

Palaeontology Program
Government of the Yukon

Occasional Papers in Earth Sciences No. 5



3rd INTERNATIONAL MAMMOTH CONFERENCE, 2003:
PROGRAM AND ABSTRACTS

Yukon Palaeontology Program

Occasional Papers in Earth Sciences

Editorial Committee

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Jeff Hunston
Manager, Heritage Resources

Editor:

John E. Storer
Yukon Palaeontologist

Objectives of the Series

The Palaeontology Program series Occasional Papers in Earth Sciences is designed to provide for the timely dissemination of technical reports, conference workshop proceedings, and dissertations relating to earth sciences research in the Yukon. The publication of these materials contributes to the realization of Government of Yukon's heritage programming mandate: to develop, enhance, and preserve the Yukon's heritage resources and communicate an appreciation and understanding of the Yukon's heritage to Yukoners and Yukon visitors.

In order to expedite timely publication of research results and keep publication costs to a minimum, manuscripts are submitted ready for printing. Errors are the responsibility of the author(s).

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Edited by John E. Storer

YUKON
Palaeontology Program
Department of Tourism and Culture
Elaine Taylor, Minister
2003

**3rd INTERNATIONAL MAMMOTH CONFERENCE
DAWSON CITY AND WHITEHORSE, YUKON
MAY 24 – 29, 2003**

HOST COMMITTEE

Jeff Hunston, Conference Chair
Beth King, General Secretary
Drew Ball
Bruce Barrett
Greg Hare
Bill LeBarge
Paul Matheus
John Storer

PROGRAM

Saturday, May 24

Evening

6:30 – 9:00 PM: Opening reception, Yukon Beringia Interpretive Centre, Whitehorse

Sunday, May 25

8:00 AM – 5:00 PM: Buses take delegates to Dawson City

Evening

6:30 – 9:00 PM: Welcoming reception and opening of fossil show and Ice Age art show, Dawson City Museum

Monday, May 26

Morning

8:00 AM: Conference opens, Dawson City Odd Fellows Hall (Arts Centre)

8:00 – 8:10 AM: Brief remarks by Conference Chair

8:10 – 8:20 AM: Greetings from Government of Yukon

8:20 – 8:30 AM: Greetings from City of Dawson (Glen Everitt, Mayor)

8:40 – 10:00 AM: Session 1, **Mammoth Evolution and Taxonomy**

10:00 – 10:20 AM: Refreshment Break

10:20 – 11:40 AM: Session 2, **Mammoth Expeditions**

11:40 AM – 1:00 PM: Lunch Break

Afternoon

1:00 – 3:00 PM: Session 3: **Some North American Mammoth Sites**

3:00 – 6:00 PM: Poster Session. Presenters will be expected to stay with their posters for discussion

3:00 – 6:00 PM: Dawson City Museum, Demonstration of sampling mammoth tusk for stable isotope analysis, by Dan Fisher

Evening

6:00 – 8:00 PM: Reception, Forty Mile Placers, Co-Sponsored by Yukon Placer Miners Association

8:00 – 10:00 PM: Public Lecture, Tr'ondek Hwech'in Cultural Centre: Dick Mol and Ralf-Dietrich Kahlke: **Mammoths by Land and Sea**

Tuesday, May 27

Morning

8:00 – 10:20 AM: Session 4: **Stable Isotopes and DNA**

10:20 – 10:40 AM: Refreshment Break

10:40 – 11:40 AM: Session 5: **Replacement Events for the Mammoth Fauna**

11:40 AM – 1:00 PM: Lunch Break

Afternoon

1:00 – 2:40 PM: Session 6: **Ice Age Hunters**

2:40 – 3:00 PM: Coffee Break

3:00 – 3:40 PM: Session 7: **Mammoth/Human Interactions**

3:40 – 4:40 PM: Session 8: **Special Elements of the Mammoth Fauna**

Evening

7:00 – 9:00 PM: Public Lecture Sponsored by Yukon Science Institute, Tr'ondek Hwech'in Cultural Centre: Evgeny Maschenko: **Excavations at the Lugovskoye Site, Western Siberia: The Northernmost Mammoth Hunting Site in Siberia**

Wednesday, May 28

Morning

8:20 – 9:40 AM: Session 9: **Paleoecology and Behavior in the Mammoth Fauna**

9:40 – 10:00 AM: Refreshment Break

10:00 – 11:40 AM: Session 10: **Extinction of the Mammoth Fauna**

11:40 AM – 1:00 PM: Lunch Break

Afternoon

1:00 – 4:20 PM: Session 11: **Composition and Distribution of the Mammoth Fauna**

2:40 – 3:00 PM: Refreshment Break

4:20 – 4:30 PM: Invitation to the 4th International Mammoth Conference

4:30 – 4:40 PM: Summary of the Conference

4:40 – 5:00 PM: Closing Remarks by the Conference Chair

Evening

6:30 – 10:00 PM: Conference Banquet, Palace Grand Theatre

Thursday, May 29

8:00 AM – 6:00 PM: Field trip to the Klondike Goldfields

Friday, May 30

8:00 AM – 4:00 PM: Buses return delegates to Whitehorse

TALKS AND POSTERS, BY SESSION

Monday, May 26

8:40-10:00 AM: SESSION 1: MAMMOTH EVOLUTION AND TAXONOMY

- 8:40 Andrei SHER, Svetlana KUZMINA, Sergey KISELYOV, and Adrian LISTER. **TUNDRA-STEPPE ENVIRONMENT IN ARCTIC SIBERIA AND THE EVOLUTION OF THE WOOLLY MAMMOTH**
- 9:00 George E. McDANIEL, Jr. and George T. JEFFERSON. **PHYLOGENY AND CHRONOLOGY OF *Mammuthus* IN NORTH AMERICA**
- 9:20 Evgeny MASCHENKO. **INDIVIDUAL DEVELOPMENT AND BIOLOGY OF THE WOOLLY MAMMOTH (*Mammuthus primigenius* BLUMENBACH, 1799)**
- 9:40 Lenka SEDLÁČKOVÁ. **OSTEOMETRIC COMPARISON OF THE POSTCRANIAL SKELETON IN FOSSIL REPRESENTATIVES OF THE FAMILY ELEPHANTIDAE FROM CHOSEN EUROPEAN LOCALITIES**

10:20 – 11:40 AM: SESSION 2: MAMMOTH EXPEDITIONS

- 10:20 Nikolaj K. VERESCHAGIN and Tatiana N. VERESCHAGINA. **ARCTIC EXPEDITIONS OF ZOOLOGICAL INSTITUTE FOR MAMMOTHS (1970-2000). PHOTO ALBUM**
- 10:40 Sergey V. LESHCHINSKIY and Elena M. BURKANOVA. **KOCHEGUR, A NEW LOCALITY FOR MAMMOTH REMAINS IN THE SHESTAKOVO BEAST SOLONETZ DISTRICT (WESTERN SIBERIA)**
- 11:00 Petr LAZAREV, Gennadiy BOESKOROV, Egor VASILYEV, and Albert PROTOPOPOV. **NEW FINDS OF MAMMOTH REMAINS IN YAKUTIA**
- 11:20 VLADIMIR E. TUMSKOY. **PERMAFROST PROCESSES AS A FACTOR OF MAMMOTH FAUNA CONSERVATION (NOVAYA SIBIR ISLAND)**

1:00 – 3:00 PM: SESSION 3: SOME NORTH AMERICAN MAMMOTH SITES

- 1:00 DANIEL J. JOYCE. **CHRONOLOGY AND CURRENT RESEARCH ON THE SCHAEFER MAMMOTH (?*Mammuthus primigenius*), KENOSHA COUNTY, WISCONSIN**
- 1:20 Christopher L. HILL. **MAMMOTH (*Mammuthus*) WITHIN THE UPPER MISSOURI AND YELLOWSTONE BASINS, NORTH AMERICA: CHRONOLOGY, STRATIGRAPHY, AND PALEOECOLOGY**
- 1:40 Eileen JOHNSON. **THE TAPHONOMY OF MAMMOTH LOCALITIES IN SOUTHEASTERN WISCONSIN (USA)**

- 2:00 Steven R. HOLEN. **PALEOECOLOGY AND TAPHONOMY OF FULL GLACIAL MAXIMUM MAMMOTH LOCALITIES IN THE CENTRAL GREAT PLAINS OF NORTH AMERICA**
- 2:20 Olga POTAPOVA. **SPECIMEN COLLECTION AND METHODS OF MAMMOTH BONE PRESERVATION AT THE HOT SPRINGS MAMMOTH SITE, HOT SPRINGS, SOUTH DAKOTA**
- 2:40 Bart A. WEIS. **PUBLIC INVOLVEMENT IN EXCAVATION AND PREPARATION OF THE STONEGATE MAMMOTH, PARKER, COLORADO: ONE OF THE OLDEST MAMMOTHS (*Mammuthus colombi*) RECORDED IN COLORADO**

3:00 – 6:00 PM: POSTER SESSION

- Kim AARIS-SØRENSEN, JEPPE MØHL, and Knud ROSENLUND. **A DANISH MAMMOTH ON DISPLAY**
- Larry D. AGENBROAD, John JOHNSON, Don MORRIS, and Thomas W. Stafford, Jr. **MAMMOTHS AND HUMANS AS LATE PLEISTOCENE CONTEMPORARIES ON SANTA ROSA ISLAND, CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA**
- Joaquín ARROYO-CABRALES, Oscar J. POLACO, and Eileen JOHNSON. **MAMMOTH AND MAN, THEIR COEXISTENCE IN MEXICO**
- Jessie ATTERHOLT, Michael GUBEREK, and George T. JEFFERSON. **A NEWLY DISCOVERED SUBADULT AND JUVENILE *Mammuthus* SITE AT THE ANZA BORREGO DESERT STATE PARK®, SOUTHEASTERN CALIFORNIA, USA**
- Bax R. BARTON. **THE MOXEE-ALEXANDRIA MAMMOTH TUSK AND OTHER MAMMOTH REMAINS FROM YAKIMA COUNTY, WASHINGTON STATE, USA**
- Dmitryi BOLSHIYANOV and Alexei TIKHONOV. **DISTRIBUTION OF MAMMOTHS ON THE BANKS OF TAIMYR LAKE**
- Margarita A. ERBAJEVA, Jim I. MEAD, and Sandra L. SWIFT. **EVOLUTION AND DEVELOPMENT OF ASIAN AND NORTH AMERICAN OCHOTONIDS**
- Irina V. FORONOVA. **HISTORY OF MAMMOTH LINEAGE IN THE SOUTHERN PART OF CENTRAL SIBERIA**
- Russell Wm. GRAHAM, Bart A. WEIS, and Steven R. HOLEN. **MAMMOTHS (*Mammuthus*) IN COLORADO, USA**
- Eileen Johnson. **MAMMOTH BONE TECHNOLOGY AND SUBSISTENCE STRATEGIES IN THE LATE PLEISTOCENE NORTH AMERICAN GRASSLANDS**
- Janis KLIMOWICZ and Gary HAYNES. **WHAT'S PRESENT IS PAST: MAMMOTH BEHAVIOR INTERPRETED THROUGH ACTUALISTIC STUDIES OF MODERN ELEPHANTS**

- Tatiana V. KUZNETSOVA, Leopold D. SULERZHITSKY, Andrei ANDREEV, Christina SIEGERT, Lutz SCHIRRMEISTER, and H.-W. HUBBERTEN. **INFLUENCE OF LATE QUATERNARY PALEOENVIRONMENTAL CONDITIONS ON THE DISTRIBUTION OF MAMMALS IN THE LAPTEV SEA REGION**
- Petr LAZAREV, Albert PROTOPOPOV, and Grigoriy SAVVINOV. **THE NEW PROSPECTS OF ORGANIZATION OF THE PALEONTOLOGIC EXPEDITIONS TO THE NORTH OF YAKUTIA**
- Adrian M. LISTER and Hans van ESSEN. **THE EARLIEST MAMMOTHS IN EUROPE**
- Sophie LOUGUET. **WAS *Mammuthus intermedius* PRESENT IN THE PLEISTOCENE SITE OF HANHOFFEN (BAS-RHIN, FRANCE)?**
- Anatoly V. LOZHKIN and Patricia M. ANDERSON. **PRESERVED WOOLY MAMMOTHS (*Mammuthus primigenius*) AND ASSOCIATED PALYNOLOGICAL SPECTRA FROM NORTHEAST SIBERIA**
- Evgeny MASCHENKO, Sergey LEV, and Natalia BUROVA. **ZARAYSK LATE PALAEOOLITHIC SITE: MAMMOTH ASSEMBLAGE, AGE PROFILE AND TAPHONOMY**
- Paul MATHEUS, R. Dale GUTHRIE, and Michael L. KUNZ. **PREDATOR-PREY LINKS IN PLEISTOCENE EAST BERINGIA: EVIDENCE FROM STABLE ISOTOPES**
- Paul MATHEUS, R. Dale GUTHRIE, and Michael L. KUNZ. **ISOTOPE ECOLOGY OF LATE QUATERNARY MEGAFUNA IN EASTERN BERINGIA**
- George E. McDANIEL, Jr. and George T. JEFFERSON. **MAMMOTHS IN OUR MIDST: THE PROBOSCIDEANS OF ANZA-BORREGO DESERT STATE PARK®, SOUTHERN CALIFORNIA, USA**
- George E. McDANIEL, Jr. and George T. JEFFERSON. **REGIONAL VARIATION IN *Mammuthus columbi* (PROBOSCIDEA, ELEPHANTIDAE) BASED ON THE DENTAL PARAMETERS OF A POPULATION OF MAMMOTH MOLARS FROM A GRAVEL QUARRY IN SOUTHERN TEXAS, USA**
- Richard E. MORLAN. **SOME PRIMITIVE MAMMOTH TEETH FROM OLD CROW LOC. 47, NORTHERN YUKON**
- Valentin NESIN and Leonid REKOVETS. **KOPACHIV – A NEW PALEOLITHIC CAMP OF MAMMOTH HUNTERS IN UKRAINE**
- Laura NIVEN and Piotr WOJTAL. **PALEOECOLOGICAL IMPLICATIONS OF TOOTH PATHOLOGIES IN *Mammuthus primigenius*: EXAMPLES FROM CENTRAL EUROPE**
- Maria Rita PALOMBO, Sergio GINESU, and Stefania SIAS. ***Mammuthus lamarmorai* (MAJOR, 1883) REMAINS IN THE MIDDLE PLEISTOCENE ALLUVIAL DEPOSITS OF CAMPU GIAVESU PLAIN (NORTH WESTERN SARDINIA; ITALY)**
- Olga POTAPOVA. **RED-BREADED GOOSE (*Rufibrenta ruficollis* Pall., 1769) ABOVE THE HEADS OF MAMMOTHS IN EUROPE**

- John E. STORER. **ADVANCES IN THE ICE AGE BIOSTRATIGRAPHY OF EASTERN BERINGIA**
- Leopold D. SULERZHITSKY. **RADIOCARBON DATING: IMPLICATIONS FOR PALEOENVIRONMENTAL STUDIES OF MEGAFUNA**
- Janis D. TREWORGY, Jeffrey J. SAUNDERS, David A. GRIMLEY, Richard JUDKINS, Lindsay MORSE, and Ramona VAN RIPER. **A WOOLLY MAMMOTH (*Mammuthus primigenius*) EXCAVATION ON A COLLEGE CAMPUS IN WESTERN ILLINOIS, USA**
- Sergey VARTANYAN and Alexei TIKHONOV. **MAMMOTH FAUNA FROM THE MAINLAND ADJACENT TO WRANGEL ISLAND**

Tuesday, May 27

8:00 – 10:20 AM: SESSION 4: STABLE ISOTOPES AND DNA

- 8:00 Dorothée DRUCKER and Hervé BOCHERENS. **CARBON-13 AND NITROGEN-15 AMOUNTS IN LARGE HERBIVOROUS MAMMAL COLLAGEN AS A TRACER OF ENVIRONMENTAL CHANGES IN THE MAMMOTH STEPPE BETWEEN 50,000 AND 10,000 BP IN NORTHERN EURASIA**
- 8:20 Hervé BOCHERENS, Dorothée DRUCKER, Stéphane PÉAN, and Marylène PATOU-MATHIS. **CONTRIBUTION OF STABLE ISOTOPES ON THE QUESTION OF MAMMOTH MEAT CONSUMPTION BY NEANDERTALS AND ANCIENT ANATOMICALLY MODERN HUMANS**
- 8:40 Daniel C. FISHER and Scott G. BELD. **GROWTH AND LIFE HISTORY RECORDS FROM MAMMOTH TUSKS**
- 9:00 David L. FOX, Daniel C. FISHER, and Sergey VARTANYAN. **TUSK GROWTH INCREMENT AND STABLE ISOTOPE PROFILES OF LATE PLEISTOCENE AND HOLOCENE *Mammuthus primigenius* FROM SIBERIA AND WRANGEL ISLAND**
- 9:20 Beth SHAPIRO, Alexei DRUMMOND, Andrew RAMBAUT, and Alan COOPER. **PLEISTOCENE EVOLUTION OF BERINGIAN BISON**
- 9:40 Alfred L. ROCA, Nicholas GEORGIADIS, and Stephen J. O'BRIEN. **ELEPHANT MITOCHONDRIAL DIVERSITY AND THE PHYLOGENY OF MAMMOTHS**
- 10:00 Alan COOPER, Beth SHAPIRO, Ross BARNETT, Jacobo WEINSTOCK, and Alexei DRUMMOND. **USING PLEISTOCENE DNA TO INVESTIGATE BERINGIAN PALAEOENVIRONMENTAL CHANGES**

10:40 – 11:40 AM: SESSION 5: MAMMOTH FAUNA REPLACEMENT EVENTS

- 10:40 Wighart v. KOENIGSWALD. **THE REPEATED REPLACEMENT OF *Mammuthus*- AND *Elephas* FAUNAS IN CENTRAL EUROPE**

- 11:00 Maria Rita PALOMBO, Maria Teresa ALBERDI, and Beatriz AZANZA. **LARGE MAMMAL TURNOVER, DIVERSITY AND ELEPHANT DISPERSAL IN THE WESTERN MEDITERRANEAN: THE ITALIAN AND IBERIAN PENINSULAS**
- 11:20 Keiichi TAKAHASHI, Yuji SOEDA, Goro YAMADA, Morio AKAMATSU, Masami IZUHO, and Kaori AOKI. **REPLACEMENT OF *Mammuthus primigenius* AND *Palaeoloxodon naumanni* ACCOMPANYING CLIMATE CHANGE IN JAPAN**

1:00 – 2:40 PM: SESSION 6: ICE AGE HUNTERS

- 1:00 Vasily N. ZENIN, Evgeny N. MASCHENKO, Sergey V. LESHCHINSKIY, Aleksandr F. PAVLOV, Pieter M. GROOTES, and Marie-Josée NADEAU. **THE FIRST DIRECT EVIDENCE OF MAMMOTH HUNTING IN ASIA (LUGOVSKOYE SITE, WESTERN SIBERIA)**
- 1:20 Piotr WOJTAL. **NEW DATA FROM THE GRAVETTIAN HUNTING AND BUTCHERING SITE KRAKÓW SPADZISTA STREET (B) (POLAND)**
- 1:40 Laura NIVEN. **WOOLLY MAMMOTHS FROM THE UPPER PALAEOLITHIC SITE OF VOGELHERD CAVE, GERMANY**
- 2:00 Gary HAYNES. **MAMMOTH LANDSCAPES: GOOD COUNTRY FOR HUNTER-GATHERERS**
- 2:20 Mikhail V. SABLIN. **MAMMOTH HUNTERS AND ICE AGE DOGS**

3:00 – 4:00 PM: SESSION 7: MAMMOTH/HUMAN INTERACTIONS

- 3:00 Stéphane PÉAN and Marylène PATOU-MATHIS. **MAMMOTH BONES AS RAW MATERIALS FOR DWELLING STRUCTURES: HUNTS OR COLLECTIONS?**
- 3:20 Evgeny N. MASCHENKO, Aleksandr F. PAVLOV, Vasily N. ZENIN, Sergey V. LESHCHINSKIY, and Luobov A. ORLOVA. **THE LUGOVSKOE SITE: RELATIONS BETWEEN THE MAMMOTH ASSEMBLAGE AND LATE PALAEOLITHIC MAN**

3:40 – 4:40 PM: SESSION 8: SPECIAL ELEMENTS OF THE MAMMOTH FAUNA

- 3:40 H. Gregory McDONALD. **MAMMOTHS AND MYLODONTS: EXOTIC SPECIES FROM TWO DIFFERENT CONTINENTS IN NORTH AMERICAN PLEISTOCENE FAUNAS**
- 4:00 Gennady BARYSHNIKOV. **LATE PLEISTOCENE ARCTIC FOX (*Alopex lagopus*) FROM CRIMEA, UKRAINE**
- 4:20 Marina SOTNIKOVA and Pavel NIKOLSKIY. **SYSTEMATIC POSITION OF THE CAVE LION (*Panthera spelaea*)**

Wednesday, May 28

8:20 – 9:40 AM: SESSION 9: PALEOECOLOGY AND BEHAVIOR IN THE MAMMOTH FAUNA

- 8:20 Grant D. ZAZULA, Alice M. TELKA, C. Richard HARRINGTON, Duane G. FROESE, and Rolf W. MATHEWES. **MAMMOTHS, HORSES AND MUCKS – OH MY! : PALEOENVIRONMENTS OF LAST CHANCE CREEK, YUKON TERRITORY**
- 8:40 Paul MATHEUS, Michael KUNZ, and R. Dale GUTHRIE. **USING FREQUENCY DISTRIBUTIONS OF RADIOCARBON DATES TO DETECT RELATIVE CHANGES IN PLEISTOCENE MAMMAL POPULATIONS – A TEST CASE FROM NORTHERN ALASKA**
- 9:00 Svetlana KUZMINA. **INSECTS AND GRAZING MAMMALS IN THE PLEISTOCENE OF NORTHEASTERN SIBERIA**
- 9:20 K. Alden PETERSON. **THE RUBBING POST: A HYPOTHESIS FOR PLEISTOCENE FAUNA AGENCY IN THE FORMATION OF ANOMALOUS POLISHED ROCK SURFACES IN NEVADA**

10:00 – 11:40 AM: SESSION 10: EXTINCTION OF THE MAMMOTH FAUNA

- 10:00 Guy S. ROBINSON, David A. BURNEY, and Lida Pigott BURNEY. **A PALYNOLOGICAL APPROACH TO THE STUDY OF MEGAHERBIVORE EXTINCTION IN THE HUDSON VALLEY**
- 10:20 R. Dale GUTHRIE. **COMPARISON OF THE EXTINCTION OF MEGAFUNA IN INTERIOR ALASKA – YUKON TERRITORY WITH THE ARRIVAL OF HUMANS**
- 10:40 Yuri A. MOCHANOV and Svetlana A. FEDOSEEVA. **THE REASONS FOR THE DISAPPEARANCE OF MAMMOTH IN WEST BERINGIA IN THE LIGHT OF ARCHEOLOGIC FACTS**
- 11:00 Ross MacPHEE. **THE WRANGEL DATE GAP AND OTHER EVIDENCE OF WIDESPREAD MEGAFUNAL COLLAPSE IN NORTHERN ASIA DURING THE EARLY HOLOCENE**
- 11:20 Gennady BOESKOROV. **THE NORTH OF EASTERN SIBERIA: REFUGE OF THE MAMMOTH FAUNA IN THE HOLOCENE**

1:00 – 4:40 PM: SESSION 11: COMPOSITION AND DISTRIBUTION OF THE MAMMOTH FAUNA

- 1:00 Petr LAZAREV. **DISCOVERIES AND STUDY OF CARCASSES OF THE MAMMOTH FAUNA IN YAKUTIA**
- 1:20 Dick MOL, Alexei TIKHONOV, Johannes VAN DER PLICHT, Ralf-Dietrich KAHLKE, Regis DEBRUYNE, Bas VAN GEEL, Jan Peter PALS, Christian DE MARLIAVE, and Jelle W.F. REUMER. **RESULTS OF THE CERPOLEX/MAMMOTHUS EXPEDITIONS ON THE TAIMYR PENINSULA, ARCTIC SIBERIA, RUSSIAN FEDERATION**
- 1:40 Alexander N. MOTUZKO and Natallia A. NAVICHKOVA. **THE MAMMOTH AND MAMMOTH FAUNA OF BELARUS**

- 2:00 Leonid REKOVETS. **MAMMOTH (*Mammuthus primigenius*) IN THE PERIGLACIAL FAUNAS OF UKRAINE**
- 2:20 Dick MOL, Klaas POST, Jelle W.F. REUMER, Hans VAN DER PLICHT, and John DE VOS. **LATE PLEISTOCENE TERRESTRIAL AND MARINE MAMMALS FROM THE EUROGEUL, NORTH SEA, THE NETHERLANDS**
- 3:00 Ralf-Dietrich KAHLKE. **CONTEMPORARY MAMMALS OF *Mammuthus meridionalis* DURING THE LATE LOWER PLEISTOCENE IN EUROPE – THE DIVERSE EPIVILLAFRANCHIAN UNTERMASFELD FAUNA**
- 3:20 Jan GLIMMERVEEN, Dick MOL, and Hans VAN DER PLICHT. **THE PLEISTOCENE REINDEER OF THE NORTH SEA; INITIAL PALAEONTOLOGICAL DATA AND ARCHAEOLOGICAL REMARKS**
- 3:40 Diego ÁLVAREZ LAÓ and Nuria GARCÍA. **A NEW SITE FROM THE SPANISH MIDDLE PLEISTOCENE WITH COLD-RESISTANT FAUNAL ELEMENTS: LA PARTE (ASTURIAS, SPAIN)**
- 4:00 Larry D. AGENBROAD. **POST – 30,000 BP MAMMOTH DISTRIBUTION IN NORTH AMERICA**

ABSTRACTS, 3rd INTERNATIONAL MAMMOTH CONFERENCE

Symbols: L = lecture; P = poster; M = Monday; T = Tuesday; W = Wednesday

Kim AARIS-SØRENSEN, Jeppe MØHL, and Knud ROSENLUND. **A DANISH MAMMOTH ON DISPLAY (P)**

Larry D. AGENBROAD. **POST – 30,000 BP MAMMOTH DISTRIBUTION IN NORTH AMERICA (L; W 4:00 PM)**

Larry D. AGENBROAD, John JOHNSON, Don MORRIS, and Thomas W. STAFFORD, Jr. **MAMMOTHS AND HUMANS AS LATE PLEISTOCENE CONTEMPORARIES ON SANTA ROSA ISLAND, CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA (P)**

Diego ÁLVAREZ LAÓ and Nuria GARCÍA. **A NEW SITE FROM THE SPANISH MIDDLE PLEISTOCENE WITH COLD-RESISTANT FAUNAL ELEMENTS: LA PARTE (ASTURIAS, SPAIN) (L; W 3:40 PM)**

Joaquín ARROYO-CABRALES, Oscar J. POLACO, and Eileen JOHNSON. **MAMMOTH AND MAN, THEIR COEXISTENCE IN MEXICO (P)**

Jessie ATTERHOLT, Michael GUBEREK, and George T. JEFFERSON. **A NEWLY DISCOVERED SUBADULT AND JUVENILE *Mammuthus* SITE AT THE ANZA BORREGO DESERT STATE PARK®, SOUTHEASTERN CALIFORNIA, USA (P)**

Bax R. BARTON. **THE MOXEE-ALEXANDRIA MAMMOTH TUSK AND OTHER MAMMOTH REMAINS FROM YAKIMA COUNTY, WASHINGTON STATE, USA (P)**

Gennady BARYSHNIKOV. **LATE PLEISTOCENE ARCTIC FOX (*Alopex lagopus*) FROM CRIMEA, UKRAINE (L; T 4:00 PM)**

Hervé BOCHERENS, Dorothée DRUCKER, Stéphane PÉAN, and Marylène PATOU-MATHIS. **CONTRIBUTION OF STABLE ISOTOPES ON THE QUESTION OF MAMMOTH MEAT CONSUMPTION BY NEANDERTALS AND ANCIENT ANATOMICALLY MODERN HUMANS (L; T 8:20 AM)**

Gennady BOESKOROV. **THE NORTH OF EASTERN SIBERIA: REFUGE OF THE MAMMOTH FAUNA IN THE HOLOCENE (L; W 11:20 AM)**

Dmitryi BOLSHIYANOV and Alexei TIKHONOV. **DISTRIBUTION OF MAMMOTHS ON THE BANKS OF TAIMYR LAKE (P)**

- Alan COOPER, Beth SHAPIRO, Ross BARNETT, Jacobo WEINSTOCK, and Alexei DRUMMOND. **USING PLEISTOCENE DNA TO INVESTIGATE BERINGIAN PALAEOENVIRONMENTAL CHANGE** (L; T 10:00 AM)
- Dorothee DRUCKER and Hervé BOCHERENS. **CARBON-13 AND NITROGEN-15 AMOUNTS IN LARGE HERBIVOROUS MAMMAL COLLAGEN AS A TRACER OF ENVIRONMENTAL CHANGES IN THE MAMMOTH STEPPE BETWEEN 50,000 AND 10,000 BP IN NORTHERN EURASIA** (L; T 8:00 AM)
- Margarita A. ERBAJEVA, Jim I. MEAD, and Sandra L. SWIFT. **EVOLUTION AND DEVELOPMENT OF ASIAN AND NORTH AMERICAN OCHOTONIDS** (P)
- Daniel C. FISHER and Scott G. BELD. **GROWTH AND LIFE HISTORY RECORDS FROM MAMMOTH TUSKS** (L; T 8:40 AM)
- Irina V. FORONOVA. **HISTORY OF MAMMOTH LINEAGE IN THE SOUTHERN PART OF CENTRAL SIBERIA** (P)
- David L. FOX, Daniel C. FISHER, and Sergey VARTANYAN. **TUSK GROWTH INCREMENT AND STABLE ISOTOPE PROFILES OF LATE PLEISTOCENE AND HOLOCENE *Mammuthus primigenius* FROM SIBERIA AND WRANGEL ISLAND** (L; T 9:00 AM)
- Jan GLIMMERVEEN, Dick MOL, and Hans VAN DER PLICHT. **THE PLEISTOCENE REINDEER OF THE NORTH SEA; INITIAL PALAEOONTOLOGICAL DATA AND ARCHAEOLOGICAL REMARKS** (L; W 3:20 PM)
- Russell Wm. GRAHAM, Bart A. WEIS, and Steven R. HOLEN. **MAMMOTHS (*Mammuthus*) IN COLORADO, USA** (P)
- R. Dale GUTHRIE. **COMPARISON OF THE EXTINCTION OF MEGAFUNA IN INTERIOR ALASKA-YUKON TERRITORY WITH THE ARRIVAL OF HUMANS** (L; W 10:20 am)
- Gary HAYNES. **MAMMOTH LANDSCAPES: GOOD COUNTRY FOR HUNTER-GATHERERS** (L; T 2:00 PM)
- Christopher L. HILL. **MAMMOTH (*Mammuthus*) WITHIN THE UPPER MISSOURI AND YELLOWSTONE BASINS, NORTH AMERICA: CHRONOLOGY, STRATIGRAPHY, AND PALEOECOLOGY** (L; M 1:20 PM)

