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A Comparative Analysis of Wood Residues on Experimental Stone Tools and Early Stone Age Artifacts: A Koobi Fora Case Study

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ABSTRACT
There have been recently reported plant residues on stone tools from the Okote Member, Koobi Fora, Kenya. No comparative microscopy, however, was available for more specific identification of the residues. Experimental research, using replica basalt tools, was conducted on six different trees native to the Koobi Fora region. Wood anatomy observed through reflected light microscopy (100-500x) of the experimental tools was compared to residues on the archaeological materials. Similar anatomical structures and patterning of residues were visible in both samples. This further supports recent evidence of woodworking by early hominids approximately 1.5 million years ago.

Introduction
Koobi Fora is a region in Kenya, east of Lake Turkana and is an area rich in Plio-Pleistocene deposits with hominids and stone tools. Many early hominids have been found in Koobi Fora and it is an important locality for understanding the evolution of our ancestors. The archaeological sites in the region date back as far as 2.5 million years ago (mya). This study focuses on sites dating to approximately 1.5 mya, a number of which were recently excavated by Hardy and Rogers (2001).

Because the only artifacts that survive at 1.5 mya are stone tools and modified animal bones, it is important to understand stone tool function. Stone tools from 1.5 mya have been analyzed for residue, but no specific identification of the residues found has been completed. Therefore, an experimental program, replicating stone tools and using them on wood was performed. This way, specific identification of the residues and past function of the artifacts from 1.5 mya could be accomplished through comparative analysis.

Background – ESA Stone Tool Function
The earliest known wood artifacts are from 400,000 years ago. These are wooden spears from the Lower Paleolithic site of Schöningen in Germany (Thieme 1997). The spears are not evidence of the first woodworking technology, rather they are the oldest preservation of wood that we have. With microscopic analysis of tool function, the dating for the presence of a woodworking technology can be pushed back even farther.

There have been few studies of stone tool function from the Early Stone Age. Of these few, most have analyzed only flint or chert tools. ninety-five percent of tools from Koobi Fora are made from basalt, a volcanic lava. Keeley and Toth

(1981) analyzed flint and chert artifacts at 1.5 mya. Also, they analyzed microwear polishes, which involves the removal of any plant residue that might be present on the tool. Using an incident-light microscope at magnifications of 50-400x, they found evidence of polishes that they feel coincide with the processing of meat, soft plants, and wood (Keeley & Toth 1981:465).
Sahnouni and de Heinzelin (1998) also analyzed microwear patterns of Early Stone Age artifacts found in Ain Hanech in Algeria. Through light microscopy on an Olympus BHM at 100-500x, they found evidence on flint tools of meat processing (Sahnouni & de Heinzelin 1998:1097).

Another analyses of artifacts from around 1.5 mya, also shows evidence of woodworking. Dominguez-Rodrigo *et al*., used SEM and light microscopy for analysis of phytoliths, which are silica bodies in plant cells that are possibly diagnostic to species, on Acheulian handaxes from Peninj in Tanzania to provide evidence of what they were used for. They found evidence of grasses and most importantly, Leguminosae (*Acacia*) or Salvadoraceae (*Salvadora persica*). Analysis of the paleosols around the artifacts show that the phytoliths found on the tools are unlikely to be from contamination (Dominguez-Rodrigo *et al*. 2001:295).

Hardy and Garufi (1998) show the importance that residue analysis has in identifying the use of stone tools. Because plants very rarely survive macroscopically, residue on tools is often the only evidence that survives. The experiments conducted show that wood residue can be analyzed to show the patterning of different use-actions, and can be identified to class and maybe even species level (Hardy & Garufi 1998:182).

Background – Paleoenvironment

Through paleoenvironment reconstruction conducted by Jeanne Sept (1986, 1994), economically viable plants at 1.5 mya were identified. Many sites in the Okote member at Koobi Fora are located in proximal floodplains along river channels. One of these sites, FxJj 50, was analyzed for pollen and was found to have been a dry, open woodland, which have *Acacia* and *Commiphora* trees as a common characteristic. Also, the pollen showed that *Acalypha*, *Ficus*, and *Ziziphus* trees were also present. This site was then compared to the modern day channel landscapes of the Voi River in southern Kenya and Il Sej Naibor in northern Kenya, east of Lake Turkana. This comparison shows that the environment now and 1.5 mya are broadly similar and the plants are the same now and then (Sept 1986).

