HEALTH AND SAFETY ISSUES IN ARCHAEOLOGY: ARE ARCHAEOLOGISTS AT RISK?

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Abstract

Archaeology is a relatively dangerous profession. The dangers associated with doing archaeology are not necessarily what one might expect after viewing certain Hollywood productions, but certainly there are things and situations out there that pose potential hazards. This paper discusses health and safety issues that occur in the archaeological field and laboratory settings, including physical, chemical, biological, and social hazards. Preventive measures to decrease the potential for injury or illness also are discussed.

Archaeologists work throughout any given year within a wide range of settings. In many of these environments, certain alterations used to create a safe work place might adversely impact or contaminate the archaeological record. Workplace safety in contract archaeology (CRM) has been discussed by Garrow (1993) and Niquette (1997). Garrow (1993) notes that standards established by the U. S. Department of Labor, Occupational Safety and Health Administration (OSHA), legally apply to archaeological projects and constitute an ethical issue which is frequently overlooked. This oversight can, and sometimes does, put individuals at risk.

Federal and state laws mandate workplace safety (e.g., Federal PL 91-596, which mandates that "each employer - shall furnish to each of his employees employment and a place of employment which are free from recognized hazards"). To implement these laws, numerous rules and regulations apply to a wide range of occupational situations (e.g., 29 CFR 1910, 29 CFR 1926, and 29 CFR 1960). Ignorance or disregard of these regulations can lead to serious injuries and punitive actions by state and federal officials (Niquette 1997). OSHA has provided a major set of implementing federal regulations that have particular application to archaeological projects in the form of 29 CFR 1926 (in particular 29 CFR 1926, Subpart P, Excavations). The various laws and implementing regulations are extensive and beyond the scope of this paper; however, they can be easily reviewed within the government documents sections of most major university libraries or by contacting OSHA directly.

One good source available to help archaeologists fulfill federal law is the *Safety and Health Requirements Manual* assembled by the U.S. Army Corps of Engineers, EM 385-1-1 (USCOE 1996). A copy of this manual can be obtained through the U.S. Government Printing Office, Superintendent of Documents, SSOP, Washington, DC 20402-9328 (ISBN 0-16-048877-X).

In addition to federal regulations, individual states often have laws and regulations regarding workplace safety. Information regarding these issues can be gained by contacting the Department of Labor of any given state.

The discussion below will focus on a wide range of potential hazards associated with doing archaeology. These hazards can be categorized as physical, biological, chemical, and social. These hazards exist both in fieldwork and in laboratory analysis of the collected material. The information below is related primarily to archaeological work in the United States.

Field Safety and Health Hazards

Safety hazards related to archaeological fieldwork are as numerous as the number of individuals involved in the discipline. Any combination of individual(s), random events, carelessness, and placement within the time-space continuum can result in an injury. This discussion will identify numerous health and safety issues applicable to the field and offer suggestions which may help reduce the risk to crew members.

Physical Hazards

Safety hazards in the field include dangers related to the use of heavy equipment (particularly backhoes), the use of power and hand tools, work in trenches and excavations (including encounters with underground utilities), underwater work and the use of boats, work along transects and on steep slopes, and work in inclement weather.

Heavy Equipment. The two pieces of heavy equipment most often associated with archaeological fieldwork are backhoes and graders. These machines are frequently used to facilitate deep excavations and help clear disturbed soils from sites. Serious injury and/or death can result from mishaps involving these two pieces of equipment, mainly from being either struck or run over by the machinery.

Under no circumstances should anyone be allowed to work underneath or in front of these machines while loads are being removed, loaded, or pushed. If individuals are to follow behind machinery, particularly graders, the machine operators should be aware at all times of the locations of those individuals working around them. Individuals on the ground should maintain frequent eye contact with the machinery and remain aware of its speed and direction of movement. These individuals should also use hand signals to communicate with the operator while the machine is in use (see USCOE 1996:114–115). Personnel should wear hard hats, safety shoes, orange or red vests, and hearing and eye protection. Specific safety regulations regarding heavy equipment can be found in the EM 385-1-1 (USCOE 1996:247–298).

Power and Hand Tools. The power tools most frequently used to clear heavily vegetated sites for excavation are chain saws and leaf blowers. The major risks associated with these pieces of equipment are abrasions and lacerations, amputations, eye injury, damage to hearing, and respiratory illness from inhalation of dust and biological microbes thrown up by leaf blowers. It is imperative that all power tools are well maintained and in good condition before use. Chain saws should be operated only by those individuals with experience in their use. As with heavy equipment, other personnel should maintain a safe distance from the operator and trees or brush being cut. Minimal protective gear when operating a chain saw should include, gloves, hard hats, safety shoes, leg chaps, snug fitting clothing, eye protection (including a face shield if necessary), and hearing protection.

Eye and hearing protection, along with a dust mask, should be worn when using a leaf blower. The use of a dust mask will reduce the risk of inhaling fungal spores and viral or bacterial organisms (some are pathogenic) which occur naturally in the soil. This simple precaution may help prevent serious respiratory infections (John Davis, personal communication to Lawrence Abbott 1998).

