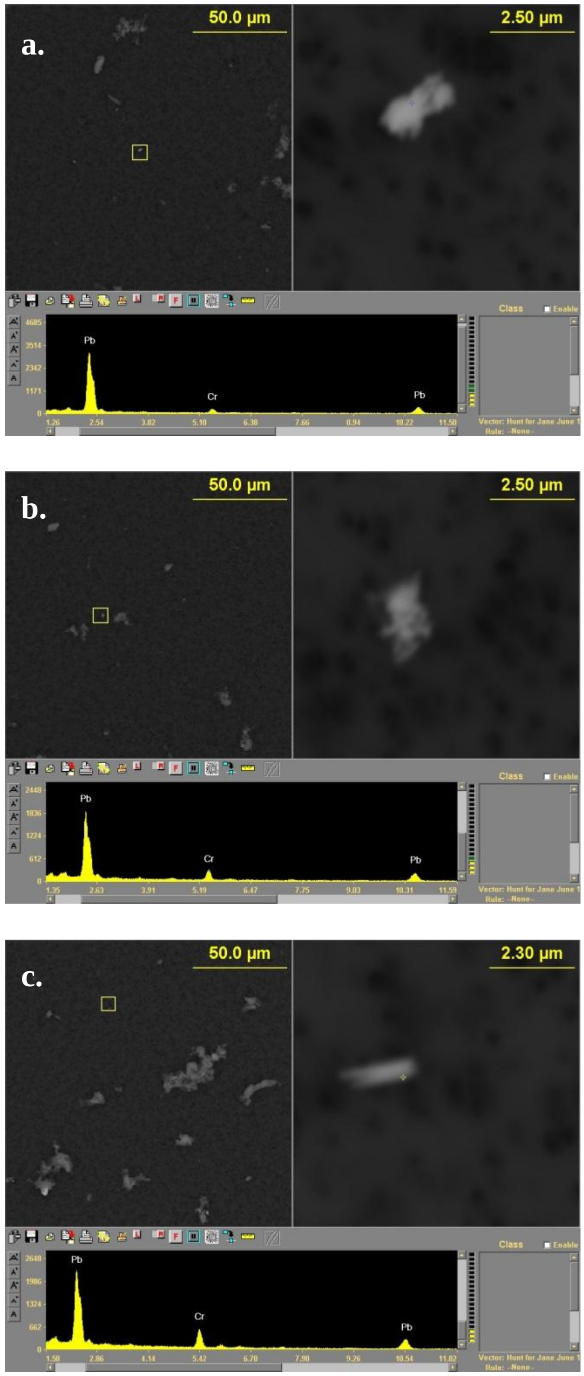


Figure C 2 House C floor dust particle with Pb pigment particles and Cr in matrix (a, b and c)

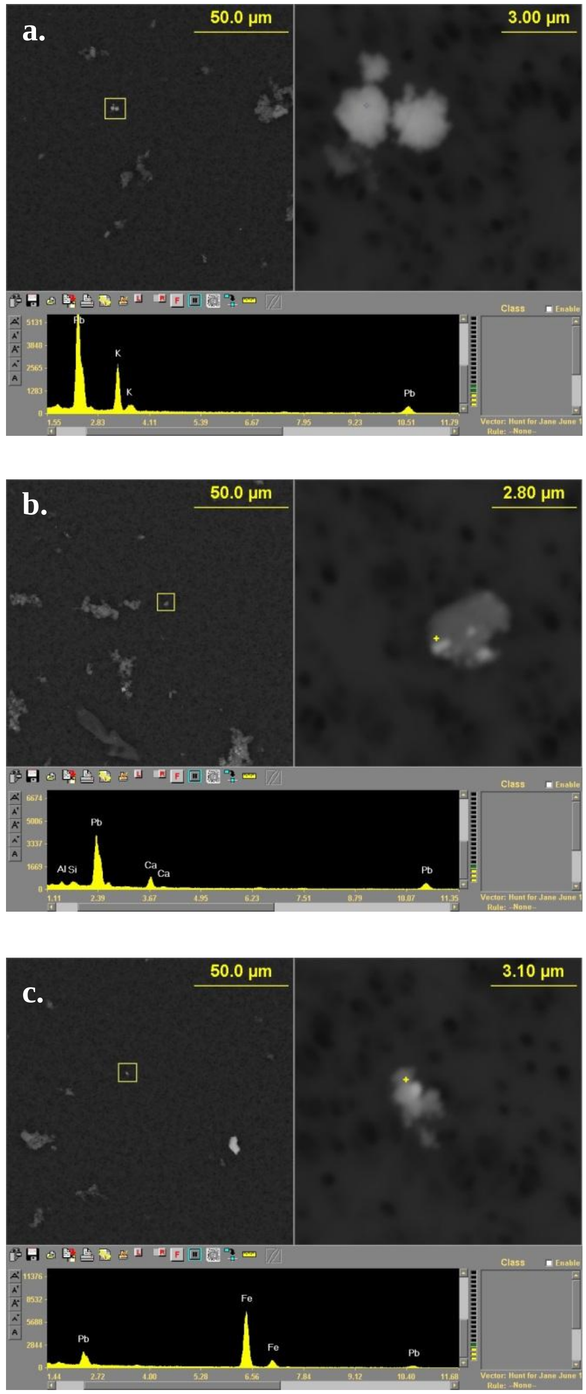


Figure C 3 House C floor dust particle with Pb pigment particles and K (a), Ca (b), Fe (c) in matrix.

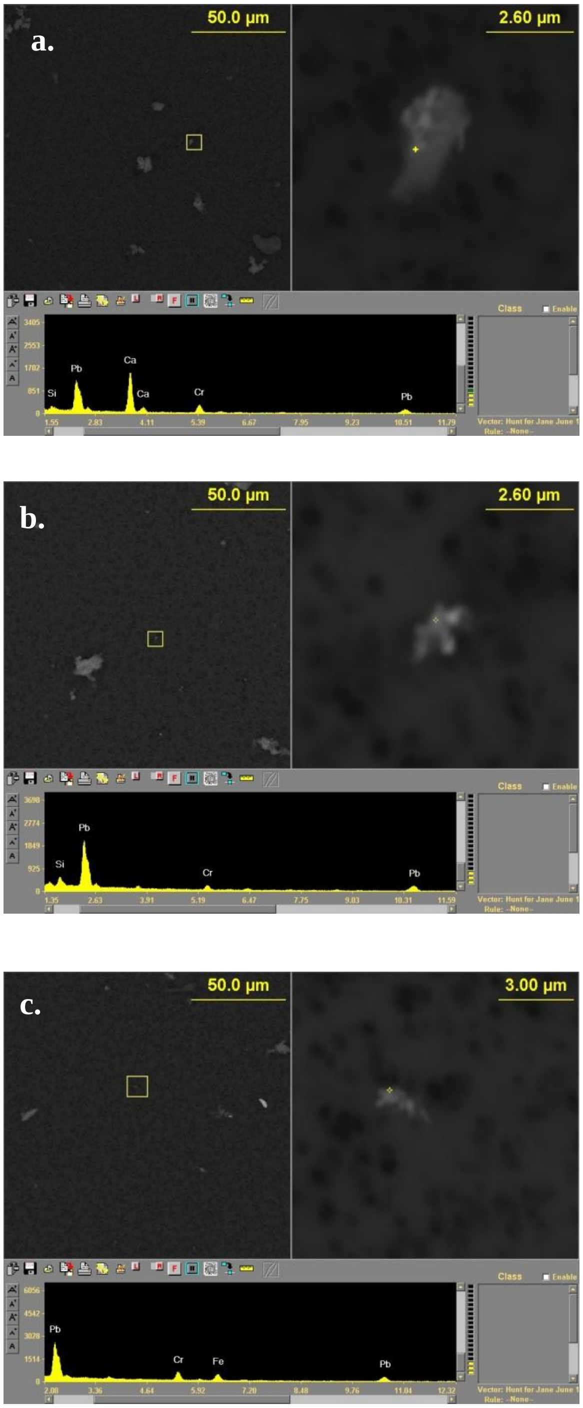


Figure C 4 House C floor dust particle with Pb pigment particles and Cr, Ca (a), Cr Si (b), Cr Fe (c) in matrix.

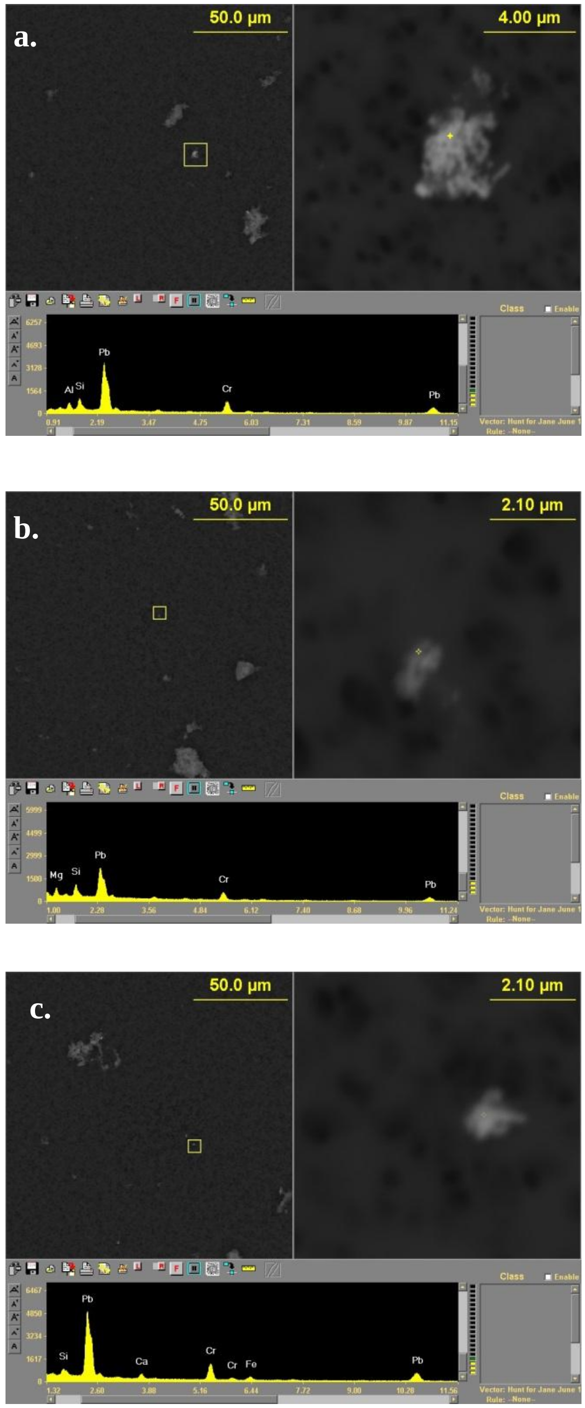


Figure C 5 House C floor dust particle with Pb pigment particles and Cr, Si, Al (a), Cr, Si, Mg (b), Cr, Fe, Ca, (c) in matrix.

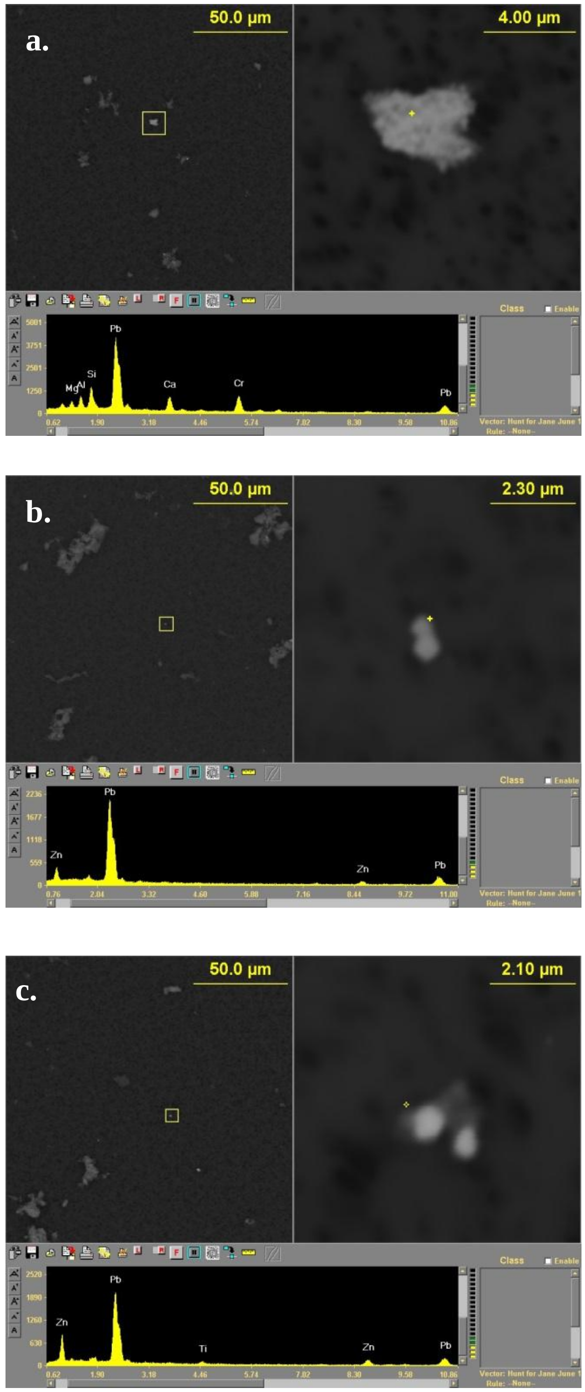


Figure C 6 House C floor dust particle with Pb pigment particles and Cr, Ca, Si, Al (a), Zn (b,c) in matrix.

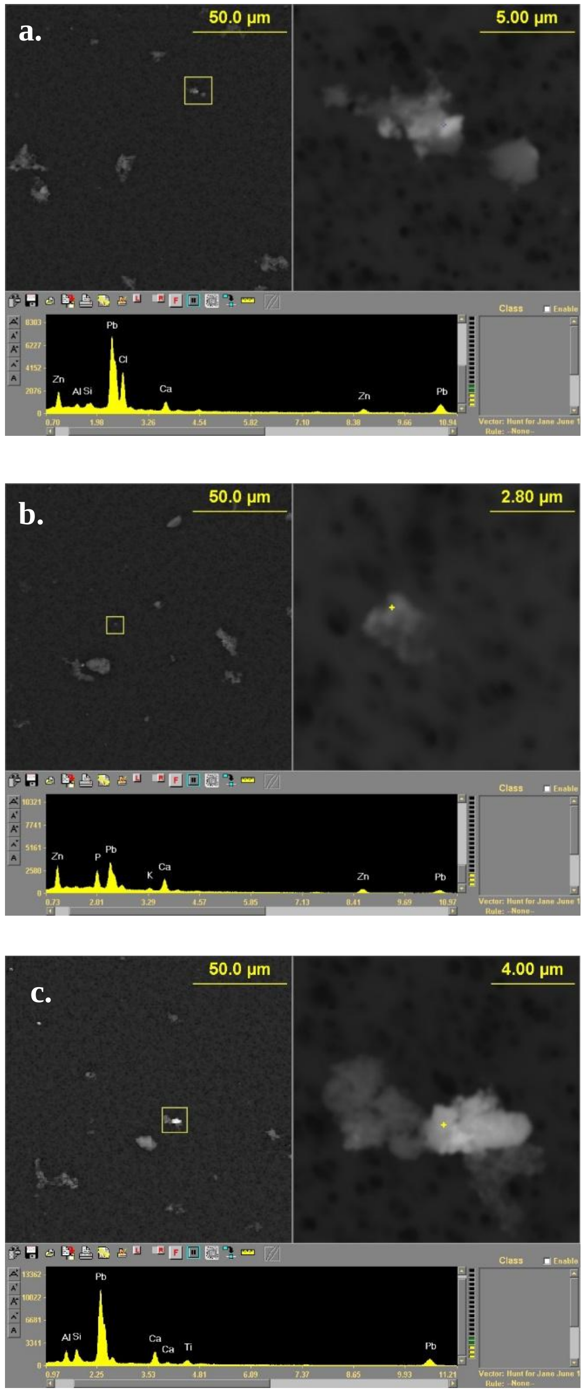


Figure C 7 House C floor dust particle with Pb pigment particles and Zn, Cl, Ca (a), Zn, P, Ca (b), Si, Al, Ca, Ti (c) in matrix.

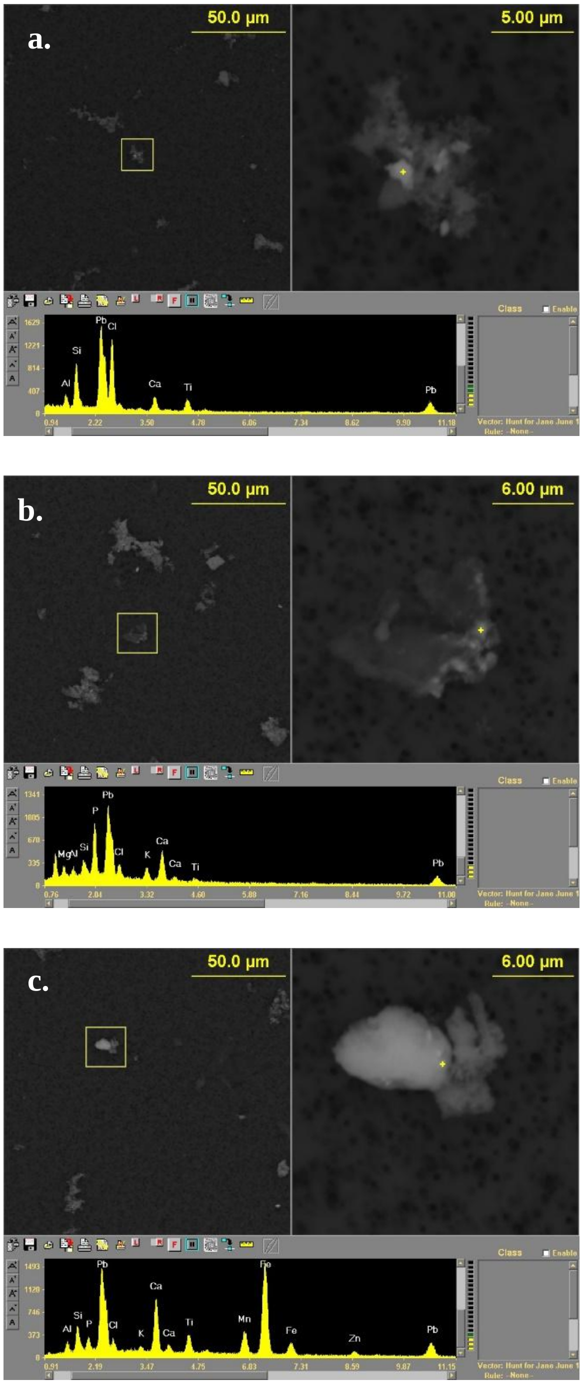


Figure C 8 House C floor dust particle with Pb pigment particles and Ti, Si, Al, Cl, Ca (a), Ca, Si, Mg, P, Na, K (b), Ti, Fe, Ca, Mn, P, Si, Al(c) in matrix.

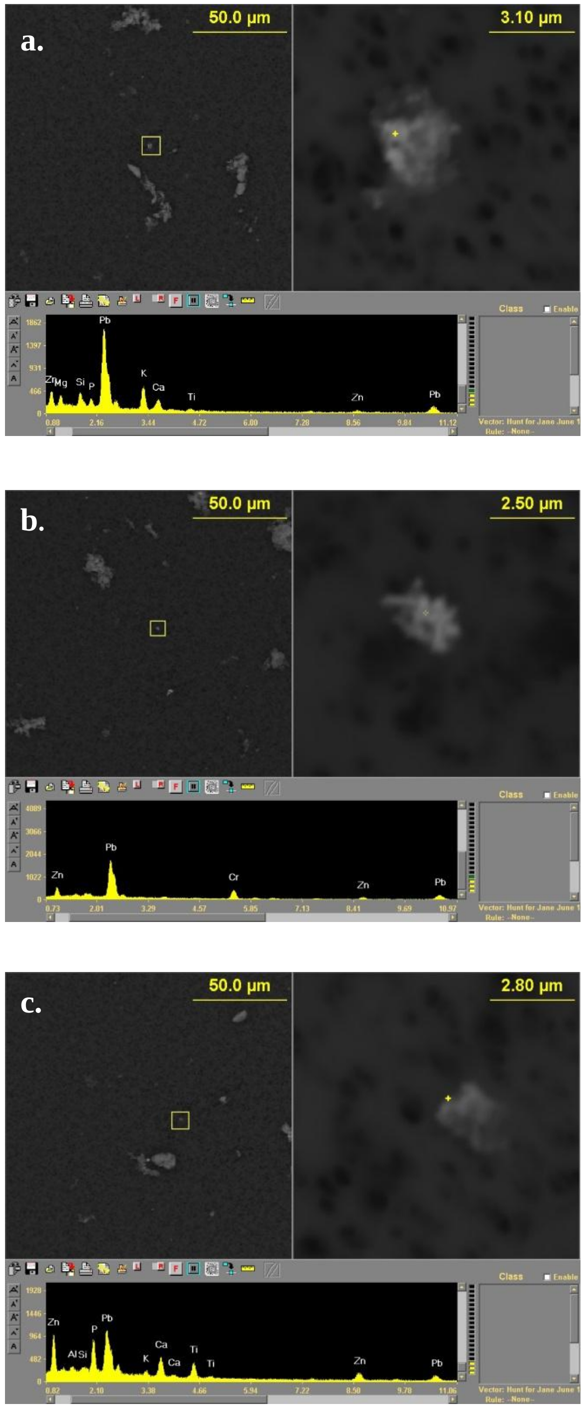


Figure C 9 House C floor dust particle with Pb pigment particles and Zn, Si, P, Mg, K, Ca (a), Cr, Zn (b), Zn, Ti, Ca, P (c) in matrix.

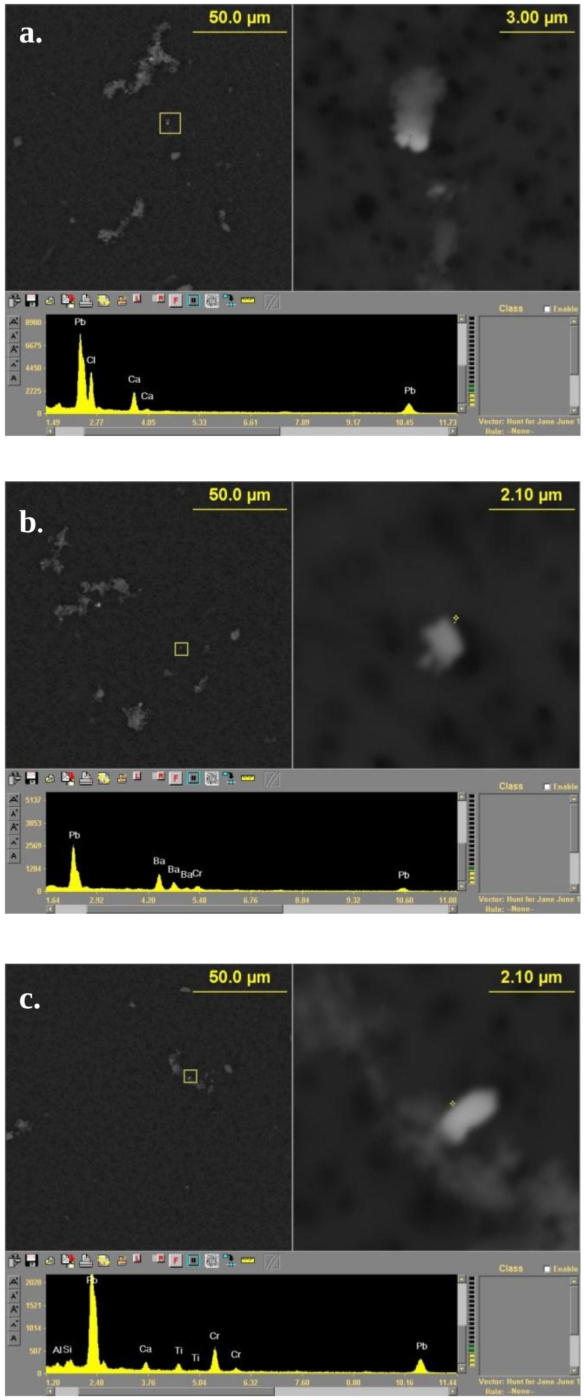


Figure C 10 House C floor dust particle with Pb pigment particles and Ca, Cl (a), Cr, Ba, Mg (b), Cr, Ti, Ca, (c) in matrix.

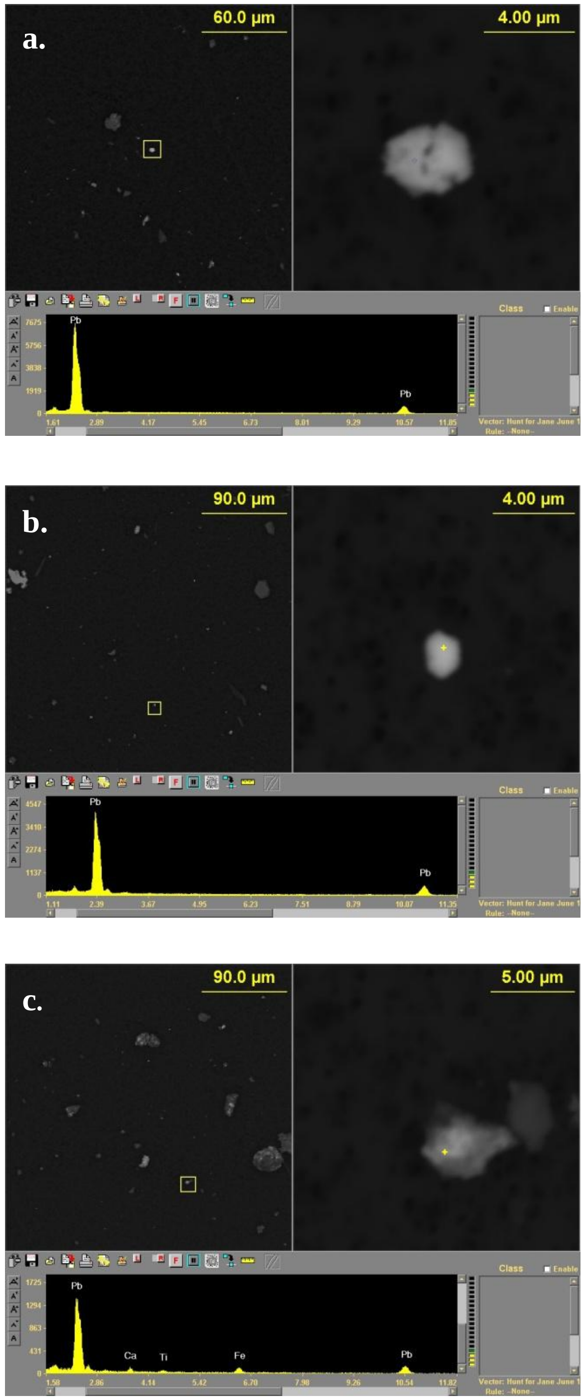


Figure C 11 House C window frame paint particle with Pb pigment particles.(a,b) and Fe (c) in matrix.

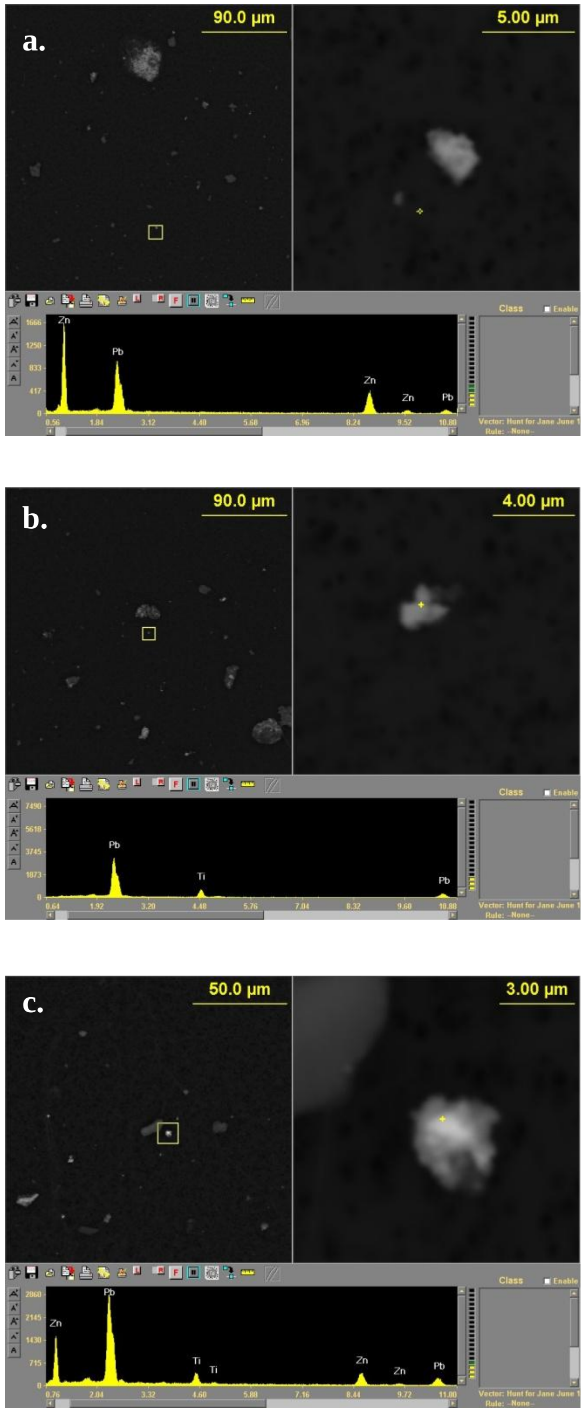


Figure C 12 House C window frame paint particle with Pb pigment particles and Zn (a), Ti (b), Zn, Ti (c) in matrix

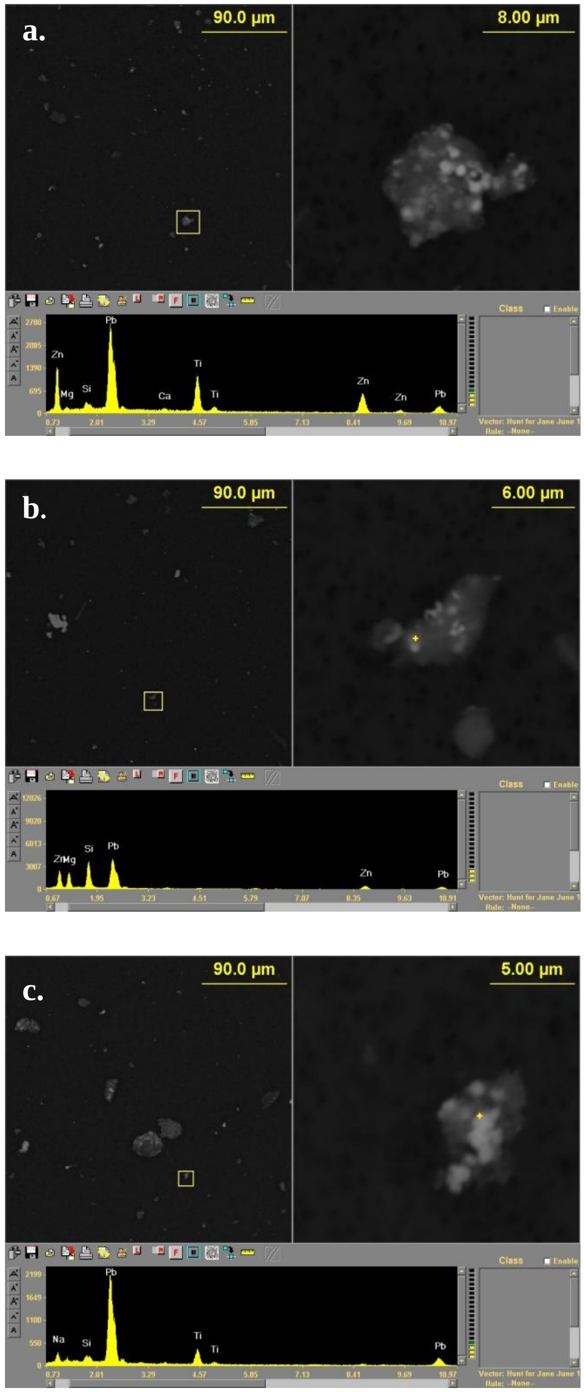


Figure C 13 House C window frame paint particle with Pb pigment particles and Zn, Ti (a), Zn, Si, Mg (b), Na, Ti (c) in matrix

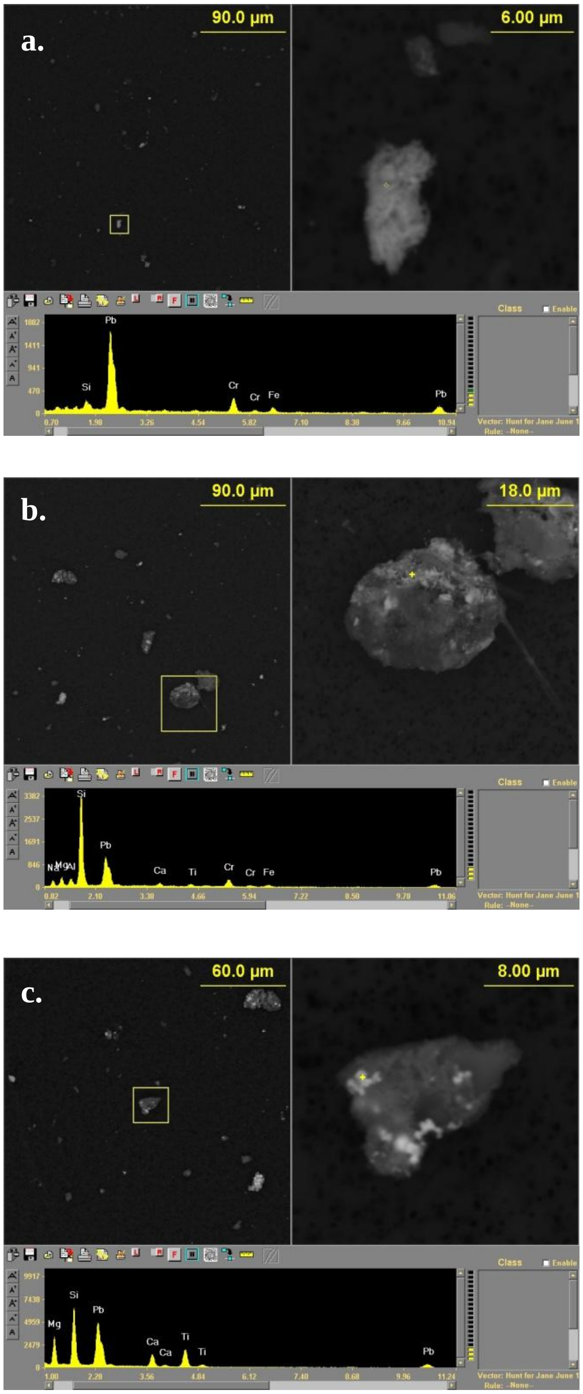


Figure C 14 House C window frame paint particle with Pb pigment particles and Cr, Fe, Si (a, b), Ti, Ca, Si, Mg (c) in matrix

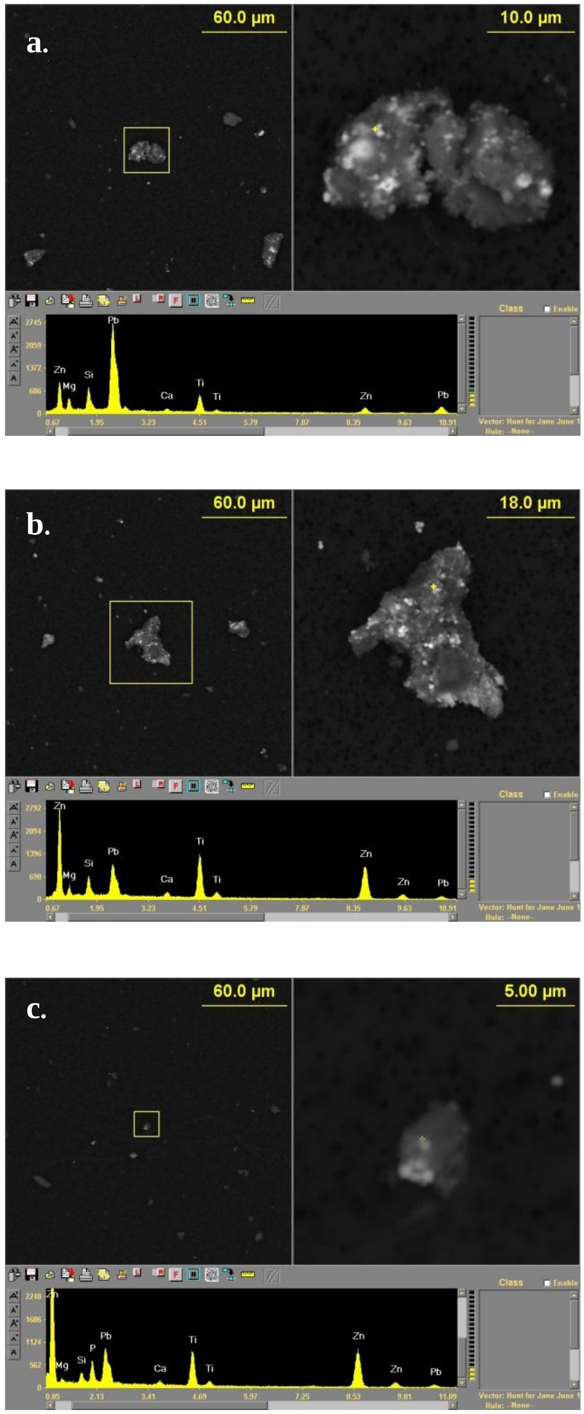


Figure C 15 House C window frame paint particle with Pb pigment particles and Zn, Ti, Si, Mg, Ca (a, b), Zn, Ti, Si, P Ca (c) in matrix

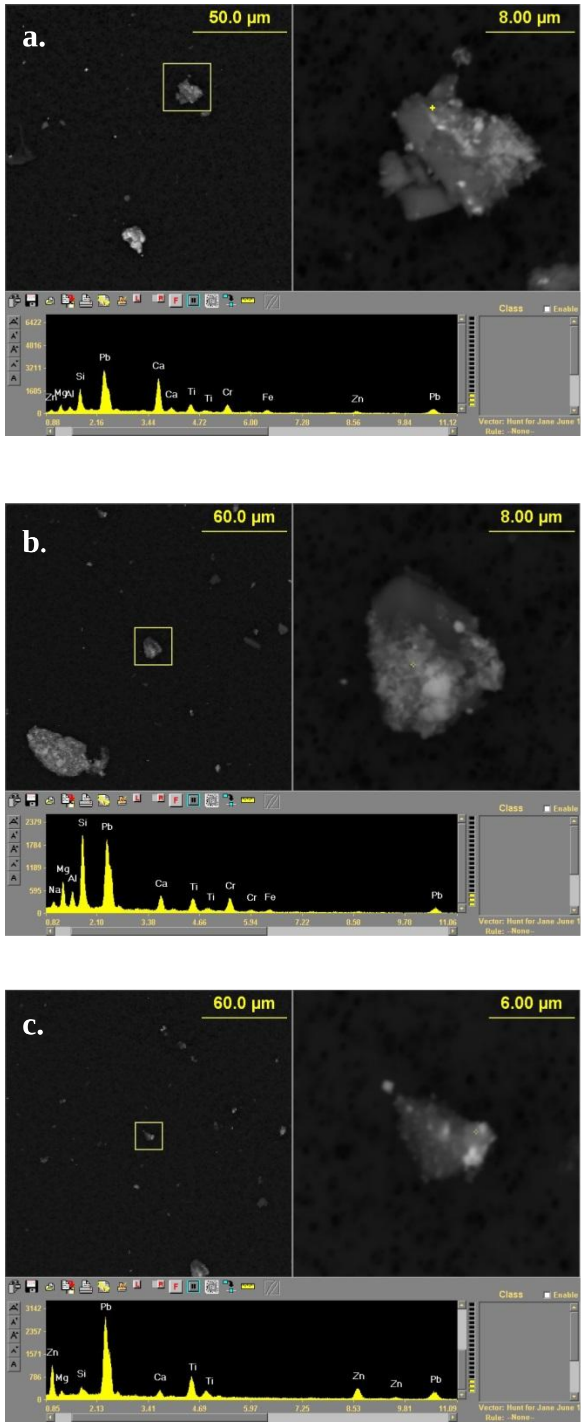


Figure C 16 House C window frame paint particle with Pb pigment particles and Cr, Ti,Ca, Si, Al, Mg, Fe (a, b), Ti (b), Zn, Ba, Ca (c) in matrix

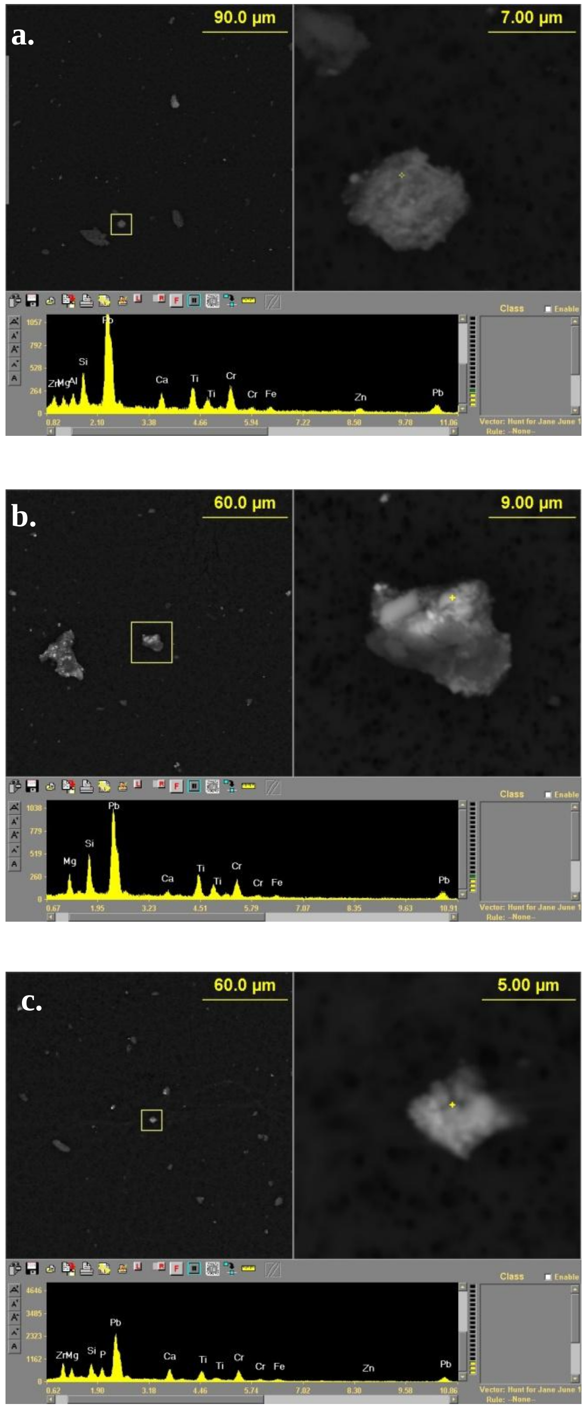


Figure C 17 House C window frame paint particle with Pb pigment particles and Zn,Ba, Cr, Ca, Si Al, Fe, Mg (a), Ba, Cr, Si, Mg, Ca (b), Cr, Ti, Ca, P, Si, Mg, Na (c) in matrix

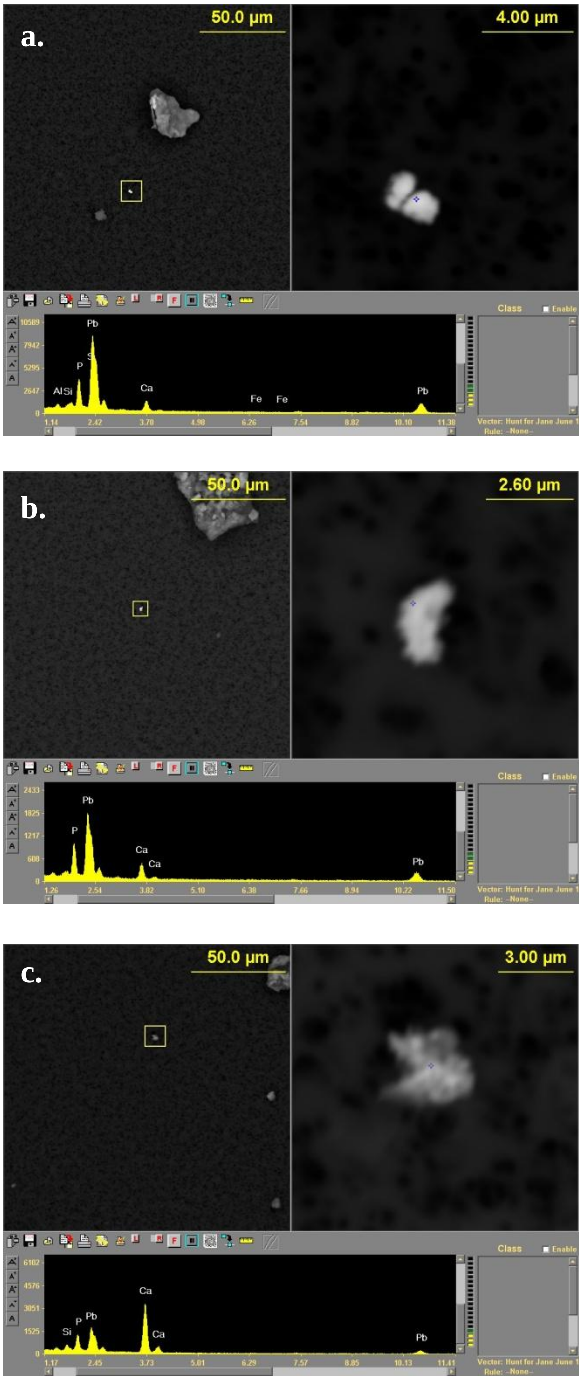


Figure C 18 House C window building line soil particle with Pb pigment particles and Ca, P (a, b and c) in matrix

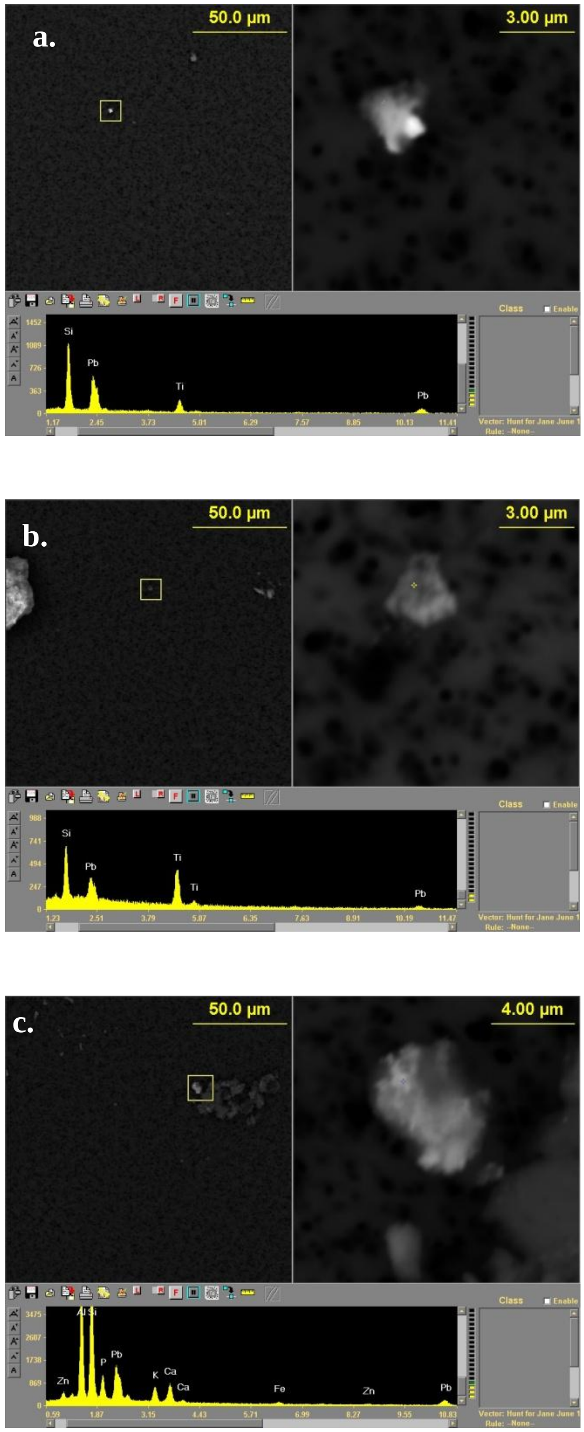


Figure C 19 House C window building line soil particle with Pb pigment particles and Ti, Si (a, b), Ca, K, P, Si, Al (c) in matrix

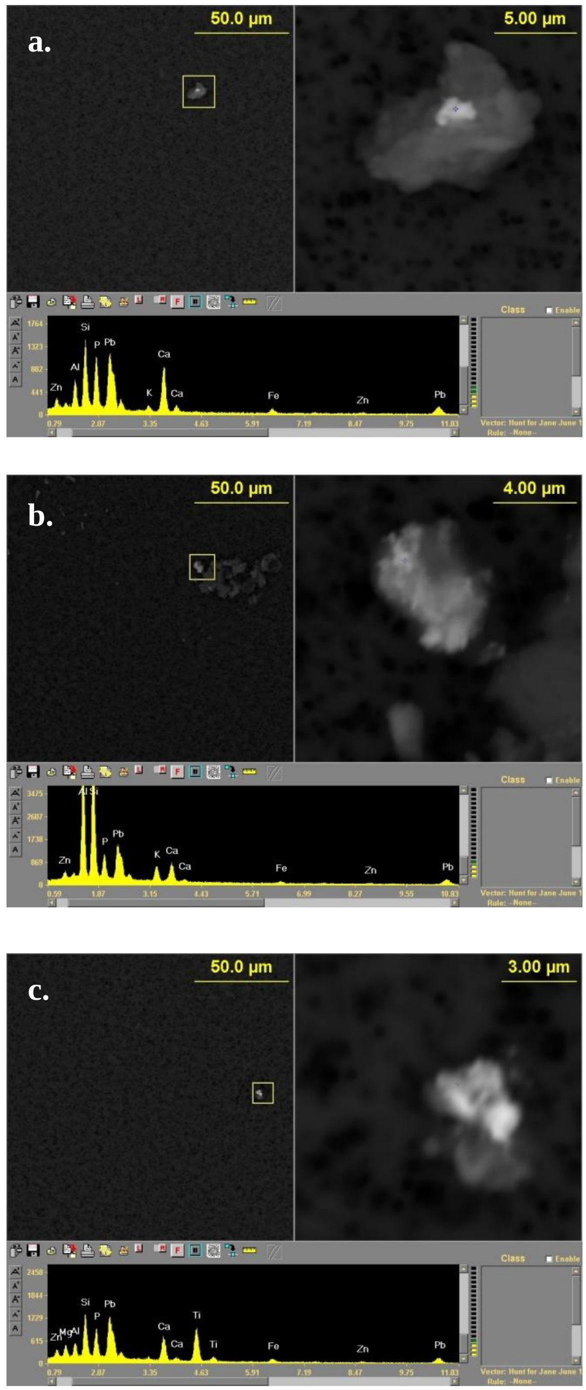
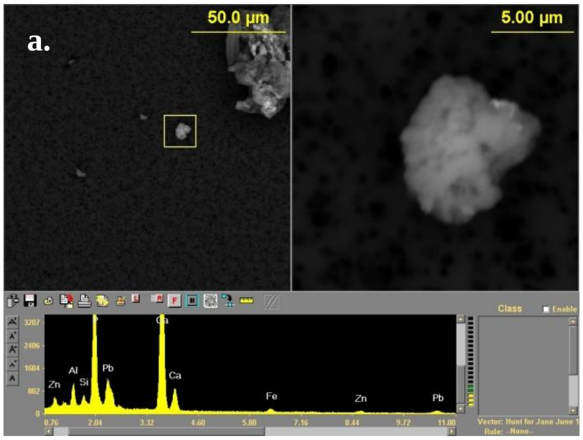