Methods

Experiments in woodworking, with replicated stone tools, were conducted for comparison with archaeological material. Six trees, *Commiphora* sp., *Salvadora persica*, two *Acacias* sp., *Boscia coriacea*, and *Delonix ela*, were chosen for the experiment since they had been identified as possible plants present at 1.5 mya in this region. Out of these six trees, five have known significance to the Dassanetch living in the area. The Dassanetch are a semi-nomadic, agro-pastoralist group that came from Sudan and Ethiopia to the north. They rely on cattle, sheep, and goats, although there is a smaller community within the Dassanetch that rely solely on fish. This group is considered poor by other Dassanetch because they have few, if any, livestock. The Dassanetch uses for the trees were gathered through unstructured interviews with two Dassanetch who were familiar with plants and one interpreter. The Dassanetch names and uses for the trees used in the experiment are in Table 1.

For the experiments, local basalt was collected and fashioned into stone tools, similar to those found at 1.5 mya. Then the trees listed above were identified and branches were collected from them. All of the wood collected for the experiment was fresh when used. To work the branches, three different use-actions were executed: whittling, cutting/sawing,

Table 1. *Dassanetch names and uses for the trees used in experiement.*

Local Name	Scientific Name	Local Uses
Lyathe	Commiphora sp.	Children eat the fruit in times of drought and the tree is used as toothbrushes and for building boumas
Nyiethe	Salvadora persica	The fruits are eaten raw, used to make fruit juice, and feed to goats. Also, it is used for toothbrushes.
Kerech	Acacia sp.	The thorns are used for needles and the trunk is used to make sitting stools, water troughs, and cups to milk animals. To fashion the cups, they scrape out the inside with stones.
Sech	Acacia sp.	The fruits are used to feed goats and baby sheep, goats also eat the leaves in times of drought. Also, it is used to dye skirts red
Zoorich	Boscia coriacea	The fruits are eaten and it is used to build houses.

and incising. Whittling consists of scraping the stone tool lengthwise along a branch to remove layers of tissue. Cutting/sawing consists of cutting into the branch crosswise. Incising consists of cutting into the branch lengthwise. Each use-action was performed for 2, 5, and 10 minutes for a total sample of 54 tools. These samples were exported back to the United States for analysis.

For the purpose of this paper, just the 10-minute duration of each use-action was examined. The wood residues on the tools were analyzed using reflected light microscopy on an Olympus BX-30, at both 100 and 500x. Diagnostic wood anatomy was identified for each use-action (Hoadley 1990). The experimental results were compared to archaeological materials excavated by Hardy and Rogers in 2000 at Okote member sites, FxJj 18IHS, FxJj 18 GU, FxJj 50, FwJj 1, FxJj 73, FxJj 17A, and FxJj 17B, at Koobi Fora (Hardy & Rogers 2001). The archaeological materials were examined using the same methods as above.

Results

Use-actions

Each use-action cuts through the wood at a different plane that can be identified and used to predict which use-action was performed.

> *Cutting/sawing* The only plane cut with a (cutting/sawing) motion is cross-sectional. However, the edge of a stone tool is not uniform and often undulates at a microscopic level. Therefore, radial sections are sometimes torn loose and adhere to the tool. Striations are parallel to the working edge.
> *Incising* Incising cuts primarily along a radial plane. Striations are parallel to the working edge.
> *Whittling* At the beginning of cutting the fragments produced are tangential. As more wood is removed, radial and even cross-sectional planes may appear. Striations are perpendicular to the working edge. [Hardy & Garufi 1998:180]

Wood Anatomy

Trees that are found in Kenya are all hardwoods, which have a more complex anatomy than softwoods. Common diagnostic anatomical features that were found include vasicentric tracheids, alternate intervessel pitting, vessel elements, scalariform pitting, and ray cells. Vasicentric tracheids occur near vessel elements, are closed at the ends, and have pits along the sides. Intervessel pitting occurs along the wall joining two vessels; this allows molecules to pass back and forth between vessels. When the intervessel pitting is alternate, this means that the pits have an irregular or diagonal pattern and are crowded together. Vessel elements are hardwood's largest cells. Scalariform pitting is "elongated barlike pits in parallel, ladderlike arrangements (Hoadley 1990:37)". Most cells in wood grow vertically, but a small percentage of them grow horizontally and are called ray cells (Hoadley 1990).

Individual Results

Figure 1 shows experimental tool #6, which is a basalt flake that was used for whittling *Salvadora persica* for 10 minutes. The anatomical features found include a vessel element and alternate intervessel pitting. There was residue visible macroscopically along the longest edge on the dorsal side. There were two small spots of residue visible on the ventral side and these were fibers that had wrapped around the edge.