The hand tools most often used to clear vegetation and conduct excavation include bush axes, machetes, axes, bow saws, augers, trowels, and shovels. The major risks associated with these pieces of equipment are contusions, muscle strains, eye injuries, abrasions, lacerations, and amputations. Hand tools should be well maintained and in good repair. Individuals should have experience using tools such as bush axes, machetes, axes, bow saws. Those who do not have experience should be instructed in proper use and closely supervised while working. General safety measures regarding tree and brush removal can be found in the EM 385-1-1 (USCOE 1996:561–572).

Shovels and trowels that have been sharpened to facilitate excavation should be treated the same as the other blade tools discussed above. The greatest danger using shovels is the risk of crew members accidentally striking each other with the blade when moving dirt either to wheel barrows, buckets or directly into screens. This risk is increased when crew members are working in close proximity within excavation units. Crew members should be aware at all times of their relative positions to each other before using a shovel. Communication among crew members is also important when working in close proximity.

The greatest danger in using a sharp trowel is the risk of injury to oneself. Sharpening and using a trowel is no different than what would be expected with a knife. Carelessness in sharpening or using a trowel can result in serious lacerations, generally to the hand. Special care should be used when transporting a sharpened trowel. The safest place is generally within a backpack rather than in one's back pocket, especially if there is any risk of falling.

All tools, when not in use, should be placed within specific, secure areas of the site and not left in a haphazard manner around the site or an excavation unit. Tools, while in periodic use around excavation units

(e.g., shovels), should be placed a minimum of two feet from the edge of the unit while personnel are at work. Tools should be secure within an enclosed tool box when being transported within a vehicle. Tools such as bush axes, machetes, axes, and bow saws should have individual blade covers when in transport or not in use. Most of the safety regulations regarding power and hand tools can be found in EM 385-1-1 (USCOE 1996:217–226).

Trenches and Excavations. Trench and excavation safety is probably the most frequently overlooked issue regarding risk in archaeological fieldwork (Niquette 1997). Safety hazards involve slumping or partially collapsing walls, general cave-ins, accidental ruptures of utility lines, falling debris, water seepage, hazardous gases or atmospheres, and individuals falling into open excavations. Federal safety requirements connected with excavations are presented by OSHA in 29 CFR 1926, Subpart P. Some general procedures for fulfilling the requirements established by OSHA are presented by Foster Wheeler Environmental Corporation (1995) and USCOE (1996:435–447). Some of the general procedures are as follows:

1. The areas surrounding open excavations should be clear of spoil and other debris (including tools and equipment) for a distance of at least two to three feet.

2. Underground power and phone lines, water and sewer lines, and other utilities should be located and marked before excavation begins. Contact power and telephone companies along with specific city or county utilities commissions to have utility locations marked on the ground surface.

3. Any excavation greater than five feet in depth (USCOE 1996:436) should be benched, sloped or supported in accordance with OSHA standards 29 CFR 1926.652, Appendices B, C, and D.

4. Any excavation greater than four feet in depth should have a means of exit available to crew members. This may be in the form of a ladder, stairway, or ramp. The distance between means of exit should not exceed 25 feet.

5. Crew members should wear hard hats and not be allowed under machinery (including the full extent of a backhoe blade) while in operation or while loads are being extracted from the excavation.

6. An appropriate form of barricade should be erected around an excavation to serve as a warning system for machinery and to prevent debris, hand equipment, and personnel from falling into the unit.

7. Walkways with standard railings should be established if personnel are to cross over any excavation.

Other safety aspects associated with trenches and excavations include water seepage, hazardous atmospheres, and the stability of adjacent structures. These issues should also be considered when working in wells, privies, shafts, and deep pit features, or on urban and industrial sites. Information regarding procedures to fulfill these safety requirements can

be found in the EM 385-1-1 (USCOE 1996) and Foster Wheeler Environmental Corporation (1995:5–8).

Underwater Work and Use of Boats. The major risk involved with underwater archaeology and the use of boats to access sites is the risk of drowning. Underwater archaeologists should follow the safety measures discussed in EM 385-1-1 (USCOE 1996:545–551) for contract diving operations. When using boats to access sites, the minimal safety requirements should include a boat in good condition and maintenance, an experienced pilot, a safe level of occupancy within the boat, and fire protection (an operational fire extinguisher) (USCOE 1996:332–333). The use of life vests is essential with any boating activities. Life vests should meet the standards suggested by the EM 385-1-1 (USCOE 1996:49–53).

Divers must make sure their tanks have not been contaminated by toxic gases when the tanks are being filled. Divers also need to be aware of the medical complications that may occur from diving. These include barotrauma to various internal organs, decompression sickness, cerebral arterial gas embolism, chokes, compression pains, and nitrogen narcosis. If diving in the ocean, the archaeologist must be cognizant of dangerous sea life such as sharks, jellyfish, and sea snakes (Thalmann 1997:617–641). OSHA has developed regulations for commercial divers (29 CFR 1910, Subpart T).