Figure C 20 House C window building line soil particle with Pb pigment particles and Ca, P Si, Al, K, Fe (a, b), Ti, Ca, P, Si, Al, Mg, Fe (c) in matrix



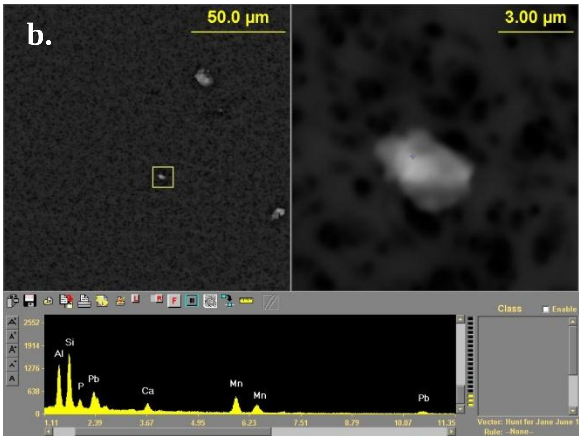


Figure C 20 House C window building line soil particle with Pb pigment particles and Ca, P, Si, Al, Zn, Fe (a), Ca, P, Si, Al, Mn, Fe (b) in matrix

Appendix D

Raw data, SEM images and X-Ray Spectra of House E

House E

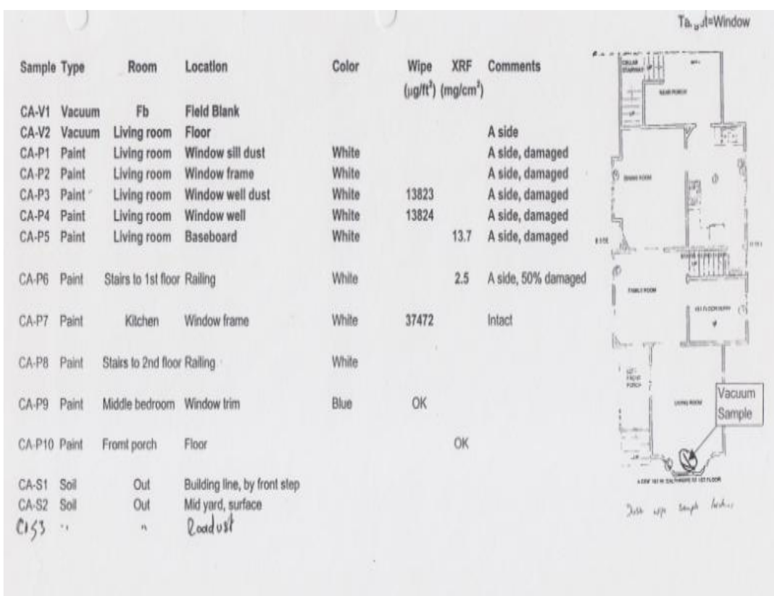
Single Implicated Window Friction Source

Window Paint in Intact Condition

Multi Story Family Home

Sampling Location:	**1st Floor Family Room**
Collected Samples:	
Dust	**1. 1st Floor Family Room Floor Dust [E1]**
Implicated Friction Surface	**2. 1st Floor Family Room Window Sill Dust** **3. 1st Floor Family Room Window Frame Paint [E2]** **4. 1st Floor Family Room Window Well Dust** **5. 1st Floor Family Room Window Well Paint [E7]**
Other LBP Surfaces	**6. 1st Floor Family Room Baseboard [E8]** **7. Kitchen Window Frame** **8. Stair Railing to Second Floor** **9. 2nd Floor Middle Bedroom Window Trim** **10. Front Porch Floor Paint**
Soil	**11. Building Line Soil by Front Step [E4]** **12. Yard by Road [E5]** **13. Road Dust [E6]**

Figure D.1 House E General View



Sample	Type	Room	Location	Color	Wipe (µg/ft²)	XRF (mg/cm²)	Comments
CA-V1	Vacuum	Fb	Field Blank				
CA-V2	Vacuum	Living room	Floor				A side
CA-P1	Paint	Living room	Window sill dust	White			A side, damaged
CA-P2	Paint	Living room	Window frame	White			A side, damaged
CA-P3	Paint	Living room	Window well dust	White	13823		A side, damaged
CA-P4	Paint	Living room	Window well	White	13824		A side, damaged
CA-P5	Paint	Living room	Baseboard	White		13.7	A side, damaged
CA-P6	Paint	Stairs to 1st floor	Railing	White		2.5	A side, 50% damaged
CA-P7	Paint	Kitchen	Window frame	White	37472		Intact
CA-P8	Paint	Stairs to 2nd floor	Railing	White			
CA-P9	Paint	Middle bedroom	Window trim	Blue	OK		
CA-P10	Paint	Fromt porch	Floor			OK	
CA-S1	Soil	Out	Building line, by front step				
CA-S2	Soil	Out	Mid yard, surface				
C1S3	"	"	Roadust				

Figure D.2 House E Floor Plan

Table D.1 House E Lead Concentration Data by XRF

Analysis Number	House Code	Sample Description	Pb Conc (µg/g)	Error (µg/g)
HUD 009-1	**E1**	House E - Cyclone Vacuum Dust Sample: Living room floor	4288.4	15.9
HUD 010-1	**E2**	House E - Target Paint: Living room window frame, intact condition	95690.6	105.1
HUD 011-1	**E7**	House E - Target Paint: Living room window well, intact condition	100008.1	111
HUD 012-1	**E8**	House E - Competing Paint: Living room baseboard, damaged	2864.4	19.5
HUD 013-1	**E5**	House E - Mid-Yard Soil	781.3	15.2
HUD 014-1	**E4**	House E - Building Line Soil: Front of house	2602.1	18.8
HUD 015-1	**E6**	House E - Road Dust: Front of house	275	23.8

Table D.2 House E Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	**House Code**	**Description**	**206/204**	**207/204**	**208/204**	**207/206**	**208/206**	**207/208**
HUD9	**E1**	House E - Cyclone Vacuum Dust Sample: Living room floor	18.065	15.615	38.036	0.86441	2.10556	0.41054
HUD10	**E2**	House E - Target Paint: Living room window frame, intact condition	17.714	15.544	37.624	0.87754	2.12404	0.41315
HUD11	**E7**	House E - Target Paint: Living room window well, intact condition	18.395	15.619	38.407	0.84906	2.08791	0.40666
HUD12	**E8**	House E - Competing Paint: Living room baseboard, damaged	18.117	15.572	38.014	0.85953	2.09827	0.40964
HUD13	**E5**	House E - Mid-Yard Soil	18.702	15.624	38.546	0.83543	2.06111	0.40533
HUD14	**E4**	House E - Building Line Soil: Front of house	18.699	15.599	38.539	0.83422	2.061	0.40477
HUD15	**E6**	House E - Road Dust: Front of house	18.76	15.634	38.443	0.83336	2.04914	0.40669

Table D 3 House E Pb bearing particles found in floor dust sample

Chemical Composition	Morphology	Size
Pb	Aggregate	23.7
Pb	Irregular	4.91
Pb	Aggregate	5.46
pb	Irregular	4.02
Pb	Aggregate	5.05
pb	Acicular	3.04
Pb	Irregular	2.1
Pb	Aggregate	3.07
Pb	Irregular	2.48
Pb	Irregular	2.9
Pb	Irregular	2.18
Pb	Aggregate	3.23
Pb	Irregular	3.03
Pb	Rounded	1.52
Pb	Rounded	1.22
Pb	Acicular	2.18
Pb	Irregular	1.81
Pb	Irregular	1.3
Pb	Irregular	2.46
Pb	Irregular	1.96
Pb	Irregular	1.7
Pb	Irregular	2.56
Pb	Irregular	1.67
Pb	Irregular	2.17
Pb	Irregular	2.32
Pb	Irregular	0.815
Pb	Aggregate	2.71
Pb	Irregular	1.88
Pb	Aggregate	4.05
PbZn	Aggregate	3.66
PbZn	Irregular	3.28
PbZn	Irregular/Pb inclusion	3.18

Table D 3 - *Continued*

PbCa	Irregular	2.76
PbCa	Irregular	2.21
PbCa	Rounded	1.52
PbCa	Irregular/Little Pb inclusion	12.1
PbCa	Irregular	1.24
PbCa	Aggregate	3.71
PbCa	Aggregate	3.67
PbCa	Irregular	2.09
PbCa	Irregular	2.44
PbCa	Irregular	1
PbCa	Rounded	1.44
PbCa	Irregular/ Little Pb inclusion	25.6
PbCaCl	Irregular	8.1
PbCaCl	Aggregate	5.18
PbClSi	Platey Aggregate	1.9
PbCaK	Irregular	7.51
PbCaK	Irregular	9.33
PbCaK	Irregular	2.54
PbCaK	Irregular	3.18
PbSiAl	Irregular	4.6
PbKNa	Aggregate	7.4
PbTiZn	Irregular/Angular	18
PbZnTi	Irregular	2.02
PbZnCa	Pigment like	1.97
PbTiCa	Irregular	1.7
PbTiCa	Platey Aggregate	4.84
PbCaSiAl	Irregular	3.1
PbZnCaP	Irregular	2.32
PbZnCaK	Angular/Irregular	9
PbZnCaK	Irregular	5.36
PbZnCaTi	Irregular/Little Pb inclussion	3.97
PbZnCaSi	Aggregate	5.55
PbZnCaCl	Irregular	2.16
PbCaKCl	Platey Aggregate	
PbCaSiAl	Irregular	5.08

Table D 3 - *Continued*

PbTiZnCaSi	Platey Aggregate	4.73
PbTiCaSiAl	Irregular	2.6
PbZnCaSiCl	Aggregate	4.62
PbZnCaSiCl	Aggregate	2.91
PbZnCaClk	Irregular/Aggregate	7.44
PbZnCaKCl	Aggregate	7
PbZnCaPCl	Rounded	1.6
PbZnBaCaK	Irregular	51.4
PbCaKClNa	Aggregate	9.94
PbCaKClNa	Angular/Irregular	2.74
PbSiAlKFe	Irregular	2.89
PbCaSiAlNa	Aggregate	2.45
PbZnBaCaKCl	Aggregate	71.4
PbZnCaPClK	Aggregate	26
PbZnCaSiMgCl	Aggregate	5.11
PbZnCaSiAlP	Irregular	2.4
PbCaSiAlKCl	Irregular	1.81
PbCaSiAlKCl	Aggregate	16.3
PbCaSiAlKFe	Aggregate	3.55
PbZnCrCaSiAlFe	Irregular	4.58
PbZnCaAlKFeCl	Aggregate	43
PbCaSiAlKClMgNa	Irregular/Elongated	1.48
PbZnTiCaSiAlKPMg	Irregular	6.72

Table D 4 House E Pb bearing particles found in window frame paint sample

Chemical Composition	**Morphology**	**Size**
Pb	Aggregate	7.15
Pb	Aggregate	7.16
Pb	Platy Aggregate	16
Pb	Aggregate	5.75
Pb	Aggregate	27.5
Pb	Hexagonal	1.65
Pb	Aggregate	10.8
PbZn	Irregular	7.25
PbZn	Aggregate	8.11
PbZn	Irregular	3.13
PbZn	Aggregate	30.5
PbZn	Aggregate	5.64
PbZn	Irregular	2.06
PbZn	Aggregate	3.81
PbZn	Aggregate	13.3
PbZn	Aggregate	5.20
PbZn	Aggregate	7.62
PbZn	Aggregate	14.7
PbZn	Irregular	4.32
PbZn	Aggregate	8.47
PbZn	Aggregate	4.48
PbZn	Aggregate	8.41
PbZn	Aggregate	7.57
PbZn	Aggregate	5.24
PbZn	Aggregate	5.56
PbZn	Aggregate	6.33
PbZn	Aggregate	9.54
PbZn	Irregular	7.71
PbZn	Irregular	10
PbZn	Aggregate	12.1
PbZn	Aggregate	4.92
PbZn	Aggregate	25.4
PbCa	Aggregate	4.78
PbTi	Aggregate	1.5

Table D 4 - *Continued*

bZnCa	Aggregate	14.6
PbZnCa	Irregular	2.6
PbZnCa	Irregular	5.35
PbCaTi	Irregular	1.53
PbCaTi	Irregular	7.84
PbCaTi	Irregular	2.22
PbZnCa	Irregular	8.53
PbZnBa	Aggregate	2.6
PbZnCl	Aggregate	8.3
PbZnCl	Aggregate	17.3
PbZnCl	Aggregate	8.68
PbZnBa	Aggregate	9.8
PbZnTi	Aggregate	12.1
PbZnTi	Aggregate	2.6
PbZnTi	Irregular	7.38
PbZnCl	Aggregate	37.8
PbZnCl	Aggregate	15.2
PbZnCl	Aggregate	34.3
PbZnCl	Aggregate	22.5
PbZnCl	Aggregate	20.8
PbZnCl	Aggregate	13
PbZnCl	Aggregate	24.7
PbZnCl	Aggregate	9.14
PbZnCl	Aggregate	5.85
PbZnBa	Irregular	3.12
PbBaNa	Irregular	4.14
PbZnCa	Aggregate	4.84
PbZnCa	Aggregate	16.4
PbCaTiZn	Irregular	2.02
PbCaTiZn	Aggregate	7.04
PbCaTiZn	Aggregate	27
PbCaTiZn	Aggregate	7.48
PbCaTiZn	Aggregate	5.27
PbCaTiZn	Aggregate	24.2
PbCaTiZn	Aggregate	5.66

Table D 4 - Continued

PbCaTiZn	Aggregate	10.3
PbCaSiAl	Aggregate	12.1
PbZnSiAl	Irregular	11.5
PbZnSiAl	Aggregate	5.83
PbZnSiAl	Aggregate	16.6
PbZnSiCa	Aggregate	10.6
PbZnBaSi	Aggregate	5.47
PbZnSiAl	Irregular	7.97
PbZnSiAl	Aggregate	12.7
PbZnSiClMg	Aggregate	17
PbZnTiCaCl	Aggregate	7.85
PbZnBaCaSi	Aggregate	8.71
PbZnCaSiTi	Aggregate	7.17
PbZnTiSiAl	Aggregate	3.9
PbZnTiSiCl	Aggregate	6.9
PbCaTiZnSiAl	Aggregate	
PbCaTiZnSiAl	Aggregate	16
PbCaTiZnSiAl	Aggregate	34.7
PbCaZnSiMgBa	Aggregate	3.95

Table D 5 House E Pb bearing particles found in building line soil sample

Chemical Composition	Morphology	Size
PbCaP	Irregular	3.65
PbCaP	Aggregate	4.4
PbCaP	Aggregate	4.85
PbCaP	Irregular	3.14
PbCaPSi	Irregular	5.93
PbCaSiFe	Aggregate	34.3
PbCaMnCl	Irregular	2.95
PbCaPCl	Aggregate	9.19
PbCaPSiAl	Irregular	4.68
PbCaPSiAl	Aggregate	5.76
PbCaPSiAl	Aggregate	13.7
PbCaPSiAl	Irregular	5.87
PbPSiAlFe	Aggregate	7.69
PbCaAlZnMg	Irregular	13.6
PbCaPSiAlZn	Irregular	3.95
PbCaPSiAlZn	Irregular	5.43
PbCaPSiAlZn	Irregular	2.8
PbAlSiPCaZn	Rounded	6.2
PbCaPSiAlZn	Irregular	3.7
PbCaPAlFeZn	Rounded	4.39
PbCaSiAlZnMg	Irregular	18.5
PbCaPSiAlMg	Irregular	7.01
PbCaPSiAlFe	Aggregate	4.4
PbCaPSiAlNa	Irregular	2.87
PbCaPSiAlK	Aggregate(Tiny Pb inclusion)	90
PbCaPSiAlK	Aggregate	9.87
PbCaPSiAlFe	Irregular	5.54
PbCaPSiAlFe	Irregular	3.7
PbCaPSiAlKZn	Aggregate	11.1
PbCaPSiAlFeZn	Irregular	6.73
PbCaPSiAlFeZn	Irregular	4.15
PbCaPSiAlFeZn	Irregular	11.6
PbCaPSiAlFeZn	Irregular	7.41

Table D 5 - *Continued*

PbCaPSiAlFeZn	Irregular	5.96
PbCaPSiAlFeZn	Irregular	10.1
PbCaPSiAlFeZn	Irregular	8.65
PbCaPSiAlFeZn	Irregular	6.78
PbCaPSiAlFeZn	Irregular	5.19
PbCaPSiAlKZn	Irregular	4.4
PbCaPSiAlFeZn	Irregular	5.62
PbCaPSiAlZnFe	Irregular	9.95
PbCaSiAlFeZnCl	Irregular	6.84
PbCaPSiAlKFe	Aggregate	7.94
PbCaPSiAlKFe	Aggregate	11.5
PbCaPSiAlKFe	Aggregate	10.5
PbCaPSiAlMnCl	Irregular	3.78
PbCaPSiAlFeNa	Irregular	6
PbCaPSiAlKFeMg	Aggregate	22.2
PbCaPSiAlMnZnFe	Irregular	7.92
PbCaPSiAlMnZnFe	Irregular	4.34
PbCaPSiAlMnZnFe	Irregular	6.4
PbCaPSiAlMnZnFe	Irregular	7.27
PbCaPSiAlKZnFe	Aggregate	11.6
PbCaPSiAlZnFeMg	Irregular	8.43
PbCaPSiAlZnFeCl	Aggregate	19.7
PbCaPSiAlZnFeCl	Irregular	5.64
PbCaSiAlKZnFeMg	Irregular	6.21
PbCaPSiAlFeMgZn	Aggregate	16.5
PbCaPSiAlNaFeCl	Irregular	4.27
PbCaPSiAlKMgFe	Aggregate	16.9
PbCaPSiAlKFeMgZn	Aggregate	9.43
PbCaPSiAlKFeMgZn	Aggregate	10.4
PbCaPSiAlKFeMgZn	Irregular	6.01
PbCaPSiAlKFeMgNa	Aggregate(Tiny Pb inclusion)	20
PbCaPSiAlKFeMgZn	Irregular	10.7
PbCaPSiAlKFeMgZn	Aggregate	36.8
PbCaPSiAlKFeMgZn	Irregular	13.8
PbCaPSiAlKFeMgZn	Irregular	13.2

Table D 5 - *Continued*

PbCaPSiAlKFeMgZn	Aggregate	16.5
PbCaPSiAlKFeMgZn	Aggregate	6.3
PbCaPSiAlKFeMgZn	Aggregate	12.2
PbCaPSiAlKFeMnZn	Irregular	2.18
PbCaPSiAlFeMnZnCl	Irregular	9.22
PbCaPSiAlFeMgZnMn	Irregular	5.3
PbCaPSiAlKMnZnMg	Aggregate	10.2
PbCaPSiAlKZnMgFe	Irregular	13.3
PbCaPSiAlKZnMgFe	Irregular	12
PbCaPSiAlKFeMgTi	Aggregate	11.5
PbCaPSiAlKFeMgNa	Aggregate	10.4
PbCaPSiAlKFeMgNa	Irregular	3.04
PbCaPSiAlKMgFeCl	Aggregate	8.04
PbCaPSiAlKMnZnMgFe	Irregular	11.5
PbCaPSiAlKMnZnMgFe	Irregular	11
PbCaPSiAlKMnZnMgFe	Irregular	3.77
PbCaPSiAlKZnMgFeMn	Aggregate	4.69
PbCaPSiAlKZnMgFeCl	Aggregate	11.6
PbCaPSiAlKZnFeMnCl	Irregular	9.06
PbCaPSiAlKFeZnMgCl	Aggregate	13.8
PbCaPSiAlKZnMgFeTi	Irregular	5.72
PbCaPSiAlKZnMgFeTi	Irregular	7.75

Table D 6 House E Pb bearing particles found in road dust sample

Chemical Composition	**Morphology**	**Size**
PbCa	Irregular	1.38
PbSiCaPAl	Irregular	1.13

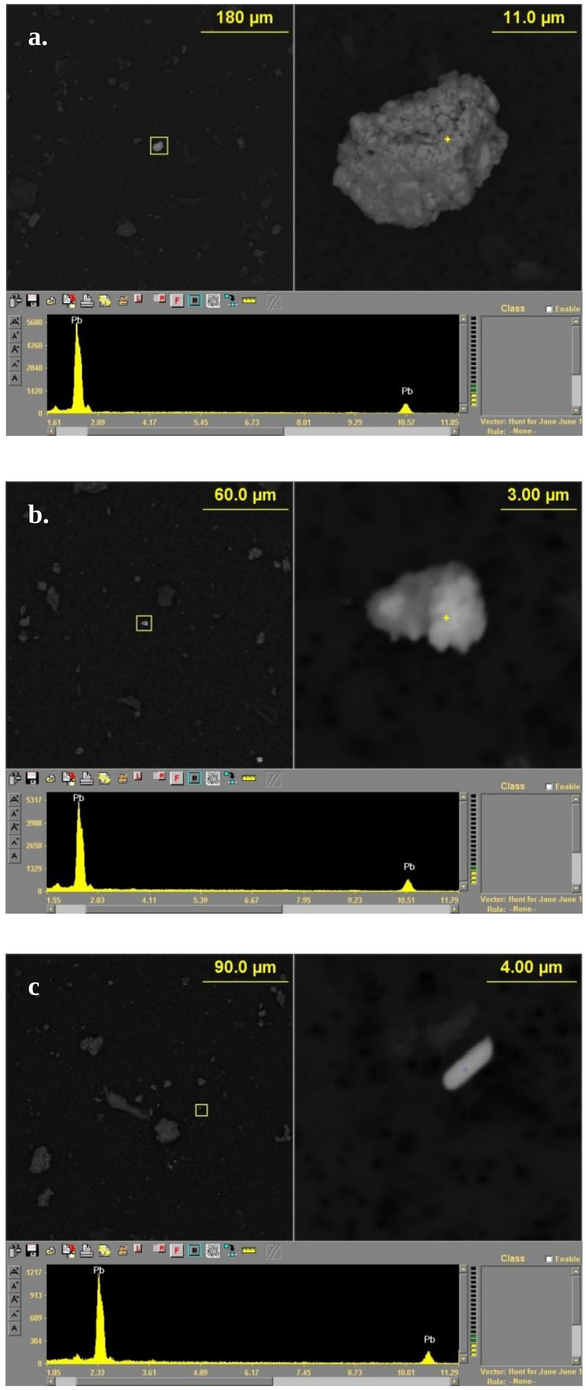


Figure D 3 House E floor dust particle with Pb pigment particles (a, b and c)

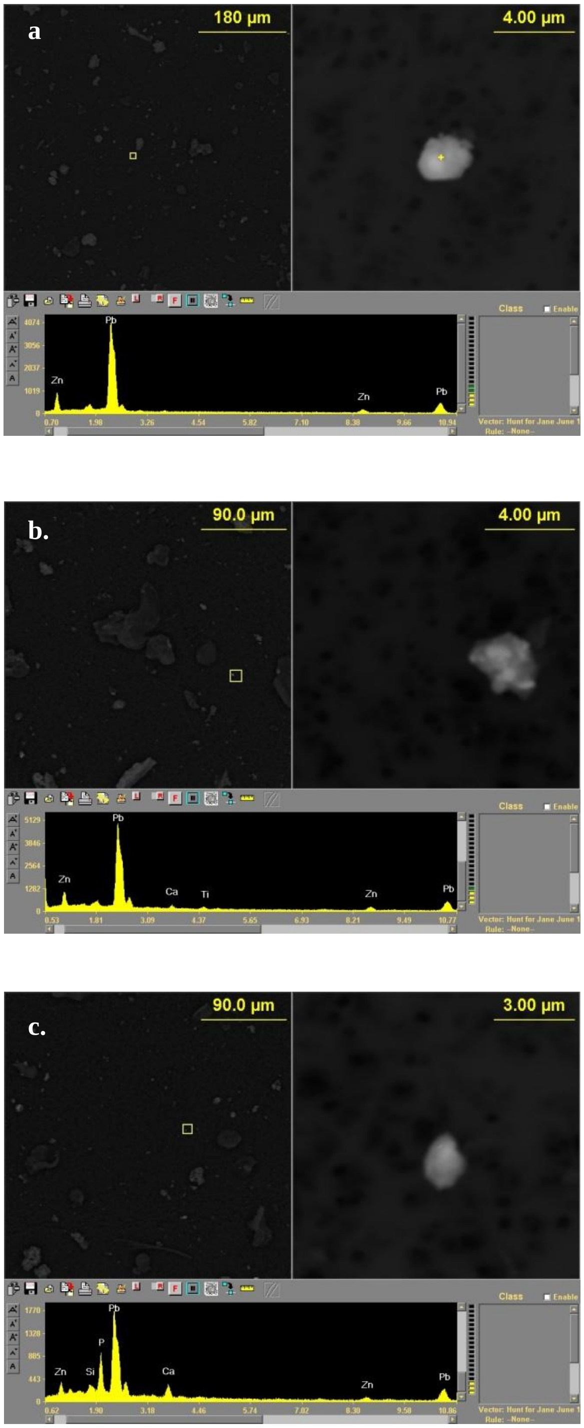


Figure D 4 House E floor dust particle with Pb pigment particles and Zn (a, b), Ca, P, Si, Zn (c) in matrix

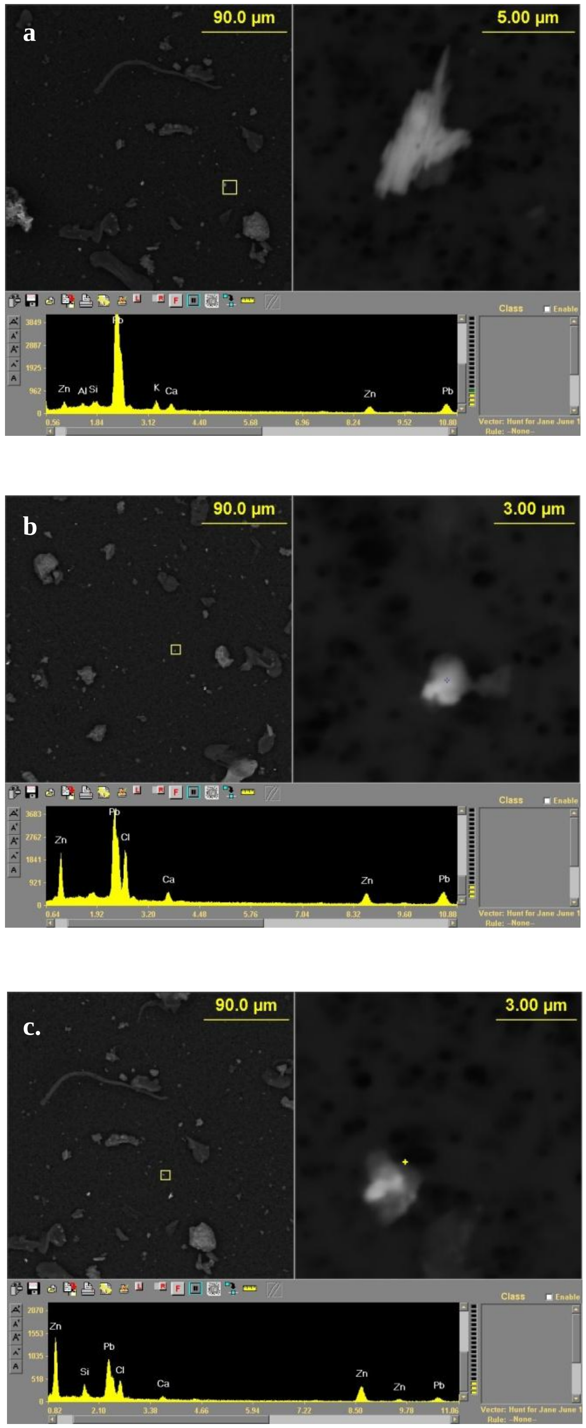


Figure D 5 House E floor dust particle with Pb pigment particles and Zn, Ca, K, (a), Zn, Cl, Ca, Si (b, c) in matrix

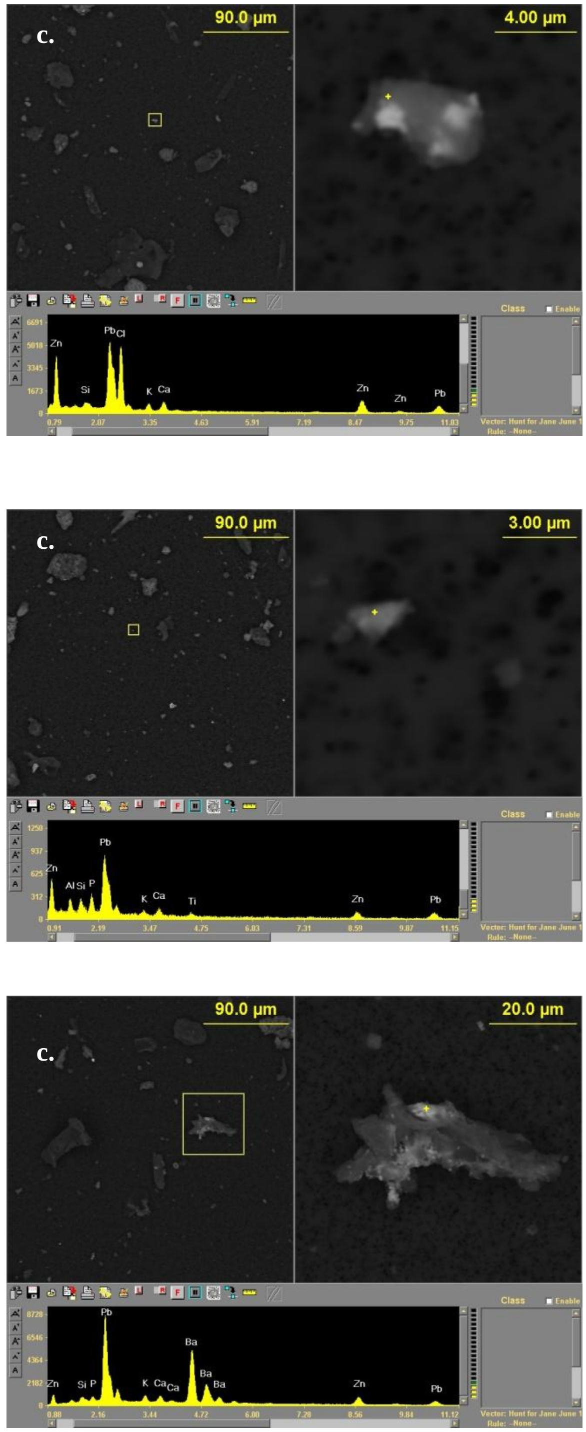


Figure D 6 House E floor dust particle with Pb pigment particles and Zn, Cl, Ca, K, (a), Zn, Ca, K, P, Si, Al (b), Zn, Ba, Ca, K (c) in matrix

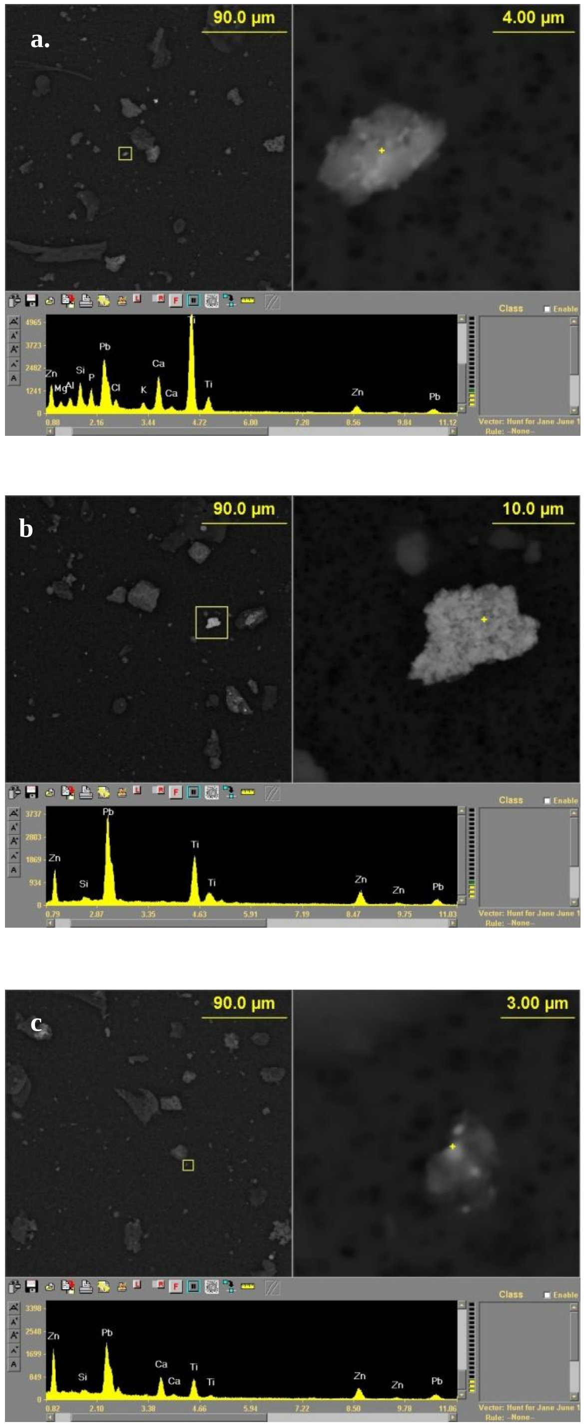


Figure D 7 House E floor dust particle with Pb pigment particles and Zn, Ti, Ca, K, Si, P, Al, Mg (a), Zn, Ti (b), Zn, Ti, Ca, (c) in matrix.

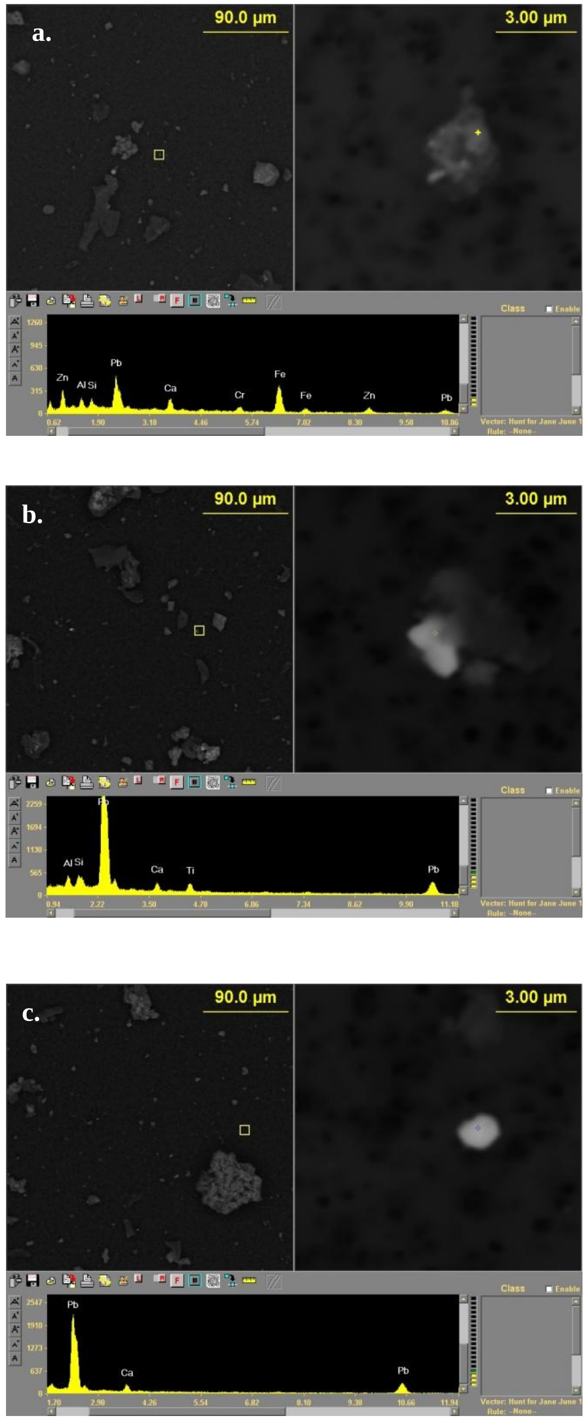


Figure D 8 House E floor dust particle with Pb pigment particles and Zn, Cr, Ca, Fe, Si, Al, (a), Ti, Ca, Si, Al (b), Ca (c) in matrix.

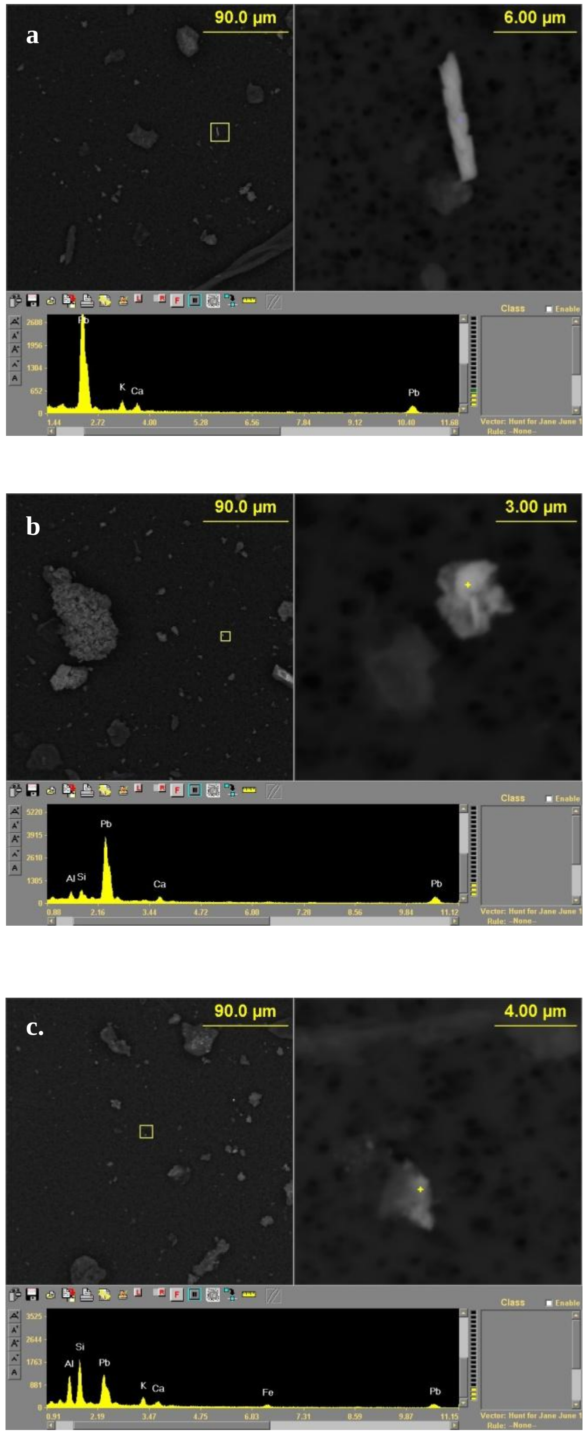


Figure D 9 House E floor dust particle with Pb pigment particles and Ca, K (a), Ca, Si, Al (b), Si, Al, K, Fe, Ca (c) in matrix.

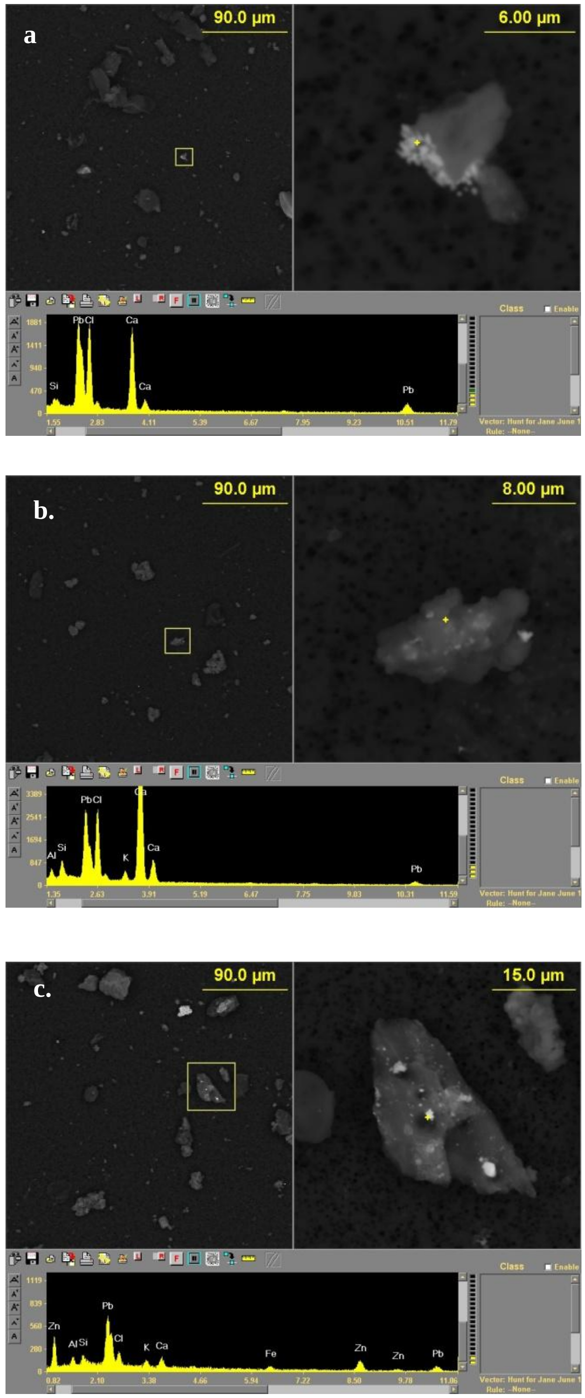


Figure D 10 House E floor dust particle with Pb pigment particles and Cr, Ca (a), Cl, Ca, K, Si, Al (b), Zn, Si, Al, K,.Ca, Fe (c) in matrix.

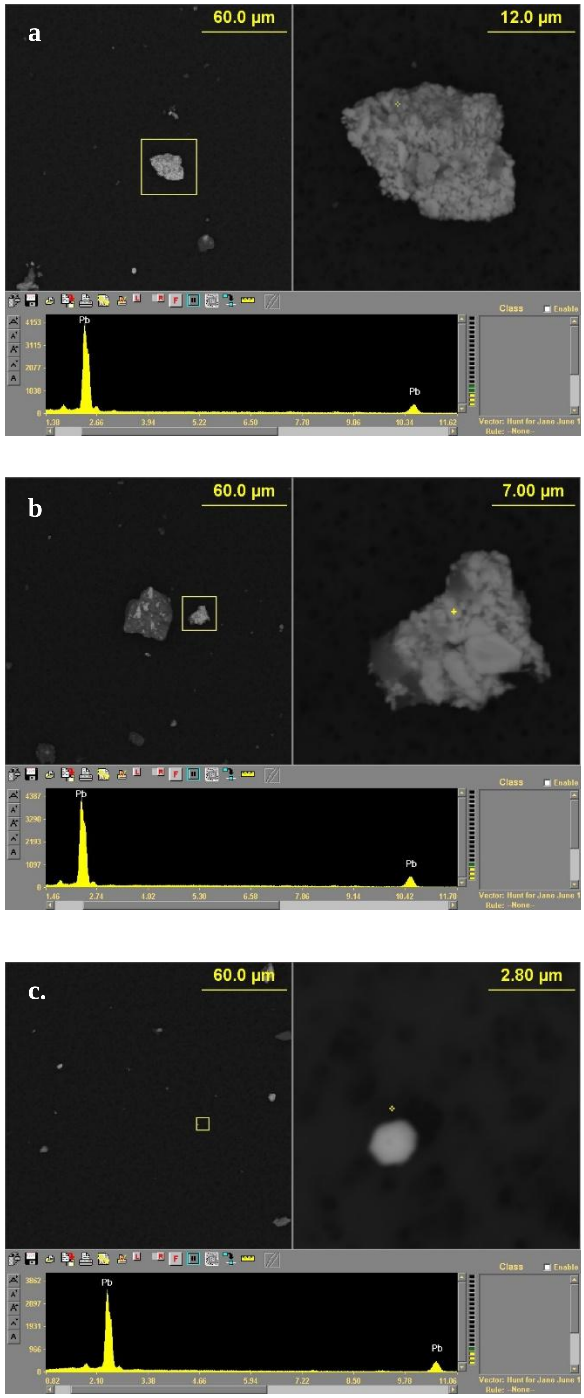


Figure D 11 House E window frame paint particle with Pb pigment particles (a, b and c)

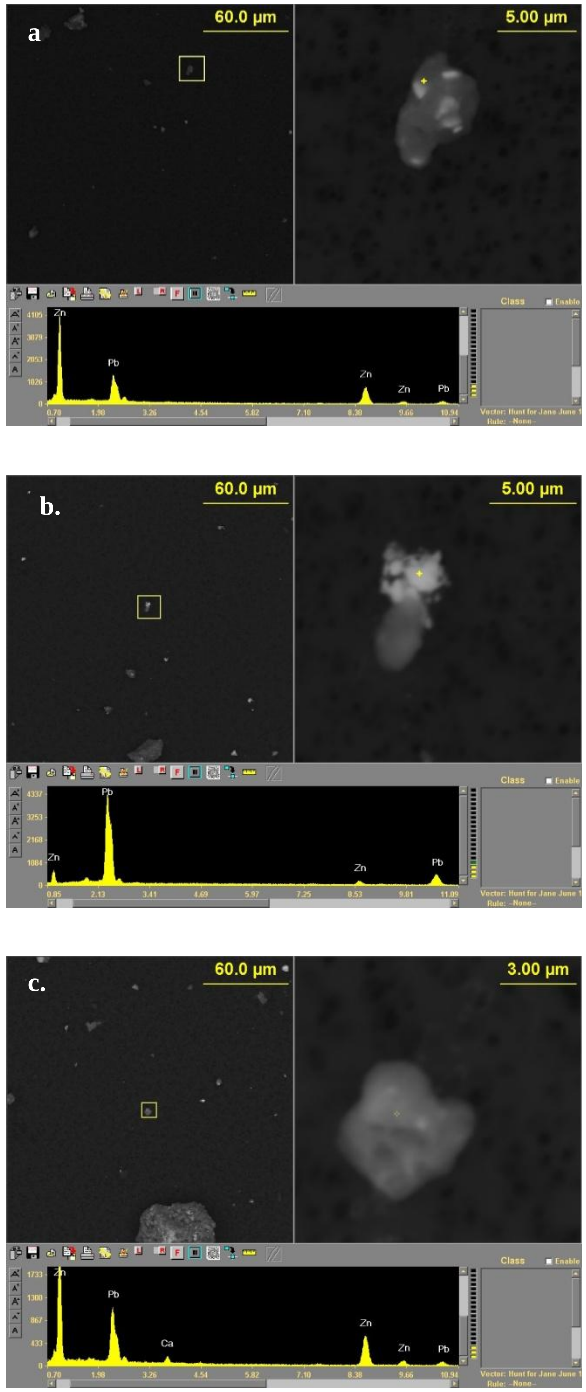


Figure D 12 House E window frame paint particle with Pb pigment particles and Zn (a, b and c) in matrix

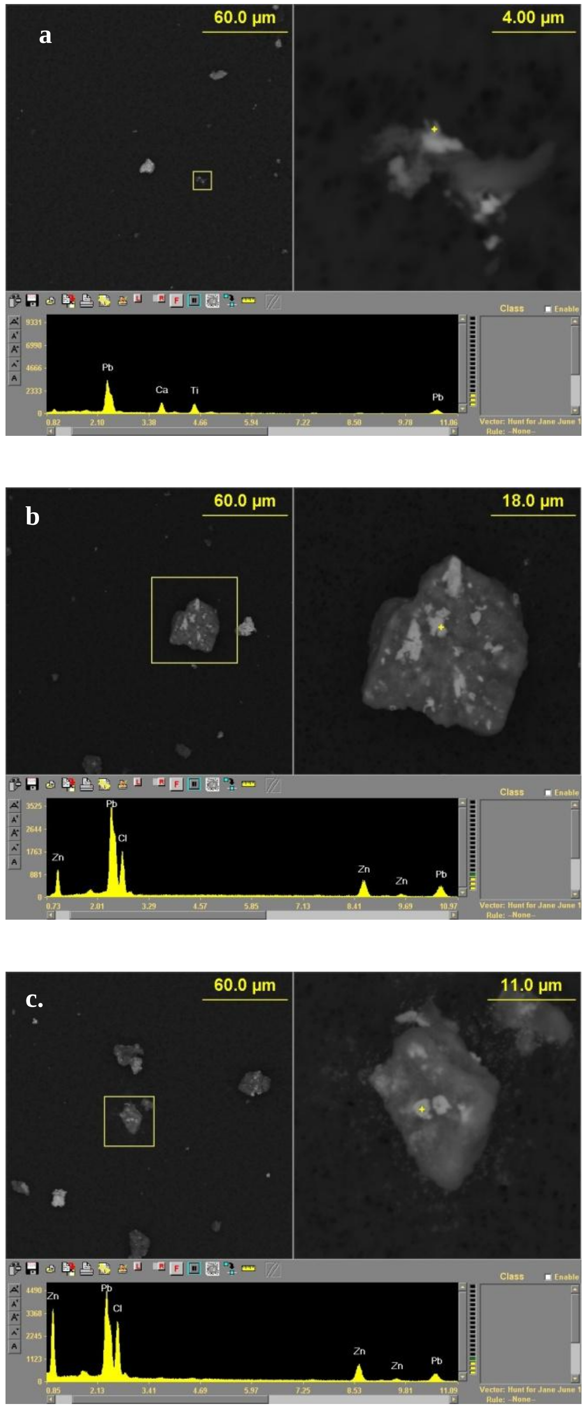


Figure D 13 House E window frame paint particle with Pb pigment particles Ti, Ca (a), Zn, Cl (b, c) in matrix

