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MINING KNIFE RIVER FLINT IN NORTH DAKOTA

The Alkali Creek site near Halliday, North Dakota, is a lithic-quarry locale that has been used since Paleoindian times for the acquisition of Knife River flint. The unique record of mining and workshop activities produced by the site is the focus of recent investigations by Metcalf Archaeological Consultants, a cultural resource management firm based in Eagle, Colorado.

When principal investigator Michael Metcalf describes the Alkali Creek site, he compares its stratigraphy to a piece of Neapolitan Swiss cheese. "There are depositional units that consist of different materials. They don't contrast all that much like the colors in a Neapolitan layer. Nevertheless, they're different and can be identified in the stratigraphy. . . . The site was used for extracting flint for probably 11,500 years, and the holes that the [prehistoric miners] dug in going after the flint, we liken to the holes in the cheese." Knife River flint, which Metcalf describes as rootbeer-colored, is a fine-grained silica-based stone, well suited for flint knapping. The flint is located in secondary gravel deposits that washed down the Spring Creek valley during glacial times.

Throughout the time that human beings intermittently excavated the site, Alkali Creek and nearby Spring Creek periodically flooded their banks, depositing layers of silt that filled in the open mines and increased the distance between the surface of the ground and the flint deposits below. Every time people mined the site, they had to dig deeper holes to reach the flint. At the time of the most recent occupation, 1600 to 2000 years ago, people dug shafts 2 m deep in order to extract the flint. "There's a fascinating evolution to the site," observes Metcalf. "It shows changing quarrying techniques as the distance down to the flint increased." He notes that some shafts give evidence of having been redug and refilled two and three times by successive excavators. The flint deposits are an average of 2.2 m below the present-day surface.

Located on an old gravel bar in a meander bend at the convergence of Alkali Creek and Spring Creek, the

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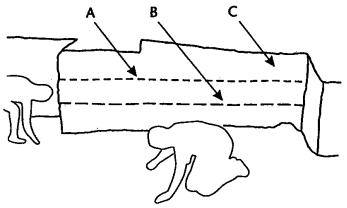
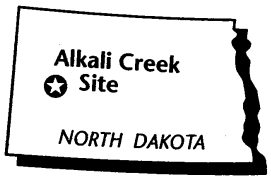


Archaeologists Bob Christenson (foreground) and Justin Harvey (left) excavate Paleoindian quarry spoils in the Goshen cultural level of the Alkali Creek site. The exposed stratigraphic sequence shows the early Archaic level (A, in drawing). The early Holocene Leonard Paleosol lies below; midway through the Leonard Paleosol is the Hell Gap level (B). The edge of a late Archaic quarry shaft, dug down through the Pleistocene flint-bearing gravels, is visible at C. *(Photo courtesy of Metcalf Archaeological Consultants.)*



Site mentioned in "Mining Knife River Flint"

INSIDE

LIVING CELLS UNLOCK ANCIENT MYSTERIES

Where did the First Americans come from? How many separate groups crossed the Bering Strait from Asia, and when? And how are the modern-day descendants of these early immigrants in North, Central, and South America related?

Until recently, even the possibility of finding a definitive answer to all of these questions seemed remote. But biochemist Dr. Douglas Wallace has turned a DNA research technique into a powerful anthropological tool that may have the potential to do just that.

Wallace, a researcher in genetics at Emory University School of Medicine in Atlanta, is using current advances in his field to study the origins of three modern, geographically diverse Amerindian tribes. Wallace's work indicates that a single migration across the Bering land bridge eventually gave rise to all three tribes. The results suggest that the earliest Americans shared a common, Asiatic origin. Wallace and his team are now working on a date for this first migration.

In the last 20 years, genetics research has experienced a breathtaking number of breakthroughs, allowing scientists to discover and study increasingly smaller structures in greater and greater detail. One new area of study has been research on mitochondrial DNA (mtDNA), a small circular form of DNA produced in genes called mitochondria that lie outside the nucleus of a cell.

Unlike nuclear DNA (the DNA found in the nucleus of a cell), the mitochondrial DNA of both parents do not recombine to form new gene arrangements for each offspring. Instead, mtDNA is transmitted only by females and is passed down intact to each daughter. "That means that the mtDNA has been transmitted from mother to daughter throughout all human history," Wallace says.

Wallace's group recently looked at the mtDNA's of native Americans from three tribes in North, Central,

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UPCOMING CONFERENCES

May 20–24, 1991 14th International Radiocarbon Conference, Tucson, Arizona.
Contact: Dr. Austin Long, Department of Geosciences, University of Arizona, Tucson, AZ 85721; Fax: (602) 621-2672.

May 27–29, 1991 Geological Association of Canada Annual Meeting, Toronto, Canada.
Contact: J. Fawcett, Department of Geology, University of Toronto, Toronto, Ontario, Canada M5S 1AD.

June 15–19, 1991 American Society of Mammologists, Annual Meeting, Manhattan, Kansas.
Contact: M.E. Hight, Department of Biological Sciences, Marshall University, Huntington, WV 25755.

August 2–9, 1991 13th INQUA International Congress on Quaternary Research, Beijing, China.
Contact: Secretariat, 13th INQUA Conference, Chinese Academy of Sciences, 52 Sanlihe, Beijing 100864, People's Republic of China.

August 13–16, 1991 Sedimentary and Paleolimnological Records of Saline Lakes, Saskatoon, Canada.
Contact: Robin W. Renaut, Department of Geological Sciences, University of Saskatchewan, Saskatoon, Canada S7N OWO; (306) 966-5683; FAX: (306) 966-8593.

September 1–7, 1991 International Union of Prehistoric and Protohistoric Sciences, 12th Congress, Bratislava, Czechoslovakia.
Contact: Archeologicky stav Slovenskij Akadmid Vied, Sekretarit XII Kongresu UISSP, 949 21 Nitra-hrad, Czechoslovakia.

September 6–11, 1991 Paleoecology, 2nd International Congress, Nanjing, China.
Contact: Ma Yu-Ying, Nanjing Institute of Geology and Palaeontology, Academia Sinica, Chi-Ming-Ssu, Nanjing 210008, People's Republic of China.