Work Along Transects and on Steep Slopes. Many accidents connected with fieldwork occur along the landscapes that archaeologists frequently must pass through to conduct a reconnaissance or survey, or access a site to do excavation. It is here that many of the random, unforeseen mishaps occur. These range from abrasions and lacerations on barbed wire to encounters with snakes, wasps, and ticks, and serious injuries from falls.

Falls while in the field can occur almost anywhere on slopes or rock outcrops, in thickets, or crossing streams. Falls can also result from almost any action such as stepping on wet, slick tree limbs, roots, or gravel surfaces; tripping on rocks or vines; stepping in holes (either animal burrows or tree falls); and falls into open wells or cisterns. Frequently, these mishaps result only in embarrassment, abrasions, or bruises. Sometimes, unfortunately, falls result in serious lacerations, back and other muscle and joint injuries (sprains and strains), fractured bones, and concussions. Any of these injuries may be life-threatening, depending on the situation surrounding the mishap.

There is no set of safety procedures which will insure that falls do not occur, particularly while traveling overland during survey or while accessing remote site locations. The best safety technique is personal awareness on the part of individual crew members. Individuals should always be alert in the field and maintain constant attention to their surroundings. Avoid stepping on exposed tree roots or limbs. Slick wood will frequently cause one to lose their footing. Avoid walking straight down any sloped surface; rather, alternate going parallel to the direction of

the slope with descending at an angle to the slope. Avoid loose rocks and branches on slopes. Do not attempt to scale or descend vertical or near verticals slopes without the proper training or equipment. Lastly, never work or allow anyone to work alone, particularly when overland travel is necessary.

Work During Inclement Weather and Environmental Condition. Most archaeological fieldwork takes place outside. As a result, one will be exposed to inclement weather and environmental extremes in terms of hot and cold air temperatures.

The greatest threats to those working in the field from inclement weather include heavy rains, lightning, damaging winds, tornadoes, hurricanes, and floods (particularly flash floods). Two major threats to personal safety are lightning and flash flooding from heavy rain. Personnel should leave the field at the first sign of lightning. If a crew is working within low areas such as arroyos, floodplains, or narrow stream valleys, personnel should leave the area at the first sign that heavy rain may occur. Failure to leave before the onset of heavy rain could block the exit route with rising water levels. A small, easily crossed stream may quickly become impassable with the runoff from heavy rain, trapping a crew within a low and flooded landscape. Field supervisors should be informed of the daily weather forecast and monitor the sky for signs of impending severe weather.

Extremes in hot and cold temperatures pose another threat to crews. In hot weather, field workers are at risk of heat-related illness. The most common problem is sunburn which may be painful and cause blister formation in sun-exposed areas. In some individuals, excess sun exposure may trigger reactivation of herpes virus resulting in "fever blisters" on the lips. The risk of developing skin cancer from chronic sun exposure is well recognized. The best prevention is the proper use of sunscreens, wearing long pants and long sleeved shirts, and wearing a hat. While we realize that this is often impractical, minimizing sun exposure from 10 AM to 3 PM, when the solar rays are the most intense, is also recommended. The use of sunglasses is recommended as long-term exposure to ultraviolet radiation from the sun may cause cataracts. Other heat-related illnesses include prickly heat, heat cramps, heat edema, heat syncope, heat exhaustion, and heat stroke. Adequate amounts of fluids, shady rest areas, frequent work breaks, acclimatization to the work environment, and frequent supervisory observation of the crew are methods to prevent heat-related illnesses (Cohen 1997:70–76).

Cold injuries may involve freezing or nonfreezing of body parts, especially the fingers, toes, ears, nose, and cheeks. Types of injuries that may occur include frostnip, chilblains, frostbite, and hypothermia (Cohen 1997:67–69). Hypothermia is often fatal and frostbite may result in the loss of fingers and toes. In cold weather, individuals should dress appropriately for the conditions. Clothing should be layered and all extremities should be covered. It is a good general rule to pack a dry change of clothing in the field during cold weather, particularly if there is

any risk of getting wet. In areas where wind chill may be a factor, some form of wind shielding is a good precaution around excavation units. Supervisory personnel should carefully monitor the weather in regards to temperature, wind speed, and moisture level. Individuals who get wet should get dry and change their clothing as soon as possible. Detailed information regarding inclement weather and environmental hazards can be found in the EM 385-1-1 (USCOE 1996:87–91).

Biological Hazards (Animal Bites, Stings, and Disease Transmission)

Encounters with harmful animals while engaged in archaeological fieldwork is inevitable. Bites, stings, and scratches from dogs, wild mammals, snakes, wasps and bees, mosquitoes, flies, and arthropods (spiders, ticks, chiggers, etc.) can be very painful as well as potentially dangerous in terms of the transmission of various diseases.