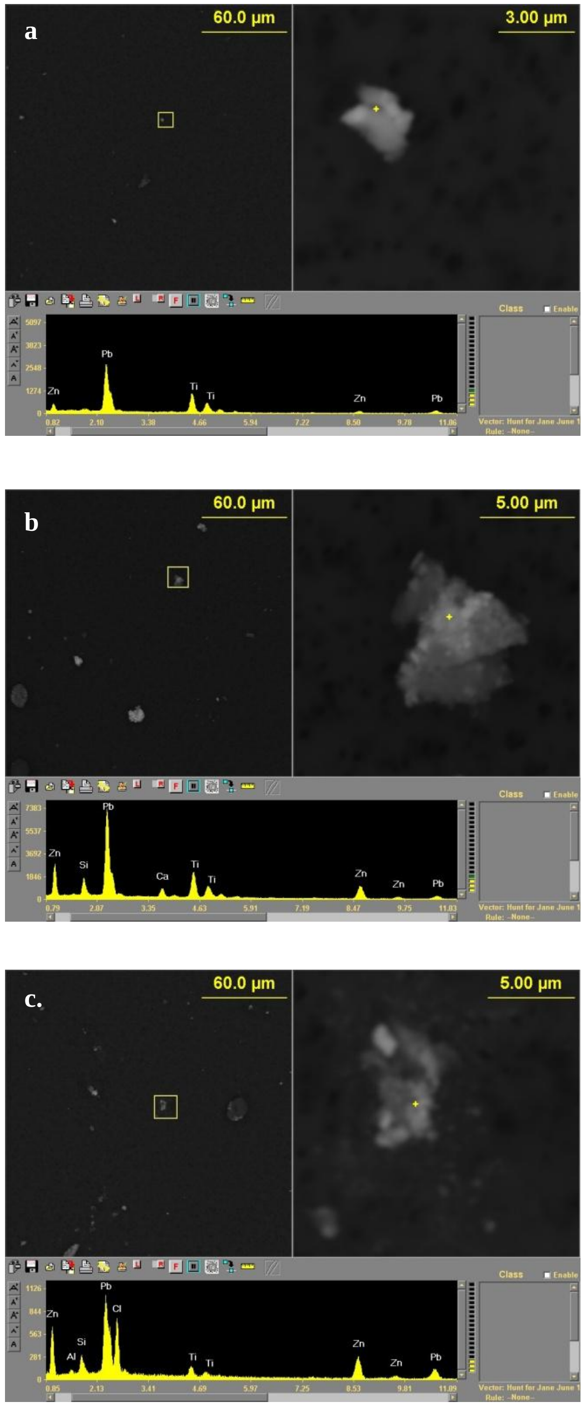


Figure D 14 House E window frame paint particle with Pb pigment particles and Zn, Ba (a), Zn, Ba, Ca, Si (b), Zn, Ti, Cl, Si (c) in matrix

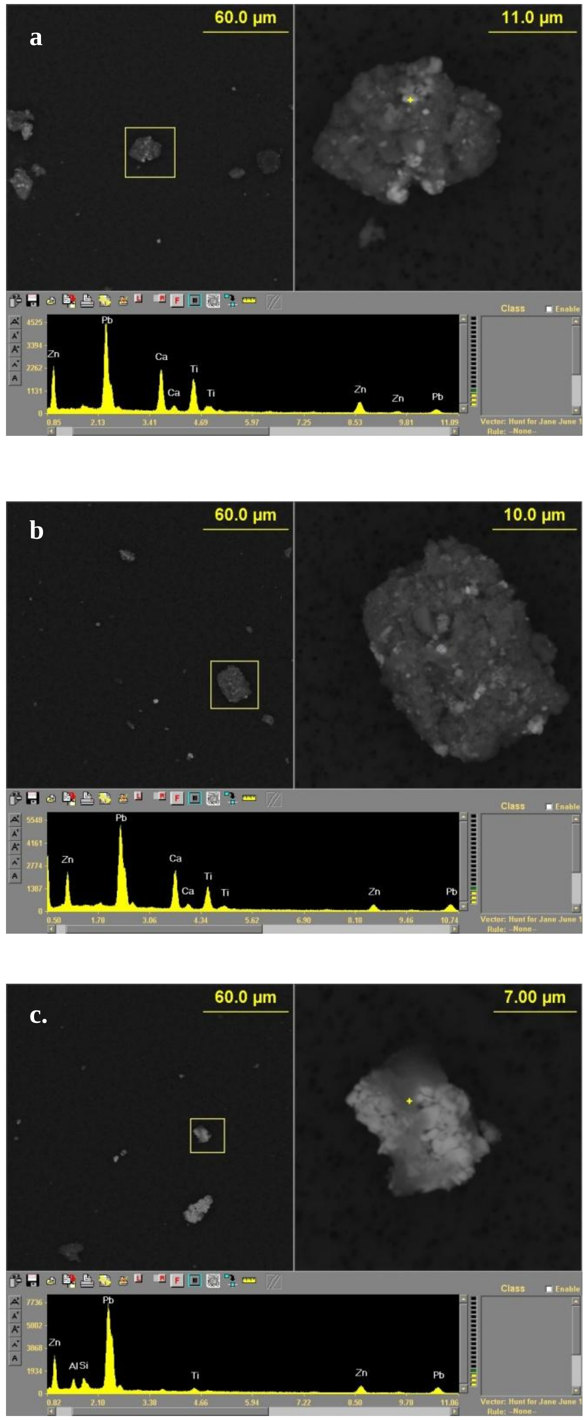


Figure D 15 House E window frame paint particle with Pb pigment particles Zn, Ti, Ca (a, b), Zn, Si, Al (c) in matrix

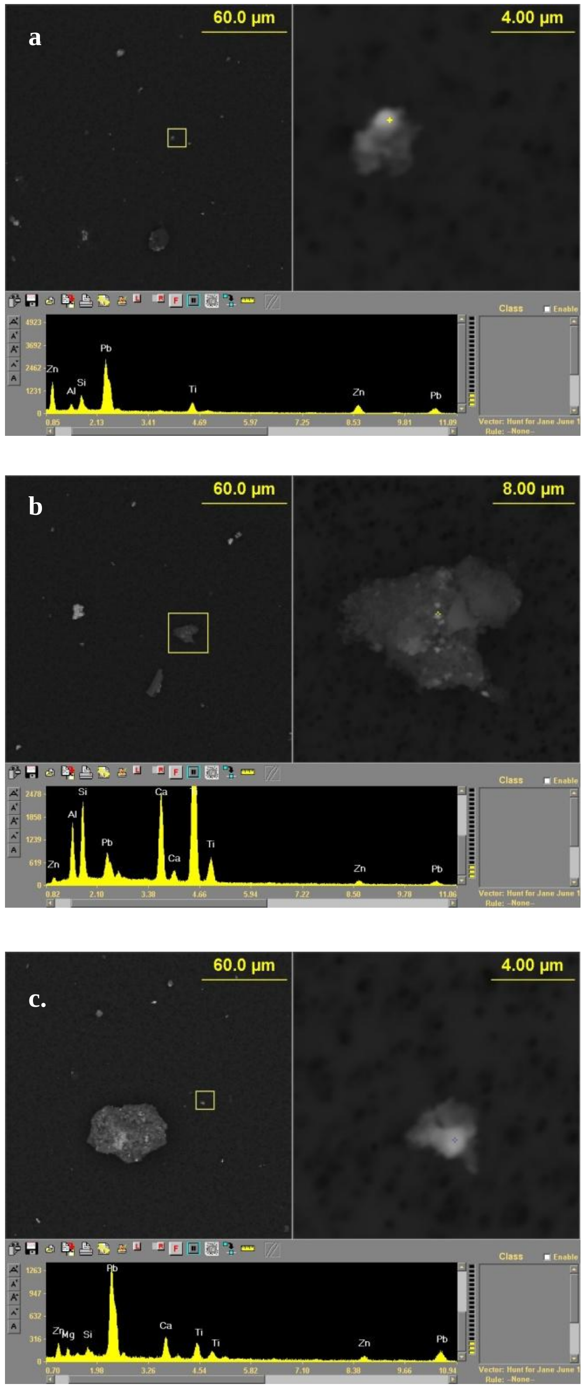


Figure D 16 House E window frame paint particle with Pb pigment particles Zn, Ti, Si, Al (a), Ti, Ca, Si, Al, Zn (b), Zn, Ti, Ca, Si, Mg (c) in matrix

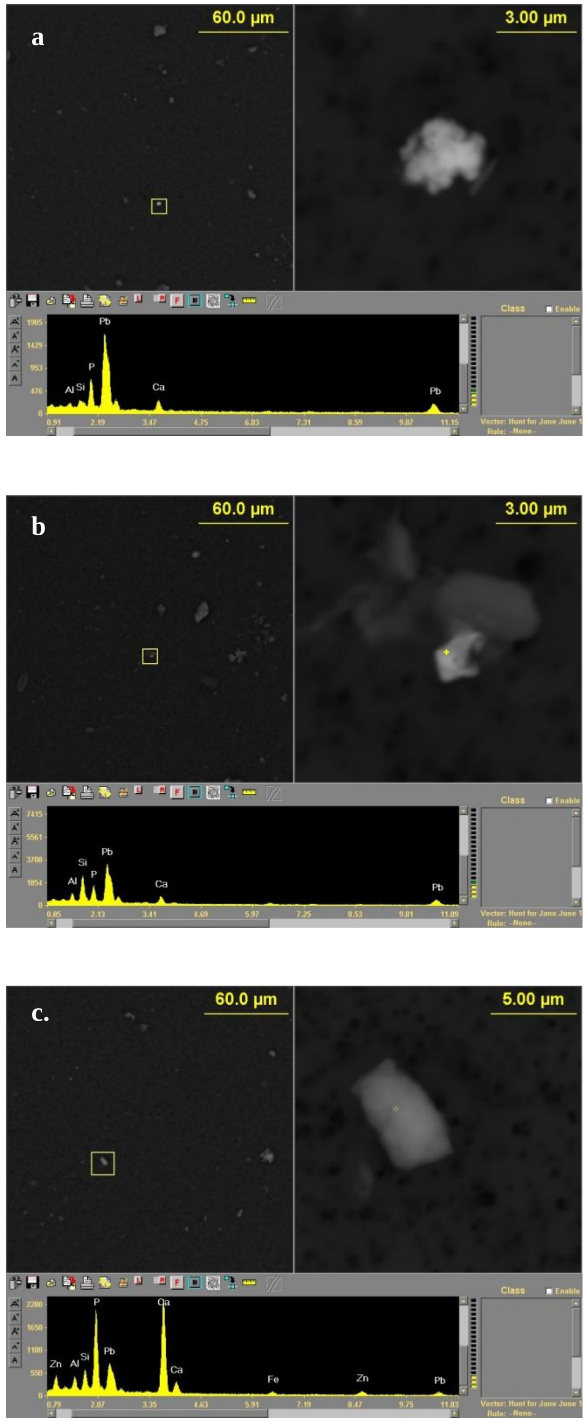


Figure D 17 House E building line soil particle with Pb pigment particles and Ca, P (a, b), Ca, P, Si, Al, Zn, Fe (c) in matrix

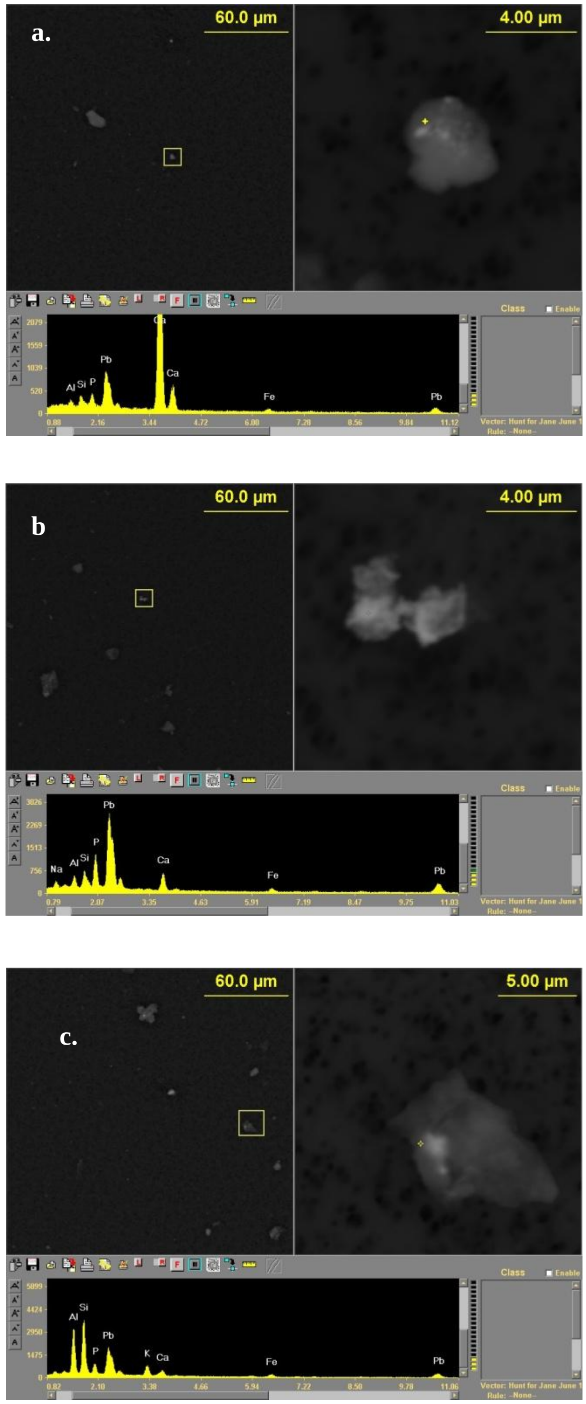


Figure D 18 House E building line soil particle with Pb pigment particles and Ca, P, Si, Al, Fe (a, b), Ca, P, Si,Al, K, Fe (c) in matrix

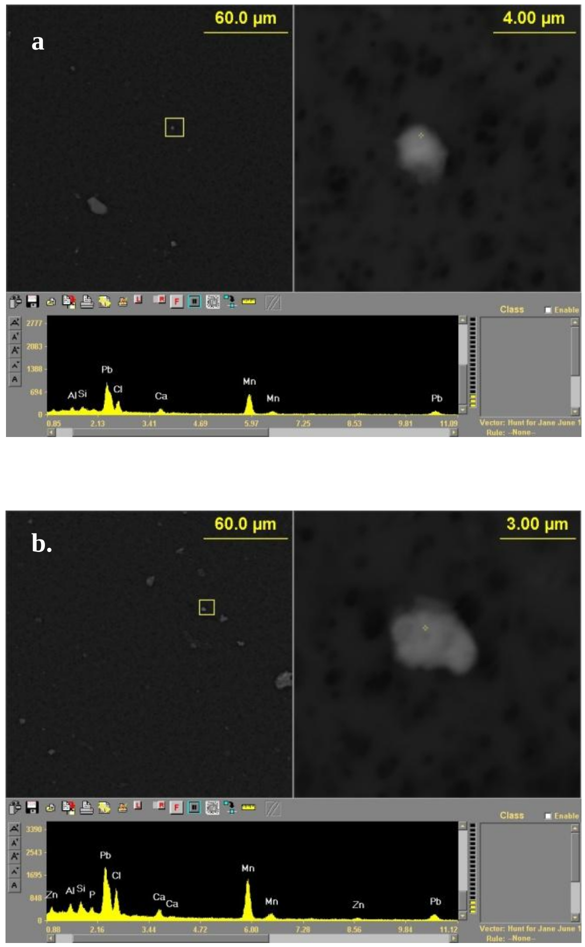


Figure D 19 House E building line soil particle with Pb pigment particles and Ca, Cl, Ca, Mn (a), Ca, Cl, Si, Al, Mn (b) in matrix

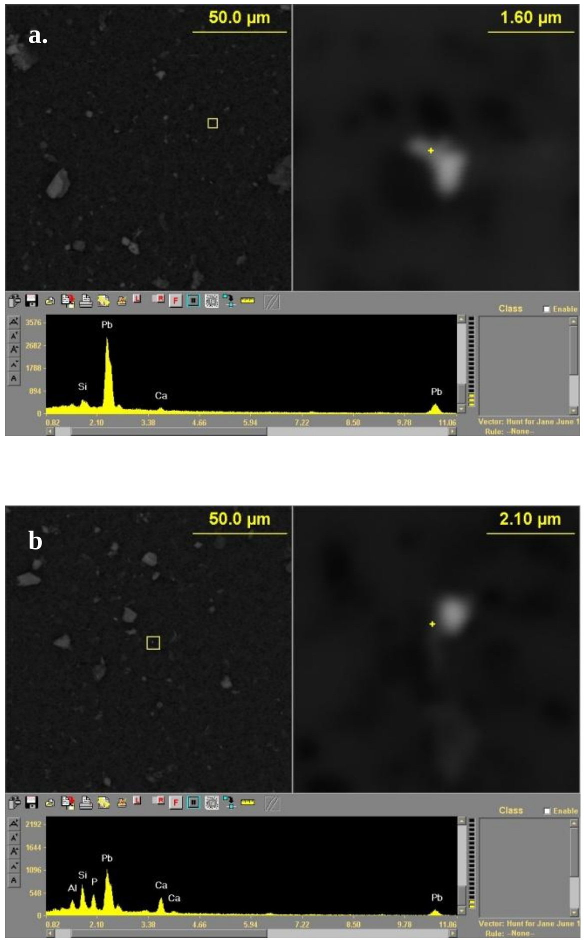


Figure D 20 House E road dust particle with Pb pigment particles and Ca (a), Ca, P, Si, Al (b) in matrix

Appendix E

Raw data, SEM images and X-Ray Spectra of House J

House J

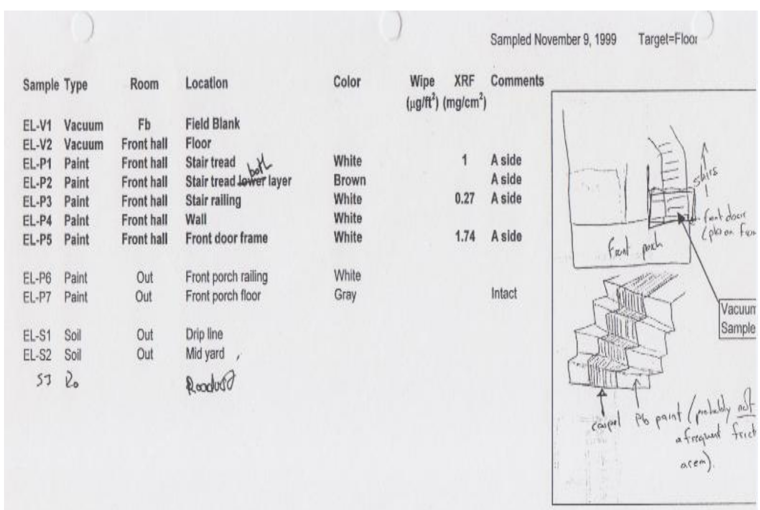
Single Implicated Floor Friction Source

Floor Paint in Poor Condition

Multi Story Family Home

Sampling Location:	**Entrance Hall**
Collected Samples:	
Dust	**1. Entrance Hall Floor Dust [J1]**
Implicated Friction Surface	**2. Entrance Hall Floor and Stair Tread [J2]**
Other LBP Surfaces	**3. Entrance Hall Stair Railing** **4. Entrance Hall Front Door Frame**
Soil	**5. Building Line Soil [J4]** **6. Mid Yard Soil [J5]** **7. Road Dust [J6]**

Figure E 1 House J General View



Sampled November 9, 1999 Target=Floor

Sample	Type	Room	Location	Color	Wipe (µg/ft²)	XRF (mg/cm²)	Comments
EL-V1	Vacuum	Fb	Field Blank				
EL-V2	Vacuum	Front hall	Floor				
EL-P1	Paint	Front hall	Stair tread	White		1	A side
EL-P2	Paint	Front hall	Stair tread ~~lower~~ both layer	Brown			A side
EL-P3	Paint	Front hall	Stair railing	White		0.27	A side
EL-P4	Paint	Front hall	Wall	White			
EL-P5	Paint	Front hall	Front door frame	White		1.74	A side
EL-P6	Paint	Out	Front porch railing	White			
EL-P7	Paint	Out	Front porch floor	Gray			Intact
EL-S1	Soil	Out	Drip line				
EL-S2	Soil	Out	Mid yard				
S3	Ro		Roadside				

Figure E.2 House J Floor Plan

Table E 1 House J Lead Concentration Data by XRF

Analysis Number	House Code	Sample Description	Pb Conc (μg/g)	Error (μg/g)
HUD 034-1	**J3**	House J - Building Line Soil	324.8	8
HUD 035-1	**J5**	House J - Road Dust: Front of house	597.4	15.7
HUD 036-1	**J4**	House J - Mid-Yard Soil	510.7	9.6
HUD 037-1	**J1**	House J - Cyclone Vacuum Dust Sample: Front hall floor	7084.8	35.6
HUD 038-1	**J2**	House J - Target Paint: Front hall stair tread, poor condition	31087.9	52.9

Table E.2 House J Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	House Code	Description	206/204	207/204	208/204	207/206	208/206	207/208
HUD34	**J3**	House J - Building Line Soil	18.588	15.647	38.465	0.84176	2.06936	0.40678
HUD35	**J5**	House J - Road Dust: Front of house	18.411	15.641	38.291	0.84954	2.07978	0.40847
HUD36	**J4**	House J - Mid-Yard Soil	18.566	15.627	38.352	0.84172	2.06569	0.40748
HUD37	**J1**	House J - Cyclone Vacuum Dust Sample: Front hall floor	18.31	15.573	38.119	0.85048	2.0818	0.40853
HUD38	**J2**	House J - Target Paint: Front hall stair tread, poor condition	18.1	15.545	37.791	0.85885	2.08795	0.41134

Table E 3 House J Pb bearing particles found in floor dust sample

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	2.19
Pb	Irregular	1.34
PbCl	Irregular	2.46
PbCl	Irregular	1.75
PbClK	Irregular	2.79
PbClKCa	Irregular	2.33
PbSiAlCa	Irregular	2.25
PbZnSiCa	Aggregate	2.14
PbSiCaTi	Aggregate	10.2
PbClSiAlCa	Irregular	1.83
PbClSiKCa	Irregular	2.24
PbCaCrFe	Aggregate	2.75
PbClSiAlCa	Irregular	2.04
PbCaTiCrFe	Irregular	1.74
PbCaTiCrFe	Aggregate	8.35
PbCaTiCrFe	Aggregate	5.6
PbClSiKCa	Irregular	2.36
PbClPSiZnCa	Angular/Irregular	2.22
PbCaTiCrFeNa	Aggregate	17.9
PbClKCaSi	Irregular	2.52
PbCaTiCrFeSi	Aggregate	23
PbClCaTiCrFe	Aggregate	5.9
PbClFeCaSiNa	Irregular	4.89
PbClZnSiCaTiCr	Aggregate	4.7
PbClKCaTiCrFeNa	Aggregate	7.05
PbPClCaSiAlMgNaK	Aggregate	8.13
PbCaClKTiFePSiAl	Irregular	1.87
PbPClCaSiAlMgNaFe	Irregular	7.98
PbClKCaSiAlMgZnFe	Aggregate	18.6
PbPClCaSiAlMgZnKFe	Aggregate	8.26
PbPSiClCaAlNaMgKFe	Irregular	24.8
PbClSiAlCaFeKPMgNa	Aggregate	19.6
PbPClCaKSiAlMgZnFe	Aggregate	5.11
PbPClCaSiAlMgNaTiCrFe	Aggregate	8.61

Table E 4 House J Pb bearing particles found in floor paint sample

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	1.79
PbCr	Aggregate	1.73
PbZnCr	Aggregate	9.01
PbZnCl	Aggregate	10.4
PbZnTi	Irregular	2.97
PbZnTi	Irregular	3.32
PbZnSi	Aggregate	46.2
PbZnCrCa	Irregular	1.34
PbCaCrFe	Aggregate	5.2
PbCaCrFe	Aggregate	22.3
PbCaCrFe	Aggregate	22
PbCaCrFe	Aggregate	7.04
PbCaCrFe	Aggregate	13.6
PbCaCrTi	Aggregate (Tiny Pb inclusion)	3.08
PbCaCrFe	Aggregate	8.5
PbCaZnMg	Irregular	12.9
PbSiAlZn	Aggregate	14.8
PbCaTiCrFe	Irregular	2.93
PbCaTiCrFe	Aggregate	14.5
PbCaTiCrFe	Aggregate	6.72
PbCaTiCrFe	Aggregate	19.4
PbCaTiCrFe	Aggregate	6.25
PbCaTiCrFe	Aggregate	13.3
PbCaTiCrFe	Aggregate	57.3
PbCaTiCrFe	Aggregate	15.3
PbCaTiCrFe	Aggregate	31
PbCaTiCrFe	Aggregate	30.4
PbCaTiCrFe	Aggregate	2.65
PbCaTiCrFe	Aggregate	14.7
PbCaTiCrFe	Aggregate	7.84
PbCaTiCrFe	Aggregate	11.4
PbCaTiCrFe	Aggregate	4.55
PbCaTiCrFe	Aggregate	85.2
PbCaTiCrFe	Aggregate	6.14

Table E 4 - *Continued*

PbCaTiCrFe	Aggregate	5.36
PbCaTiCrFe	Aggregate	5.56
PbTiCrCaFe	Aggregate	11.8
PbTiCrCaFe	Aggregate	13
PbTiCrCaFe	Aggregate	13.6
PbZnCaSiMg	Aggregate	7.03
PbZnTiCrSi	Aggregate	39.4
PbCrCaFeNa	Aggregate	10.2
PbZnTiCrCaFe	Aggregate	6.19
PbZnTiCrCaFe	Aggregate	10.4
PbZnTiCaSiMg	Aggregate	5.24
PbTiCrCaFeNa	Aggregate	9.58
PbZnTiCrCaFe	Aggregate	43.8
PbTiCrCaFeCl	Aggregate	27.6
PbTiCrCaFeCl	Aggregate	11.7
PbTiCrCaFeSi	Aggregate	4.24
PbZnTiSiAlCl	Aggregate	5.1
PbZnTiCrCaFeSi	Aggregate	7.58
PbZnTiCrCaFeSi	Aggregate	1.91
PbTiCrCaSiMgFe	Aggregate	4.83
PbTiCrCaFeMgNa	Aggregate	26.5
PbZnTiCrCaSiMgFe	Aggregate	4.54
PbCrSiAlKMgFeNa	Aggregate	3.15
PbTiCrCaSiAlFeMgNa	Aggregate	9.91
PbTiCrCaSiAlKFeMgNa	Aggregate	19.9

Table E 5 House J Pb bearing particles found in building line soil sample

Chemical Composition	**Morphology**	**Size**
PbCl	Irregular	2.3
PbClMn	Aggregate	3.12
PbCaP	Irregular	9.91
PbCaSiAlFeP	Irregular	2.56
PbClSiMn	Aggregate	3.07
PbSiMgFeTi	Aggregate	2.02
PbCaSiAlPNaFe	Irregular	3.1
PbClCaSiMgFe	Aggregate (Tiny Pb Inclusion)	4.99
PbClMnSiAlKMg	Aggregate	5.8
PbClCaMnSiAlNa	Aggregate	4.16
PbCaSiAlMgPNaFe	Irregular	2.45
PbCaSiAlMgNaP	Irregular	6.22
PbClCaMnSiAlKMg	Aggregate	3.8
PbCaSiAlMgFeP	Irregular	5.57
PbCaSiAlMgNaP	Irregular	5.59
PbClCaMnSiAlKMg	Irregular	7.56
PbClCaMnSiAlKMgFe	Irregular	6.88
PbClCaMnSiAlKMgFe	Aggregate (Tiny Pb Inclusion)	4.41
PbCaSiAlKMgFeNa	Irregular	4.6
PbCaSiAlKMgFeNaP	Irregular	5.15
PbCaSiAlKMgFeP	Irregular	8.37
PbCaSiAlKMgFeZnP	Irregular	7.33
PbCaSiAlKMgFeZnP	Irregular	3.89
PbClCaSiAlZnFeP	Irregular	4.45
PbClCaMnSiAlKMgFe	Irregular	3.32
PbClCaMnSiAlKMgFe	Aggregate	4.62
PbCaSiAlKMgFeNaP	Irregular	4.66
PbCaSiAlMgFeNaP	Irregular	2.84
PbCaMnSiAlKMgFeP	Irregular	8.35
PbCaSiAlKMgFeP	irregular	5.56
PbCaSiAlKMgFeNaP	Irregular	2.95
PbClCaMnSiAlKMgFe	Irregular	4.4
PbClCaMnSiAlKMgFeP	Irregular	6.57
PbClCaMnSiAlKMgFe	Aggregate	4.95

Table E 5 - *Continued*

PbClCaMnSiAlKMgFeNa	Aggregate	4.7
PbClCaMnSiAlKMgFe	Irregular	8.44
PbClCaMnPSiAlKMgFeP	Aggregate	14.5
PbClCaMnSiAlMgFeZnP	Irregular	3.75
PbCaSiAlMgFePNaTi	Irregular	1.9
PbCaMnSiAlKMgFePNa	Irregular	4.3
PbCaSiAlKMgFePNa	Irregular	2.75
PbCaMnSiAlKMgFePNa	Irregular	7.26
PbClCaMnSiAlKMgTiP	Irregular	2.83
PbClCaMnSiAlKMgFe	Irregular	3.51
PbClCaMnSiAlKMgFeP	Aggregate	2.41
PbClCaMnSiAlKMgFePNa	Aggregate	4.57
PbClCaMnSiAlKMgFeP	Aggregate	3.46
PbClCaMnSiAlKMgFePNa	Irregular	5.55
PbClCaMnSiAlKMgFeTi	Aggregate	6.58

Table E 6 House J Pb bearing particles found in road dust sample

Chemical Composition	**Morphology**	**Size**
PbCl	Irregular	1.84
PbCl	Irregular	2.05
PbClCaK	Irregular	1.78
PbClSiSn	Irregular	4.04
PbClSiCaAl	Irregular	6.01
PbClSiCaAlMgFe	Aggregate	2.16
PbClSiCaAlMgFe	Irregular	4.18
PbSiCaAlMgFeK	Aggregate	7.43
PbClSiAlMgFeKMn	Irregular	4.78
PbSiCaAlMgFeK	Aggregate	3.94
PbSiCaAlMgFeKNa	Irregular	7.02

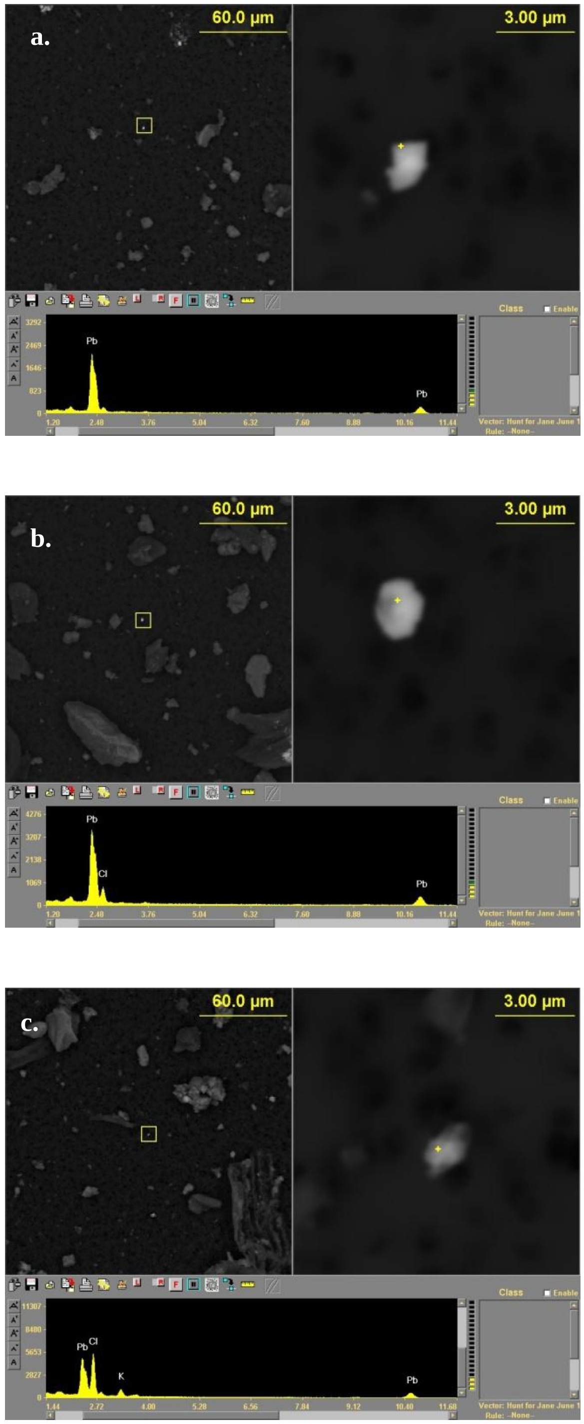


Figure E 3 House J floor dust particle with Pb pigment particles (a) and Cl (b),Cl, K (c) in matrix

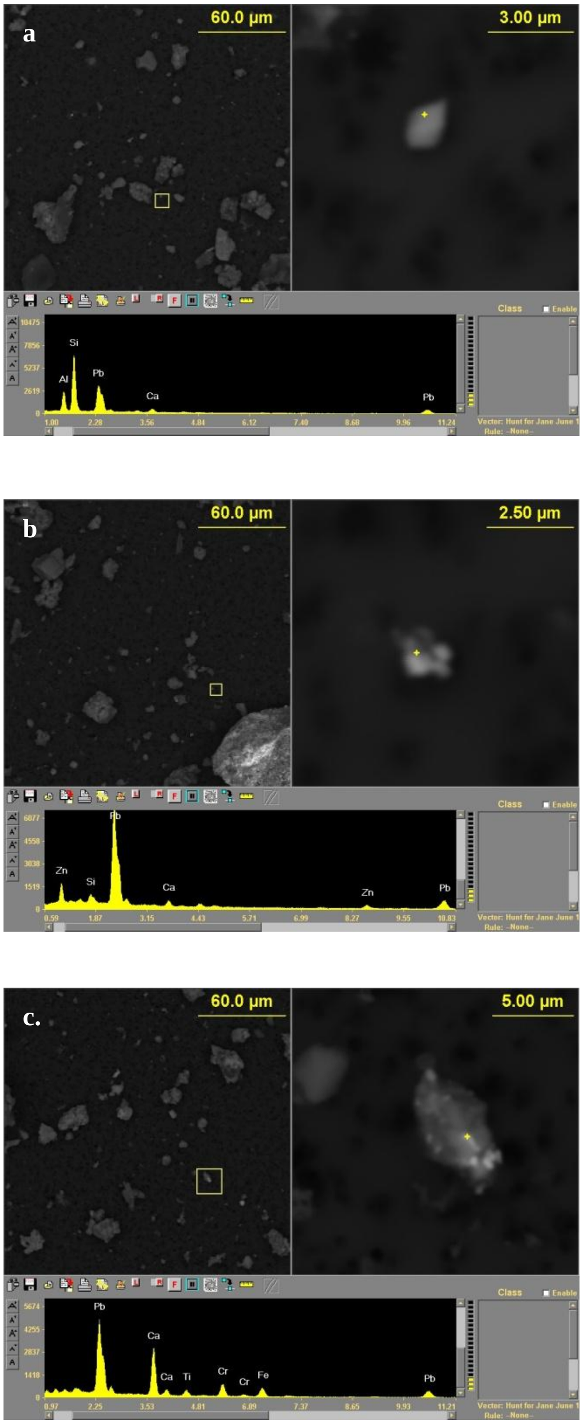


Figure E 4 House J floor dust particle with Pb pigment particles and Si, Al, Ca (a), Zn, Ca, Si (b), Ca, Ti, Cr, Fe (c) in matrix

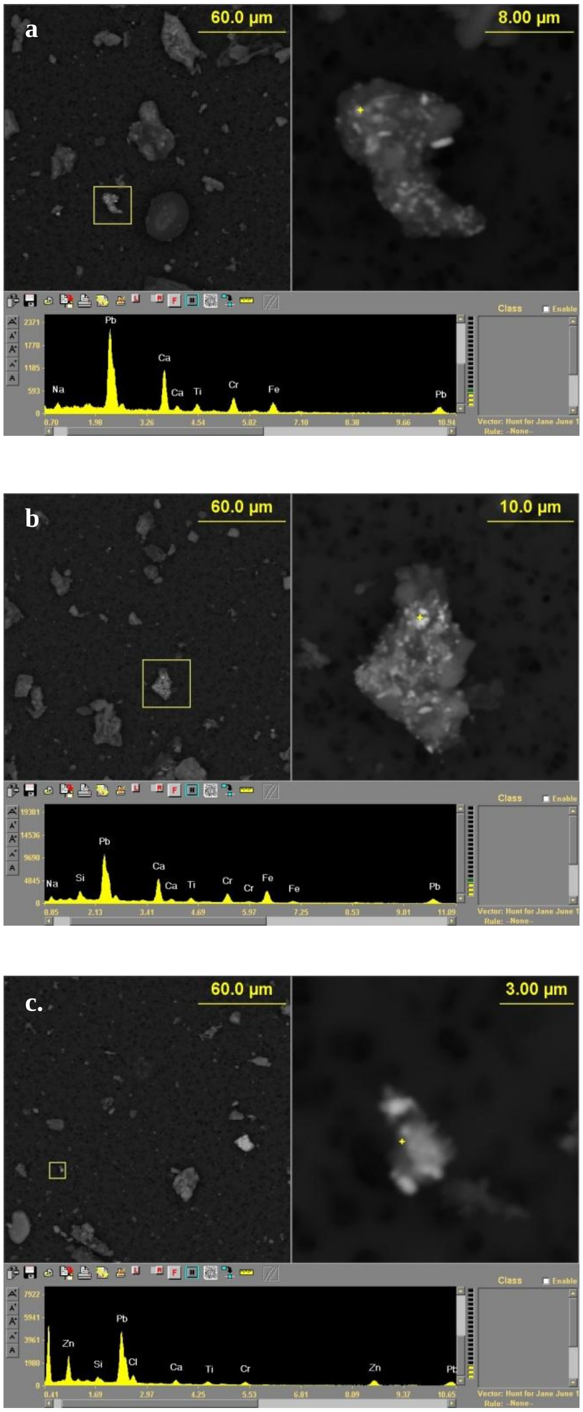


Figure E 5 House J floor dust particle with Pb pigment particles and Ca, Ti, Cr, Fe (a), Ca, Ti, Cr, Si, Fe (b), Zn, Ca, Ti, Cr (c) in matrix

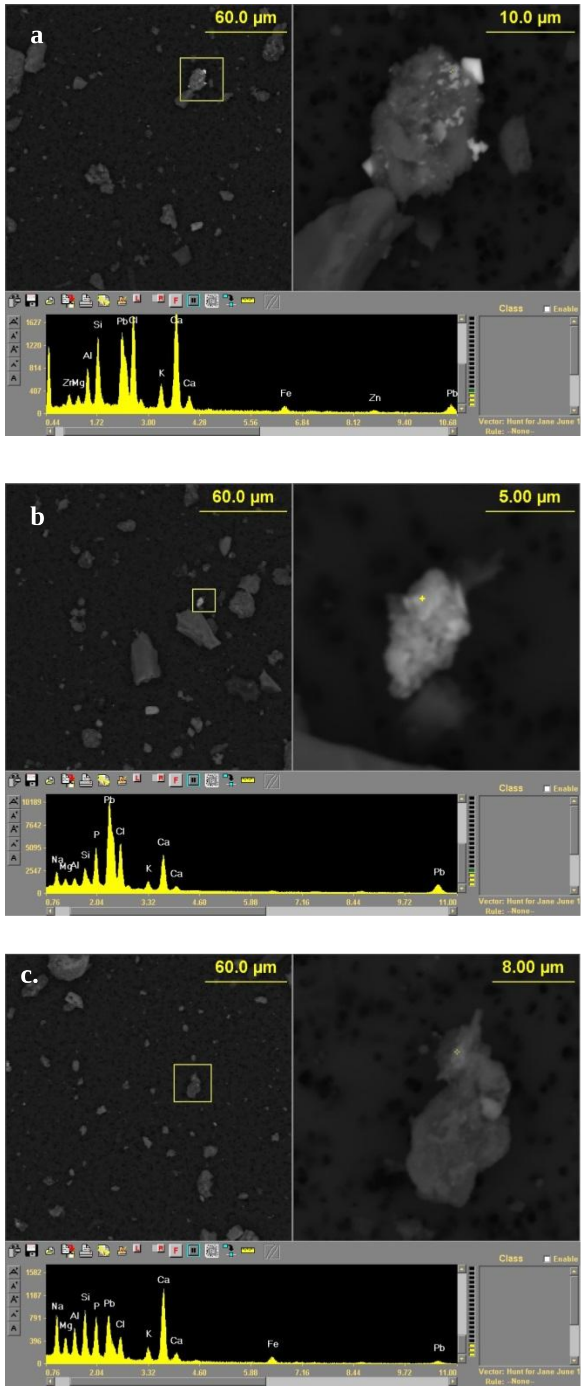


Figure E 6 House J floor dust particle with Pb pigment particles and Ca, K, Cl, Si, Al, Mg, Zn, Fe (a), Ca, K, Cl, P, Si, Al, Mg, Na (b), Ca, K, Cl, P, Si, Al, Mg, Na (c) in matrix

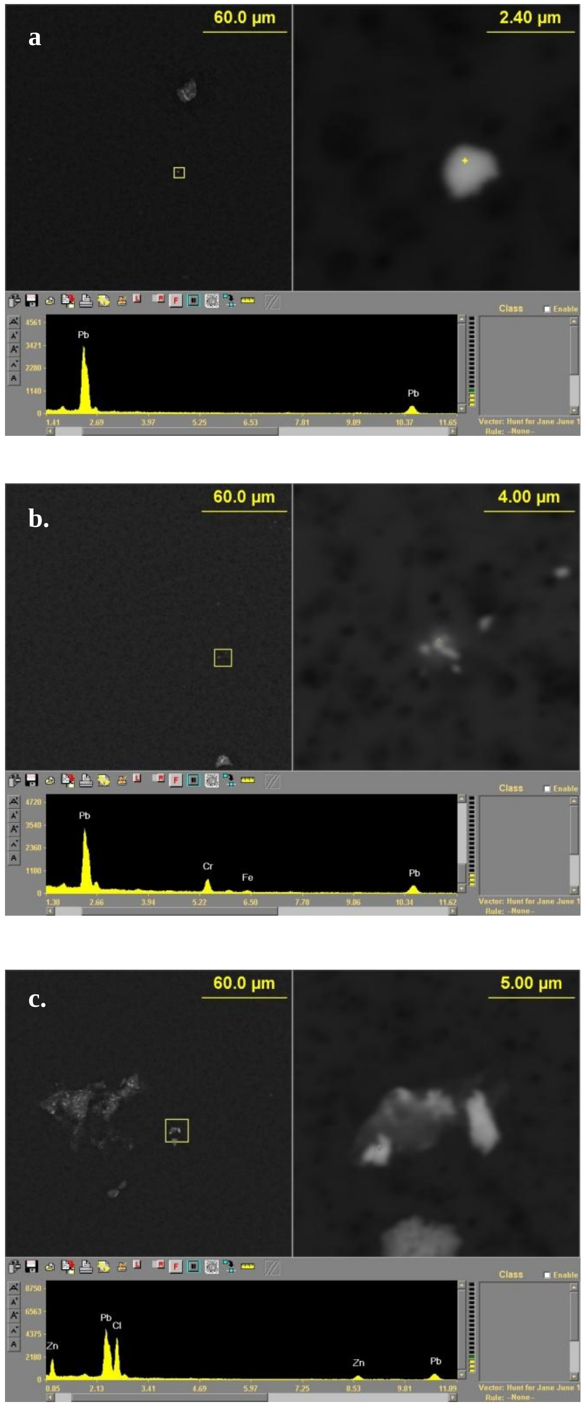


Figure E 7 House J floor paint particle with Pb pigment particles (a) and Cr (b),Cl, Zn (c) in matrix

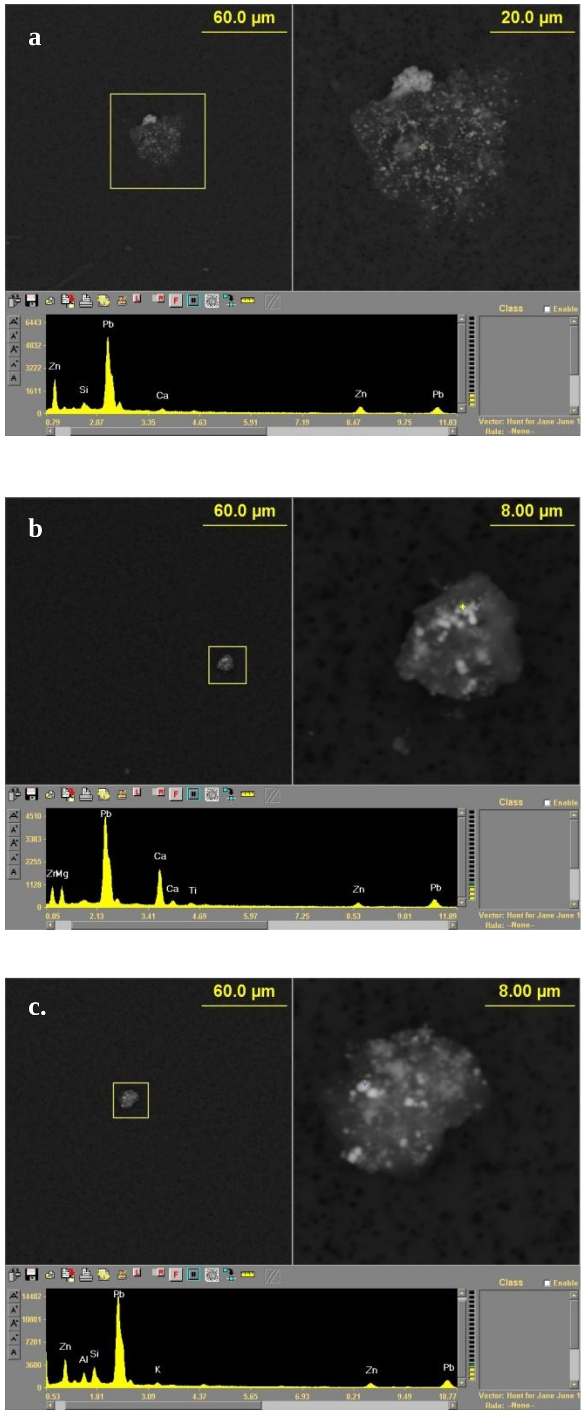


Figure E 8 House J floor paint particle with Pb pigment particles and Zn, Ca (a), Zn, Ca, Mg (b), Zn, Si, Al (c) in matrix

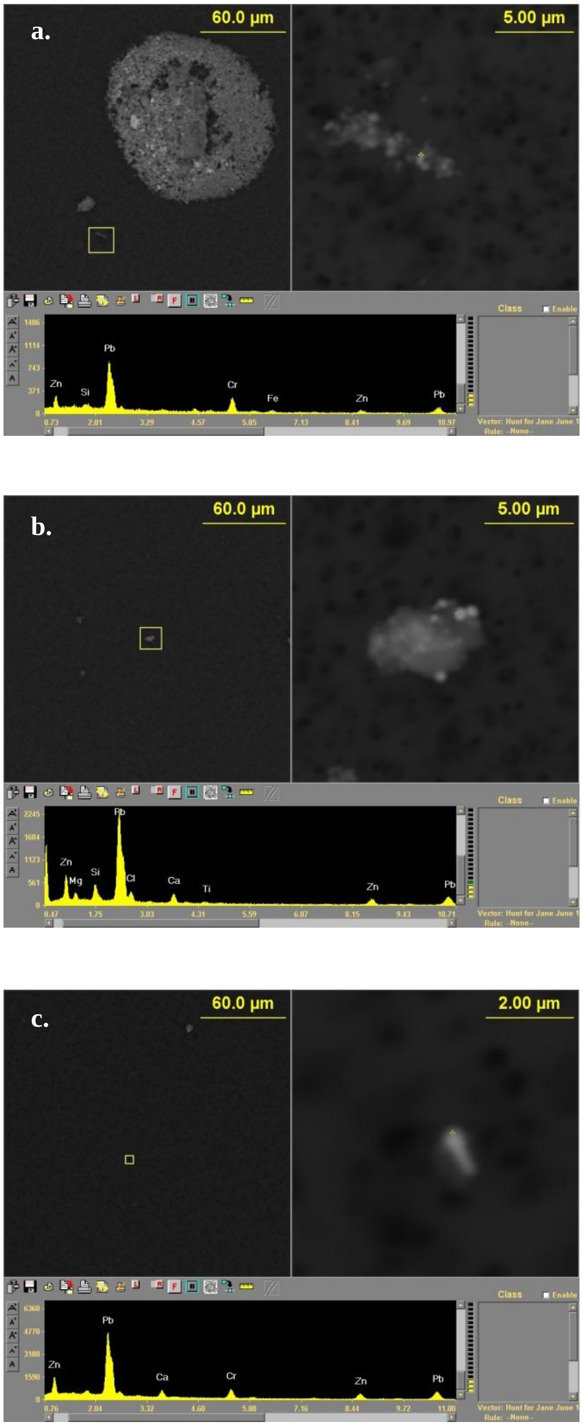


Figure E 9 House J floor paint particle with Pb pigment particles and Zn, Cr (a), Zn, Ca, Si (b), Zn, Ca, Cr (c) in matrix