October 6–11, 1991 8th International Congress on Human Genetics, Washington, DC.
Contact: John J. Mulvihill, M.D., Secretary-General ICHG, 9650 Rockville Pike, Bethesda, MD 20814.

October 21–24, 1991 Geological Society of America Annual Meeting, San Diego, California.
Contact: GSA, 3300 Penrose Place, Boulder, CO 80301; (303) 447-2020.

October 27–November 1, 1991 Soil Science Society of America Annual Meeting, Denver, Colorado.
Contact: SSA, 677 S. Segoe Road, Madison, WI 53711; (608) 273-8080.

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EARTHWATCH BRIDGES THE GAP

The era of glasnost in the USSR has given Soviet scientists previously undreamed-of freedom to receive visits from, and even collaborate with, their foreign counterparts. Earthwatch, an internationally known organization based in Watertown, Massachusetts, that works to match scientists with willing volunteers, is taking on a new kind of match-making. If all goes well, the first collaboration between Soviet and American archaeologists will take place in the summer of 1991. Exchanges will go two ways: Soviet archaeologists will study and work at sites in North and South America; and American archaeologists and Earthwatch volunteers will excavate sites in the USSR.

There has always been intellectual contact between Soviet and American archaeologists. For example, research by Soviet archaeologists is sometimes translated into English and published. In addition,

"There's never been any kind of agreement like this that encourages volunteer, lay-person participation."

exchanges between American and Soviet scientists have not been unknown, says Earthwatch's Jim Chiarelli of the Center for Field Research. He mentions the Smithsonian Institution's IREX (International Research Exchange) program, which has supported exchanges between U.S. and Soviet personnel for the last twenty years.

"There are many archaeologists in [the United States]," explains Chiarelli, "who know their Soviet counterparts very well, and vice versa. They've been traveling back and forth quietly over the years." It is the chance to work together on a project—instead of simply visiting each other's sites and laboratories—that is new.

"There's never been a specific move like this one to encourage collaborative research," Chiarelli says, "and there's certainly never been any kind of agreement like this that encourages volunteer, lay-person participation."

By the time the Soviet archaeologists arrive in the United States in 1991, years of planning will already have taken place. The project got underway in 1987 when Brian Rosborough, the president of Earthwatch, attended the Chautauqua Conference on U.S.–Soviet Relations in New York State. At the conference, Soviet scientists broached the idea of collaborative research with American scientists.

Rosborough immediately got in touch with the Soviet Academy. Together, he and the Soviets made tentative plans for an exchange program to be called Mission to Earth. This exchange would have involved scientists in all disciplines, not just archaeologists.

In 1989 events sped up when Margaret MacLean of Earthwatch met Anatoli Derevyanko at an archaeological conference in Seattle on the prehistory of the Pacific Rim. MacLean and Derevyanko, director of the Institute of History, Philosophy, and Philology in Novosibirsk, Siberia, discussed the possibility of an exchange. Ten days later, while visiting colleagues at Harvard University, Derevyanko stopped at the Earthwatch office in Watertown and delivered a proposal for a ten-year program of collaborative research. As part of the plan, Derevyanko suggested a ten-person panel of advisors, consisting of five Soviets and five Americans. Each scientist would review proposals for research projects in his or her area of expertise.

The Soviet scientists suggested by Derevyanko represented four regions of the USSR—Central Russia, Soviet Georgia, Uzbekistan, and Siberia (both Derevyanko and his wife, also an archaeologist, represent this region). Each of these advisors has control over the archaeological research that occurs in his or her region.

The five Soviet advisors and the Earthwatch staff next met at the Earthwatch Principal Investigators' Conference, in March, 1990. There, they signed a detailed, ten-page agreement that spelled out the research to be undertaken in each of the regions represented by the Soviet panel members. The proposals included a large variety of site types in the Soviet Union, ranging from neolithic locales in Eastern Europe to paleolithic sites in Siberia. Excavations at Greek, Roman, and Viking sites have also been proposed. With regard to paleolithic sites, the Soviets would like to study cultural continuities between Siberia and North America, and evidence of the peopling of the New World. "They're as interested in those questions as we are," Chiarelli says.

The next major planning step occurred in late July and early August, 1990, at a conference in Novosibirsk. Chiarelli and several other American archaeologists, including Robson Bonnichsen of the Center for the Study of the First Americans, attended this conference and examined some of the proposed Siberian sites.

The Soviets have also identified research they would like to undertake in other parts of the world. They have expressed a particular interest in New World sites that have produced evidence of pre-Clovis occupations.

Chiarelli explains that there are archaeologists in the Soviet Union who are experts in the prehistory of every part of the world. "They have experts on Mesoamerica (Mexico and Guatemala), another on Peru. They are very interested in going to . . . these sites that they have never been allowed to work on." The scientists have been unable to work abroad not only because of restrictive Soviet travel policies, but also because in the past, many countries have refused to allow Soviet citizens within their borders.

"Just as the Soviets were strict about allowing foreigners into their country to work on archaeological sites, many countries in the West have been just as restrictive about [letting] Soviet archaeologists [into their countries]." For example, until recently, Soviet citizens were not even allowed into places like Mexico or Peru. "Their expert on Andean prehistory has never been to Peru. . . . Now that things have opened up a little bit politically, we're hoping that we can interest people in other countries in working collaboratively with Soviet archaeologists as well."

The idea of lay people working alongside scientists is alien to the Soviets. Unused to working with non-scientists, Chiarelli explains, a Soviet scientist might say, "I trained for so long to do this, how can I possibly show somebody who's never done it before

Earthwatch staff members have worked hard to communicate their belief in the value of lay participation in scientific research.

what to do and why we do it?" Earthwatch staff members have worked hard to communicate their belief in the value of lay participation in scientific research.

Chiarelli expects a total of five to eight projects to be undertaken in the USSR. This is the largest number of projects the limited number of Earthwatch volunteers can support. He hopes to increase the number of collaborations (in both the Soviet Union and in the rest of the world) by two per year throughout the 1990s.

Summing up, Chiarelli says, "It isn't as if we're giving the Soviets their first contact with the outside world, that isn't the case at all.