Dogs and wild animals should be avoided if possible. Do not approach any of these animals. When approaching residential areas, a visual inspection by the supervisor should be made for unleashed dogs. If approached by an aggressive dog do not attempt to run or make sudden motions; but, slowly back away and protect yourself (if needed) as best you can. Dogs, in general, are very territorial and will usually stop pursuit once an individual is out of their space. Seek medical attention immediately for anyone bitten by a dog or wild animal. In addition, local authorities should be contacted with information regarding the incident.

Venomous snakes are another major threat. Those venomous snakes most common to the United States include copperheads, rattlesnakes, coral snakes, and water moccasins. Some of these snakes may be active throughout the year, dependent on where one happens to be within the country. Some of the best advice is to wear heavy leather boots whenever doing fieldwork. Never wear tennis shoes or low cut styles of footwear which are soft and expose one's ankle and lower leg. If one needs to wear soft shoes in an excavation unit, carry them to the site and put them on before entering the unit. Wear snake leggings in areas where snakes are likely to be encountered.

Be careful and observe any area before you sit down or stop to work. Avoid old logs and rocky areas where possible. Be observant when crossing streams and look for snakes on low branches and around the water. Always check an excavation unit before entering to work. Snakes and other creatures sometimes fall into units, even those that are covered, during the night or during periods when the units are unattended. If you encounter a snake of any kind, do not try to pick it up. Avoidance is the best way to deal with any snake. Walk away and around any snake noted. If avoidance is not possible (if there is a snake in an excavation unit), use extreme caution to remove the snake. In some cases, if left alone a snake will leave voluntarily. If someone is bitten by a snake, keep the individual calm and seek medical attention as quickly as possible. Do not apply ice to the wound or attempt to cut the area.

Stings from bees, wasps, and hornets are also highly likely at some point in one's career. Again, observe any area for signs of these insects. Where possible, avoid the general areas in which they are nesting. Always carry topical medication designed for stings in a first aid kit. A major factor in regard to these types of insects is to identify any individual who may have an allergic reaction to stings. Individuals with a history of severe allergic reaction to an insect sting must carry an anaphylactic kit with them at all times. Additional information on prevention of insect stings can be found in EM 385-1-1 (USCOE 1996:62–63).

Numerous infectious diseases may be contracted while doing fieldwork. Fortunately, these events are not frequent, as many of these illnesses may be serious. Table 1 presents a list of infectious diseases to which an archaeologist may be exposed.

To lessen the likelihood of contracting an infectious disease while doing fieldwork, one can use insect repellants containing DEET or permethrin. DEET can be applied to the skin (avoid mucus membranes) or the clothing, while permethrin is applied to the clothing. One should avoid using flea and tick collars as protective tools. These devices are designed for use on pets and not humans (Murdock 1992).

One should inspect himself/herself frequently throughout the day for ticks and remove them as soon as possible. The longer the tick is attached, the higher the likelihood is for transmitting a disease (Murdock 1992). If a tick is found attached to the body, Murdock (1992:2) suggests that it should be removed immediately with a pair of tweezers. The tweezers should be placed as closely as possible to the head of the tick and pulled slowly to remove it from the skin. One should avoid grasping the tick's abdomen during the removal process. Once the tick is removed, the bite should be cleaned with alcohol and the hands should be washed and disinfected. The date of the bite should be noted on a calendar and one should watch for the development of any illness over the next month. Work clothes should be removed as quickly as possible and isolated within one's room or house. Work clothes and any ticks contained within can easily be isolated by placing them in plastic garbage bags and storing the bags in a safe, isolated area.

Avoid drinking water directly from streams, rivers, and untested wells. Proper hand washing and personal hygiene are keys to avoiding most infectious agents. Do not make physical contact with wild or even domestic animals. Certain vaccines are available to prevent infections. Depending on where you are working, vaccination may be indicated. Treat all bites and wounds immediately. Wash with soap and water and apply topical antiseptics. Any bites from mammals should be evaluated by medical personnel, as rabies may occur in any mammal.

One potentially fatal disease transmitted through contact with rodents is Hantavirus. Most of the work related to Hantavirus in the United States has been carried out on reported cases in the southwestern United States (Fink 1994a, 1994b, 1994c; Fink and Engelthaler 1996; Zeitz et al. 1995); however, outbreaks of the disease have recently been identified in the eastern United States (Brackett et al. 1994; Centers for Disease Control

Table 1. Infections in the Field.