Figure 2 shows experimental tool #14, which is a basalt flake that was used for incising *Commiphora* sp. for 10 minutes. The anatomical features found on this tool, were wood fragments and vasicentric tracheids with visible pits. There was residue visible macroscopically along one edge both on the dorsal and ventral surfaces.

Figure 3 shows experimental tool #8, which is a basalt flake that was used for cutting *Acacia* sp. for 10 minutes. Diagnostic features found were a wood fiber, a vessel element, and a radial section of ray cells. This tool also had residue visible macroscopically along one edge both on the dorsal and ventral surfaces.

Figure 4 shows archaeological tool FxJj18IHS-5003, which is a split basalt flake. The features diagnostic of wood on this tool are alternate intervessel pitting and possible scalariform pitting. There was residue visible macroscopically along the split edge on the dorsal surface and on the corner opposite the split edge on the ventral surface.

Figure 5 shows archaeological tool FxJj18GU-5020, which is a basalt flake. Found on the flake was vessel elements and tracheids with pitting. There was residue visible macroscopically on one edge of the dorsal surface and on the opposite edge on the ventral surface.

The final figure, Figure 6, shows archaeological tool FxJj17A-1092, which is a basalt flake that has wood fragments and ray cells. This tool had residue visible macroscopically on the dorsal surface.

Discussion

The diagnostic anatomical features such as pitting, ray cells, vessel elements and tracheids, both on the experimental tools and on the archaeological materials show that wood is present in both cases. Both experimental tool #6 and tool FxJj18IHS-5002 have residue with alternate intervessel pitting and both experimental tool #8 and tool FxJj17A-1092 have ray cells. These anatomical features are not diagnostic to genus and species, but they do confirm the identification of hardwood.

The results of this study have possible implications for hominid behavior. The confirmed wood residue on stone tools at 1.5 mya shows that early hominids were utilizing wood. However, this cannot be narrowed down to a specific task or behavior that they were performing. The ethnobotany suggests possible behaviors and why certain plants are economically feasible for use by the Dassanetch in the Koobi Fora area today. The same plants may have been economically viable in the past but not necessarily for the same purposes. There are limits to using the Dassanetch as a model for early hominid behavior. For one, the Dassanetch are agro-pastoralists and early hominids were foragers. Also, the Dassanetch have had 1.5 million years of evolution compared to the early hominids that made the original artifacts. The Dassanetch have not been living in isolationary time-warp and, as Chris Gosden says, "we have no justification for using the present of one society simply to interpret the past of another, especially as the present is often seen as a latter-day survival of stages passed elsewhere in the world (Gosden 1999:9)." Nevertheless, the identification of wood residues is possible through experimental archaeology and modern groups do provide ideas about possible uses of plants in the past.

Conclusion

Analysis of microscopic residue on stone tools is a valuable resource, because it provides evidence of what would otherwise be invisible. Wood may be nonexistent in the archaeological record at 1.5 mya, but that is not because early hominids were not using wood. Rather, wood cannot survive macroscopically for that long. The earliest preserved wood that has been found is from 400,000 years ago (Thieme 1997). But wood was being utilized far before that. Because evidence of a wood industry would not survive on a macroscopic level at 1.5 mya, microscopic analysis of the residue left on stone tools is the only indicator available to be able to infer hominid behavior. The results of this study show that wood residue is present on tools from the Okote member and this strengthens the argument for a woodworking industry at 1.5 mya at Koobi Fora.

Figure 1. *Experimental Tool #6, Basalt Flake, whittling, Salvadora persica, 10 minutes; A) vessel element; B) alternate intervessel pitting; and C) alternate intervessel pitting.*