"What we're trying to interest them in is the things that Earthwatch is about, above and beyond the actual support of scientific research. Our agenda is two-fold: supporting scientific research, and education. Not only the kind of education where people go out and learn things, but also . . . forging bonds of better understanding between scientists and lay people."

–Nancy Allison

The Soviet archaeologists and some of the Earthwatch staff members involved in the exchange project. From left to right, the individuals shown in the photograph are: Brian A. Rosborough, President of Earthwatch; Dr. Valeri Guliaev, Deputy Director, Institute of Archaeology, USSR Academy of Sciences, Moscow; Academician Anatoli P. Derevyanko, Director, Institute of History, Philosophy, and Philology, Siberian Division of the USSR Academy of Sciences, Novosibirsk; Sally A. Evans, USSR Program Coordinator, Earthwatch; Professor C. C. Lamberg-Karlovsky, Department of Anthropology, Harvard University; Dr. Tatyana Chikisheva, Physical Anthropologist, Institute of History, Philosophy, and Philology, Siberian Division of the USSR Academy of Sciences, Novosibirsk; Academician Valeri P. Alexeev, Director, Insitute of Archaeology, USSR Academy of Sciences, Moscow; Dr. Otar Lordkipanidze, Director, Center for Archaeological Research, Academy of Sciences of Georgia SSR, Tbilisi; James A. Chiarelli, Associate Director for Social Sciences, The Center for Field Research, Earthwatch. (Note: The fifth member of the Soviet delegation, Academician Akmadali Askarov, Vice President, Academy of Sciences of Uzbekistan SSR and Secretary, Institute of History, Linguistics, and Literary Criticism, Academy of Sciences of Uzbekistan SSR, Tashkent, returned to the Soviet Union before this photo was taken.) *(Photo courtesy of Jim Chiarelli.)*

Mining Knife River Flint

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60-by-120-m site is what Metcalf calls "a geologic freak," noting that "it's just accident that this particular part of the gravel bar didn't get scoured out at some point by the course of Spring Creek."

Flint quarry pits were discovered in 1988, when Soil Conservation Service workers excavating a flood control project for the town of Halliday, North Dakota, uncovered large quantities of stone debris and bison bone. The Soil Conservation Service notified Dr. Stan A. Ahler of the University of North Dakota about the finds, and Ahler did a short, exploratory field-work session the same year. Ahler, who has been a primary researcher of the Knife River Flint quarry area over the last 10 years, contributed to the research design at Alkali Creek and is acting as an advisor for the project.

"The site was used for extracting flint for probably 11,500 years"

After funds were secured from the Federal government and the Soil Conservation service in 1989, the Soil Conservation Service contracted Metcalf Archaeological Consultants to investigate the Alkali Creek locality. In the summer of 1990, Metcalf's team worked at the site for almost five months.

The most complex work involved in the investigations, Metcalf says, was determining the stratigraphic levels in the quarry pits. "The history of the site, both natural and cultural . . . was extremely complex because there are a lot of mechanisms for filling the mine shafts and pits." Once prehistoric workers abandoned a mine, there were different ways the hole could be filled in: silt from the periodic flooding of the creek could fill in a hole naturally, or sometimes a human being might fill in a hole with back dirt from an adjacent pit, either "sequentially in the same occupation, or," as Metcalf notes wryly, "a few thousand years later." Geoarchaeologists Juliann VanNest of the Department of Geology, University of Iowa, and Anne McKibbin of Metcalf Archaeological Consultants worked with Metcalf to distinguish natural deposits from the disturbances made by human beings.

So far, the site has yielded evidence of three periods of intensive quarry use and occupation.

During the early Paleoindian period, when the flint deposits were very close to the living surface, people dug broad, shallow pits from which they extracted flint. Each pit was 3 to 4 m across, big enough for several people to work in at one time. Typologically, remains from this earliest period range from about 9500 yr B.P. to perhaps as old as 11,500 yr B.P. Archaeological deposits from the Paleoindian horizon have produced a vast quantity of debitage—the flakes of stone that occur when a piece of flint is shaped by chipping. Living surfaces and quarry deposits that produced these artifacts are clearly defined and occur at depths ranging from 1.2 to 2.7 m below the present surface. They can be traced across a good part of the site.

The earliest projectile point found in the Paleoindian stratigraphic level is a Goshen point, a broken piece of a finished tool. "Somebody did some rehafting and discarded the broken base. That's unusual," Metcalf notes. Goshen points, named by the late Henry Irwin, have been found in the central and northern Great Plains region. George Frison of the University of Wyoming, who has studied several Goshen sites, believes that the Goshen culture existed between the time of the Clovis and Folsom cultures, at about 10,800 to 11,300 years ago.

The Hell Gap point found at this level dates from the first half of the Paleoindian big-game hunting period, 9500–10,000 yr B.P. "This point was worn out," Metcalf says. "It had been reworked—typical for Hell Gap—down to almost nothing. It wasn't broken—it was a complete specimen—but it had been resharpened so many times the blade part was short and stubby, with a high edge angle. It wouldn't be useful for much." Both the Goshen and Hell Gap points are made of Knife River flint.

The second occupation occurred during the early Plains Archaic period, at about 5000 to 7000 yr B.P. This occupation level was found at a depth of 1 m. During this period, the site was not mined as intensively as it had been during the Paleoindian period. Like the Paleoindian-occupation level, the early Plains Archaic-level produced a large quantity of debitage. Only a few points were found, including one broken point and one in pristine condition. No radiocarbon dates are yet available, but Metcalf suspects the points will date from about 6000 to 7000 years ago.

The third and last period of occupation involved intensive and varied use of the site. During this occupation, found at a depth of 30 to 40 cm below ground surface, people excavated hundreds of mines and left behind extensive numbers of artifacts, including finished points and large amounts of debitage. They also reused abandoned mine shafts in several ways.

Because the flint was now well below the surface, these late miners developed more complex mine shafts to reach the flint. Although only one person would have been able to dig inside a shaft at a time, probably several other individuals were present to haul the dirt away. Digging these deeper shafts was a cooperative activity. In many instances, the miners dug roughly hourglass-shaped mine shafts. Although the shafts varied considerably one from another, they followed a general pattern. The mouths of the shafts were from 1 to 1.5 m in diameter; at a depth of about 1 m they narrowed to a diameter of 1 m; and at the bottom, the shafts belled out to a diameter of 2 to 2.5 m. In a few instances, the miners dug short lateral tunnels under a paleosol that formed a stable ceiling.