Disease	Agent*	Arthropod/ Vector	Illness	Vaccine
Acanthamoebiasis	A		Meningitis	No
Aeromoniasis	B		Wound Infection, Gastroenteritis	No
Anthrax	B		Pneumonia, Sepsis Skin Lesions	Yes
Babesiosis	B	Tick	Sepsis with Hemolytic Anemia	No
Blastomycosis	F		Skin Lesions, Pneumonia, Disseminated Disease	No
California Encephalitis	V	Mosquito	Aseptic Meningitis, Encephalitis	No
Campylobacteriosis	B		Gastroenteritis	No
Colorado Tick Encephalitis	V	Tick	Encephalitis	No
Cryptococcosis	F		Pneumonia, Meningitis Disseminated Disease	No
Cryptosporidiosis	B		Gastroenteritis	No
Cutaneous Larvae Migrans	P		Skin Lesions	No
Dirofilariasis	P	Mosquito	Cysts in Organs	No
Eastern Equine Encephalitis	V	Mosquito	Encephalitis	No
Echinococcosis	P		Cyst in Organs	No
Ehrlichiosis	B	Tick	Rash, Flu-like Illness	No
Epidemic Typhus	B	Louse	Rash, Headache	No
Giardiasis	B		Gastroenteritis	No
Hantavirus	V		Pneumonia, Hemorrhagic Shock	No
Histoplasmosis	F		Skin Lesions, Pneumonia, Disseminated Disease	No
Leptospirosis	B		Conjunctivitis, Hepatitis Meningitis	No
Lyme Disease	B	Tick	Skin Rash, Arthritis, Cardiac and Neurologic Disease	Yes
Murine Typhus	B	Flea	Rash, Fever, Headache	No
Naegleriasis	A		Meningoencephalitis	No
Pasteuellosis	B		Cellulitis, Pneumonia, Meningitis, Sepsis	No
Plague	B	Flea	Lymphadenitis, Pneumonia, Sepsis	Yes
Psittacosis	B		Pneumonia	No
Rabies	V		Encephalitis	Yes
Rocky Mountain Spotted Fever	B	Tick	Headache, Rash Multisystem Illness	No
Salmonellosis	B		Gastroenteritis	No
Sporotrichosis	F		Soft Tissue Infection	No
St. Louis Encephalitis	V	Mosquito	Meningitis, Encephalitis	No
Tetanus	B		Muscle Contractions	Yes
Tularemia	B	Deer Fly, Tick	Lymphadenitis, Pneumonia, Conjunctivitis	No
Vibriosis	B		Wound Infection, Gastroenteritis, Sepsis	No
Venezulan Equine Encephalitis	V	Mosquito	Encephalitis	Yes

Table 1 continued.

Disease	Agent*	Arthropod/ Vector	Illness	Vaccine
Visceral Larval Migrans	P		Cough, Abdominal Pain, Eye Lesions	No
Western Equine Encephalitis	V	Mosquito	Encephalitis, Meningitis	No
Yersiniosis	B		Gastroenteritis, Sepsis	No

*Agent: A - Amoeba; B - Bacteria; F - Fungus; P - Parasite; V - Virus

and Prevention 1994a, 1994b; Fink and Engelthaler 1996; Hjelle et al. 1995; Morzunov et al. 1995). Additional guidance to prevent fungal infections and Hantavirus infections can be obtained from the following federal agencies: Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, and USDA Forest Service (Lenaway et al. 1999; Lenhart et al. 1997; USDA 1996; Werner et al. 1972).

A question that often arises among archaeologists studying human remains is what is their risk of contracting smallpox or parasitic infections from eggs. Based on extrapolations, if numerous bodies were in the same grave and numerous cases of smallpox occurred in the victims, it is theoretically possible for the smallpox virus to be viable for 100 years (Baxter et al. 1988; Kennedy 1994; Meers 1985). Parasite eggs that are infectious to humans may remain viable in the environment up to 20 years (James R. Lichtenfels, U.S. Department of Agriculture, National Parasite Collection, personal communication to Ricky Langley, 1999). However, certain microbial agents that produce spores may remain dormant for decades (e.g., anthrax) or even hundreds of years (e.g., thermophilic actinomyces) and still be cultured under proper environmental conditions (Benenson 1995; Seaward et al. 1976).

Biological Hazards (Harmful Plants)

One of the most frequently encountered hazards to archaeologists is contact with harmful plants (e.g., poison ivy, poison oak, and poison sumac). Exposure to these plants can occur by direct contact with the leaves and vines or by digging and handling the roots in screens. As a result, archaeologists can contract the itching, blistering, and widely spread rashes any time of the year. The EM 385-1-1 recommends the following protective measures:

1. removal or destruction of plants, where practical;
2. appropriate protective clothing such as gloves;
3. protective ointments;

4. soap and water for washing exposed parts;

5. approved first aid remedies; and

6. instruction in recognition and identification of the plants (USCOE 1996:63).

In spite of every effort, coming down with a case of poison ivy is almost synonymous with doing fieldwork in the United States. Individuals can help protect themselves by observing where the plants are located and avoiding those areas as much as possible. At the most basic level, an individual should wear gloves and use soaps or ointments designed to help remove the poisonous oils from the skin (Garner 1999). A doctor should be consulted if the rash spreads, large blisters develop, or any area becomes infected.

Chemical Hazards

Encounters with dangerous chemicals and wastes pose a potentially serious threat to individuals involved in fieldwork. Contact with these agents can occur almost anywhere and under quite unexpected circumstances (McCarthy 1994). An entire crew could be digging and handling soils laced with very dangerous chemicals and organic wastes without any indication of their presence or the risks involved.