Steven R. HOLEN. **PALEOECOLOGY AND TAPHONOMY OF FULL GLACIAL MAXIMUM MAMMOTH LOCALITIES IN THE CENTRAL GREAT PLAINS OF NORTH AMERICA** (L; M 2:00 PM)

Eileen JOHNSON. **THE TAPHONOMY OF MAMMOTH LOCALITIES IN SOUTHEASTERN WISCONSIN (USA)** (L; M 1:40 PM)

Eileen JOHNSON. **MAMMOTH BONE TECHNOLOGY AND SUBSISTENCE STRATEGIES IN THE LATE PLEISTOCENE NORTH AMERICAN GRASSLANDS** (P)

Daniel J. JOYCE. **CHRONOLOGY AND CURRENT RESEARCH ON THE SCHAEFER MAMMOTH (?*Mammuthus primigenius*), KENOSHA COUNTY, WISCONSIN** (L; M 1:00 PM)

Ralf-Dietrich KAHLKE. **CONTEMPORARY MAMMALS OF *Mammuthus meridionalis* DURING THE LATE LOWER PLEISTOCENE IN EUROPE – THE DIVERSE EPIVILLAFRANCHIAN UNTERMASFELD FAUNA** (L; W 3:00 PM)

Janis KLIMOWICZ and Gary HAYNES. **WHAT'S PRESENT IS PAST: MAMMOTH BEHAVIOR INTERPRETED THROUGH ACTUALISTIC STUDIES OF MODERN ELEPHANTS** (P)

Wighart v. KOENIGSWALD. **THE REPEATED REPLACEMENT OF *Mammuthus*- AND *Elephas* FAUNAS IN CENTRAL EUROPE** (L; T 10:40)

Svetlana KUZMINA. **INSECTS AND GRAZING MAMMALS IN THE PLEISTOCENE OF NORTHEASTERN SIBERIA** (L; W 9:00 AM)

Tatiana V. KUZNETSOVA, Leopold D. SULERZHITSKY, Andrei ANDREEV, Christina SIEGERT, Lutz SCHIRRMESTER, and H.-W. HUBBERTEN. **INFLUENCE OF LATE QUATERNARY PALEOENVIRONMENTAL CONDITIONS ON THE DISTRIBUTION OF MAMMALS IN THE LAPTEV SEA REGION** (P)

Petr LAZAREV. **DISCOVERIES AND STUDY OF CARCASSES OF THE MAMMOTH FAUNA IN YAKUTIA** (L; W 1:00 PM)

Petr LAZAREV, Gennadiy BOESKOROV, Egor VASILYEV, and Albert PROTOPOPOV. **NEW FINDS OF MAMMOTH REMAINS IN YAKUTIA** (L; M 11:00 AM)

- Petr LAZAREV, Albert PROTOPOPOV, and Grigoriy SAVVINOV. **THE NEW PROSPECTS OF ORGANIZATION OF THE PALEONTOLOGIC EXPEDITIONS TO THE NORTH OF YAKUTIA (P)**
- Sergey V. LESHCHINSKIY and Elena M. BURKANOVA. **KOCHEGUR, A NEW LOCALITY FOR MAMMOTH REMAINS IN THE SHESTAKOVO BEAST SOLONETZ DISTRICT (WESTERN SIBERIA) (L; M 10:40 AM)**
- Adrian M. LISTER and Hans van ESSEN. **THE EARLIEST MAMMOTHS IN EUROPE (P)**
- Sophie LOUGUET. **WAS *Mammuthus intermedius* PRESENT IN THE PLEISTOCENE SITE OF HANHOFFEN (BAS-RHIN, FRANCE)? (P)**
- Anatoly V. LOZHKIN and Patricia M. ANDERSON. **PRESERVED WOOLLY MAMMOTHS (*Mammuthus primigenius*) AND ASSOCIATED PALYNOLOGICAL SPECTRA FROM NORTHEAST SIBERIA (P)**
- Ross MacPHEE. **THE WRANGEL DATE GAP AND OTHER EVIDENCE OF WIDESPREAD MEGAFANAL COLLAPSE IN NORTHERN ASIA DURING THE EARLY HOLOCENE (L; W 11:00 AM)**
- Evgeny MASCHENKO. **INDIVIDUAL DEVELOPMENT AND BIOLOGY OF THE WOOLLY MAMMOTH (*Mammuthus primigenius* BLUMENBACH, 1799) (L; M 9:20 AM)**
- Evgeny MASCHENKO, Sergey LEV, and Natalia BUROVA. **ZARAYSK LATE PALAEOLITHIC SITE: MAMMOTH ASSEMBLAGE, AGE PROFILE AND TAPHONOMY (P)**
- Evgeny N. MASCHENKO, Alexandr F. PAVLOV, Vasiliy N. ZENIN, Sergey V. LESHCHINSKIY, and Luobov A. ORLOVA. **THE LUGOVSKOE SITE: RELATIONS BETWEEN THE MAMMOTH ASSEMBLAGE AND LATE PALAEOLITHIC MAN (L; T 3:20 PM)**
- Paul MATHEUS, R. Dale GUTHRIE, and Michael L. KUNZ. **PREDATOR-PREY LINKS IN PLEISTOCENE EAST BERINGIA: EVIDENCE FROM STABLE ISOTOPES (P)**
- Paul MATHEUS, R. Dale GUTHRIE, and Michael L. KUNZ. **ISOTOPE ECOLOGY OF LATE QUATERNARY MEGAFANAL IN EASTERN BERINGIA (P)**

Paul MATHEUS, Michael KUNZ, and R. Dale GUTHRIE. **USING FREQUENCY DISTRIBUTIONS OF RADIOCARBON DATES TO DETECT RELATIVE CHANGES IN PLEISTOCENE MAMMAL POPULATIONS— A TEST CASE FROM NORTHERN ALASKA** (L; W 8:40 AM)

George E. McDANIEL, Jr. and George T. JEFFERSON. **MAMMOTHS IN OUR MIDST: THE PROBOSCIDEANS OF ANZA-BORREGO DESERT STATE PARK®, SOUTHERN CALIFORNIA, USA** (P)

George E. McDANIEL Jr. and George T. JEFFERSON. **PHYLOGENY AND CHRONOLOGY OF *Mammuthus* IN NORTH AMERICA** (L; M 9:00 AM)

George E. McDANIEL, Jr. and George T. JEFFERSON. **REGIONAL VARIATION IN *Mammuthus columbi* (PROBOSCIDEA, ELEPHANTIDAE) BASED ON THE DENTAL PARAMETERS OF A POPULATION OF MAMMOTH MOLARS FROM A GRAVEL QUARRY IN SOUTHERN TEXAS, USA** (P)

H. Gregory McDONALD. **MAMMOTHS AND MYLODONTS: EXOTIC SPECIES FROM TWO DIFFERENT CONTINENTS IN NORTH AMERICAN PLEISTOCENE FAUNAS** (L; T 3:40 PM)

Yuri A. MOCHANOV and Svetlana A. FEDOSEEVA. **THE REASONS FOR THE DISAPPEARANCE OF MAMMOTH IN WEST BERINGIA IN THE LIGHT OF ARCHEOLOGIC FACTS** (L; W 10:40 AM)

Dick MOL, Klaas POST, Jelle W.F. REUMER, Hans VAN DER PLICHT, and John DE VOS. **LATE PLEISTOCENE TERRESTRIAL AND MARINE MAMMALS FROM THE EUROGEUL, NORTH SEA, THE NETHERLANDS** (L; W 2:20 PM)

Dick MOL, Alexei TIKHONOV, Johannes VAN DER PLICHT, Ralf-Dietrich KAHLKE, Regis DEBRUYNE, Bas VAN GEEL, Jan Peter PALS, Christian DE MARLIAVE, and Jelle W.F. REUMER. **RESULTS OF THE CERPOLEX/MAMMUTHUS EXPEDITIONS ON THE TAIMYR PENINSULA, ARCTIC SIBERIA, RUSSIAN FEDERATION** (L; W 1:20 PM)

Richard E. MORLAN. **SOME PRIMITIVE MAMMOTH TEETH FROM OLD CROW LOC. 47, NORTHERN YUKON** (P)

Alexander N. MOTUZKO and Natallia A. NAVICHKOVA. **THE MAMMOTH AND MAMMOTH FAUNA OF BELARUS** (L; W 1:40 PM)

Valentin NESIN and Leonid REKOVETS. **KOPACHIV – A NEW PALEOLITHIC CAMP OF MAMMOTH HUNTERS IN UKRAINE** (P)

- Laura NIVEN. **WOOLLY MAMMOTHS FROM THE UPPER PALAEOOLITHIC SITE OF VOGELHERD CAVE, GERMANY** (L; T 1:40 PM)
- Laura NIVEN and Piotr WOJTAL. **PALEOECOLOGICAL IMPLICATIONS OF TOOTH PATHOLOGIES IN *Mammuthus primigenius*: EXAMPLES FROM CENTRAL EUROPE** (P)
- Maria Rita PALOMBO, Maria Teresa ALBERDI, and Beatriz AZANZA. **LARGE MAMMAL TURNOVER, DIVERSITY AND ELEPHANT DISPERSAL IN THE WESTERN MEDITERRANEAN: THE ITALIAN AND IBERIAN PENINSULAS** (L; T 11:00 AM)
- Maria Rita PALOMBO, Sergio GINESU, and Stefania SIAS. ***Mammuthus lamarmorai* (MAJOR, 1883) REMAINS IN THE MIDDLE PLEISTOCENE ALLUVIAL DEPOSITS OF CAMPU GIAVESU PLAIN (NORTH WESTERN SARDINIA; ITALY)** (P)
- Stéphane PÉAN and Marylène PATOU-MATHIS. **MAMMOTH BONES AS RAW MATERIALS FOR DWELLING STRUCTURES: HUNTS OR COLLECTIONS?** (L; T 3:00 PM)
- K. Alden PETERSON. **THE RUBBING POST: A HYPOTHESIS FOR PLEISTOCENE FAUNA AGENCY IN THE FORMATION OF ANOMALOUS POLISHED ROCK SURFACES IN NEVADA** (L; W 9:20 AM)
- Olga POTAPOVA. **RED-BREASTED GOOSE (*Rufibrenta ruficollis* Pall., 1769) ABOVE THE HEADS OF MAMMOTHS IN EUROPE** (P)
- Olga POTAPOVA. **SPECIMEN COLLECTION AND METHODS OF MAMMOTH BONE PRESERVATION AT THE HOT SPRINGS MAMMOTH SITE, HOT SPRINGS, SOUTH DAKOTA** (L; M 2:20 PM)
- Leonid REKOVETS. **MAMMOTH (*Mammuthus primigenius*) IN THE PERIGLACIAL FAUNAS OF UKRAINE** (L; W 2:00 PM)
- Guy S. ROBINSON, David A. BURNEY, and Lida Pigott BURNEY. **A PALYNOLOGICAL APPROACH TO THE STUDY OF MEGAHERBIVORE EXTINCTION IN THE HUDSON VALLEY** (L; W 10:00 AM)
- Alfred L. ROCA, Nicholas GEORGIADIS, and Stephen J. O'BRIEN. **ELEPHANT MITOCHONDRIAL DIVERSITY AND THE PHYLOGENY OF MAMMOTHS** (L; T 9:40 AM)

Mikhail V. SABLIN. **MAMMOTH HUNTERS AND ICE AGE DOGS** (L; T 2:20 PM)

Lenka SEDLÁČKOVÁ. **OSTEOMETRIC COMPARISON OF THE POSTCRANIAL SKELETON IN FOSSIL REPRESENTATIVES OF THE FAMILY ELEPHANTIDAE FROM CHOSEN EUROPEAN LOCALITIES** (L; M 9:40 AM)

Beth SHAPIRO, Alexei DRUMMOND, Andrew RAMBAUT, and Alan COOPER. **PLEISTOCENE EVOLUTION OF BERINGIAN BISON** (L; T 9:20 AM)

Andrei SHER, Svetlana KUZMINA, Sergey KISELYOV, and Adrian LISTER. **TUNDRA-STEPPE ENVIRONMENT IN ARCTIC SIBERIA AND THE EVOLUTION OF THE WOOLLY MAMMOTH** (L; M 8:40 AM)

Marina SOTNIKOVA and Pavel NIKOLSKIY. **SYSTEMATIC POSITION OF THE CAVE LION (*Panthera spelaea*)** (L; T 4:20 PM)

John E. STORER. **ADVANCES IN THE ICE AGE BIOSTRATIGRAPHY OF EASTERN BERINGIA** (P)

Leopold D. SULERZHITSKY. **RADIOCARBON DATING: IMPLICATIONS FOR PALEOENVIRONMENTAL STUDIES OF MEGAFUNA** (P)

Keiichi TAKAHASHI, Yuji SOEDA, Goro YAMADA, Morio AKAMATSU, Masami IZUHO, and Kaori AOKI. **REPLACEMENT OF *Mammuthus primigenius* AND *Palaeoloxodon naumanni* ACCOMPANYING CLIMATE CHANGE IN JAPAN** (L; T 11:20 AM)

Janis D. TREWORGY, Jeffrey J. SAUNDERS, David A. GRIMLEY, Richard JUDKINS, Lindsay MORSE, and Ramona VAN RIPER. **A WOOLLY MAMMOTH (*Mammuthus primigenius*) EXCAVATION ON A COLLEGE CAMPUS IN WESTERN ILLINOIS, USA** (P)

Vladimir E. TUMSKOY. **PERMAFROST PROCESSES AS A FACTOR OF MAMMOTH FAUNA CONSERVATION (NOVAYA SIBIR ISLAND)** (L; M 11:20 AM)

Sergey VARTANYAN and Alexei TIKHONOV. **MAMMOTH FAUNA FROM THE MAINLAND ADJACENT TO WRANGEL ISLAND** (P)

Nikolaj K. VERESCHAGIN and Tatiana N. VERESCHAGINA. **ARCTIC EXPEDITIONS OF ZOOLOGICAL INSTITUTE FOR MAMMOTHS (1970-2000). PHOTO ALBUM** (L; M 10:20 AM)

Bart A. WEIS. **PUBLIC INVOLVEMENT IN EXCAVATION AND PREPARATION OF THE STONEGATE MAMMOTH, PARKER, COLORADO: ONE OF THE OLDEST MAMMOTHS (*Mammuthus columbi*) RECORDED IN COLORADO** (L; M 2:40 PM)

Piotr WOJTAL. **NEW DATA FROM THE GRAVETTIAN HUNTING AND BUTCHERING SITE KRAKÓW SPADZISTA STREET (B) (POLAND)** (L; T 1:20 PM)

Grant D. ZAZULA, Alice M. TELKA, C. Richard HARINGTON, Duane G. FROESE, and Rolf W. MATHEWES. **MAMMOTHS, HORSES AND MUCKS – OH MY! : PALEOENVIRONMENTS OF LAST CHANCE CREEK, YUKON TERRITORY** (L; W 8:20 AM)

Vasiliy N. ZENIN, Evgeny N. MASCHENKO, Sergey V. LESHCHINSKIY, Aleksandr F. Pavlov, Pieter M. GROOTES, and Marie-Josée NADEAU. **THE FIRST DIRECT EVIDENCE OF MAMMOTH HUNTING IN ASIA (LUGOVSKOYE SITE, WESTERN SIBERIA)** (L; T 1:00 PM)

A DANISH MAMMOTH ON DISPLAY

Kim AARIS-SØRENSEN, Jeppe MØHL, and Knud ROSENLUND

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Remains of the woolly mammoth (*Mammuthus primigenius* (Blumenbach)) are common in Scandinavia but most abundant in Denmark and the southernmost part of Sweden. Here they are found redeposited in glaciogenic deposits with the most frequently discovered elements being molars and tusk fragments whereas bone fragments are rare.

About 30 carbon-14 dates place the majority of the remains between ca. 22 000 and 36 000 BP although some are older with infinite ages > 40 000 BP. This corresponds to an ice free Middle Weichselian stage antedating the main ice advance reaching southern Scandinavia around 22 000 BP. A single specimen shows the re-immigration of the mammoth into southern Scandinavia *after* the deglaciation with a date of 13 200 BP (Lockarp, Lu-796, 796:2, 865) corresponding to the Late Weichselian.

In a new exhibition at the Zoological Museum in Copenhagen, dealing with the Danish fauna throughout 20 000 years, a life-sized reproduction of a woolly mammoth has become the main attraction. This poster, besides presenting facts about the South Scandinavian mammoth, describes the construction of the mammoth model step by step: the making of a model on the scale of 1:10, the transformation of the model into 22 life-sized cross sections in chip board, the joining of these frames, the modelling of the body and casting of the tusks and finally the patient work of covering the model with musk ox hair.

The mammoth is displayed in a diorama with dead ice and drifting clouds as a background and with a breeze gently moving the long hair hanging from its belly.

POST – 30,000 BP MAMMOTH DISTRIBUTION IN NORTH AMERICA

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Recently, the FAUNMAP database has been used to generate maps of mammoth distribution. These maps have been interpreted as providing evidence of glacial maximum range collapse, leading to extinction of the genera. FAUNMAP data is limited to the continental United States. A continent-wide record of mammoth distribution and ¹⁴C chronology provides an alternative scenario for the last 30,000 years. In particular, the post-glacial interval of 15,000-10,000 BP has the most wide-spread mammoth distribution of any 5,000 year interval.

MAMMOTHS AND HUMANS AS LATE PLEISTOCENE CONTEMPORARIES ON SANTA ROSA ISLAND, CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA

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Radiocarbon dating of a pygmy mammoth (*Mammuthus exilis*) thoracic vertebra has provided evidence of the contemporaneity of the pygmy mammoth and early human remains on Santa Rosa Island, Channel Islands National Park, California. Charcoal associated with the vertebra was radiocarbon dated (AMS) at 11,010 yr BP (B-133594). That date was significantly close to the extinction date for continental mammoths to warrant a date directly from the bone. The vertebral centrum was drilled and submitted for AMS bone collagen dating. The resultant date was 11,030 yr BP (CAMS-71697), only 20 years older than the charcoal date. The significance of the dates was immediately apparent, in that a date from human remains from the Arlington Springs Site (CA-SRI-173), Santa Rosa Island was reported by Johnson *et al.* in 1999, as 10,960 yr BP (CAMS-16810). The contemporaneity of the mammoth bone date and human bone date indicated that mammoths were still extant on the islands when humans arrived. This is data from only one mammoth and only one human... more research needs to be done on the mammoth and human remains on the island. Was the contemporaneity coincidence, or the prelude to extinction?

A NEW SITE FROM THE SPANISH MIDDLE PLEISTOCENE WITH COLD-RESISTANT FAUNAL ELEMENTS: LA PARTE (ASTURIAS, SPAIN)

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The La Parte site, northern Spain, contains a cold-adapted faunal assemblage preserved in a horizon radiometrically dated to a minimum age of 150 ka. It represents the most ancient site with cold resistant fauna in the Iberian Peninsula.

Among the species recorded in La Parte, two represent the typical cold-adapted large mammal association, following Kahlke (1999) who only considers those species inhabiting the arctic to subarctic or inner-continental regions: *Coelodonta antiquitatis* and *Rangifer tarandus*.

The presence of the Woolly Rhino at La Parte makes this site specially important for a number of reasons; this taxon can provide relevant environmental information about the Mammoth Steppe; and furthermore La Parte is placed in the Middle Pleistocene, when this species is not as abundant as during the Late Pleistocene, so its cold-adapted features can be studied from an evolutionary perspective. The remains attributed to *Rangifer tarandus* also recovered from this site, suggest an open woodland ecosystem.

The presence of *Marmota* sp. in the same level is confirmed at La Parte based on a fragmentary humerus, and could suggest an alpine or periglacial ecosystem. Nevertheless, recent results do not support the correlation between phylogeny and climatic tolerance for extant species of *Marmota* (López and Cuenca 2002). In some Middle Pleistocene sites, remains of *Hystrix vinogradovi* have been recovered in association with *Marmota marmota* and, based on this evidence, it is questioned whether *Hystrix* and *Marmota* are valuable climatic indicators (Cuenca-Bescos *et al.* 1999), at least in the Iberian Middle Pleistocene. The presence of *Marmota* in the La Parte site suggests an open landscape with cold conditions.

The rest of the taxa included in the La Parte assemblage (*Crocota crocuta*, *Panthera leo*, *Cervus elaphus*, *Megaloceros* cf. *giganteus*, *Bison priscus* and *Equus caballus*) are usually associated with typical cold-adapted faunas, but they are also found in woody temperate zones so these do not in themselves characterise a cold period. The faunal association from La Parte suggests a combination of steppic and open woodland ecological conditions.

The level containing the faunal remains is included in a karstic complex cavity. The construction of a highway caused the destruction of part of the terrain surface and thus the discovery of such a cave filling. The ossiferous level is rich in speleothems which surround or fill the fossil bones. U-series analyses of two speleothems, which included several bone fragments, coming from the bone accumulation level, yielded dates of 188 ± 11 ka and 141 ± 8 ka. Following these results obtained by the team of geochronologists who worked out the analyses (Institut de Ciències de la Terra “Jaume Almera”, Barcelona), the most likely minimal age for this level is 150 ka. The La Parte faunal association is biochronologically consistent with the end of the Middle Pleistocene, during a timespan that could correspond with oxygen isotope stage 6, a cold period.

The origin of the bone accumulation seems to be related to a hyaena den. This is interpreted from a variety of evidence: almost the totality of the fossil remains correspond to herbivores, being mainly limb bones, which are the easiest to disarticulate and to transport into a cave; furthermore, a high percentage of the bone assemblage presents puncture marks and gnawing damage produced by the spotted hyaena's dentition; in addition, several coprolite accumulations, attributed to hyaenas, were discovered at all stratigraphic levels. Furthermore, a fragmentary P² of a juvenile *Crocota crocuta* was recovered, which also confirms the presence of this taxon.

The cold-adapted taxa are considered rare in the Iberian Peninsula (when compared with other European countries), so any new faunal discovery is of relevance and provides important information related to the glacial mammalian species. Furthermore, the La Parte site represents the first occurrence of *Coelodonta antiquitatis* and *Megaloceros giganteus* in Asturias, a region situated in the most occidental margin of the Cantabrian Mountain Range.

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MAMMOTH AND MAN, THEIR COEXISTENCE IN MEXICO

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The mammoth (Proboscidea, *Mammuthus*) is an animal that lived in most of North America during the Pleistocene, from northern Canada and Alaska (USA) to southern México and northern Central America. During the late Pleistocene, they co-inhabited with early people who populated North America, with the exception of the Yucatán Peninsula. However, little information about that coexistence is available for the southern populations.

Written reports on the presence of mammoth in México are first documented 400 years ago. At least 271 localities all over México are known to contain mammoth remains, from an isolated molar to an almost complete skeleton. Where identified, the species is *M. columbi*, the southern or plains mammoth. From those localities, a minor percentage is reported to have evidence of a human – mammoth relationship.

Five archaeological sites have been documented in México regarding human – mammoth relationship. Those sites are: La Villa, Distrito Federal; Santa Isabel Iztapan and Tocuila, Estado de México; Valsequillo, Puebla; the Basin of Chapala-Zacoalco, Jalisco; and El Cedral, San Luis Potosí. The El Cedral site is the most interesting, as it had a hearth lined on the outside by mammoth metapodials (some show burn marks). Ash from the hearth has been dated at $31,850 \pm 1,000$ years before present (yrs BP). This date is the oldest one for human presence in México, and one of the most ancient for Mexican mammoths. Remains of the American mastodon (*Mammuthus americanum*) are also found in the site.

Some written reports comment on the use of mammoth remains for making tools, or mammoth bones with human activity marks. Only Tocuila, however, has bone clearly modified by humans. This site has been dated around 11,200 yrs BP. Santa Isabel Iztapan has some lithic artifacts associated with mammoth remains; stratigraphy is uncertain and radiometric controls are lacking, and dates between 11,000 and 16,000 yrs BP have been allocated to the deposit. A tusk and a mandible from La Villa show several cut marks, but it is not certain at what taphonomic stage they were produced; recently, the material was dated at 11,320 yrs BP. Valsequillo has been reported to contain human-modified mammoth remains, but they could not be located in a recent search. Again, confusing and conflicting evidence provides dates for the regional fauna between 21,500 and 280,000 yrs BP. Finally the Basin of Chapala-Zacoalco has provided some modified proboscidean bones, but without known localities and radiocarbon ages.

Future research in México calls for detailed stratigraphic and radiometric controls for all these previously known localities and sites, and discovery of new localities in order to understand better the distribution of mammoths through time and space, and the relationship between this ancient proboscidean and early peoples.

A NEWLY DISCOVERED SUBADULT AND JUVENILE *Mammuthus* SITE AT THE ANZA BORREGO DESERT STATE PARK®, SOUTHEASTERN CALIFORNIA, USA

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The protruding proximal ends of two tusks and basicranial and maxillary skull fragments of proboscidean origin were found *in situ* in the western Borrego Badlands of Anza Borrego Desert State Park® (ABDSP). The site was discovered during a scheduled intensive survey conducted in February, 2002 by the ABDSP Paleontology Society. Further examination revealed additional cranial and cheek tooth fragments.

The tusks and premaxilla belong to a subadult specimen of *Mammuthus* sp. (ABDSP V6520). The longer of the two preserved I2/ measures about 90 cm in length and is 12.5 cm in diameter at the base. Age of the specimen at the time of death is estimated to be about 20-23 AEY (Craig Scale in Haynes, 1991). This determination is based on tooth wear comparisons and I2/ diameter in *M. columbi* (= *M. imperator*) ABDSP(IVCM) V4056. The basicranial and maxillary fragments including a Dp3/ are from a juvenile *Mammuthus* sp. (ABDSP V6524). This younger animal is estimated to have been <3 AEY (Craig Scale in Haynes, 1991) at the time of death. No postcranial materials were found on or near the site.

The site was assigned locality number ABDSP 2286 and its location determined by GPS. The fossils were located about 95 m above the base of the Ocotillo Conglomerate. This horizon is thought to be approximately 1.25 Ma based on paleomagnetic analyses

and estimated depositional rates (Remeika and Beske-Diehl, 1996). The age of these specimens is about 900 ka BP or within the mid Irvingtonian NALMA.

Both of the specimens were recovered from near the base of a 1.3 m-thick, pale gray green, moderately well sorted, silty fine-grained sandstone. The sandstone fines upward into a carbonate-rich siltstone, suggesting burial in a lacustrine and/or paludal environment. Pebble imbrication measurements in braid stream deposits that underlie the fossiliferous horizon indicate the direction of water flow was south-southeast, 90 degrees from present west drainages. A bone-bed map was prepared. The long axis of ABDSP V6520 trends north and the northeast end of the specimen lies about 2 m northwest of ABDSP V6524. Initial microfossil sampling and analyses revealed fish and reptile remains.

The inaccessibility of the site by land vehicles dictated the use of portable tools for the excavation. Gasoline-powered drills and pneumatic tools were employed to break up and remove over 3 m³ of overburden. Once exposed, the fossils were jacketed in two plaster casts weighing approximately 100 and 400 kg each. These were airlifted by helicopter to the Stout Paleontology Laboratory for preparation, analyses and curation. Additional smaller fossil fragments and matrix were removed and transported out on foot.

These specimens present an interesting taphonomic study to determine the possible simultaneity and cause of death. Planned work on ABDSP V6520 includes tusk wear pattern analysis and ring analysis to determine the individual's health. Ancillary microfossil floral and faunal work is in progress.

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THE MOXEE-ALEXANDRIA MAMMOTH TUSK AND OTHER MAMMOTH REMAINS FROM YAKIMA COUNTY, WASHINGTON STATE, USA

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Yakima County, covering some 11,054 km², is the second largest county in the state of Washington. In the eastern portion of the county mammoth finds are most common in the Yakima Valley. Most publications dealing with the distribution of mammoths in the state have previously not cited any more than two mammoths for this county. However,

analysis of newspaper accounts, museum collections, published research, and personal accounts indicates that no fewer than 13 mammoth finds have been identified throughout the county over the past 122 years. All 13 of these are from the Yakima Valley, and are located in areas inundated by slackwater floods from late Pleistocene glacial Lake Missoula. For 12 of these finds there is little recorded associated geologic data, and none of the 12 have adequate dating control (such as associated radiocarbon dates).

The recent discovery of a heavily fragmented but nearly complete tusk near the town of Moxee City provides new data concerning mammoths in the Yakima Valley. Study of the geologic context of the Moxee-Alexandria tusk revealed that the tusk had been ice-rafted to the site and ultimately deposited within the uppermost of three local flood deposited units. Regionally these units are known as the Touchet Beds. A radiocarbon analysis on the tusk gave a date of $14,570 \pm 50$ (CAMS-79942) yr BP (years before present). This date is consistent with the geology of the site, and adds further evidence towards an accurate dating of the Touchet Beds and the Lake Missoula floods. Preliminary examination of the tusk's Schreger angles suggests that the tusk is from a mammoth, and not a mastodon. The tusk is therefore most likely from a Columbian mammoth (*Mammuthus columbi*), the only mammoth species found in the Pacific Northwest at that time (Lillquist *et al.* 2003).

This well dated and defined context for the Moxee-Alexandria tusk allows us to correlate this find with regional palaeoenvironmental data sets. Pollen analysis at Carp Lake (Barnosky 1985), and recent phytolith studies by Blinnikov *et al.* (2001) indicate that the climate of the time was cold and dry, and the landscape was open, dry and dusty, and predominately grassland. Analysis of the Moxee-Alexandria tusk provides crucial local and regional contextual data toward our greater understanding of the biogeography of mammoths in the Pacific Northwest and western North America.