So far, Metcalf's team has not been able to identify the culture of this most recent occupation. Bison bones recovered from this level in 1988 produced dates of 1600 to 2000 yr B.P. The dates correspond with a complex known as Besant, which occurred on the northern Great Plains. Because of the radiocarbon dates and because of the large number of Besant sites in surrounding areas of North Dakota, Metcalf suspects that the latest quarries at the site were the work of Besant people. One Besant point has been found in this horizon, along with other late Prehistoric-period points.

In addition to intensive mining, Alkali Creek's most recent occupants made secondary use of quarry shafts. The researchers found parts of 13 bison in abandoned shafts, including one intact bison. This animal may have been a natural die-off, a bison that fell into the pit and died there. "If it was a cache, they cached the whole animal," Metcalf says. Other bison clearly had been butchered. Because of these remains, the team has hypothesized that some of the pits were used for meat caches during the cold season.

In addition to the bison remains, pits have also yielded the remains of three dogs that seem to have been intentionally buried. One pit contained a dog skeleton and most of a bison skeleton; a second pit contained a dog skeleton and a lone bison skull; and a third pit contained a dog skeleton and part of a bison skeleton, including a skull. The dogs had not been butchered.

"There's a fascinating evolution to the site. . . . It shows changing quarrying techniques as the distance down to the flint increased."

"Whether it was just a place for dumping dead dogs or whether there was a ceremonial connotation between associating the dog skeletons with bison skulls, we're not real sure at this point," says Metcalf. He notes that no other indications of ceremonial activity, such as red ochre, exotic materials, or trade items, have been found at the site. It is clear, though, that the dogs had been domesticated: the canine teeth of all three dogs had been broken off. Metcalf explains that this was fairly commonly done by prehistoric peoples to make the dogs less dangerous. "They were big dogs."

The three occupation levels at Alkali Creek suggest a busy industrial site. At the site, people carried out the first stages of the long and involved process of producing stone tools: they dug the stone out of the ground, knocked the rough corners off, and shaped the stone into a blank that could be taken from the site and finished at some other location.

It was this early-stage lithic reduction process that produced the vast quantities of debitage found at the site. The total number of finished points is tiny by comparison, and there is almost no evidence that any finished tools were manufactured at the site.

The researchers have already isolated a number of workshop areas where lithic reduction and possibly shaping of bifaces occurred. Two of these workshops can be attributed to Goshen, one to Hell Gap, and a number of others to the early Plains Archaic and later time periods. "We'll be able to do a very detailed analysis of each flake within those restricted proveniences," Metcalf says. "We'll be looking at it from the standpoint of flake types and a replicative approach: How would you do this today in order to get these flake types?

"Whether it was just a place for dumping dead dogs or whether there was a ceremonial connotation between associating the dog skeletons with bison skulls, we're just not sure at this point."

"It is quite rare to isolate workshop activities at this stage and trace them to a defined component. There's no place that I know of where you can say 'This is a Goshen quarry workshop.' The same is true of Hell Gap and early Archaic components."

In addition to analyzing the debitage, a multidisciplinary team of researchers will investigate other aspects of the site, particularly those dealing with the interplay between climatic change and changing human activities during the past 11,000 years. Holmes Semken of the University of Iowa is studying microvertebrates. Danny Walker from the University of Wyoming is doing a taphonomic and skeletal analysis of bison bone and its context. Alan Cvancara from the University of North Dakota and John Hoganson of the North Dakota Geologic Survey are studying beetles and snails found at the site. Linda Scott-Cummings of PaleoResearch Laboratories of Golden, Colorado, is conducting a pollen analysis. And VanNest and McKibbin are studying the soil development and geomorphology of the site area.

In addition to the information the site has yielded on early Paleoindian activities, Metcalf finds the extent of activity in the Besant horizon particularly arresting. "They [the Besant people] dug almost as intensively as the early Paleoindians . . . there are probably 100 shafts that have been sunk into the site . . . people working in cooperative, organized fashion to go after flint.

"At this site, it appears to me, that we're looking at what we would term an industrial level of activity. Obviously we're dealing with cooperative teams that are going after flint as more than just a casual endeavor . . . . I think this occurred at many other quarries, too. It may just make us take a harder look at some of the models of prehistoric behavior."

—Nancy Allison

Living Cells Unlock Mysteries

continued from page 1

and South America. Wallace explains, "We wanted to ask the question of whether the tribes of those three continents were genetically similar to each other or very different. One of the big debates in the linguistics of American Indians has been whether the Paleoindians have multiple origins, or only one or a few.

"The reason is that there are multiple major American Indian language groups. There are about 200 different languages, which group down into something on the order of 17 language groups. The question is: does each of these language groups represent a separate migration and an independent origin, or did they in fact derive from an even more ancient protolanguage?

"Joseph Greenberg of Stanford University has proposed the hypothesis that all of the Paleoindians shared an original protolanguage, which he calls Amerind. Now if there WAS a protolanguage, then it would suggest a single migration. So we argued that if that were the case, then if we looked at North, Central, and South American Indian populations, they should all have mtDNA's derived from one common female origin."

Wallace's work on mtDNA began in 1971. As the technology for looking at the structure of mtDNA advanced, Wallace was able to study its mutation rate and its sequencing—strings of molecules called nucleotide that are arranged in a certain order.

And, because mtDNA never recombines, "the only way it can change is by progressive mutations. Therefore, you can look at the changes because they're cumulative, sequential. One is added to the next is added to the next." This is known as sequential mutation.

Another interesting feature of mtDNA is that it changes its sequence about 10 to 20 times faster than nuclear DNA. Since changes can only be caused by sequential mutations along the female lineage, scientists can compare the mtDNA sequences of two modern individuals to directly measure the time that has passed since they shared a common maternal ancestor.

The key to tracing ancient migrations lies in this unique sequential mutation. To illustrate this, Wallace describes a simplified example of a lineage.