McCarthy (1994), citing the *Historical Hazardous Substance Data Base* provided by the Illinois State Museum (1992), provides a partial list of industrial-era industries and their waste products to graphically illustrate the types of substances archaeologists may encounter in the field. According to McCarthy (1994:1), these include:

1. *leather tanning and finishing* - amyl acetate, sulfuric acid, lead, chromium, manganese, benzene, arsenic, and mercury;

2. *paper making* - lead, arsenic, alum, chromium, and mercury; and

3. *steel making and founding* - hydrogen chloride, benzol, tar, carbon bisulphide, benzene, fluorene, naptha, nitrobenzene, phenol, toluene, and xylene.

These chemicals are, among other things, carcinogens, caustic substances, poisons, or combinations of all three. All are potentially hazardous and put a crew at risk, particularly those individuals who may be pregnant or have specific medical conditions. In addition, work within or around historic structures can expose crew members to lead in old paints, asbestos, fuel oil, rusted metals, glass fragments, and garbage dumps. Soils from industrial sites should be tested before commencement of fieldwork to determine the presence of contaminants and levels of toxicity.

The excavation of historic cemeteries can also expose personnel to hazardous chemicals. Recent work by Meyers et al. (1998) suggests a

potential hazard from arsenic poisoning when excavating historic cemeteries dating from circa 1860 to 1910. Arsenic was used as an embalming fluid during this period until its use became illegal in 1910. Arsenic can occur as a residual in the excavated soil and may be potentially hazardous to archaeologists. Meyers et al. (1998:3) note that the best precaution to take regarding suspected arsenic contamination within cemeteries is to test the soil prior to commencement of work. As a result, Louis Berger and Associates, Inc. have created a set of guidelines to test for arsenic contamination at historic cemeteries (Meyers et al. 1998:3–5).

Another potential hazard, particularly for contract archaeologists, is seepage from septic tanks. Many waste-water outfall lines follow the natural drainage patterns of the landscape and flow based on gravity. This often leads archaeologists on corridor survey through the backyards of residential areas which may contain leaking septic tank systems (often the survey being conducted is to facilitate the connection of these residences into municipal or county waste-water lines). In many cases the sight and smell is unforgettable; however, this is not always the case. Individuals should be observant in residential areas for septic tank seepage and avoid digging in these areas until the waste has been removed by professionals (if warranted).

Other hazardous chemicals resulting from agricultural practices may also be encountered. Unhealthy levels of pesticides and herbicides can become concentrated in the soil over time. There are still many questions regarding the long-term effects of exposure to these substances; however, serious allergic reactions can occur in some individuals, even with minimal contact (J.H. Brothers personal communication to Lawrence Abbott, 1999).

Fieldwork on lands under the control of the Department of Defense expose individuals to a special set of hazards. The rules and regulations regarding work on military installations are very detailed and specific regarding safety. The military is adept at minimizing most of the risks to civilians working within their installations. Individuals (i.e., explosive ordnance disposal personnel) are specially trained to locate, remove (or mark), and/or dispose of any unexploded ordnance and other dangerous substances that may be present on post ranges prior to the commencement of any fieldwork. Regular communication between archaeologists and range control personnel (often through two-way radio) is usually mandatory.

Despite all the efforts to make a military post safe for work, some hazards still exist. Strands of barbed wire and discarded communication wire (for land lines) are frequently encountered in the field. These can cause lacerations and falls if not seen and avoided. Other hazards include buried wastes from bivouacs and unit training areas that may be unmarked by the military, and unspent rounds from small arms and automatic weapons (many are generally training rounds, but are also dangerous to handle). The primary rule while working on any military post is “don’t pick anything up.” Any type of discarded equipment or hardware that

appears to be associated with military training should be left alone, and all perceived hazards should be reported to range control personnel.

The general rule regarding digging through any area or on any site that may contain hazardous wastes is that no amount of caution is too much. Any area where hazardous wastes are suspected should be tested prior to the commencement of fieldwork by professionals with the necessary training. In addition, at least one of the supervisory staff should have formal training in the recognition of hazardous materials and the procedures to follow in the event of exposure. All of the crew should be instructed in the potential dangers of hazardous materials and report anything suspicious to supervisory personnel. The EM 385-1-1 (USCOE 1996:499–522) contains an extensive section on hazardous materials and the procedures for dealing with these substances.

Laboratory Safety Hazards

Not all workplace dangers are in the field. Health hazards can also be found in the laboratory. If not properly identified, some of the dangerous substances noted by McCarthy (1994) and Meyer et al. (1998) can find their way into the lab on artifacts or human remains and within soil samples or feature fill. In addition, the range of acids and caustic chemicals employed by laboratory personnel to conserve, process, or identify archaeological materials for study pose major hazards if improperly used or stored. A list of chemicals used on National Museum of Natural History collections is shown in Table 2 (Makos and Dietrich 1995:235). Ethnobotanical and faunal specialists also face risks processing and handling organic materials, particularly from historic contexts. Risks associated with the chemicals used in processing samples for some forms of analyses (e.g., phytolith analysis) extend to both prehistoric and historic contexts (Lentfer and Boyd 1999).