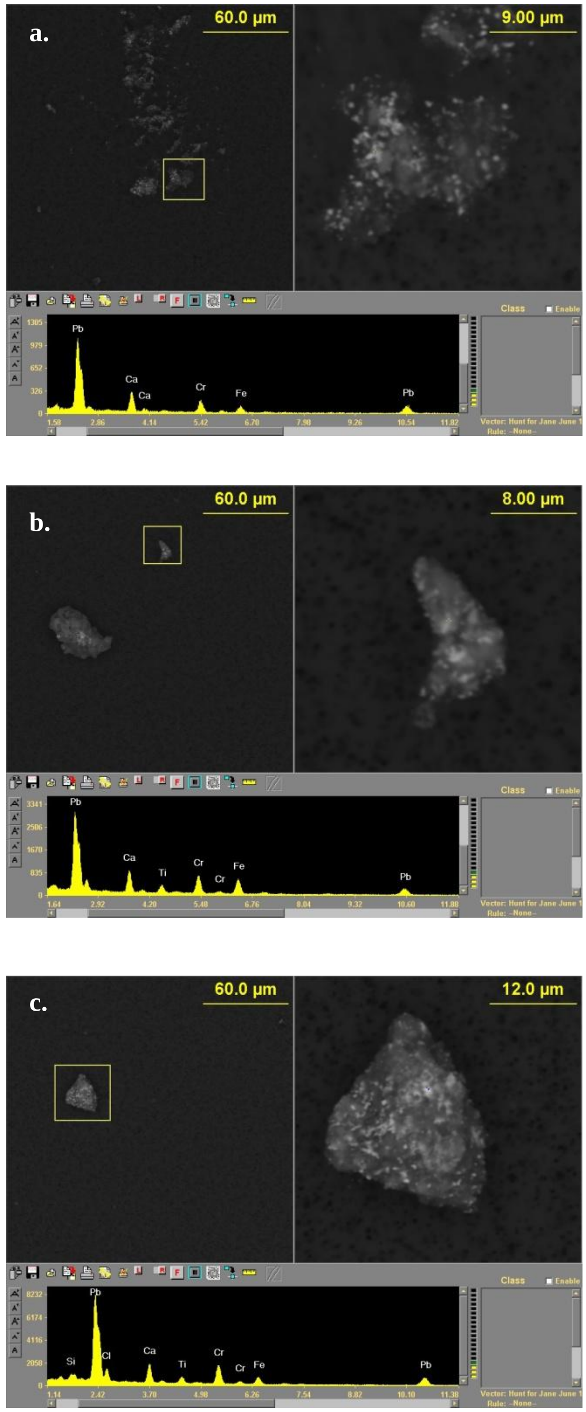


Figure E 10 House J floor paint particle with Pb pigment particles and Cr, Ca, Fe (a), Cr, Ti, Ca, Fe (b, c) in matrix

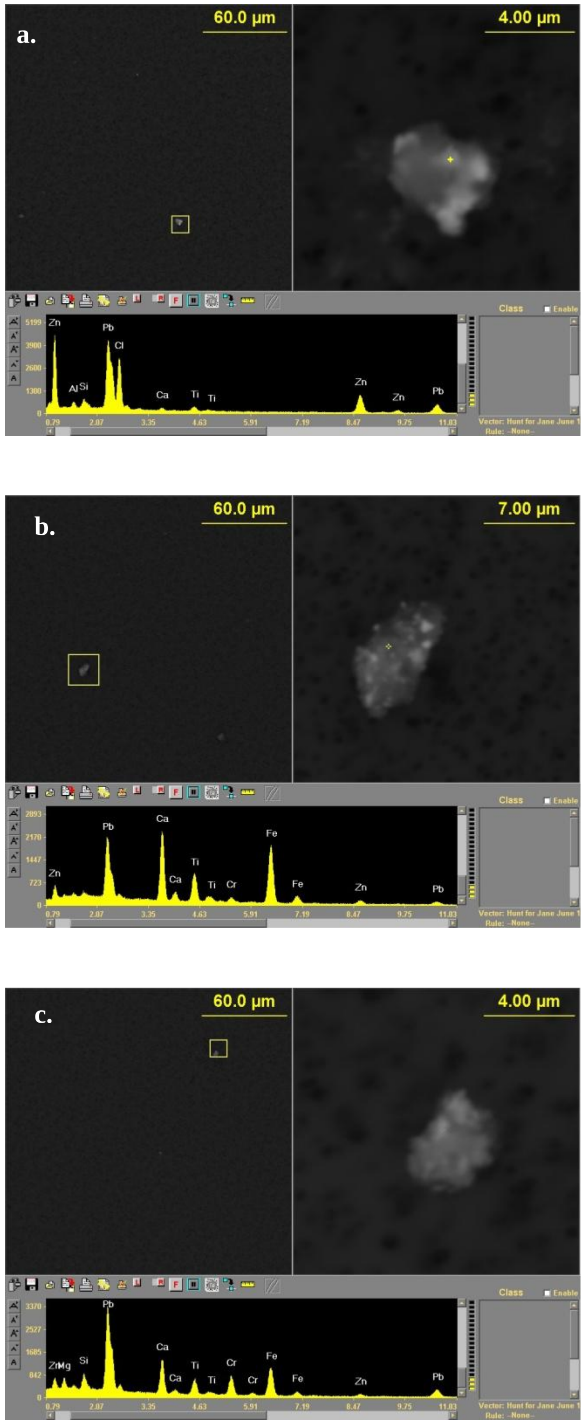


Figure E 11 House J floor paint particle with Pb pigment particles and Zn, Cl (a) Ca, Ti, Cr, Fe, Zn (b), Zn, Ca, Ti, Cr, Fe, Si, Mg (c) in matrix

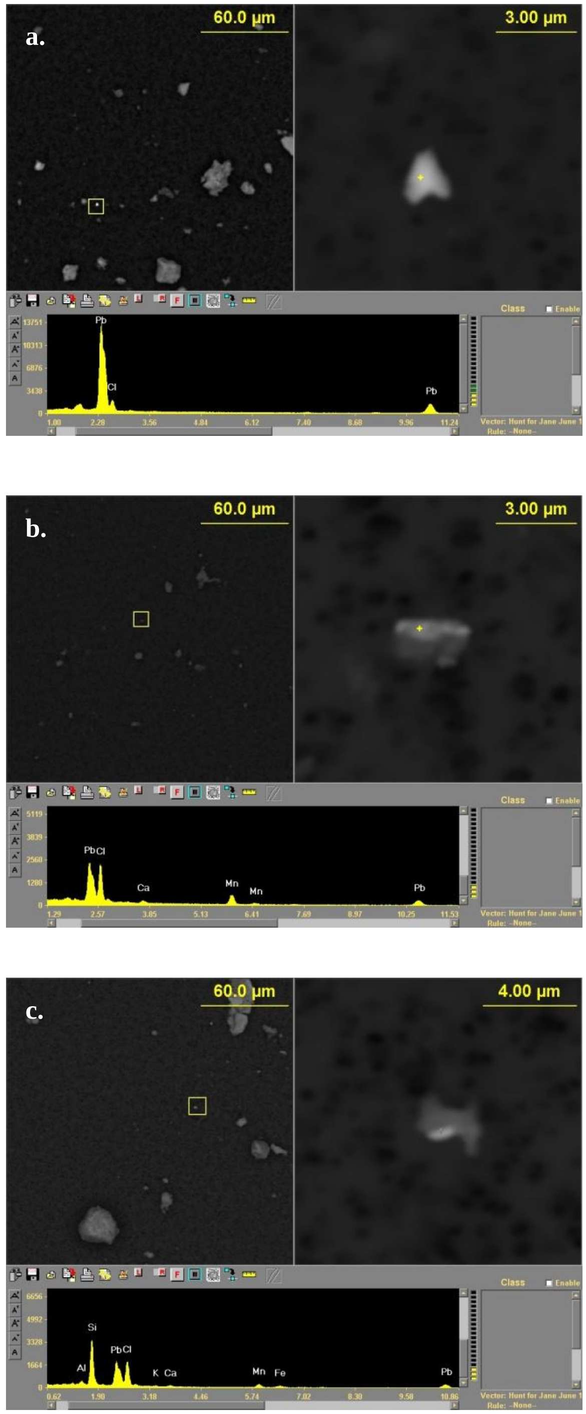


Figure E 12 House J building line soil particle with Pb pigment particles and Cl (a) Cl, Mn (b), Cl, Si, (c) in matrix

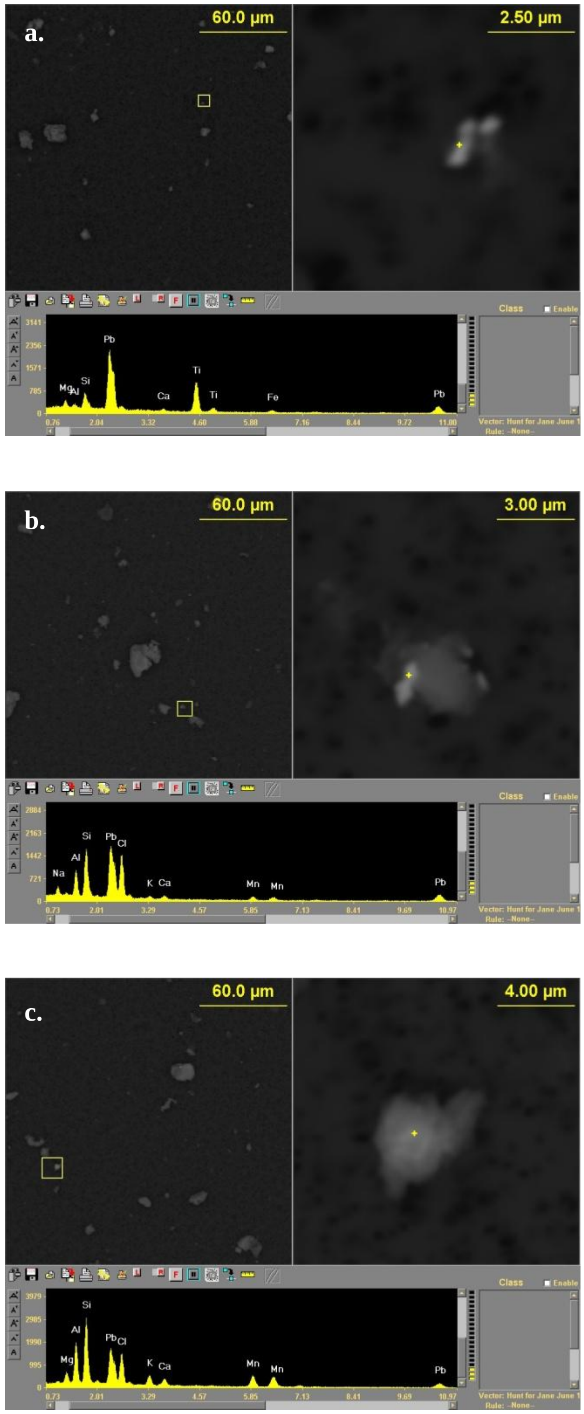


Figure E 13 House J building line soil particle with Pb pigment particles and Ti, Si Mg

(a) Cl, Si, Al, Na, Mn (b), Cl, Si, Al, Mg, Mn, K, Ca (c) in matrix

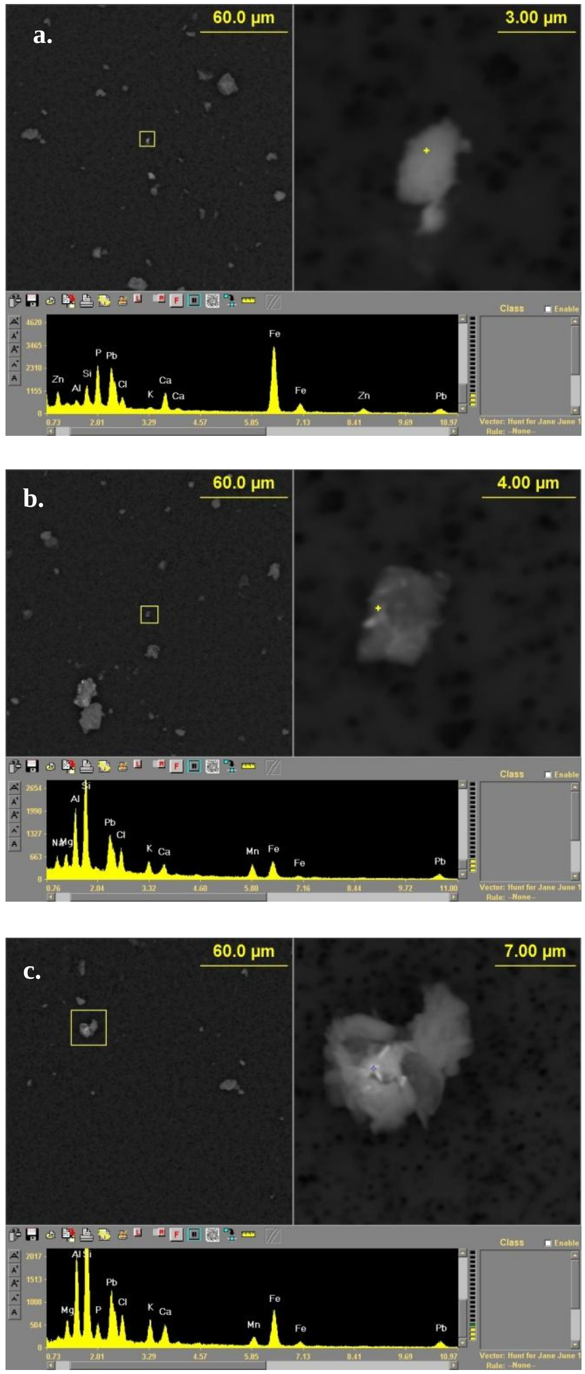


Figure E 14 House J building line soil particle with Pb pigment particles and Zn, Ca, P, Si Fe (a), Cl, Si, Al, Na, Mn Mg, Fe, Ca, K (b), Cl, Si, Al, Mg, Mn, K, Ca, Fe, P (c) in matrix

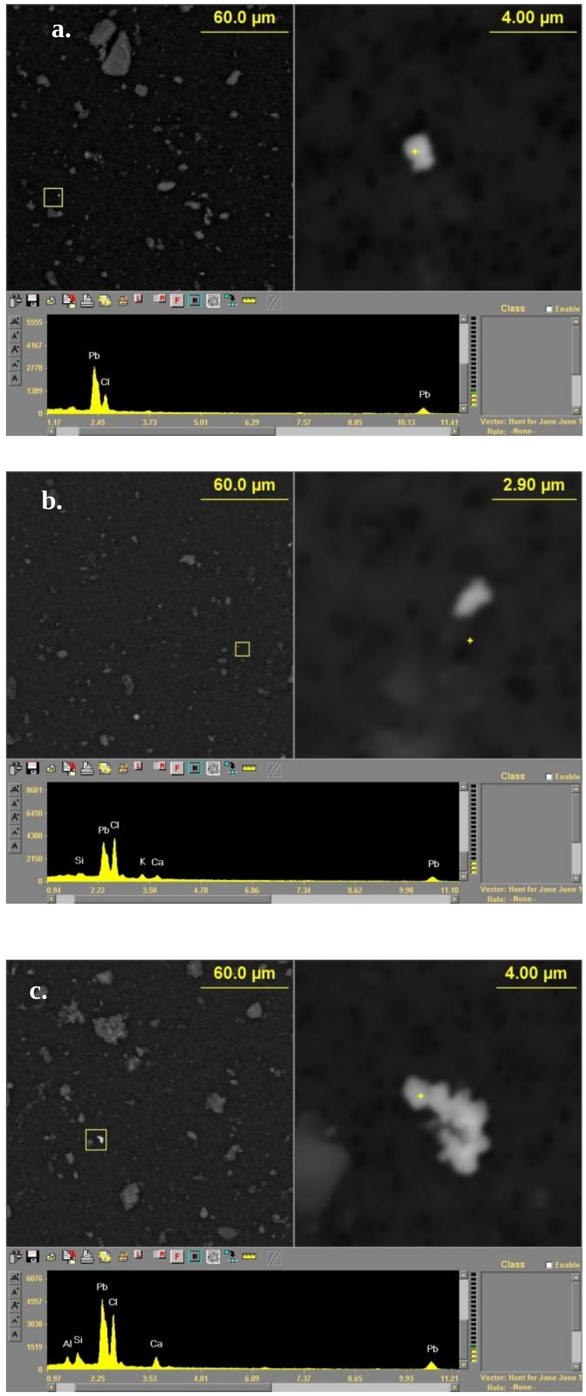


Figure E 15 House J road dust particle with Pb pigment particles and Cl (a), Cl, Ca, K (b), Cl, Si, Al, Ca (c) in matrix

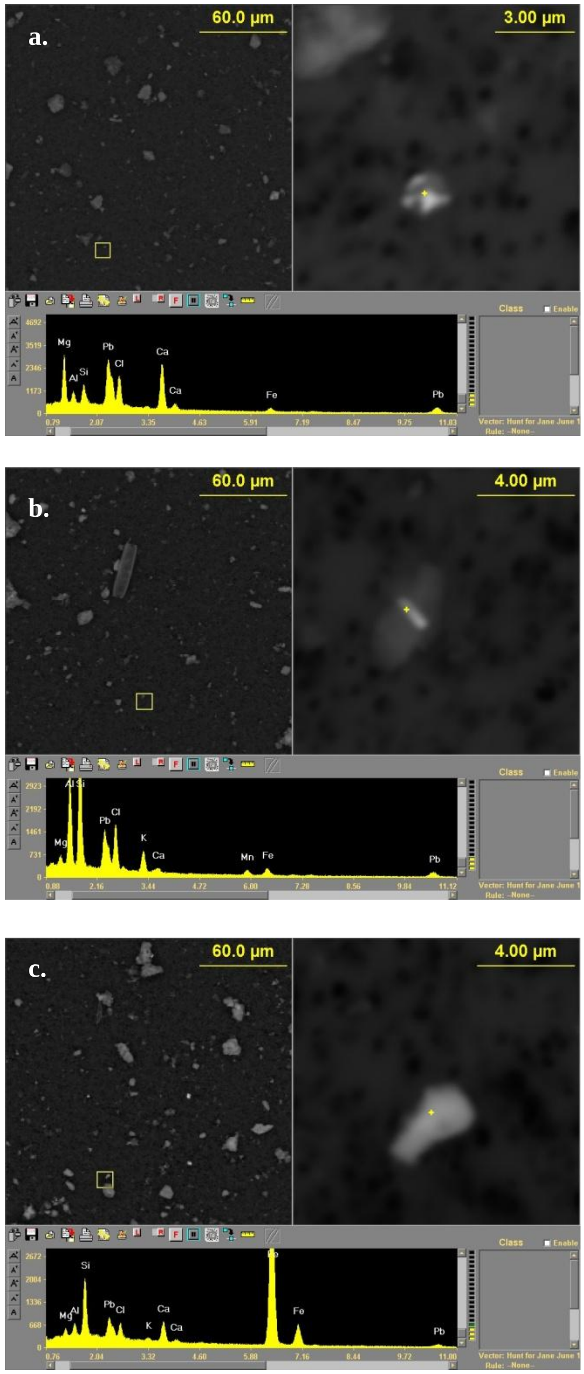


Figure E 16 House J road dust particle with Pb pigment particles and Cl Ca, Si, Al, Mg, Fe (a), Cl, Mn, K, Si, Al, Mg, Fe (b), Cl, Si, Al, Ca, Fe (c) in matrix

Appendix F

Raw data, SEM images and X-Ray Spectra of House K

House K

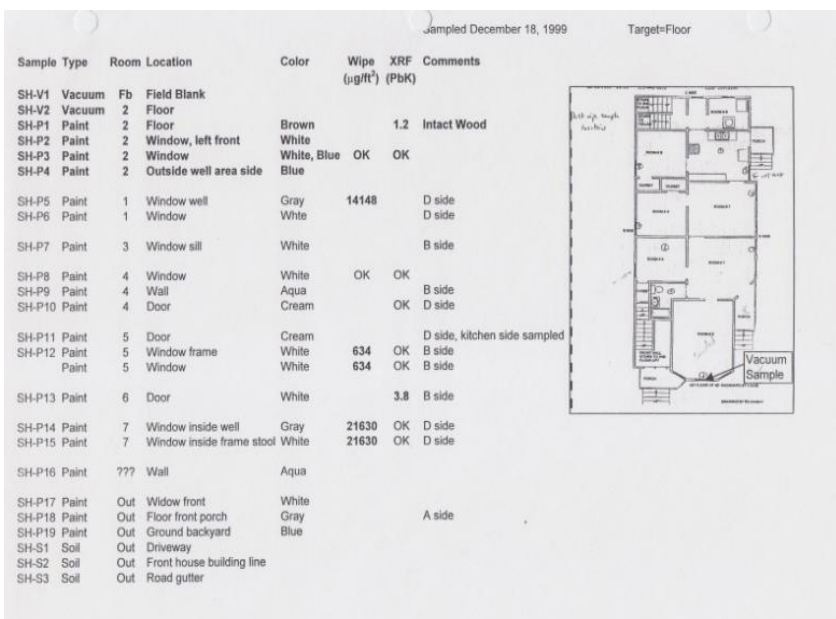
Single Implicated Floor Friction Source

Floor Paint in Moderate Condition

Multi Story Family Home

Sampling Location:	**1st Floor Bed Room**
Collected Samples:	
Dust	**1. 1st Floor Bed Room Floor Dust [K1]**
Implicated Friction Surface	**2. 1st Floor Bed Room Floor Paint [K2]**
Other LBP Surfaces	**3. 1st Floor Family Room (room #1) Window Frame Paint [K7]** **4. 1st Floor Bed Room (room # 5) Window Frame Paint** **5. 1st Floor Room (room # 7) Window Frame Paint** **6. Front Porch Floor Paint**
Soil	**7. Building Line Soil Front [K4]** **8. Mid Yard Soil [K5]** **9. Road Dust [K6]**

Figure F 1 House K General View



Sampled December 18, 1999 Target=Floor

Sample	Type	Room	Location	Color	Wipe ($\mu g/ft^2$)	XRF (PbK)	Comments
SH-V1	Vacuum	Fb	Field Blank				
SH-V2	Vacuum	2	Floor				
SH-P1	Paint	2	Floor	Brown		1.2	Intact Wood
SH-P2	Paint	2	Window, left front	White			
SH-P3	Paint	2	Window	White, Blue	OK	OK	
SH-P4	Paint	2	Outside well area side	Blue			
SH-P5	Paint	1	Window well	Gray	14148		D side
SH-P6	Paint	1	Window	Whte			D side
SH-P7	Paint	3	Window sill	White			B side
SH-P8	Paint	4	Window	White	OK	OK	
SH-P9	Paint	4	Wall	Aqua			B side
SH-P10	Paint	4	Door	Cream		OK	D side
SH-P11	Paint	5	Door	Cream			D side, kitchen side sampled
SH-P12	Paint	5	Window frame	White	634	OK	B side
	Paint	5	Window	White	634	OK	B side
SH-P13	Paint	6	Door	White		3.8	B side
SH-P14	Paint	7	Window inside well	Gray	21630	OK	D side
SH-P15	Paint	7	Window inside frame stool	White	21630	OK	D side
SH-P16	Paint	???	Wall	Aqua			
SH-P17	Paint	Out	Widow front	White			
SH-P18	Paint	Out	Floor front porch	Gray			A side
SH-P19	Paint	Out	Ground backyard	Blue			
SH-S1	Soil	Out	Driveway				
SH-S2	Soil	Out	Front house building line				
SH-S3	Soil	Out	Road gutter				

Figure F.2 House K Floor Plan

Table F.1 House K Lead Concentration Data by XRF

Analysis Number	House Code	Sample Description	Pb Conc (µg/g)	Error (µg/g)
HUD 057-1	**K5**	House K - Mid-Yard Soil, By driveway	1364.7	14.8
HUD 058-1	**K4**	House K - Building Line Soil, Front fo house	310.1	11.2
HUD 059-1	**K6**	House K - Road Dust	477.9	9.5
HUD 060-1			0	2086.7
HUD 061-1	**K2**	House K - Target Paint: Living room floor, moderate condition	37680.5	181.4
HUD 062-1	**K7**	House K - Competing Paint: Room 1 widnow well	99938.1	104.5
HUD 063-1	**K8**	House K - Competing Paint: Front porch floor	72338.4	97.3
HUD 064-1	**K1**	House K - Cyclone Vacuum Dust Sample: Living room floor	3454.6	63.6

Table F.2 House K Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	House Code	Sample Description	206/204	207/204	208/204	207/206	208/206	207/208
HUD57	**K5**	House K - Mid-Yard Soil, By driveway	18.747	15.618	38.585	0.83308	2.05823	0.40476
HUD58	**K4**	House K - Building Line Soil, Front of house	18.788	15.656	38.616	0.83331	2.05531	0.40544
HUD59	**K6**	House K - Road Dust	18.947	15.666	38.673	0.82679	2.04108	0.40508
HUD61	**K2**	House K - Target Paint: Living room floor, moderate condition	18.257	15.584	38.209	0.85359	2.09282	0.40786
HUD62	**K7**	House K - Competing Paint: Room 1 window well	18.958	15.664	38.802	0.82624	2.04677	0.40368
HUD63	**K8**	House K - Competing Paint: Front Porch floor	19.372	15.734	39.091	0.81218	2.01788	0.40249
HUD64	**K1**	House K - Cyclone Vacuum Dust Sample: Living room floor	18.461	15.555	38.259	0.84257	2.07244	0.40656

Table F 3 House K Pb bearing particles found in floor dust sample

Chemical Composition	**Morphology**	**Size**
Pb	Rounded	1.51
Pb	Acicular	14.4
Pb	Irregular	1.71
Pb	Aggregate	1.05
Pb	Irregular	2.13
PbCr	Elongated	4.93
PbCr	Irregular	1.5
PbCr	Irregular	1.83
PbCr	Elongated	1.51
PbCr	Irregular	1.21
PbCr	Aggregate	4.38
PbCr	Irregular	1.5
PbCr	Accicular	1.6
PbCr	Accicular	1.21
PbCr	Aggregate	3.18
PbCr	Irregular	1.74
PbCr	Irregular	1.07
PbCr	Aggregate	2.37
PbCr	Aggregate	3.86
PbCa	Irregular	2.57
PbCa	Aggregate	2.89
PbCaFe	Irregular	3.97
PbCaP	Irregular	1.92
PbCaSi	Aggregate	1.78
PbClK	Irregular	2.9
PbCrFe	Aggregate	7.33
PbCrFe	Irregular	2.19
PbCrFe	Aggregate	4.36
PbCrFe	Aggregate	5.6
PbCrFe	Aggregate	3.75
PbCrFe	Aggregate	4.24
PbCrFe	Aggregate	2.67

Table F 3 - *Continued*

PbCrFe	Irregular	2.33
PbCaCr	Irregular	0.72
PbCrCa	Elongated	2.18
PbCrCa	Irregular	0.766
PbCrCa	Aggregate	4.01
PbCrCa	Irregular	1.77
PbCrCa	Aggregate	1.14
PbCrCa	Aggregate	3.1
PbCrCa	Irregular	0.66
PbCrSi	Irregular	0.993
PbCrSi	Elongated	1.11
PbZnCa	Aggregate	2.48
PbCrZn	Aggregate	2.71
PbCrSiNa	Irregular	1.6
PbCrFeNa	Aggregate	7.93
PbCrCaFe	Aggregate	4.42
PbCrCaFe	Aggregate	1.93
PbCrCaFe	Irregular	2.94
PbCrCaSi	Irregular	1.39
PbCrCaP	Irregular	1.5
PbZnCaFe	Aggregate	6.57
PbZnSiMg	Aggregate	8.61
PbZnCrFe	Aggregate	6.03
PbZnCrFe	Aggregate	7.46
PbZnCrFe	Aggregate	5.71
PbCrZnFe	Irregular	2.83
PbCrBaCa	Irregular	2.63
PbCrBaCa	Aggregate	6.6
PbCrBaCa	Aggregate	5.45

Table F 3 - *Continued*

Chemical Composition	**Morphology**	**Size**
PbCrBaCa	Irregular	2.84
PbCrBaFe	Irregular	2.35
PbCrBaFe	Aggregate	2.97
PbCaKCl	Aggregate	11.3
PbCrBaCa	Irregular	2.84
PbZnCaSiFe	Aggregate	6.53
PbCrCaMgFe	Irregular	2.34
PbCrCaKCl	Irregular	2.59
PbZnCrCaFe	Irregular	2.83
PbZnCrCaFe	Aggregate	4.84
PbCrZnCaFe	Irregular	4.77
PbZnCrCaFe	Aggregate	6.56
PbCrZnBaCl	Aggregate	15.4
PbZnCrBaCa	Irregular	2.96
PbZnCrBaFe	Aggregate	6.35
PbZnCrBaFe	Aggregate	5.75
PbZnCrBaFe	Aggregate	11.8
PbZnCrBaFe	Irregular	2.12
PbZnCrCaFe	Aggregate	4.84
PbZnCrBaFe	Aggregate	2.3
PbZnCrBaFe	Aggregate	6.31
PbZnCrBaFe	Aggregate	7.04
PbZnCrBaFe	Aggregate	5.16
PbZnCrBaCa	Aggregate	4.82
PbZnCaSiAlFe	Irregular	6.62
PbCrCaSiAlFe	Aggregate	4.31
PbZnCrCaSiFe	Aggregate	6.28
PbZnCrCaSiFe	Aggregate	3.36
PbCrBaCaKFe	Aggregate	2.82
PbCrBaCaKFe	Aggregate	7.11
PbZnCrCaSiFe	Irregular	3.01
PbCrZnBaCaFe	Aggregate	4.37
PbZnCrBaCaFe	Aggregate	5.21
PbZnCrBaCaFe	Aggregate	4.51

Table F 3 - *Continued*

PbCrZnBaCaFe	Irregular	4.21
PbZnCrBaCaFe	Aggregate	5.88
PbZnCrBaCaFe	Aggregate	17.4
PbZnCrBaCaFe	Aggregate	15.3
PbZnCrBaCaFe	Aggregate	3.27
PbZnCrBaCaFe	Aggregate	6.64
PbZnCrBaCaFe	Aggregate	6.16
PbCrZnBaCaFe	Aggregate	3.45
PbCrZnBaCaFe	Irregular	8.25
PbCrZnBaCaFe	Aggregate	8.52
PbCrZnBaCaFe	Aggregate	3.32
PbCrZnBaCaFe	Irregular	2.47
PbCrZnBaCaFe	Aggregate	17.9
PbCrZnBaCaFe	Aggregate	24.7
PbCrZnBaCaFe	Aggregate	12
PbCrZnBaCaFe	Aggregate	4.37
PbCrZnBaCaFe	Aggregate	12.1
PbCrZnBaCaFe	Aggregate	6.12
PbCrZnBaCaFe	Aggregate	5.74
PbZnCrBaCaFe	Aggregate	8.64
PbCrCaSiAlKFe	Aggregate	5.05
PbCrCaSiAlKFe	Aggregate	2.77
PbCrCaSiAlKFe	Aggregate	8.29
PbZnBaCaSiAlFe	Aggregate	15
PbZnBaCaSiAlFe	Aggregate	15
PbCrZnBaCaSiKFe	Irregular	4.07
PbZnCrBaCaSiKFe	Aggregate	9.38
PbCrZnBaCaSiAlfe	Elongated	5.43
PbZnCrBaCaSiAlFe	Aggregate	5.55
PbCaSiAlKClMgNa	Aggregate	25.1
PbZnCrBaCaSiAlKFe	Aggregate	4.34
PbZnCrBaCaSiAlKMgFe	Aggregate	3.57
PbZnCrBaCaSiAlKFeMg	Aggregate	9
PbCaSiAlKPMgNaClFe	Aggregate	15.7
PbCrCaSiAlKPMgNaFe	Irregular	5.01

Table F 4 House K Pb bearing particles found in floor paint

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	2.31
Pb	Irregular	0.64
Pb	Aggregate	4.29
Pb	Irregular	1
PbCr	Irregular	4.57
PbCr	Irregular	2.13
PbCr	Irregular	1.8
PbCr	Irregular	0.947
PbCr	Irregular	1.99
PbCr	Irregular	1.74
PbCr	Irregular	2
PbCr	Irregular	2.65
PbZn	Aggregate	3.87
PbZn	Aggregate	12.1
PbCrFe	Aggregate	2.1
PbCrFe	Irregular	1.82
PbCrAl	Elongated	1.47
PbZnFe	Aggregate	4.25
PbBaCr	Irregular	1.83
PbBaZn	Aggregate	7.38
PbZnBa	Aggregate	10.7
PbSiAl	Irregular	1.7
PbCrZn	Aggregate	2
PbCrZn	Aggregate	7.31
PbCrZn	Aggregate	5.35
PbCrZn	Aggregate	6.22
PbCrZn	Irregular	2.96
PbCrZn	Irregular	3.33
PbCrZn	Aggregate	6.22
PbCrZn	Aggregate	4.34
PbZnCr	Aggregate	2.76
PbZnCr	Irregular	3.48
PbCrFe	Aggregate	7.67
PbCrFe	irregular	3.61

Table F 4 - *Continued*

PbZnCrSi	Aggregate	5.7
PbZnCrFe	Aggregate	5.43
PbZnCrFe	Irregular	3.61
PbZnSiAl	Aggregate	3.57
PbZnSiAl	Aggregate	5.52
PbZnBaCr	Aggregate	4.43
PbZnBaCr	Aggregate	4.77
PbZnBaCr	Aggregate	8.04
PbCrSiAlCl	Aggregate	13
PbBaCrFeNa	Aggregate	4.03
PbZnBaSiFe	Aggregate	3.35
PbZnBaCrFe	Aggregate	27.2
PbZnBaCrFe	Aggregate	12.3
PbZnBaCrFe	Platy Aggregate	8.64
PbZnBaCrFe	Aggregate	4.64
PbZnBaCrFe	Aggregate	21
PbZnBaCrFe	Aggregate	6.37
PbZnBaCrFe	Aggregate	5.93
PbZnBaCrFe	Aggregate	4.08
PbZnBaCrFe	Aggregate	7.62
PbZnBaCrFe	Aggregate	3.33
PbZnBaCrFe	Aggregate	18.2
PbZnBaCrFe	Aggregate	11.6
PbZnBaCrFe	Aggregate	9.48
PbZnBaCrFe	Aggregate	7.39
PbZnBaCrFe	Aggregate	8.49
PbZnBaCrFe	Aggregate	7.38
PbZnBaCrFe	Irregular	5.53
PbZnBaCrFe	Aggregate	8.79
PbZnBaCrFe	Aggregate	2.64
PbZnBaCrFe	Irregular	4.35
PbZnBaCrFe	Platy Aggregate	21.5
PbZnBaCrFe	Aggregate	19.2
PbZnBaCrFe	Aggregate	2.38
PbZnBaCrFe	Aggregate	20

Table F 4 - *Continued*

PbZnTiCrFe	Aggregate	7.68
PbZnCaSiAlFe	Aggregate	21.2
PbZnBaCrSiFe	Aggregate	6.3
PbZnBaCrSiFe	Aggregate	7.73
PbZnBaCrSiFe	Aggregate	5.76
PbZnBaCrCaFe	Aggregate	5.25
PbZnBaCrSiFe	Platy Aggregate	27.4
PbZnBaCrSiFe	Aggregate	6.1
PbZnBaCrSiFe	Aggregate	5
PbZnBaCrSiFe	Aggregate	6.47
PbZnBaCrSiFe	Aggregate	20.3
PbZnBaCrSiFe	Aggregate	8.21
PbZnBaCrSiFe	Aggregate	13.9
PbZnBaCrSiFe	Aggregate	27
PbZnBaCrSiFe	Aggregate	14.3
PbZnBaCrSiFe	Aggregate	13.8
PbZnBaCrSiFe	Aggregate	4.98
PbZnBaCrSiFe	Aggregate	8.35
PbZnBaCrSiFe	Aggregate	3.96
PbZnBaCrSiFe	Aggregate	7.01
PbZnBaCrSiFe	Aggregate	20
PbZnBaCrSiFe	Aggregate	3.96
PbZnBaCrSiFe	Aggregate	7.01
PbZnBaCrSiClFe	Aggregate	20
PbZnBaCrCaFe	Aggregate	5.25
PbZnBaCrCaFe	Aggregate	13.2
PbZnBaCrCaFe	Aggregate	7.1
PbZnBaCrCaFe	Aggregate	6.58
PbZnBaCrCaFe	Platy Aggregate	31.2
PbZnBaCrCaFe	Aggregate	7.61
PbZnBaCrSiAl	Aggregate	8.6
PbZnBaCrSiAl	Aggregate	15.8
PbZnCaSiAlKFe	Aggregate	6.51
PbZnBaCrSiAlFe	Aggregate	9.45
PbZnBaCrSiAlFe	Aggregate	5.13

Table F 4 - *Continued*

PbZnBaCrSiAlFe	Aggregate	11.4
PbZnBaCrSiAlFe	Aggregate	10.8
PbZnBaCrSiAlFe	Aggregate	8.37
PbZnBaCrCaSiAlFe	Aggregate	11.2
PbZnBaCrCaSiAlFe	Aggregate	13
PbZnCrCaSiAlFeMg	Aggregate	20.4

Table F 5 House K Pb bearing particles found in building line soil particles

Chemical Composition	**Morphology**	**Size**
PbCaPSiAlCl	Irregular	3.8
PbCaPSiAlKMgFe	Irregular	29.8

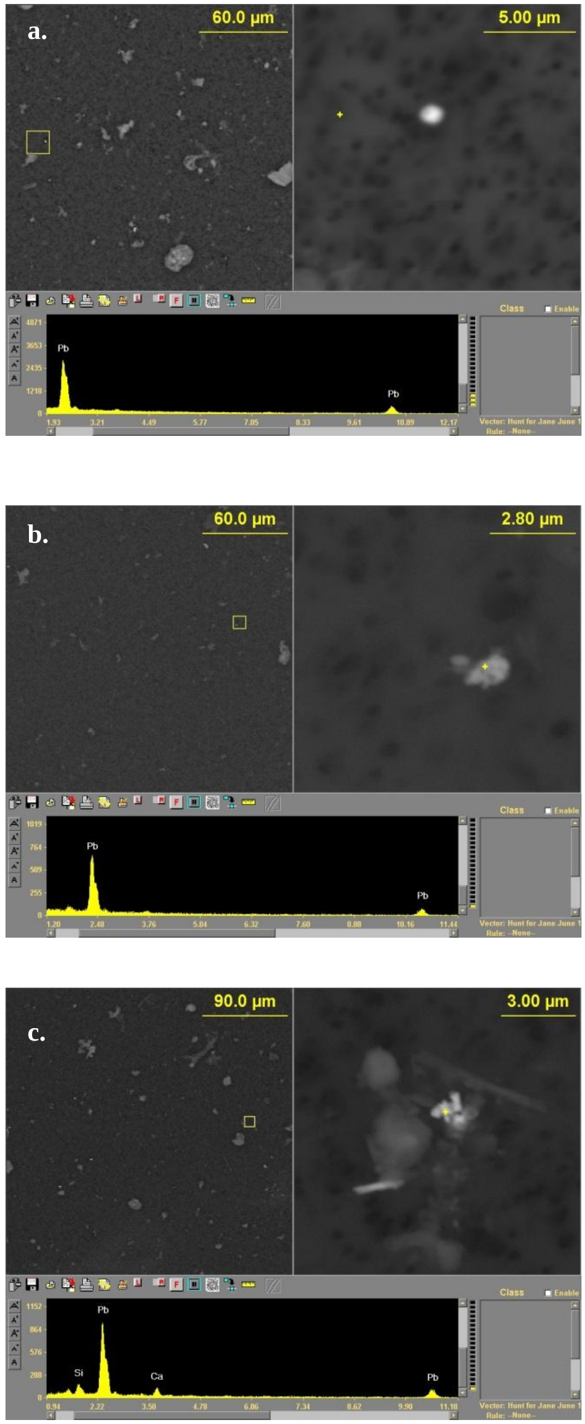


Figure F 3 House K floor dust particle with Pb pigment particles (a. b) and Si, Ca (c) in matrix

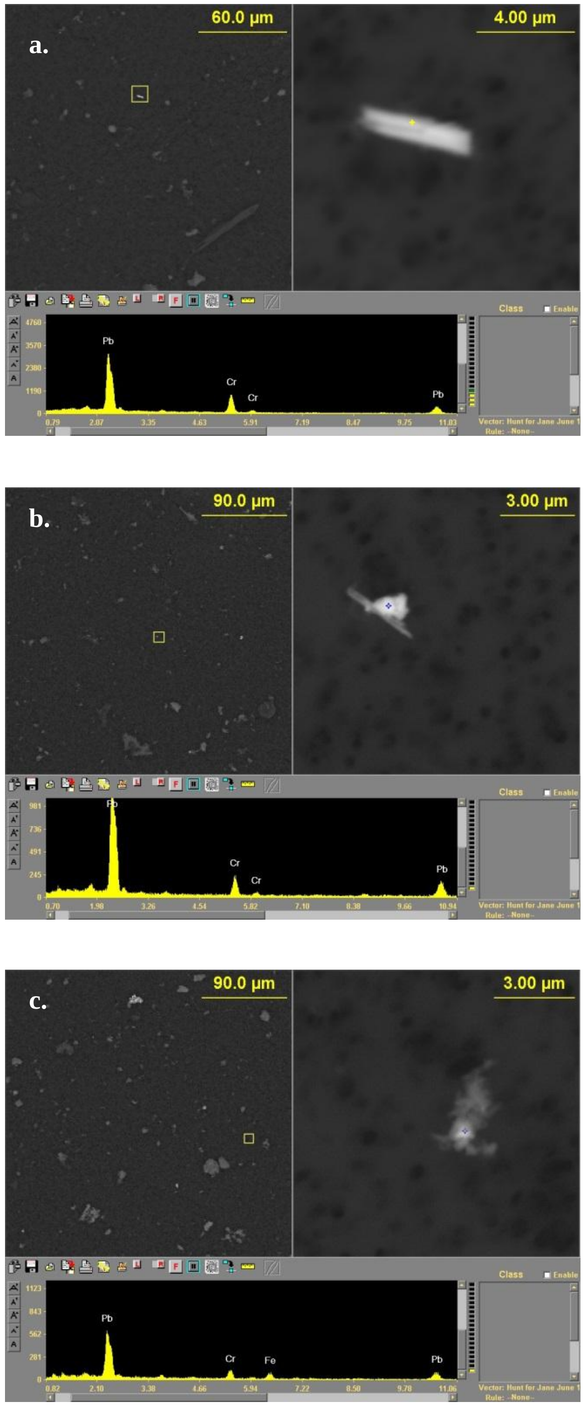


Figure F 4 House K floor dust particle with Pb pigment particles and Cr (a. b), Cr, Fe (c) in matrix

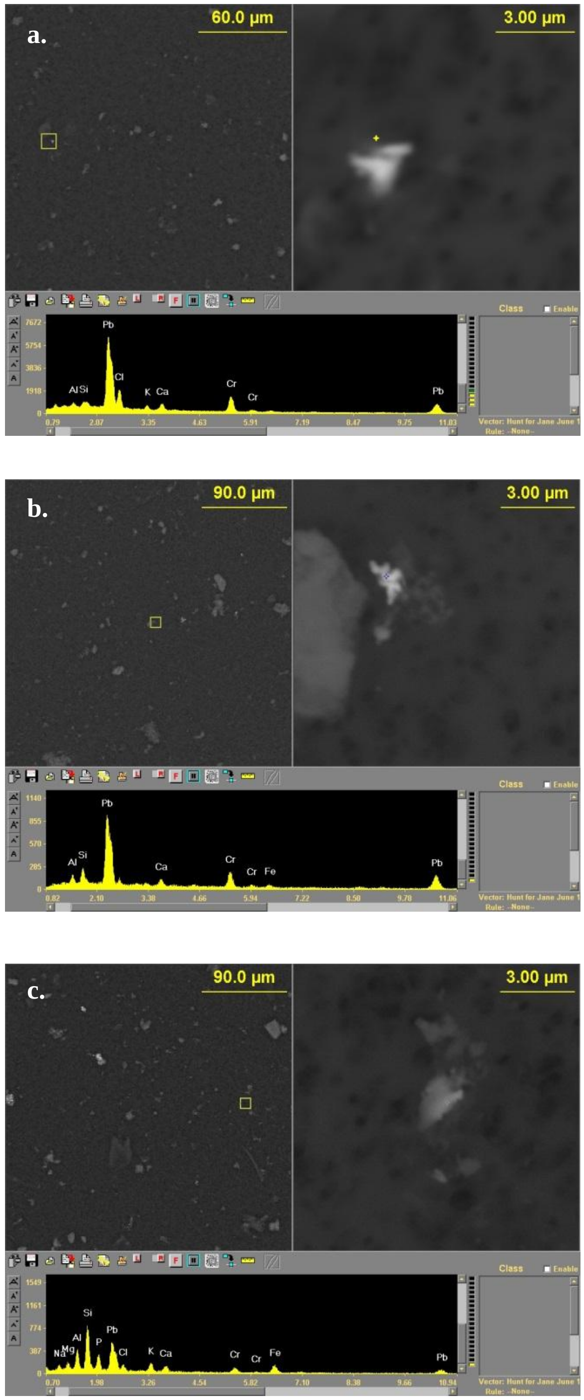


Figure F 5 House K floor dust particle with Pb pigment particles and Cl, Cr Ca (a), Si, Al, Ca Cr (b), Si, P, Al, K, Ca, Cr, Fe (c) in matrix

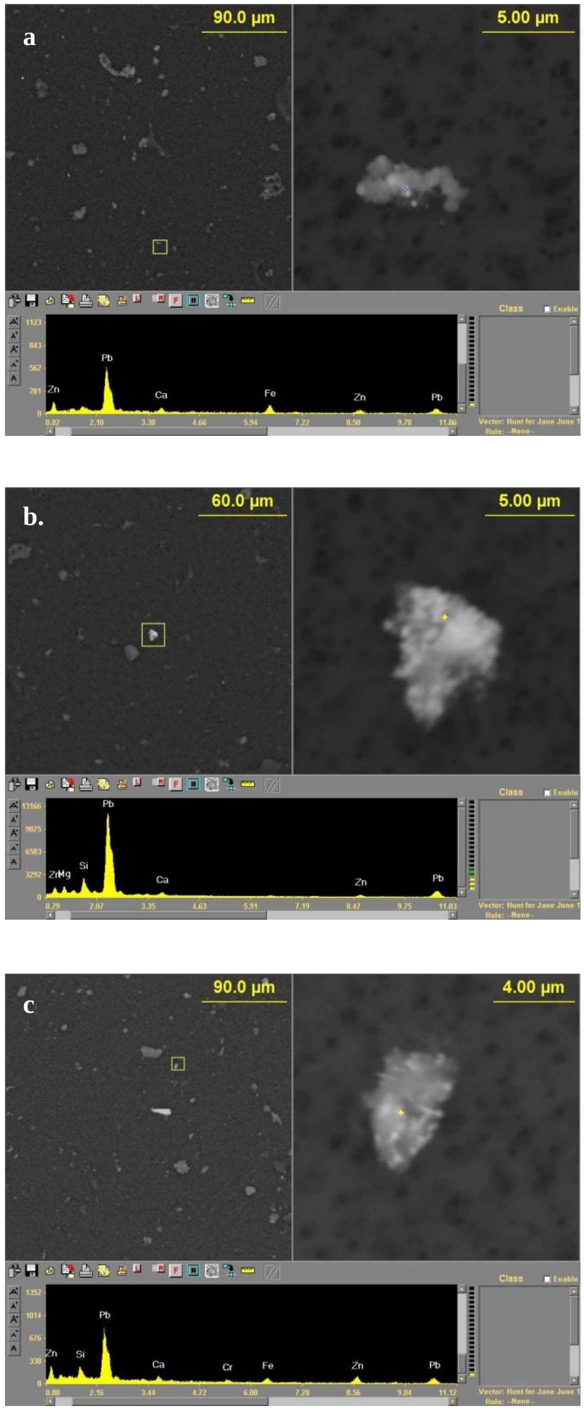


Figure F 6 House K floor dust particle with Pb pigment particles and Zn, Ca, Fe (a), Zn, Si, Mg (b), Zn, Si, Ca, Cr, Fe (c) in matrix

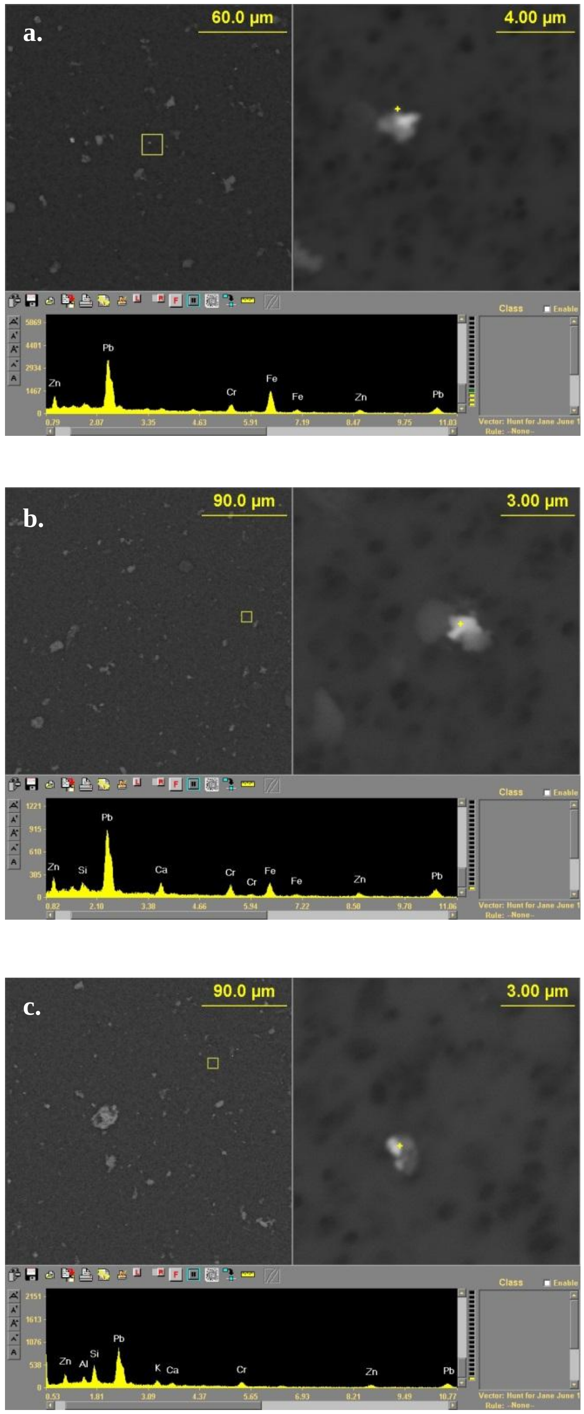


Figure F 7 House K floor dust particle with Pb pigment particles and Zn, Cr, Fe (a), Zn, Si, Ca, Cr, Fe (b), Zn, Si, Ca, Cr, Al, K, Ca (c) in matrix