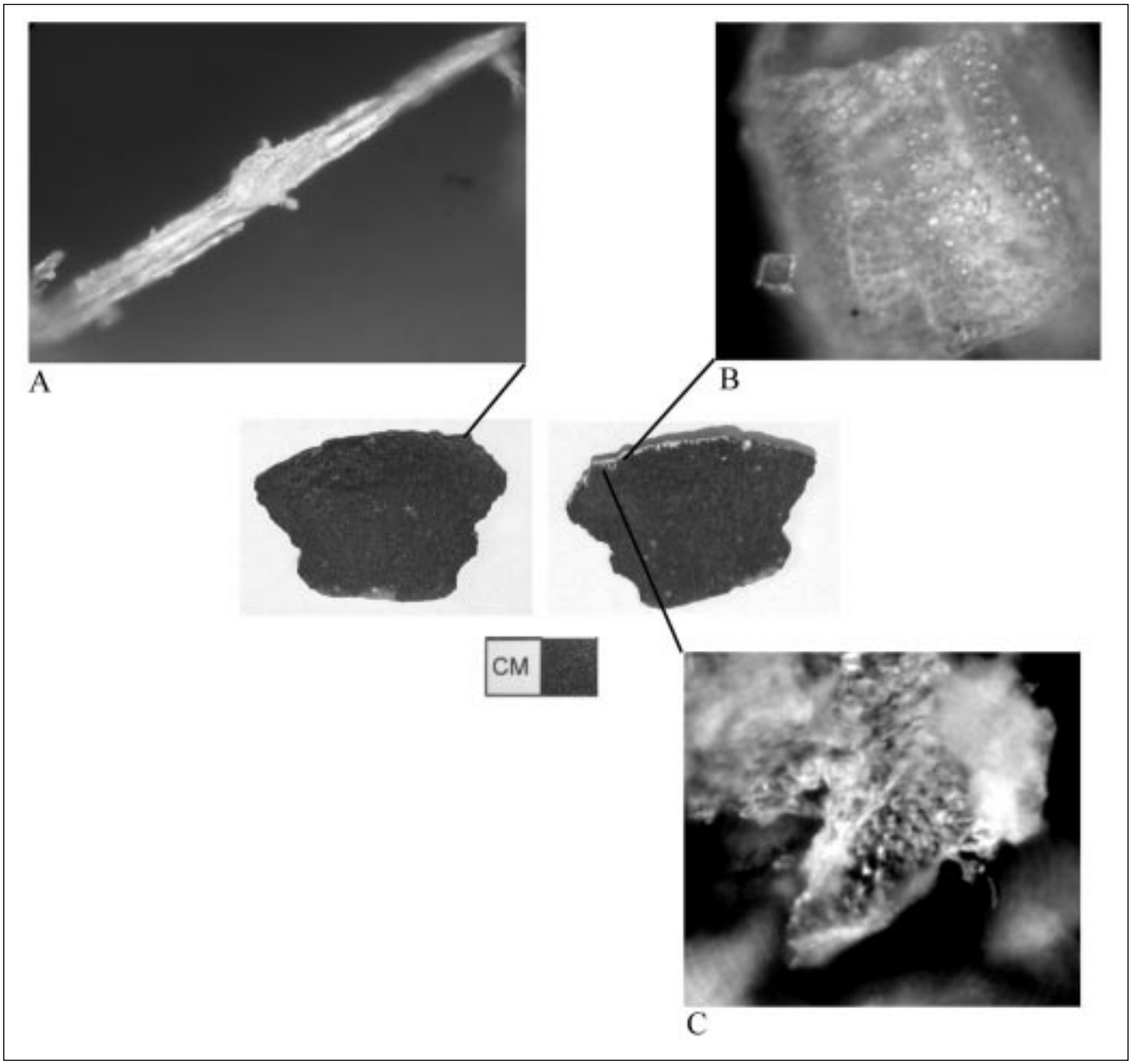


Figure 2. *Experimental Tool #14, Basalt Flake, incising Commiphora sp., 10 minutes; A) wood fragments; B) vasicentric tracheids, arrows indicate pits.*

