



# THE PALEODIGGER MACHINE

Mechanically Excavated Test Pits for Phase I Archaeological  
Surveys

## ABSTRACT

The PaleoDigger is a mechanized system and method specifically designed to alleviate the high labor cost of deep archaeological testing and to improve data quality in phase I archaeological surveys. The machine can excavate a standard-size shovel test pit (STP) to depths of 7 meters. The machine has excellent vertical control and can remove soil in 5 or 10 cm levels. The self-closing auger bucket eliminates cross contamination between excavation levels. Soil is efficiently processed through a powered rotary screen and then hand sorted for artifacts on a self-supported box screen. The method includes an electronic device for automated tracking and recording of excavation level depths which reduces errors in recording artifact provenience.

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## Historical Development of Archaeological Surveys

Archaeology has remained a labor-intensive endeavor that relies heavily on hand tools for the removal and sifting of soil. During the early twentieth century, picks, shovels, and wheelbarrows were the dominant tools used for digging and grading roads, building sites, and mine pits. We owe the rapid expansion and improvement of the nation's roads to gangs of depression era relief workers who were armed with hand tools. After World War II, most forms of construction and excavation work evolved from the use of hand tools to mechanized methods of digging and moving soil. Archaeology has not followed this trend in mechanization, due in large part for the need to maintain precise control over the excavation process. Field methods in archaeology have changed little since the 1930s. The use of hand shovels and trowels continues as the established method for conducting archaeological excavations.

Compliance archaeology began in the 1960s after Congress enacted the Reservoir Salvage Act and the National Historic Preservation Act (NHPA). Initially, Section 106 of the NHPA only protected archaeological sites that were listed on the National Register of Historic Places. Through a 1972 executive order, President Nixon extended protection to historic properties that are eligible for listing on the National Register, after which all federal undertakings were required to identify the presence of archaeological sites prior to ground disturbing activities and determine their National Register eligibility status (King 2004:21-24). This requirement fueled the growth of compliance archaeology and Cultural Resource Management (CRM) as an emerging industry.

The NHPA also facilitated the establishment of State Historic Preservation Offices (SHPO), which acquired much of the burden of managing historic preservation activities and compliance archaeology review. Guidelines published by each SHPO established accepted methods for conducting compliance related archaeological surveys within their perspective state. The survey and review process is typically divided into three phases. The goal of Phase I archaeological surveys is to identify the presence of archaeological sites within the area of potential ground disturbance. Phase II investigations are designed to evaluate each archaeological site for National Register eligibility. In cases where archaeological sites are found and determined to be National Register eligible, and the site cannot be avoided, detailed Phase III data recovery excavations are conducted to document the archaeological context and to collect a significant sample of the cultural artifacts. This mitigation process helps to ensure that important archaeological data is not destroyed by development activities.

Most of the work in compliance archaeology occurs as Phase I surveys. The goal of this initial step in conducting archaeological surveys is to determine if archaeological deposits are contained within the ground across a given survey area. The established survey method is to hand dig or excavate a round or square hole using a spade shovel. Such small diameter holes are called shovel test pits (STPs). Typical hole diameters range from 35 cm to 57 cm depending upon regulations established by each state or federal agency. STPs are dug at regular intervals across the survey area. An interval of 15 meters or 50 feet is commonly required by regulatory agencies.

Soil is removed from the STP in 5 or 10 cm levels and placed in a portable screen box that is designed to separate and remove cultural artifacts from the soil. A typical hole size for the hardware cloth within the screen box is 4 holes per inch, also known as 1/4" hardware cloth. If present, artifacts are collected, bagged, and inventoried from each excavation level. Cultural artifacts found within a test hole indicate the presence of an archaeological site. The horizontal boundary of an archaeological site can be determined by the presence or absence of cultural artifacts excavated from test holes that are spaced at regular intervals across the survey area. The vertical limits of archaeological deposits can be estimated by documenting the depths of excavation levels from which cultural artifacts are recovered.

STPs are excavated to the lowest depth at which archaeological deposits can potentially occur. The potential depth of archaeological deposits is dependent upon the geological setting of the survey location. In

upland settings where rates of sediment deposition are low, archaeological deposits are typically found at depths of less than one meter. Along streams and rivers sediment accumulates from multiple episodes of overbank flooding. Floodplain deposits containing archeological deposits can reach several meters thick along larger streams and rivers.