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LATE PLEISTOCENE ARCTIC FOX (*Alopex lagopus*) FROM CRIMEA, UKRAINE

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At present, the arctic fox, *Alopex lagopus* (L.), is confined to a circumpolar range, inhabiting the northernmost regions of Eurasia and North America. The nominotypical subspecies *A. l. lagopus* occupies the Eurasian mainland and adjacent islands. The smaller *A. l. spitzbergenensis* (Barrett-Hamilton et Bonhote) occurs in Spitsbergen and Franz Josef Land. The two largest subspecies, *A. l. beringensis* (Merriam) and *A. l. semenovi* Ognev, are found in the Commander Islands.

In the late Pleistocene, the arctic fox spread far to the south, reaching Spain and the southern part of France in Western Europe (Kurtén 1968). In Eastern Europe, the southernmost records are from the Crimea. In Siberia it is known from the Altai Mountains (Denisova Cave).

The fossil subspecies *A. l. rossicus* Kuzmina et Sablin has been described from the late Weichselian of European Russia (Eliseevichi, Yudinovo, and Kostenki) (Kuzmina and Sablin 1993, Sablin 1994). This subspecies is similar to the Recent mainland subspecies in the length of the lower carnassial tooth m1, differing in its width: m1 in the fossil subspecies is relatively narrower (Sablin 1994).

I have examined the material from Mousterian levels in the Prolom 2 grotto in Crimea (collections of Dr. Yu. G. Kolossov, Kiev), which is dated as early Weichselian (Eisenmann and Baryshnikov 1995, Chabai 1998).

In the length of m1 (13.0-14.2 mm, $M=13.62$ mm, $n=27$), the late Pleistocene Crimean arctic fox appears to be 4.3% smaller than *A. l. rossicus* from Kostenki and Recent *A. l. lagopus* ($P < 0.001$), demonstrating in this character the similarity to the Recent insular subspecies *A. l. spitzbergenensis*. However in the latter subspecies this tooth is consistently narrower ($P < 0.001$). The ratio of width to length of m1 in the Prolom 2 sample is calculated, on average, near 37%, as in *A. l. rossicus* from Kostenki (Sablin 1994).

The postcranial bone dimensions in Prolom 2 also indicate that the *A. lagopus* population was represented there by very small animals. Measurements show that the fore and hind limbs were especially short in their distal portions. Average values of the lengths of metacarpals and metatarsals of the polar fox in Prolom 2 correspond to minimal values of those of *A. l. rossicus*.

Therefore in its small size, the early Weichselian *A. lagopus* from Crimea resembles the subspecies *A. l. spitzbergenensis* from the arctic islands, which currently inhabits Spitsbergen and Franz Josef Land.

Such a type of appearance (small size and short limbs) may be explained by unfavorable environmental conditions for this species (e.g., by scarcity of food). It may be considered as a maintenance phenotype in Geist's (1987) interpretation.

The morphometrical peculiarity of the late Pleistocene arctic fox from Crimea suggests that it should be regarded as a distinct subspecies.

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CONTRIBUTION OF STABLE ISOTOPES ON THE QUESTION OF MAMMOTH MEAT CONSUMPTION BY NEANDERTALS AND ANCIENT ANATOMICALLY MODERN HUMANS

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Mammoth meat consumption by prehistoric humans is still a debated issue. Carbon and nitrogen isotopic abundances in bone collagen directly reflect those of the protein fraction of average diet. When collagen is well preserved in fossil bone, its isotopic signature provides direct information on the prey consumed by predators.

Mammoth exhibit a carbon and nitrogen isotopic signature different from that of coeval herbivorous mammals. It is thus possible to test the consumption of mammoth meat using prehistoric human stable isotopic composition in bone collagen. Using mathematical models, quantitative estimations of mammoth meat consumption can be produced for Neandertals and fossil anatomically modern humans. The results obtained on Neandertal from Saint-Césaire (around 36,000 years BP, France) and Gravettian modern humans from Milovice (around 25,000 years BP, Czech Republic), compared with those of the coeval fauna, indicate that mammoth is a possible dietary item. However, an uncertainty remains about the possible contribution of freshwater fish, which may be similar in isotopic signature to mammoth meat. Taking into account the archaeozoological data allows us to present a likely scenario about mammoth meat consumption by ancient humans.

THE NORTH OF EASTERN SIBERIA: REFUGE OF THE MAMMOTH FAUNA IN THE HOLOCENE

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The global climate changes at the end of the Pleistocene led to extinction in the huge area of Northern Eurasia of the typical representatives of the Mammoth fauna: mammoth, woolly rhinoceros, wild horse, bison, muskox, cave lion, etc. Undoubtedly the Mammoth fauna underwent strong pressure from Upper Paleolithic Man, whose hunting activity could have played the main role in decreasing the numbers of mammoths and other representatives of the megafauna. Archaeological data testify that the typical representatives of the Mammoth fauna were hunted only until the end of the Pleistocene. Their bone remains are usually not found in the settlements of Mesolithic Man. Formerly it was supposed that the megafauna of the "Mammoth complex" was extinct by the beginning of the Holocene. Nevertheless the latest data testify that the global extinction of the Mammoth fauna took place in Northern Eurasia between the Pleistocene and the Holocene and was significantly delayed in the northern part of Eastern Siberia. In the 1990s radiocarbon dates proved that mammoths existed for most of the Holocene on Wrangel Island - from 8000 till 3700 years BP. New radiocarbon data show that wild horses inhabited the northern part of Eastern Siberia (the lower stream of Enissey river, the Novosibirskie Islands, and East Siberian seacoast) 3000 - 2000 years BP. Muskoxen lived on the Taimyr Peninsula and the Lena River delta about 3000 years BP. Some bison remains from Eastern Siberia are Holocene in age. The following circumstances could promote the survival of representatives of the Mammoth fauna. The cool and dry climate of this region promoted the maintenance of steppe associations - habitats of those mammals. Late Paleolithic and Mesolithic settlements are not found in the Arctic zone of Eastern Siberia from the Taimyr Peninsula to the lower stream of the Yana River; they are very rare in the basins of the Indigirka and Kolyma rivers. So the small number of Stone Age hunting tribes in Northeastern Siberia was another factor in long-term survival of some representatives of the Mammoth fauna.

DISTRIBUTION OF MAMMOTHS ON THE BANKS OF TAIMYR LAKE

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Owing to the length of its coastline Taimyr Lake is one of the richest localities in mammoth remains on the Taimyr Peninsula. Here at the mouth of Nizhnyaya Taimyra the first Taimyr mammoth was found by the Middendorf expedition in 1843. Owing to data accumulated in the last few years including new paleontological finds, radiocarbon dates on mammoth remains, description of the structure of Quaternary deposits and relief of the Taimyr Lake basin it is possible to note an interesting relationship. The correlation between flow fluctuation of the lake and presence of mammoths on its banks is striking. Favourable conditions for mammoths arose in the following time intervals: 10-14; 16-18; 20-21; and 20-25 thousand years ago. These were times of low water level in the lake. The majority of dated mammoth bones are known from the last interval. Until now there have been no dates between 14-16; 18-20; and 25-27 years ago from this region. Those were times of high water levels. The water level of the lake fluctuated greatly at the end of the Late Pleistocene. The highest points during the Karginnyi transgression exceed the recent one by 30-40 m. At that time the vast territories of Taimyr lowland were flooded. Rivers became estuaries, and Pyasina River and Taimyra River as two estuaries were united in one basin. At the same time some species of fresh water organisms from Baikal Lake penetrated to the Pyasina River and Taimyr Lake.

One of the most significant lowerings of the lake level and correspondingly the level of the sea happened 20-25.000 years ago. After this event the level of the sea rapidly dropped whereas the level of Taimyr Lake rapidly rose because of development of a local glacier which covered the valley of Nizhnyaya Taimyra River at the mouth of its tributary the River Shrenk. The lowering of the water level occurred 12-13.000 years ago, as a result of catastrophic draining of the lake, which had been blocked by a glacier. Mammoth were quite numerous on the banks of the lake after this event. When the level started to rise at about 10.000 years ago, mammoth disappeared from this region forever.

During the Sartan glaciation (the last of the Late Pleistocene) vast areas on Taimyr Peninsula were covered by glaciers. But the glaciers did not form a glacial shield because they were made up of vast fields of "dead" ice and small glacial domes which were formed on uplands that rose more than 100 m. The glaciers formed and disappeared very quickly, so between them the fauna could survive. In the earliest stages of the Late Pleistocene the Taimyr Peninsula was a region of marine sedimentation and as a result of this the glacial shields were absent at that time.

Traces of glaciation synchronous with marine transgression were found only on the Byrranga Mountains. Mammoths did not live on the banks of Taimyr Lake before 40-50.000 years ago. On the northern part of the peninsula glaciers were widely distributed especially during Sartan time, so no mammoth remains of this age are known from the region.

Evidently the distribution of mammoths was limited by at least two factors: rises in water level in the sea and lakes, and expansion of glaciers.

USING PLEISTOCENE DNA TO INVESTIGATE BERINGIAN PALAEOENVIRONMENTAL CHANGE

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Studies of permafrost preserved DNA have revealed a number of surprising evolutionary processes, particularly with regard to the genetic interactions of populations in the Late Pleistocene. We have studied populations of bison, brown bears, lions, and horse from Europe, Siberia, Alaska, Canada, and the continental US. Changes in distribution and genetic diversity record a dynamic landscape, with frequent localised extinction events, replacements, and dispersals. Recent studies have also revealed that ancient DNA records of plants and animals may survive in environments even in the absence of macrofossils. This information has huge potential for palaeoecological studies, and analyses of palaeoenvironmental change. New analytical techniques mean that these DNA sequences can be combined with carbon dates to establish precise taxon-specific evolutionary rates, which in turn allow detailed investigations on the timing of Late Pliocene – mid Pleistocene biological events.

CARBON-13 AND NITROGEN-15 AMOUNTS IN LARGE HERBIVOROUS MAMMAL COLLAGEN AS A TRACER OF ENVIRONMENTAL CHANGES IN THE MAMMOTH STEPPE BETWEEN 50,000 AND 10,000 BP IN NORTHERN EURASIA

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Large herbivorous mammals record in their collagen the isotopic signature of their diet, which changes according to some environmental parameters. Recent systematic investigations performed on fossil collagen retrieved from fossil bones of herbivorous mammals from French archaeological sites ranging in age from 35,000 years BP to 6,000 years BP have allowed us to decipher the relationships between environmental parameters and isotopic signatures. Among them, the density of plant cover influences the carbon-13 amount in plants, and thus in herbivore collagen. For nitrogen, the characteristics of nitrogen-cycling processes in soils are key factors for nitrogen-15 amounts in plants, and therefore in their consumers (Drucker *et al.*, in press). This approach has been used to evaluate the changes that occurred in the Mammoth Steppe across Europe and Siberia between 50,000 and 10,000 years BP, using isotopic data published for mammoths and other large herbivores (Bocherens *et al.*, 1996; lacumin *et*

al., 2000; Bocherens, 2003). The results allow us to reconstruct the dynamics of the environments in view of the demographic evolution of mammoth, chronologically and geographically. This study illustrates the use of isotopic tracing as a novel approach of investigation on the extinction of mammal species, such as mammoth.

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EVOLUTION AND DEVELOPMENT OF ASIAN AND NORTH AMERICAN OCHOTONIDS

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Ochotonids are one of the ancient groups of mammals that originated in the Oligocene of Asia. Judging from cranial and postcranial skeletons of both extinct and extant taxa, the main external features of ochotonids remained invariable for a long time. Studies of the fossils indicate that ochotonids show general evolutionary trends in cheek teeth from rooted towards rootless and from brachydonty to hypsodonty; enamel structure on the occlusal surface of cheek teeth from simple to complicated in P^3 and P_3 ; hypostria of P^4 - M^2 from shallow to deep; and talonids of P_4 - M_2 from narrow to wide.

The earliest Oligocene ochotonids were represented by the genus *Sinolagomys* distributed in Asia. At the beginning of the Miocene with the climate becoming more continental and arid, and open landscapes becoming widespread, a wide adaptive radiation of ochotonids took place. At that time a number of new genera appeared and spread widely throughout many continents. The genera *Sinolagomys*, *Bellatona*, *Heterolagus*, *Albertona*, *Marcuinomys*, *Lagopsis*, *Alloptox*, *Paludotona*, and *Proochotona*

inhabited Eurasia; two genera *Kenyalagomys* and *Austrolagomys* occurred in Africa; and the genus *Oreolagus* appeared in North America. By the Early Pliocene, most genera of ochotonids became extinct and their distributional range shrank. However, the genera *Ochotonoides* and *Ochotona* flourished throughout Eurasia. At that time the genus *Ochotona* migrated to North America (*Ochotona spanglei*) (Shotwell, 1956) and Europe (*Ochotona* sp.).

During the Early Pleistocene there was another immigration of ochotonids to North America. The large-sized pika, *Ochotona whartoni*, is known from Cape Deceit and Gold Hill Cut in Alaska (Guthrie and Matthews, 1971), and from Old Crow River basin in the Yukon (Harington, 1977). Specimens of small-sized pikas morphologically close to the “pusilla” group are known from several Middle Pleistocene sites including Cumberland and Trout Caves in the Appalachians, and The Pit and Velvet Room in Porcupine Cave, Colorado (Mead *et al.*, 2003).

At the same time, several species differing in size existed in Northern Asia, including: *Ochotona* cf. *whartoni* (West and East Siberia and Kolyma) small pikas of the “pusilla” group – *Ochotona pusilla* (Northern Kazakhstan), *Ochotona* sp. from West Siberia and *Ochotona filippovi* (East Siberia), *Ochotona bazarovi*, *Ochotona* cf. *nihewanica* (West Transbaikalia) and *Ochotona* ex gr. *hyperborea* from Kolyma (Erbajeva and Belolyubsky, 1993; Erbajeva, 2000).

It is possible to consider that large sized *Ochotona whartoni* and small pikas of the “pusilla” group were widespread throughout Northern Asia and North America, including the development of the Late Pleistocene and Recent small species.

All Late Pleistocene extinct ochotonids of North America appear to belong to *Ochotona princeps*, and pikas from East Siberia, Yakutia, North-East Siberia and from Northern Kazakhstan relate to the extant *Ochotona hyperborea* and *Ochotona pusilla* respectively.

The latter species as well as *Ochotona princeps* and *O. collaris* living in North America have the same number of chromosomes ($2n=68$). It appears that these three species had a common ancestor, which may have migrated from Asia to North America at the beginning of the Pleistocene.

GROWTH AND LIFE HISTORY RECORDS FROM MAMMOTH TUSKS

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Periodically formed incremental features are a fundamental aspect of proboscidean tusk dentin. Dentin increments are organized hierarchically, with first-, second-, and third-order features encompassing successively shorter time intervals, and each typically repeated with characteristic frequency within increments of more inclusive order (third within second and second within first). First-order increments show annual periodicity and reflect environmental signals and organismal responses that vary seasonally. Third-order increments appear to show daily periodicity and are interpreted as a structural

reflection of circadian physiological rhythms, normally entrained to the environmental dark-light cycle. Until recently, there has been no clear physiological or environmental explanation for second-order features. In tusk dentin of mammoths (both *Mammuthus primigenius* and *M. columbi*) from temperate latitudes of North America, second-order features appear to show circaseptan, or approximately weekly, periodicity. However, in the last years of life recorded in two mammoth tusks from the Klondike region of Alaska, there are fewer second-order features per year than in tusks from lower latitudes. This pattern may be explained if second-order features record the “beat-frequency” produced by interaction of two different physiological rhythms, the circadian rhythm and a rhythm intrinsic to the tusk itself, possibly related to mineralization. If circadian rhythms in mammoths at high latitude become free-running during the polar winter’s long “night” (or the polar summer’s long “day”), they should shift to a different period, changing the period of their interaction with the intrinsic tusk rhythm and thus the number of second-order features per year. The extent of this effect should vary with latitude, as entrained and free-running conditions contribute differentially to the annual cycle.

Intra- and interannual variation in incremental patterns becomes even more informative in the context of the entire life history. As part of an international collaborative effort (the “*Mammuthus* Project”), we sampled Siberian *M. primigenius* tusks by coring at multiple positions along the tusk axis. Overlapping records are correlated by matching patterns of incremental laminae in dentin thin sections. Long-term growth records are compiled along the tusk, yielding multiple decades of data on rates of tusk growth. We interpret years with ca. 52 second-order increments as evidence of presence below the Arctic Circle and values <50 as evidence of movement above the Arctic Circle. Intra-tusk variation in these patterns suggests large-scale latitudinal movement of individuals during their lifetimes. Preliminary data suggest that males were evicted from matriarchal family units while in the north, came south to mature fully, and only went to the far north again during musth intervals, after which they retreated to lower latitudes to recover for multi-year periods. Adult females spent longer periods in the north, probably associated with a lower risk of predation on new-born and young calves. They appear to have come south after weaning their calves, going north again for the birth of their next calf.

HISTORY OF MAMMOTH LINEAGE IN THE SOUTHERN PART OF CENTRAL SIBERIA

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Successive stages of mammoth lineage development in Southern Siberia have been reconstructed by the author in detail, on the basis of material from Southwestern Siberia (Foronova, 1999, 2001a,b). Numerous fossils from another large and rich Quaternary locality situated in the Southern part of Central Siberia were also studied (North-Minusinsk Basin, Kurtak archaeological region, 20-km stretch of Krasnoyarsk reservoir shore in the valley of Enissey).

Elephant molars (M3) were studied using original methods of constructing and analyzing multidimensional diagrams, incorporating coordinates of enamel thickness

(E), average length (PL) and frequency (PF) of plates in the crown (discussed in Foronova and Zudin, 1999, 2001). It was found that all major taxa in the mammoth lineage, beginning with *M. trogontherii*, occurred in the area under study in the Middle and Late Pleistocene. A diagram of data for the territory shows the same number and sequence of thick- and thin-enameled forms of *Mammuthus* as in Western Siberia (Foronova, 2001a, Fig.1). It is assumed that these forms were ecologically differentiated; predominance in different paleoclimatic environments being caused by different morphofunctional adaptations. Molars mainly belong to a number of transitional forms between *M. trogontherii* and late mammoth (*M. p. primigenius*). Some of the forms require systematic description and re-description, so the names used are rather conventional.

Molars of relatively thick-enameled *M. aff. ?chosaricus* (parameters: PF 6,75 ; E 1,95) originate from deposits corresponding to the Tobolsk interglacial (Holsteinian) and containing tools of the Acheulian-Mousterian complex. Large thin-enameled *Mammuthus* sp. (PF 7,0 -7,3; E 1,5-1,8) correlates with the Samarovo glaciation (Early Saalian). A peculiar thick-enameled *M. cf. intermedius* (PF 7,5; PL 13,4; E 2,1), whose numerous fossils were found in locality Ust-Izhul 1, correlates with the Shirta (intra-Saalian) interglacial. The range of this mammoth was vast—it covered all of Europe and Siberia. The two latter forms are worth distinguishing as independent taxa. During further warm epochs— Kazantsevo (Eemian) and Karga (Middle Weichselian)—Middle Siberia was also inhabited by the mammoths with thick-enamel phenotype, more advanced than before (their respective parameters: PF 7,8; E 1,7: PF 9,2; E 1,75). *M. primigenius* with the most efficient cutting and milling function of molars, having band-like plates and very thin enamel (PL 13,0; E 1,4: PL 11,5; E 1,25: PL 10; E 1,15), was typical of periglacial faunas of the end of the Middle and Late Pleistocene (Taz, Ermakovo, Sartan - Late Saalian, Early and Late Weichselian).

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TUSK GROWTH INCREMENT AND STABLE ISOTOPE PROFILES OF LATE PLEISTOCENE AND HOLOCENE *Mammuthus primigenius* FROM SIBERIA AND WRANGEL ISLAND

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We are using variations in tusk growth rate and stable isotope composition to investigate the extinction of Eurasian mammoths (*Mammuthus primigenius*) in Siberia during the latest Pleistocene and on Wrangel Island (off the northeast coast of Siberia) during the middle Holocene. Changes in the thickness of periodically formed tusk dentin increments can be used to assess season of death and infer changes in the timing or frequency of life history events such as sexual maturation, calving, and migration. Growth increment profiles can also be used as a guide for serial microsampling of tusk dentin for stable isotope analysis and can provide auxiliary data to help reconstruct aspects of mammoth ecology from stable isotope profiles. The oxygen isotope composition ($\delta^{18}\text{O}$) of tusk dentin apatite is influenced by the $\delta^{18}\text{O}$ value of local precipitation, which is sensitive to air temperature, and by humidity. Warmer temperatures and high aridity correspond to higher tusk $\delta^{18}\text{O}$ values. The carbon isotope composition ($\delta^{13}\text{C}$) of tusk dentin apatite reflects the dietary proportions of plants using the C_3 (trees, shrubs, cool-climate grasses) and C_4 (warm-climate grasses) photosynthetic pathways, and the $\delta^{13}\text{C}$ of tusk collagen reflects the C_3 : C_4 ratio of dietary protein sources. Based on the modern tropical to temperate distribution of C_4 plants, mammoth populations in the Eurasian Arctic probably only consumed C_3 biomass. However, because the $\delta^{13}\text{C}$ of plants is sensitive to environmental factors such as water and light stress, carbon isotope ratios from tusks can still provide insight into mammoth foraging behavior, and comparisons between oxygen and carbon isotope ratios in the same samples can constrain paleoclimatic interpretations. The nitrogen isotope composition ($\delta^{15}\text{N}$) of collagen reflects nutritional stress because catabolism of body protein to maintain nitrogen balance causes an increase in the $\delta^{15}\text{N}$ of body protein formed in a nutritionally stressed animal.

To date, we have a full complement of analyses for about three years of growth for one tusk from the Taimir Peninsula of Siberia (the Jarkov mammoth; ca. 20,300 rybp) and growth increment and tusk apatite carbon and oxygen isotope ratios for two to three years of growth from two tusks from Wrangel Island (4,400 and 4,120 rybp). Our sampling focused on the last several years of life in these tusks, which are preserved in the dentin adjacent to the pulp cavity. The $\delta^{18}\text{O}$ values of structural carbonate in apatite from the Jarkov mammoth ($15.3 \pm 1.3\text{‰}$ VSMOW) are similar to published values for other Siberian mammoths and to mean values for high-latitude North American mammoths. The values for the two Wrangel specimens are higher ($21.1 \pm 1.0\text{‰}$ and

22.4±0.9‰ VSMOW) and more like values for mammoths from eastern Russia and Hot Springs, South Dakota. The higher $\delta^{18}\text{O}$ values in the Wrangel tusks relative to the Jarkov mammoth and others from Siberia suggest considerably warmer temperatures and/or major differences in moisture transport during the middle Holocene relative to the late Pleistocene. Apatite and collagen $\delta^{13}\text{C}$ values for the Jarkov mammoth (-12.9±0.9‰ and -21.3±0.4‰ VPDB, respectively) and apatite carbon isotope values for one of the Wrangel mammoths (-12.7±0.8‰ VPDB) match the expectation for a pure C_3 diet with typical carbon isotope composition. However, the second Wrangel tusk has surprisingly high $\delta^{13}\text{C}$ values (-8.2‰±0.9‰), which we tentatively interpret as a reflection of the influence of aridity on the carbon isotope composition of the C_3 plants in the diet. The collagen $\delta^{15}\text{N}$ values from the Jarkov mammoth range from 9.0 to 11.9‰ AIR and imply two intervals of moderate nutritional stress, including one period just prior to death.

Results for just these three individuals indicate strong geographic and temporal differences in the environments of mammoths from central Siberia and Wrangel Island. Stable isotopic data and AMS radiocarbon dates for an additional 15 tusks from Siberia and stable isotopic data from three additional tusks from Wrangel Island dated to 6,190-6,560 rybp will allow us to track changes in the ecology of mammoth populations prior to local extinctions in the late Pleistocene and Holocene. These data will also help resolve the pattern and timing of climate change at high latitude across the Pleistocene-Holocene boundary.

THE PLEISTOCENE REINDEER OF THE NORTH SEA; INITIAL PALAEOONTOLOGICAL DATA AND ARCHAEOLOGICAL REMARKS

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Introduction

"Late Pleistocene terrestrial and marine mammals from the Eurogeul, North Sea, The Netherlands" (Mol *et al.*, this volume), describes the plenitude of fossilized remains of Pleistocene mammals to be found on the North Sea floor. These mammals inhabited the area during limited periods of the entire Pleistocene and fossils dating especially from the Late-Pleistocene are salvaged by the tens of thousands every year. In the so-called North Sea project interdisciplinary co-operation enables accurate dating, determination and study of this fossil fauna.

Of major interest is to answer the question of when and in what biotope and climate reindeer, *Rangifer tarandus*, inhabited the area which now forms the North Sea floor; and especially whether or not it co-existed with *Homo sapiens*, i.e. with reindeer-hunting cultures. As yet there is, perhaps surprisingly, no evidence of such co-existence.

The North Sea Project

About a year ago the North Sea Project was started in the Netherlands. Organized within the framework of the CERPOLEX/Mammuthus program this multi-year project has involved the participation of a number of universities and governmental institutes, establishing a frequent and close co-operation. This broad interdisciplinary approach combines palaeontology, geology, palynology, dendrology, and archaeology and isotope science.

The project's ambitious goal is, among other things, following the determination and dating of accumulated fossil materials which constitute a reliable empirical basis, to offer an accurate description of the successive floras and faunas which occurred during the Pleistocene in what is now the Southern Bight of the North Sea situated between the British Isles and the Netherlands.

As man was part of these faunas the gathered materials, along with numerous fossilized mammalian remains dating from Pleistocene and Holocene, include artefacts, especially from the Palaeolithic and Mesolithic period. Tools made of flint, well-made axes amongst them, are salvaged from the loads which sand- and shell-dredgers active in the area bring ashore in the Netherlands. In the same way, tools made of bone and antler have been collected. Similar finds come from the drag-nets of fishing-boats which frequent the area.

Palaeontology and archaeology meet here in the analysis of what remains of the interaction between Palaeolithic man and his environment, especially of the use he made of animal material to survive. Palaeolithic man is often described as a reindeer-hunter. Hence, part of the project consists in systematically accumulating all fossil remains of reindeer as well as all artefacts made of bone and antler. A collection has been formed consisting of several thousands of reindeer fossils and over a hundred artefacts made of the same material, some of which were made with extraordinary craftsmanship, but none of the collected reindeer bones or reindeer antlers show traces of handling.

The North Sea Reindeer

Rangifer tarandus is known from the Pleistocene and Holocene. It appeared in the Irvingtonian Cape Deceit fauna in Alaska about a million years ago (Geist, 1998). The oldest known fossils of *Rangifer tarandus* in Europe were found in Süssenborn, Germany and dated at ca. 500,000 BP (Kurten, 1968). Considering the geographical position of the North Sea we expected the reindeer as being part of the North-Sea-fauna from this time on. However, until now we did not find any reindeer remains in the fauna of the Bavelien (the latest period of the Early Pleistocene, ca. 1,000,000 - 750,000 BP), nor during the Middle and early Late Pleistocene. It does, however, constitute a typical part of the Late Pleistocene Mammoth-fauna (Mol *et al.*, this volume).

¹⁴C-dating has been carried out in order to obtain detailed insight in the occurrence of reindeer in this area. The results are listed in Table 1.

Table 1

Sample name	Laboratory number*	¹⁴ C age (BP)	sigma	Geographical co-ordinates
GL02, Calcaneum	20254	44,100	+1250, -1100	52°44' N, 03°11' E
GL03, Metacarpal	20255	39,150	+700, -650	52°22' N, 03°06' E
GL05, Last Phalanx	20257	39,200	+700, -650	52°11' N, 02°48' E
GL06, Astragal	20294	29,460	± 250	52°11' N, 02°48' E
GL07, Astragal	20259	42,300	+1000, -900	52°29' N, 03°07' E
GL08, Radius	20260	41,200	+900, 800	52°48' N, 02°46' E
GL09, Epistropheus	20261	39,000	+700, -600	53°06' N, 02°40' E
GL14, Metacarpal	20303	>45,000		SW of the Brown Bank
GL15, Bone	20475	>45,000		SW of the Brown Bank

* GrA - Groningen AMS.

As can be inferred from the list reindeer inhabited the area at least in the Late Pleistocene, but not continuously (note a similar conclusion for the late Quaternary mammalian megafauna of the Taimyr Peninsula in MacPhee *et al.*, 2002). *Rangifer tarandus* probably wandered in during three periods of favourable climate:

- One sample has been dated 29,460 ± 250 BP. This specimen lived therefore either at the close of the Denekamp-interstadial (a steppe-tundra with summer-temperatures averaging 5-10° Celsius, ca. 29,000 - 32,000 BP) or during the transitional period between the interstadial and the polar desert of the extremely cold Upper Pleniglacial (ca. 28,000 - 22,000, the so-called Weichsel maximum, with summer temperatures on average hardly above freezing-point). (Borman *et al.*, 1984; Van der Vlerk and Florschütz, 1949). Climate and flora of these periods formed an excellent environment for the animal.
- Six samples have been dated ca. 44,000 - 39,000 BP. During the Middle Pleniglacial (ca. 28,000 - 50,000 BP) three interstadials can be discerned in the area (Denekamp, Hengelo, and Moershoofd) (Zagwijn, 1974). During the colder periods the land was a steppe-tundra, during the interstadials it was mostly covered in low growth and birch. For the occurrence of reindeer the datings suggest a cold period. Most likely reindeer inhabited the area only during the colder stadials, but further research and dating must confirm or refute this hypothesis. However, *Rangifer tarandus* certainly was part of the Mammoth fauna, for a sample of *Mammuthus primigenius* and *Coelodonta antiquitatis* from the area has been dated to the same period (43,800 (+600/-550) and 39,910 (+1070/-950) BP) (Mol *et al.* this volume).
- Finally, two sample-datings indicate that reindeer may have occurred in the area during an even earlier period, before 45,000 BP; as an estimate 45,000 - 100,000 BP. The degree of fossilization of the samples seems to preclude the Early as well as the Middle Pleistocene, and considering the rather high average temperature of the Eemien reindeer probably did not inhabit the area during that period either.

Some remarks about ¹⁴C

Radiocarbon dating uses the natural decay of the radioactive isotope ¹⁴C. This carbon isotope is present in nature, including living organisms, in minute concentrations. Living organisms exchange ¹⁴C with their environment; after death the ¹⁴C content diminishes

as a result of radioactive decay only. Therefore, by measuring the remaining ^{14}C content in materials such as prehistoric bones, these materials can be dated.