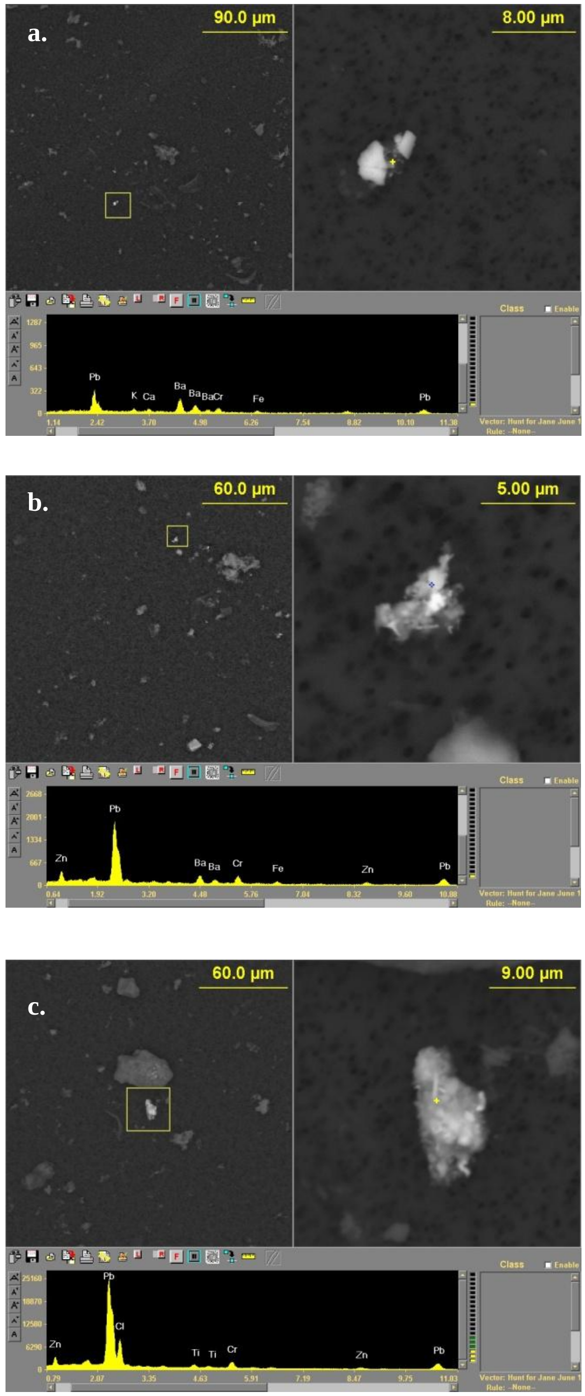


Figure F 8 House K floor dust particle with Pb pigment particles and Ba, Cr, Fe (a), Zn, Ba, Cr, Fe (b), Zn, Cl, Cr (c) in matrix

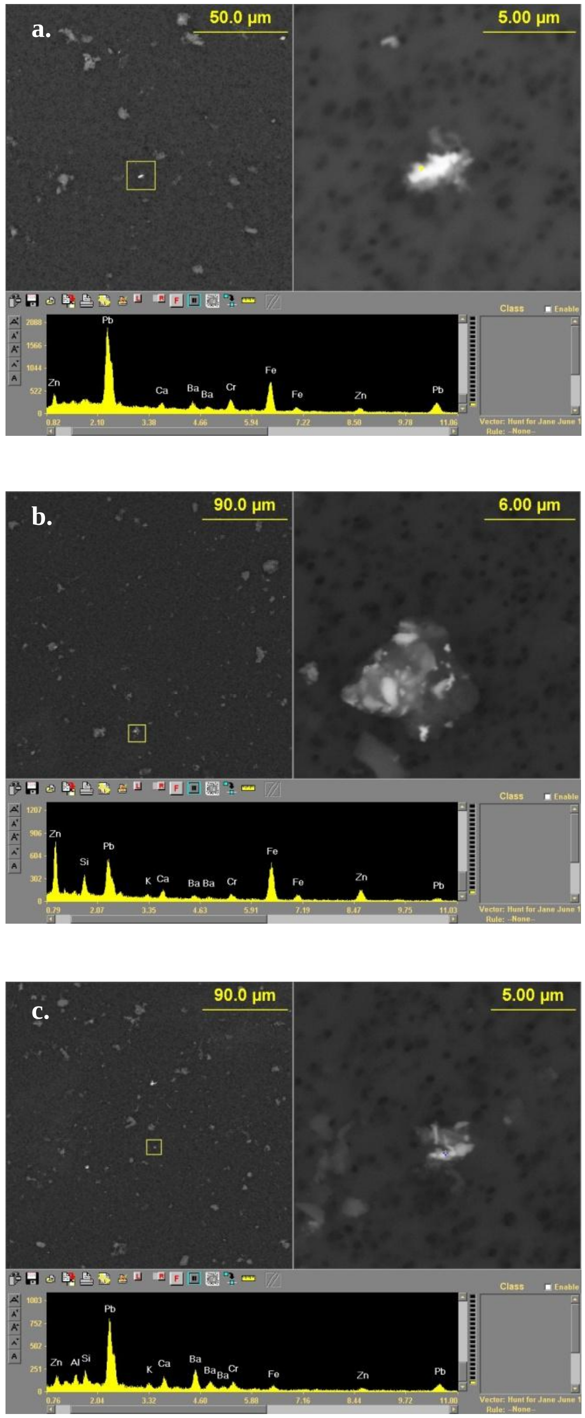


Figure F 9 House K floor dust particle with Pb pigment particles and Zn, Ca, Ba, Cr, Fe (a), Zn, Si, Ca, Cr, Fe, Ba (b), Zn, Si, Ca, Cr, Al, K, Ca, Ba, Fe (c) in matrix

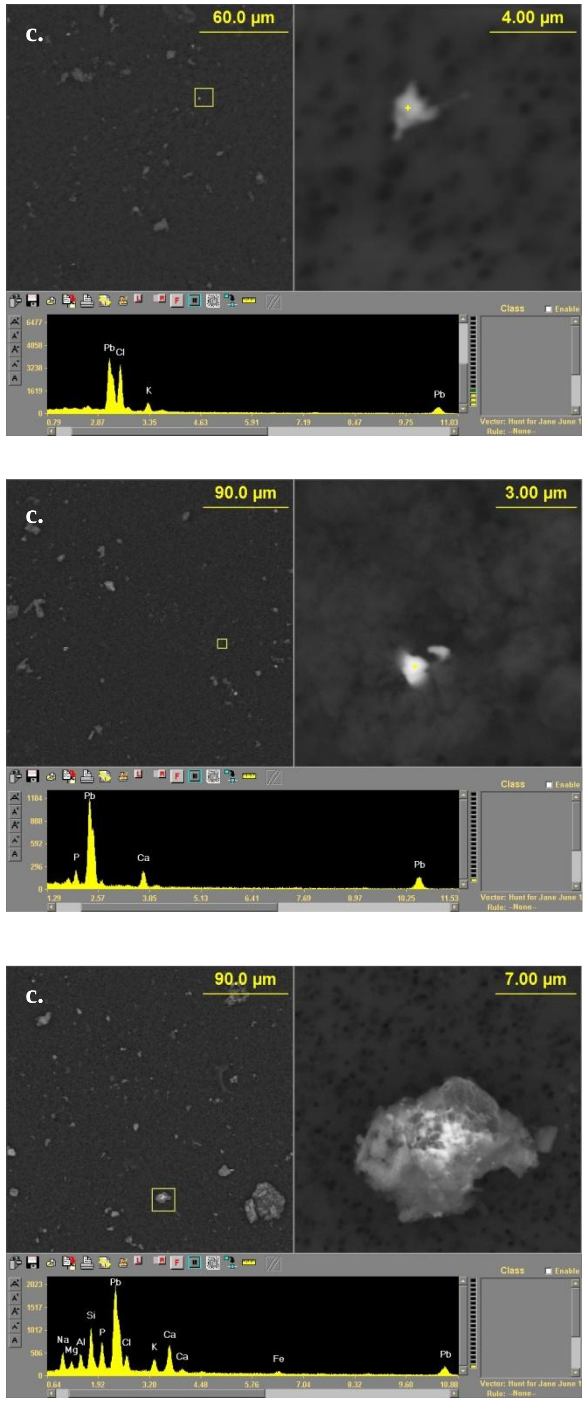


Figure F 10 House K floor dust particle with Pb pigment particles and Cl, K (a), Ca, P (b), Si, Ca, Al, K, P, Mg, Na, Cl (c) in matrix

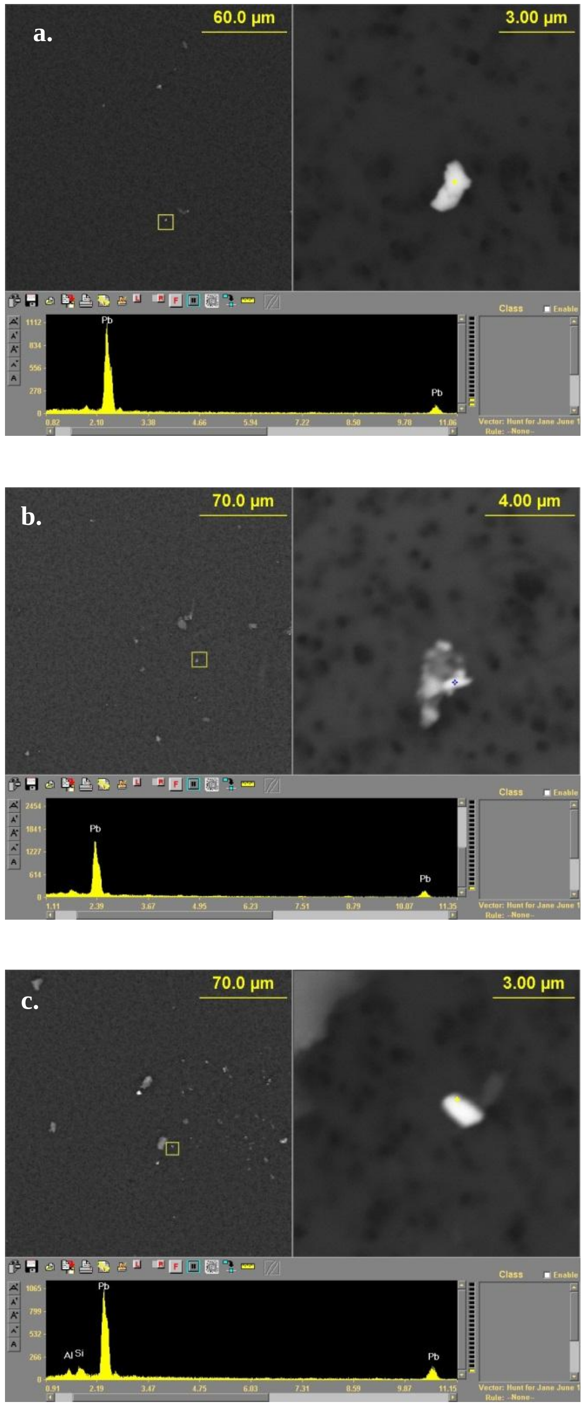


Figure F 11 House K floor paint particle with Pb pigment particles (a, b) and Si, Al (c) in matrix

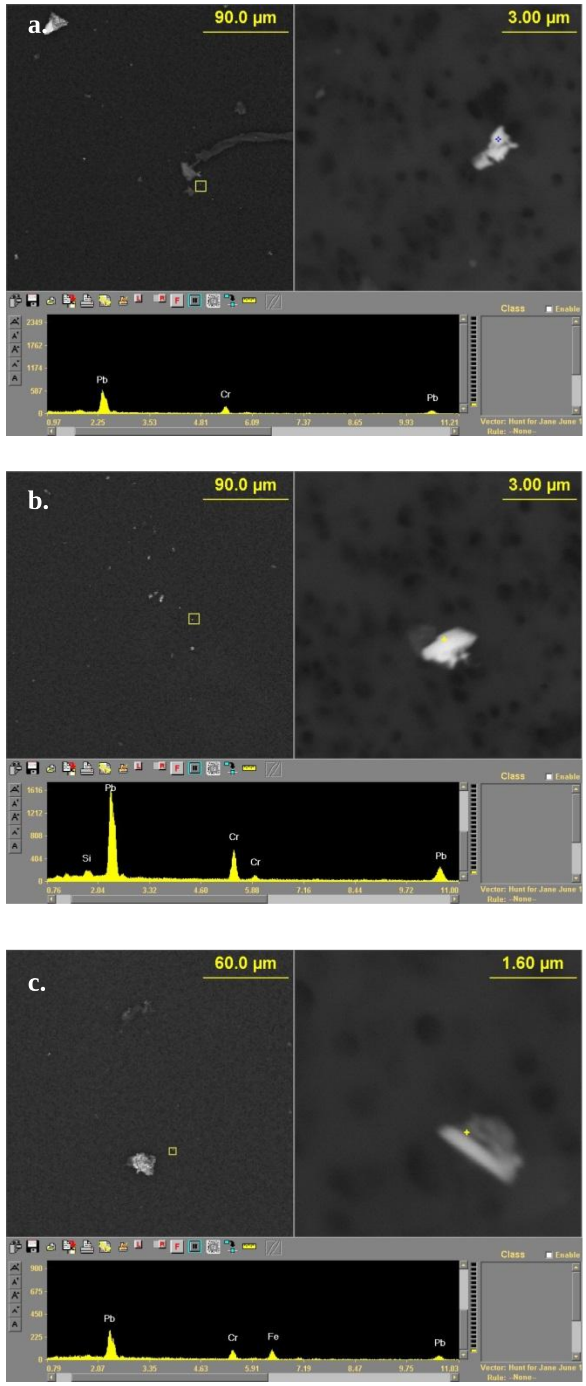


Figure F 12 House K floor paint particle with Pb pigment particles and Cr (a, b), Cr, Fe (c) in matrix

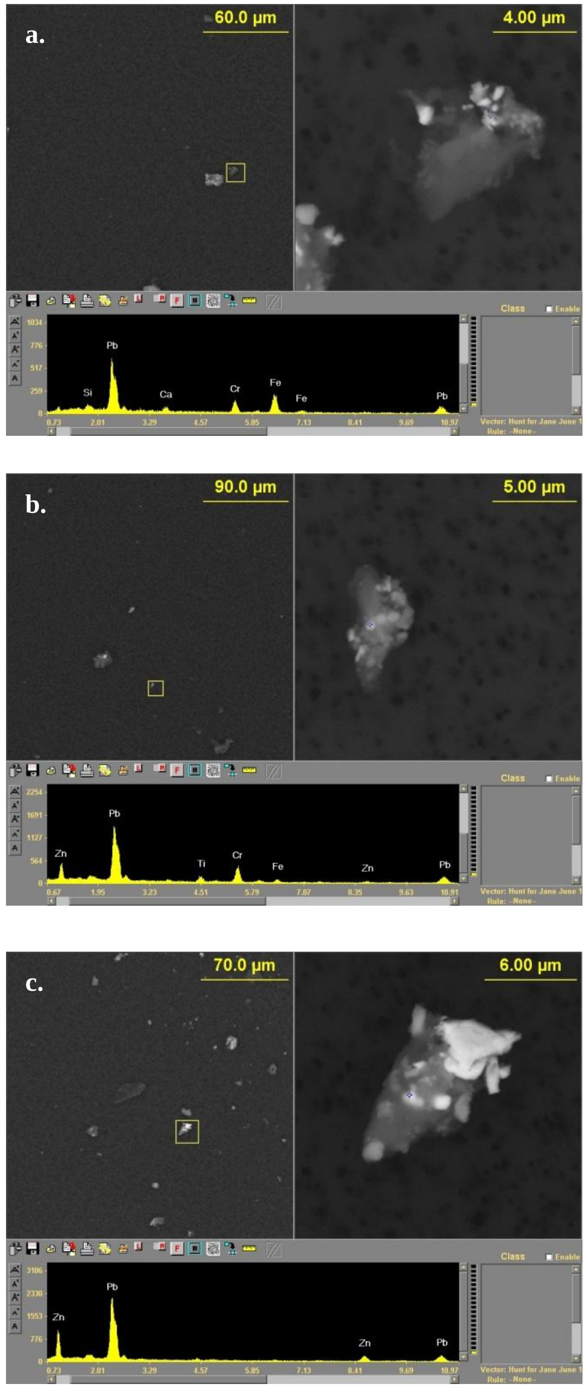


Figure F 13 House K floor paint particle with Pb pigment particles and Cr, Fe, Ca (a), Zn,Ti, Cr, Fe (b), Zn (c) in matrix

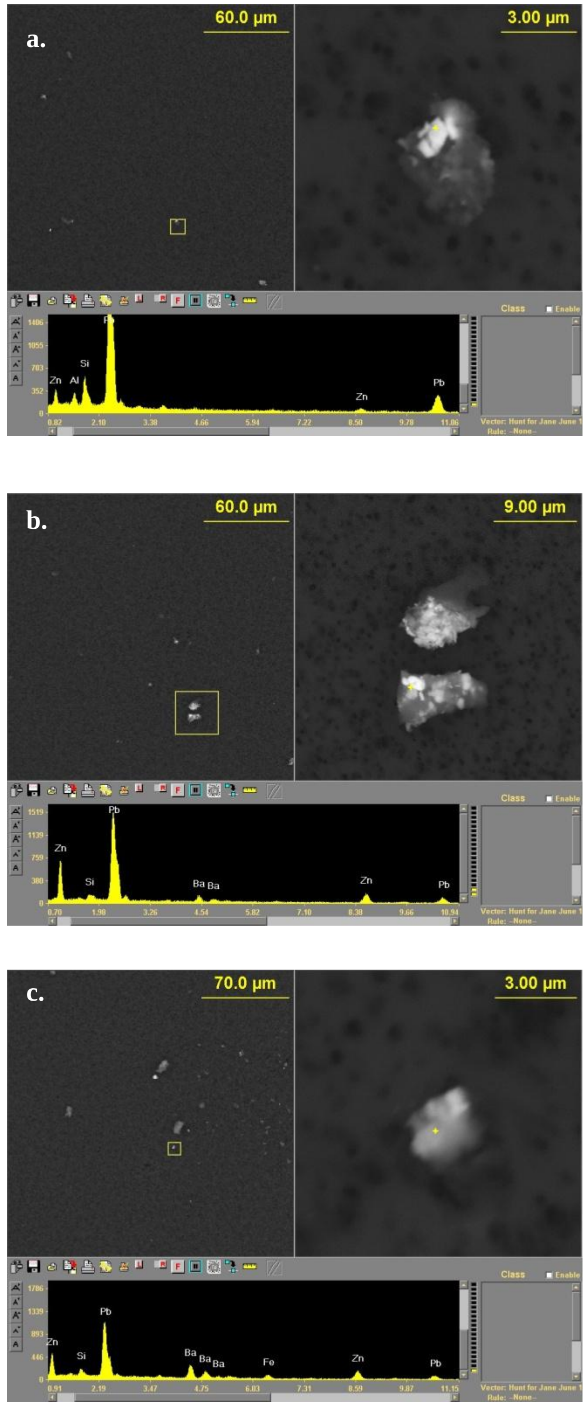


Figure F 14 House K floor paint particle with Pb pigment particles and Zn, Si, Al (a), Zn, Ba (b), Zn, Ba, Si, Fe (c) in matrix

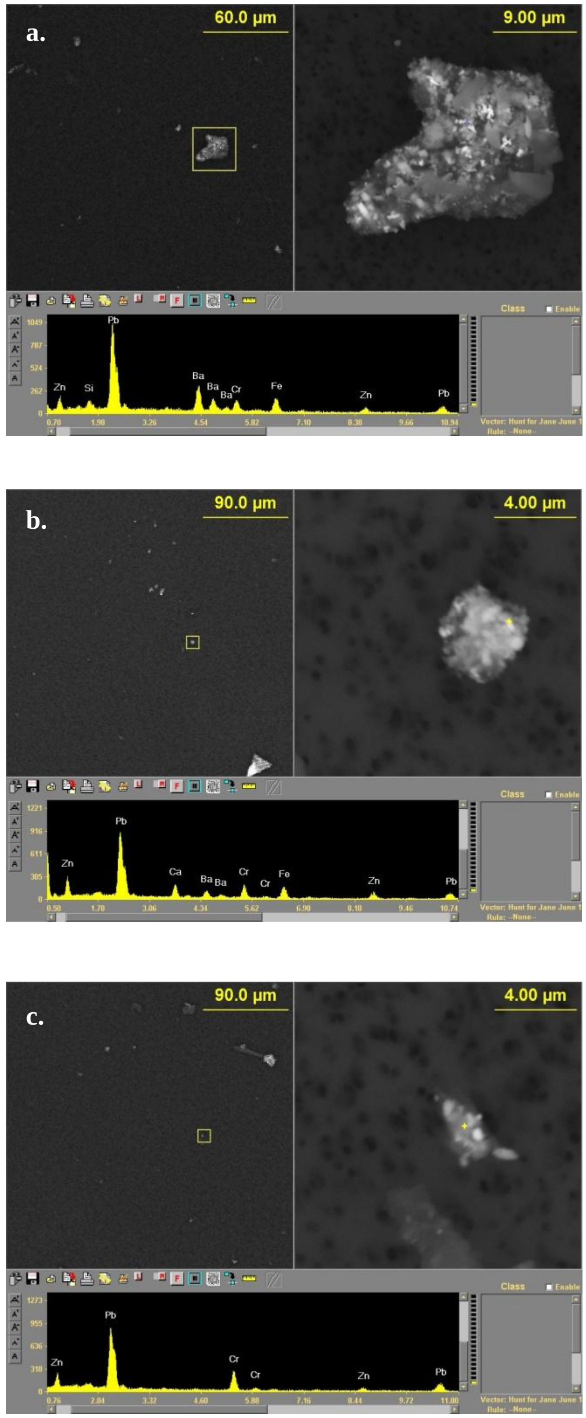
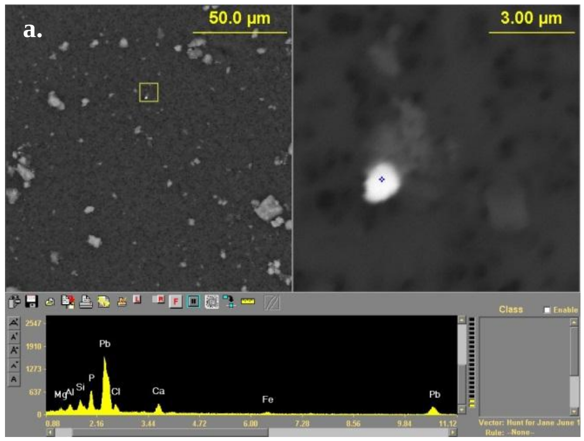


Figure F 15 House K floor paint particle with Pb pigment particles and Zn, Ba, Cr, Fe, Si (a), Zn, Ca, Ba, Cr, Fe (b), Zn, Cr (c) in matrix



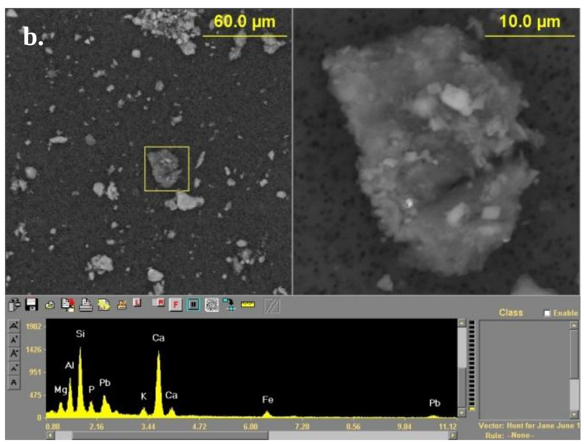


Figure F 16 House K building line soil particle with Pb pigments and Ca, P, Si, Al (a),

Ca, K, Fe, P, Si, Al, Mg (b) in matrix

Appendix G

Raw data, SEM images and X-Ray Spectra of House L

House L

Single Implicated Floor Friction Source

Floor Paint in Intact Condition

Multi Story Family Home

Sampling Location:	**Rear 1st Floor Porch**
Collected Samples:	
Dust	**1. 1st Floor Rear Porch Floor Dust [L1]**
Implicated Friction Surface	**2. 1st Floor Rear Porch Floor Paint [L2]**
Other LBP Surfaces	**3. Front Porch Trim [L7]**
Soil	**6. Building Line Soil by Rear Porch [L4]** **7. Mid Yard Soil [L5]** **8. Road Dust [L6]**

Figure G.1. House L General View

Table G 1 House L Lead Concentration Data by XRF

Analysis Number	**House Code**	**Sample Description**	**Pb Conc (µg/g)**	**Error (µg/g)**
HUD 051-1	**L2**	House L - Target Paint: Porch floor, intact condition	322564.9	218.7
HUD 052-1	**L7**	House L - Competing Paint: Front porch upper trim, intact condition	123439	123.1
HUD 053-1	**L5**	House L - Mid-Yard Soil	1042	12.9
HUD 054-1	**L4**	`	2292.2	17.6
HUD 055-1	**L6**	House L - Road Dust	206	10.7
HUD 056-1	**L1**	House L - Cyclone Vacuum Dust Sample: Porch floor	8500.4	63.5

Table G.2 House L Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	**House Code**	**Sample Description**	**206/204**	**207/204**	**208/204**	**207/206**	**208/206**	**207/208**
HUD51	**L2**	House L - Target Paint: Porch floor, intact condition	17.219	15.546	37.199	0.90286	2.16037	0.41792
HUD52	**L7**	House L - Competing Paint: Front porch upper trim, intact condition	18.193	15.677	38.222	0.86168	2.1009	0.41015
HUD53	**L5**	House L - Mid-Yard Soil	18.522	15.619	38.343	0.84328	2.07016	0.40735
HUD54	**L4**	`House L - Building Line Soil: By rear porch entrance	17.964	15556	37.761	0.86594	2.10206	0.41195
HUD55	**L6**	House L - Road Dust	18.617	15638	38.394	0.83997	2.06234	0.40729
HUD56	**L1**	House L - Cyclone Vacuum Dust Sample: Porch floor	17.488	15.514	37.372	0.88712	2.13696	0.41513

Table G 3 House L Pb bearing particles found in floor dust

Chemical Composition	**Morphology**	**Size**
Pb	Aggregate	7.52
Pb	Irregular	1.75
Pb	Irregular	3.95
Pb	Rounded	2.71
Pb	Irregular	3.19
Pb	Irregular	4.19
Pb	Aggregate	7.34
Pb	Irregular	1.8
Pb	Irregular	2.81
Pb	Irregular	2.38
Pb	Irregular	3.2
Pb	Irregular	2.29
Pb	Irregular	2.76
Pb	Irregular	2.19
Pb	Hexagonal	2.34
Pb	Irregular	3.32
Pb	Aggregate	4.45
Pb	Irregular	0.964
Pb	Irregular	2.58
Pb	Irregular	2.45
Pb	Aggregate	4.37
Pb	Irregular	2.48
Pb	Irregular	3.15
Pb	Irregular	4.5
Pb	Irregular	1.94
Pb	Blocky	2.31
Pb	Hexagonal	2.32
Pb	Irregular	2.24
Pb	Irregular	1.41
Pb	Irregular	1.43
Pb	Irregular	2.06
Pb	Irregular	1.25

Table G 3.- *Continued*

Pb	Irregular	0.712
Pb	Irregular	2.16
Pb	Irregular	1.2
Pb	Irregular	0.859
Pb	Irregular	1.19
Pb	Irregular	4.33
Pb	Irregular	3.06
Pb	Irregular	1.28
Pb	Irregular	1.42
Pb	Rounded	2.01
Pb	Blocky	6.33
Pb	Aggregate	3.01
Pb	Aggregate	3.15
PbSi	Irregular	2.53
PbSi	Aggregate	5.24
PbSi	Aggregate	3.62
PbSi	Irregular	2.11
PbSi	Irregular	1.88
PbSi	Irregular	2.34
PbSi	Platty Aggregate	6.12
PbSi	Elongated	1.6
PbSi	Irregular	2.3
PbSi	Irregular	1.24
PbSi	Irregular	1.67
PbSi	Irregular	1.36
PbSi	Aggregate	1.84
PbCl	Aggregate	5
PbCl	Irregular	1.93
PbCl	Angular	3.54
PbCl	Aggregate	3.02
PbCl	Irregular	2.66
PbZn	Piatty Aggregate	5.73
PbZn	Irregular	1.27
PbCa	Irregular	2.23
PbCa	aggregate	1.87

Table G 3 - *Continued*

PbCa	Irregular	2.04
PbCa	Irregular	2.6
PbK	Irregular	3.48
PbTi	Irregular	1.7
PbCa	Irregular	3.43
PbSi	Aggregate	3.81
PbSi	Irregular	1.52
PbK	Irregular	2.72
PbP	Irregular	2.45
PbSiCl	Aggregate	3.24
PbSiAl	Irregular	1.52
PbCaP	Irregular	2.12
PbClSi	Irregular	2.9
PbZnCl	Aggregate	28.4
PbCaP	Irregular	2.16
PbCaP	Irregular	1.83
PbCaP	Irregular	1.53
PbCaSi	Aggregate	5.55
PbTiCa	Aggregate	12
PbZnCl	Aggregate	3.93
PbCaSi	Aggregate	4.73
PbPNa	Blocky	6.88
PbSiNa	Aggregate	4.7
PbSiAl	Irregular	2.44
PbClPNa	Irregular	6.35
PbClCaSi	Irregular	2.9
PbCaClP	Aggregate	3.71
PbCaClP	Irregular	2.77
PbCaClP	Irregular	1.71
PbCaClP	Irregular	3.54
PbCaClP	Irregular	1.64
PbCaClP	Aggregate	2.97
PbCaClP	Rounded	1.01
PbCaClP	Irregular	1.56
PbCaClP	Irregular	2.21

Table G 3 - *Continued*

PbCaPNa	Irregular	2.6
PbCaPNa	Aggregate	3.62
PbCaPSi	Irregular	2.83
PbZnCaP	Irregular	5.7
PbZnCaP	Irregular	2.9
PbTiCaSi	Aggregate	1.4
PbTiSiAl	Aggregate	4.04
PbTiSiAl	Irregular	1.2
PbTiSiAl	Irregular	1.91
PbZnCaP	Irregular	11.3
PbCaSiMg	Aggregate	
PbCaSiP	Aggregate	3.9
PbCaPClNa	Aggregate	8.38
PbCaPClNa	Irregular	2.52
PbCaPClNa	Rounded	2.37
PbCaPClNa	Irregular	2.32
PbCaPClSi	Aggregate	4.23
PbCaPClSi	Aggregate	3.06
PbCaPSiAl	Irregular	2.48
PbZnCaSiP	Irregular	2.84
PbZnCaSiP	Irregular	2
PbZnCaClP	Irregular	5.19
PbZnCaClP	Irregular	2.03
PbZnCaClP	Irregular	8.29
PbZnCaSiP	Irregular	5.7
PbZnTiCaCl	Irregular	2.54
PbZnTiCaSi	Aggregate	11.5
PbZnTiCaP	Irregular	6.52
PbClPSiNa	Irregular	3.41
PbZnCaSiP	Irregular	3.25
PbZnCaSiP	Irregular	3.54
PbZnCaSiP	Irregular	3
PbZnCaSiPMg	Aggregate	5.64
pbSiAlKPNa	Aggregate	8.08
PbZnTiCaCl	Aggregate	26.5

Table G 3 - *Continued*

PbZnCaSiPCl	Aggregate	6.34
PbCaSiPClNa	Irregular	5.01
PbCaSiPClNa	Irregular	2.32
PbTiCaSiPNa	Irregular	3.65
PbTiCaSiAlFe	Aggregate	16.2
PbBaSiPClNa	Aggregate	8.13
PbZnBaCaPCl	Irregular	6.57
PbCaSiClPNaFe	Irregular	2.76
PbCaSiAlKPFe	Irregular	2.77
PbZnTiCaClSiAl	Aggregate	9.93
PbZnTiCaSiAlP	Aggregate	6.2
PbZnTiCaSiAlMg	Aggregate	3.78
PbZnBaCaSiMgP	Aggregate	11.5
PbZnBaCaSiKFe	Aggregate	6.45
PbTiCaClSiPNa	Irregular	2.55
PbZnCaSiPFe	Irregular	4
PbTiCaSiClPNaK	Irregular	4.71
PbCaSiAlClPNaK	Irregular	12.5
PbTiCaSiAlKMgFe	Aggregate	18.4
PbTiZnCaSiPMgCl	Irregular	5.1
PbTiCaSiAlPNaCl	Aggregate	14.1
PbTiCaSiAlKMgPNaCl	Irregular	4.92

Table G 4 House L Pb bearing particles found in floor paint sample

Chemical Composition	**Morphology**	**Size**
Pb	Aggregate	7.15
Pb	Irregular	3.82
Pb	Aggregate	8.46
Pb	Aggregate	5.54
Pb	Aggregate	9.48
Pb	Aggregate	6.4
Pb	Aggregate	2.94
Pb	Aggregate	4.81
Pb	Hexagonal	3.53
Pb	Irregular	2.38
Pb	Aggregate	4.61
Pb	Aggregate	5.5
Pb	Aggregate	9.18
Pb	Aggregate	5.75
Pb	Aggregate	13.2
Pb	Aggregate	4.21
Pb	Aggregate	4.76
Pb	Rounded	2.05
Pb	Irregular	7.7
Pb	Aggregate	2.75
Pb	Aggregate	9.49
Pb	Hexagonal	4.95
Pb	Aggregate	4.26
Pb	Aggregate	13.5
Pb	Irregular	3.85
Pb	Irregular	9.08
Pb	Aggregate	4.24
Pb	Aggregate	14.7
Pb	Aggregate	12
PbCa	Aggregate	8.02
PbCa	Aggregate	11.4
PbCa	Aggregate	6.6
PbTi	Aggregate	8.04
PbTi	Aggregate	12

Table G 4 -*Continued*

PbTi	Irregular	4.91
PbSi	Irregular	1.71
PbSi	Aggregate	4.76
PbZn	Irregular	5.67
PbZn	Aggregate	4.33
PbZn	Aggregate	13.5
PbZn	Aggregate	23
PbZnTi	Aggregate	7.23
PbZnTi	Aggregate	13.4
PbZnTi	Aggregate	7.83
PbZnTi	Aggregate	4.42
PbZnTi	Aggregate	6.71
PbZnTi	Aggregate	8.75
PbZnTi	Aggregate	9.51
PbZnTi	Aggregate	
PbZnTi	Irregular	7.57
PbZnTi	Aggregate	7.25
PbZnBa	Aggregate	6.29
PbZnBa	Aggregate	12
PbZnBa	Aggregate	9.52
PbZnCa	Aggregate	6.7
PbZnCa	Aggregate	7.45
PbZnCa	Aggregate	40
PbZnP	Irregular	6.78
PbZnP	Irregular	8.09
PbZnP	Aggregate	3.4
PbZnP	Irregular	6.48
PbZnP	Aggregate	6.65
PbTiNa	Aggregate	11.3
PbSiP	Irregular	3.68
PbTiCa	Aggregate	13.7
PbZnBaCa	Aggregate	14.5
PbZnBaCa	Aggregate	6.24
PbZnBaCa	Irregular	6.29
PbZnBaSi	Aggregate	9.02

Table G 4 - *Continued*

PbZnTiCa	Aggregate	14.6
PbZnTiCa	Aggregate	7.83
PbZnTiCa	Aggregate	7.01
PbZnTiCa	Aggregate	19.2
PbZnTiCl	Aggregate	7.04
PbZnTiCl	Aggregate	14.3
PbZnTiCl	Aggregate	13.1
PbZnTiCl	Aggregate	8.88
PbZnTiCl	Aggregate	9.5
PbZnTiCl	Aggregate	10.1
PbZnTiCl	Aggregate	8.09
PbZnTiCl	Aggregate	5.1
PbZnTiCl	Aggregate	5.5
PbZnTiCl	Irregular	5.24
PbZnTiSi	Aggregate	12.8
PbZnTiFe	Aggregate	17.3
PbCaSiAl	Aggregate	10
PbSiAlK	Aggregate	19.7
PbZnSiP	Aggregate	9.81
PbZnSiAl	Aggregate	14.8
PbZnSiAl	Aggregate	10.2
PbTiCaFe	Aggregate	9.53
PbZnCaMg	Aggregate	9.31
PbZnCaP	Aggregate	13.3
PbZnCaP	Aggregate	14.1
PbZnTiP	Irregular	7.22
PbZnCaPCl	Aggregate	2.77
PbZnCaPFe	Aggregate	10.8
PbZnCaPFe	Aggregate	17
PbZnTiSiMg	Aggregate	8.01
PbZnTiSiMg	Aggregate	9.73
PbZnBaSiCa	Aggregate	33.1
PbZnBaSiCa	Aggregate	11
PbZnTiCaSi	Aggregate	12.8
PbZnTiCaSi	Irregular	10.9

Table G 4- *Continued*

PbZnTiCaSi	Aggregate	15
PbZnTiCaCl	Aggregate	4.82
PbZnTiCaCl	Aggregate	17.9
PbZnTiCaCl	Aggregate	8.68
PbZnTiSiCl	Aggregate	9.31
PbZnTiCaK	Aggregate	15
PbZnTiClFe	Aggregate	15.4
PbZnTiCaP	Aggregate	14
PbZnTiCaP	Aggregate	6.76
PbZnBaCaFe	Aggregate	19
PbZnBaSiFe	Aggregate	6.1
PbZnBaSiP	Aggregate	36
PbZnTiCaSiAl	Aggregate	13.6
PbZnTiCaSiMg	Aggregate	14.6
PbZnTiSiClFe	Aggregate	6.1
PbZnTiCaSiMg	Aggregate	11.4
PbZnTiCaSiMg	Irregular	7.48
PbZnTiClSiMg	Aggregate	6.65
PbZnTiCaClP	Aggregate	10.4
PbZnTiCaPFe	Aggregate	6.16
PbCaClPFeNa	Aggregate	14
PbTiCaSiAlNa	Aggregate	18.3
PbZnTiCaSiAlP	Aggregate	24
PbZnTiCrCaSiMg	Aggregate	10.5
PbZnTiCaSiPFe	Irregular	6.87

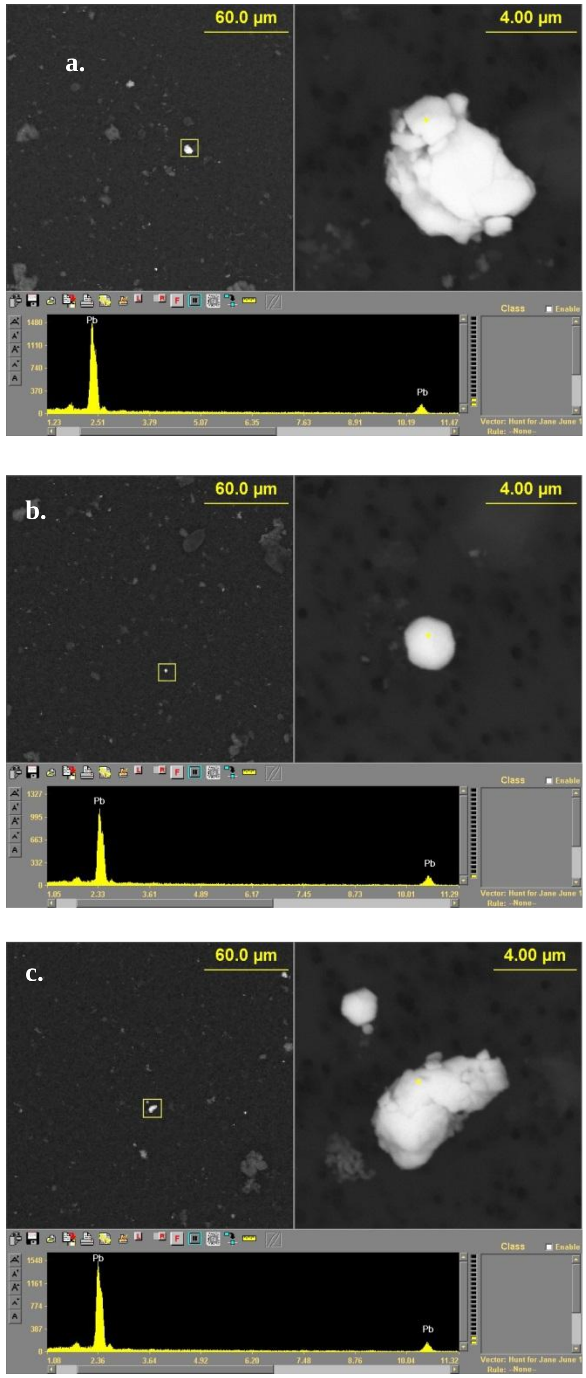


Figure G 3 House L floor dust particle with Pb pigments (a,b,c)

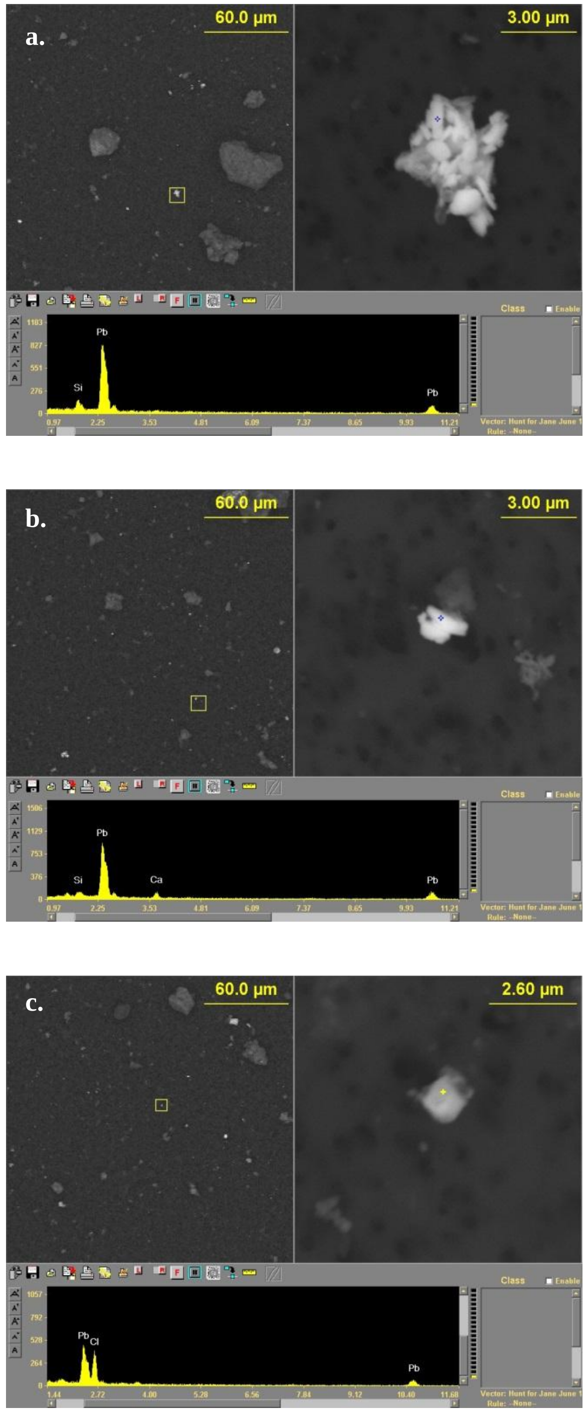


Figure G 4 House L floor dust particle with Pb pigment particles and Si (a), Ca (b), Cl (c) in matrix

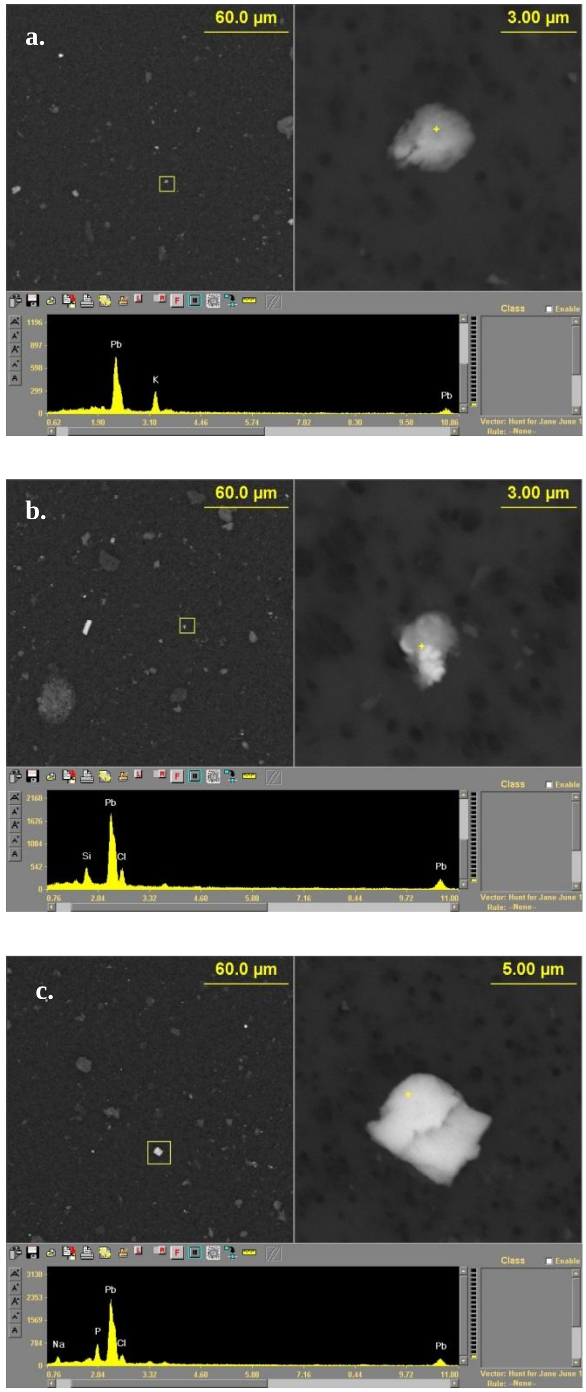


Figure G 5 House L floor dust particle with Pb pigment particles and K (a), Si, Cl (b), P, Na (c) in matrix

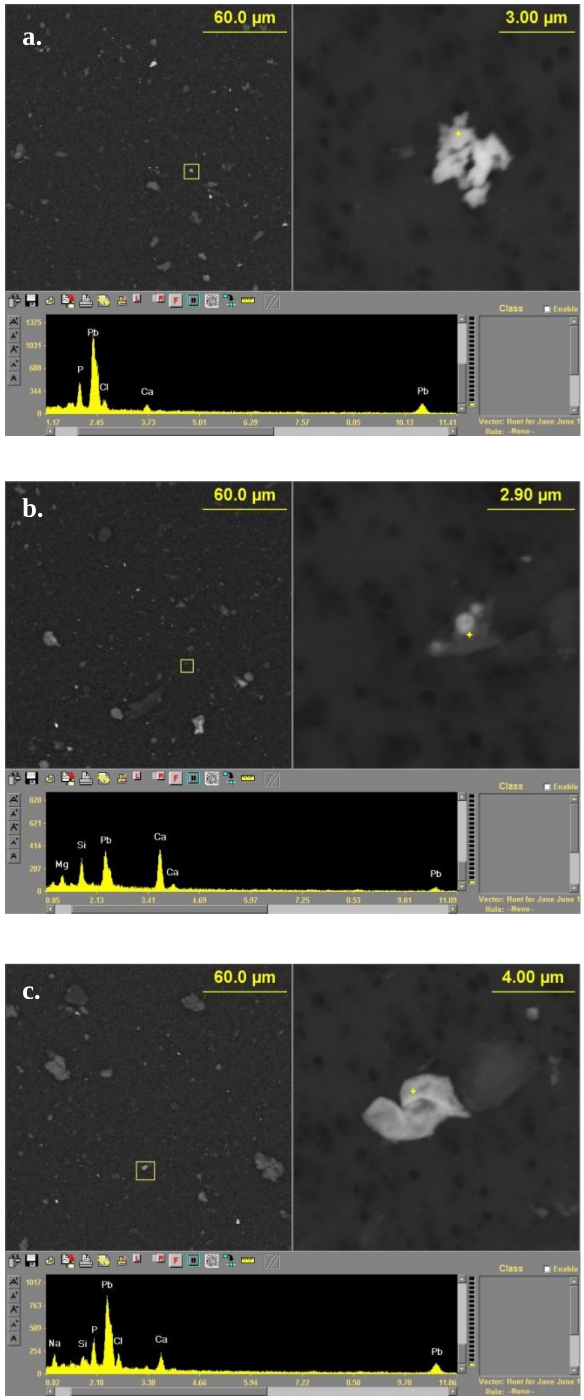


Figure G 6 House L floor dust particle with Pb pigments particles and Ca, P (a), Ca, Si, Mg (b), Ca, Cl, P, Na (c) in matrix

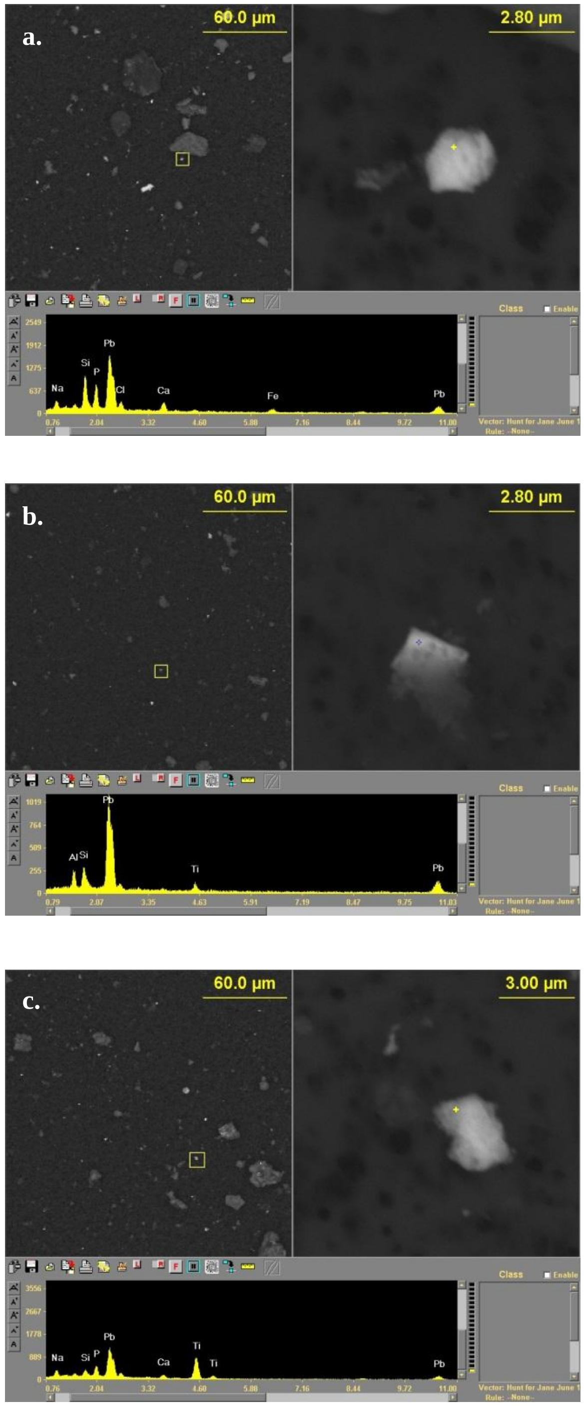


Figure G 7 House L floor dust particle with Pb pigment and Si, P, Ca, Fe, Na (a), Si, Al, Ti (b), Ca, P, Si, Ti, Na (c) in matrix