Due to their small diameter, STPs are inefficient for digging to depths of more than one meter. When the potential for archaeological deposits exceeds one meter in depth, SHPO guidelines typically require excavation of larger one-by-one-meter squares often spaced over a larger survey interval. In Pennsylvania, SHPO guidelines require the excavation of one-by-one-meter squares at 30 m intervals which equals 4 square meters per acre (PA SHPO 2017). Four one-by-one-meter squares is equivalent to 16 STPS per acre place at 15 m intervals. In circumstances where archaeological deposits exceed 1.5 m in depth, larger test pits or approved wall shoring are required for worker safety due to the increased potential for wall collapse.

## Mechanically Excavated Test Pits

The PaleoDigger is a mechanized system and method specifically designed to alleviate the high labor cost of deep archaeological testing and to improve data quality in phase I archaeological surveys. The PaleoDigger consists of a vertical drilling mast and rotary screen that is hydraulically powered by an attached skid steer loader (Figure 1). The drilling mast supports a hydraulic drive motor that is attached to an enclosed bucket auger. Soil is excavated by rotating the auger bucket and lowering it into the ground. A straight cutting edge on the bottom of the bucket directs soil into the bucket through two holes in the bottom plate (Figure 2). Excavation continues until the desired depth is reached, typically 10 cm. The rotation is then reversed, and the bottom of the auger bucket closes. The auger bucket is lifted from the hole, kicked outward from the drilling mast, and hinged open to dump the soil from the bucket. While the bucket is being emptied, another worker measures and records the depth of the test pit.

Figure 1.



Test Excavations at the Slickerman Bottom Site (36SO304), a known Paleoindian site located along Beaver Dam Creek in Somerset County.

The soil is then transferred to a rotary screen basket with 4-holes-per-inch hardware cloth. The screen basket is rotated by a hydraulic drive motor and the bulk of the loose soil is expelled through the hardware cloth. The screen basket is then tipped over to empty the remaining soil, stones, and artifacts into a tub. The contents of the tub are then transferred to a stationary screen box where the artifacts are sorted and collected. One to three screeners are needed depending upon soil conditions. The auger bucket is lowered back into the hole and the process is repeated to extract the next 10 cm level of soil. An electronic device tracks and records the excavation level depths for each test pit. This three-stage process enhances work flow productivity and allows for additional screeners if dictated by soil conditions.

Figure 2.



The bottom plate of the auger bucket rotates between its open and closed position.

The machine can excavate a standard-size shovel test pit (STP) to a depth of 7 meters. The machine has excellent vertical control and can remove soil in 5 or 10 cm levels. Each excavation level is cut to a flat surface. The self-closing auger bucket eliminates cross contamination between excavation levels. The PaleoDigger produces a hole with a consistent diameter, thus eliminating any vertical sampling bias (Figure 3).

### Standard Interval Phase I Testing

The above capabilities of the machine make it possible to excavate STPs at 15-meter intervals with the option of excavating close-spaced radials around positive STPs. The quality of the phase I survey is enhanced by the ability to delineate horizons of cultural deposits both horizontally and vertically (Figure 4). This deep testing

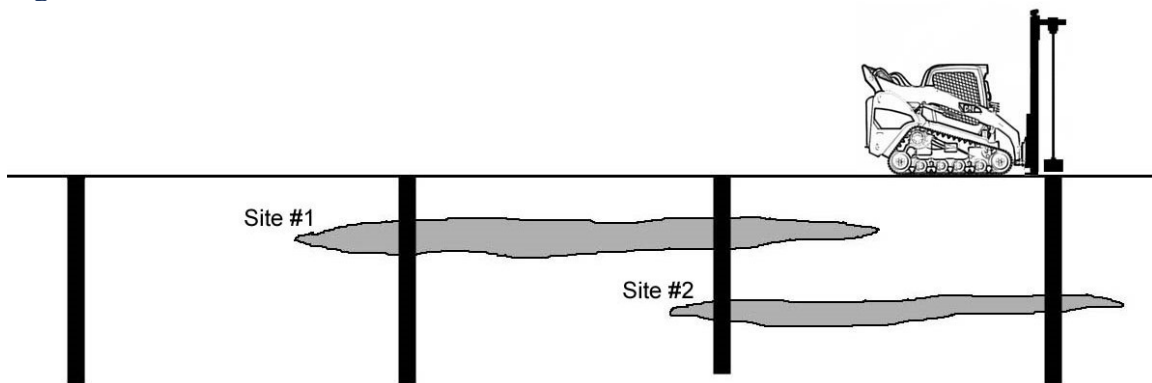
method eliminates the need for larger hand-dug test pits spaced at longer intervals. The hazard of workers entering deep excavation pits and the need for complex wall shoring are eliminated. Most importantly, the cost of labor and time needed to complete Phase I deep testing is greatly reduced while the quality of the results is enhanced.