This method would be rather straightforward if the decay constant (or half-life) of ^{14}C were exactly known, and the ^{14}C concentration in nature were constant. Unfortunately, neither is true. In addition, there are isotope effects (called fractionation) in physical/chemical processes (such as photosynthesis), which change the ^{14}C content and therefore the "age". To deal with these problems a ^{14}C timescale has been defined using the following conventions (Mook and Streurman, 1983):

1. the ^{14}C activity should be measured relative to a standard activity;
2. a specific half-life value is used to calculate ^{14}C ages;
3. fractionation effects are corrected for using the stable isotope ^{13}C ;
4. the unit for reporting ^{14}C ages is BP.

One has to bear in mind that in BP, meaning Before Present, the P refers to AD 1950 - the year the definition was introduced - and corresponds with the standard activity of that time.

Mainly because of ^{14}C variation during the past millennia, a ^{14}C (BP) chronology differs from a calendar chronology. The two timescales can be connected; ^{14}C -dating of dendrochronologically dated wood samples has established a calibration curve for the Holocene (Stuiver and Van der Plicht, eds., 1998). However, all North Sea samples presented here are Pleistocene. Although for samples predating ca. 15.000 BP calibration datasets are available, such tables are in disagreement, in particular on dates lying before ca. 30.000 BP (Van der Plicht, 2000; Richards and Beck, 2001). In this case, therefore, measurements can thus far only be presented in BP.

The errors quoted in the table correspond to 1σ (1-sigma) errors. In statistical theory this means that the probability of finding the true age within the given range of error is 68%. Note that these errors in most cases are asymmetric. The reason is that these ages are close to the dating limit of the ^{14}C method. This limit is 45-50,000 BP, beyond which the ^{14}C signal is no longer detectable.

Discussion and Conclusions

At locations throughout Europe fragments of man-made tools of bone and antler have been found, dated to the Middle and, especially, the Late Palaeolithic (Gaudzinski, 1999). Although these finds have been rare one might expect nevertheless to find similar artefacts on the North Sea floor, dating in particular from the Late Palaeolithic. It has been established that reindeer-hunting cultures, especially from the period of ca. 13,000 - 10,000 BP, frequently used reindeer material (see, e.g., Rust, 1943).

Much of the material collected by the first author, dated to the Middle and/or Late Palaeolithic, bears marks which can be interpreted as evidence of handling by man. This collection consists of more than one hundred bone fragments, especially of woolly mammoth, bison (*Bison priscus*) and horse (*Equus caballus*). None of the marks can be said to be undeniably man-made, but marks which suggest cutting or hacking, or the cracking of bones to get to the marrow, are currently being studied.

Sophisticatedly carved tools from antler of red deer (*Cervus elaphus*) and bone of aurochs (*Bos primigenius*), definitely Mesolithic material, have been salvaged; and many

other finds imply that Mesolithic man hunted moose (*Alces alces*), horse, and boar (*Sus scrofa*) in the area (Louwe Kooijmans, 1971; Post, 2000). Recent finds which have been ¹⁴C dated confirm this hypothesis.

One of these more recent finds, a humerus of a wild boar which shows marks of cutting and breaking, has been ¹⁴C dated to 9450 ± 70 BP. Remarkably, considering that skeleton parts of wild boar from the North Sea are very rare, no less than 28 similar fragments of humeri belonging to *Sus scrofa* have been salvaged; all of them distal fragments which must have been deliberately broken by man, considering that they have been chopped off all in the same place and in the same way (Post, 2000). This constitutes apparent evidence of wild boar-slaughtering.

Man must have inhabited the area and indeed remains of Mesolithic man have been salvaged from the bottom of the North Sea; three of them have been ¹⁴C dated (see Table 2) (Post, 2000). In addition, ¹⁴C dating of two recently found samples of red deer phalanges confirms that this animal inhabited the North Sea Basin during the same period as man did. ¹⁴C-datings of three artefacts made of red deer antler are due in the near future; they may constitute further proof for the co-existence of Mesolithic man and red deer in the area.

The findings prove that Mesolithic man lived and, probably, hunted in various ways in the North Sea Basin in the woody surroundings which formed the habitat of *Cervus elaphus* and *Sus scrofa*.

Table 2

Sample name	Laboratory number*	¹⁴ C age (BP)	sigma	Geographical co-ordinates
<i>Cervus elaphus</i>				
GL01, Second Phalanx	GrA 20353	8.350	50	52°27' N, 02°55' E
GL04, First Phalanx	GrA 20256	8.820	60	52°22' N, 03°06' E
<i>Sus scrofa</i>				
NO.2684, Humerus	UtC 7886	9.450	70	Southern Bight North Sea
<i>Homo sapiens</i>				
NO.1063, Cranial bone	UtC 3750	9.640	400	52°10' N, 02°49' E
Cranial bone	?	8.340	130	Southern Bight North Sea
Mandible	GrA 11642	8.370	50	53°00' N, 02°54' E

* GrA – Groningen AMS; UtC - Utrecht AMS

Reindeer bones or antlers with marks of handling by man have as yet not been salvaged from the North Sea floor. Judging from other finds, artefacts made of reindeer material may have been rare even in reindeer hunting cultures. Nevertheless the fact remains that many fossilized remains of reindeer have been collected, as well as several Palaeolithic flint artefacts, but nothing which indicates handling of reindeer bone or antler. As a relatively large proportion of the salvaged remains of Mesolithic red deer does show marks of handling, one would expect to find at least some of the reindeer remains showing the same, because reindeer-hunters are more focused on a single species and must have put the parts of the animal they hunted to many uses.

The lack of evidence for human handling of reindeer bones may be explained by the fact that *Rangifer tarandus* did not inhabit the area during the relatively warm periods, when man did. The other possibilities suggested by the salvaged material are that in the Late Palaeolithic either man was absent too from the area or that there may have been more than just reindeer cultures.

Of course, further research is needed to substantiate or falsify these tentative conclusions.

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MAMMOTHS (*Mammuthus*) IN COLORADO, USA

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Colorado is located in the mid-continent of North America. It is topographically and ecologically diverse with flat to low relief plains in the eastern half of the state and the spine of the central Rocky Mountains running north-south down the central part with 52 peaks between 14-15,000 ft MSL. These mountains were glaciated in the Pleistocene. There are both eastern and western slopes to the mountains, with the Colorado plateau in the southwest. There are more than 35 documented mammoth sites in Colorado and these sites are restricted to the central Rocky Mountains, eastern slope, and the eastern plains. Sites are not known from the western slope and the Colorado plateau. However, a survey of the FAUNMAP database (Faunmap Working Group 1994) shows a lack of Pleistocene faunal sites, in general, in these parts of Colorado. In addition, FAUNMAP records 4 mammoth sites in the upper reaches of the Colorado River in eastern Utah adjacent to Colorado's western slope. Therefore, the absence of mammoth sites in the western third of Colorado is probably the result of limited survey and research in this area rather than any environmental cause.

Mammoths occur from the low elevations of ca. 4,000 ft MSL on the plains to approximately 10,000 ft MSL in the mountains. A mammoth from Florissant at about 9,500 ft MSL is beyond radiocarbon age (> 40 ka) and numerous specimens from the Front Range Area are from alluvial sequences that may date to 200 ka. The youngest dated mammoths from the Dent site (a Clovis cultural site) date to 10.8 ka. Undated mammoths from the mountains are probably late Pleistocene in age but anything younger than 12 ka has not been confirmed. These distributional patterns suggest that mammoths ranged throughout a variety of environments for a relatively long time in the late Quaternary. Also, these patterns do not support the hypothesis that mammoths retreated to higher elevations during the terminal Pleistocene (Agenbroad 1984).

All identifiable mammoth teeth from all elevations represent *Mammuthus columbi*. So far, *Mammuthus primigenius* has not been found at higher elevations. The oldest identifiable specimen, the Stone Gate Mammoth, is from the Louviers Alluvium (ca. 200 ka) southeast of Denver and appears to be transitional between *Mammuthus imperator* and *M. columbi*. Many of the mammoth sites from the plains have associated fauna. Horses (*Equus* spp.), camels (*Camelops hesternus*), bison (*Bison bison*) and Harlan's ground sloth (*Glossotherium harlani*) are common elements in all of these faunas. All of these taxa are characteristic of open habitats with few trees. Alpine mammoths generally have not been found with associated fauna.

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COMPARISON OF THE EXTINCTION OF MEGAFUNA IN INTERIOR ALASKA-YUKON TERRITORY WITH THE ARRIVAL OF HUMANS

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The controversy about the latest mammoths and the first humans touches two of the major puzzles in prehistory: the causes of late Pleistocene extinctions and the timing of North American human colonization. A comparison of new dates for mammoths across the Mammoth Steppe reveals that dates for the first humans did overlap regionally with those of the last mammoths. This is particularly true in Alaska and the Yukon Territory (AK-YT), where sufficient dates on both mammoths and humans have recently reached a numerical threshold that provides distinct patterns across time. This mammoth-human overlap gives credence to the hypothesis that humans could have been involved with megafaunal extinction. However, the pattern of dates for AK-YT horses shows that some species became extinct well before human numbers reached archaeological visibility.

The pattern of new dates for mammoths and the other species in the northern megafauna, allows us to test some of the theories as to what forces had prevented human colonization of the far north prior to around 12-12.5 thousand radiocarbon years ago (ka). Though evidence is suggestive that some species of the megafauna were present but in reduced population numbers during LGM, their numbers increased dramatically in the period of 16-13 ka. If large mammal hunting opportunities had been the factor limiting human range expansion during and prior to the LGM, that is likely to have been remedied by 15 ka. Yet humans failed to move northward and take advantage of this higher game density. It would appear then that either climatic factors (wind, cold, rarity of trees and tall shrubs, and cover), or the rarity of supplemental

vertebrates, such as fish, birds, and mid-sized mammals, part of the familiar Holocene abundance, kept them from doing so.

Combining pollen and plant macrofossils, physical paleoclimatic data, and new dates on the megafauna we can construct a model that best accounts for the explosion of human numbers around 12 ka and thereafter, why it took them down the ice-free corridor, and how they managed to radiate rapidly south of the ice sheet.

MAMMOTH LANDSCAPES: GOOD COUNTRY FOR HUNTER-GATHERERS

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Proboscideans, because of their great size and unique behaviors, affect habitats in conspicuous ways. In landscapes where proboscideans live, many information-rich signs can be found that provide knowledge about animal health, individual and group movements, and demography, among other features. Dung deposits, trail networks, rubbing sites, and excavations in elephant country afford abundant environmental clues to prey health and density. Prehistoric human groups able to subsist by opportunistic exploitation of mammoths or mastodons could have taken advantage of such information to be efficient foragers and rapid dispersers into new ranges. In addition, proboscidean landscapes have potential (future) fossil deposits containing skeletons of many animal taxa, isolated bone elements, fractured and flaked bones and tusks, and plant parts preserved due to proboscidean behavior.

MAMMOTH (*Mammuthus*) WITHIN THE UPPER MISSOURI AND YELLOWSTONE BASINS, NORTH AMERICA: CHRONOLOGY, STRATIGRAPHY, AND PALEOECOLOGY

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Middle and Late Pleistocene Mammoth (*Mammuthus*) fossils are present in the intermountain valleys of the Rocky Mountains and on the northern Great Plains within the Missouri River and Yellowstone River drainages. The chronologic status of these finds has been determined by direct radiocarbon dating of faunal remains, as well as luminescence and K/Ar dating of stratigraphically related deposits. Ecological landscapes and taphonomic contexts include debris flow, paludal, swamp, lacustrine, fluvial, and aeolian settings.

Alluvial deposits below the Pre-Illinoian Lothair-Havre Till (correlated with oxygen isotope stages 16-18, and thus probably older than 600,000 years old) with *Mammuthus* are known from the Missouri River drainage near Havre, Montana. These deposits also contain *Equus* and *Camelops*. High terrace gravels (alluvium) along the Yellowstone

contain *Mammuthus columbi*. Associated fauna includes *Mammuthus americanus*, *Megalonyx jeffersonii*, *Paramylodon harlani*, *Equus*, *Camelops*, *Bootherium* (*Symbos*), and *Arctodus simus*. Stratigraphic and geomorphic relationships between these deposits and tephras indicate the gravels are Sangamon or Illinoian.

Luminescence and radiocarbon measurements appear to demonstrate the presence of a Late Pleistocene, pre-Last Glacial Maximum stratigraphic sequence in the headwater region of the Missouri River, in Centennial Valley. Paludal, lacustrine, fluvial, and debris flow depositional contexts all contain *Mammuthus*. Some of the mammoth remains can be referred to *Mammuthus columbi*, other fauna includes *Canis latrans*, *Canis lupus*, *Homotherium serum*, *Ursus*, *Equus*, *Camelops*, Cervidae, Antilocapridae, *Bison*, and *Castor*. On the Great Plains, *Mammuthus columbi* fossils from near Box Creek have also been radiocarbon dated to before the Last Glacial Maximum to ca. 33,280 radiocarbon years before present (RCYBP). Gravels forming one of the lower terraces along the Yellowstone River near Glendive contain *Mammuthus* dated to ca. 20,470 RCYBP.

Mammoths were present in some paleoecologic contexts associated with the Full Glacial to Late Glacial transition. In the drainage of the Sun River, a tributary of the Missouri situated along the eastern front of the Rocky Mountains, remains of mammoth have been discovered in swamp deposits. These deposits have been dated to about 11,500 RCYBP and indicate the presence of Rancholabrean fauna in this region after the melting of glaciers that originated in the mountains. Glaciofluvial deposits resulting from the melting of the continental ice sheet also contain remains of *Mammuthus*; for instance in the Saco area (north-central Montana) remains of *Mammuthus* are situated in outwash gravels. Upland areas within the Yellowstone River drainage also contain paleoecological information linked to the glacial to interglacial transition. For instance, remains of *Mammuthus columbi* radiocarbon dated to about 12,330 RCYBP are present within aeolian silts overlain by paleosols.

PALEOECOLOGY AND TAPHONOMY OF FULL GLACIAL MAXIMUM MAMMOTH LOCALITIES IN THE CENTRAL GREAT PLAINS OF NORTH AMERICA

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Five mammoth (*Mammuthus columbi*) localities on the Central Great Plains of North America are discussed, four excavated from Last Glacial Maximum (LGM) loess and one excavated from LGM fine-grained alluvial deposits. Paleoecological data is presented from studies of microfauna, phytoliths, gastropods, and geology. These data suggest a cool arid steppe ecosystem in place during the LGM. A detailed discussion of the taphonomy of one mammoth excavated from loess and one from fine-grained alluvium is presented. These mammoth skeletons exhibit numerous spirally-fractured limb elements. Hypotheses including carnivore activity, mammoth trampling, and human-induced fracturing, are evaluated as possible causes of the highly fractured limb bone. A sixth locality, previously excavated in the 1960s, yielded two nearly complete *Mammuthus columbi* male skeletons excavated from fine-grained alluvium. This locality

presents a taphonomic contrast to the other five localities because the limb bones do not exhibit the spiral fractures common on the other five mammoths.

THE TAPHONOMY OF MAMMOTH LOCALITIES IN SOUTHEASTERN WISCONSIN (USA)

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Four southeastern Wisconsin mammoth localities (Schaefer, Hebior, Mud Lake, Fenske), located within a glacial landscape, had well-preserved remains found in inter-morainal depressions filled with lacustrine clays covered with peat. Numerous radiocarbon ages dated the mammoths to the late Pleistocene and provide a time period of ca. 13,530 to 12,300 yr BP. The taphonomic analysis focused on determining the agency or agencies involved in site formation and the agency or agencies involved in modification to the bones. An objective was to evaluate human involvement in bone pile formation. Taphonomic variables were established and each element systematically examined and all marks categorized.

Both discrete and continuous data statistical approaches to bone orientation data underscore that water transport was not a factor in the formation of the bone beds nor was water movement a disturbance factor. The taphonomic profile of the overall assemblage is dominated by chemical weathering, followed by other chemical and microbiological processes. Root etching is the most common biological modification and the most frequent modifications are involved with the microenvironments of the surface to burial substrate. Cultural modification accounts for only a small portion of the cortical damage to the bones. This general profile indicates an assemblage far more influenced by the immediate environment than by passing animals or people.

The contrast between the general profile and individual locality profiles indicates that the range of variation appears to reflect differing microenvironments. This situation is underscored by results from an initial diagenetic analysis of two of the localities. Although the predominant hydrological regime has been one of saturation, the Hebior remains reveal that little microbial attack of any significance has occurred over the thousands of years of burial while the Schaefer remains significantly are less well preserved than those from Hebior. On the other hand, the frequency of subaerial weathering is considerably higher at Hebior than at Schaefer. Season of death and burial most likely was different between the two localities.

The frequency of carnivore modification in general was low but much greater than that seen at terminal Pleistocene localities on the grasslands. None of the bones were dynamically fractured. Human intervention was recognized based on the identification of incised (cutting) and pry (leverage) marks on the bones. Although people played a role in modifying the bones from all four localities and in disturbing the carcasses, the cause of death for all four mammoths was inconclusive. The localities as a whole were most affected by agencies acting after burial, meaning diagenetic processes.

MAMMOTH BONE TECHNOLOGY AND SUBSISTENCE STRATEGIES IN THE LATE PLEISTOCENE NORTH AMERICAN GRASSLANDS

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During the late Pleistocene, the North American grasslands stretched from the Basin of Mexico through the Great Plains and eastward. The extent of these grasslands and the resources they contained are significant aspects in examining the late Pleistocene peopling of the landscape and evidence for early occupations. The northernmost area of the grasslands is in southeastern Wisconsin, with a cluster of four mammoth localities. These localities are located within a glacial landscape and are found within lowlands between moraine ridges. Two of the localities date to ca. 13,470 and the other two to ca. 12,300 yr BP. Various marks found on the bones were caused by non-human agencies, but two mark types are identified as being involved with human carcass processing, specifically butchering activities involving disarticulation and defleshing tasks. The patterns formed by the cultural marks are the basis for interpreting different strategies in meat and fat acquisition, one involved with found carcasses (scavenging) and the other with fresh carcasses.

Two localities on the Southern High Plains of Texas represent a more central part of the vast grasslands. These localities are located within a non-glacial landscape that was formed through depositional and erosional processes. The Sand Creek locality is in lacustrine sediments from a paleo-lake basin, with a single date of ca. 13,450 yr BP. Human involvement with mammoth is identified based on the bone breakage pattern and interpreted as bone quarrying to secure long bone segments for other production purposes. The terminal Pleistocene occupation at Lubbock Lake is within a fluvial setting, on a gravel bar dated ca. 11,100 yr BP. Identified mark types and the pattern formed by the cultural marks indicate butchering activities oriented towards meat and fat acquisition from fresh mammoth carcasses. People also were engaged in bone quarrying of mammoth remains.

At the southern end of the grasslands, Tocuila is located in the Basin of Mexico, which lies within an active volcanic area. The locality is in a mud flow at the edge of one of the many shallow paleo-lakes within the main basin. A number of radiocarbon dates provide an average age of ca. 11,188 yr BP. Human involvement with mammoth is limited to bone breakage and interpreted as bone quarrying to produce cores for transport elsewhere. People were on the grasslands prior to the terminal Pleistocene and had developed strategies to obtain some of the resources represented by mammoth carcasses. These strategies, and in particular scavenging mammoth carcasses, appear to be part of a standard repertoire of strategies for late Pleistocene peoples for at least 2,500 years throughout the North American grasslands.

CHRONOLOGY AND CURRENT RESEARCH ON THE SCHAEFER MAMMOTH (*?Mammuthus primigenius*), KENOSHA COUNTY, WISCONSIN

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The Schaefer site in extreme southeastern Wisconsin was excavated in 1992 and 1993. Seventy-five percent of a Mammoth, *?Mammuthus primigenius*, the woolly mammoth (but being compared as well with *M. jeffersonii*, Jefferson's mammoth) was recovered. Analysis indicates that the animal was a male, Laws Group XXI or 36 years of age (African equivalent years) at death. Disarticulated elements were deposited in a dense concentration and soon covered with shallow water. In addition to the animal, drifted wood specimens and macrofossils were also recovered from the site.

Fourteen AMS-XAD Gelatin (KOH Collagen) radiocarbon assays on bone, cluster between 12,200 and 12,500 radiocarbon years BP. Additionally fourteen dates on wood specimens, intimately associated with the bone, yield a range of dates from 12,200 to 12,950 radiocarbon years BP firmly bracketing the mammoth bone dates.

Twenty specimens of wood have been identified as spruce (*Picea sp.*), spruce/tamarack (*Picea/Larix sp.*), or unidentified hardwood. Multiple pollen analyses indicate that the animal was deposited during the *Picea* maximum with little or no *Larix* being present. Additionally, macrofossils in the form of cones have been identified as Black Spruce (*Picea mariana*). These initial studies indicate a possible spruce dominated ecosystem associated with this particular mammoth. These preliminary data do not appear to support the traditional environment inferred for the woolly mammoth and support a need for study of the animal's attribution to species. This study is presently underway.

The remains themselves also exhibit multiple cut and wedge marks that are interpreted as being caused by stone tools. Non-diagnostic stone tools were found immediately below and in contact with the pelvis. A fully disarticulated bone pile deposited in a low energy environment also indicates human interaction in the Southwestern Lake Michigan Basin at this early date. Several additional lines of preliminary study by others are presented including the site specific geomorphic context, paleontological analysis, paleopathology, lithic analysis, amino acid racemization and the potential for DNA analysis. Future analysis on the Schaefer mammoth, other mammoths recovered in the area and the overall research potential of the area are also presented.

CONTEMPORARY MAMMALS OF *Mammuthus meridionalis* DURING THE LATE LOWER PLEISTOCENE IN EUROPE – THE DIVERSE EPIVILLAFRANCHIAN UNTERMASFELD FAUNA

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Mammuthus meridionalis, the descendent of less evolved European members of the mammoth evolutionary line originating from Africa, underwent several evolutionary steps during the period between 2.7 and 0.65 Ma BP. After a phase where local populations coexisted in Europe, their evolutionary levels differing remarkably (Lister and Sher 2001), *M. meridionalis* was finally replaced by *M. trogontherii*. Little is known about the evolutionary history of the genus *Mammuthus* and its accompanying fauna in Europe between 1.2 and 0.9 Ma BP (Epivillafranchian). Until now, the scarcity of finds and localities from this period has led to most late Lower Pleistocene Palaeartic faunal communities being interpreted as simple mixtures of “typical Villafranchian” (Upper Pliocene to earliest Pleistocene, 3.6-1.2 Ma B.P.) and “typical early Middle Pleistocene” (0.8-0.4 Ma BP) elements. However, the recovery of some 13,000 determinable vertebrate remains from the site of Untermassfeld (Thuringia, Germany) has provided the first opportunity to study a more complete faunal assemblage of corresponding age (Kahlke (ed.) 1997, 2001a, 2001b). The fossil material, comprising 101 taxa (including 44 mammal species), derives from high-flood sediments of fluvial origin that are stratigraphically positioned just above the base of the Jaramillo polarity subzone (OIS 31, earliest part of the European MNQ zone 20, approximately 1.05 Ma BP; Kahlke 2000).

The mammoth remains from Untermassfeld belong to an evolved form of *Mammuthus meridionalis* (MNI = 6; including the skull of an infant with dM^2 - dM^3 sin. et dex.). The evolutionary stage is characterized by the serial construction of the carpus and, in comparison to the population from the type locality of *M. trogontherii* (Süssenborn, Germany), lower crowned molars.

Bison menneri, the earliest true bison from Europe, is a common element of the accompanying fauna (MNI > 46; type locality). This long-legged and slender form replaced more ancient bovids of the genus *Leptobos* and members of the *Eobison* group in Europe. Based on a recent discovery, the Untermassfeld sediments preserve the first appearance of the early roe deer *Capreolus cusanoides* (MNI = 5, type locality), considered to be less evolved than the early Middle Pleistocene *C. suessenbornensis*. The moose *Alces carnutorum* (MNI = 4) is larger than the Middle and Upper Villafranchian (2.6-1.2 Ma BP) *A. gallicus*, but is lighter in build than the later, Holarctic-dispersed *A. latifrons*. The fallow deer sized *Cervus* s.l. *nestii vallonnetensis* (MNI > 47) is thought to be derived from a Villafranchian stock of Mediterranean origin. Early red deer are absent from the Untermassfeld fauna. Members of this group first appeared in Europe just below the Lower/Middle Pleistocene (=Matuyama/Brunhes) Boundary. The comb-antlered *Eucladoceros giulii* (MNI > 60) from Untermassfeld (type locality), and a few other European sites, represents the final, enlarged stage of another cervid evolutionary line that originated in the Upper Pliocene. According to cranial features, the very large Untermassfeld hippo *Hippopotamus amphibius antiquus* (MNI = 20) is more

evolved than the Upper Villafranchian type specimen (Upper Valdarno, Italy), but does not reach the evolutionary level of European early Middle Pleistocene forms. The well recorded rhino population from Untermassfeld (*Stephanorhinus etruscus*, MNI = 29) morphometrically links Southern European Upper Villafranchian forms with early Middle Pleistocene examples from Germany.

The jaguar, which is relatively abundant at Untermassfeld (MNI = 5), is assigned to the Epivillafranchian / early Middle Pleistocene chronosubspecies *Panthera onca gombaszoegensis*, not to the older "Tuscany Jaguars" (*P. onca toscana*). The large cheetah *Acinonyx pardinensis pleistocaenicus* (MNI = 1) from the site also differs from corresponding forms of the European Villafranchian. The discovery of an Old World puma (*Puma pardoides*; syn. *Viretailurus schaubi*, MNI = 1) initiated discussion on the Eurasian origin of the New World pumas. The dirk-toothed cat from Untermassfeld (MNI = 2), together with that from Venta Micena (Spain), is differentiated as a very evolved subspecies *Megantereon cultridens adroveri* from more ancient members of this species. The Untermassfeld fossil record represents the most recent occurrence of European dirk-toothed cats. The sympatric sabre-toothed cat *Homotherium crenatidens* (MNI = 3) is distinct from the Middle and Upper Pleistocene species *H. latidens*. The Untermassfeld bear population (*Ursus dolinensis*; syn. *U. rodei*, MNI = 9, type locality) is less evolved than that from the younger (latest Lower Pleistocene) European hominid site of Atapuerca / Gran Dolina (Spain; N. Garcia, personal communication 2002). The large canid *Canis (Xenocyon) lycaonoides* from Untermassfeld (MNI = 5) clearly differs from Eurasian forms of Upper Villafranchian age on the basis of dental features. The abundant remains of the medium-sized wolf *Canis lupus mosbachensis* (MNI = 18) can also be distinguished morphometrically from forms of Middle Villafranchian to older post-Villafranchian and early Middle Pleistocene ages.

The distinct evolutionary stages observed in many of the animal groups recorded from Untermassfeld, in combination with the unique assemblage of species discovered there (see Figure 1), contradicts the interpretation of European mammal faunas between 1.2 and 0.9 Ma BP in age as simple combinations of "older" (Villafranchian) and "younger" (early Middle Pleistocene) elements. In Europe during this period, evolved populations of *Mammuthus meridionalis* formed part of a characteristic Epivillafranchian animal life. The backdrop to the development of this faunal complex was a global period of forced climatic variability.

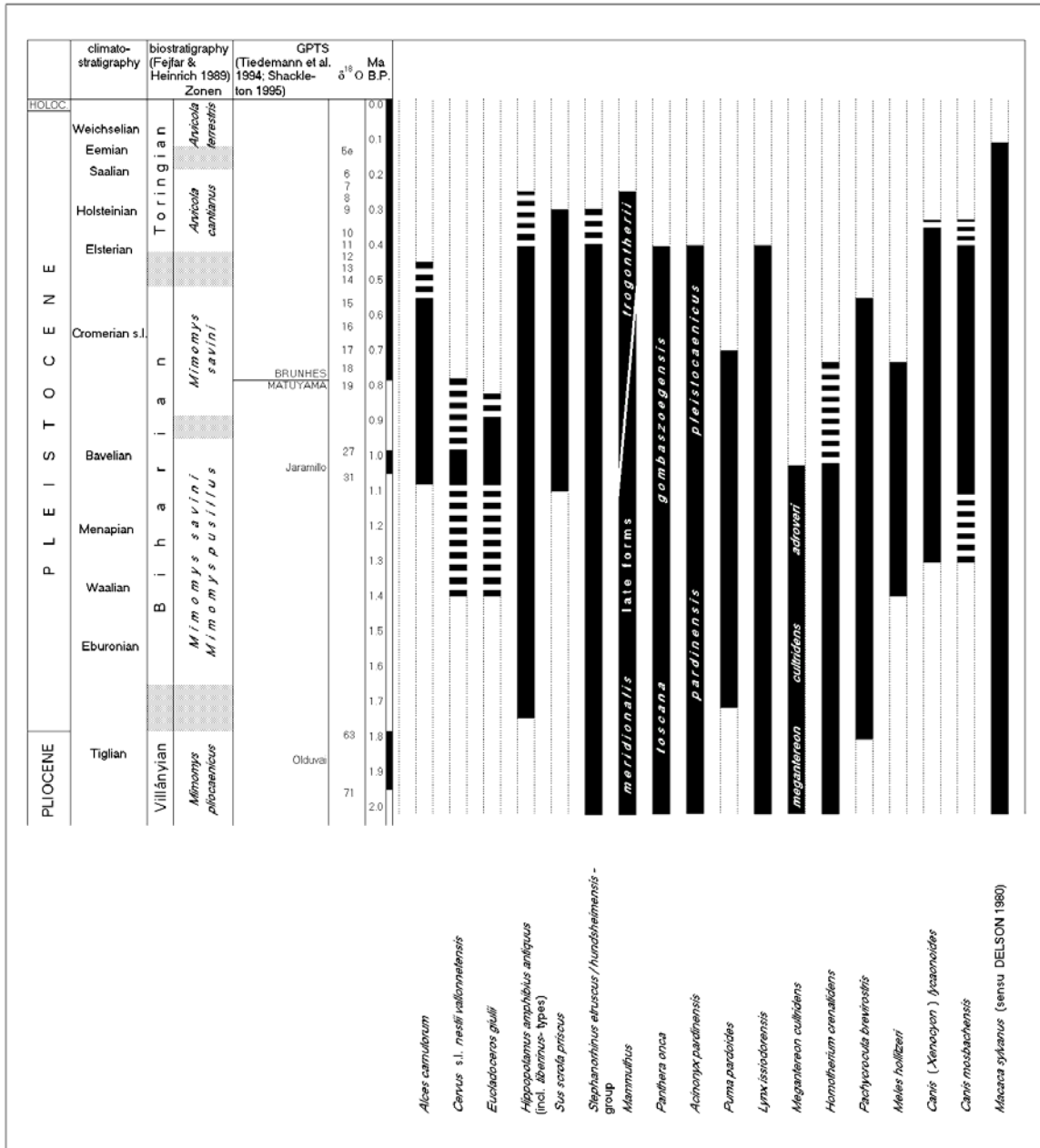


Figure 1: Biostratigraphic ranges of larger mammal taxa recorded at Untermassfeld in the European Plio/Pleistocene

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WHAT'S PRESENT IS PAST: MAMMOTH BEHAVIOR INTERPRETED THROUGH ACTUALISTIC STUDIES OF MODERN ELEPHANTS

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Long-term actualistic studies of wild elephant populations provide many clues to the ways extinct mammoths lived and died. Over the past 21 years, we have examined African elephant behavior in southern African protected areas including Hwange National Park, Zimbabwe, and noted the types of places where elephants die, the causes of death, and the variable taphonomic histories of bones. Over the 2 decades of study, patterns of future fossil deposits have begun to emerge, many very different from the earliest apparent patterns noted at the study's beginnings. We have used these analyses to interpret localities where the remains of mammoths have been found in groups or alone.