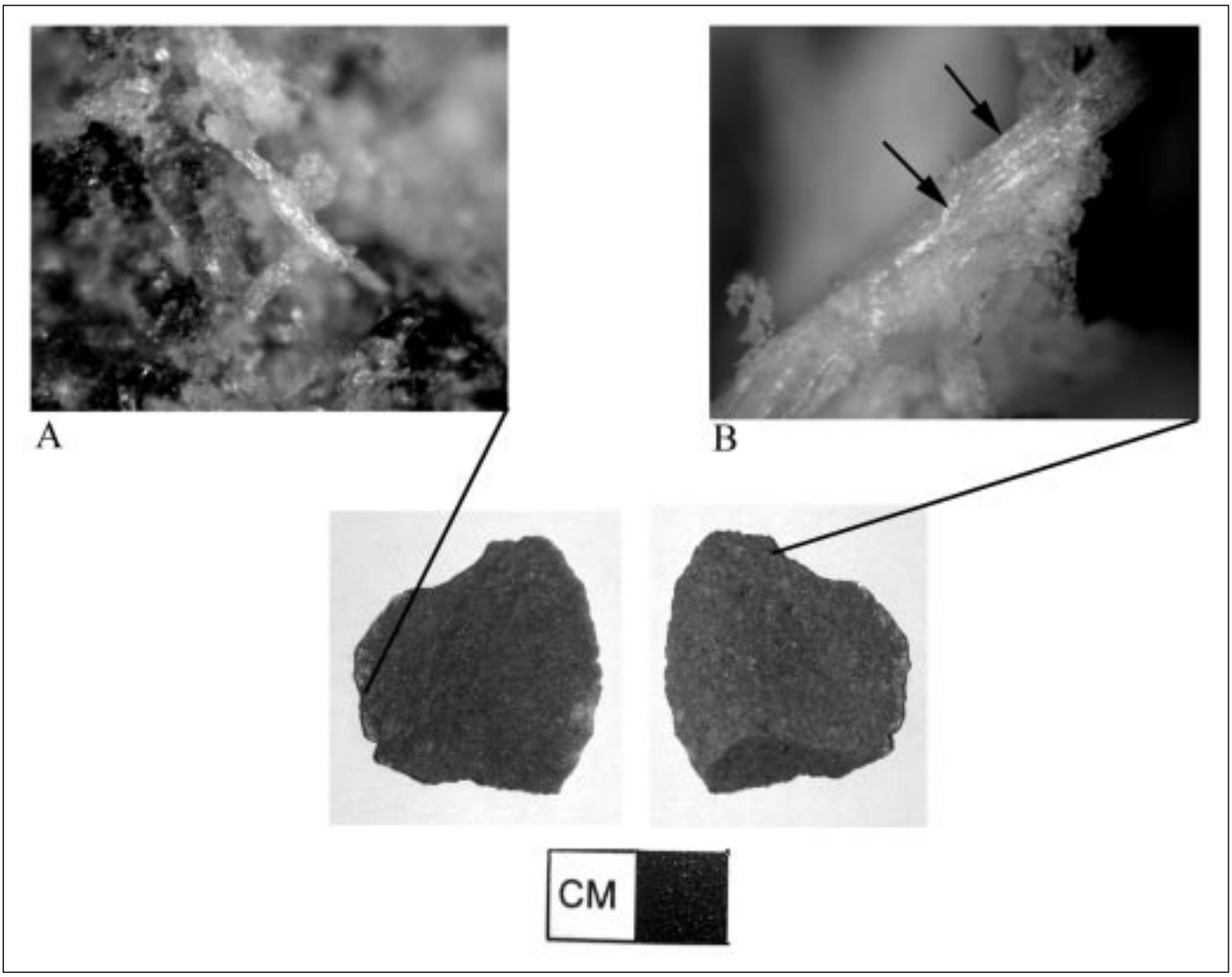


Figure 3. *Experimental Tool #8, Basalt Flake, cutting Acacia sp., 10 minutes; A) wood fiber; B) vessel element; C) ray cells, radial section.*