Figure 3.



Example of a test pit excavated by the PaleoDigger machine.

Figure 4.



Closely spaced deep test pits can spatially delineate multiple horizons of cultural deposits.

### Trench Box Method

In some instances, it may be desirable to use a combination of hand excavated one-by-one-meter test pits to a depth of 1.5 meters and then use the PaleoDigger machine to continue the excavation below the floor of the hand excavated test pit (Figure 5). This approach allows for careful examination of the soils and cultural deposits

in the upper 1.5 meters of the excavation while permitting deep testing below the depth at which OSHA requires wall shoring and stepped back excavations. After completion of the hand excavations, a wooden trench box is lowered into the test pit (Figure 6). The test pit is then backfilled around the trench box. The height of the trench box is designed to match the depth of the test pit, so that the top of the box is at the level of the ground surface. The PaleoDigger machine continues the excavation through the trench box. The purpose of the trench box is to stabilize the hole and prevent the walls from collapsing under the weight of the skid loader. After the deep testing is completed, the trench box is extracted from the ground and reused in the next test pit.

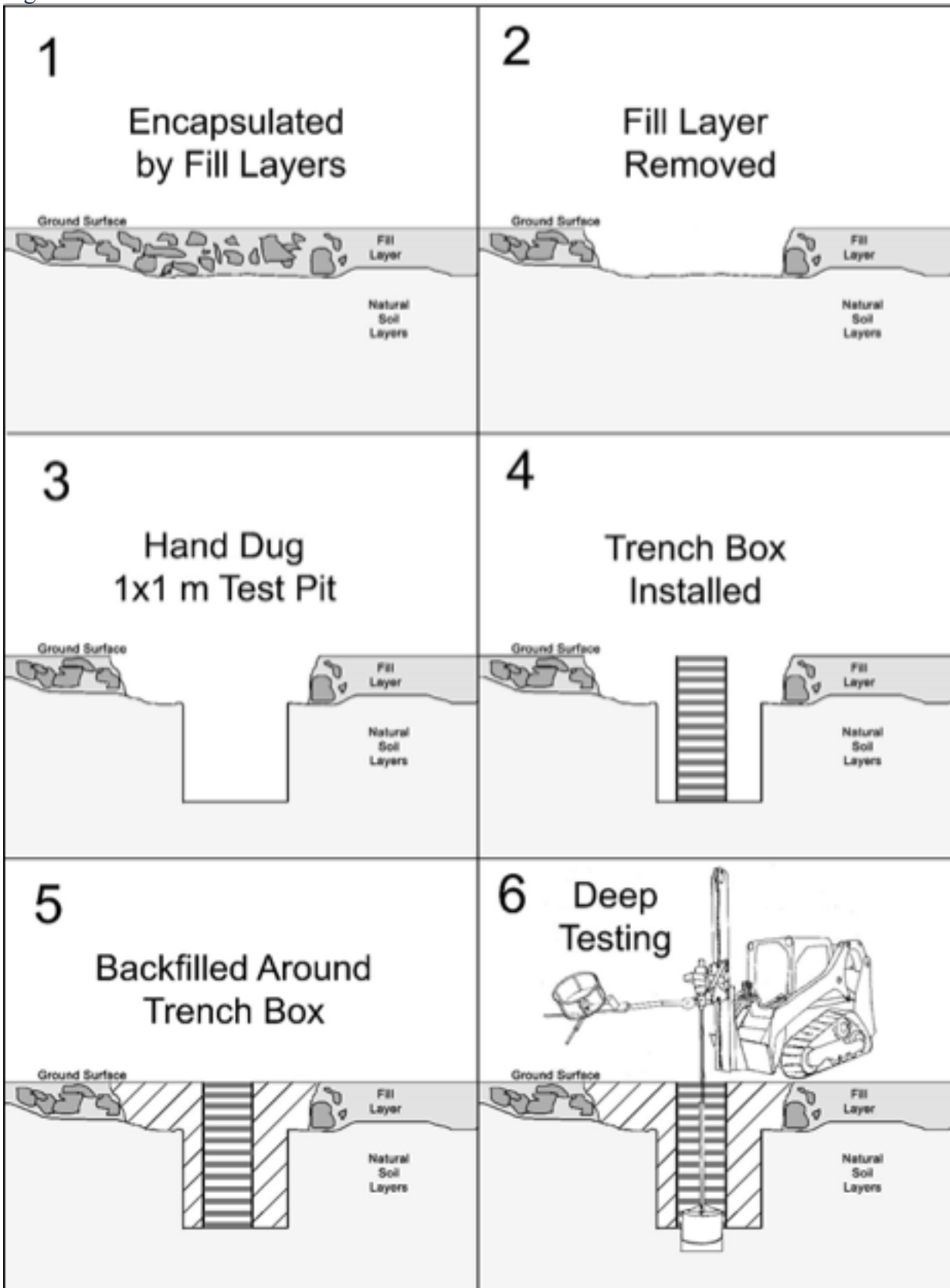
A variation of this method can be used when the natural soils are encapsulated by coarse fill materials. A backhoe is used to remove the fill layers. A trench box is inserted into the backhoe trench and the soil is backfilled around the trench box. The PaleoDigger machine then completes the deep testing through the trench box. Alternatively, the fill layers can be removed through hand excavations and continued to the OSHA limit of 1.5 m, followed by installation of a trench box and deep testing with the machine. Any combination of mechanical removal of fill layers and hand excavated test pits can be used as long as the height of the trench box matches the depth of the test pit before backfilling around the trench box.