Behavior of extinct species is not only reflected in death sites, but is evident and obvious when other clues that are left behind are examined. For example, this poster will show how in modern elephant populations relatively high occurrences of broken tusk fragments in single localities may indicate a seasonally stressed population. Similar behaviors are also reflected in mammoth sites. Other features present in modern day, non-cultural sites include abundant spirally fractured bone, pseudo-"cut-marked" bones, and bone subtraction through numerous processes.

THE REPEATED REPLACEMENT OF *Mammuthus*- AND *Elephas* FAUNAS IN CENTRAL EUROPE

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During the Middle and Upper Pleistocene, two ecologically very different faunas occurred repeatedly in Central Europe. They are characterized by the proboscideans *Mammuthus primigenius* and *Elephas antiquus*, respectively. The multiple faunal exchange was caused by climatic oscillations which affected Central Europe more severely than most other parts of the world. This is due to the specific geographic position of Central Europe which led to a shift from a strongly continental climate during glacial periods to a more maritime climate during warm periods. Thus, very antithetic species like *Ovibos* and *Hippopotamus* were able to inhabit the same area, e.g., the Rhine valley, but at different times. A new model of repeated immigration and local extinction is presented. It focuses on the distinction between temporarily inhabited areas and core areas for the various species. The model sheds a new light on which geographic areas were crucial for the survival or the extinction of the Pleistocene mammals.

INSECTS AND GRAZING MAMMALS IN THE PLEISTOCENE OF NORTHEASTERN SIBERIA

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The environment that supported large herbivorous mammals, such as mammoth, horse, bison, and others in arctic Siberia in the Pleistocene is commonly called "tundra-steppe". The existence of the tundra-steppe landscape, which has no complete modern analogues, is proven by various fossils, including insects. Chances to be preserved as fossils are good for the insects with the most solid exoskeleton elements. Most common are fossils of coleopterans (beetles), but some remains of ants, hemipterans (true bugs), caddis-flies and flies can be preserved.

The composition of various fossil beetle assemblages shows certain regularities and is believed to reflect the relative abundance of species in the past and, eventually, to give some idea on the former occurrence of their preferred habitats and the proportion of those habitats in the landscape. The most typical feature of fossil insect assemblages of the tundra-steppe type is that they include species which do not occur together at present. Besides that, these assemblages often demonstrate uncommon proportions of the ecological groups of insects, which are not observed in the modern fauna. Each fossil assemblage usually includes more or less abundant remains of species currently widespread in northeastern Siberia. Many of them have very broad ranges covering several natural zones. Some species are now restricted to the tundra zone, but are very common there (*Chrysolina subsulcata*, *Tachinus arcticus*), while the others are currently

known from a few tundra areas, but were much more widespread in the Pleistocene (*Sitona borealis*, *Cholevinus sibiricus*, *Isochnus arcticus*). Among the species that are known in the modern fauna of northeastern Siberia, some are very common or even dominate the fossil assemblages, although their present distribution is limited to a few isolated areas, representing the remnants of the past much broader ranges (*Morychus viridis*, *Poecilus nearcticus*, *Phyllobius kolymensis*). On the other hand, tundra-steppe insect assemblages include some species which are currently distributed much further south (e.g., in the steppe zone) and are either not known in northeastern Siberia at present at all (e.g., *Stephanocleonus tricarinatus*), or occur there in narrow refugia, isolated from their main southern range, thus demonstrating discontinuous relict distribution. The latter group is quite large, and includes several species of weevils (*Stephanocleonus eruditus* and others), ground beetles and leaf beetles of steppe origin, having their main present ranges in southern Siberia and Mongolia, and surviving in scattered refugia in Central Yakutiya and the Yana-Indigirka-Kolyma upstreams. Finally, the tundra-steppe assemblages include some extinct species (a few weevils, a leaf beetle, and a dung beetle). The recent discoveries of these extinct species provide additional evidence of the peculiar character of the tundra-steppe insect fauna.

In accordance with the pollen spectra, picturing wide distribution of grass-herb vegetation, and with the general grazing character of fossil mammal fauna, insect assemblages of the tundra-steppe type include many species, related to grasses and herbaceous plants. Some beetles feed on grasses, like *Curtonotus alpinus*, a ground beetle, very common and often abundant in the Pleistocene. Several species are related to legumes (weevils *Sitona borealis*, *Hypera ornata* and others), many to *Artemisia*, crucifers, some to chenopods and caryophylls. Tundra-steppe assemblages also include species, related to shrubs, mostly willows (weevils *Lepyrus*, *Isochnus*, *Dorytomus*), or to trees, like weevils *Pissodes* living on larch, or some ants, often dwelling in tree trunks. Although shrub and tree insects (except willow weevils) are usually much less abundant than grass and herb species, they occur quite often. That shows a complex pattern of tundra-steppe vegetation.

Many insect species in tundra-steppe assemblages, like their host plants, prefer scattered vegetation communities of pioneering character. That is in agreement with the presence of many ruderal plants in plant macrofossil spectra (Kienast *et al.*, 2001; Schirrmeyer *et al.*, 2002) One of the best examples of this kind is a pill beetle *Morychus viridis*. It occurs in almost all Pleistocene assemblages, and sometimes is very abundant or even the absolute dominant. Currently it lives in floristically very impoverished biotopes, where the main plants are short-stem xerophilic sedges and some mosses. Well-drained in summer and almost snow-free in winter, these habitats are basically very dry, but subjected to a huge range of soil temperature variations. These plant communities are classified as hemicyphitic steppe (Yurtsev, 1981, Berman *et al.*, 2001) or "sedge heath"; they are a kind of pioneering community, and were a common element of the Pleistocene landscape.

In most cases, the high abundance of *Morychus viridis* is accompanied by the presence of true steppe species and is well correlated with a relatively high proportion of various xerophilic insects, indicating more diverse herbaceous vegetation, which is often confirmed by pollen spectra with an increasing proportion of various herb families. That allows us to assume that in tundra-steppe mosaic the sedge heath patches were associated with (or surrounded by) richer grass-herb communities, more productive for the mammalian grazers. The grazing by itself could, besides physical reasons,

contribute to the wide distribution of very low productive sedge heath, a consequence of trampling and selective consuming of more nutritious plants by mammals.

Insect species directly associated with large mammals, which are quite numerous in true (zonal) steppe, are surprisingly rare in tundra-steppe fossil assemblages. Dung beetles are represented by a few species of the genus *Aphodius*, and only one of them is common (most likely, an extinct species). Meanwhile, the dung beetles are one of the main groups of coleopterans in the true steppe. The tundra-steppe faunas include almost no carrion beetles. It seems likely that the main role in utilization of mammal metabolic products and their dead bodies belonged to dipterans (flies). There are many occurrences of fossil bones, such as mammoth mandibles, filled with fly puparia. It can be assumed that, along with the preservation effect of permafrost, the lack of carrion beetles and other necrophilous insects was one of the factors responsible for excellent preservation of mammalian fossils in northeastern Siberia.

The earliest known insect assemblages of the tundra-steppe type in northeastern Asia come from the Early Olyorian - the regional Land Mammal Age that started about 1.5 million years ago (Kiselev, 1981; Sher, 1986). Though peculiar for many extinct mammals, the Olyorian fauna was a typical grazing assemblage that existed in an open grass and herb dominated environment. Since at least that time, and through the whole Pleistocene, large mammals and tundra-steppe insect faunas coexisted in northeastern Siberia and actually were components of the same very peculiar biome. It is reasonable to assume that complex interactions and feedbacks between mammals, insects and vegetation existed in that biome, probably similar to those of the extant biomes of pasture type with diverse grazing mammals; these interactions and feedbacks are still to be understood in further detail. Although insects are more resistant to unfavorable environments, surviving in small refugia, the tundra-steppe insect fauna disappeared in the Early Holocene, very soon after the mass extinction of mammals and the collapse of the Pleistocene "mammoth" biome.

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INFLUENCE OF LATE QUATERNARY PALEOENVIRONMENTAL CONDITIONS ON THE DISTRIBUTION OF MAMMALS IN THE LAPTEV SEA REGION

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Understanding of the paleoenvironment is only possible through multidisciplinary studies of terrestrial deposits from the shelf land. Perennially frozen sediments along the Laptev Sea coast and New Siberian Islands contain various bioindicators of the past environment including mammal bones, fragments of insects, mollusk shells, remains of plant macrofossils, diatoms, pollen, ostracods etc. The study of these indicators, supplemented by ¹⁴C dating, provides excellent archives of past life and Pleistocene environmental conditions.

In the frame of the joint Russian-German "Lena Delta Expeditions" (1998-2002), carried out under the umbrella of the Russian-German cooperation "System Laptev Sea 2000", we investigated Late Pleistocene and Holocene deposits on the Laptev Sea coast, southwest coast of the East Siberian Sea and New Siberian Islands. Our collection of large mammal bones contains more than 3000 samples. It is unique because all bone findings were collected and registered, in contrast to former collections. Such an approach combined with radiocarbon dating of bone collagen (more than 300 dates) makes it possible to bring out some important aspects of date distribution of large animals in the studied area during the Late Quaternary. It is the first time that we have had such complete and well-dated material from the Arctic region.

A large part of the collection consists of *Mammuthus primigenius* bones (nearly 38%) and mammoth dates in our database are predominant (about 200 dates). The distribution of the bone ages is heterogeneous, especially for the mammoths. All dates may be divided into three groups. The first group consists of dates from ca 50 ka BP to 35-34 ka BP with a maximal number of dates around 40-38 ka BP. The second group (33 ka BP - 23-22 ka BP) has two periods with maximum numbers of dates: 33-32 ka BP and 25-24 ka BP. The last large number of dates belongs to the period from 15 ka BP to 9 ka BP with a maximum number of dates around 11-10 ka BP.

The distribution of radiocarbon dates probably reflects periodic changes in the size of mammal populations that was determined by alterations of environmental conditions. Increases in mammoth fossil bone numbers and their subsequent decreases indicate favorable and less favorable environmental conditions for woolly mammoths during periods of amelioration and deterioration of climate, fluctuations in the population size and/or migrations of the mammoth herds (Schirmer *et al.*, 2002). We have attempted to compare our “mammoth” periods with climatic periods by analysis of pollen remains.

The ca 50 ka BP - 35-34 ka BP period corresponds to the Middle Weichselian (Early Karginisky) Interstadial. It was the beginning of climatic warming, drainage of lakes and active development of ice complex formation on the Taymyr Peninsula (Siegert *et al.*, 1999). Pollen data from the southern Taymyr indicate the presence of open *Larix* forest with *Betula nana* and *Alnus fruticosa*. Pollen-based climate reconstruction shows that it was a rather warm and wet period with temperatures 0.5-1.5°C warmer and precipitation 25-75 mm higher than today (Andreev *et al.*, 2002b). On the contrary, pollen data from the Laptev Sea coast (Bykovsky Peninsula and Bol'shoy Lyakhovsky Island) indicate treeless vegetation and rather cold and dry climate (Andreev *et al.*, 2002a).

The second “mammoth” period (33 ka BP - 23-22 ka BP) is correlated with the Late Karginisky interval reflected in pollen records from the northern Taymyr Peninsula and Laptev Sea coast (Andreev *et al.*, 2002a, 2003). According to pollen spectra, open steppe-like herb communities dominated vegetation. Environmental conditions were rather severe (with temperatures 2-5°C colder and precipitation 50-100 mm lower than today).

The last “mammoth” period is from 15 ka BP to 9 ka BP with a maximum number of dates around 11-10 ka BP. The 11.5-10 ka BP interval is characterized by a rapid increase of warm and wet elements in pollen spectra. It can be interpreted as amelioration of climatic conditions (Andreev *et al.*, 2002a, b, 2003). The reconstructed temperatures were 1.5° warmer and precipitation was ca. 25 mm higher than today. It is also a period with the largest number of woolly mammoth dates during the Late Pleistocene. This may indicate that it was a period with the most favorable environmental conditions for the mammoths.

The period of the most unfavorable environmental conditions was probably between 22 ka BP and 15 ka BP as only a few dates from woolly mammoth bones were obtained (Kuznetsova *et al.*, 2001). It is interpreted as an extremely cold and dry period during the Late Pleistocene. The lack of mammoth dates for this period does not indicate the total absence of mammoths in the Laptev Sea region, but it reflects a relative decrease in their numbers.

Muskox and horse bone ages prove that these large grazing mammals lived during not only the Pleistocene and the Early Holocene, but also during the Late Holocene in the East Siberian Arctic. Three muskox dates between 3-2.7 ka BP from the Taymyr Peninsula (Sulerzhitsky and Romanenko, 1997) and two recently obtained dates (3200±40 and 3180±100 yr BP) from Bykovsky Peninsula reveal a wide muskox distribution in the Laptev Sea region during the Late Holocene. There are also two new horse Holocene dates: 4610±40 yr BP from the Bykovsky Peninsula and 2200±50 yr BP

from the Bol'shoy Lyakhovsky Island. This is in contrast to the previous opinion that wild horses had not lived during the Holocene in the Siberian Arctic.

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DISCOVERIES AND STUDY OF CARCASSES OF THE MAMMOTH FAUNA IN YAKUTIA

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Interest in research on soft tissues of mammoth and its companions - woolly rhinoceros, bison, horse, lion, and other representatives of the mammoth fauna - has been growing in several countries recently. Scientists in Germany, France, England, Canada, Japan and Russia have achieved great progress in this area of study. Yakutia is one of the main sources of well-preserved materials of fossil animals. Yakutian tissues sealed in permafrost show us a wonderful natural storeroom for preservation of carcasses of Pleistocene animals.

The Berelekh burial ground, situated on the bank of the Berelekh polar river flowing into the lower reaches of the Indigirka River, is a unique burial place. About 10 thousand bones belonging to 160 mammoths were excavated by our expedition in 1970. The remains of the Shandrinsky mammoth with internal organs were excavated from the bank of the Shandrin River in 1971. Fragments of the carcass of a two month old mammoth found in autumn, 1990, on the right bank of the Indigirka River at the Mylahchyn site was another wonderful discovery. There is not time to describe all the finds of these ancient animals, so I will simply list some of them. In 1968 the almost intact carcass of the Selericansky horse without its head was found along the higher reaches of the Indigirka River. Its absolute age was 37 thousand years. In 1981 the carcass of a horse that had died 26 thousand years ago was discovered on the shore of Ducarskoe Lake. In 1994-1995 the skin of a ten year old mammoth and the skin and part of the back leg of another mammoth were discovered on Big Lyahovsky Island. In 1997 the forefoot of a mammoth with its thick hair cover and a piece of mammoth skin were found on the bank of the Maksunuokha River. In 2002 two mammoth legs were excavated there.

Some specialists carry out molecular research aimed at tracing phylogenetic connections between the mammoth and African and Indian elephants (D. Haut, F.K. Zimmerman, U. Joger - Germany; T. Osava, S. Hayasi - Japan; V. Mihelson - Russia; H. Bocherens, A. Mariotti - France).

The goal of other scientists is to obtain well-preserved DNA from the cells of mammoth soft tissues and restore the species to life by cloning. Experimental molecular research has not yet given positive results.

Japanese scientists A. Iritani, H. Kato, K. Goto and Sh. Okutsu hope to produce a hybrid by fertilizing a female elephant with the sperm of a male mammoth, then approximate a mammoth as closely as possible through selective breeding. Japanese scientists consider that sperm is very stable, and they hope that it has preserved well in the permafrost.

In conclusion, I suggest that we set up an international project titled "Discoveries and Study of Carcasses of the Mammoth Fauna in Yakutia".

NEW FINDS OF MAMMOTH REMAINS IN YAKUTIA

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In summer, 1994 a local fisherman found part of a mammoth cranium with tusks and a front part of its leg thawing from the permafrost on the bank of the Maksunuokha River, which flows into Sellyakhskaya Bay of the Laptev Sea. Information about this find did not reach the Mammoth Museum in Yakutsk until 1997. A reconnaissance trip was made by helicopter to investigate the burial location. Following preliminary excavations a fragment of the mammoth front leg and forefoot with soft tissues and an exposed radius were extracted from the permafrost. A piece of skin 30 cm long was seen in the permafrost but large-scale excavations were impossible to do at that time. The excavations could be continued only in June, 2001, with the participation of the Moscow Paleontologic Institute. A considerable number of the mammoth's bones, a piece of its skin and another mammoth leg with soft tissues were found. It was decided to discontinue excavating the soft tissues until the next year, enlisting cooperation of a large number of workers with a portable pump. In August, 2002, the excavations were continued. The burial place could be opened completely with the portable pump, and a monolith weighing 150 kg with fragments of two frozen mammoth legs and 30 mammoth bone remains was removed from the permafrost. Thus, up to the present time the fragments of three mammoth legs with skin and muscles (obviously belonging to one individual) and about 160 mammoth bone remains (belonging to at least 5 individuals) have been found within a small section of a bank of the Maksunuokha River.

The accumulation of such a great number of mammoth remains on a small section of the riverbank, and discovery of only three partial limbs of mammoths with soft tissues, are mysterious. One possible explanation is presence of a natural trap (e.g. mud ravine) on the Maksunuokha riverbank, in which several mammoths were stuck in the late Pleistocene Karginian interglacial period. Perhaps only the lower parts of mammoth legs belonging to one individual frozen after death (perhaps death occurred in autumn) have been preserved. Another potential explanation is that the upper Paleolithic man could have created the mammoth cemetery.

THE NEW PROSPECTS OF ORGANIZATION OF THE PALEONTOLOGIC EXPEDITIONS TO THE NORTH OF YAKUTIA

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Dozens of valuable finds of fossil animals have been discovered in Russia as a result of systematic paleontological researches carried out in the last twenty years. The Magadan region, the Taimyr and Yamal peninsulas and especially Yakutia are rich in finds where both bone and carcass remains of representatives of the mammoth fauna are well

preserved due to permafrost. The most intensive and fruitful searches were carried out starting in 1948, after establishment of the Mammoth Committee under the Zoological Institute of the Academy of Sciences of USSR. A large number of expeditions were launched and many bone and carcass remains of mammoths and other Pleistocene fossil animals were found during that time.

At the beginning of the 1990s the situation changed radically. The number of transport vehicles, especially helicopters, was drastically reduced, fuel became expensive, and many meteorological, hydrologic and polar stations were closed. At present the organization of expeditions to the Novosibirsky islands and the Arctic coast has become very expensive. There are difficulties in chartering helicopters, ships, and cross-country vehicles because they are not available in the proposed study areas. Less information about new finds comes to scientists, and local authorities cannot support expeditions because of financial difficulties.

To overcome all these problems and continue search and reconnaissance efforts at their previous level, the Yakutian Public Fund for the development of mammoth research was created in 2002 under the Mammoth Museum of the Institute of Applied Ecology of the North, of the Academy of Sciences of the Sakha Republic (Yakutia). During its first year this Fund organized the work of five paleontological expeditions and one international field party on the Maksunuokha River, on the bank of which two well preserved mammoth legs were excavated. The Fund has worked out a program to create a net of permanent scientific bases operating in summer, situated in districts which are quite rich in mammoth localities, to bring about the consistent presence of paleontologists in places where valuable finds are most likely to be made. The Novosibirsky islands, the Arctic coast in Yakutia, and the basins of the Indigirka and Yana Rivers are the most promising areas in this respect. Working at the bases that operate each summer, equipped with modern means of communication, the field parties can investigate vast territories using motorships and bogships. When information about a new find is received from any nearby base, researchers will be sent to check up, and if the information is confirmed, excavation operations will be organized quickly and the find will be transported to the nearest large settlement. Foreign scientific researchers and institutions can take part in these expeditions and in further paleontologic and microbiologic studies. Participation in such projects can be arranged through establishment of a contract with the Institute of Applied Ecology of The North and the Yakutian Public Fund for the development of mammoth research.

KOCHEGUR, A NEW LOCALITY FOR MAMMOTH REMAINS IN THE SHESTAKOVO BEAST SOLONETZ DISTRICT (WESTERN SIBERIA)

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In the latter part of the 20th century a new locality type for fossil mammalian remains was discovered by a group of scientists from Tomsk, Novosibirsk and Moscow. This locality

represents burials of animal remains in the beast solonetz* (Leshchinskiy, 1998, 2001a, b; Derevianko *et al.*, 2000). It was established that the richest localities of mammoth remains (*Mammuthus primigenius*) in Western Siberia (Shestakovo in the Kemerovo region and Volchya Griva in Novosibirsk region) were preserved in the beast solonetz of the Late Pleistocene.

In July, 2002, a new locality for mammoth remains, Kochegur, was discovered 3.5 km northeast of the Shestakovo locality. Numerous bone and tooth fragments were preserved within the deposits of the upper part of the section on the right bank of the Kiya River, at a height of about 80 m above the water line. Preliminary excavations were carried out to establish the species composition, stratigraphic position and taphonomy of faunal remains over the area of ~ 6 m². More than one hundred fragments of bones and teeth were detected belonging to at least three *M. primigenius* individuals aged fifteen to thirty years. Most of the fossil remains occurred at a depth of 0.55 to 1.3 m within the bottom of the gray-brown loess-like loam (up to 0.55 m thick). Within the bottom of the bed there was, along with fossil remains, a great quantity of gravel and pebbles (occasionally boulders up to 0.3 m in size), as well as much gruss and rock debris derived from underlying Cretaceous deposits. This coarse material establishes the eolian-talus genesis of the deposits. Loam pinches out at the edge of the outcrop, and bones are embedded immediately under the Holocene black earth (0.5 - 0.8 m thick) and are occasionally intercalated into it. Subjacent to the bone-bearing horizon is pinkish-brown talus loam (1.5 - 1.7 m thick) of presumably Late Pleistocene age. Lower Cretaceous clays and silts underlie these latter deposits disconformably. Thus, the whole Quaternary section does not exceed 3 m at the survey point.

The sedimentation conditions have caused the absence of skeletal fragments from certain anatomical positions, as well as the profound fragmentation of bones. Only a scapula, half of a pelvis, several ribs, an atlas, two mandibles and teeth were relatively intact. The rest of the bones were represented by both small (up to 1 cm) and large fragments (up to 60 cm). Both fossil remains and coarse detritus are concentrated within the linearly elongated depression to which they might have been carried by gravitational processes intensified by rainfall and snowmelt runoff. Thus, the bone-bearing horizon represents a lens more than 3.5 m in length, 2.5 m in width and up to 0.4 m thick.

The palynological analysis of rocks contained in the inner cavities of mandibles and teeth demonstrated the prevalence (93.7%) of moss spores of the Bryidae subclass. The percentage of arboreal vegetation represented by the pollen *Pinus* sp. (6 grains) and *Betula* sp. (12 grains) comes to 1.57%. Of herbage, *Artemisia* sp. (11 grains; 0.99%) and Chenopodiaceae (2 grains; 0.18%) were detected. Among the angiosperms, indeterminate (underdeveloped?) tricolpate pollen makes up the greatest portion (3.22%) of the whole spectrum composition. In addition, unicellular algaoids, fungal fruit bodies and hyphae presumed to be lichen components are abundant. The overall quantity of miospores in four preparations is 1116. The severe deformation and mineralization of pollen, and its small quantity, probably result from unfavorable conditions of fossilization. But they could equally reflect unfavorable environments and

* The "beast solonetz" is a term accepted in Russia for a ground surface site containing a great quantity of certain macro- and microelements. It denotes a zoogeological unit, in distinction to solonetz as a pedological designation. Animals came to a beast solonetz to eat soil and rock, and to drink mineralized water from springs, in order to maintain their water-salt balance and make up a deficiency of minerals in their tissues.

the real relationship within the plant community in the severe climate of the Sartan cooling. The qualitative composition of the miospores and their position in the palynospectrum document the existence of an open landscape with an overmoistened surface. The plant cover was not closed at the formation of the bone-bearing horizon and consisted of predominantly mosses and lichens which were capable for growing on different substrates including clayey rocks, animals' putrefied corpses and excrement.

The conditions of burial of mammoth remains, geology and relief of the Kochegur locality completely meet the criteria for the beast solonetz which were ascertained at the key locality Shestakovo, whose absolute age falls in the range 26 - 18 thousand years. The C14 dating of the tusk from the Kochegur locality also agrees with this time: 18580 ± 240 years (SOAN -4945). Consequently, it is valid to say that during this time interval a minimum of two beast solonetz groups existed in the Shestakovo district where mass gathering of animals, principally mammoths, occurred when the animals' mineral deficiency was most severe. The death percentage and burial conditions are presumed to have been sufficient for the formation of bone-bearing horizons at the localities. Of Late Pleistocene mammals, mammoths seem to suffer from mineral deficiency most of all. Mammoths needed chemical elements the most, especially Ca, Mg, and Na, on account of their huge skeletons. The lower Cretaceous bedrock was much richer in these elements than adjacent landscapes.

Destructive (osteoporotic?) changes in mammoth bone tissues, detected in numerous specimens from the Kochegur locality, are unique evidence for metabolic disturbance due to mineral deficiency. Rounded hollows (up to 5 cm in diameter) were recorded mainly in the bones. These hollows were formed both in compact and in cancellous bone tissues (Figure 1), and they are both closed and opened even inward toward the marrow cavity of long bones (Figure 2). Destructive growth along the margins of glenoid surfaces, osteomalacia of spinous processes of thoracic vertebrae, transverse fractures of ribs accompanied with callus formation, and other afflictions were also very pronounced. As a whole, the degeneration processes affected not less than 50% of determinable bones (humerus, scapula, pelvis, mandibles, ribs and vertebrae), and these can result only from endemic disease. Probably, the deficit of Ca was responsible for the homeostasis disorder as is characteristic in modern instances of the spread of Urov (Kashin-Beck) disease.

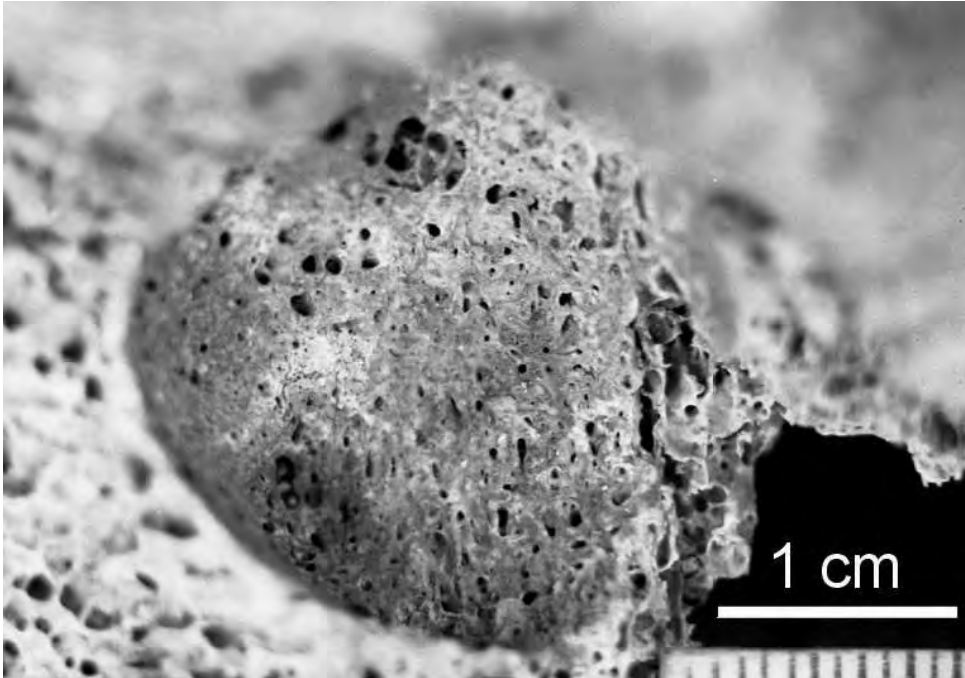


Figure 1. Destructive change in the scapula of *Mammuthus primigenius*.