"We'll start with the first mtDNA in human beings. That mtDNA gets transmitted to a number of women, and then a mutation occurs at, let's say, position A in one of those women. So now she has a mtDNA that differs from all the others by a change of site A, a single nucleotide change.

"Then let's say this woman with mtDNA at site A has many offspring. A new mutation occurs in one of those offspring that gives a new site, B. So now THAT lineage has site A plus site B.

"Now let's go back to where we had the first individual with the mutation A. She has a lot of daughters in addition to the one that got B. Let's say another daughter gets mutation E. Now that means that daughter has A plus E. Then if she goes on and has daughters, and one of those has a mutation, let's say F, then that individual would have A plus E plus F.

"And so, [because the] changes [are] cumulative and sequential, the record is unambiguous; it's not complex."

Statistically, these mutations occur at a set rate. As a result, Wallace is able to identify and count the differences between the mtDNA of any two modern individuals. The time that has passed since they had a common maternal ancestor is equal to half the total amount of differences between them, multiplied by the mutation rate. (The number of differences is halved because each has gone down one leg of the same tree.)

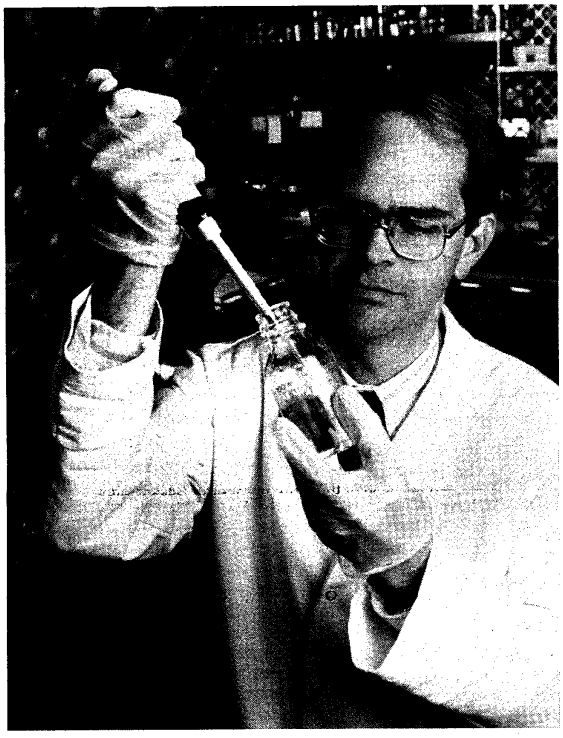
"Since the mutations occur along sequential and maternal lineages, you can literally track migrations as women have migrated from one continent to the next, because they accumulate these mutations. Over time, more and more mutations occur.

"Not only can we follow migrations by looking at what the founding population is and what's derived from it, but we can also look at the relationship between populations, as well as calculate the times that different populations became separated from each other.

"So," says Wallace, "by comparing the mtDNA's of different people around the world, we can build a tree of the female lineage, which basically makes the mtDNA a biological history book of women."

In the laboratory, the differences in individuals' mtDNA show up as patterns, called morphs, which are precise enough to discriminate between even closely related groups. A morph for a particular individual is formed by using an enzyme, called a restriction nuclease, to digest the mtDNA obtained from a sample of that person's blood. The enzyme cuts the circular mtDNA at a specific site, in a specific number of places. This results in two or more pieces of mtDNA, depending on the number of cuts that the enzyme made. The basic pattern when two fragments are created by a particular enzyme is called morph 1.

When the same enzyme is used to digest the mtDNA from a different individual, that individual might have either the same pattern or an altered pattern related to the number of additional mutations in the mtDNA. One additional mutation would produce an additional site change, and cause the mtDNA to break into three fragments instead of two. This pattern of three fragments is called morph 2 for that enzyme; still another mutation or site change would produce a pattern called morph 3, and so on.



Genetic research by Dr. Douglas C. Wallace suggests that a single migration of early American immigrants gave rise to nearly all modern American Indian groups. *(Photo courtesy of Dr. Douglas C. Wallace.)*

Each morph then differs from the previous morph by a single site change, owing to a single mutation. So a difference of morph 2 to morph 3 for an enzyme would indicate a single mutation that occurred in a direct lineage between two individuals.

Researchers may use as many as 15 or 20 different restriction enzymes to look at a single individual's mtDNA, with each enzyme making a characteristic number of cuts in the mtDNA.

Since many mtDNA morphs have been found to correlate highly with geographic and ethnic origins, these data can be used to trace the origins of the group being sampled. Wallace emphasizes that one of the strengths of this method is that "the results are highly reproducible. Anyone can do this kind of study on any kind of population they want to, as long as it's a well-defined population; that is, aboriginal, not just something like New York City. [You] will get a well-defined set of data that can easily be integrated into a world phylogenetic tree, or world population."

Wallace and his colleagues began with the Pima, a tribe in the southwestern U.S. They found that 40.5% of the Pima individuals had HincII morph 6, a specific pattern for the enzyme HincII, while 55% of them had HincII morph 2. Since HincII morph 6 primarily occurs only in Asia, this confirmed the hypothesis that the ancestors of this group originally came from Asia.

According to Wallace, HincII morph 6 "happens to differ from morph 2, the most common pattern, by a single site change. So HincII morph 2 goes to morph 6 by a single site loss. And that site loss, or site change, is the marker for the Amerindians."

To represent South America, the group chose the Ticuna, a linguistically distinct and geographically isolated tribe from the western Amazon rain forest of Brazil. Blood analysis had previously shown that the Ticuna were relatively free of genetic mixture with non-natives.

For Central America, Mayan Indians in a remote area of the Yucatan Peninsula were chosen. Blood-type analysis revealed a European ancestry of about 10%.

The DNA of each individual was extracted from blood samples taken from members of the tribe. The mtDNA was then digested with six different enzymes, and the resulting morphs for each enzyme were compared with those of the Pima and with morphs from Asian populations.

As with the Pima, the results for the enzyme HincII were the most significant, with 11% of the Maya mtDNAs and 42% (44%) of the Ticuna mtDNAs identifiable as HincII morph 6. The remaining samples in both tribes for HincII were morph 2. The high frequency of HincII morph 6 in all three tribes suggests that it was characteristic of a single founding Paleoindian population.