Figure 5.



Deep testing through a wooden trench box as part of the Phase I Archaeology for the Pittston Bridge Replacement Project in West Pittston, Pennsylvania in January 2023. The box rests at 1.5 meters below the ground surface. The deep test pit continues to a depth of 4 meters.

Figure 6.



Deep testing using the trench box method.

## Questions and Criticisms

During the development of the PaleoDigger machine, I discussed my ideas about mechanized excavation with a number of archaeologists. Careful attention was given to their questions and criticisms of the machine and method. Each criticism is addressed below.

### The Inability to See a Profile at Depth

The inability to see a soil profile at depth is the most common criticism expressed by seasoned archaeologists. One-by-one-meter excavation squares provide a good view of the soils and depositional stratigraphy. This is especially important when test units are limited or spaced 30 meters apart. To some extent, the soil profile is used to interpolate the potential presence or absence of cultural deposits across the 30 m interval between sample locations.

Wall profile visibility is reduced in the smaller test pits excavated by the machine. However, there are plenty of opportunities to examine the color, texture, and content of the soil as it is removed from the test pit. In a given test area, test pits dug by the machine at 15-meter intervals will outnumber one-by-one-meter test pits four to one. This greater number of test pits distributed more evenly across the surface may collectively yield better soil data than the larger test pits.

Deep testing with the machine requires a shift in perspective from the traditional method. With the ability to dig deep test pits at the closer 15-meter spacing, examining the soil profile becomes less important. In addition, the machine is perfectly capable of digging radial STPs at 5-meter intervals or less. In compliance archaeology, if there are no artifacts, then there is no site. The principal goal of the Phase I survey is to identify the presence of archaeological sites and to delineate site boundaries. For deeply buried sites, the machine is better able to achieve this result compared to any alternative method. Let the machine define the horizontal and vertical site boundaries during the Phase I survey and then utilize that information to design a well targeted Phase II excavation using one-by-one-meter test pits. Collect detailed soil profile information during Phase II excavations which can then be combined with the large set of soil data collected from the Phase I test pits. Organizing the data collection in this manner will save time and labor and produce higher quality data.

### Damage to Sensitive Artifacts and Cutting through Features

Presently, not enough artifacts have been recovered by the PaleoDigger machine to fully address this question. Pebbles that were extracted by the machine do not show evidence of damage. However, in one case a cobble-size rock that was too big to enter the digging bucket was fractured into three pieces. More experience with the machine is needed. My feeling is that the machine will produce no more damage, and possibly less damage to artifacts than a spade shovel. Nearly all Phase I STPs and one-by-one-meter squares are dug with spade and flat shovels. Shovels damage artifacts. Even hand trowels damage the edges of flaked stone, bone, and earthen ware artifacts when struck. It is important to remember that the alternative to using the machine, i.e. hand shovels, is not a damage-free alternative.

A case in point is the Phase I testing that discovered the Brick House site (36AR559) located along Redbank Creek in Armstrong County, Pennsylvania (Fritz and Bercel 2013). During excavation of a one-by-one-meter test pit in alluvial soils, the crew dug through an Early Archaic hearth feature at a depth of 116 cm. The presence of the feature was not recognized until the shovel cut in half a complete Kirk Corner-notched point. Hand shovels damage artifacts. Failure to recognize cultural features before digging through them is a common occurrence in Phase I testing.