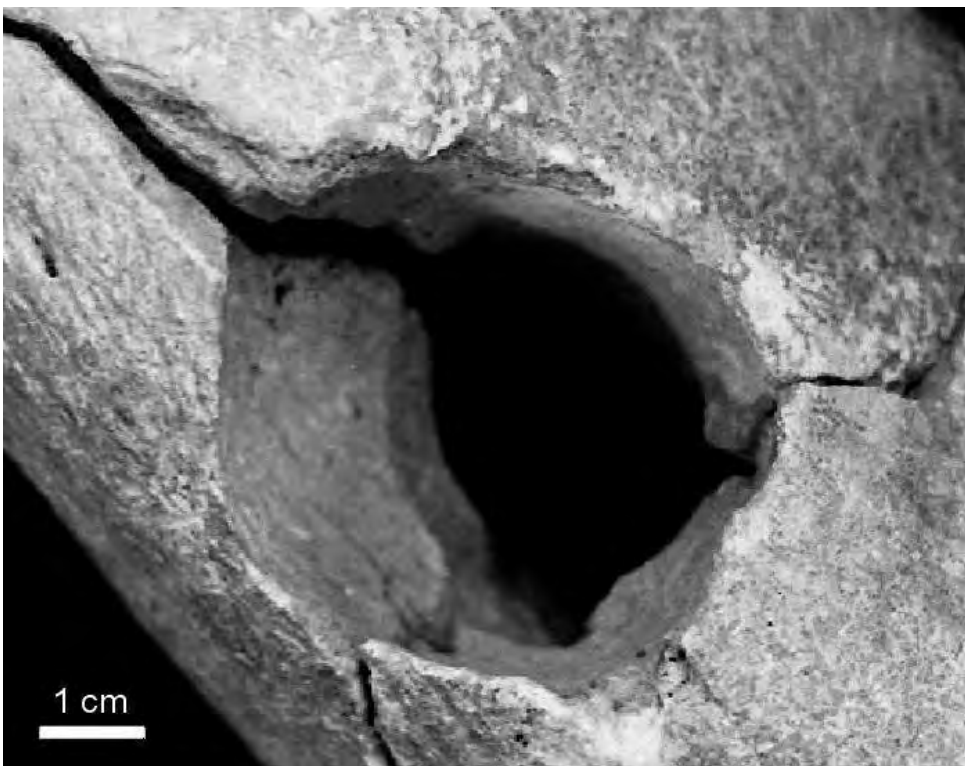


Figure 2. Destructive change in the humerus of *Mammuthus primigenius*.

These reported cases of osteodystrophy prove the reality of endemic diseases of mammoths during the Sartan cooling. This can be considered as the main reason for the extinction of Siberian megafauna in the Pleistocene/Holocene boundary.

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THE EARLIEST MAMMOTHS IN EUROPE

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Dental remains of elephantids, provisionally referred to the *Mammuthus* lineage, are first recorded with certainty from Europe in the Middle Pliocene, ca. 3.5-2.5 Ma, especially from the Dacic Basin of Rumania, the Red Crag Formation of England, and the Montopoli Faunal Unit of Italy. These remains are distinctly more primitive than those of *Mammuthus meridionalis*, and can be referred to the species *Mammuthus rumanus* (Stefăneşcu). The species '*Mammuthus gromovi*' (Alexeeva and Garutt), from the Khapry Complex of Russia, is both chronologically younger and morphologically more advanced than *M. rumanus*, and in its dental morphology at least, does not differ substantially from typical *M. meridionalis*. Further work on the crania of these forms is required, however. Dental remains from various other European localities, which have previously been regarded as very early or primitive forms of mammoth, are reviewed; most are found wanting in either morphological completeness, geological context, or both. A molar from Cernăteşti, Rumania, is proposed as the neotype of *M. rumanus*.

WAS *Mammuthus intermedius* PRESENT IN THE PLEISTOCENE SITE OF HANHOFFEN (BAS-RHIN, FRANCE)?

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The gravel pits of Hanhoffen, located on a Quaternary terrace of the Rhine Valley, in Alsace in Eastern France, have produced large Elephantidae remains resulting from a mortality of natural origin. Very detailed measurements of each molar of mammoth allowed us to determine the species to which the animal belonged. The molars of these very large herbivores show the evolving tendency of the mammoth lineage, a reduction of the enamel thickness accompanied by an increased lamellar frequency. The main data we will take into account in this work are the lamellar frequency index (F) and the enamel thickness of the ridges (e). In Hanhoffen were present *Mammuthus trogontherii*, *Mammuthus primigenius*, and an intermediate form of mammoth whose molars seem to combine the morphological and biometric characteristics of the two previous species. Several hypotheses will be taken into account in this work. The first possibility is that the intermediate form is an advanced form of *M. trogontherii*. The second hypothesis considers that it is an archaic form of *M. primigenius*. Finally, the last hypothesis considers that this form corresponds to *Mammuthus intermedius*, the intermediate species.

PRESERVED WOOLY MAMMOTHS (*Mammuthus primigenius*) AND ASSOCIATED PALYNOLOGICAL SPECTRA FROM NORTHEAST SIBERIA

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Northeast Siberia is a region well known for its finds of bones and tusks from late Pleistocene megafauna. However, the frozen unconsolidated sediments of the Northeast have also preserved soft tissues of woolly mammoths (*Mammuthus primigenius*). These important discoveries include a leg from the Indigirka lowland (radiocarbon dated to $13,700 \pm 80$, MAG-114; all dates herein are from the mammoth remains proper), a right leg from the Kolyma lowland ($32,810 \pm 720$, MAG1001A; $32,890 \pm 200$, MAG1001B), and a complete body of a baby mammoth found in the upper Kolyma basin (five dates ranging from $38,590 \pm 850$, LU-718A, to $41,000 \pm 1,100$, MAG-366B). These remains fall within the late Sartanski stade and the mid-Karginiski interstade, and the associated palynological data indicate the animals lived in a variety of environments.

The Indigirka mammoth ($70^{\circ} 35' N$, $145^{\circ} 00' E$) was found in association with a 2-m-thick bone bed (commonly known as the Berelyekh graveyard site containing $> 8,400$ bones) exposed in a cut-bank of the Berelyekh River (Lozhkin, 1977, 1998; Vereshchagin,

1977). The leg had well-preserved muscles, skin and fur. The bone bed is overlain by a paleosol and underlain by alluvium. Palynological analysis of the “mammoth” horizon indicates an abundance of Poaceae pollen with moderate but significant percentages of *Artemisia*, *Betula*, and *Alnus* pollen and green moss (Bryales, *Sphagnum*) spores. The late stadial vegetation is inferred to be a Poaceae-*Betula*-*Salix* tundra with local xeric habitats.

The second mammoth leg (68° 10' N, 165° 56' E), known as the Enmynveem mammoth, was discovered during a mining operation along the Enmynveem River, Malyi Anyui basin (Lozhkin *et al.*, 1988; Anderson *et al.*, 2002). The leg was discovered in a colluvial silt that underlies an early Holocene peat. Palynological data obtained from the mammoth fur and attached silt yielded high percentages of Poaceae and *Artemisia* pollen and spores of *Selaginella rupestris* and Bryales. Shrub taxa have low percentages (<10%), with *Salix* dominating. The Karginiski landscape supported *Salix*-herb tundra, perhaps approximating modern vegetation bordering the East Siberian Sea.

The most famous find is the Kirgilyakh or baby Dima mammoth (62° 40' N, 147° 59' E), which also was exposed during mining operations along the Kirgilyakh Stream. Dima is a virtually complete specimen, and extensive anatomical and geomorphological analyses are reported in Shilo *et al.* (1983). The site consists of three colluvium-covered river terraces. Although Dima was discovered on the second terrace, fragments of fur remaining in the third terrace suggest this was the point of original deposition. Evidently, the body was encapsulated in ice and moved from the third to the lower second terrace through solifluction. The baby mammoth likely became mired in a pool and drowned, as evidenced by silts found in his lungs. Palynological samples were taken from the stomach, intestines, and the surrounding silt (Lozhkin *et al.*, 2002). Herb pollen (60-78% total pollen and spores), particularly Poaceae and Cyperaceae, dominated the samples from the digestive tract. Arboreal taxa (14-27%) are predominantly from *Betula* and *Salix*, but with a minor, consistent presence of *Larix*. Macrofossils preserved in the stomach and intestines represent arctic and subarctic taxa, including *Pleurozium* and other Bryales spp., *Selaginella rupestris*, *Carex* spp., *Ranunculus* spp., *Potentilla*, *Mnium affine*, *Aulacomnium*, *Rumex acetosella*, and numerous fungi. Palynological samples taken from the third terrace, with radiocarbon dates similar to those from the mammoth, are comparable to modern and mid-Holocene assemblages from this region. Unlike the spectra from the digestive tract, the terrace samples include abundant *Pinus pumila* pollen. The vegetation was certainly forested, perhaps with *Larix* restricted to favorable valley sites. While *Betula* and *Alnus* shrubs were clearly an important element of the vegetation, the contradictory *Pinus pumila* results make inferences about its presence or abundance difficult.

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THE WRANGEL DATE GAP AND OTHER EVIDENCE OF WIDESPREAD MEGAFUNAL COLLAPSE IN NORTHERN ASIA DURING THE EARLY HOLOCENE

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What is the significance of the large gap, ~12,000 to 7700 BP, in the ¹⁴C record of Wrangel Island *Mammuthus primigenius*? Did elephants actually disappear from the island during this interval? And what happened to the rest of the high Arctic megafauna at this time?

Although the use of chronometric records to determine extinction times is often confounded by sampling inadequacies, Signor-Lipps effects, and other problems, in this case ¹⁴C date distributions are consistent with the argument that large mammals may have virtually disappeared from northernmost Asia for a time during and immediately after the Pleistocene/ Holocene transition (PHT).

These date distributions help not only to constrain extinctions - long linked notionally with the PHT - but also to identify major local population crashes (extirpations) among those

megafaunal species that did not become extinct at this time. Among possible sequelae of the megafaunal collapse are the following:

1. In some cases catastrophe was followed by recovery, with abandoned ranges eventually being restocked from populations hypothesized to have persisted elsewhere.
2. Among megafaunal species known to have survived into the Holocene, mammoths made a very limited recovery, repopulating Wrangel Island (?from the mainland) during the period ~7700 to 3700 BP only. Woolly rhinos (*Coelodonta antiquitatis*; "last" occurrence, ~11,000 BP) and steppe bison (*Bison priscus*; "last" occurrence, 8800 BP) evidently did not recover at all.
3. Of great interest is the pattern seen in ^{14}C records for muskox (*Ovibos moschatus*) and horse (*Equus cf. caballus*). Both disappeared from the high Arctic during or just after the PHT, then reappeared almost simultaneously shortly after 4000 BP. By 2000 BP, muskox were extinct in Eurasia; horses survived.

Although aspects of this pattern (PreBoreal disappearance, late Hypsithermal reappearance) correlate well with climate change, the role of factors such as overhunting and emerging infectious diseases ought to be considered as well.

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INDIVIDUAL DEVELOPMENT AND BIOLOGY OF THE WOOLLY MAMMOTH (*Mammuthus primigenius* BLUMENBACH, 1799)

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Unique materials comprising 5 complete skeletons of Late Pleistocene mammoth calves of different individual ages (from newborn to 6-7 years) and partial skeletons of adults from the Sevsk Locality, Bryansk Region (geological age by ^{14}C is 13950 ± 70) made it possible to study early stages of the ontogenesis of the woolly mammoth (*Mammuthus primigenius*). The data on these skeletons are of special importance. The Sevsk Locality preserves the remains of a family group or several family groups that appear to be close relatives (Maschenko, 2002). The death of 33-34 mammoths buried here occurred simultaneously as a result of a flood (Maschenko, 1992). Before the discovery of the Sevsk Locality, availability of family groups or male groups in the representatives of genus *Mammuthus* had remained hypothetical (Agenbroad, 1990; The Hot Springs Mammoth Site, 1995).

Earlier hypotheses on similarity of physiology and biology in recent elephants (*Loxodonta africana*, *Elephas maximus*) and woolly mammoth have been supported by the materials from the Sevsk Locality (Haynes, 1991). The differences between recent elephants and *M. primigenius*, as well as between *M. primigenius* and other representatives of the group of mammoth-like elephants, stem from the unique specialization of mammoths to the conditions of cold seasonal climate. No other representative of mammoth-like elephants has reached specialization of the kind seen in genus *Mammuthus* (according to the author, in Eurasia this genus comprises only *M. trogontherii* and *M. primigenius* and their subspecies). The specialization of *M. primigenius* is expressed in the ontogenesis of this species. Some ontogenetic peculiarities should be included into the diagnosis of genus *Mammuthus*. Earlier eruption and quick change of dp2, dp3 and dp4 generations, as well as di and I is observed in *M. primigenius*. As a result, in the upper and lower jaws up to 3 generations of teeth may be functional simultaneously. Simultaneous formation of all the dp2 plates in comparison with ordinal (from the anterior edge of the crown to the posterior) formation of all other generations teeth is indicative, first, of early specialization of dentition in Elephantidae, and second, possibly is an index of a deciduous generation. In the skull, from median side to the lateral, alveoli of the rudimentary tusk, I and di are situated. The di alveola is formed only by the premaxillary bone, and the I alveola is formed by premaxilla and maxilla. These differences in the alveolar morphology and reciprocal situation of the tusks suggest that the rudimentary tusk and di are deciduous incisors, possibly di¹ and di². I is the permanent incisor I³.

Hypsodonty and larger number of plates forming the tooth are compensatory for feeding exclusively on withered vegetation during the long winter. This character is most strongly expressed in *M. primigenius* and exhausts the inadaptive potential of this group. Ontogenesis in *M. primigenius* is subdivided into three stages reflecting deep adaptations of this species: from prenatal to one year of postnatal development, from one year of age to 6 - 7 years and from 6 - 7 years to the end of lifetime. Similar subdivisions of the ontogenesis are typical of different species of recent mammals. Changes in speed of growth and formation of the skull and post-cranial bones suggest that in mammoth rapid growth and substantial morphological and physiological transformations decline by 6-7 years, and the mammoth cows are mature at 7-8. In mammoth bulls the puberty period is longer, up to 13-15 years. Growth dynamics show that at 17 years of age females grow by one order slower than in childhood (1 to 6 years). By 30, mammoth cows stop growing (the stage of functional M2). Mammoth bulls after 17 -18 years continue to grow rather fast and growth becomes slow to the same degree as in mammoth cows only after 35. Relatively earlier maturation of *M. primigenius* in comparison with recent elephants is combined with faster growth of the calves during the first year of their life: approximately 25-30% faster than the calves of recent elephants.

These features show that, on the one hand, mammoths were influenced by similar selection factors as recent elephants. On the other, earlier maturation and faster growth of calves are due to the survival strategy of mammoths in the conditions of cold seasonal climate of the Late Pleistocene.

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ZARAYSK LATE PALAEOLITHIC SITE: MAMMOTH ASSEMBLAGE, AGE PROFILE AND TAPHONOMY

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The open-air Upper Paleolithic site of Zaraysk is located in the center of the town of that name, about 155 km south of Moscow. Intensive research at the site has been carried out by the Zaraysk archaeological expedition of the Institute of Archaeology of the Russian Academy of Sciences (the expedition leader is Prof. H. Amirkhanov). After 12 seasons of excavation, an area of 265 m² has been fully investigated in the center of the site and along its edges. About 140 m² of this area are included in excavation No. 4, the principal zone of investigation. The area which has been investigated so far constitutes only a small part of the site's total area of cultural deposits. In terms of stone tool inventory and typology, the characteristic cultural features in the occupation layers (a variety of pits, hearths, etc), and the structure and design of the settlement-units in the complex (at least in the part presently known to us), Zaraysk shows closest similarity to sites of the Kostenki culture. The Zaraysk site is the northernmost known occurrence of the Kostenki-Avdeevo archaeological culture (Gravettian tradition) on the Russian Plain. More than 20 radiocarbon dates (¹⁴C dates - 23 000 ± 400(GIN 8397a); 17 900 ± 200(GIN 8865); etc.) have been produced from the site. An outstanding art object from Zaraysk, discovered during the excavations of 2001, is a figurine of a bison made from mammoth ivory. It represents the artistic expressiveness of the created object, a high level of expertise and naturalism, but it is also very notable for its size (16 cm long) and, no less important, the fact that it has a stratified context.

The complex stratigraphic context reflects that populations of the same culture occupied the site several times. Four levels of inhabitation are recognized at this site. It is possible to correlate the majority of significant features (pits, hearths, etc.) with those occupation levels. Frost cracks of two generations are also good indicators in objects' interstratifications. Sometimes these cracks destroy artificial objects (pits, etc.), but in some cases the cracks have also been used and even modified for different economic purposes.

The data on mammoth assemblages collected from excavations made in 2001-2002 (40 m²) is introduced. This excavated area is characterized by presence of objects of all levels of inhabitation including storage pits, hearths and other constructions (dwellings?) forming their separate spatial structure within each level of inhabitation. There are 22 deeper features including 2 hearths, 16 different pits and 4 large pits, and some of them probably could be interpreted as dwellings. One large pit (depression) about 8 m² is identified as a dwelling. Its cultural layer, about 30 cm, contains stone artifacts and also many mammoth remains including 14 lower jaws, several skulls, scapulas, long bones, tusks, etc.

The list of species found on the site includes: *Citellus* sp., *Marmota* sp., Muridae gen. indet., *Canis lupus*, *Alopex lagopus*, *Gulo gulo*, *Mammuthus primigenius*, *Rangifer tarandus*, and (?) *Bison priscus*. In 2002 on the bottom of an earth-dwelling a milk incisor of *Homo sapiens* was found. Remains of mammoth (*Mammuthus primigenius* Blum., 1799) are most common and comprise 98% of the total number of mammal bones which are present at the site (Table 1). Such prevalence of mammoth remains shows its importance for ancient inhabitants. A variety of bone artifacts produced mainly of mammoth bone and ivory affirm the picture regarding utilization of bones in economic activity. But the question of how such a large quantity of bones appeared at the site – as a result of man's hunting or transporting remains from a natural bone-bearing locality – is still open. The spatial distribution of mammoth remains in the site is extremely uneven. Some reasons for bone utilization could be their use in construction, for firing ceramics, and as a raw material for producing tools and art objects. True evidence of mammoth hunting has still not been discovered at the Zaraysk site. The character of the mammoth remains and their spatial distribution on the site indicate that they were used mainly for construction of dwellings.

Remains are: skulls - 9 (7.08 % of total number of bones), lower jaws - 16 (12.6 %), scapulas - 4 (3.14 %), long bones - 7 (3.13 %), isolated teeth - 36 (23.6 %), tusks - 14 (11.02 %), the bones of distal parts of the legs - 5 (3.93 %), and ribs - 9 (7.08 %) (Table 1). Counting by the upper and lower teeth and lower jaws, the minimum number of individuals is about 25. Only adult mammoths were found at the site (Table 2). The following age groups are indicated: 6-8 years – 3 (?); 12-20 years – 5; older that 30-35 years – 16-17. Bones of juvenile and subadult individuals are absent. Massive parts of the mammoth skeleton (skulls, jaws, tusks) predominate. There are also many finds of individual teeth. Restored lengths of preserved humeri with fusion of epiphyses are 104, 87 and 77 cm. According to this data skeletal height of the largest individual was 3.09 m (mammoth bull), and a smaller one was 2.43 m tall (mammoth cow?). These characteristics correspond to size variation in the mammoth population during the Late Pleistocene. Large diameters of tusks such as 17-20 cm are the maximum values for the species *Mammuthus primigenius*. The age profile of Zaraysk mammoths shows selectivity in mammoths preserved in this excavated area – only adult individuals were found. In addition, parts of the mammoth skeleton preserved at Zaraysk do not have

much nutritive value. An absence of butchering traces could also indicate the gathering of remains at a natural bone-bearing locality somewhere near the site. Though archaeozoologic data is not rich enough to be conclusive, the last hypothesis is the most likely. Tooth morphology of Zaraysk mammoths indicates a homogeneous mammoth population at all levels of habitation. Morphological analysis of teeth dp4-M3 (Table 3) shows their homogeneous composition for all stratigraphical layers (chronological stages), suggesting the existence of a homogeneous mammoth population throughout this period. The main morphological characteristics of teeth correspond to those in samples of *M. primigenius* from the Late Pleistocene of Central Russia. Thickness of enamel for M3/m3 is 1.6-1.8/1.2-2.1 and frequency of plates per 10 cm is 11(?) -12. Morphological comparison of mammoth teeth from Zaraysk and Kostenki I, (layer 1) (Table 3) shows no significant differences. The reason for such close similarity could be the existence of a common area of mammoth population in Central Russia during the period 17 000-23 000 BP. Analysis and comparison of faunal data from the whole area of the site is the key element in solving the problems regarding hunting activities of ancient inhabitants and reconstruction of their economic characteristics.

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Table 1. Number and composition of mammoth bones from Zaraysk Site (2001-2002).

Name of the bone	Number of bones
Femur	2
Fibula	1
Humerus	3
Ulna	1
Radius	-
Pelvis	2
Scapula	4
Vertebra	4
Cranium	9
Mandible	16
Tusk	14
Rib	9
Isolated upper tooth	15
Isolated lower tooth	21
Total number of bones	>127

Table 2. Measurements (mm) of mammoth lower jaws from Zaraysk Site.

	N 8	-	-	N 90	N 1	N 4
Field number	I-9	Z-8	Z-9	I-9	Z-8	I-8
Teeth generation in wearing	dp4	m2 (all plates in wear)	m3 (all plates in wear)	m1-m2	m2 (14 plates remain)	m2
Maximal length	-	-	-	420	580	515
Maximal height	-	-	-	-	-	-
Width of coronoid process	-	-	-	185	248	-
Depth of corpus mandibulae at the posterior edge of the alveola	93	142	-	137	156	150
Length of interalveolar crest	-	-	-	21	-	143
Maximum width	370	370	480	-	-	650
Diameter between the left and right interalveolar crests	49	49	74	-	-	-
Length of symphysis	-	83	84	-	82	68
Distance between teeth (anteriorly/posteriorly)	-	-	92/180	-	63/115	75/160
Thickness of corpus mandibulae at the posterior edge of the alveola	-	105	120	120	145	109
Length of mental processus	-	-	-	74	-	-

Table 3. Mammoth tooth morphology in Zaraisk (2000-2001) and Kostionki I Sites, Layer 1.

Length of the tooth		Width of the tooth		Total number of plates		Enamel thickness	
Zaraisk	Kostionki	Zaraisk	Kostionki	Zaraisk	Kostionki	Zaraisk	Kostionki
dp4/dp ₄							
<u>136</u>	<u>104-110</u>	<u>58</u>	<u>48-56</u>	<u>16</u>	<u>11-13</u>	<u>1.2</u>	<u>0.95</u>
104-111	94-128	53	45-58	12	11-12	0.8	0.95
M1/M ₁							
<u>123-153</u>	-	<u>56-60</u>	-	<u>16-18</u>	-	<u>0.9-1.4</u>	-
-	-	-	-	19	-	1-1.4	-
M2/M ₂							
<u>-----</u>	<u>152.5-200</u>	<u>69-83</u>	<u>70-79</u>	<u>-</u>	<u>14-18</u>	<u>0.9-1.5</u>	<u>1.1-1.5</u>
147-200	142-205	67-85	64-92	18-20	15-18	1.0-1.5	1.2-1.8
M3/M ₃							
<u>-</u>	<u>250-269</u>	<u>68-110</u>	<u>76.5-91</u>	<u>-</u>	<u>23-25</u>	<u>1.0-1.8</u>	<u>1.5 - 2</u>
230	220-309	61.5-82	80-91	-	20-26	1.2-2.1	1.7-2.1

THE LUGOVSKOE SITE: RELATIONS BETWEEN THE MAMMOTH ASSEMBLAGE AND LATE PALAEOLITHIC MAN

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The Lugovskoe Mammoth site (60° 57' 28.8" north, 68° 32' 17.4" east) has been studied since 1994 (Pavlov and Maschenko, 2001). Lugovskoe is a unique locality of Late Pleistocene mammal remains. Up till now more than 5000 fossil bones have been collected at the site. Among these *Mammuthus primigenius* remains prevail. ¹⁴C dates from mammoth bones are 10210±135 – 18250±1100 BP. Dating of *Coelodonta antiquitatis* bones is 30090±800, 10770±250. Eleven ¹⁴C dates may fall into three groups: about 30 thousand (1), 11 400 -18 250 (7), and less than 11 thousand (3). The first and second groups reflect dating of specimens discovered *in situ*. The third group of dates was derived from reburied specimens. In the opinion of one of the authors (E.M.), these specimens may seem younger because of reburial during the Holocene. In 1999 some Palaeolithic artefacts were found in the Lugovskoe site by Dr. A. Pavlov.

Geological data on the Lugovskoe site are only tentative. The locality is situated on the first terrace of the left bank of the old river bed of the Ob river. The terrace is raised 5 – 5.5 m above low water level. The basement of the terrace is composed of heavy clays over 2 m thick according to synoptic estimation (Pavlov *et al.*, 2002). All finds of fossil mammal bones and Palaeolithic artefacts originate directly from the Lugovskoe creek bed. The creek traverses the terrace in a North-South direction. The minimal width of the creek bed is 0.5 – 1 m. The genesis of the bone bearing layers is not clear. It is possible that the bone bearing layers were formed during the Late Sartanian. The sediments of the creek are (from top to bottom): (1) brown oozy sediment with small fragments of reburied bones and teeth, 0.1 – 0.2 m thick; (2) sandy clay sediments with turf lenses up to 0.7 m thick. The bone bearing layer coincides with the second sedimentary layer. Between points 17 and 19 in the creek bed (190 – 205 m from the mouth), screening yielded about 300 Palaeolithic implements. This signals that the Lugovskoe is the northernmost known Palaeolithic site on the Western Siberian Plain. 271 Palaeolithic implements (2-3 mm) representing debris from broken tools and bone coal were found while screening the clay incorporating local accumulations of mammoth bones between points 12 and 17 (135 – 185 m from the creek mouth).

The Lugovskoe site represents the majority of species (13) of small and large mammals belonging to the “mammoth fauna”: *Microtus* sp.; *Lepus* sp.; *Mammuthus primigenius*; *Alopex lagopus*, *Canis lupus*, *Ursus arctos*, *Panthera spelaea*; *Coelodonta antiquitatis*, *Equus caballus*; *Rangifer tarandus*, *Alces* sp., *Bison* sp., and (?) *Ovibos moschatus*. Mammoth bones constitute over 98 % of vertebrate remains at the site. Three partial

mammoth skeletons were found *in situ*. Morphological characters of the most complete skeleton suggest that it is a full grown mammoth cow of extremely small size (femur – 897 mm, humerus – 740 mm). The body height of this individual is about 2 m. It is possible that this individual is the smallest mammoth known from the Siberian Mainland. The woolly rhinoceros remains (20 bones) are the second most numerous mammal remains. Other mammals are represented by 1 - 20 bones or teeth. Among the predators, wolf and arctic fox bones prevail. Brown bear and cave lion are represented by only one tooth fragment each. Preliminary estimation of population size shows that more than 27 mammoths died in Lugovskoe. Among these both the adult bulls and cows, and the calves and foetuses are represented. Sexual dimorphism in the mammoth population from the Lugovskoe site is well expressed. The body height in the largest mammoth bull is approximately 2.6 m. Woolly rhinoceros is represented by the remains of at least 7 individuals (including 1 calf), reindeer – 4 (1 subadult and 3 adults), elk – 1, bison – 1, musk ox – 1, wolf 3 - 4 (all adults), brown bear – 1, cave lion – 1, and arctic fox – 2 - 3. Mammal bones are usually well preserved. Many fragments of teeth and bones were collected reburied from the recent deposits of the Lugovskoe creek. In bone bearing layers most bones are not damaged, but many of them are disarticulated and skeleton fragments in anatomical position occur very seldom. It is clear, however, that some bone accumulations belong to associated skeletons. Different stages of erosion of the few isolated bones may signal incomplete burial of the carcasses. The availability of carcasses explains the high percentage of the remains of scavengers that were attracted by the cadavers. The character of the bone bearing layers and preservation of many bones testifies to the burial of the mammal remains in a marsh. In the vicinity of point 12, an 80 cm deep accumulation of mammoth long bones was observed *in situ*. It is possible that the marsh provided a natural trap where weaker animals died. The age diagram demonstrates non-selective death of individuals of different ages at the burial place. This is probably the result of frequent visits to this site by family and male groups of mammoths during a long time. According to one hypothesis, the Lugovskoe Site formed because the creek valley during the end of the Sartanian was a place where mineral substances were available for the mammoth groups and other mammals (Pavlov *et al.*, 2003). The grey clays from the base of the river terrace may provide such a source.

Among the most interesting finds of 2002 is a mammoth vertebra (7-9) damaged with a spearhead. This vertebra was found near point 12. This is the second discovery of Eurasian evidence (the first one in Siberia) of mammoth bone damaged with a Palaeolithic weapon (Praslov, 1995). The epiphyses of the processus transversus are completely fused. Between the epiphyses of the corpus vertebra, the epiphyseal suture is preserved. The bone is of relatively small size – height and width of corpus vertebra are 82 and 97 mm, respectively, and epiphyseal fusion suggests that the individual was a full-grown mammoth cow older than 23-24 years. Comparative data suggest that the body height of this individual at the shoulder was 215-230 cm, and the body weight was 2.5-2.7 tonnes (Maschenko, 2002, Vartanyan *et al.*, 1993). The cone-shaped hole made by the spearhead is situated in the right lateral side of the corpus vertebra in its middle part, closed to the caudal surface. The depth of the hole is 25 mm. The opening of the hole is ellipse-shaped, with even edges. The long axis of the ellipse is vertical. The ends of the long axis are marked with quartzite plates sitting inside the vertebral body (Zenin *et al.*, this volume). This damage suggests that the strike was aimed at the heart of the animal, but missed. The weapon had a bone point with stone inserts. As the heart of mammoths and modern elephants is centred in the body cavity at the level of the 4-9 thoracic vertebrae, the strike could have come from either side (Zalensky, 1903). The strike was 25-30 cm high, so the point struck the body of the vertebra. It is probable that

the point penetrated through the upper edge of the scapula (about 15 mm thick). The thickness of the soft tissues in this part of the mammoth body is about 100 mm. The total depth of penetration is 130-135 mm. The strike was very powerful. If the strike had been directed correctly, the point would have penetrated twice as deeply, and the area of the pericardium and the right lung would have been affected. Such wounds could kill even adult mammoths. The orientation of the hole in relation to the body surface and its depth suggest that the powerful blow was inflicted at short distance (probably no more than 5 meters) while the animal was standing upright (this is the opinion of one of the authors (E.M.)). It is also a testimony to the high efficiency of the weapon, because the thoracic vertebrae and scapulae have very tough substantia spongiosa and thick substantia compacta (about 3 mm in the vertebra). This point with fixed stone inserts may be comparable in efficiency to a small arms bullet. The Lugovskoe data, however, do not permit the suggestion that mammoth hunting was a frequent occupation at the Lugovskoe site, as two partly excavated bone accumulations and about 5000 mammoth bones yielded only one vertebral injury, despite numerous finds of Palaeolithic implements. It is more probable that butchering of mammoth carcasses occurred in Lugovskoe, as well as burning of bones. Lack of traces of butchering on the mammoth bones can be accounted for by aponevrosis morphology in mammoths and recent elephants (Haynes, 1991; Haynes, personal communication).