Health hazards in a laboratory setting can also come from unexpected sources. In the past, arsenic was used to treat manuscripts for insect pests (i.e., worms and other paper-eating insects) (James Brothers personal communication to Lawrence Abbott, 1999). This may pose a risk of poisoning to those individuals who handle these materials (Hawks and Williams 1986:1–4; Williams and Hawks 1986:21–49).

According to Coy (1978:14–15), faunal materials are generally safe to handle. Some bones from historic sites (those associated with the nineteenth and twentieth centuries) can pose a slight health risk to analysts. She notes that anthrax is a potential danger to archaeologists who handle animal bone, since it can survive in soil and bone for at least 60 years (Coy 1978:15).

Coy (1978:15) concludes that the risks from handling archaeological faunal materials are slight. Others have reported upper respiratory infections after handling bone and other fill material from late nineteenth to early twentieth century urban privies (Lisa D. O'Steen personal communication to Lawrence Abbott, 1999).

Table 2. Chemicals Used on National Museum of Natural History Collections.*

Substance	Chemical Content
Alcoholic solution of oil of bitter almonds	Hexane
Alcoholic solution of oil of red cedar	Hydrocyanic acid
Alum	Kaolin
Arsenic	Kerosene
Arsenic trioxide	Mercuric chloride
Benzene	Menthol
Borax	Methyl bromide
Camphor	Mineral spirits
Carbolic acid	Naphthalene
Carbon disulfide	Paradichlorobenzene
Carbon tetrachloride	Petroleum ether
Corn cob dust	Renuzit™
Cornmeal	Sawdust
Dichlorodiphenyltrichloroethane (DDT)	Sodium fluorosilicate
2,2 Dichlorovinyl dimethyl phosphate (DDVP)	Strychnine
Ethylene dichloride	Sulfuryl fluoride
Formaldehyde	Thymol
Gasoline	Trichloroethane

*Adapted from Makos and Dietrich (1995:235)

The greatest health risk to a faunal analyst may be in the assembly of a comparative collection (Coy 1978:15; Irvin et al. 1972). Building a comparative collection from road kills and other chance findings of wild animal carcasses is potentially hazardous, exposing an individual to risks involving rabies and other diseases (Lisa D. O'Steen personal communication to Lawrence Abbott, 1999). If a comparative collection is built in this manner, basic precautions should minimally include wearing gloves and face mask, isolation and proper disposal of putrefied materials, proper storage of processed bone, and good personal hygiene (Lisa D. O'Steen personal communication to Lawrence Abbott, 1999). Consideration should also be given to obtaining tetanus and rabies vaccinations.

Some molds found in libraries, archival collections, and archaeological labs (e.g., *Aspergillus fumigatus*) can be a serious health hazard to susceptible individuals (Conservation Center for Art and Historic Artifacts 1994). Mold outbreaks in a lab or within collections can cause respiratory symptoms, skin and eye irritation, and, rarely, infections. Individuals who suffer from certain allergies or asthma, and those who take steroids, may be more adversely affected.

In the past, mold outbreaks were treated by fumigation with ethylene oxide. Other fumigates included thymol crystals, orthophenyl phenol, and formaldehyde. All of these chemicals are hazardous to humans and presently are not used in the treatment of molds (Northeast Document Conservation Center 1993).

If a mold outbreak is noted in archaeological collections, a professional mycologist should be consulted to insure that the mold species is not toxic (Conservation Center for Art and Historic Artifacts 1994:2; Northeast Document Conservation Center 1993:4). In the event a toxic species is detected, the collections will require the attention of professionals trained in cleaning molds. If the outbreak is a non-toxic variety, the following safety measures are recommended for cleaning mold from collections:

1. Use a respirator with a particulate filter, not a dust mask;
2. Wear disposable plastic gloves;
3. Wear coveralls or laboratory coats, preferably disposable;
4. Wear foot and head covers for a very dirty situation;
5. Remove coveralls, laboratory coats, and protective gear in a designated "dirty" area; and
6. Periodically disinfect nondisposable gear. Wash laboratory coats, coveralls, and other washable items in hot water and bleach. Wipe respirators with isopropanol (rubbing alcohol), or Lysol™, and change particulate filters regularly (Conservation Center for Art and Historic Artifacts 1994:3).

The best defense against mold is environmental control. Labs should maintain low humidity levels and be prepared to isolate any small outbreaks of mold in plastic garbage bags and separate storage areas (Conservation Center for Art and Historic Artifacts 1994). Air conditioning units or HVAC systems should be maintained and in good repair at all times. Any leaks in a system should be repaired immediately, as molds thrive in moist environments.

Routine inspections of a lab for toxic chemicals, molds, and other hazards will help reduce the risk to personnel. While no method is fail-safe, precaution and prevention still are the best methods of defense against health risks in the lab.