## Encountering Historic Features and Foundations

The machine cannot dig through heavy stonework. If a foundation is struck, mechanical excavation would stop, and traditional excavation methods would be employed. In the case where a foundation is represented by a loose assemblage of smaller stones, the machine may cut through that layer of stones. Recognition of the foundation's presence would be no better or no worse than if encountered in a hand excavated STP. Given that the principal application of the PaleoDigger machine is excavation in deep alluvial soils, I do not expect to encounter foundations often.

## Encountering Heavy Fill in Urban Areas

The machine has a limited capacity to cut through gravelly layers. In most alluvial settings, when basal gravel is encountered, there is no need to dig deeper. Floodplains and terraces in urban areas often have a layer of fill that caps the undisturbed layers below. If a heavy fill layer is encountered, it may be necessary to remove that fill layer with a backhoe, as it would with any other method of archaeological testing. It may be possible to employ a more aggressive digging auger on the PaleoDigger machine to cut through the fill layer and then switch back to the auger bucket when the obstruction is cleared. This may save the extra cost of hiring a backhoe if proven to work.

## It will put Archaeologists out of Work

A principal goal in designing the machine was to reduce labor costs and the time needed to complete Phase I surveys. How this would translate into the loss or gain of archaeology jobs is uncertain and hard to predict. I do know that the cost of completing deep archaeological testing using traditional methods has caused the cancellation of development projects. In those cases, the archaeology was not completed, and as a result, those potential jobs were lost.

A case in point is the Westfall Senior Apartments Project located along the Delaware River in Pike County, Pennsylvania (Fritz 2014). The proposed housing development was slated for construction across a floodplain along the west bank of the river. The project developer planned to utilize federal loans tied to low-income housing to help finance the construction which triggered NHPA Section 106 compliance and the need to conduct an archaeological investigation. A geomorphology survey found that the soils across the floodplain ranged in depth from 1.5 meters to 3 meters. The proposed cost of conducting the Phase I survey was so expensive that the developer declined the federal funding and moved ahead with construction without completing the archaeological surveys.

The Westfall project would have been ideal for using the PaleoDigger machine, but my idea for the machine was only on paper at that time. We will never know if the availability of the machine would have lowered the cost enough to move forward with the Phase I survey. What is certain is that no archaeological sampling was done prior to the destruction of the terrace. If there were archaeological sites present, they are now lost.

To argue that mechanization of archaeology should not occur because it will put archaeologists out of work is akin to saying that mechanized road construction equipment should be banned, and gangs of workers should be assembled with hand picks, shovels, and wheelbarrows. The cost of re-instating 1930s era methods of manual labor would not be acceptable in today's society. We need to recognize that the high cost of hand excavation is a potential threat to the public's continued support of compliance archaeology. Perceptions matter. When a developer visits a work site and finds the archaeology crew utilizing shovels and home-made screens, the question arises, "What am I paying for here?" I have personally been asked by a client who was frustrated with the cost of a Phase I proposal, "Don't you have a machine to do this?"

## Conclusions

Archaeologists have been resistant to the idea of mechanized excavation. Construction equipment that most archaeologists are familiar with is perceived as brute force and lacking the spatial control needed for good archaeology. For the most part, this perception is accurate. Construction machines were not designed for archaeological applications. The PaleoDigger machine is the first machine that was specifically designed for excavating archaeological test pits.

As of January 2023, the PaleoDigger machine has been used to excavate 4-meter-deep test pits on two highway related projects, the Riverlands SR322 Project at the Confluence of the Juniata and Susquehanna Rivers and the Pittston Bridge replacement Project located in West Pittston, Pennsylvania (Figure 7). My machine and method were approved for use by the Pennsylvania Department of Transportation, the Federal Highways Administration, and the Pennsylvania State Historic Preservation Office. In both cases, the machine was cost effective for determining that no deeply buried archaeological deposits were present. The machine demonstrated good vertical control and spatial consistency in the test pits. Improvements continue to be made to the machine, and the machine's productivity is progressing with each design iteration. While the discussion above is focused on using the machine for compliance archaeology, what excites me the most is the PaleoDigger machine's potential for finding deeply buried Paleoindian sites and the prospects for advancing First American studies.

Figure 7.



Deep testing through a wooden trench box as part of the Phase I Archaeology for the Pittston Bridge Replacement Project in West Pittston, Pennsylvania in January 2023.

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## Videos

Building the PaleoDigger Machine <https://youtu.be/i8dDJ6hbdgM>

Susquehanna River Dig <https://youtu.be/nwtlREaQfvs>

West Pittston Dig [https://youtu.be/BMiWd\\_RbpAc](https://youtu.be/BMiWd_RbpAc)

## Dig Deeper!