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30,000 years old wild flax fibers - testimony for fabricating prehistoric linen

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Only on rare occasions does prehistoric organic material**,** other than bones**,** turn up in the excavations. Here we report a discovery of wild flax fibers from a series of Upper Paleolithic layers at Dzudzuana cave, located in the foothills of the Caucasus, Georgia (1), indicating that prehistoric hunter-gatherers were making cords for hafting stone tools, weaving baskets, or sewing garments. Other early reports of the use of plant fibers include Dolni Vestonice (Czech Republic) at ca. 29-32 ka cal BP (probably nettle, *Urtica sp.*) (*2*) and unidentified species in Ohalo II (Israel) at ca. 21 ka cal BP (*3*).

Radiocarbon dates demonstrate that Dzudzuana cave was inhabited in the Upper Palaeolithic period, during 32-26 ka 14C BP (36-31 ka cal. BP; Unit D), 23-19 ka 14C BP (28-24 ka cal. BP; Unit C), and 13-11 ka 14C BP (15.5-13 ka cal. BP; Unit B), capped by Late Neolithic/Eneolithic deposits of Unit A (6.3-5 ka 14C BP; 7-6 ka cal. BP) (*1*) (Table **S1).**

We found the flax fibers during palynological analyses of 86 clay samples of 50 grams each collected from five locations within the excavated area in 2007-2008 (Table S2). The clay deposits are rich in carbonate, and produced large amounts of non-pollen palynomorphs, including microfossils of fungi, algae, cormophytes, and animal hair. The flax fibers were present throughout the sequence with a peak in the early stages of Unit C.

Flax fibers were identified according to the characteristic properties of the structure and morphology, defined by us studying comparative microscopic samples of modern flax fibers (Figs. **S1, S2**). Literature on fibers was used in the process of identification too (*5-9*). Some of the characteristic features of the flax fibers structure are their considerable thickness (3-5 μm) and that they consist of multiple longitude segments (*6, fig.3,4; 8,fig.2*). Applying these criteria, flax fibers are easily separated from other plant fibers. For instance, cotton fibers are thin (1.5-2 μm), flattened and not segmented (*7,fig.6*). An important diagnostic property is also the particular structure of the fiber extremities. Those of flax fibers are completely straight ("cut-like"), while for example the cotton fibers ends are loose and create a convex arch, or an angle (*5, 10*). The structure of the flax fibers is linear,while that of cotton is

smooth (*6*, fig.3,-4; *8*, fig. 2; *7*, fig.6).

We consider some of the colored fibers as dyed, since the majority of the fibers in the assemblage are colorless, as in their natural state. A wide range of natural pigments was available to the Upper Paleolithic occupants of the cave including roots and other plant parts from the flora of the Caucasus where 224 plant species used as natural pigments for dying strings and textiles were recorded (*11*). The colors range includes yellow, red, blue, violet, black, brown, green and khaki.

The earliest archaeological context in Dzudzuana - Unit D - represents the early Upper Paleolithic tool-kit of unidirectional short blades and small bladelets. The distinctive tool type is a small, finely retouched bladelet, typically < 4 mm wide. The lithic industry in Unit C is dominated by small bladelets detached from carinated cores. Unit B is rich in blades and bladelets removed from bipolar cores, shaped into microgravettes, elongated straight-backed items and numerous end scrapers. Unit A represents admixture of Late Neolithic/Eneolithic and historical occupations (*1*). All the units contain worked bone artifacts including a perforated needle from Unit C as well as groundstone utensils and faunal remains (*4*).

All 27 clay samples from Unit D produced fibers of flax (N=488) (Table **S2**); some were spun (N=13) and dyed (N=58), the colors are mostly black-to-grey and turquoise. One of the threads is twisted. The complete fibers are long (> 200-μm), rounded, and comprised of segments of smaller lengths. Individual fibers are linear with thin and translucent walls. Several ends of both the complete and disbanded fibers were cut across (Fig.1)**.**

We recovered 787 fiber fragments of various lengths from Unit C. The highest concentration was in sub-layer C-5 (Table **S2**). A few fibers were spun (N=18), and one string had numerous knots in Unit C-3. We found 38 colored fibers - black, grey, turquoise, and a pink one.

Fewer flax fibers were found in all seven samples of Unit B (N=48; only three of which were colored – one black and two turquoise) and in five samples of Unit A (N=30).

Although climatic fluctuations are recorded through the depositional sequence, flax plants would likely have survived in the immediate environment of the cave. Several samples from Unit C) appear to be two-ply S-twisted in a relatively complex pattern (Fig. 2). The colored fibers may indicate that the inhabitants of the cave were engaged in producing colorful cloths (?). We also recovered a few tur hairs in Unit D, including colored and twisted ones (Figure **S3**). The combination of flax fibers, some tur hair, microremains of skin beetles

(Fig.**S4:**1-3) and moth can be interpreted as an evidence for processing of fur, skin and cloth. This conclusion is supported by the presence of spores of the *Chaetomium* fungus (Fig.**S4:**4-5), usually growing on clothes and textiles, and unfortunately destroying them (*12*).

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