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PREDATOR-PREY LINKS IN PLEISTOCENE EAST BERINGIA: EVIDENCE FROM STABLE ISOTOPES

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We reconstructed predator-prey links of the large carnivores and herbivores that inhabited the late Pleistocene Mammoth Steppe of eastern Beringia by analyzing stable isotope ratios (¹³C, ¹⁵N) in fossil bone collagen. Overall, the large carnivore guild (composed of lions, scimitar cats, short-faced bears, wolves, and wolverines) was heavily dependent on bison, horse and mammoth and less so on caribou and muskox. Among the extinct carnivores, scimitar cats ate the most mammoth, lions were bison-specialists, and short-faced bears were scavengers having diverse diets. Wolves and wolverines, still extant in the region, had diverse prey bases. Wolverine diets probably included small mammals and vegetation. Wolves ate a surprising amount of mammoth, presumably scavenged. Brown bears had omnivorous diets similar to inland populations today and did not eat salmon. Reorganization of the guild and carnivore extinctions ca. 11,000 ¹⁴C BP are correlated with the extinction of key prey species and the collapse of the Pleistocene food web.

ISOTOPE ECOLOGY OF LATE QUATERNARY MEGAFaUNA IN EASTERN BERINGIA

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Five large mammals dominate the late Pleistocene Mammoth Steppe community in eastern Beringia: bison, mammoth, horse, muskox, and caribou. Bison, mammoth, and horse are believed to have been almost exclusively grazers, but had different strategies for foraging and processing grasses, while muskox and caribou are mixed grazers and

browsers adapted mostly to foraging tundra plants. We explored ways that differences in diet, habitat selection, climate and physiology of these herbivores were manifested in stable isotope (SI) ratios ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) of collagen for 280 fossil bones collected in central and northern Alaska.

Carbon and nitrogen isotope ratios in consumers are mainly determined by SI composition of forage plants. Unfortunately, SI ratios of northern C3 forage plants do not vary much within any given growth form (e.g., among shrubs, among forbs), making it difficult to use SI to detect many fine-grained differences in diet among the five herbivores. However, our data support the following inferences and hypotheses (Fig. 1):

1. Bison had relatively narrow ranges of $\delta^{15}\text{N}$ and $\delta^{13}\text{C}$, reflecting narrower diets than other herbivores. Absolute values indicate bison ate high amounts of grasses and sedges and seemingly ate little shrubby browse.
2. Mammoths are slightly depleted in ^{13}C , but unusually enriched in ^{15}N relative to all other herbivores. Even though it is argued that mammoths were grazing-adapted, no known forage plants have $\delta^{15}\text{N}$ values high enough to explain this pattern via diet alone. Various other explanations have been hypothesized, particularly adaptation to environmental aridity. We reject the aridity hypothesis for a number of reasons, primarily because data from modern arid ecosystems predict that other Beringian mammals in addition to mammoths should be enriched in ^{15}N , too. Other physiological and ecological explanations need to be explored, including the effects of monogastric vs. ruminant digestion on ^{15}N fractionation. Ruminants, such as bison, are predicted to have relatively lower $\delta^{15}\text{N}$ values in their tissues because they recycle urea, which is isotopically light. Monogastrics, which do not recycle urea, are predicted to have higher $\delta^{15}\text{N}$ when fed the same diet as ruminants. This ruminant vs. monogastric model is not completely satisfying, however, because $\delta^{15}\text{N}$ values in Beringian ruminants do not seem particularly depleted, and $\delta^{15}\text{N}$ values in mammoths are enriched beyond those predicted by diet and standard processes of urea formation and excretion. Horse, the other monogastric in the system, display a wide range in $\delta^{15}\text{N}$, but their average $\delta^{15}\text{N}$ value is much less than mammoth (and slightly greater than bison) and some horses exhibit $\delta^{15}\text{N}$ values too low to be consistent with the monogastric-ruminant model.
3. Overall, horses are somewhat heavier in ^{15}N and lighter in ^{13}C than bison, suggesting horses ate more shrubby browse, most likely *Salix*. Our data also suggest that *Artemisia* may have been an important forage item for horses.
4. Muskox exhibit highly variable isotopic signatures, particularly for $\delta^{15}\text{N}$. Modern muskox have mixed diets dominated by willow and sedges, and annual forbs to a lesser degree. We conclude that Pleistocene muskox ate mostly graminoids, particularly sedges along with more forbs, but less willow, than modern muskox. Individual diets varied considerably, however, in the percentage of graminoids, willows, and forbs.
5. Caribou exhibit extremely variable isotope values. This is best explained by varying amounts of lichen in diets otherwise including graminoids, forbs, and willow.

To explain the often wide variation in isotopic signatures within taxa, we examined changes in $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ over time in 237 radiocarbon-dated specimens from northern Alaska. Interpretations are confounded because two different mechanisms may drive changes in consumer isotope ratios over time: changes in diet or environmentally-driven

changes in the isotopic composition of forage plants. The following patterns were found and are explained in light of these two mechanisms:

1. In horses, $\delta^{15}\text{N}$ declines and $\delta^{13}\text{C}$ increases ca. 26-24 k BP, followed by a rise in $\delta^{15}\text{N}$ (peaking during the late glacial) and a slight decrease in $\delta^{13}\text{C}$. Any number of changes in diet could account for this. The best explanation, however, is that full glacial plants were water stressed (higher $\delta^{13}\text{C}$) and utilized immature (more reduced, less mineralized and thus isotopically lighter) sources of soil nitrogen. Consequently, horse diets may not have changed significantly during the LGM .

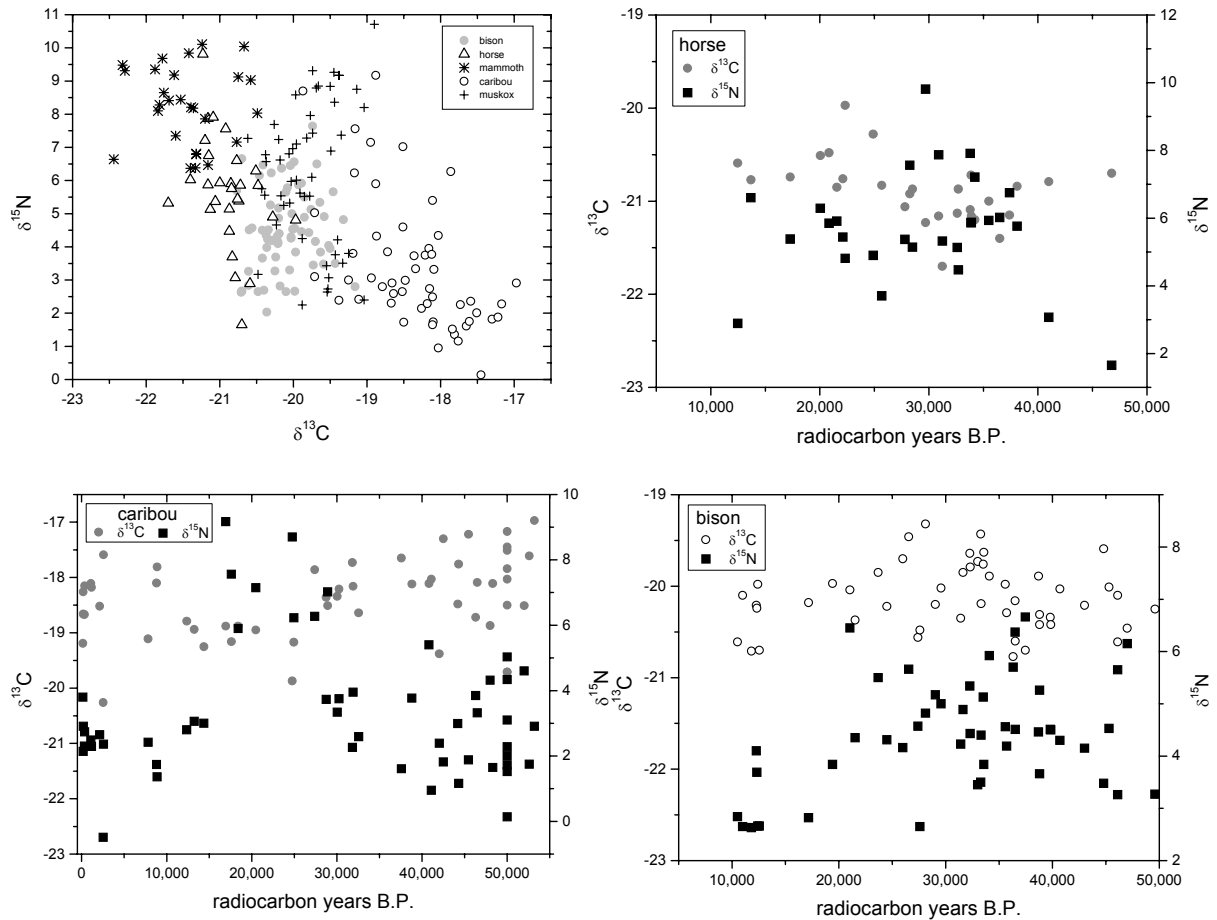
2. In bison, $\delta^{13}\text{C}$ peaks during late MIS 3, ca. 34-26 k BP, then declines to pre-34 k BP levels. $\delta^{15}\text{N}$ also peaks late in MIS 3, declines thereafter, but unlike $\delta^{13}\text{C}$ continues to decline through the late glacial. If these patterns reflect changing diets, they most strongly suggest a peak in grass-eating from about 34-25 k BP, and a shift to more shrubby browse thereafter. We find that scenario to be improbable, since shrubby taxa apparently declined and herbaceous taxa increased during the LGM. Therefore, some climatically-driven changes in plant isotope ratios likely occurred.

3. Full glacial caribou are lighter in $\delta^{15}\text{N}$ but heavier in $\delta^{13}\text{C}$, strongly suggesting that lichen fell out of their diet during that time. A decrease in caribou abundance is indicated for the LGM, supporting the conclusion that fruticose lichens were not common and caribou carrying capacity was reduced during cold, dry conditions of the LGM, at least in northern Alaska.

4. Temporal variation could not be explored for muskox because of 51 dated specimens, all but eight returned infinite dates. However, those results indicate that muskox apparently were more common during the middle Pleistocene and relatively rare during the late Pleistocene in northern Alaska.

5. Likewise, no clear temporal patterns in isotopes were ascertainable for mammoths, because only two dated to <25 k BP.

Figure 1



USING FREQUENCY DISTRIBUTIONS OF RADIOCARBON DATES TO DETECT RELATIVE CHANGES IN PLEISTOCENE MAMMAL POPULATIONS— A TEST CASE FROM NORTHERN ALASKA

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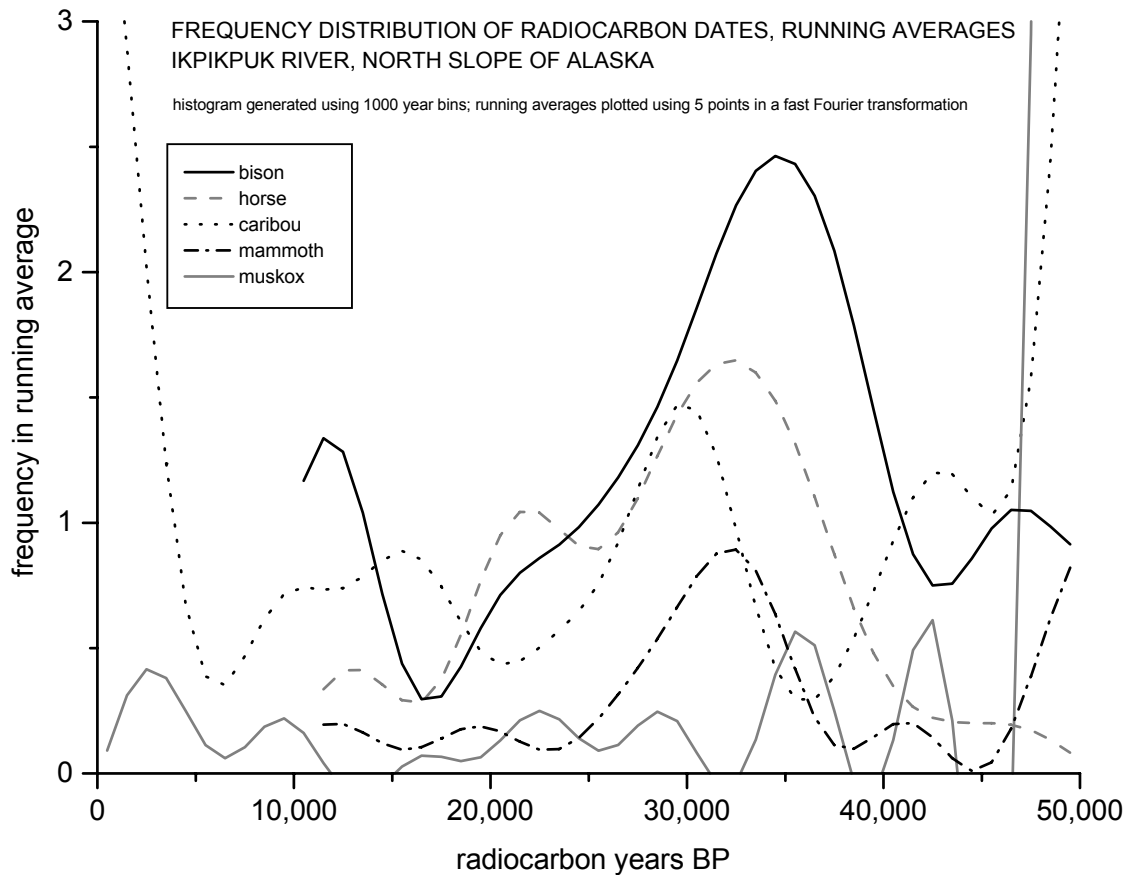
While radiocarbon dating is a long established tool in paleontological research, only recently have we seen the development of large, regionally constrained radiocarbon data sets for individual taxa. When large enough, these data sets may be able to detect the presence or absence of taxa for time periods as short as 1000 years. However, the frequency and distribution of radiocarbon dates has traditionally not been considered to be a valid reflection of individual abundance or population densities. Here, we propose

that frequency distributions of radiocarbon dates can be used to detect *relative* changes in population sizes when compared among multiple species deriving from a single locale and certain depositional environments.

We explore this method using radiocarbon dates generated on 237 specimens of bison, horse, mammoth, caribou, and muskox from the upper Ikpikpuk River on the north slope of Alaska (Fig. 1). Bones have accumulated in the Ikpikpuk fluvial corridor since the late middle Pleistocene in sediments eroding from the adjacent low hills and the river valley itself. Each spring, the river erodes large numbers of bones from cutbanks and deposits them on point bars in high densities. For four summers, we have collected every identifiable bone fragment from ~35 point bars, totaling over 2000 specimens, of which 234 have been radiocarbon dated. Relative frequency distributions of dates suggest that:

1. The peak frequency of radiocarbon dates for all species falls around 34-30 kbp, late in the last interstadial, MIS 3. This may reflect a period of favorable bone preservation more so than higher population densities. However, it is notable that muskox dates are uncommon during that period.
2. There is a decline in radiocarbon dates during the transition from MIS 3 to MIS 2, starting at or shortly after 30 kbp. Because the trend occurs for all taxa, this also may reflect a taphonomic decline in bone preservation more than a reduction in population levels.
3. The full glacial was particularly adverse for caribou, but horse numbers probably increased during the early LGM.
4. The lowest frequencies for all species fall variably during the period 16-21 kbp.
5. Caribou show a rise in radiocarbon dates ca. 17-15 kbp, a time when the radiocarbon frequencies of other taxa are declining.
6. There is a late glacial (ca. 15-11 kbp) rise in radiocarbon frequencies for bison, horse, and perhaps mammoth.
7. All taxa other than muskox and caribou are extinct by 10,500 ¹⁴C years BP. Both exhibit an early Holocene decline in dates, but this may be taphonomic.
8. Youngest dates for extinct north slope taxa: bison = 10,510 ¹⁴C years BP; horse = 12,465 ¹⁴C years BP; mammoth = 12,490 ¹⁴C years BP.
9. Muskox fossils are common in the Ikpikpuk assemblage, constituting ~20% of all bones. However, of 62 muskox dated, all but 5 yielded infinite dates, suggesting that they were not particularly common in the late Pleistocene community. Instead, it appears that their bones persist in the system longer than those of other taxa.
10. An apparent rise in radiocarbon numbers between 40-35 kbp is a remnant of statistical averaging which includes infinite radiocarbon dates.

Fig. 1.



MAMMOTHS IN OUR MIDST: THE PROBOSCIDEANS OF ANZA-BORREGO DESERT STATE PARK®, SOUTHERN CALIFORNIA, USA

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Anza-Borrego Desert State Park® (ABDSP) has an exceptional proboscidean fossil record. The remains of Gomphotheriidae and Elephantidae span 10+ Ma and encompass over eighty productive sites. Significant specimens include one of the most complete skeletons of *Archidiskodon meridionalis* in North America.

ABDSP, which covers over 242 k hectares, is located at the western edge of the Colorado Desert portion of the Sonoran Desert, approximately 129 km east of San Diego, California. Here, the fossiliferous sedimentary deposits occur along the west side

of the Salton Trough, an active rift valley that extends from northwest of Palm Springs south to the Sea of Cortez, and from the eastern margin of the Peninsular Ranges east to the San Andreas Fault Zone. A volcanic spreading ridge runs south from the Salton Sea, which occupies the center of the Salton Trough well below sea level.

Over 6 km of fossiliferous sediments have been deposited within the Salton Trough. These provide a 10+ million year record of changing environments. Both marine and terrestrial paleoecologic systems are represented and yield over 550 taxa of terrestrial plants, marine and lacustrine invertebrates, and marine, fresh water and terrestrial vertebrates. Represented are intercontinental vertebrate immigrants from South America and from Asia, including the proboscideans.

A majority of proboscidean remains (52) are from the Ocotillo Conglomerate in the Borrego Badlands (Remeika and Jefferson, 1995), and Bautista beds in the Coyote Badlands that crop out in the northern part of the Park. Both formations are Irvingtonian in age. The Irvingtonian age Hueso Formation in the Vallecito Creek/Fish Creek Basin of southern ABDSP yields twenty-three (23) proboscidean sites. Additional records include a single Hemphillian age site from the Split Mountain or Anza Formation and a single Blancan age site from the Diablo Formation (stratigraphic terms follow Cassiliano, 2002). Five localities are found in the Salton Trough east of the Park and are presumed to be Rancholabrean in age.

Some sites have produced remains that can be identified only as "Proboscidea". Many proboscidean tooth fragments, which exhibit thick enamel not found in *Mammuthus* tooth plates, have been referred to "Gomphotheriidae or Mammutidae". *Gomphotherium* or *Pliomastodon* (N = 1) (Jefferson and McDaniel, 2002) and *Stegomastodon* (N = 1) have been fully documented. However, most specimens identified to the generic level are *Archidiskodon* or *Mammuthus* (N = 13). *Archidiskodon meridionalis* (N = 12) and *Mammuthus columbi* (= *M. imperator*, Agenbroad, in press) (N = 13) regionally co-existed (McDaniel and Jefferson, in press). Both taxa have been recovered from the same strata, dated at approximately 1.1 to 0.9 Ma in the Borrego Badlands (Remeika and Beske-Diehl, 1996).

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PHYLOGENY AND CHRONOLOGY OF *Mammuthus* IN NORTH AMERICA

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The systematics of the family Elephantidae, as noted by Aguirre (1969), is quite confused. Over the years, several systems have been developed for the group. Osborn (1942) noted ten genera and fifty-nine species. More recently, systems have been proposed by Maglio (1973), Kurtén and Anderson (1980), Madden (1981), Graham (1986), and Agenbroad (1984, 1994). Issues critical to understanding the systematics and phylogeny of the elephantids, specifically the genera *Archidiskodon* and *Mammuthus*, appear to center on the status of *A. meridionalis* Pohlig 1885.

There are two major branching points in the evolution of the elephantids. Early proboscideans have a long, low skull, shallow mandible with low coronoids, and the ascending ramus projects posteriorly at an obtuse angle. In the first transition, the thick lophids of the molars became compressed into thin lamellae. In the second transition, the mandible developed an ascending ramus that is oriented to a vertical or near vertical position. The mandible became more massive, shortened and the coronoids became higher and moved anterior to the posterior edge of the dentary alveolus. The skull became short and high.

Aguirre (1969) and Maglio (1973) argued that *Archidiskodon* and *Mammuthus* are congeneric. However, based on the morphological differences in the skull, mandible, and postcranial elements, these nominal genera were considered distinct by Dubrova (1994). Accordingly, Dubrova (1994) placed *meridionalis* under *Archidiskodon*, and *M. trogontherii* and *M. primigenius* within the genus *Mammuthus*. She stated that three subspecies of *Archidiskodon meridionalis* were recognized in the Commonwealth of Independent States (formerly U.S.S.R.): *A. m. meridionalis* (Nesti 1825), *A. m. tarabenensis* Gabunia and Vekua 1963, and *A. m. tamanensis* Dubrova 1964. Based on dental parameters, she considered *A. m. meridionalis* the most primitive of the three subspecies, and *A. m. tamanensis* the most advanced with 12-17 lamellae in the M3s.

However, the morphology of the skull and mandible of *A. m. tamanensis* exhibits an early morphology, and that of *A. m. meridionalis* is more advanced. Skull morphology contradicts the ancestor-descendant relationships discerned from the dental characters.

The diagnostic characteristics of *Archidiskodon* Pohlig 1885 best fit *A. meridionalis tamanensis*, and those of *Mammuthus* Brooks 1828 (Burnett 1830 of some authors) best fit *A. meridionalis meridionalis*. *A. m. tamanensis* has a long low skull, and a long mandible with low coronoids and the ascending ramus directed posteriorly, typical of an early form. *A. m. meridionalis* has a relatively short high skull, a shortened mandible with high coronoids and the ascending ramus rotated to a near vertical position. These features are typically found in later forms. The subspecies *A. m. tamanensis* and *A. m. meridionalis* should be considered two separate taxa at specific or possibly generic levels.

Specimens of the earlier form, comparable to *Archidiskodon meridionalis tamanensis* Dubrova 1964, from North America include: 1, San Bernardino County Museum (SBCM A2944-0021) from Victorville, California (pers. observation); 2, Shoshone Museum (L200(SSU)106) from the Tecopa Lake beds, California (McDaniel and Jefferson, 2001); 3, New Mexico University (UNM 11,028) from the Sierra Ladrones Formation, Lincoln County, New Mexico (Lucas and Effinger, 1991); and 4, University of California Berkeley (UCMP 69128) from San Francisco, California (Hall, 1965). The New Mexico specimen is dated at 1.6 Ma BP (Lucas and Effinger, 1991), and the Tecopa Lake beds specimens are both <600 ka (McDaniel and Jefferson, 2001).

Mammoth specimens of the later form, comparable to *A. m. meridionalis*, have been reported from: 1, Anza-Borrego Desert State Park, California (ABDSP(IVCM)V5126) (McDaniel and Jefferson, 1997, in press); 2, Texas Memorial Museum (TMM 43341-1) from Stout Ranch, Texas (pers. observation); University of Florida (UF 67200) from Leisey Shell Pits, Florida (Webb *et al.*, 1989); and 4, Denver Museum of Natural History (DMNH 1359) from Angus, Nebraska (Osborn, 1932). The Anza-Borrego specimen is dated at 1.1 Ma BP. The Florida materials are Irvingtonian in age and the Texas specimen is Rancholabrean (E. Lundelius, pers. comm.).

Harington (1984) suggested that the steppe mammoth, *Mammuthus trogontherii*, arrived in North America about 1.2 Ma BP, and was immediately ancestral to *M. columbi* (= *M. imperator*) (Agenbroad, in press). *M. columbi* occurs in North America as early as 1.1 Ma BP (McDaniel and Jefferson, 1997). Due to the great differences in the morphology of the skull, mandible, and tusks of *A. meridionalis meridionalis* and *M. columbi*, as represented by coeval specimens from Anza-Borrego Desert State Park[®], it appears highly unlikely that the former is immediately ancestral to the latter (McDaniel and Jefferson, in press).

Such observations shed light on the systematics of the Elephantinae and *Mammuthus*, and the placement of *A. meridionalis* (including nominal subspecies) within the mammoth lineage. Two possible phylogenetic scenarios may be considered: 1, an *M. subplanifrons* - *M. trogontherii* - *M. primigenius* lineage, and a separate *A. meridionalis* lineage evolving from a surviving elephantid stem represented by the nominal *A. m. tamanensis*; or 2, an *M. subplanifrons* - *M. africanavus* lineage that evolves no further, and an *A. m. tamanensis* - *A. m. meridionalis* - *M. trogontherii* - *M. primigenius* lineage. If retained, the generic name *Archidiskodon* might be applied to *A. m. tamanensis* and its ancestors, but not to later forms.

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REGIONAL VARIATION IN *Mammuthus columbi* (PROBOSCIDEA, ELEPHANTIDAE) BASED ON THE DENTAL PARAMETERS OF A POPULATION OF MAMMOTH MOLARS FROM A GRAVEL QUARRY IN SOUTHERN TEXAS, USA

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A large sample (N=149) of *Mammuthus columbi* teeth was excavated from a single Rancholabrean North American Land Mammal Age (NALMA) site near Mathis, San Patricio County in southern Texas. This attritional assemblage, which also includes Xenarthra, Equidae, Camelidae, Cervidae, and *Bison*, was recovered from fluvial point bar deposits. Standard mammoth dental measurements and metrics (enamel thickness, plate width, plate number, and lamellar frequency) from a minimum of 28 individuals vary widely, and indicate that the tooth plate numbers are most reliable in the identification of specimens to the species level. Enamel thickness and lamellar frequency suggest that the Mathis sample represents a regional population of *Mammuthus columbi* that approaches conditions found in Irvingtonian NALMA populations usually placed under *M. imperator* (considered a junior synonym of *M. colombi* by some authors).

MAMMOTHS AND MYLODONTS: EXOTIC SPECIES FROM TWO DIFFERENT CONTINENTS IN NORTH AMERICAN PLEISTOCENE FAUNAS

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Throughout the Cenozoic the North American mammalian fauna has been enriched by the appearance of new taxa originating on different continents. During most of the Tertiary the primary source area of these new taxa was Eurasia with dispersal across some version of the Bering Land Bridge. In the late Pliocene ca. 2.5 mya the creation of the Panamanian Land Bridge permitted the northward dispersal of species of South American origin including ground sloths. One of these sloths was "*Glossotherium*" *chapidmalense*, which in turn gave rise to the Pleistocene species *Paramylodon harlani*. Mammoth, *Mammuthus* sp., first appeared in North America at the beginning of the Irvingtonian at 1.9 million years. Despite originating on two different continents the two species are often found together in North American Pleistocene faunas. This suggests the two species were able to share a common habitat although mammoths did not disperse into South America and mylodont sloths were not able to disperse into Eurasia.

Both of these lineages are commonly interpreted as grazers and indicative of open grassland habitat. In North America these two exotic species shared this habitat with North American endemics such as horses and antilocaprids, also interpreted as grazers. There is no evidence that the appearance of either exotic species resulted in the extinction of any native lineages. The question is how these different species, immigrants and endemics, were able to survive and thus enrich the overall North American Pleistocene fauna while sharing a common habitat, presumably utilizing similar food resources and avoiding competition.

THE REASONS FOR THE DISAPPEARANCE OF MAMMOTH IN WEST BERINGIA IN THE LIGHT OF ARCHEOLOGIC FACTS

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1. As the reasons for the disappearance of the mammoth various scientists suggest both abiotic, biotic, and human factors, each taken separately or a complex of these factors.
2. Furthermore, many scientists believe that even if Paleolithic hunters could cause serious damage to the mammoth fauna in Europe, the human factor would have played no significant role in this respect due to low population density in North Asia, especially in its western part.
3. Our 45 years of study of the Paleolithic of North East Asia (an area situated in the east from the Enisey valley and in the north from the Amur basin) have shown that the

Paleolithic population density in this region was lower in the Pleistocene than the mammoth hunter density in Europe.

4. The annually increasing number of Paleolithic monuments in North East Asia shows that complete disregard of the human factor might result in misrepresentation of mammoth disappearance and the history of the origin of the modern fauna formation in this territory.

LATE PLEISTOCENE TERRESTRIAL AND MARINE MAMMALS FROM THE EUROGEUL, NORTH SEA, THE NETHERLANDS

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Introduction

Hundreds of thousands of fossil bones of Pleistocene mammals, both terrestrial and marine, have been fished from the bottom of the North Sea between Great Britain and the Netherlands. Most of this material, first brought ashore as a bycatch as early as 1874, is without any exact locality data. Huge quantities of this material have been assembled in public and private collections. The collections in the National Museum of Natural History (Naturalis, Leiden) are considered the largest. Today some 7,500 specimens of woolly mammoth *Mammuthus primigenius* are to be found in this museum, not to speak of other taxa. The commonest "locality" name on the labels is "Bruine Bank", or "Brown Bank", a shallow region where many fishing vessels are actively catching flat-fish such as sole, dab, turbot or plaice. The fossils generally date from the Late Pleistocene, a period with a low sea level when Britain and the Low Countries were connected by what is now the Southern Bight of the North Sea. The Late Pleistocene fauna is dominated by *Bison priscus*, *Equus cf. caballus*, *Mammuthus primigenius* and *Coelodonta antiquitatis*.

We now have fossils from other Pleistocene periods as well. Intensive cooperation between collectors and the fishing industry during the last decade brought many (i.e., several tens of thousands) mammal fossils ashore that became available for scientific research. Crew members on board are not only willing to cede the material for research purposes, but they also provide us with GPS coordinates for the exact localities where the material was fished up (Mol *et al.*, 2003). In this way a profusion of data has been assembled that provide us with a reasonable knowledge about the places where either Early, Middle or Late Pleistocene fauna is found. Geological data from the Southern Bight, at the Netherlands Institute of Applied Geoscience (TNO-NITG) and the

Geological Survey of Britain, allowed confirmation of the identifications of material as either from the Early, Middle or Late Pleistocene.

One of the most spectacular recent finds is a mandible of the Late Pleistocene saber-toothed cat *Homotherium latidens*, described by Reumer *et al.* (2003). This made clear that *Homotherium* was part of the NW European mammoth fauna (the Late Pleistocene ecosystem) by c. 28,000 BP.