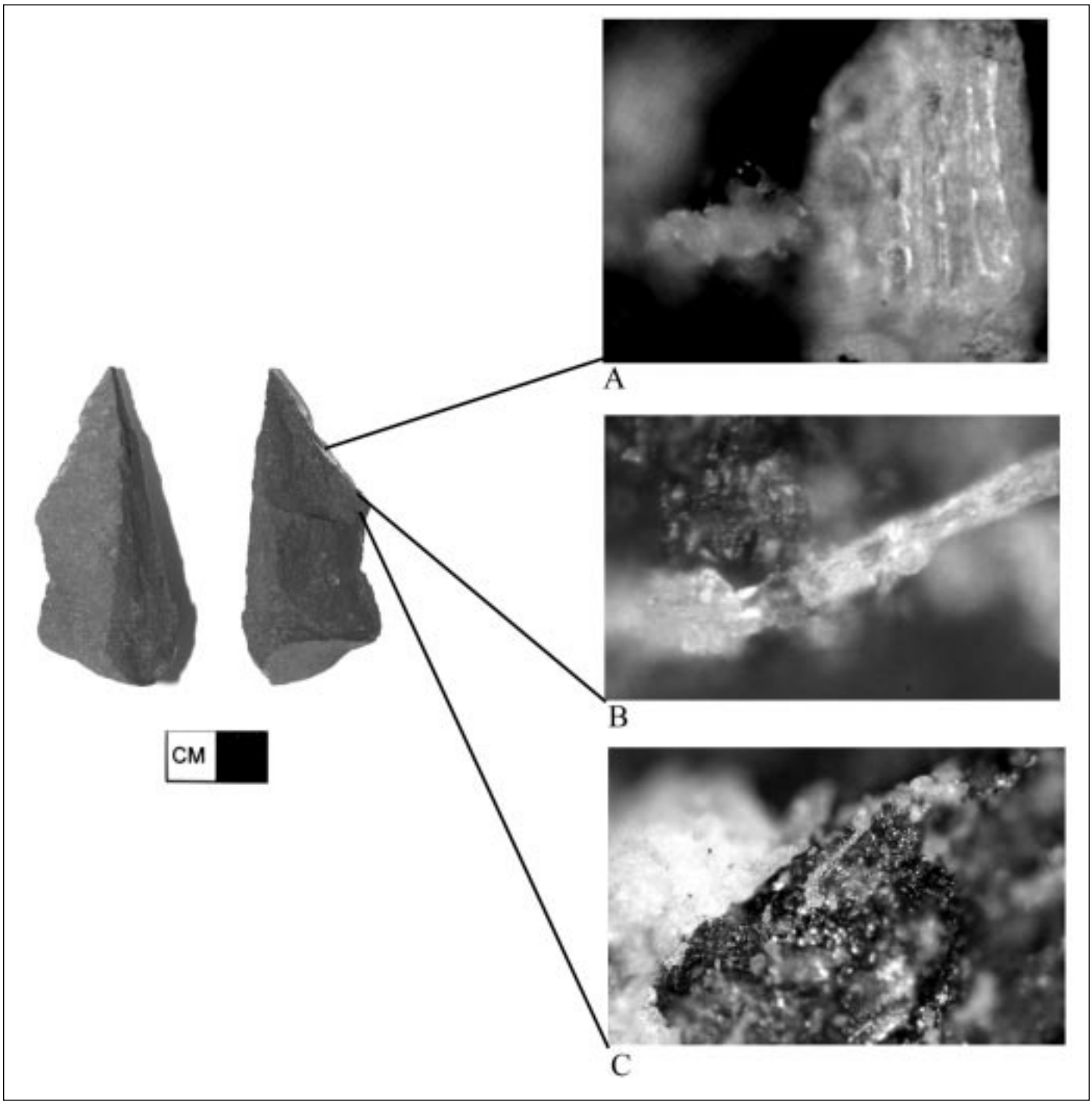


Figure 4. *FxJj18IHS-5003, Split Basalt Flake; A) alternate intervessel pitting; B) possible scalariform pitting*