In addition, the incidence of morph 6 among the populations that were studied was almost 20 times higher than it is in Asia. This indicates to Wallace that the "ancestral population of the Paleoindians was composed of a small number of maternal lineages.

"We did indeed find that all of the mtDNA's of North, Central, and South American Indians that we looked at were derived from four founding female mtDNA's, or four founding lineages. Each of the three tribes had at least three of the four mtDNA's, so those four had to have been members of the founding population.

"Therefore it looks like a single migration came across the Bering land bridge carrying these four mtDNA types. Otherwise, if each came in a different migration, you would expect different percentages—that is different tribes would have different inputs.

"Those individuals radiating out [from the first migration] then gave rise to the North, Central, and South American Indians. Therefore, our data would be consistent with . . . Greenberg's hypothesis."

If a significant concentration of HincII morph 6 could be found in a population elsewhere, it would suggest a specific place of origin for the First Americans. To date, none has been found. So far the occurrence of HincII morph 6 in Asia is scattered and rare, rather than in any significant frequency.

However, Wallace says the team will soon be able to look at Siberian populations. "We have an agreement with the Soviet Union for them to sample people, and that will help tie things together. We're looking forward to that because that might be a possible origin."

What are the larger implications of this work if Wallace's findings are confirmed? To begin with, when the time of migration is established it could help settle controversies over whether the Americas were populated earlier than 15,000 years ago. Further tracing of the American Indian mtDNA tree could also clarify much more of the overall migration patterns of early populations throughout the Americas, perhaps tying in with archaeological and linguistic data.

Finally, this technique allows scientists to trace the genetic lineage of our species as a whole. Thus far, all of the mtDNA's studied throughout the world can be traced back to a single mtDNA—suggesting that modern humans share a common female ancestor. It also appears that the *Homo sapiens* mtDNA tree is relatively young, with an age of less than 200,000 years. "The implications," says Wallace, "are that *Homo sapiens* is a very young species."

–Sue Simpson

AN INTERVIEW with BEN WALLER

Editor's Note:

Sports divers Ben Waller, Bill Royal, and Don Serbousek were among the first to bring the importance of underwater archaeological and paleontological resources to the attention of the scientific community. Ben Waller has a broad and thorough knowledge of sites throughout the state and has shared this information with the scientific community. He has long been a vital link between amateurs and professionals in the field of archaeology.

The following discussion was taken from an interview with Mr. Waller conducted by Dr. James Dunbar for the Florida Anthropologist *(1983* Florida Anthropologist *Interview with Ben Waller,* Florida Anthropologist *36:31-39). We thank the* Florida Anthropologist *for permission to republish selected excerpts of this conversation.*

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On January 15, 1983, James Dunbar conducted an interview with Ben Waller, an avocational underwater archaeologist in Ocala, Florida. Mr. Waller has more practical experience investigating and observing inundated Clovis/Suwannee age Paleo-Indian sites than any other underwater archaeologist in the state (professional or avocational). He has spent thousands of hours of dive time pursuing this endeavor. Mr. Waller's experience as a former animal trainer with Ross Allen's Reptile Institute, his personal study and his varied experience as a diver have given him insight and a field savvy which have led to numerous important discoveries.

FA: When did you first begin to Scuba dive?

BW: I started diving in the late 1940s as a spear fisherman. Then I stopped spearing and began photographing fish. Eventually, I became interested in clear water photography, which led me to cave diving. We started finding things that were unique in the caves—stalactites that shouldn't have been there, animal remains—the kinds of things that sparked my curiosity.

FA: How did the early Scuba equipment compare to today's standards?

BW: My first regulator I made from instructions in *Popular Science* magazine which showed you how to make it out of a Maxwell House coffee can. The one I made wasn't real successful.

That must have been in 1948 or 1949. I bought my first tank and regulator in 1950. It was the very last part of 1950 and finally several of them came in at the same time. I wanted to buy the first one I ever saw and as I remember that first regulator cost $25.

FA: When did you first begin to notice and investigate underwater sites in Florida?

BW: We were interested in and trying to explore caves, when a man with the State geological survey asked me to let him know where the caves were and what was in them.

One of my early dives was at Little Salt Springs. I can remember we were decompressing from that dive when I began to hear a metal-like sound—dink, dink, dink. It was one of the other divers clanking two fossil bones together. Gosh, that's embarrassing to think of now with all the very good work that is being done on the site recently.

Soon after, we began finding more and more things underwater and we contacted Dr. Clayton Ray, then with the Florida State Museum in Gainesville. Dr. Ray convinced us that we should be working with the Museum recording the things that we were recovering underwater.

I eventually worked on diving expeditions with Bob Allen and Dr. Goggin of the University of Florida. Since then I have worked with Dr. Webb, Dr. Hoffman, Ripley Bullen, and a little with Dr. Purdy, even though the latter two were not divers.

FA: What are your major interests in the field of archaeology?

BW: I'm interested in the animals that were hunted by the first people that came here—the Paleo-Indians. I'm torn between paleontology and archeology, but I don't think I have to be because what it boils down to is that I am most interested in the time when now-extinct animals and man coexisted. There is more and more evidence being discovered to indicate that Paleo man was close to the extinct animals that lived here. That is most pleasing to me because it creates a situation where paleontology and archaeology become a bit of the same.

FA: What kinds of experiences have you had which have helped you to interpret underwater sites?

BW: I was part of a body recovery team for a long time and there was a rule of thumb that if you knew where a victim had entered the water, the body could be found within one and one-half times the depth of the water. If a victim dropped in 30 feet of water you could expect to find the body within 45 feet from where he originally fell in.

FA: Did you begin to notice the same kind of things in underwater sites?

BW: Yes, I kept hearing a theory that artifacts dropped in at point A and washed down to point Z; therefore, they had meaningless context. I didn't feel that was true because normally when we found sites we would find concentrations of points and artifacts within a confined area. If artifacts had washed randomly down river they would have been scattered up and down the river and not concentrated. I worked on a project with the Department of Paleontology of the Florida State Museum where we uncovered two-million-year-old antelopes [that were] still partially articulated. Now that's a pretty good argument against the idea of downstream washing of the much later period artifacts.