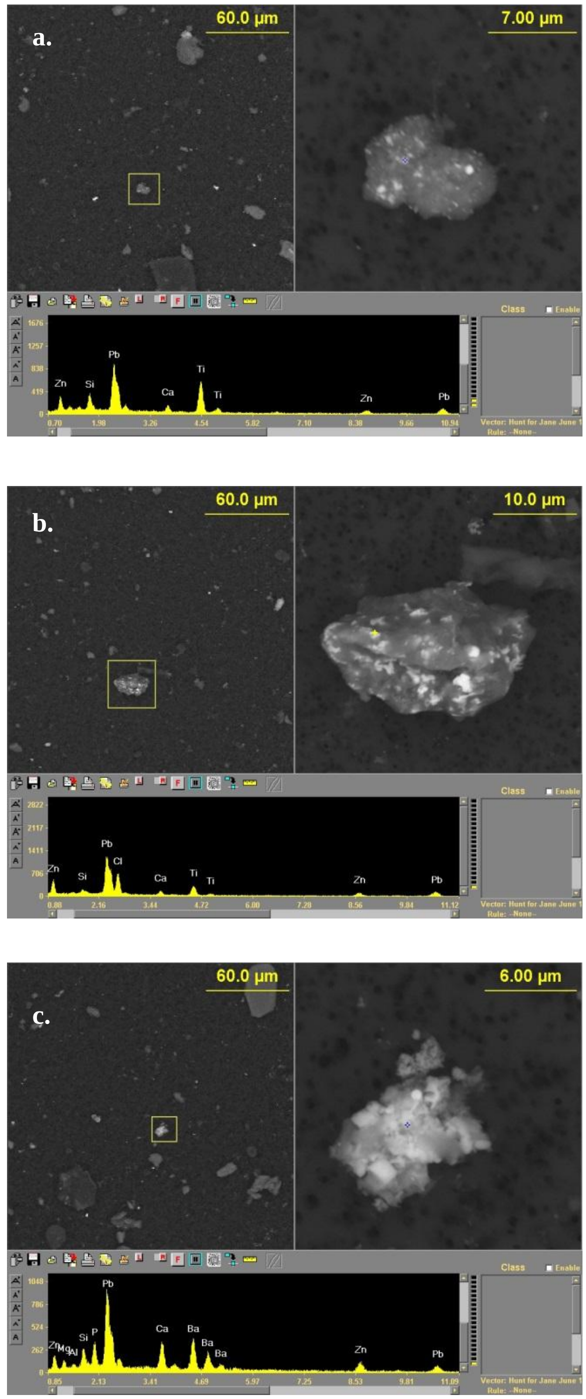


Figure G 8.House L floor dust particle with Pb pigment and Zn, Ti, Si, Ca (a), Zn, Ti, Ca, Cl (b), Zn, Ba, Ca, P, Si, Mg(c) in matrix

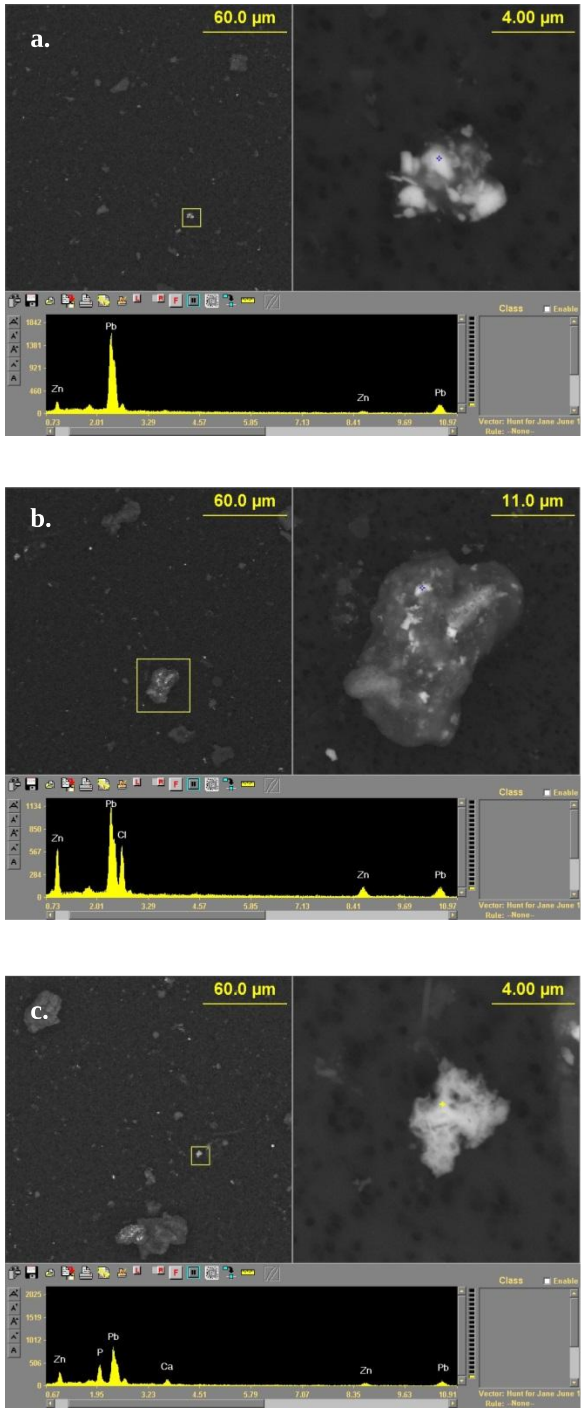


Figure G 9 House L floor dust particle with Pb pigment and Zn (a), Cl, Zn (b), Ca, P, Zn (c) in matrix

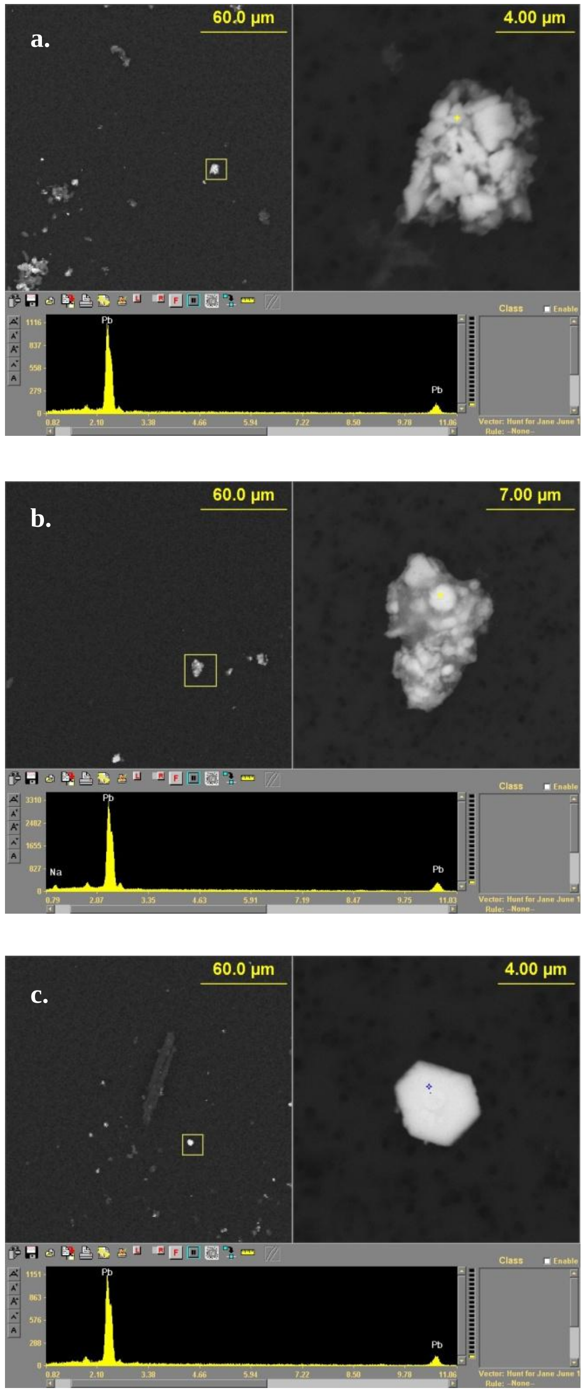


Figure G 10 House L floor dust particle with Pb pigment particles (a, b, c)

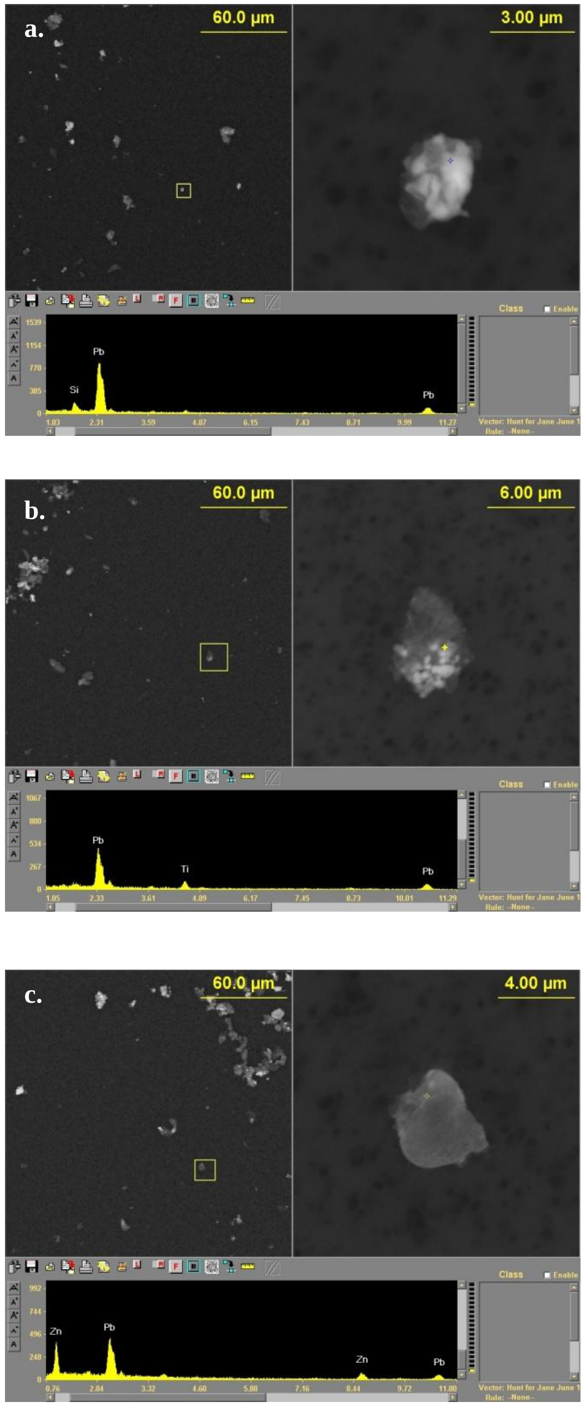


Figure G 11 House L floor dust particle with Pb pigment and Si (a), Ti (b), Zn(c) in matrix

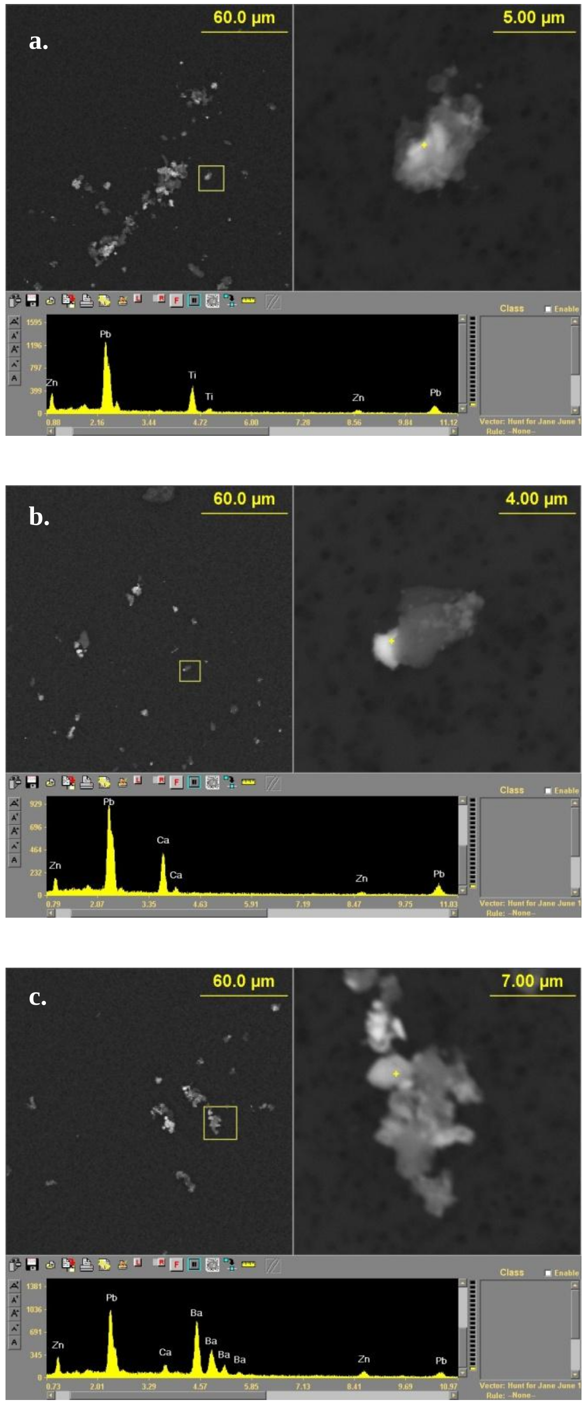


Figure G 12 House L floor dust particle with Pb pigment and Ti, Zn (a), Ca, Zn (b), Ba, Zn, Ca (c) in matrix

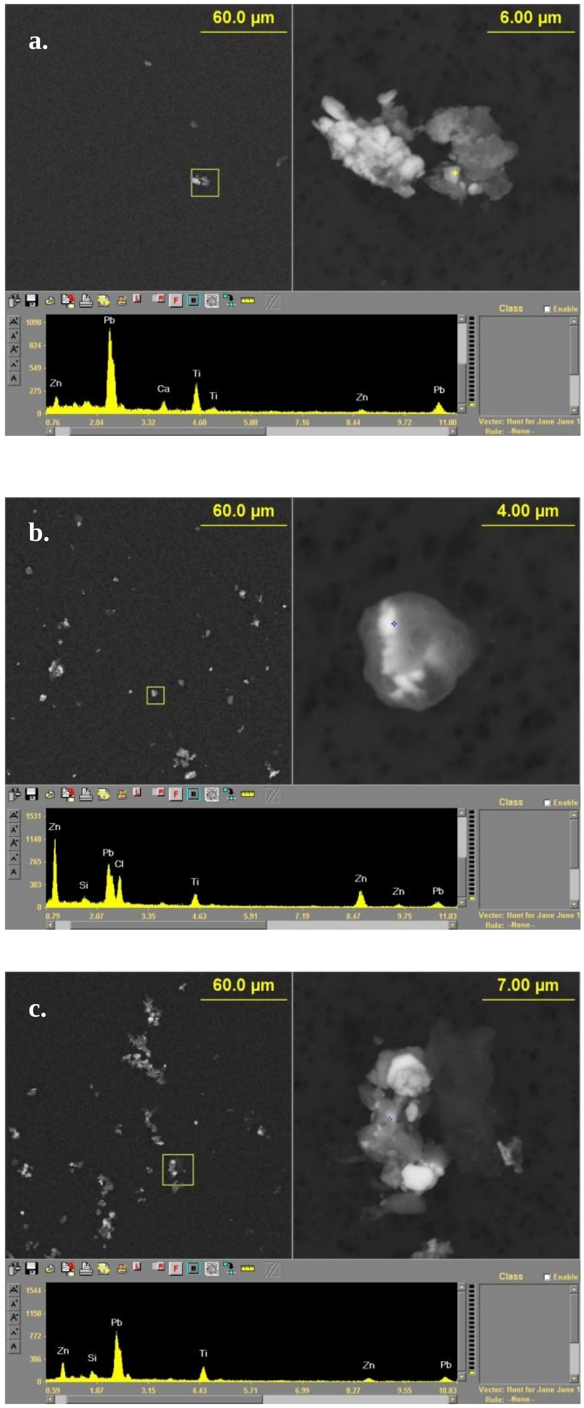


Figure G 13 House L floor dust particle with Pb pigment and Zn, Ti, Ca (a), Zn, Ti, Cl (b), Zn, Ti, Si (c) in matrix

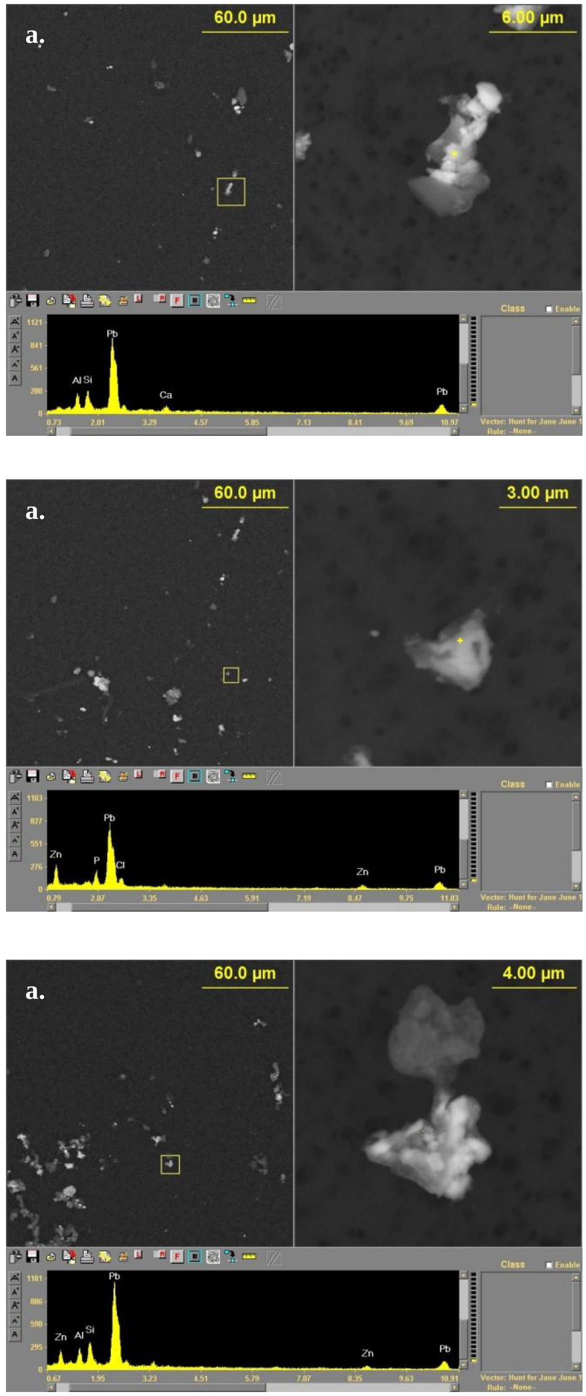


Figure G 14 House L floor paint particle with Pb pigment and Si, Al, Ca (a), Zn, P (b), Zn, Si, Al (c) in matrix

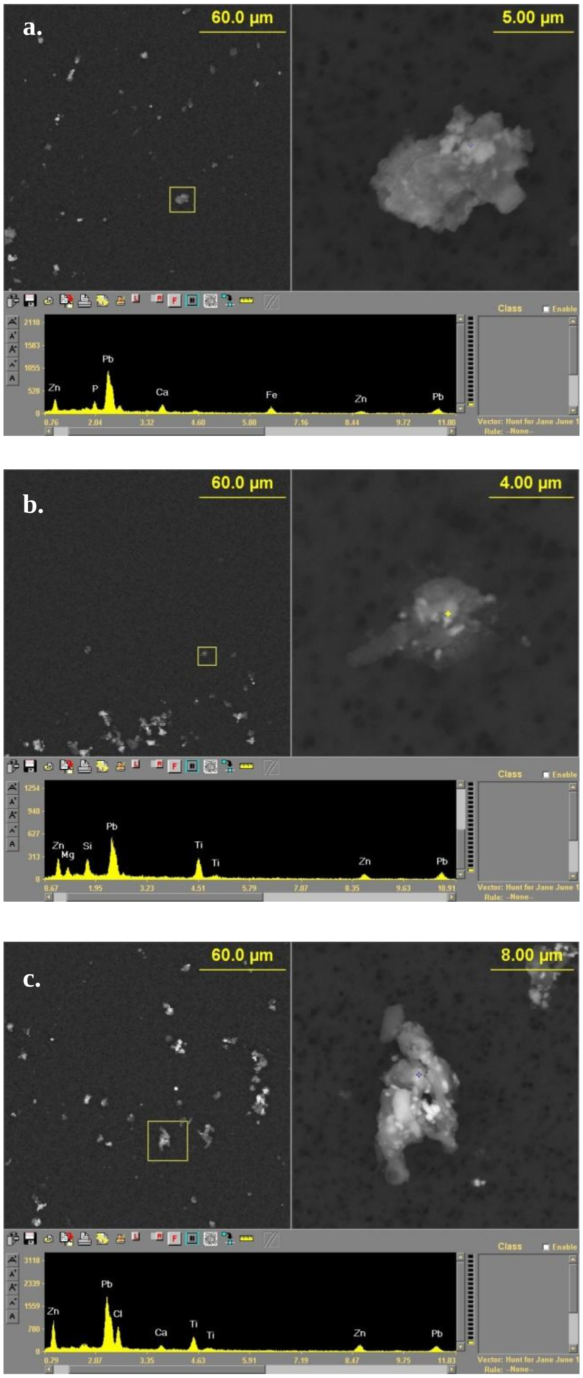


Figure G 15 House L floor paint particle with Pb pigment and Zn, P, Ca, Fe (a), Zn, Ti, Si, Mg (b), Zn, Ti, Cl, Ca (c) in matrix

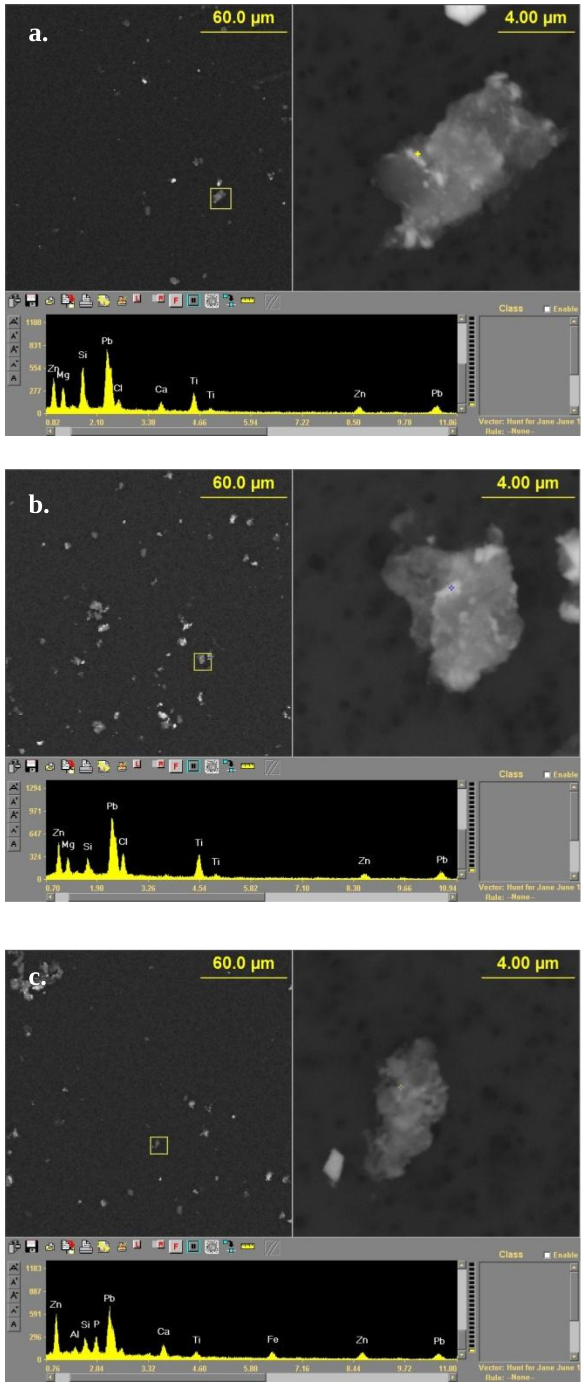


Figure G 16 House L floor paint particle with Pb pigment and Zn, Si, Mg,Cl, Ti Ca (a, b), Zn, Si, Al, P, Ca, Ti, Fe (c) in matrix

Appendix H

Raw data, SEM images and X-Ray Spectra of House O

House O

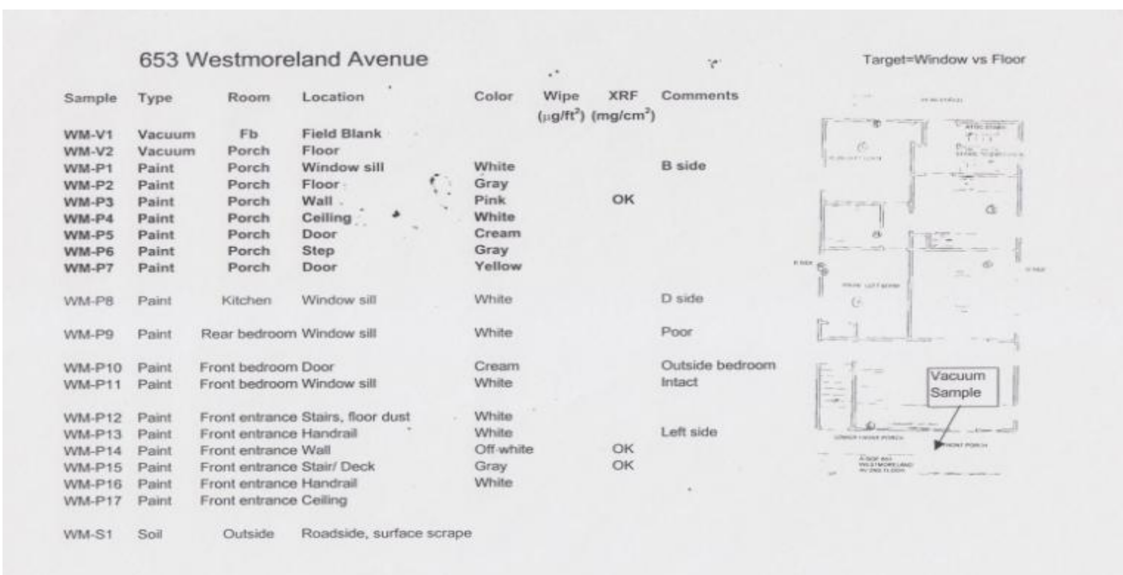
Twin Implicated Friction Sources

Window (poor condition) vs. Floor (poor condition)

Multi Story Family Home

Sampling Location:	**2^{nd} Floor Front (enclosed) Porch**
Collected Samples:	
Dust	**1. 2^{nd} Floor Front Porch Dust [O1]**
Implicated Friction Surface	**2. 2^{nd} Floor Front Porch Window Paint [O2]** **3. 2^{nd} Floor Front Porch Floor Paint [O3]**
Other LBP Surfaces	**4. 2^{nd} Floor Front Porch Door Paint (intact) [O7]** **5. 2^{nd} Floor Rear Kitchen Window** **6. 2^{nd} Floor Rear Bedroom Window** **7. 2^{nd} Floor Front Bedroom Window** **8. Front Entrance Stairs** **9. Front Entrance Wall** **10. Front Entrance Handrail**
Soil	**11. Yard Soil [O4]** **12. Road Dust [O5]**

Figure H 1 House O General View



653 Westmoreland Avenue

Sample	Type	Room	Location	Color	Wipe (μg/ft²)	XRF (mg/cm²)	Comments
WM-V1	Vacuum	Fb	Field Blank				
WM-V2	Vacuum	Porch	Floor				
WM-P1	Paint	Porch	Window sill	White			B side
WM-P2	Paint	Porch	Floor	Gray			
WM-P3	Paint	Porch	Wall	Pink		OK	
WM-P4	Paint	Porch	Ceiling	White			
WM-P5	Paint	Porch	Door	Cream			
WM-P6	Paint	Porch	Step	Gray			
WM-P7	Paint	Porch	Door	Yellow			
WM-P8	Paint	Kitchen	Window sill	White			D side
WM-P9	Paint	Rear bedroom	Window sill	White			Poor
WM-P10	Paint	Front bedroom	Door	Cream			Outside bedroom
WM-P11	Paint	Front bedroom	Window sill	White			Intact
WM-P12	Paint	Front entrance	Stairs, floor dust	White			
WM-P13	Paint	Front entrance	Handrail	White			Left side
WM-P14	Paint	Front entrance	Wall	Off-white		OK	
WM-P15	Paint	Front entrance	Stair/ Deck	Gray		OK	
WM-P16	Paint	Front entrance	Handrail	White			
WM-P17	Paint	Front entrance	Ceiling				
WM-S1	Soil	Outside	Roadside, surface scrape				

Figure H 2. House O Floor Plan

Table H 1 House O Lead Concentration Data by XRF

Analysis Number	House Code	Sample Description	Pb Conc (µg/g)	Error (µg/g)
HUD 066-1	**O3**	House O - Target Paint 1: Front porch window sill	25934.4	56
HUD 067-1	**O2**	House O - Target Paint 2: Front porch floor	163110.8	143.4
HUD 068-1	**O7**	House O - Competint Paint: Front porch door	172547.2	141.8
HUD 069-1	**O1**	House O - Cyclone Vacuum Dust Sample, Front porch	24229.9	53.5
HUD 070-1	**BLANK**		#DIV/0!	#DIV/0!
HUD 071-1	**O5**	House O - Mid-Yard Soil: By roadside	219.6	9.8
HUD 072-1	**O6**	House O- Road Dust	400.3	6.9

Table H.2 House O Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	House Code	Sample Description	206/204	207/204	208/204	207/206	208/206	207/208
HUD66	**O3**	House O - Target Paint 1: Front porch window sill	22.016	15.92	41.146	0.72313	1.86892	0.38692
HUD67	**O2**	House O - Target Paint 2: Front porch floor	19.995	15.754	39.603	0.7879	1.98058	0.39781
HUD68	**O7**	House O - Competint Paint: Front porch door	19.298	15.69	38.934	0.81307	2.01753	0.403
HUD69	**O1**	House O - Cyclone Vacuum Dust Sample, Front porch	19.703	15.737	39.34	0.79871	1.9966	0.40004
HUD71	**O5**	House O - Mid-Yard Soil: By roadside	18.708	15.635	38.402	0.83574	2.05273	0.40714
HUD72	**O6**	House O- Road Dust	18.742	15.677	38.487	0.83643	2.05349	0.40732

Table H 3 House O Pb bearing particles found in floor dust sample

Chemical Composition	**Morphology**	**Size**
Pb	Aggregate	1.85
Pb	Irregular	2.69
Pb	Irregular	1.67
Pb	Irregular	1.84
Pb	Irregular	1.05
Pb	Irregular	3.64
Pb	Irregular	2.43
Pb	Irregular	1.63
Pb	Irregular	2.2
Pb	Aggregate	2.24
Pb	Irregular	3.8
Pb	Irregular	1.68
Pb	Irregular	2.37
Pb	Irregular	1.73
Pb	Irregular	1.5
Pb	Irregular	2.18
Pb	Irregular	1.99
Pb	Aggregate	1.52
Pb	Irregular	1.44
Pb	Irregular	2.06
Pb	Irregular	2.41
Pb	Irregular	3.01
Pb	Irregular	0.595
Pb	Aggregate	2.61
Pb	Irregular	1.07
Pb	Irregular	1.56
PbCl	Irregular	7.3
PbTi	Aggregate	6.16
PbSi	Irregular	0.959
PbZn	Irregular	0.845
PbTi	Irregular	1.3
PbTi	Aggregate	20.1
PbP	Irregular	2.28
PbP	Irregular	1.92

Table H 3 - *Continued*

PbZn	Irregular	1.35
PbZn	Irregular	1.44
PbSi	Aggregate	4.19
PbSi	Aggregate	4.63
PbZnCa	Irregular	3.15
PbPNa	Irregular	3.18
PbCaP	Irregular	2.5
PbCaP	Irregular	1.77
PbZnSi	Aggregate	5.85
PbSiMg	Irregular	3.31
PbZnSi	Aggregate	2.18
PbZnP	Irregular	3.14
PbKNa	Irregular	2.87
PbCaP	Irregular	1.54
PbZnCa	Irregular	3.16
PbCaP	Irregular	1.66
PbCaP	Irregular	2.57
PbZnP	Irregular	4.08
PbZnCaP	Irregular	1.33
PbZnCaP	Irregular	2.74
PbZnCaP	Aggregate	3.04
PbZnCaP	Irregular	4.27
PbZnCaP	Irregular	1.42
PbZnSiMg	Aggregate	23.5
PbZnPCl	Irregular	3.9
PbZnCaP	Irregular	7.53
PbZnCaP	Irregular	1.74
PbZnCaP	Irregular	1.87
PbZnCaP	Aggregate	15.8
PbZnCaP	Irregular	1.66
PbZnCaP	Irregular	1.65
PbZnCaSi	Aggregate	5.18
PbCaPCl	Irregular	2.86
PbZnCaP	Irregular	1.68
PbZnCaP	Irregular	2.05

Table H 3 - *Continued*

PbZnSiMg	Aggregate	5.27
PbZnBaP	Aggregate	3.29
PbZnCaP	Aggregate	3.81
PbZnCaP	Irregular	4.46
PbZnCaP	Aggregate	4
PbZnCaP	Aggregate	2.91
PbZnCaP	Aggregate	2.97
PbZnCaP	Aggregate	3.12
PbZnBaCa	Aggregate	3.6
PbZnCaP	Aggregate	2.11
PbBaCaSi	Irregular	3.28
PbZnCaP	Aggregate	13.3
PbZnSiAlMg	Aggregate	4.5
PbZnCaPCl	Irregular	3.5
PbZnCaPCl	Aggregate	2.36
PbZnCaSiP	Irregular	1.13
PbZnCaSiP	Irregular	0.921
PbZnCaPCl	Irregular	3.11
PbZnBaCaP	Aggregate	2.55
PbZnCaPCl	Irregular	2.97
PbZnCaPCl	Irregular	1.66
PbZnCaPCl	Irregular	2.77
PbZnCaPCl	Irregular	1.52
PbZnCaPCl	Irregular	2.83
PbCaAlPNa	Irregular	7.34
PbZnTiCaSi	Aggregate	4.73
PbZnCaPCl	Aggregate	3.34
PbZnCaSiP	Aggregate	4.5
PbZnBaCaP	Irregular	3.3
PbZnCaAlFe	Aggregate	3.09
PbCaPClNa	Irregular	3.67
PbZnCaSiP	Aggregate	1.86
PbZnCaSiP	Aggregate	3.15/10.5
PbZnCaPFe	Irregular	1.13

PbZnCaSiP	Aggregate	5.22

Table H 3 - *Continued*

PbZnCaPFe	Irregular	1.26
PbZnCaSiP	Aggregate	2.46
PbZnTiCaP	Irregular	4.3
PbZnBaCrCaSi	Aggregate	5.81
PbCaSiPClNa	Irregular	1.55
PbZnCaSiPCl	Aggregate	4.83
PbZnCaSiPCl	Irregular	4.24
PbZnCaSiPCl	Irregular	3
PbZnCaSiPCl	Irregular	6.02
PbZnCaAlPMg	Aggregate	5.01
PbCaSiAlClNa	Aggregate	6.33
PbZnCaSiPCl	Aggregate	7.65
PbZnSiAlCaP	Irregular	5.86
PbZnCaSiPMg	Irregular	3.2
PbZnCaSiPCl	Aggregate	11.5
PbZnCaSiPCl	Aggregate	2.84
PbZnBaCaSiP	Aggregate	15.1
PbCaSiAlPNa	Aggregate	2.03
PbZnBaCaSiP	Aggregate	5.77
PbZnCaSiPCl	Aggregate	2.37
PbZnCaSiAlP	Aggregate	2.15
PbZnBaCaSiP	Aggregate	6.42
PbZnTiCaSiP	Aggregate	4.54
PbZnCaSiPCl	Aggregate	3.91
PbZnCaSiAlP	Aggregate	3.71
PbZnBaCaSiP	Aggregate	3.16
PbZnTiCaPCl	Aggregate	2.93
PbZnCaSiAlPFe	Irregular	1.51
PbZnCaSiAlPCl	Aggregate	4.26
PbZnBaCaKPCl	Irregular	9.66
PbZnCaSiAlPCl	Irregular	2.53
PbZnCaSiAlPCl	Irregular	4.75
PbZnCaSiPClMg	Aggregate	4.7
PbZnBaCaSiAlP	Aggregate	2.27

PbZnCaSiAlKP	Aggregate	4.26

Table H 3 - *Continued*

PbZnBaCaSiPCl	Aggregate	10.1
PbTiCaSiAlPNaFe	Aggregate	3.24
PbZnCaSiAlPFe	Aggregate	5.86
PbZnTiCaSiKPFe	Aggregate	5.98
PbZnCaPClMg	Aggregate	2.9
PbZnBaCaSiAlP	Aggregate	1.92
PbCaSiAlPMg	Irregular	6.28
PbZnCaSiAlKPCl	Aggregate	7.29
PbZnBaCaSiPMg	Aggregate	2.78
PbZnCaSiPMg	Aggregate	12.8
PbZnBaCaSiAlP	Irregular	4.74
PbZnCaSiPMg	Aggregate	3.7
PbZnCaSiAlKP	Irregular	2.73
PbZnCaSiAlPMgFe	Aggregate	5.62
PbZnCaSiAlClPMg	Irregular	5.41
PbZnCaSiAlKPFe	Aggregate	4.25
PbZnBaCaSiPMg	Aggregate	10.9
PbZnCaSiAlKPFe	Aggregate	5.51
PbZnCaSiAlPClMg	Aggregate	4.52
PbZnBaCaSiAlPMg	Aggregate	6.67
PbZnCaSiAlKClPFe	Aggregate	4.14
PbZnCaSiAlKPClFe	Aggregate	5.1
PbZnBaCaSiAlPMg	Aggregate	4.48
PbZnCaSiAlKPFe	Irregular	5.52
PbZnCaSiAlPClMgFe	Aggregate	3.22
PbZnBaCaSiPMgFe	Aggregate	4.06
PbZnTiCrCaSiAlMg	Aggregate	15.4
PbZnCaSiAlKPMgFe	Aggregate	6.33
PbZnCaSiAlKPMg	Aggregate	3.81
PbCaSiAlKPClMgNa	Irregular	2.79

Table H 4 House O Pb bearing particles found in front porch window sill paint

Chemical Composition	Morphology	Size
Pb	Irregular	3.01
Pb	Aggregate	3
Pb	Irregular	1.37
Pb	Irregular	2.31
Pb	Irregular	2.27
Pb	Irregular	1.61
Pb	Irregular	2.04
Pb	Irregular	1.55
Pb	Aggregate	3.08
Pb	Irregular	2.26
Pb	Irregular	1.28
Pb	Irregular	1.1
Pb	Aggregate	1.45
Pb	Aggregate	1.32
Pb	Irregular	1.22
Pb	Irregular	1.57
Pb	Irregular	1.52
Pb	Irregular	1.33
Pb	Irregular	1.28
Pb	Aggregate	4.67
Pb	Irregular	1.71
Pb	Irregular	1.24
Pb	Irregular	1.28
Pb	Irregular	1.2
Pb	Irregular	3.06
Pb	Aggregate	1.9
Pb	Irregular	1.37
Pb	Irregular	1.8
Pb	Irregular	2.37
Pb	Irregular	2.08
Pb	Irregular	1.8
Pb	Irregular	1.52
Pb	Irregular	1.91
Pb	Irregular	1.28

Table H 4 - *Continued*

Pb	Irregular	1.67
Pb	Irregular	2
Pb	Irregular	1.28
Pb	Irregular	1.33
Pb	Aggregate	1.58
Pb	Aggregate	4.65
Pb	Irregular	1.21
Pb	Irregular	1.52
Pb	Aggregate	6.77
Pb	Aggregate	4.47
Pb	Aggregate	3.35
Pb	Aggregate	4.58
Pb	Irregular	4.47
PbTi	Aggregate	2.81
PbTi	Aggregate	2.48
PbTi	Aggregate	5.46
PbTi	Aggregate	3.41
PbTi	Aggregate	2.17
PbTi	Aggregate	2.48
PbTi	Aggregate	6.9
PbTi	Aggregate	2.97
PbTi	Aggregate	3.3
PbTi	Aggregate	7
PbTi	Irregular	1.65
PbTi	Aggregate	1.76
PbTi	Aggregate	1.88
PbTi	Aggregate	3.94
PbTi	Aggregate	3.21
PbTi	Aggregate	3.66
PbTi	Aggregate	6.4
PbTi	Aggregate	7.96
PbZn	Aggregate	3.5
PbZn	Irregular	2.86
PbZn	Aggregate	4.54
PbP	Irregular	3.23

Table H 4 - *Continued*

PbTiZn	Aggregate	3.34
PbTiZn	Aggregate	5.62
PbTiZn	Aggregate	6.98
PbTiZn	Aggregate	1.7
PbTiZn	Aggregate	5.28
PbTiZn	Aggregate	3.44
PbTiZn	Aggregate	2.5
PbTiZn	Aggregate	3.72
PbTiZn	Aggregate	5.08
PbTiZn	Aggregate	3.48
PbTiZn	Aggregate	4.67
PbTiZn	Aggregate	5.22
PbTiZn	Aggregate	4.67
PbTiZn	Aggregate	4.93
PbTiZn	Aggregate	5.12
PbTiZn	Aggregate	5.65
PbTiZn	Aggregate	2.35
PbTiZn	Aggregate	8.47
PbTiZn	Aggregate	6.65
PbTiZn	Aggregate	2.56
PbTiZn	Aggregate	3.53
PbTiZn	Aggregate	4.15
PbTiZn	Aggregate	6.17
PbPNa	Aggregate	8.42
PbZnCl	Aggregate	5.77
PbZnMg	Aggregate	3.9
PbTiZn	Aggregate	8.46
PbTiZn	Aggregate	16.2
PbTiZn	Aggregate	6.94
PbTiZn	Aggregate	7.98
PbTiZn	Aggregate	6.06
PbTiZn	Aggregate	5
PbTiNa	Aggregate	2.6
PbSiMg	Aggregate	5.5
PbTiZnSi	Aggregate	3.13

Table H 4 - *Continued*

PbTiZnSi	Aggregate	15
PbTiZnSi	Aggregate	7.09
PbTiSiMg	Aggregate	8.04
PbTiSiMg	Aggregate	5.67
PbTiSiMg	Aggregate	8.6
PbZnBaSi	Aggregate	6.38
PbCaSiMg	Irregular	1.75
PbTiZnSiMg	Aggregate	7.89
PbTiZnSiMg	Aggregate	17
PbTiZnSiMg	Aggregate	6.44
PbTiZnSiMg	Aggregate	7.14
PbTiZnSiMg	Aggregate	12
PbTiZnSiMg	Aggregate	13.6
PbTiZnSiMg	Aggregate	3.76
PbTiZnSiMg	Aggregate	11
PbTiZnSiMg	Aggregate	3.88
PbTiZnSiMg	Aggregate	4.01
PbTiZnSiMg	Aggregate	11.6
PbTiZnSiMg	Aggregate	4.9
PbTiSiMgNa	Aggregate	6.73
PbTiSiMgNa	Aggregate	3.27
PbTiSiMgNa	Aggregate	3.38
PbTiZnCaSi	Aggregate	6.21
PbTiZnCaSi	Aggregate	5.81
PbZnSiAlP	Irregular	4.23
PbTiSiAlMg	Aggregate	6.05
PbTiZnSiAlMg	Aggregate	6.11
PbTiZnCaSiMg	Aggregate	10.8
PbTiZnCaSiMg	Aggregate	70
PbTiZnCaSiMg	Aggregate	134
PbTiZnCaSiMg	Aggregate	17
PbTiZnCaSiMg	Aggregate	27.5
PbTiZnCaSiMg	Aggregate	6.9
PbTiZnCaSiMg	Aggregate	12.4
PbTiZnCaSiMg	Aggregate	8.4

Table H 4 - *Continued*

PbTiZnCaSiMg	Aggregate	3.33
PbTiZnCaSiMg	Aggregate	9.57
PbTiZnCaSiMg	Aggregate	4.6
PbTiZnCaSiMg	Aggregate	23.2
PbTiZnCaSiMg	Aggregate	11.5
PbTiZnCaSiMg	Aggregate	9.47
PbTiZnCaSiMg	Aggregate	5.4
PbTiZnCaSiMg	Aggregate	10
PbTiZnCaSiMg	Aggregate	10.7
PbTiZnCaSiMg	Aggregate	11
PbTiZnSiAlMg	Aggregate	6.44
PbTiZnSiAlMg	Aggregate	14.6
PbTiZnCaSiMg	Aggregate	4.92
PbTiZnCaSiAlMg	Aggregate	6.02
PbTiZnCaSiAlMgFe	Aggregate	25.6
PbTiZnCaSiAlMgFe	Irregular	6.93
PbTiSiAlKMgFeP	Irregular	3.41
PbCaSiAlKPMgFeNa	Irregular	8.45

Table H 5 House O Pb bearing particles found in front porch floor paint sample

Chemical Composition	**Morphology**	**Size**
Pb	Irregular	2.01
Pb	Irregular	1.72
Pb	Irregular	1.31
Pb	Irregular	2
Pb	Aggregate	3.02
Pb	Aggregate	1.21
Pb	Aggregate	2.74
Pb	Irregular	1.48
Pb	Aggregate	2.36
Pb	Irregular	0.87
Pb	Aggregate	6.8
Pb	Aggregate	4.12
Pb	Rounded	1.03
Pb	Irregular	1.26
Pb	Irregular	1.09
Pb	Aggregate	3.53
Pb	Aggregate	3.1
Pb	Aggregate	4.54
Pb	Aggregate	1.73
Pb	Aggregate	1.54
Pb	Irregular	3.52
Pb	Irregular	1.18
Pb	Aggregate	10.8
Pb	Irregular	2.33
Pb	Aggregate	4.66
Pb	Aggregate	3.52
Pb	Irregular	3.33
PbZn	Aggregate	4.67
PbZn	Aggregate	4.37
PbZn	Aggregate	3.03
PbZn	Aggregate	4.3
PbZn	Aggregate	3.09
PbZn	Aggregate	2.85
PbZn	Aggregate	7.72

Table H 5 -*Continued*

PbZn	Aggregate	3.97
PbZn	Aggregate	2.53
PbZn	Aggregate	5.64
PbZn	Aggregate	2.91
PbZn	Aggregate	1.95
PbZn	Aggregate	2.67
PbBa	Aggregate	2.88
PbBa	Aggregate	11.2
PbTi	Aggregate	2.53
PbTi	Aggregate	3.7
PbTi	Aggregate	1.48
PbZnP	Irregular	1
PbSiMg	Aggregate	4.05
PbZn	Aggregate	5.94
PbZn	Aggregate	6.29
PbZn	Aggregate	4.5
PbZn	Irregular	1.53
PbZnBa	Aggregate	4.27
PbZnBa	Aggregate	3.71
PbZnBa	Aggregate	2.28
PbPNa	Aggregate	2.07
PbPNa	Aggregate	2.42
PbPNa	Irregular	3.48
PbPNa	Irregular	2.5
PbPNa	Irregular	1.7
PbBa	Aggregate	5
PbTiSi	Aggregate	9.62
PbSiP	Irregular	8.37
PbZn	Aggregate	4.29
PbZnBaSi	Aggregate	16.8
PbZnSiMg	Aggregate	5.84
PbZnSiMg	Aggregate	8.6
PbZnSiMg	Aggregate	4.98

Table H 5 - *Continued*

Chemical Composition	**Morphology**	**Size**
PbZnBaSi	Aggregate	4.7
PbZnBa	Aggregate	2.38
PbPClNa	Aggregate	2.87
PbTiCaP	Aggregate	8.73
PbZnCaP	Irregular	2.96
PbZnCaP	Aggregate	5.54
PbZnCaP	Aggregate	3.46
PbZnP	Aggregate	3.13
PbZnClP	Aggregate	4.02
PbZnP	Aggregate	2.75
PbZnP	Irregular	1.92
PbZnClP	Irregular	1.44
PbZnClP	Irregular	2.7
PbZnSiP	Irregular	3.02
PbBaNaP	Aggregate	1.96
PbBaNaP	Aggregate	3.95
PbCaNaP	Irregular	2.58
PbNaClP	Aggregate	3.36
PbZnSiAl	Aggregate	5.9
PbNaSiP	Aggregate	7.54
PbNaSiP	Aggregate	3.46
PbNaSiP	Irregular	2.25
PbZnCaP	Aggregate	2.81
PbZnCaPCl	Irregular	3.76
PbZnPCl	Irregular	1.63
PbZnPCl	Aggregate	2.9
PbZnPCl	Irregular	2.58
PbZnCaPCl	Irregular	1.64
PbZnCaP	Aggregate	2.51
PbZnCaP	Aggregate	5.01
PbZnP	Irregular	6.5
PbTiSiMgNa	Aggregate	3.2
PbZnBaSiMg	Aggregate	5.6
PbZnBaSiMg	Aggregate	14.8

Table H5 - *Continued*

Chemical Composition	**Morphology**	**Size**
PbZnCaSiMg	Aggregate	3.28
PbZnTiCaP	Aggregate	3
PbZnP	Irregular	2
PbZnSiPMg	Aggregate	8.41
PbCaPNa	Irregular	2.04
PbCaPNa	Aggregate	2.35
PbZnSiP	Aggregate	4.1
PbZnSiMg	Aggregate	3.74
PbCaNaClP	Irregular	1.7
PbTiSiP	Aggregate	8.77
PbTiCaNaP	Aggregate	3.21
PbZnBaSiAlP	Aggregate	3.4
PbZnCaSiPMg	Irregular	2.26
PbZnCaSiPMg	Irregular	1.2
PbZnTiCaClP	Aggregate	4
PbZnTiCaClP	Irregular	2.43
PbZnTiCaClP	Irregular	2.7
PbZnBaCaClP	Aggregate	10.7
PbTiCaSiPNa	Aggregate	4.98
PbZnBaCaSiP	Irregular	2.51
PbZnSiPClMg	Aggregate	9.11
PbZnTiSiAlP	Aggregate	3.31
PbZnBaCaClP	Aggregate	6.43
PbZnCaSiClP	Aggregate	4.63
PbZnBaSiMgFe	Aggregate	14
PbSiAlKNaP	Irregular	3.17
PbZnSiPMg	Irregular	5.16
PbZnSiPMg	Irregular	7.05
PbZnTiCaSiPMg	Irregular	4.26
PbZnTiCaSiPMg	Aggregate	5.34
PbZnTiCaSiPMg	Irregular	4.24
PbZnTiCaSiP	Aggregate	4.09
PbBaSiPMgNa	Aggregate	3.54
PbZnBaCaP	Aggregate	2.76

Table H5 - *Continued*

Chemical Composition	**Morphology**	**Size**
PbZnBaSiP	Aggregate	4.92
PbZnBaCaSiPMg	Aggregate	18.39
PbZnBaCaSiPMg	Aggregate	3.94
PbTiCaSiPMgNa	Aggregate	4.23
PbTiCaSiAlPNa	Aggregate	2.85
PbZnBaSi	Aggregate	12.2
PbZnBaCaSiMgP	Aggregate	10.5
PbZnBaCaSiAlPMg	Aggregate	11.4
PbZnTiCaSiPClMg	Aggregate	4.24
PbZnCaSiAlPClFe	Irregular	2.7
PbZnCaSiAlPFe	Irregular	2.96
PbZnTiCaSiAlKPFe	Aggregate	32.2