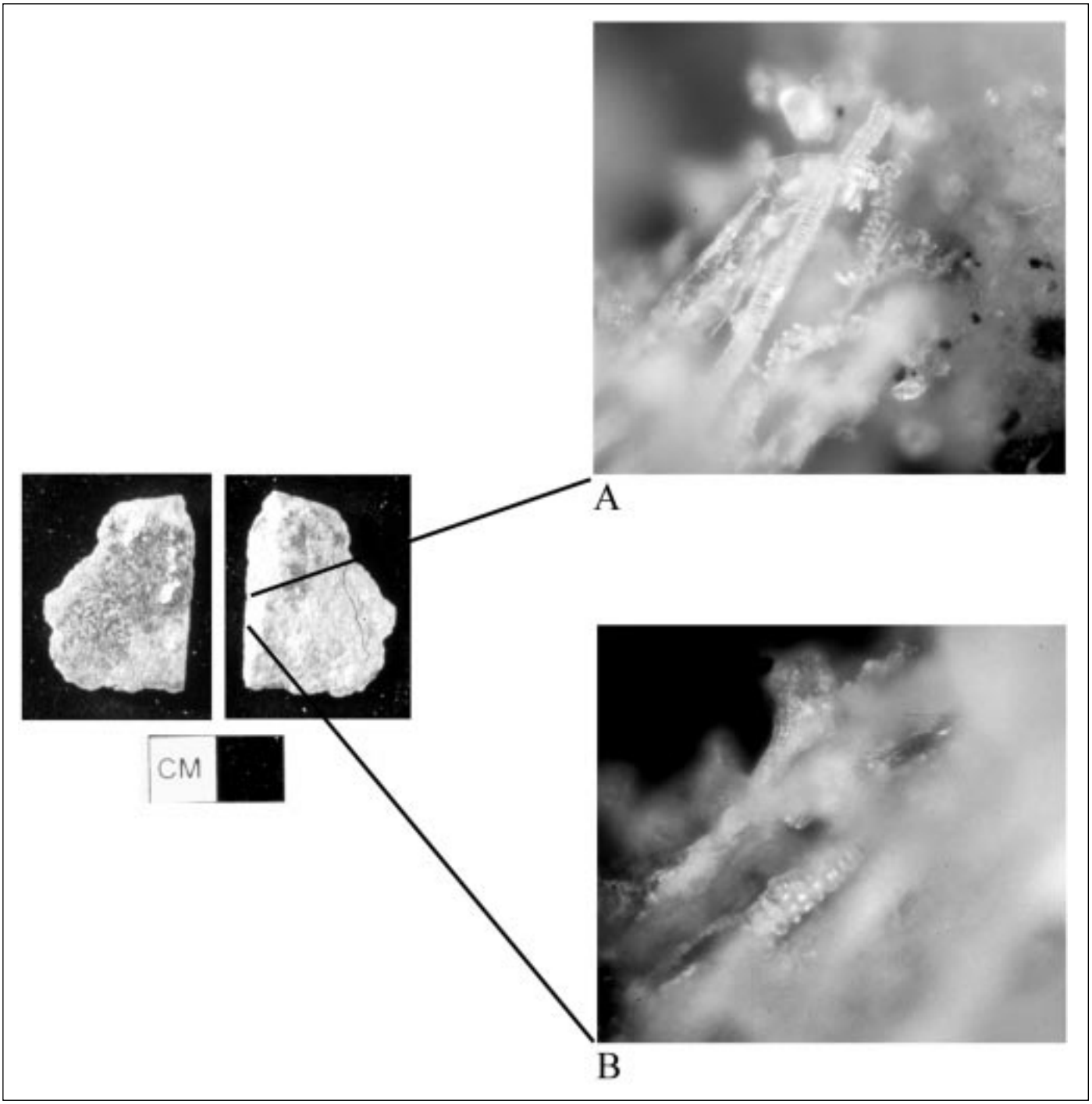


Figure 5. *FxJj18GU-5020, Basalt Flake; A) vessel elements and tracheids; B) vessel elements and tracheids with pitting.*