Social Hazards

Archaeologists often work for extended periods of time in many different places, frequently living in motels, field camps, or rental properties. Over time, this sort of lifestyle can cause relative degrees of stress which may manifest adversely in certain individuals.

Alcohol Abuse

Alcohol consumption is almost synonymous with archaeology. We have all heard (or even contributed to) some of the near-epic tales of nightly drinking marathons around the campfires during the famed Projects X, Y, and Z. In reality, chronic alcohol abuse can lead to serious

problems. In addition to the long term health hazards associated with alcohol abuse, there are potentially serious risks in the field associated with accidents and disorientation.

Individuals who are intoxicated or severely "hung over" constitute a major hazard in the field. These individuals risk injury to themselves and others on the crew in terms of accidents associated with tools or machinery and injuries associated with falls and other mishaps. On survey transects, there is also the potential for an intoxicated individual to become disoriented and/or lost. In addition, valuable field time can be lost dealing with individuals for whom alcohol abuse is an issue. In the event that these people show signs of intoxication, they should not be allowed to work. Under no circumstances should they be allowed to drive work vehicles or use other machinery and hand tools.

Drug Abuse

The use of illicit drugs by archaeological crew members is a legal as well as safety issue. The general safety issues are basically the same as discussed above for alcohol abuse. These issues may also apply to the abuse of legal prescription and over-the-counter drugs, especially if mixed with too much alcohol.

A project manager or director is also culpable if drug use by crew members is known or suspected and not stopped. The discovery of illicit drugs by law enforcement agents can result in arrests and the seizure of property. Property seizure could include anything from field equipment to vehicles and bring a given project to a screeching halt. A situation of this nature may also result in the revocation of grants or contracts and lead to problems obtaining future funding of any sort.

Robbery and Assaults

Unfamiliarity with local settings, particularly within the first few weeks of a project, can put some individuals at risk. Field crews should use a little common sense in strange or new settings (particularly in urban areas). Simple precautions such as going out in groups, making no ostentatious public displays of money or other possessions, and avoiding potentially dangerous areas or situations will help minimize the risk of assault. Project managers should consider providing transportation to stores and restaurants for those crew members who lack vehicles. This could be accomplished through the use of carpools or a designated driver of a company or field vehicle. Field crew should also consider the use of a buddy system in potentially dangerous areas.

Summary

Maintaining a healthy and safe work environment for archaeologists is mandated by federal law (Garrow 1993). Rules and regulations developed by OSHA apply to archaeological projects and all

archaeologists should make an effort to increase workplace safety. A few basic steps can help in this matter.

We feel that all archaeologists should have some basic training in first aid and become certified in CPR. Work areas should be inspected prior to the commencement of fieldwork to identify any hazardous conditions. Any identified risks should be addressed in an appropriate manner and field crews and lab personnel should be informed of potential safety hazards in the workplace. Individuals with special health conditions such as allergies, diabetes, heart problems, or others should be confidentially identified before the commencement of fieldwork and provided opportunities to communicate with field supervisory personnel and emergency responders. Any conditions within the workplace that might adversely effect these individuals should be identified and communicated to them. No one should be allowed to work alone. In the case of survey in remote areas, the establishment of a "buddy system" is a good idea. All crews should maintain an adequately stocked first aid kit, both in the lab and field (see USCOE 1996:21). Centrally located first aid kits should be easily accessible to crews involved in excavation. Individual crews doing survey work should each be supplied with a kit.

All crew members should have the telephone numbers of the nearest rescue squad or emergency medical facility. In addition, each individual should be aware of how to physically get to the nearest medical facility. While in the field, it is important to take advantage of modern technology and carry a cell phone in the case of an emergency. In remote areas, additional cell phones and two-way radios for crew members may be appropriate. Any accident or injury should be reported to supervisory personnel immediately. Never hesitate to seek professional medical assistance during an emergency.

Something that all archaeologists should do is to develop a safety policy and implementing safety plan. This policy and plan should be communicated to each crew member and placed on a job site within easy access. A basic outline for a safety plan can be found in EM 385-1-1.

All archaeologists should be familiar with the federal and state laws, along with the implementing rules and regulations, that apply to workplace safety. Publications, such as the EM 385-1-1, should be obtained and consulted to insure that a given project is conducted in a safe manner and in compliance with federal law. Niquette (1997) suggests that

> SAA, ACRA, SHA and other organizations, perhaps in cooperation with the Corps of Engineers, the National Parks Service, and the Forest Service, should attempt to enter into a dialogue with OSHA. If realistic archaeological workplace safety standards could be developed and presented to OSHA, I am certain that we would all profit from the effort.

Once established, these standards could be extended to the individual states in a dialogue with individual state departments of labor and SHPO offices. An extended dialogue of this nature would fully encompass the legal requirements (both state and federal) regarding workplace safety. If successful, these dialogues would address both the special needs and

circumstances surrounding the study of the archaeological record, and provide us all with a safer work environment.

Notes

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