Table H 6 House O Pb bearing particles found in road dust sample

Chemical Composition	**Morphology**	**Size**
PbZnSiCl	Irregular	1.25
PbZnSiAlFe	Aggregate	1.6
PbCaSiAlKCl	Aggregate	8.01/3.03

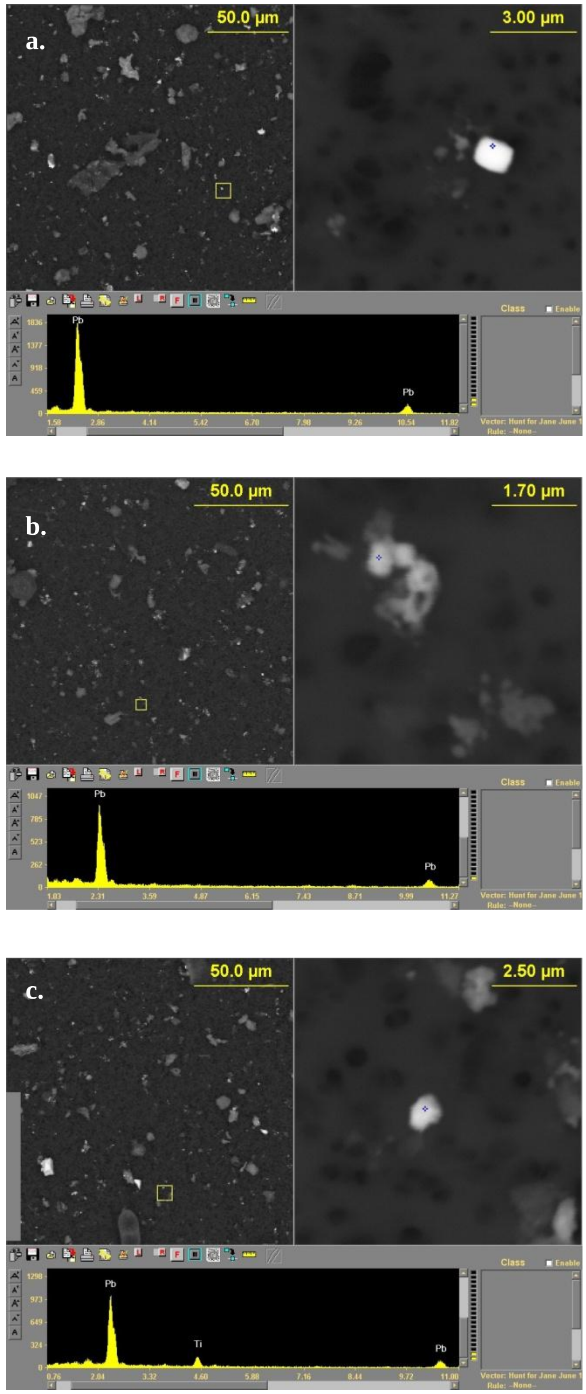


Figure H 3 House O front porch floor dust particle with Pb pigment particles (a, b) and Ti (c) in matrix

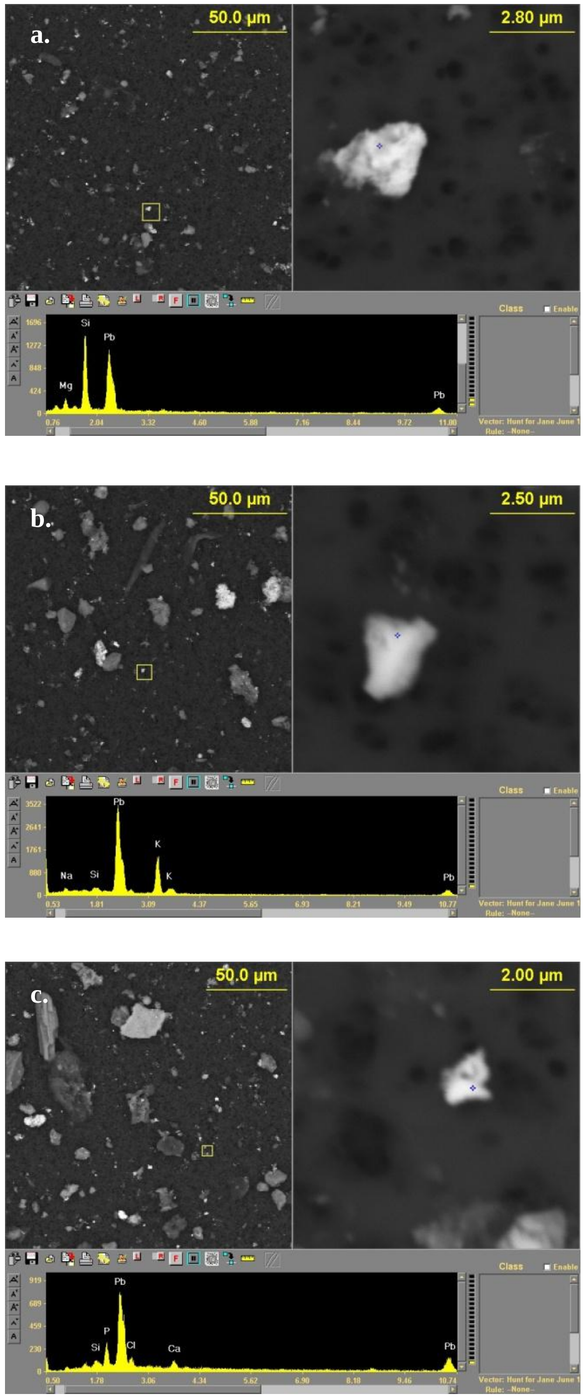


Figure H 4 House O front porch floor dust particles with Pb pigment and Si, Mg (a), K (b), Ca, P (c) in matrix

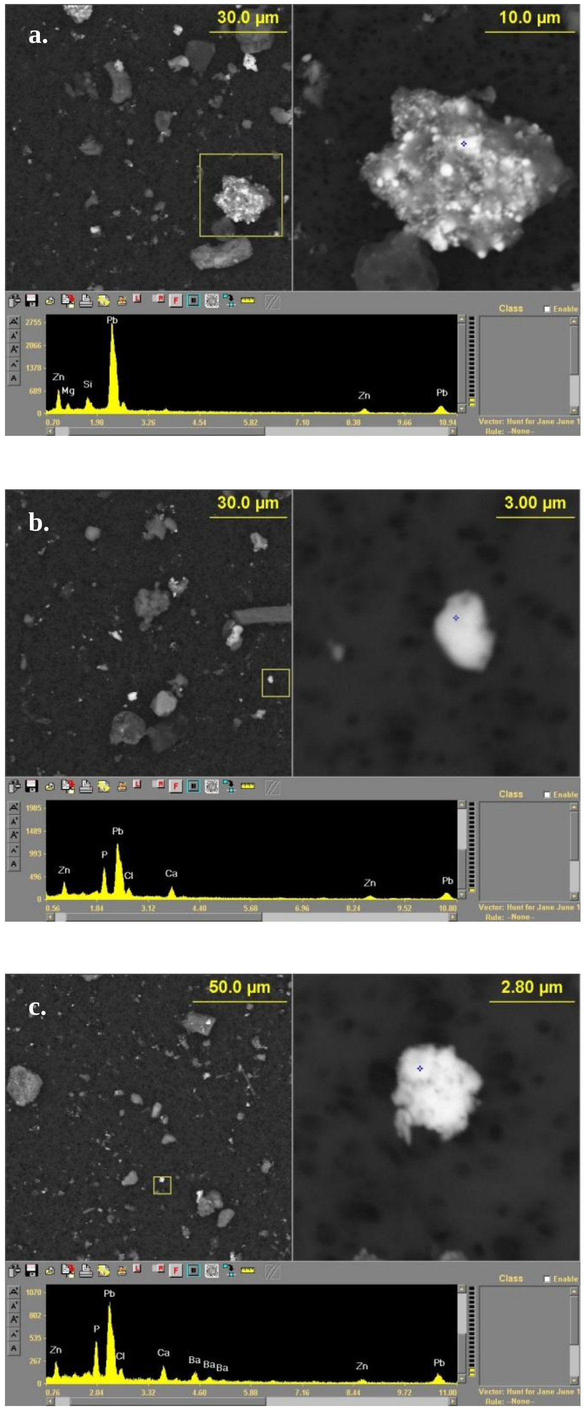


Figure H 5 House O front porch floor dust particles with Pb pigment and Zn, Si, Mg (a), Zn, P, Ca (b), Ca, P, Zn, Ba (c) in matrix

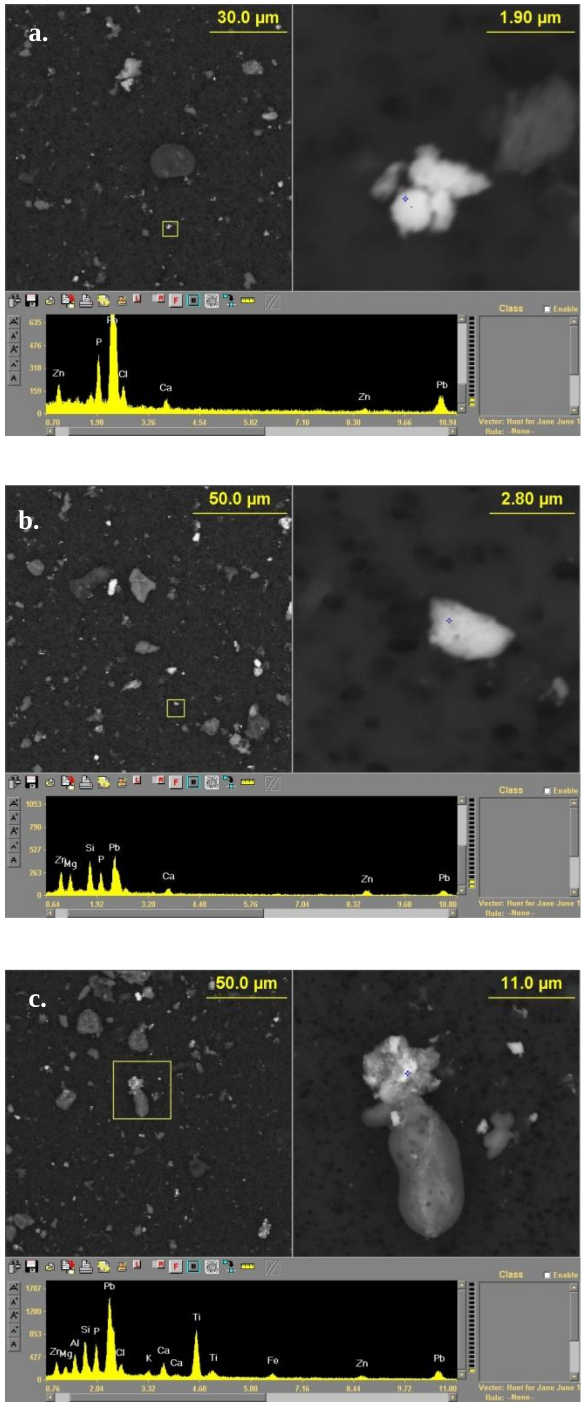


Figure H 7 House O front porch floor dust particles with Pb pigment and Zn, P, Cl, Ca (a), Zn, Si, Mg, P, Ca (b), Ca, P, Si, Al, Zn, Ti Fe, K, Mg (c) in matrix

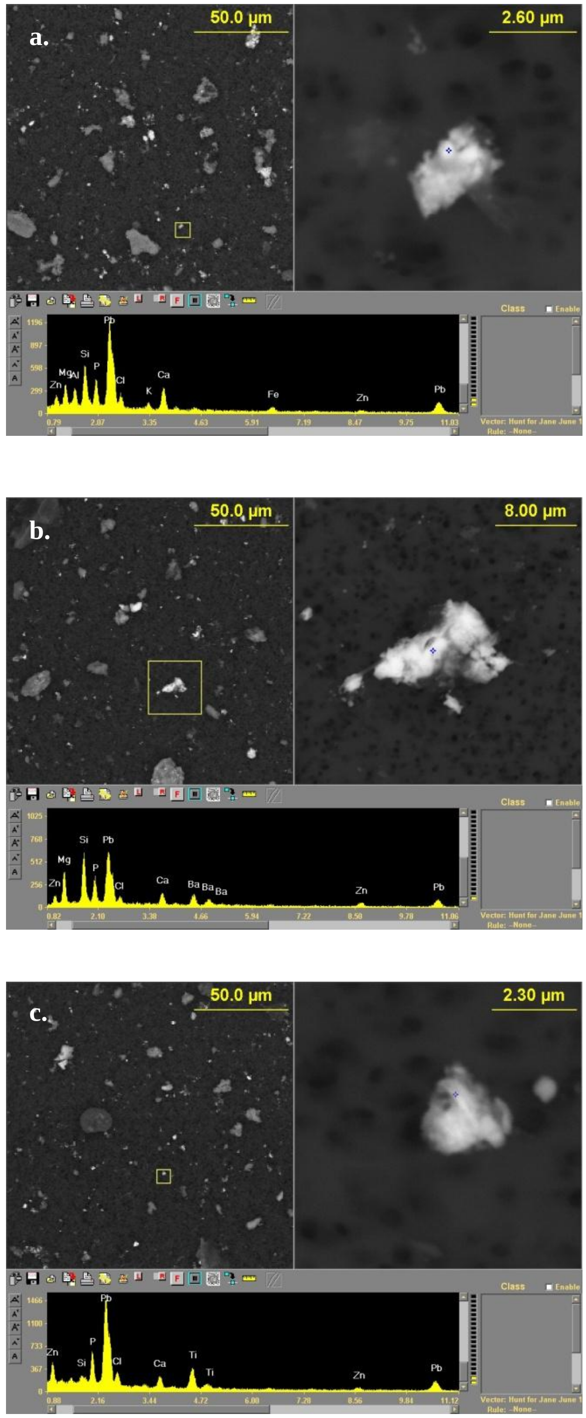


Figure H 8 House O front porch floor dust particles with Pb pigment and Ca, P, Si, Al, Zn, Fe, K, Mg (a), Zn, Mg Si, P, Ca, Ba (b), Ca, P, Zn, Ti (c) in matrix

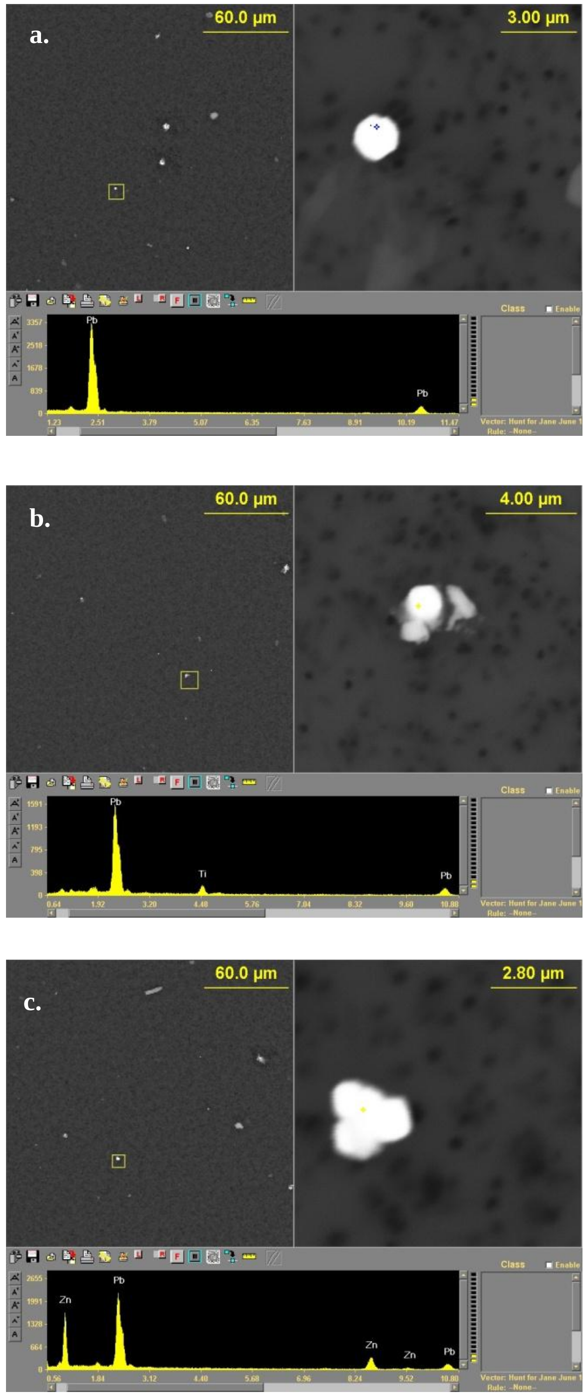


Figure H 9. House O window sill paint particles with Pb pigment (a), and Ti (b), Zn (c) in matrix

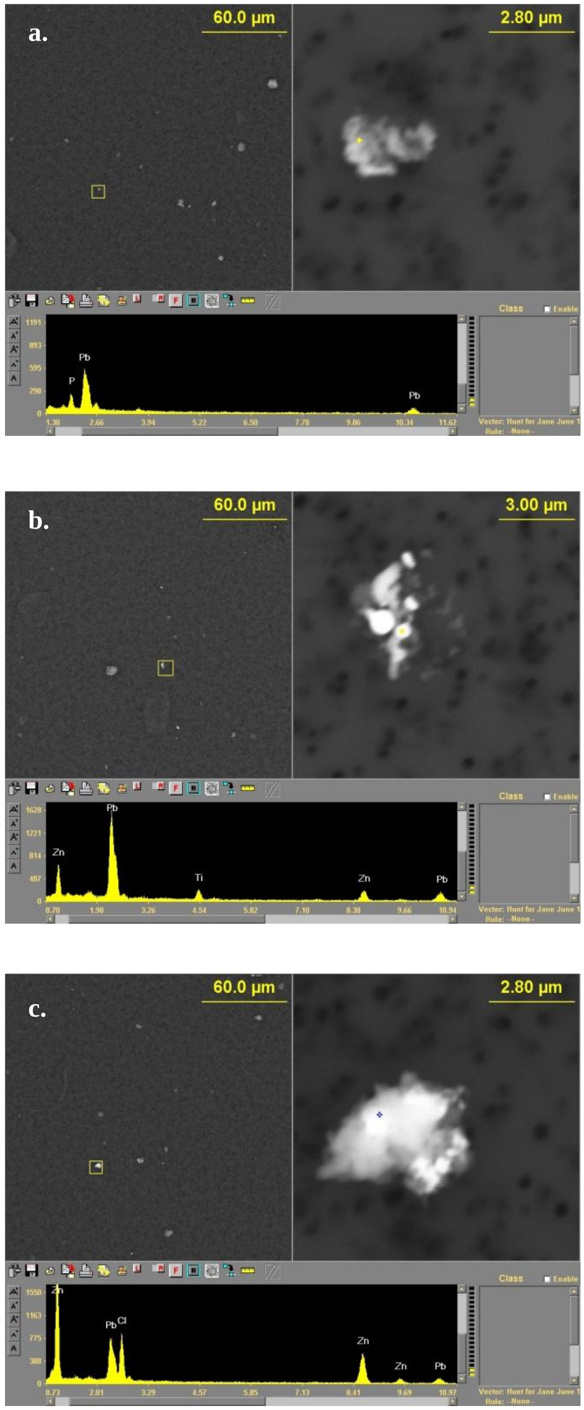


Figure H 10. House O window sill paint particles with Pb pigment and P (a), Zn, Ti (b), Zn, Cl (c) in matrix

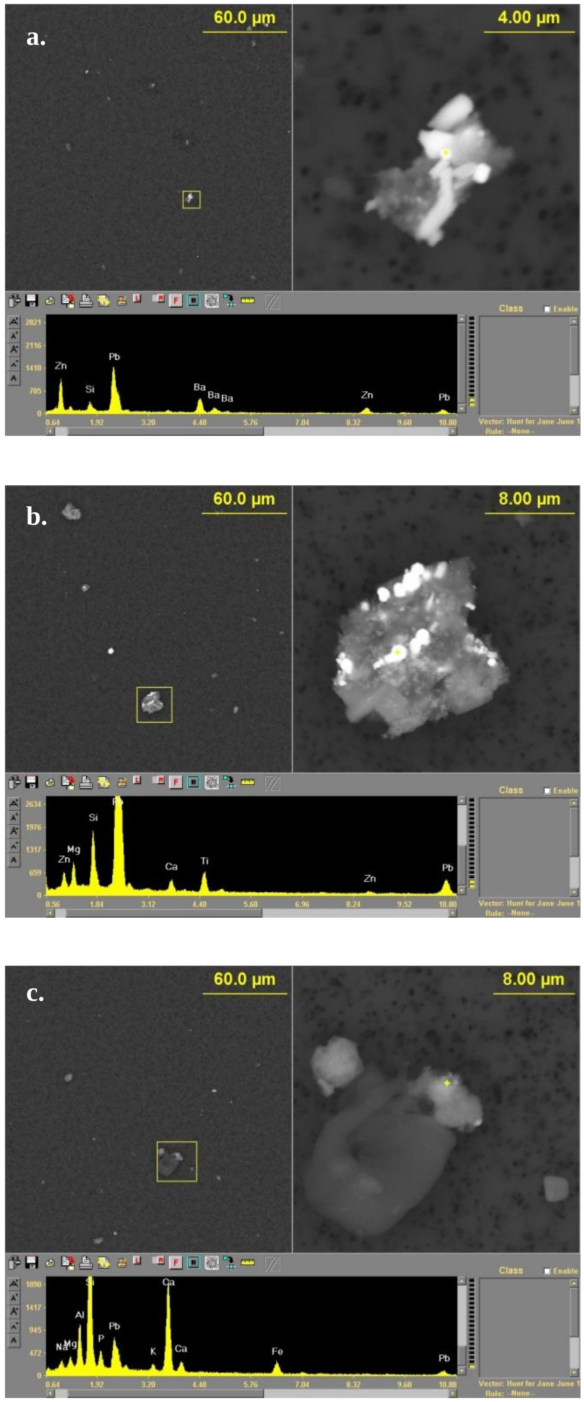


Figure H 11. House O window sill paint particles with Pb pigment and Zn, Ba, Si (a), Ti, Ca, Si, Mg, Zn (b), Ca, K, P, Si, Al, Mg, Fe (c) in matrix

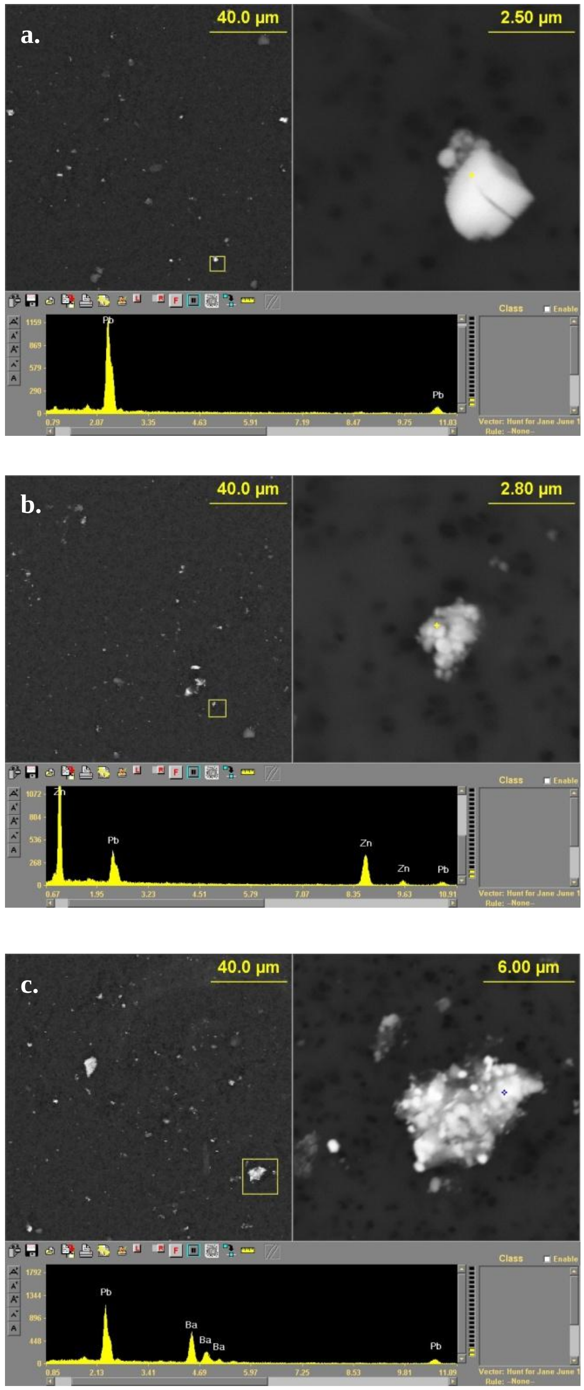


Figure H 12. House O front porch floor paint particles with Pb pigment (a), and Zn (b), Ba (c) in matrix

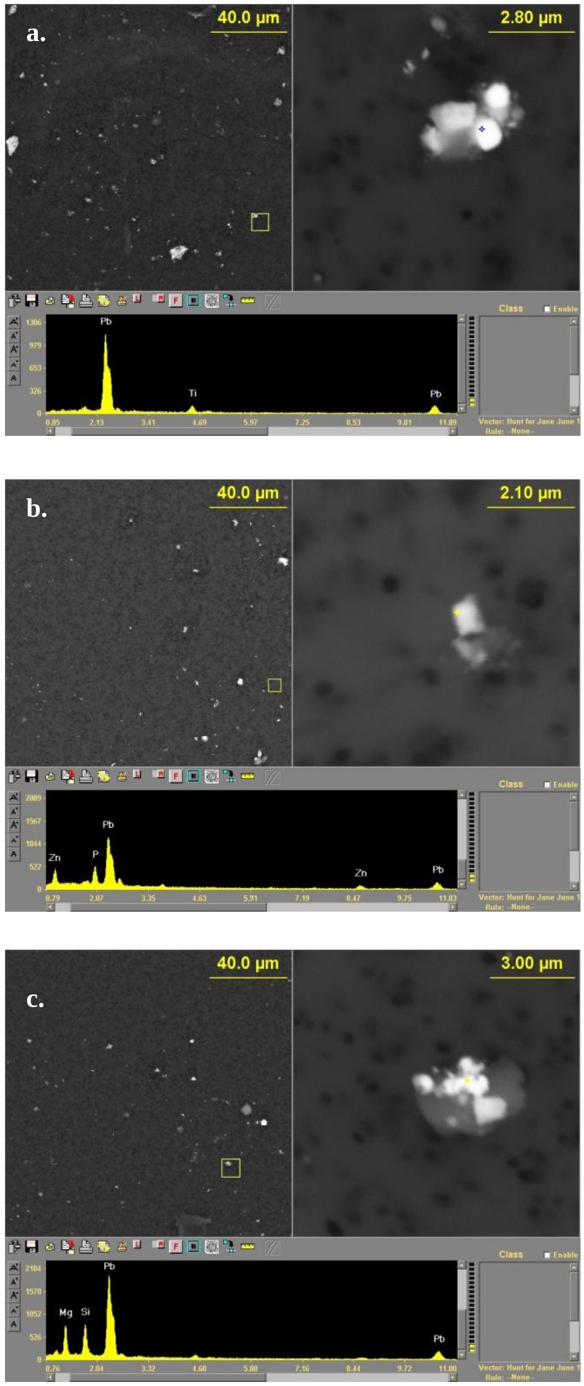


Figure H 13. House O front porch floor paint particles with Pb pigment and Ti (a), Zn, P (b), Si, Mg (c) in matrix

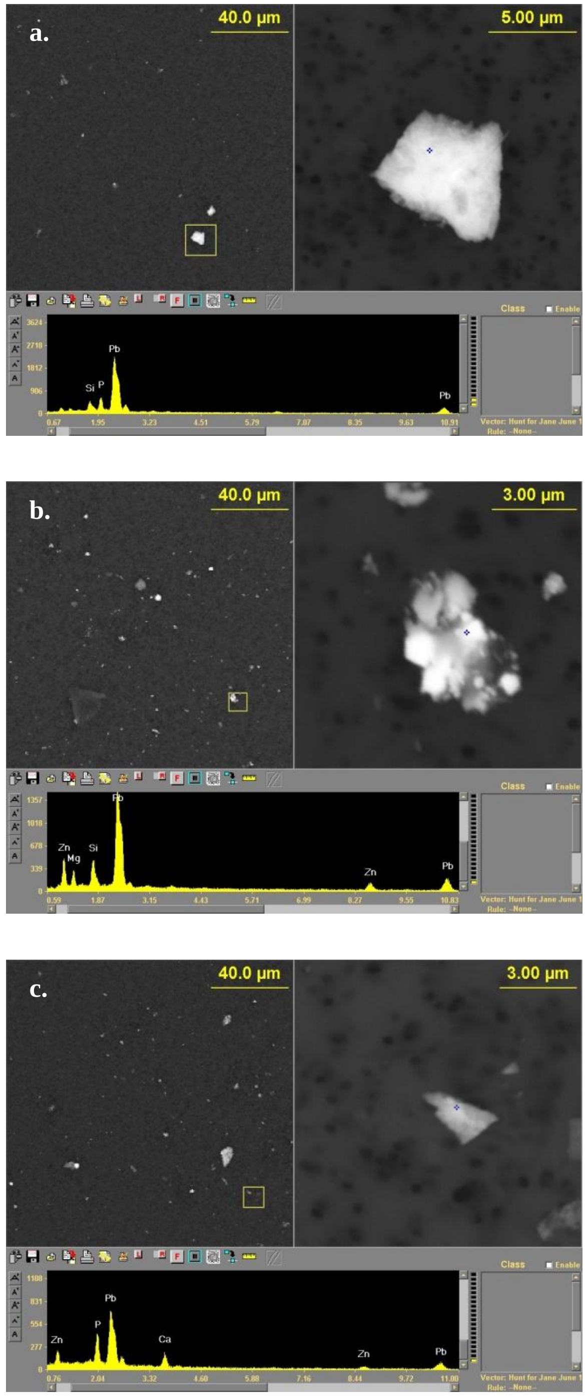


Figure H 14. House O front porch floor paint particles with Pb pigment and P, Si (a), Zn, Si, Mg (b), Zn, P, Ca (c) in matrix

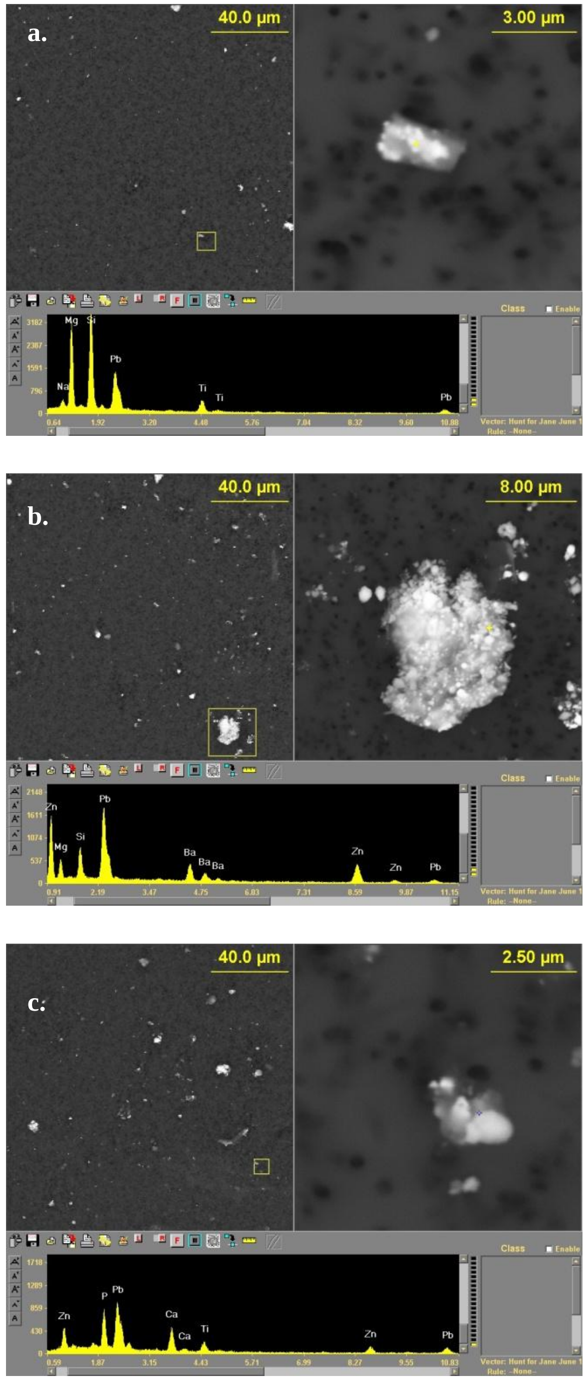


Figure H 15. House O front porch floor paint particles with Pb pigment and Si, Mg, Ti (a), Zn, Ba, Si, Mg (b), Ca, P, Zn, Ti (c) in matrix

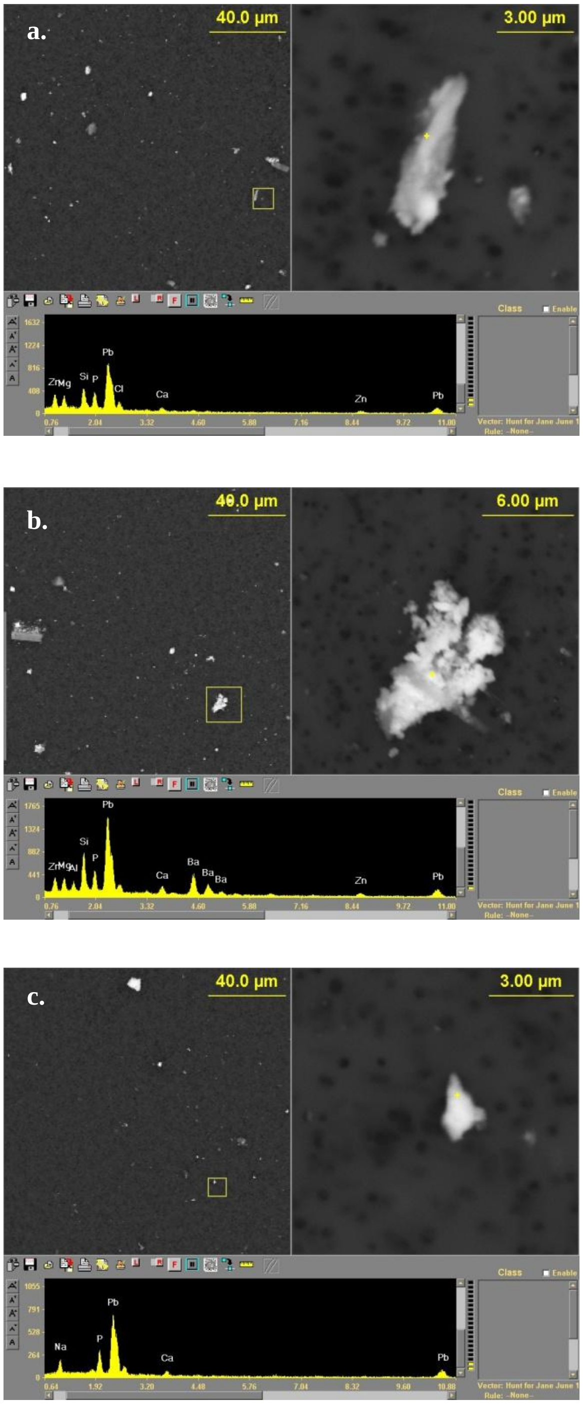


Figure H 16. House O front porch floor paint particles with Pb pigment and Zn, Si, Mg, P, Ca (a), Zn, Ba, Ca, P, Si, Al, Mg (b), Na, P, Ca (c) in matrix

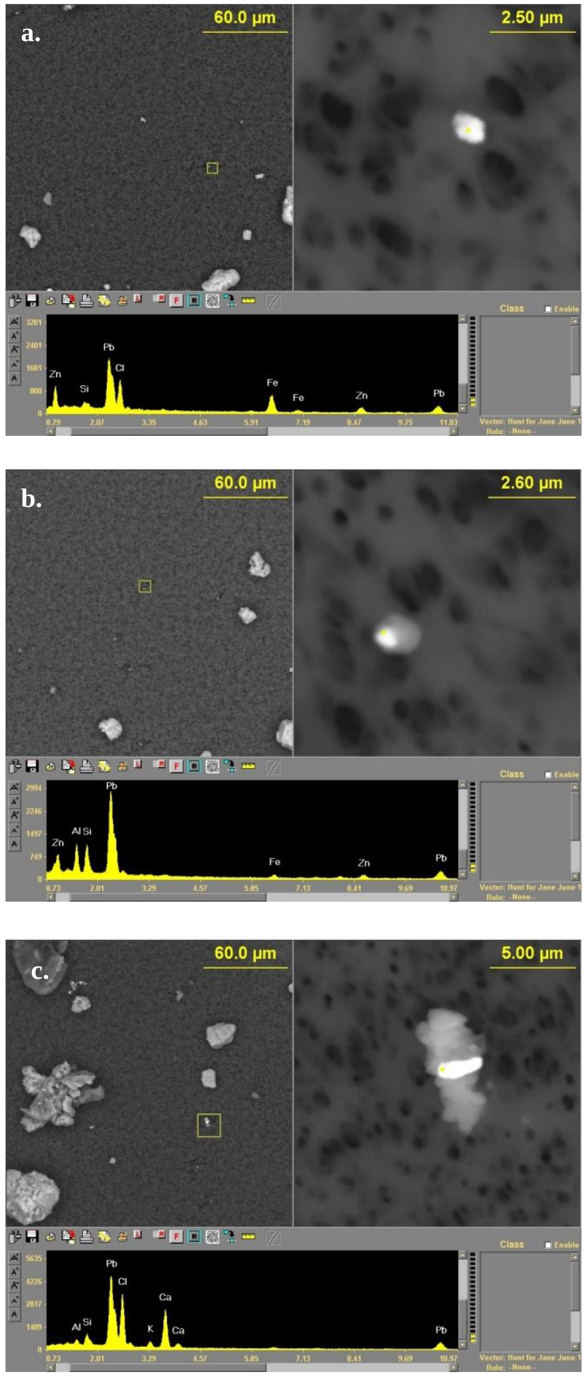


Figure H 17. House O road dust particles with Pb pigment and Zn, Cl, Fe (a), and Zn, Si, Al, Fe (b), Ca, Cl, Si, K(c) in matrix

Appendix I

Raw data, SEM images and X-Ray Spectra of House P

House P

Twin Implicated Friction Sources

Door (poor condition) vs. Floor (intact condition)

Multi Story Family Home

Sampling Location:	**1st Floor Rear Entrance**
Collected Samples:	
Dust	**1. 1st Floor Rear Entrance Dust [P1]**
Implicated Friction Surface	**2. 1st Floor Rear Entrance Door Paint [P2]** **3. 1st Floor Rear Entrance Floor Paint [P3]**
Other LBP Surfaces	**4. 2nd Floor Stairway Window Paint (intact)**
Soil	**5. Building Line Rear House [P4]** **6. Yard Soil [P5]** **7. Road Dust [P6]**

Figure I 1 House P General View

Table I.1 House P Lead Concentration Data by XRF

Analysis Number	House Code	Sample Description	Pb Conc (μg/g)	Error (μg/g)
HUD 039-1	**P1**	House P - Cyclone Vacuum Dust Sample: Rear entrance floor	18096.7	50.8
HUD 040-1	**BLANK**		-144.3	-937.1
HUD 041-1	**P5**	House P - Mid-Yard Soil: Front yard	804.4	11.5
HUD 042-1	**P4**	House P - Building Line Soil: By rear door	1340.2	12.7
HUD 043-1	**P6**	House P - Road Dust: Front of house	210.5	9.2
HUD 044-1	**P2**	House P - Target Paint: Rear entrance door, poor condition (P1)	50687.2	68.5
HUD 045-1	**P3**	House P - Competing Paint: Rear entrance floor, intact condition	6240.2	29.8

Table I-2 House P Lead Isotopic Ratio Data by Mass Spectroscopy

Analysis #	House Code	Sample Description	206/204	207/204	208/204	207/206	208/206	207/208
HUD39	**P1**	House P - Cyclone Vacuum Dust Sample: Rear entrance floor	18.592	15.651	38.601	0.84184	2.07628	0.40546
HUD41	**P5**	House P - Mid-Yard Soil: Front yard	18.864	15.661	38.79	0.83016	2.05625	0.40373
HUD42	**P4**	House P - Building Line Soil: By rear door	18.575	15.651	38.436	0.84258	2.06918	0.40721
HUD43	**P6**	House P - Road Dust: Front of house	18.719	15.644	38.461	0.83576	2.05472	0.40675
HUD44	**P2**	House P - Target Paint: Rear entrance door, poor condition (P1)	21.222	15.908	40.796	0.7496	1.92241	0.38993
HUD45	**P3**	House P - Competing Paint: Rear entrance floor, intact condition	19.039	15.686	38.781	0.82392	2.03697	0.40448

Table I-3 House P Pb bearing particles found in floor dust

Chemical Composition	Morphology	Size
Pb	Aggregate	9.28
Pb	Irregular	1.82
Pb	Irregular	4.46
Pb	Aggregate	1.61
Pb	Irregular	1.3
Pb	Irregular	2.03
Pb	Irregular	2.27
Pb	Irregular	1.4
Pb	Aggregate	8.67
Pb	Irregular	1.94
Pb	Irregular	1.97
Pb	Irregular	1.23
Pb	Aggregate	1.36
Pb	Irregular	1.52
Pb	Irregular	1.67
Pb	Irregular	2.14
Pb	Irregular	2.13
Pb	Irregular	1.53
Pb	Irregular	30.6
Pb	Aggregate	2.24
Pb	Aggregate	1.91
Pb	Irregular	1.92
Pb	Irregular	1.75
Pb	Irregular	2.18
Pb	Irregular	4.64
Pb	Aggregate	1.61
Pb	Irregular	3
Pb	Irregular	1.75
Pb	Aggregate	2.04
Pb	Irregular	1.66
Pb	Irregular	4.62
Pb	Irregular	1.22
Pb	Aggregate	5.44
Pb	Irregular	4.16

Table I 3 - *Continued*

Pb	Irregular	1.45
Pb	Irregular	5.08
Pb	Rounded	2.62
Pb	Irregular	0.93
Pb	Aggregate	1.4
Pb	Irregular	3.47
Pb	Irregular	1.15
Pb	Irregular	2.57
Pb	Irregular	0.95
Pb	Irregular	0.9222
Pb	Irregular	1.22
Pb	Irregular	1.15
Pb	Irregular	1.05
Pb	Irregular	1.63
Pb	Irregular	1.62
Pb	Irregular	1.63
Pb	Irregular	6.33
Pb	Irregular	1.93
Pb	Irregular	0.939
Pb	Aggregate	2.56
Pb	Irregular	0.7
Pb	Irregular	0.884
Pb	Irregular	0.983
Pb	Irregular	2.17
Pb	Irregular	1.88
Pb	Aggregate	1.72
Pb	Irregular	1.62
Pb	Irregular	3.16
Pb	Aggregate	2.15
Pb	Irregular	1.35
Pb	Aggregate	5.24
Pb	Irregular	2.02
PbSi	Irregular	1.71
PbSi	Aggregate	2.11
PbSi	Aggregate	2.41

Table I 3 - *Continued*

PbSi	Irregular	1.18
PbSi	Irregular	1.25
PbSi	Irregular	2.81
PbSi	Irregular	1.21
PbSi	Aggregate	3
PbSi	Irregular	1.32
PbSi	Irregular	1.43
PbSi	Rounded	1.04
PbSi	Irregular	1.65
PbSi	Aggregate	2.71
PbSi	Rounded	0.808
PbSi	Irregular	1.78
PbSi	Aggregate	2.85
PbCa	Irregular	1.65
PbCa	Irregular	1.73
PbCa	Irregular	0.751
PbCa	Irregular	2.05
PbCa	Aggregate	3.23
PbZn	Aggregate	7.74
PbZn	Irregular	1.82
PbZn	Aggregate	1.5
PbZn	Aggregate	3.3
PbZn	Irregular	2.6
PbZn	Irregular	1.85
PbZn	Aggregate	4.61
PbZn	Irregular	2.03
PbZn	Aggregate	2.07
PbZn	Aggregate	1.47
PbZn	Aggregate	2.19
PbZn	Aggregate	2.32
PbCr	Irregular	1.94
PbCr	Irregular	2.9
PbCl	Irregular	3.54
PbCl	Irregular	4.5
PbCl	Aggregate	2.67

Table I 3 - *Continued*

PbTi	Aggregate	3
PbTi	Irregular	1.5
PbSiAl	Irregular	2.73
PbSiAl	Aggregate	3
PbSiAl	Irregular	0.85
PbSiAl	Irregular	1.15
PbSiAl	Irregular	1.52
PbSiAl	Irregular	1.15
PbSiAl	Irregular	0.829
PbSiAl	Irregular	9.86
PbSiAl	Irregular	1.73
PbSiAl	Irregular	1.23
PbSiAl	Irregular	0.923
PbSiAl	Irregular	1.91
PbSiAl	Irregular	1.33
PbSiAl	Irregular	3.04
PbSiAl	Irregular	1.87
PbSiAl	Irregular	1.34
PbFe	Aggregate	5.52
PbSiCl	Aggregate	2.52
PbSi	Aggregate	8.03
PbSiCa	Irregular	1.7
PbSiCa	Irregular	1.05
PbSiMg	Irregular	0.73
PbSiSn	Aggregate	1.78
PbPNa	Irregular	1.58
PbTiSi	Irregular	2.5
PbTiCa	Aggregate	4.4
PbZnCa	Irregular	1.95
PbZnCa	Aggregate	2.3
PbZnCa	Irregular	0.884
PbZnCa	Aggregate	1.5
PbZnCa	Aggregate	1.18
PbZnSi	Irregular	0.97
PbZnSi	Aggregate	3.97

Table I 3 - *Continued*

PbZnSi	Aggregate	2.21
PbZnSi	Aggregate	8.12
PbZnCl	Irregular	1.93
PbZnCl	Aggregate	2.27
PbZnCl	Aggregate	7.67
PbZnCl	Aggregate	8.44
PbZnCl	Aggregate	3.86
PbZnCl	Aggregate	1.83
PbZnCl	Aggregate	4.11
PbZnCl	Aggregate	4.17
PbZnFe	Irregular	1.78
PbCaSi	Aggregate	1.75
PbCaSi	Rounded	0.62
PbCaSi	Irregular	2
PbCaSi	Aggregate	3.34
PbCaSi	Irregular	3.88
PbCaNa	Aggregate	2.53
PbZnSiCl	Aggregate	29.4
PbZnSiMg	Aggregate	3.47
PbZnSiAl	Aggregate	2.57
PbZnSiCl	Aggregate	2.94
PbZnSiCl	Aggregate	10.3
PbZnSiCl	Aggregate	5.2
PbZnSiCl	Aggregate	5.05
PbZnCaCl	Aggregate	6.15
PbZnCaCl	Aggregate	7.68
PbZnCaCl	Irregular	1.4
PbZnCaSi	Irregular	1.3
PbZnCaSi	Aggregate	5.34
PbZnCaSi	Aggregate	28
PbTiSi	Aggregate	3.4
PbSiAlFe	Aggregate	8.7
PbBaCaNa	Aggregate	10.5
PbCaSiAl	Aggregate	2.53
PbCaSiAl	Aggregate	4.41

Table I 3 - *Continued*

PbCaSiAl	Irregular	3.06
PbCaSiAl	Irregular	0.987
PbCaSiNa	Irregular	1.86
PbCaClK	Irregular	2.58
PbClSiAl	Irregular	1.1
PbSiAlK	Elongated	1.26
PbSiAlMg	Aggregate	3.53
PbTiCaSi	Irregular	0.408
PbZnCaSiMg		1.41
PbZnTiSiMg	PlattyAggregate	8.02
PbZnCrSiMg	Aggregate	6.48
PbZnSiMgCl	Aggregate	14.1
PbZnCaSiAl	Aggregate	4.57
PbZnCaSiAl	Irregular	1.78
PbZnCaSiCl	Aggregate	4.67
PbZnCaSiCl	Irregular	1.05
PbZnCaSiAl	PlattyAggregate	2.96
PbZnCaKP	Irregular	1.38
PbZnSiAlCl	Aggregate	9.68
PbZnSiAlMg	Aggregate	3.82
PbTiCaSiAl	Irregular	2.66
PbTiCaSiAl	Aggregate	1.98
PbTiCaSiAl	Aggregate	4.68
PbTiSiAlNa	Paint like Aggregate	2.53
PbCaSiAlMg	Irregular	2.27
PbCaSiAlMg	Aggregate	3.92
PbCaSiAlMg	Aggregate	1.25
PbCaSiAlP	Irregular	1.5
PbCaSiAlCl	Irregular	3.25
PbCaSiAlCl	Aggregate	3.35
PbCaKNaP	Irregular	1.26
PbCaSiNaFe	PlattyAggregate	7.08
PbSiAlMgFe	Aggregate	1.42
PbSiAlMgFe	Aggregate	5.11
PbZnBaCaCl	PlattyAggregate	26

Table I 3 - *Continued*

PbZnTiCaSi	Aggregate	1.5
PbCaSiAlMgFe	Aggregate	3.4
PbCaSiAlClP	Irregular	3.4
PbCaSiClPNa	Aggregate	3
PbCaClPNaK	Irregular	1.5
PbZnCaSiAlMg	Aggregate	4.09
PbZnCaSiClMg	Aggregate	4.3
PbZnCaSiClMg	Aggregate	16
PbTiZnCaSiAl	Aggregate	4.05
PbTiZnCaSiAl	Aggregate	6.28
PbTiZnSiAlMg	Aggregate	5.75
PbTiZnCaSiMg	Aggregate	23
PbZnBaSiMgCl	Platty Aggregate	21
PbZnBaSiMgCa	Irregular	2.98
PbSiAlMgKFe	Aggregate	8.6
PbZnTiCaSiMgCl	Aggregate	12.1
PbZnTiCaSiMgCl	Platty Aggregate	12
PbZnTiCaSiAlMg	Aggregate	11.6
PbZnCaSiAlMgCl	Aggregate	4.95
PbZnCaSiAlClFe	Aggregate	11.4
PbZnBaCaSiAlCl	Aggregate	4.12
PbCaSiAlKMgCl	Irregular	3.88
PbCaSiAlMgNaFe	Aggregate	5.16
PbTiCrCaSiAlFe	Aggregate	12.7
PbCaSiAlPClKNa	Aggregate	5.77
PbCaSiAlPClMgNa	Aggregate	8.05
PbZnTiCrCaSiAlMgFe	Aggregate	13.6
PbTiCaSiAlMgClPNa	Irregular	1.52