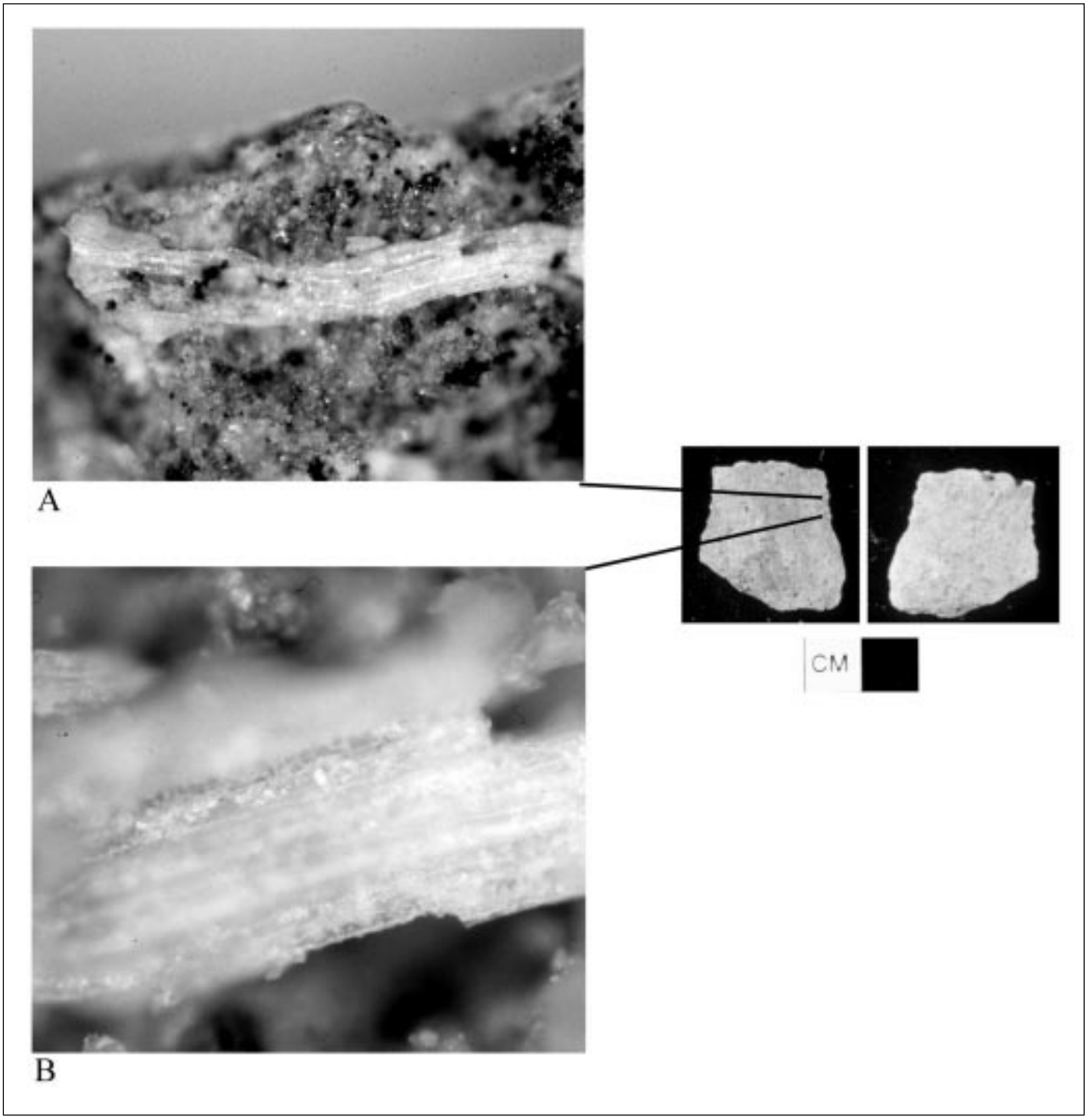
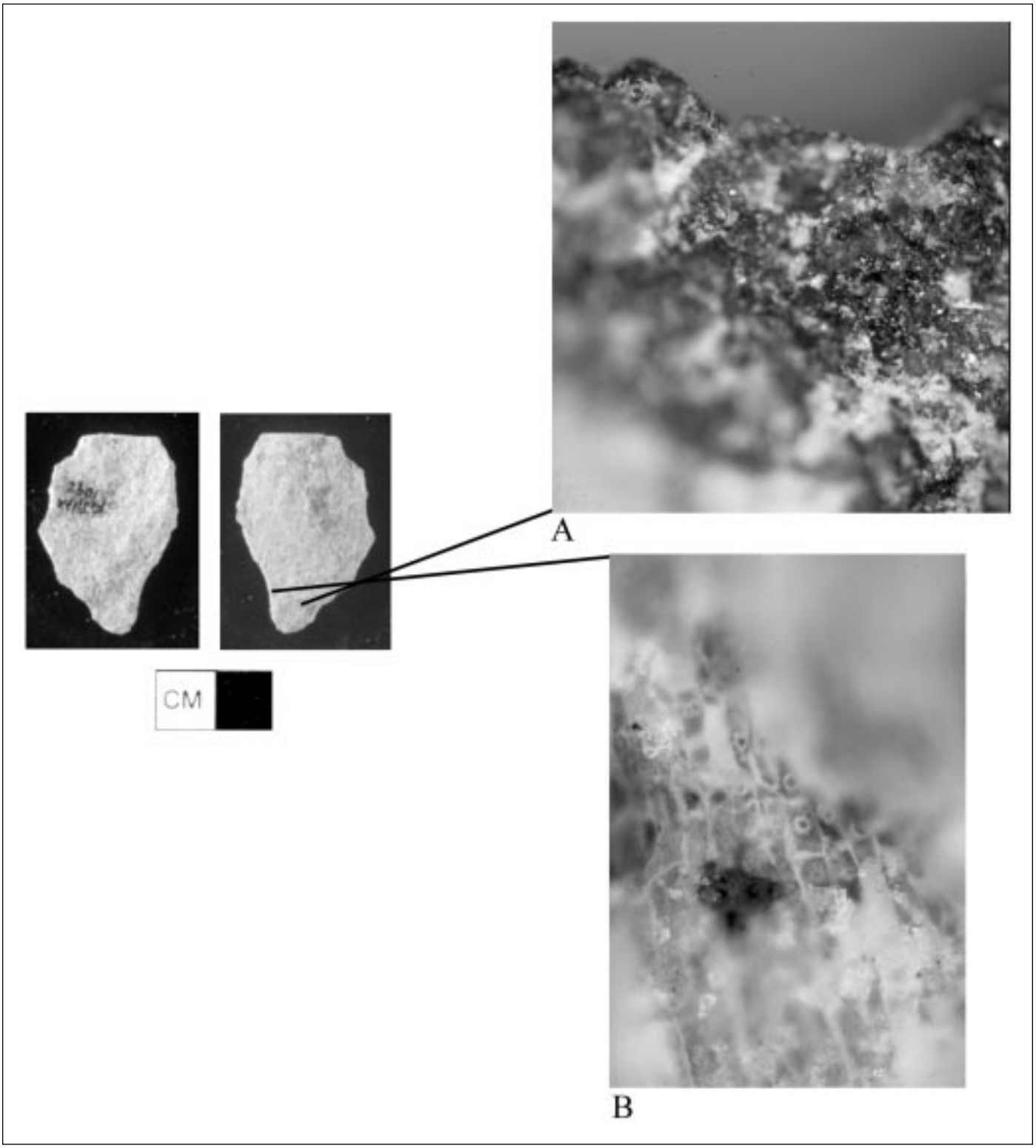


Figure 6. *FxJj17A-1092, Basalt Flake; A) wood fragments; B) ray cells*



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