We did another thing that was interesting and it's something that needs to be followed up. We took 500 flint spalls, painted them and then placed them in a very fast moving area of the river to check if horizontal movement occurred. The degree of movement over two years was almost nothing. Finally, we spent one day recovering them and removed about 375 spalls. We would have probably gotten more if we had had more time to remove the sand cover. We noticed that the fast-moving water had removed much of the paint.

We found that manatee was the most common animal at the early sites. The second most common was elephant and then there was horse in that order. Deer came in fourth or fifth. At Archaic sites deer invariably was first and turtle was second.

FA: Do you know if the manatee bone was of late Pleistocene age or could it have been earlier fossilized material?

BW: I don't really know, although I couldn't believe it when a paper came out stating that manatee bones had not been used by Indians. I think it would have been a lot easier to hunt manatees than elephants. When you find manatee ribs and flint spalls together, it is an almost sure key that you have located a Paleo-Indian site. Also, I have found tools carved from manatee bone, such as a beautiful banner stone out of a manatee rib.

FA: Do you have any carved manatee bone that you think is Paleo-Indian?

BW: Yes, I have a "clubhead" which has been described as being Paleo-Indian age.

FA: Let's move to questions that deal with Paleo-Indian river sites. How would you characterize the typical Paleo-Indian river channel site or are there different types?

BW: As I have previously described, there are the types of sites containing much animal bone. I believe some of these are the kill sites but you don't always find points at sites that produce fossil bone. In other places you just have large outcroppings of flint and almost no fossils there at all, so obviously, I don't think those are kill sites. Basically, the places that I was describing as kill sites are places that you hate to see if you drive an outboard. In other words, in areas of swift water rapids, areas that are shallow that could have served as a river ford for game animals. I think animals were killed and butchered on these sites where rock juts out into the river and for some reason you find more tools than points. I believe that as the animals waded across, their legs were impeded by the water and they became easy hunting prey. As a result, the river rapid areas are good places to look. We spent hours and hours finding points in places where our tanks weren't even under water.

FA: In other words, these sites occur in areas of irregular topography?

BW: Yes.

FA: Which river has produced the largest concentration of Paleo-Indian sites in the state?

BW: Well, I don't think there is any doubt that the Santa Fe River has produced more than all the other Florida rivers put together. For example, I always wondered why large multicomponent sites in the Suwannee River only produced low percentages of Paleo-Indian material. In the Santa Fe River, a tributary of the Suwannee, similar sites have high percentages of Paleo material.

FA: Where is the single largest Paleo-Indian river site you have investigated in terms of the number of diagnostic artifacts recovered?

BW: Without any question, the biggest site is the Santa Fe 1 Site. It is the most significant Paleo site I've ever seen. It is a classic kill site where a shallow rapids area gives way and the channel bottom drops off to deep water. There is a tremendous amount of debitage and points. At one time I kept track of the number of points

Diver Ben Waller holds the lower jaw of a mastodon recovered from one of the many fossil and artifact localities in and along the Florida Aucilla River. *(Photo courtesy of John Clayton.)*

from the site, and there would be over one hundred whole and broken Paleo points, which include Clovis/Suwannee and Simpson types in various collections. I have personally found 27 complete Paleo-Indian points from this site, which is only about 200 feet long by 100 feet wide. About 50 complete points have been found altogether.

FA: It is my understanding that sites have been discovered that have produced a few diagnostic points along with the remains of what appeared to be a single late Pleistocene species (i.e., horse, mammoth, etc.) These sites may be surface finds in river channels; however, late cultural material or . . . other fossil bone is absent, suggesting the possibility of an isolated kill site. Can you describe as many of these sites as possible?

BW: Yes, of course, there is the Guest Mammoth Kill Site, but the one I enjoyed was the horse site at the junction of the Suwannee and Santa Fe Rivers—that was my favorite site.

FA: Can you describe that site a little?

BW: Yes, in 1963 we had been finding a number of points there—over one hundred that day—when we came across the front part of a Pleistocene horse snout eroding out of a submerged portion of the north bank of the river. The maxilla is not part of the skull that you often find preserved, so we collected it, and then uncovered the left mandible. Then we started finding articulated vertebra and realized that it might be a significant fossil site. I tried laying the skull pieces back down in the exact same positions we had seen them. After a little more work we suddenly uncovered a Suwannee point in the neck region pointing down towards the legs. Later we found another one not quite a foot away from the first and still another about 22 inches from the first two. All three were in the neck region. Finally, we found a fourth around the pelvic girdle area. We then covered the site back up and tried to get a professional to come to the site, but nobody could; that was on a Saturday. The next week it was the same story. Nobody came. On the following week it started raining and we were afraid that if the water got dark, by the time it cleared back up, the whole bank in the site area might have collapsed, so we removed the horse. Bear in mind that the horse site was but part of a much larger site (8Su2/8Gi1), but in that particular area the only things found were the partially articulated horse remains with the four Suwannee points.

In another case, we found the isolated remains of an elephant in the Waccasassa River with nothing else around. That is, nothing until we noticed a rib with cut marks and upon turning the rib over we found four inches of a Clovis-like base.

. . . in the Santa Fe River . . . elephant remains were found eroding out of the bank. We found one whole and one broken Paleo point and those were the only two pieces of flint in the area. We also found a number of bone pins at this site. Bob Alan also found a mammoth site in the Santa Fe River with one point and the one animal. Then we found a tapir site in the Oklawaha River, but it was not a Paleo site, or I should say, that the point found with the remains is known to us as the Wacissa type. That's the only time I've ever seen any point [associated] with a tapir. There was a site in the Steinhatchee, which had one elephant with one point. But perhaps more significant were the other sites with a tremendous quantity of bone pins associated with elephant remains. These sites were in the Steinhatchee River and Aucilla River. I have seen two of the elephant sites and have heard of a third one. The people who found the sites recovered tremendous quantities of these pins.

Then, of course, there is the Alexon Bison Site in the Wacissa River. This site produced the bones of an extinct bison with a point fragment imbedded in the skull. That was the first time I had ever seen anything like that. That's really mind-boggling.