Table I-4 House P Pb bearing particles found in door paint sample

Chemical Composition	Morphology	Size
Pb	Irregular	1.53
Pb	Irregular	1.3
Pb	Irregular	2.1
Pb	Irregular	1.92
Pb	Irregular	1.42
PbZn	Aggregate	6.12
PbZn	Aggregate	12.1
PbZn	Aggregate	12.1
PbZn	Aggregate	6.3
PbZn	Aggregate	4.86
PbZn	Aggregate	2.42
PbZn	Aggregate	7.37
PbZn	Aggregate	5.46
PbZn	Aggregate	3.44
PbZn	Aggregate	3.28
PbZn	Aggregate	5.6
PbZn	Aggregate	4.82
PbZn	Aggregate	4
PbZn	Aggregate	4.62
PbZn	Aggregate	36.1
PbZn	Aggregate	4.16
PbZn	Aggregate	4.8
PbZn	Aggregate	4.26
PbZn	Aggregate	5.96
PbZn	Aggregate	2.51
PbZn	Aggregate	3.4
PbZn	Aggregate	2.3
PbZn	Aggregate	7.8
PbZn	Aggregate	3.91
PbZn	Aggregate	4.05
PbZn	Aggregate	7.07
PbZn	Aggregate	6.06
PbZn	Aggregate	4.7
PbZnSi	Aggregate	8.56

Table I 4 - *Continued*

PbZnSi	Aggregate	21.3
PbZnSi	Aggregate	56
PbZnSi	Platty Aggregate	11.1
PbZnSi	Platty Aggregate	4.28
PbZnSi	Aggregate	3.61
PbZnSi	Aggregate	6.86
PbZn	Aggregate	6.3
PbZnSi	Platty Aggregate	3.8
PbZnSi	Aggregate	27.2
PbZnBa	Aggregate	7.7
PbZnBa	Aggregate	7.7
PbZnBa	Aggregate	3.37
PbZnBa	Platty Aggregate	5.34
PbZnCa	Aggregate	15.3
PbZnCa	Aggregate	3.85
PbZnCa	Aggregate	6.02
PbZnCa	Aggregate	9.17
PbZnP	Aggregate	4.14
PbZnSiAl	Aggregate	13.2
PbZnSiAl	Aggregate	14.6
PbZnSiMg	Aggregate	20
PbZnSiMg	Aggregate	18.8
PbZnSiMg	Aggregate	9.71
PbZnSiMg	Aggregate	5.97
PbZnSiMg	Aggregate	14
PbZnSiMg	Platty Aggregate	42.4
PbZnSiMg	Aggregate	5.7
PbZnSiMg	Aggregate	13
PbZnBaSi	Aggregate	8.22
PbZnBaSi	Aggregate	41.6
PbZnBaCa	Aggregate	3.72
PbZnBaCa	Aggregate	6.89
PbZnCaSi	Aggregate	3.76
PbZnTiCa	Aggregate	3.08
PbZnTiCa	Platty Aggregate	6.58

Table I 4 - *Continued*

PbZnTiCa	Aggregate	11.5
PbZnTiCa	Aggregate	12.7
PbZnCaSiMg	Aggregate	8.32
PbZnCaSiMg	Aggregate	10.5
PbZnCaSiMg	Aggregate	12.4
PbZnCaSiMg	Aggregate	3.6
PbZnTiCaSi	Aggregate	8.88
PbZnTiCaSi	Aggregate	8.28
PbZnBaCaSi	aggregate	40.2
PbZnBaCaSi	aggregate	73.5
PbZnBaCaSi	aggregate	33.4
PbZnBaCaP	Aggregate	7.45
PbZnBaSiMg	Platty Aggregate	10.8
PbZnSiPMg	Aggregate	26.7
PbZnSiPMg	Aggregate	4.01
PbZnCaAlP	Irregular	6.03
PbZnCaSiMg	Aggregate	2.58/21
PbZnTiCaSiMg	Aggregate	33.1
PbZnTiCaSiMg	Aggregate	11.3
PbZnTiCaSiMg	Platty Aggregate	11.4
PbZnTiCaSiMg	Aggregate	11.4
PbZnTiCaSiAl	Aggregate	40
PbZnBaCaSiMg	Aggregate	33.4
PbZnCaSiMgP	Aggregate	6.41
PbZnCaSiMgP	Aggregate	8.77
PbZnCaSiMgCl	Aggregate	21
PbZnBaCaSiPMg	Aggregate	10.7
PbZnBaCaSiMg	Aggregate	67.7
PbZnBaCaSiPMg	Aggregate	36.3
PbZnTiCaSiAlMg	Aggregate	28.6
PbZnTiCaSiAlMg	Aggregate	31.5
PbZnCaSiAlKP	Aggregate	7.93
PbZnCaSiMgKP	Aggregate	6.53

Figure I 5 House P Pb bearing particles found in floor paint sample

Chemical Composition	Morphology	Size
Pb	Irregular	3.85
Pb	Irregular	2.07
Pb	Rounded	1.15
Pb	Irregular	1.27
Pb	Aggregate	3.3
Pb	Irregular	1.31
Pb	Irregular	2.93
Pb	Irregular	4.1
Pb	Irregular	1.7
Pb	Irregular	0.68
Pb	Irregular	2.34
Pb	Irregular	1.34
Pb	Irregular	1.64
Pb	Irregular	1.9
PbZn	Aggregate	2.85
PbZn	Aggregate	1.67
PbZn	Aggregate	2.3
PbZn	Irregular	1.38
PbZn	Aggregate	1.47
PbZn	Aggregate	6.48
PbZn	Irregular	1.47
PbZn	Aggregate	4.53
PbZn	Aggregate	6.3
PbZn	Aggregate	2.7
PbZn	Aggregate	3.9
PbZn	Aggregate	5.57
PbZn	Aggregate	3.18
PbZn	Aggregate	3.8
PbZn	Aggregate	5
PbZn	Irregular	1.73
PbZnBa	Aggregate	4.8
PbZnMg	Aggregate	2.08
PbPNa	Irregular	1.9
PbPNa	Aggregate	9.55

Table I 5 - *Continued*

PbPNa	Irregular	1.36
PbTiCa	Aggregate	10
PbTiCa	Aggregate	3.08
PbCrCa	Aggregate	0.97
PbTiCrCa	Aggregate	2.72
PbTiCrCa	Aggregate	3.71
PbTiCrCa	Aggregate	1.63
PbZnTiSi	Aggregate	9.57
PbZnTi	Aggregate	2.81
PbZnTiSi	Aggregate	3.63
PbZnTiCa	Aggregate	4.42
PbClPNa	Aggregate	9.68
PbCaPNa	Irregular	1.54
PbCaPNa	Irregular	5.38
PbCaPNa	Irregular	2.2
PbCaPNa	Irregular	1.34
PbCaPZn	Aggregate	3.67
PbZnSiMg	Aggregate	8.18
PbZnSiMg	Aggregate	5.5
PbZnSiMg	Aggregate	2.95
PbZnSiMg	Aggregate	4.58
PbZnCaCl	Aggregate	2.42
PbZnCaP	Aggregate	1.46
PbZnBaCa	Aggregate	7.47
PbSiPNa	Aggregate	2.77
PbCakClNa	Aggregate	4.62
PbCaPClNa	Irregular	3.15
PbCaPClNa	Aggregate	3.12
PbZnCaPCl	Irregular	2.02
PbZnCaPCl	Irregular	1.6
PbZnCaPCl	Irregular	2.12
PbZnCaPCl	Aggregate	1.38
PbZnCaSiP	Aggregate	4.8
PbZnCaSiP	Aggregate	1.71
PbZnCrTiCa	Aggregate	2.47

Table I 5 - *Continued*

PbZnTiCaK	Aggregate	3.1
PbTiCrCaNa	Aggregate	2.2
PbZnBaSiMg	Aggregate	5.55
PbTiCaSiAl	Aggregate	4.23
PbTiCaNaP	Irregular	3.45
PbZnCaSiAlMg	Aggregate	3.4
PbZnCaSiMgFe	Aggregate	5.14
PbZnCaSiMgFe	Aggregate	5
PbZnTiCaSiMg	Aggregate	5.14
PbZnTiCrCaSi	Aggregate	4.81
PbZnTiCrCaSi	Aggregate	2.24
PbZnCaSiPCl	Aggregate	3.47
PbBaCaSiPNa	Aggregate	2.21
PbZnCaSiKPMg	Aggregate	17.6
PbZnCaSiPMgCl	Aggregate	3.97
PbCaSiKNaCl	Aggregate	1.81
PbZnTiCaSiPMg	Aggregate	5.5
PbZnTiCaSiAlPMg	Aggregate	9.06
PbZnTiCaSiAlPCl	Aggregate	2.14
PbZnTiCaSiAlFeMg	Aggregate	8.23
PbZnTiCrCaSiAlFe	Aggregate	3.06
PbZnCaSiClMgFe	Aggregate	3.1
PbZnCaSiAlKMgFe	Aggregate	7.73
PbZnCaSiAlKPClMg	Irregular	2.94
PbZnTiCaSiAlPMgFeCl	Aggregate	3.38
PbZnTiCaSiAlKMgFeCl	Irregular	2.78

Table I 6 Houese P Pb bearing particles found in building line soil

Chemical Composition	**Morphology**	**Size**
PbTi	Irregular	0.87
PbCa	Irregular	1.1
PbCaP	Irregular	0.872
PbZnClKSi	Aggregate	11.4
PbCaClPSi	Irregular	2.24
PbCaPClNa	Irregular	1.08
PbCaClPSiAl	Irregular	5.62
PbCaClPSiAl	Irregular	6.24
PbCaClPSiAl	Irregular	3.11
PbCaPSiAl	Irregular	0.97
PbCaPClSiAlNa	Aggregate	9.8
PbCaPSiAlKNa	Irregular	0.97
PbCaPClSiAlMgNa	Aggregate	4.48
PbCrCaSiAlKMgFe	Aggregate	4.91
PbTiCaSiAlPMgFe	Irregular	1.67
PbZnSnSiAlPCuClFe	Aggregate	12.2
PbCaSiAlKPClMgFeNa	Aggregate	5.63
PbCaSiAlKPClMgFeNa	Aggregate	2.77
PbZnCaSiAlKPClMgFe	Aggregate	6.8

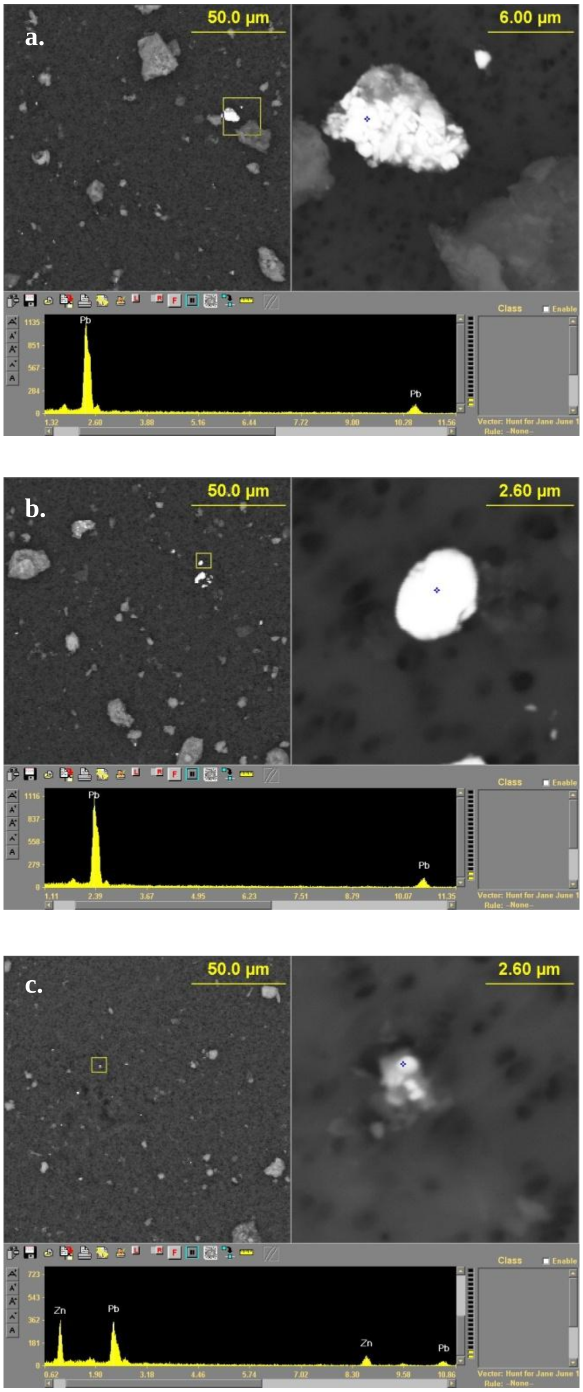


Figure I 2 House P floor dust particle with Pb pigment particles (a, b) and Zn (c) in matrix

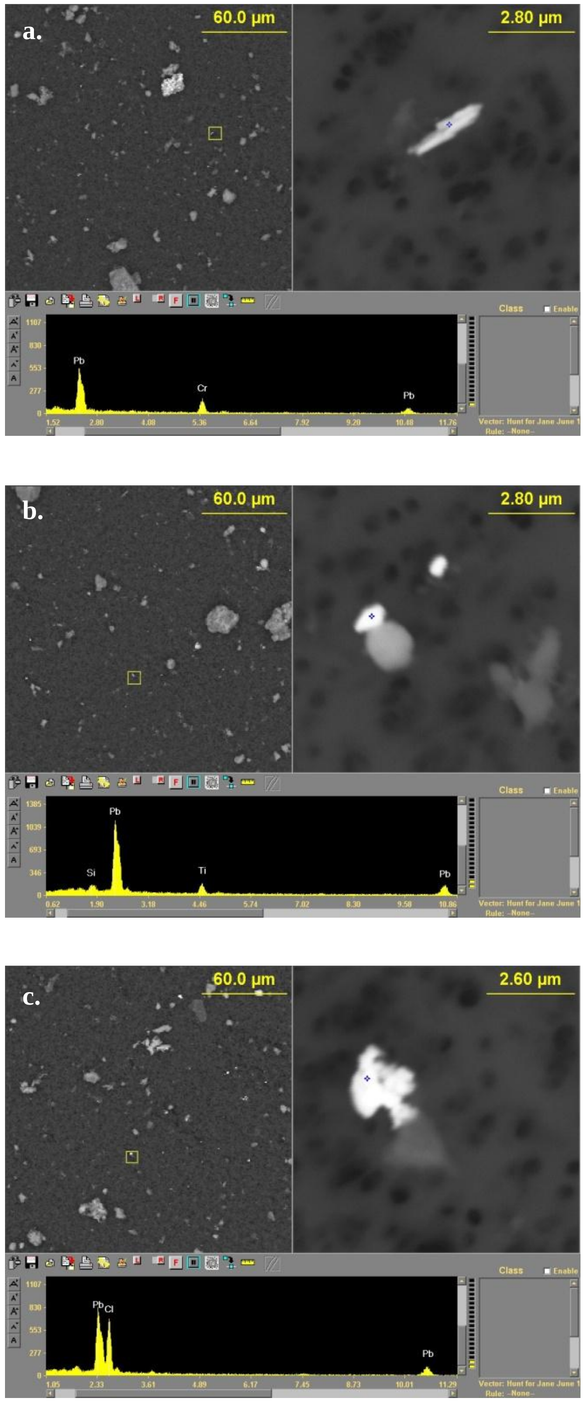


Figure I 3 House P floor dust particle with Pb pigment and Cr (a), Ti (b), Cl (c) in matrix

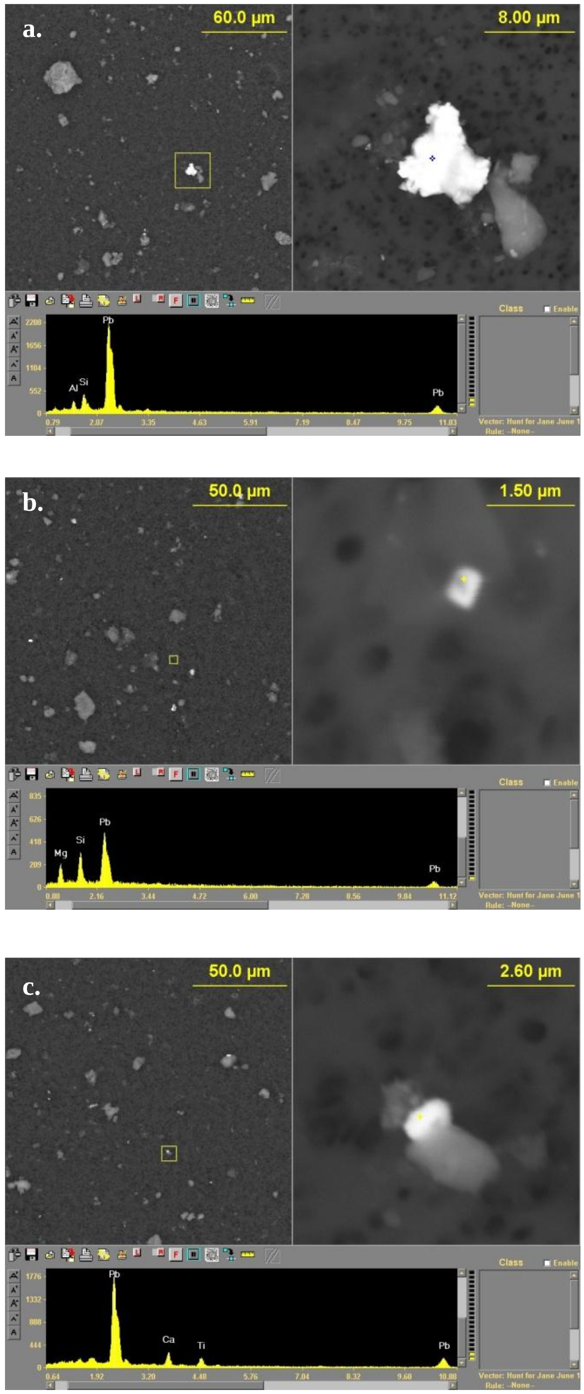


Figure I 4 House P floor dust particle with Pb pigment and Si, Al (a), Si, Mg (b), Ca, Ti (c) in matrix

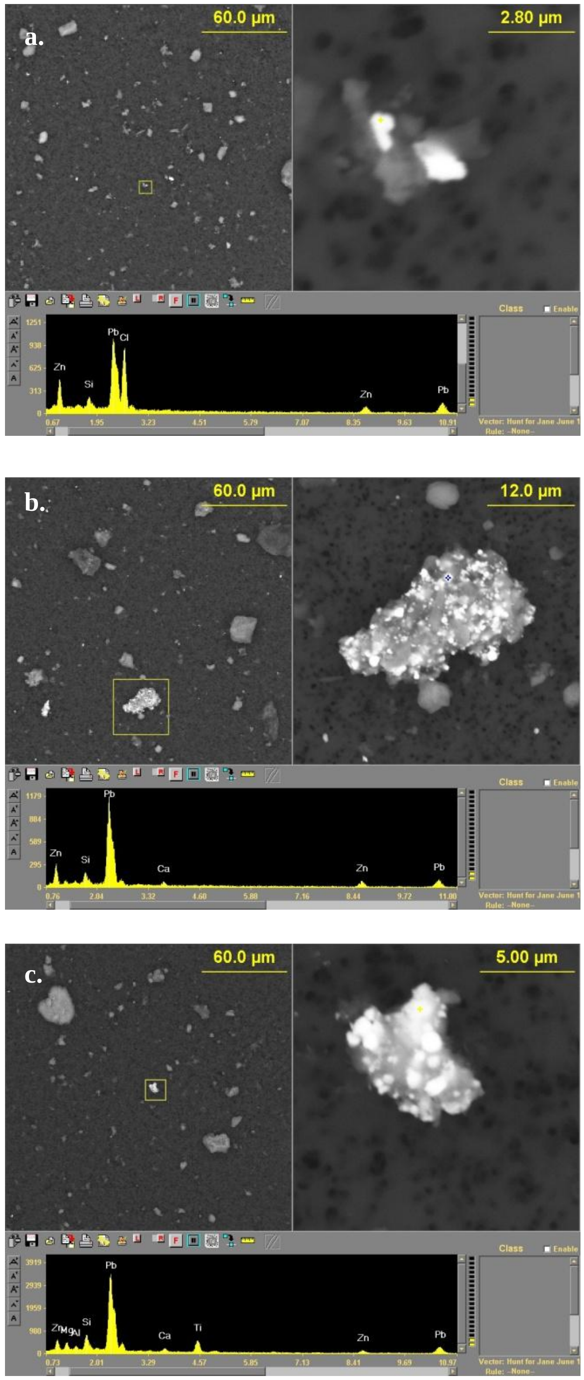


Figure I 5 House P floor dust particle with Pb pigment Zn, Cl, Si (a), Zn, Si, Ca (b), Zn, Ti, Si, Mg, Ca (c) in matrix

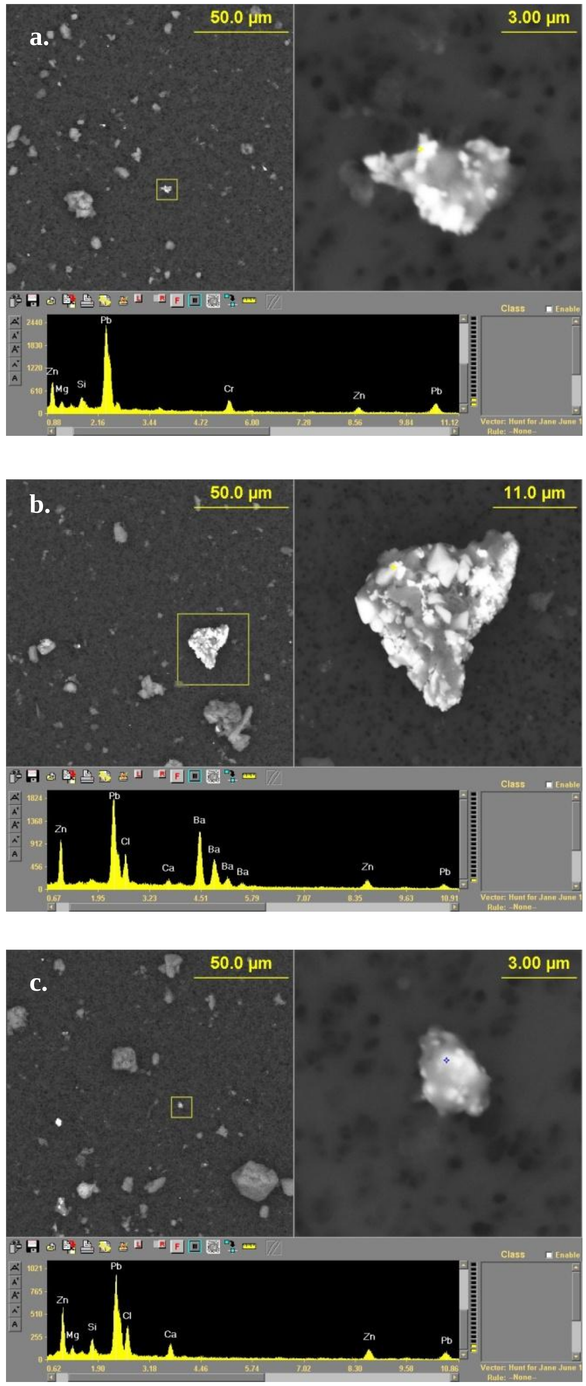


Figure I 6 House P floor dust particle with Pb pigment Zn, Cr, Si, Mg (a), Zn, Ba, Cl, Ca (b), Zn, Cl, Si, Ca, Mg (c) in matrix

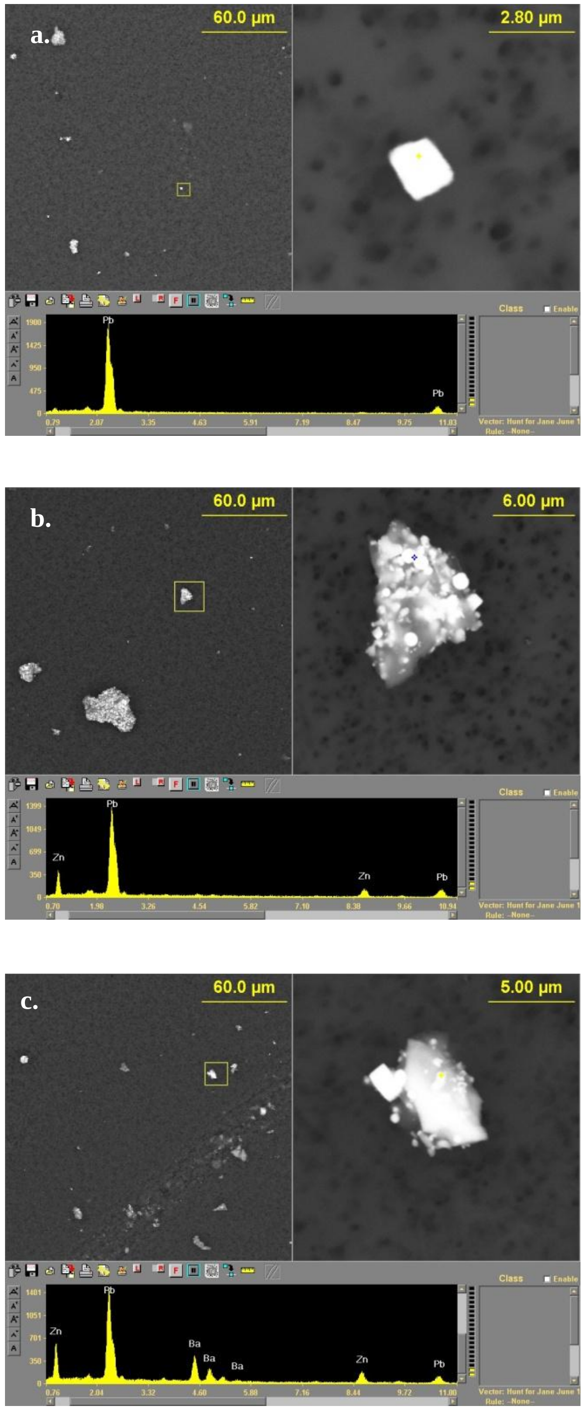


Figure I 7 House P door paint particle with Pb pigment particles (a), Zn (b), Zn, Ba (c) in matrix

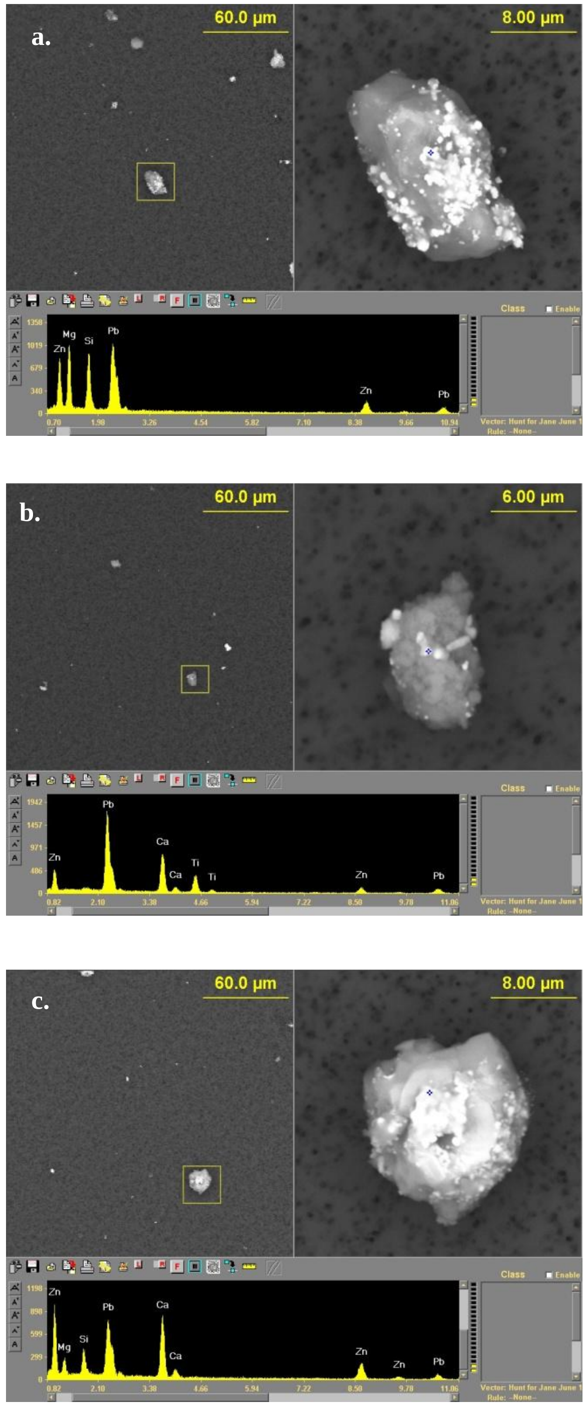


Figure I 8 House P door paint particle with Pb pigment and Zn, Si, Mg (a), Zn, Ca, Ti (b), Zn, Ca, Si, Mg (c) in matrix

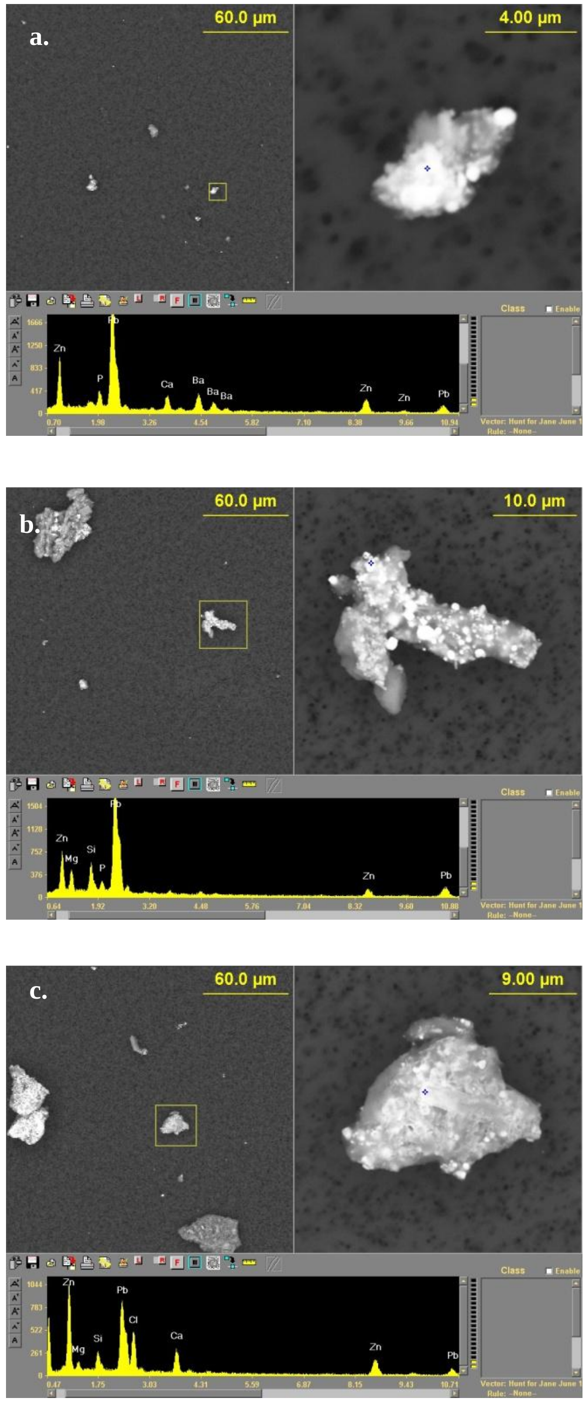


Figure I 9 House P door paint particle with Pb pigment and Zn, Ba, Ca, P (a), Zn, P, Si, Mg (b), Zn, Ca, Si, Cl, Mg (c) in matrix

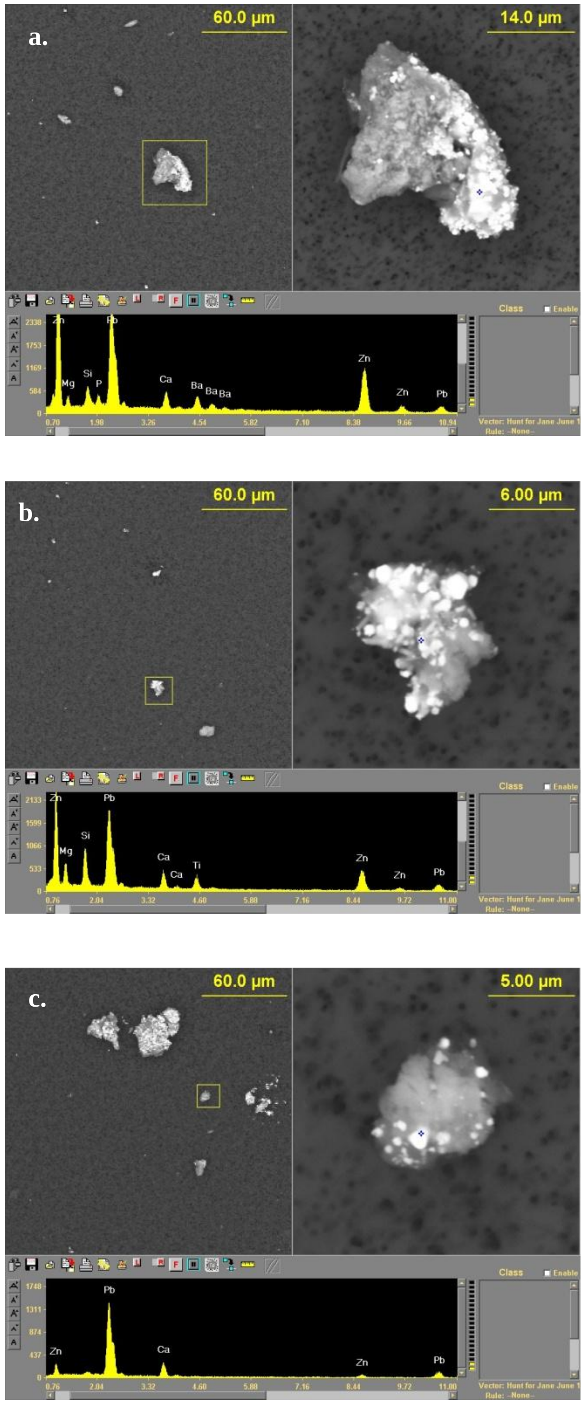


Figure I 10 House P door paint particle with Pb pigment and Zn, Ba, Ca Si, Mg P (a), Zn, Ca, Ti, Si, Mg (b), Zn, Ca (c) in matrix

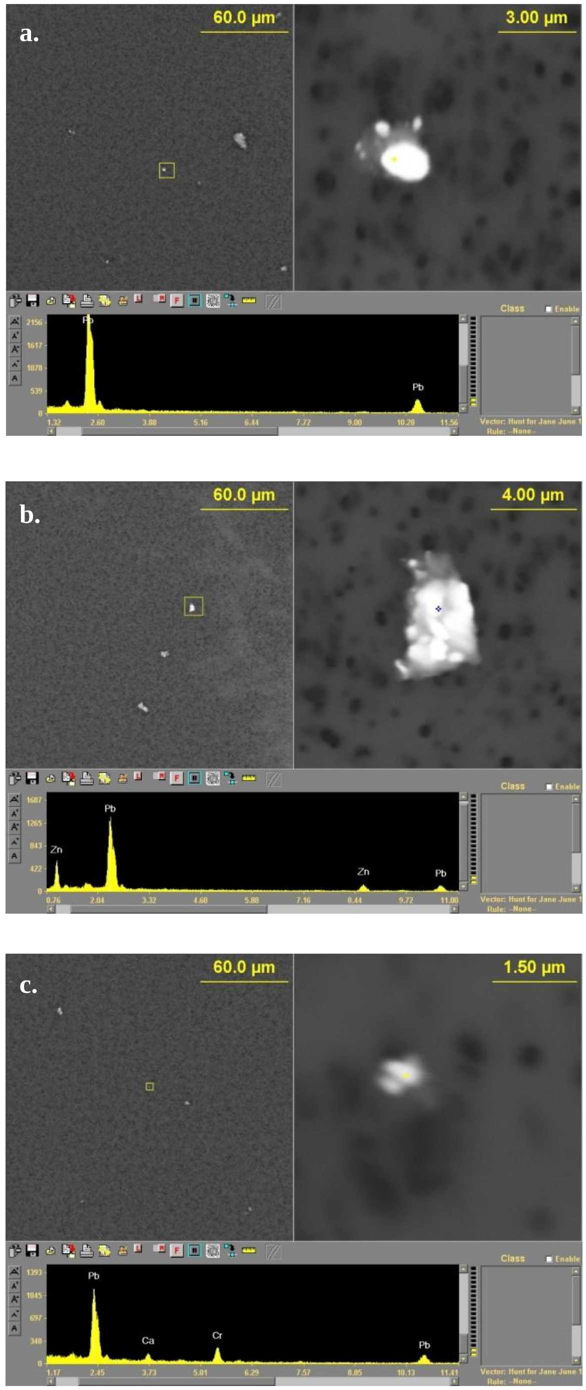


Figure I 11 House P floor paint particle with Pb pigment particles (a) and Zn (b), Zn, Ca, Cr (c) in matrix

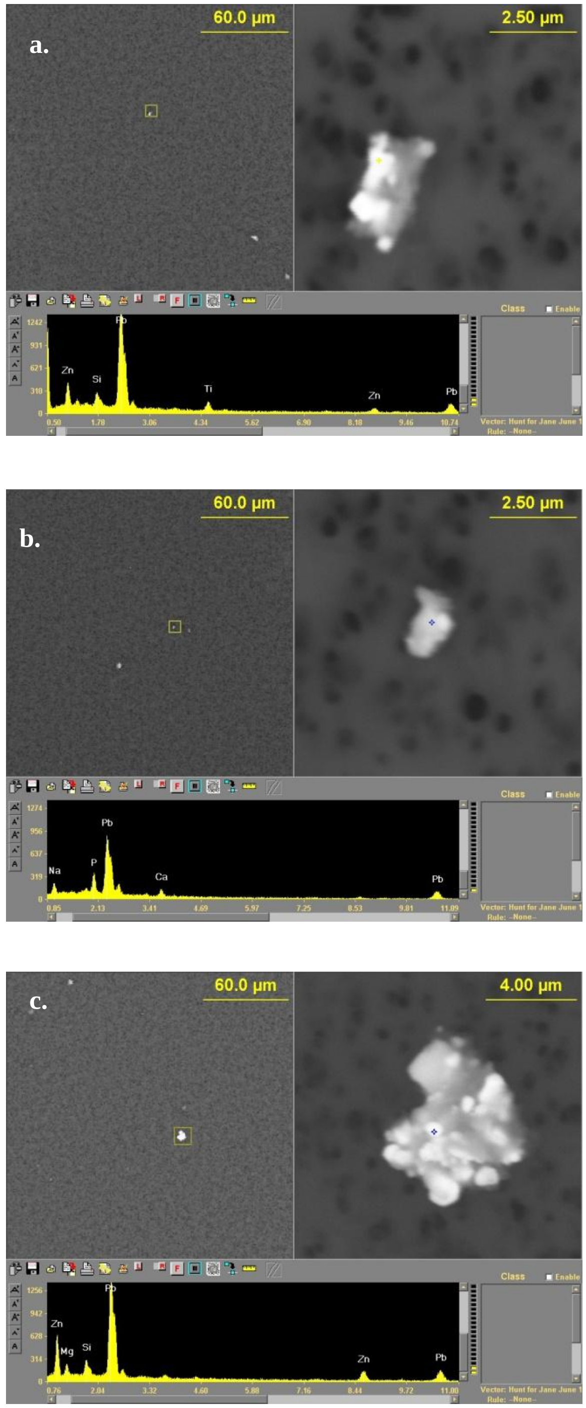


Figure I 12 House P floor paint particle with Pb pigment and Zn, Si, Ti (a), Ca, P, Na (b), Zn, Si, Mg (c) in matrix

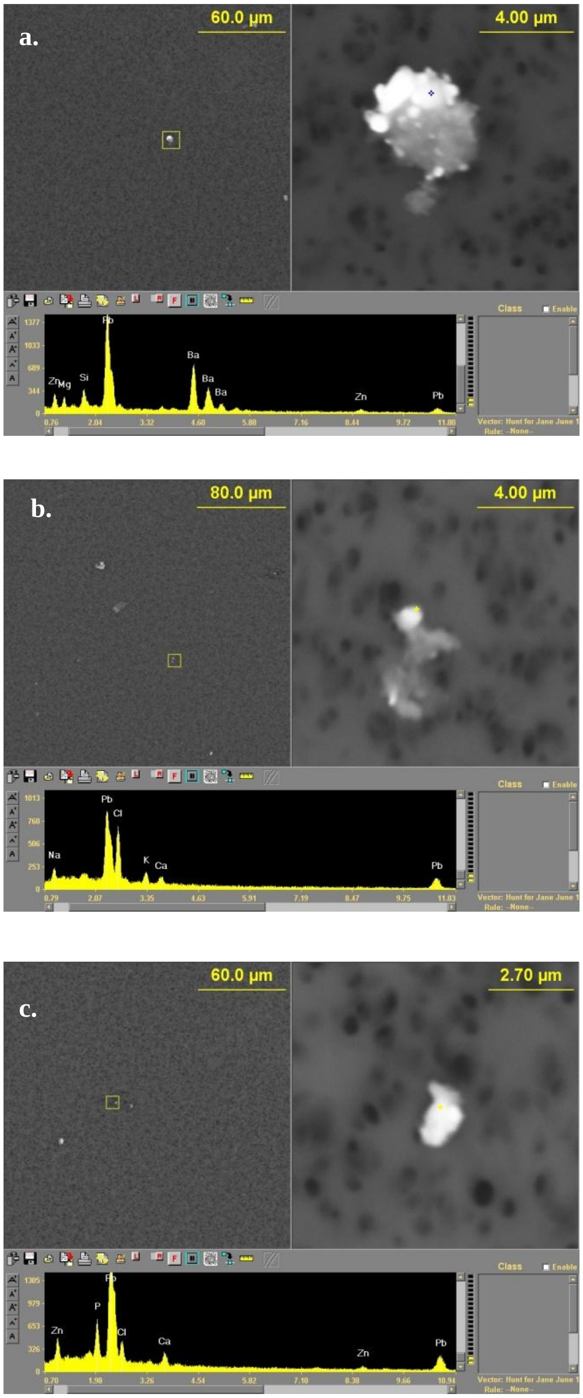


Figure I 13 House P floor paint particle with Pb pigment and Zn, Ba, Si, Mg (a), Ca, Cl, K, Na (b), Zn, P, Cl, Ca (c) in matrix

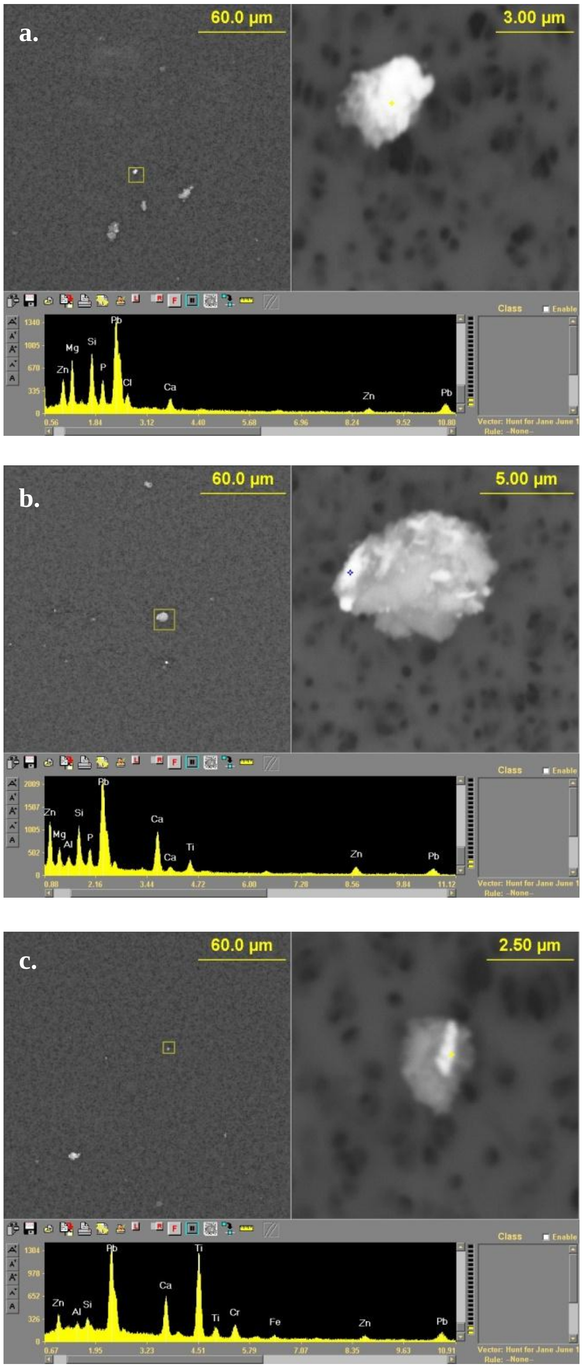


Figure I 14 House P floor paint particle with Pb pigment and Zn, Si, Ca, P, Mg (a), Ca, P, Zn, Si, Al, Mg, Ti (b), Zn, Si, Ca Ti, Cr (c) in matrix

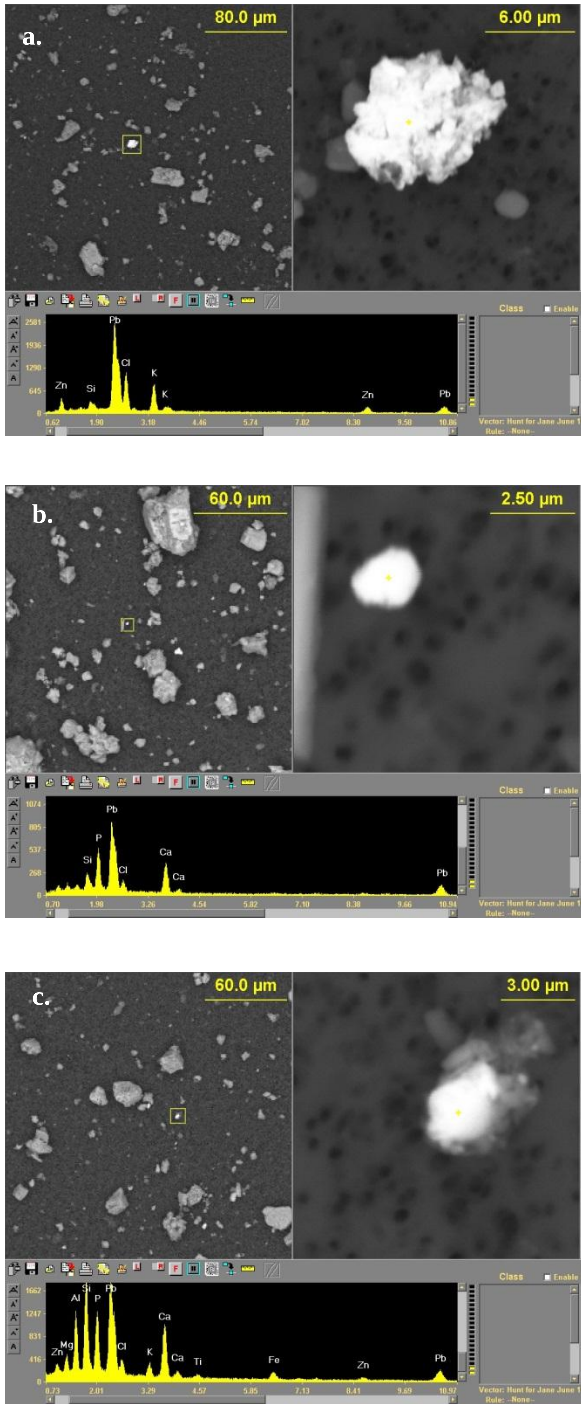


Figure I 15 House P building line soil particle with Pb pigment and Zn, Cl, K, Si (a), Ca, P, Si (b), Zn, Si, Mg, Al, P, K, Ca, Fe (c) in matrix

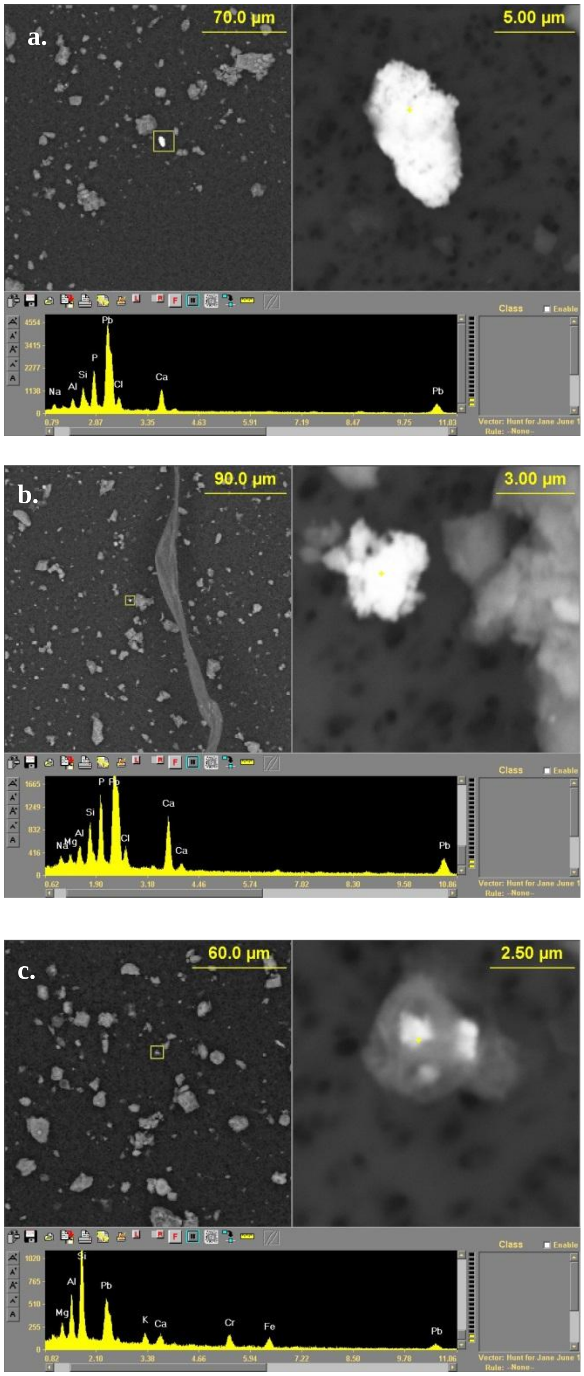


Figure I 15 House P building line soil particle with Pb pigment and Ca, Cl, P, Si, Al Mg, Na (a, b),Si, Mg, Al, K, Ca, Cr, Fe (c) in matrix

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