FA: You mentioned bone pins in conjunction with Paleo sites. Do you think bone pins are an important Paleo tool?

BW: Yes. Of course, I've been pushing that idea for years. I totally believe that they are the most common Paleo tool found in Florida. When I say pins, I am generally speaking of the double-pointed variety.

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GETTING NEW INFORMATION OUT

The **Center for the Study of the First Americans** has initiated a consignment program to facilitate the distribution of publications relating to the peopling of the Americas. Over the last decade, the Center has developed a computerized distribution network to place publications in the hands of interested individuals on a world-wide basis. The purpose of our new consignment program is to make our distribution network available to individuals and organizations who develop quality publications important to understanding America's earliest cultural heritage.

We have established working arrangements with the Smithsonian Institution's Paleoindian Program, the Hot Springs Mammoth site, Arizona University, the Department of Anthropology at the University of Pittsburgh, and the Buffalo Museum of Science and Technology. Some of the most important new publications, included in the listing below are: *Megafauna and Man: Discovery of America's Heartland,* edited by L. D. Agenbroad, J. I. Mead, and L. W. Nelson; *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface,* edited by J. A. Willig, C. M. Aikens, and J. L. Fagan; and *Clovis: Origins and Adaptations,* edited by R. Bonnichsen and K. Turnmire.

If you have limited-edition publications relating to the peopling of the Americas and would be interested in developing a consignment agreement with the Center, please contact us.

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Interview with Ben Waller

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FA: Do you think they may have been used as projectiles?

BW: I am uncertain of their use; however, I would like to say that the people who have seen the Steinhatchee elephant sites agree that bone pins were common in early tool kits. However, there are a lot of people that just won't buy the idea. I guess years ago the earliest date for their manufacture was believed to be five to six thousand years ago; therefore, even the obvious can be questioned. But I believe that the bone points are *in situ* on Paleo sites and are part of the Paleo tool kit.

FA: Do the double-pointed bone pins have any distinctive features like basal roughening that might separate them from those of a later age?

BW: I don't know, but the ones I'm speaking of are made of the cannon bone of the deer. I think four pins can be made from each cannon bone. I think they cut off the epiphysis of the bone, split the remaining long shaft into four sections, and sharpened both ends of each of the sections.

FA: You also mentioned butcher-marked Pleistocene bone from one of the river sites; how many have you seen from Florida?

BW: Well, I think it's safe to say that there are at least eleven Pleistocene animal bones displaying butchering marks. I was fortunate to have discovered the first one to be reported [see Bullen, Webb, and Waller, 1970, *American Antiquity* 35(2):203-205]. The specimen was a vertebral spine of a large mammoth recovered from the Santa Fe River. What was most significant, as Dr. Webb was quick to realize, is that the cut marks were in strategic places; for example, ligament attachments were cut away to separate the meat from the bone. Since then, there have been other specimens found with even more distinctive cut marks.

FA: What are some of the traits that you would look for that would characterize a river bottom Paleo site?

BW: Well, as I mentioned earlier, the occurrence of manatee rib and flint spalls is diagnostic. In the Santa Fe River you quite often notice and come across a site that has chert which is not extremely translucent, nor of the highest grade. I don't know my stone that well, so just bear with me in this poor definition of it, but sometimes the chert has multicolors that go through it, like white, yellow, etc. Anyway, I think that type of stone is frequently found at the early sites.

FA: How frequently do you find good bone preservation at the river Paleo sites?

BW: Very often. Many paleontologists feel that some of the best preserved bone in the United States has come out of the Florida rivers. I think the rivers' tanic acid is one of the big reasons for this excellent preservation.

FA: What about preservation of the fragile organic materials, such as wood, etc., that date to the Paleo-Indian period?

BW: The objects that I really consider to be wooden artifacts are rare and are generally more recent. I do think it is possible to find early wood artifacts because of the wood preservation at the 100,000-year-old sloth site in Daytona Beach. At that site, logs were strewn throughout the area and had to be removed to get at the fossil remains.

FA: Have you ever seen a component of a Paleo river channel site eroding out of fresh-water marl other than the Guest Site?

BW: In the Santa Fe there is a real fine-grained white sand, usually up next to a bank, and I have seen Paleo material come from that type of sediment. There is usually very little bone at these sites and I would not call them kill sites. Near Wilson Springs is a good area to find this setting. You can go up near the bank adjacent to a channel site and hand fan and find points in this extremely fine-grained sand.

FA: Do the river channel sites occur at great depth or are they shallow or do they vary from site to site?

BW: I've never seen any at great depths in the river; although, we've seen Paleo points in deep holes in the rivers.

FA: Deep holes?

BW: Yes, 60 feet or more. One of these had several points. Of course, not many rivers have sixty-foot-deep holes. Most of the holes in rivers that we think of as so deep are only 25 feet deep when checked with a depth gauge.

FA: What is the average depth of the Paleo-Indian river channel sites?

BW: Most of the Paleo sites are in 12 to 20 feet of water, but probably averaging closer to 12 feet.

FA: Have you ever investigated an offshore Atlantic or Gulf Paleo site or fossil locality?

BW: Yes, I have visited fossil localities. We found elephant remains considerable distances out in the Gulf of Mexico—six miles out. Usually you get into an area where you just see fragments of bones that are highly covered with barnacles. There is a lot of terrestrial material, for example, off Venice.

FA: Late Pleistocene age fossil bone?

BW: Yes. One nice Paleo point came from the beach as well.

FA: What avenues of research would you like to see take place in the future?

BW: First of all, I think that many people need to get over the idea that Florida rivers wash artifacts great distances downstream. The classic argument that modern refuse—like Coke bottles—can be found together with Paleo points does not negate the fact that artifacts from a river site were originally deposited within that site's boundaries and not ten miles upstream. I think the river banks adjacent to the extra good sites should be tested. Sometime in the future the site we have all been waiting for will be found. Unfortunately, no systematic search effort has ever been attempted.

Personally, I would like to continue plotting the distribution of these early sites. I think there will be a staggering number of sites eventually plotted once more people start sharing that kind of information. People need to share this information and professionals and avocational archaeologists need to do more active field work because I think we're going to flip when we see the amount of material and good information that is retrieved.