Mol *et al.* (2003) described fossil mammals from a locality called "het Gat", between the UK and the Netherlands at 46 m depth. A fishing expedition specifically aimed at this locality was undertaken in 2001 by CERPOLEX/Mammuthus. Over 150 fossils were collected that are considered to belong to a Bavelian (late Early Pleistocene) fauna correlated around an age of 1.0 - 0.75 My. The sampling methods used allow us to consider this fauna from "het Gat" as uncontaminated. This present communication describes another such uncontaminated fauna, from a locality called "Eurogeul".

The "Eurogeul" locality

Some 5 nautical miles W of the Rotterdam harbour mouth, close to the buoy "Maas Centre" and on the bottom of the so-called "Eurogeul" (the dredged shipping lane), we find a concentration of mammoth bones. These mammalian remains are perfectly preserved and often show intricate anatomical detail. Sometimes bones belonged to the same individual, e.g., a mammoth skull with accompanying mandible. In the Eurogeul complete skeletons or parts of skeletons are found, which indicates a lack of secondary transportation. Mammoth skeletons belonged to animals of all ontogenetic ages, foetus to senile. Silting up of the Eurogeul is being prevented by sand-removing suction-dredgers in order to facilitate the entry of heavy-draught ships into the port of Rotterdam. Larger fossils, especially those of *Mammuthus*, are being freed from the sediment and stay behind on the bottom of the Eurogeul. Subsequently, smaller fishing vessels (so-called Euro-cutters) get these bones in their dredge-nets while fishing. The locality where this takes place is at 52° 01' 69" N - 03° 49' 03" E, with a depth of c. 28 m below the surface. The geology at the locality is rather complicated and subject to further study. Presently available knowledge shows the following layers from the top (= the bottom of the sea) downward:

- (a) the Middle Holocene to recent Blight Bank Member of the Southern Bight Formation,
- (b) Early Holocene lagoonal sediments
- (c) a Late Weichselian/Early Holocene grey clay of the Naaldwijk Formation
- (d) the fossiliferous Kreftenheye Formation
- (e) Late Saalian fluvial deposits (that are not being touched in the Eurogeul) of the Urk Formation.

The Kreftenheye Formation (d) in which the Eurogeul mammals are found can be divided into three layers: on top fine-grained fluvial sands, underlain by fluvial sands without marine indicators, and – finally – sands containing Eemian marine molluscs. The age of this Formation is Eemian to Late Weichselian (Laban *et al.*, 1984; Laban and Rijdsdijk, 2002).

Faunal list

CERPOLEX/Mammuthus, in close collaboration with the Natural History Museum Rotterdam and the National Museum of Natural History in Leiden, led several one-day

expeditions to the area. Together with the material that has been brought ashore by the Euro-cutters we now have the following fauna from the Eurogeul locality.

Proboscidea

Mammuthus primigenius - woolly mammoth

Artiodactyla

Bison priscus - bison

Rangifer tarandus - reindeer

Megaloceros giganteus - Irish elk

Alces alces - moose

Cervus elaphus - red deer

Perissodactyla

Equus caballus - horse

Coelodonta antiquitatis - woolly rhino

Carnivora - Fissipedia

Ursus arctos - brown bear

Crocuta crocuta - hyaena

Panthera spelaea - cave lion

Canis lupus - wolf

Carnivora - Pinnipedia

Phocidae

Pagophilus groenlandica - harp seal

Pusa hispida - ringed seal

Odobenidae

Odobenus rosmarus - walrus

Cetacea - Odontoceti

Monodontidae

Delphinapterus leucas - beluga

Delphinidae

Orcinus orca - killer whale

Cetacea - Mysticeti

Eschrichtidae

Eschrichtius robustus - gray whale

Terrestrial mammals

With the possible exception of *Cervus elaphus*, this fauna can be considered a typical mammoth fauna as found in many places in Eurasia. Two antler fragments of *C. elaphus* clearly show traces of human activity and they are probably of early Holocene age. The moose *Alces alces* is generally considered an inhabitant of forested areas along rivers, and not as a member of the Late Pleistocene mammoth fauna that inhabited cold and dry steppes. Nevertheless, *A. alces* could have been part of the mammoth fauna, especially so in wet regions such as a river delta. Moose was found as part of the mammoth fauna on the Taymir Peninsula (N. Siberia, Novaya River, Ari-Mas) during the Late Pleistocene (around 48,000 BP; GrA-17346, 47,900 ±1,000/-900; MacPhee *et al.*, 2002). A ¹⁴C dating of the Eurogeul material may provide a solution.

Coelodonta antiquitatis was an extremely common element during the Late Pleistocene in the southern part of the North Sea. The species is very common in the Eurogeul fauna. There may be no other region in Eurasia where this species is so commonly found as in the North Sea. This must be due to biotope characteristics and/or to

biogeographical phenomena. Woolly rhino had a wide distribution, from Britain in the west to NE Siberia in the east. It is however completely absent from N America (Boeskorov, 2001), indicating it did not cross the Bering land bridge.

Flerov (1967) suggested that leaves and twigs of shrubs must have been the major food source for the woolly rhino. The absence of shrubs in the Late Pleistocene mammoth steppe of NE Siberia should then have been the reason why this species never reached North America, which explains its absence from the New World. However, food remains found in dental crevices and in the intestinal tract (e.g., in the Churapachi rhino from Yakutia; Lazarev, 1977) showed that tough grasses were the major food source. Nowadays (Ermolova, 1978; Boeskorov, 2001) it is supposed that large parts of the extreme northeast were covered with hard layers of frozen snow during the Late Pleistocene, hampering the spread of woolly rhino to N America. It is furthermore noteworthy that *Coelodonta antiquitatis* is absent from the mammoth fauna on the entire Taymir Peninsula.

Marine mammals

A number of marine taxa is known from the Pleistocene of the southern part of the North Sea in addition to the above-mentioned terrestrial mammals. Marine mammals are also found in the Eurogeul. These remains belong to two different faunas.

1) An early Holocene fauna with a.o. gray whale *Eschrichtius robustus*. Van Deinsen and Junge (1937) discovered that the fossil species that was sparsely found in W Europe is actually the same species as recent whales that now exclusively live near the American West Coast. Many fossil remains of this species are described from the Netherlands. All these remains (and much as yet undescribed material as well) originate from the former or the present bottom of the North Sea. These fossils have a (reservoir effect corrected) age of ca. 8,400 BP to about 1,300 BP (Bryant, 1995). It is interesting to note that researchers of old written sources think that gray whale hunting still took place during the Middle Ages in the North Sea. Even though Pleistocene gray whale fossils are found nowhere else in the world, several fossils with a possibly Pleistocene age are known from the North Sea. A ¹⁴C dating should provide clarity in this matter. The fossils we found in the Eurogeul agree both in colour and in fossilisation with the known and dated Holocene samples; hence an early Holocene age seems plausible.

2) A Late Pleistocene cold fauna with harp seal *Pagophilus groenlandica*, ringed seal *Pusa hispida*, walrus *Odobenus rosmarus*, beluga *Delphinapterus leucas*, and orca (killer whale) *Orcinus orca*. The North Sea is probably the richest fossil walrus source in the world. Thousands of skeletal parts and hundreds of (sometimes complete) skulls were found. Datings lie between 50,000 and 23,500 BP (Aaris-Sørensen *et al.*, 1990; Post, 1999) indicating that walrus occurred for a long period of time (albeit perhaps intermittently). This rather southern occurrence of walrus has a parallel in the Pacific Ocean (Hoshimi and Akagi, 1994). Apparently a global climate change forced the species to move southwards in both Atlantic and Pacific Oceans. Pleistocene occurrence of beluga and harp seal is clearly evidenced by North Sea fossils (Post and Kompanje, 1995; Post 1999). Two datings of beluga (from the coast of Zeeland and the Bruine Bank) resulted in 38,500 ±800 and 34,600 -400/+500 BP respectively (Post, 1999). Harp seal must have occurred in vast colonies along the Dutch coast, but unfortunately only one fossil from the Brown Bank has been dated thus far (45,000 ±1,500 BP; Post, 1999).

All species found are either bound to coastal environments (the pinnipeds), or are species that can thrive in very shallow water (beluga, gray whale). So far only one killer whale fossil has been found, and this species is also a rare find in other areas of the North Sea. Of course these fossils could originate from carcasses washed ashore, but living orca does not avoid shallow water, especially not when hunting for seal.

¹⁴C datings

Samples for ¹⁴C dating purposes were taken from all terrestrial and marine species found in the Eurogeul locality. Three results are so far known:
Mammuthus primigenius: 43,800 -550/+600 BP (GrA 20134);
Mammuthus primigenius: 37,580 -740/+810 BP (GrN 27410);
Coelodonta antiquitatis: 39,910 -950/+1070 BP (GrN 27411).
Other measurements are now being processed at the Centre for Isotope Research, Radiocarbon Laboratory, University of Groningen (the Netherlands). The authors hope to present the results at the 3rd IMC in Dawson City, Yukon, Canada.

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RESULTS OF THE CERPOLEX/MAMMUTHUS EXPEDITIONS ON THE TAIMYR PENINSULA, ARCTIC SIBERIA, RUSSIAN FEDERATION

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Introduction

At the 2nd International Mammoth Conference held in May, 1999, in Rotterdam (the Netherlands) Buigues and Mol (1999) announced the discovery of the Jarkov Mammoth in the permafrost of the Taimyr Peninsula, Arctic Siberia. The Jarkov Mammoth is a male woolly mammoth, *Mammuthus primigenius*, that died at an age of 47-49 AEY, on the Taimyr Peninsula, c. 20,380 BP. In September/October, 1999, introducing a new technique, the CERPOLEX / Mammuthus team excavated a huge block of frozen sediment that likely included the remains of the mammoth. On October 17th, this 23-ton block of permafrost was successfully airlifted by an MI 26 helicopter. It was placed in an underground ice cave system in Khatanga, c. 250 km south of the locality (Bolshaya Balakhnya River) where the Jarkov Mammoth had been discovered in 1997. The goal of the team is to defrost the frozen block in the safety of the ice cave at a constant temperature of -11° to -15°C, in order to collect as many data as possible from the sediment surrounding the remains of the Jarkov Mammoth. This event in 1999 was the start of the CERPOLEX / Mammuthus programme “Who or What Killed the Mammoths” to contribute to the unsolved questions on the extinctions of the Pleistocene megafauna around 10,000 BP.

The Pleistocene Fauna of the Taimyr Peninsula

The Taimyr Peninsula in the Far North of Siberia is one of the most interesting places where the rich Pleistocene Mammoth Fauna can be found. This fauna is well known from many sites in the Northern Hemisphere (Europe, Asia and North America). It is generally known that the frozen ground preserves remains of animals such as woolly mammoth, woolly rhinoceros, steppe bison, reindeer, etc., in excellent condition. Sometimes, soft parts such as skin, fur and underfur, or internal organs are preserved, providing paleontologists with a lot of information on the exterior of these animals that lived on the so-called Mammoth Steppe between 110,000 and 10,000 BP. A good example is the preservation of almost complete mammoth carcasses, amongst others the famous mammoth baby “Dima” and the “Berezovka Mammoth”, both now curated in the Zoological Museum of Saint Petersburg. Thousands of studies have been published on the Mammoth Fauna and the Mammoth Steppe by experts from all over the world.

The Mammoth Fauna of Taimyr is of great interest for understanding why these impressive animals became extinct around 10,000 BP. At that time, a dramatic climatic change took place and the paleogeography of the world changed accordingly, e.g., Eurasia and North America became separated by the Bering Strait and the Bering Sea. The composition of the Mammoth Fauna in Siberia, Alaska and Europe consists of horses, steppe bison, reindeer, mammoth and other species. To the other species belonged, amongst others, the musk-ox which became extinct in Europe and Asia around 8,000 BP with the exception of the Taimyr Peninsula and some northern parts of Yakutia. There the musk-ox disappeared around only 3,000 BP. In Pleistocene Alaska and Europe this animal was rare because it invaded occasionally only, but in Siberia it was common. It survived in North America and it became a relict of the Ice Age, adapted to the extreme cold of the tundra. The answer to the question of the extinction is still unknown.

The first information about the mammoth fauna of the Taimyr Peninsula was reported in 1843 when Alexander Middendorf traversed more than 2000 km in this remote area. His expedition found a mammoth skeleton on the River Nizhnaya Taimyra. It was the first

documented find of mammoth remains on Taimyr. One of the most representative mammoth finds was made in 1908 on the Western Taimyr, when an expedition of the Russian Academy of Sciences excavated on the River Mokhovaya an adult mammoth male skeleton with soft tissues. During Soviet time many paleontological and geological expeditions worked in Taimyr. In 1948 a complete mammoth skeleton was found along the River Schrenk; this find gave birth to a special scientific committee, the Mammoth Committee of the Russian Academy of Sciences. In the late 1970s it was headed by Prof. Nikolai Vereshchagin, who organised an expedition to excavate the most complete mammoth carcass of Taimyr. After this find in 1977 no representative parts of mammoth carcasses were found in this vast region until 1997.

New discoveries of mammoths

The Jarkov Mammoth

In 1997 the Jarkov Mammoth was discovered by the Jarkov family. It was excavated by CERPOLEX / Mammuthus in 1998 and 1999 (Mol *et al.* 2001). Since that publication, new investigations took place, including defrosting of the block in the ice cave. We present the following results:

The geology of the block

The block containing the Jarkov Mammoth was geologically mapped and studied using field methods. It contains four sedimentary units, reflecting different genetic processes and geological origin. (1) The lowermost horizon (up to 140 cm thick) is a grayish brown silty clay. At a level below the actual block, it contained fossil plant remains that have been radiocarbon dated to ca. 27,000 BP. In the eastern section of the block, a gravel interfingers with the clay. This lowermost sedimentary unit is of fluvio-limnic character. The plant remains indicate a relatively warm period prior to the Sartanian (late Weichselian, 18,000 - 12,500 BP). (2) The next youngest horizon (up to 35 cm thick) is a pale brown clayey silt, which occasionally exhibits horizontal bedding. The layer is an aeolian sediment indicating dry and cold climatic conditions, most likely of Sartanian age. (3) The third horizon (up to 25 cm thick) is a clearly laminated silty-fine sand. Cross-bedding is visible in the western section of the block. The sediment was transported and deposited by shallow water of moderate current strength. This unit seems to have been produced by reworking of windblown sediment originating from the horizon immediately below. It indicates a depositional setting involving flowing water and most likely was deposited during summer. Units (1)-(3) predate the Jarkov mammoth and have not produced remains of larger vertebrates. (4) The uppermost horizon, containing the remains of the Jarkov Mammoth, has a total thickness up to 160 cm, although only the lowermost part (maximum 40 cm thick) is represented in the block itself, as the overlying part had been removed during the initial excavation. It is formed by a dark to pale-brown silty clay with a texture suggesting solifluction. After death and subsequent burial of the mammoth, solifluction processes disarticulated the cadaver and spread the remaining fragments over an area larger than the surface of the block. In the northwestern part of the block, the uppermost part of the laminated sand (3) was affected by solifluction. In the northern section of the block, ice is exposed (up to 120 cm thick). The ice is contemporary with, or younger than, the lowermost sediment layer (1). The Jarkov Mammoth cadaver was buried at least 300 km from the North Taimyr ice marginal zone (NTZ *sensu* Alexanderson *et al.* 2001, 2002), which was formed by the youngest advance of a relatively thin ice sheet that originated from the shelf of the Kara Sea

inundating the area of the current Taimyr Peninsula from the north/northwest during the last global glacial maximum (LGM).

Remains of the Jarkov Mammoth

The following remains (followed by the CERPOLEX / Mammuthus catalogue number) of the Jarkov Mammoth have been excavated: Left tusk (2001/341), right tusk (2001/342), maxilla with M3 sin. et dext. (2001/339), mandibula (2001/340), vertebra thoracalis (2001/323), costae (2001/324 to 2001/337), radius dext. (2001/321 + 2001/338), ulna dext. (2001/322). The block is containing many non-numbered skeletal parts and soft tissue. The block is numbered 2001/XXXA. These remains are stored in the underground ice cave in Khatanga. Samples of both bones and hair/wool have been taken for DNA research by Ross MacPhee (American Museum of Natural History, New York) and by Regis Debruyne (Muséum National d'Histoire Naturelle, Paris). Several samples of the tusks have been drilled out by Daniel Fisher (Ann Arbor, Michigan) for tusk analysis. Results will become available in the near future. About 15% of the upper layer of the block has been defrosted so far. The sediments from the block are stored in frozen condition in the ice cave.

Paleoecological results

Microfossils (pollen, algae, fungal spores) were studied in sediment samples taken from between the hairs of the Jarkov Mammoth. The analysis of microfossils was combined with the identification of fruits, seeds and vegetative plant remains. The pollen spectra are dominated by Poaceae, *Artemisia* and *Papaver*. Macrofossils of these taxa were also present. Mosses such as *Racomitrium lanuginosum*, *Pogonatum* cf. *P. urnigerum* and cf. *Polytrichum piliferum* indicate dry, sandy or stony environments, with cryogenic phenomena as well as disturbance as a consequence of trampling or grazing. The vegetation reconstruction based on the recorded microfossils and macroremains indicates a steppe (cool and dry climatic conditions), and this fits well with the reconstructions based on palynological studies of lake sediments in Taimyr (Andreev *et al.* 2002; Hahne and Melles 1999). But some mosses (*Calliargon giganteum*, *Drepanocladus aduncus*, *Rhizomnium pseudopunctatum*) and the alga *Pediastrum* indicate that some wet sites were also present in the predominantly dry landscape of Taimyr. The abundance of ascospores of the dung-inhabiting fungus *Sporormiella* (Davis 1987) and *Sordaria* type (Van Geel 2001, Van Geel *et al.* 2003) is a clear indication of a high population density of herbivores.

Fishhook Mammoth

The Fishhook Mammoth is a $20,620 \pm 70$ BP old woolly mammoth carcass (Mol *et al.* 2001, MacPhee *et al.* 2002). It was discovered in the estuary of the Upper Taimyra River, in 1990 and some parts of the carcass were removed in 1990 and 1992. After the site had been flooded for 8 years, it was rediscovered in 2000. In May 2001 the remains were excavated under extreme cold conditions as a part of the CERPOLEX / Mammuthus programme "Who or What Killed the Mammoths". The ground-penetrating radar (GPR) technique was firstly used to accurately locate the bones and tissue of the carcass. The remaining parts of the carcass, including soft tissue, fur and underfur were extracted from the frozen ground together with the surrounding sediments to learn more about the environment and the time of death of the Fishhook Mammoth. One block of approximately 1100 kg with a hind part of the Fishhook Mammoth was airlifted and put

on a truck that drove it to the ice cave in Khatanga where it is stored under controlled conditions. The expedition and the first results on the investigations on the Fishhook Mammoth were published by Mol *et al.* (2001). The block was cleaned in the summer of 2000. Part of the skeleton is still in anatomical position, and among other bones, 6 vertebrae thoracalis, 2 vertebrae lumbalis, and 16 ribs are exposed. It became clear that a lot of soft tissue is preserved in this block of frozen sediment, including remains of the stomach and stomach contents. It is interesting that some internal organs can be seen in this block, such as some intestines still filled up with digested food remains.

The second aspect of GPR application consisted in sounding the block with the Fishhook Mammoth remains in order to define the detailed distribution of the bones and tissue, valuable information for researchers in charge of excavation work. The results of using GPR for paleontological research in the permafrost were published by Grandjean *et al.* (2003). The encouraging results open up various perspectives for using GPR in expeditions in the Far North of Arctic Siberia. Grandjean *et al.* demonstrated that the GPR technique operated at 900 Mhz is well suited to sounding the upper few meters of permafrost. Even though radar penetration is not very deep due to the dielectric properties of the permafrost, it is sufficient to locate mammoth or other mammal remains within the layer where it is technically possible to extract them.

The pollen spectrum of the sampled stomach content of the Fishhook Mammoth was completely dominated by grasses (97.8 % Poaceae). Some clusters of unripe grass pollen were found in the pollen slides. This may indicate that the animal died in the flowering season of the grasses. The pollen spectrum from the stomach may be strongly biased by the food preference of the mammoth and therefore cannot be considered as indicative for the regional vegetation pattern. Nevertheless, the conclusion can be made that the landscape was very poor in trees. Apart from grass pollen low amounts of other herbaceous plants were also recorded: *Artemisia* (0.2 %), Asteraceae liguliflorae (+), Caryophyllaceae (1.0 %), Ranunculaceae (0.5 %), *Rumex acetosa* type (0.2 %), Liliaceae (0.2 %) and *Polemonium* (+). Some ascospores of the dung-inhabiting fungus *Sporormiella* (illustrated by Van Geel, 2001) were found. The matrix of the stomach sample from the Fishhook Mammoth consisted of a mass of unidentifiable grassy material. Among the identifiable remains were leaves of *Dryas octopetala* (dryad), *Salix* sp. (willow), *Betula nana* (dwarf birch), *Vaccinium* species, a catkin of *Alnus fruticosa* (alder), and needles of *Larix* (larch). The sample also contained a large number of mosses, as well as some inflorescences of *Polygonum viviparum* and seeds/fruits of about 15 taxa of other herbs. Among these are at least four species of grasses, two Cyperaceae (sedges), two Juncaceae (rushes) and *Papaver radicum* (arctic poppy). Furthermore, droppings of lemmings were found as well as several remains of Coleoptera (beetles).

The conclusion from the palynological analysis may be supplemented as follows: the Fishhook Mammoth had been grazing a moist, open vegetation dominated by grasses, with a lot of mosses in the ground cover. However, the presence of vegetation types of dry ground, as well as border scrub of forest tundra is also reflected by the plant remains. The find of *Larix* is especially interesting, because the site where the Fishhook Mammoth was found is situated at about 200 kilometres north of the present timber line.

Nikolai Mammoth

Another (partial) skeleton of a woolly mammoth was found during the 2002 field campaign by Nikolai Rudenko, working with the CERPOLEX / Mammuthus team. On the west bank of Lake Taimyr, a pair of tusks were found, together with the mandibula and some other parts of the skeleton. Other remains are still hidden in the permafrost at the locality near Cape Sablera. The tusks are spirally twisted and one of them is missing a small portion of the tip. The measurements are: c. 283 cm for the right one and c. 253 cm for the left one. The diameter for both tusks at the beginning of the pulp cavity is 10 and 11 cm. The pulp cavity is not deep, and the length, diameter and curvation of the tusks point to an old male individual. The preservation of the ivory is excellent. The mandibula with the molars m3 sin. et dext., indicate that the animal died at an age of 40 - 42 AEY. The state of preservation of the mandibula and its molars is excellent. An expedition to the site is planned for the near future to take out the other remains of the Nikolai Mammoth.

Holocene Mammoths

Holocene woolly mammoth have been reported from the Taimyr Peninsula by Sulerzhitsky and Romanenko (1997). The youngest record dates 9670 ± 60 yr BP (GIN-1828). The youngest bone of a woolly mammoth, collected by us on the Taimyr Peninsula, is a lower jaw. This jaw appeared to be of an extremely small specimen, probably an old female individual. The jaw was dated by means of ¹⁴C at Groningen University and proved to be 9,920 ± 60 BP (Laboratory # GrA-17350/DM5, 13delta: -22.80 ‰). This result shows that the woolly mammoth occurred on Taimyr until the beginning of the Holocene. A short description and comparison with other small mammoth remains was published by Reumer and Mol (2001).

Taimyr Megafauna Investigations

Vereshchagin (1959) published a paper on the Late Pleistocene megafauna of the Taimyr Peninsula. He listed the following species and the percentages of recovered skeletal remains for these species: *Alopex lagopus* (14,3 %), *Lepus timidus* (3,9 %), *Elephas primigenius* (11,7 %), *Equus caballus* (27,2 %), *Bison priscus priscus* (1,3 %), *Bison priscus* subsp. indet. (3,9 %), *Ovibos moschatus* (14,3 %), *Rangifer tarandus* (20,8 %), *Monodon monoceros* (1,3 %), *Delphinapterus leucas* (1,3 %).

In the 2000, 2001 and 2002 field campaigns the team of CERPOLEX / Mammuthus collected thousands of fossil bones at several localities on the Taimyr Peninsula. A total of 623 items have so far been described in our catalogue (as by August 2002; several numbers bear sub-numbers); *Mammuthus primigenius* (395 specimens = 63,41 %), *Ovibos moschatus* (103 specimens = 16,54 %), *Equus cf. caballus* (57 specimens = 9,15 %), *Rangifer tarandus* (34 specimens = 5,45 %), *Bison priscus* (26 specimens = 4,17 %), *Alces alces* (5 specimens = 0,8 %) and *Canis lupus* (3 specimens = 0,48 %). Several remains of small mammals (including *Lepus timidus*) and of birds have been collected but have not yet been identified.

New Results

- 1) New for the fauna of the Late Pleistocene *Mammuthus* Fauna is the moose, *Alces alces* (for radiocarbon dates see MacPhee *et al.*, 2002). These finds represent the northernmost record of fossil moose in Eurasia (compare Kahlke 1999).
- 2) The most abundant species in the list of Vereshchagin (1959) is the horse (*Equus caballus*), followed by reindeer (*Rangifer tarandus*), musk-ox (*Ovibos moschatus*) and the polar fox (*Alopex lagopus*) and then the woolly mammoth (*Mammuthus primigenius*).
- 3) The most common species, collected during the field campaigns in the period 2000-2002 by CERPOLEX / Mammuthus, is the woolly mammoth (*Mammuthus primigenius*), followed by the musk-ox (*Ovibos moschatus*), horse (*Equus cf. caballus*), etc. (see above).
- 4) Compared to other regions of the northern hemisphere, e.g., Western Europe, *Ovibos moschatus* was very common during the Late Pleistocene in the far north of Siberia.
- 5) The woolly rhino, *Coelodonta antiquitatis*, common in Eurasian faunas with the woolly mammoth, is unknown from the Late Pleistocene of the Taimyr Peninsula, as is the case for North America. A well preserved cranium of the woolly rhino, which is stored in the Historical and Natural History Museum of Dudinka (South-Western Taimyr), was not collected on the peninsula.
- 6) The steppe bison, *Bison priscus*, lasted in eastern Taimyr until the beginning of the Holocene. The youngest radiocarbon date is $8,810 \pm 40$ BP (B-148623) for a well preserved horn sheath.
- 7) MacPhee *et al.* (2002) presented 75 new radiocarbon dates, among others 46 dates for the woolly mammoth, based on the late Quaternary mammal remains recovered in the eastern Taimyr Peninsula and adjacent parts of the northern Siberian lowlands, including *Mammuthus primigenius*, *Bison priscus*, *Ovibos moschatus*, *Alces alces*, *Rangifer tarandus*, *Equus caballus* and *Canis lupus*.

The collections of CERPOLEX / Mammuthus are stored in the ice cave in Khatanga, Taimyr Peninsula at -11° to -15°C . In our opinion this is the best place to keep these Late Pleistocene faunal remains in the best state of preservation for future research (radiocarbon dating, DNA research).

Other Interesting Finds

Rangifer tarandus

During the summer of 2001, dry weather conditions led to a rapid lowering of the water level of Lake Taimyr. In August of that year, on the northwestern shore of the lake and 3 km NE of Cape Sablera ($74^{\circ}31'$ N, $100^{\circ}30'$ E), an almost complete *Rangifer tarandus* skeleton was discovered in silty sediments of the defrosted lake bottom. The find (CERPOLEX / Mammuthus collection number: 2002/471) represents the first fossil reindeer skeleton known so far from Taimyr, and probably from Arctic Siberia in general. The stomach contents were radiocarbon dated at Groningen University to $13,040 \pm 80$ BP (AMS date GrA-19245). The anatomical arrangement of the skeletal elements indicates they have not been disturbed by either cryogenic or solifluction processes. The skull, which includes a poorly developed antler fragment and the mandible, was excavated, as were the extremities with an almost complete set of hooves (including the after claws), parts of the coat and the contents of the intestinal tract. This specimen

bridges the previously existing chronometric gap in radiocarbon dated *Rangifer* finds from Taimyr between 20,250 and 8,700 BP and supports the theory that this species occurred at Taimyr, without interruption, since at least 36,000 BP (see MacPhee *et al.* 2002).

The pollen spectrum of a sample of plant remains in the stomach was dominated by grasses (Poaceae 54.3 %) and *Artemisia* (30.9 %), indicating an open steppe landscape. However, birch (*Betula*) pollen reached 7.4 % and many small wood fragments of cf. *Betula* in the pollen slides indicate that shoots of Birch were also used as a food source. Other taxa recorded in the pollen slides were Cyperaceae (5.9 %), Ranunculaceae (0.4 %), *Salix* (0.3 %), *Alnus* (0.3 %) and *Valeriana* (+). Remains of the algae *Pediastrum* and *Botryococcus* will have entered the stomach with drinking water. Spores of the fungus *Sporormiella* indicate the presence of dung in the area where *Rangifer* was grazing and may even reflect a relatively high population density of mammals (Davis 1987).

The matrix of the macroscopic plant remains from the stomach consisted of a mass of small twigs, mainly *Betula* and *Salix*, together with very few grass remains and some mosses. The assemblage of macroscopic remains reflects different types of environment: open water (fruits of *Potamogeton* sp., *Ranunculus* subg. *Batrachium*, *Hippuris vulgaris*, ehippia of *Daphnia* sp.), mesotrophic bank vegetation (*Menyanthes trifoliata*, *Potentilla palustris*, *Carex aquatilis*), but also vegetation of higher, drier ground, as indicated by *Cassiope tetragona*, *Dryas octopetala*, *Minuartia rubella*. The conclusion that the reindeer used shoots of shrubs as a food source is corroborated by the finds of catkins and achenes of *Alnus*, fruits and bud scales of *Salix*, and *Betula* seeds.

Ancient DNA of a woolly mammoth femur (2002/473 Arilakh)

Methodological background

Conservation of DNA in mammoth carcasses or isolated bones has been a source of many developments in sequencing of ancient DNA for the last ten years (Greenwood 2001). Independent studies have revealed that, notwithstanding that specimen age plays an obvious role in DNA preservation, three categories of other factors have to be taken into account: (1) fossilisation, (2) conservation conditions through time, and (3) recent preservation. In the first category we include environmental conditions of the deposit and quickness of burial. Nature of the deposit, erosion and climatic variations are considered in the second category, while the third one includes the treatments and conditions of conservation subsequent to the “discovery” of the material. The conditions for fossilisation are most of the time speculative because, with few exceptions (like Jarkov or Fishhook Mammoth carcasses), most of the mammoth discoveries are isolated bones exposed as a result of solifluction and/or erosion. At most these conditions can be correlated to the completeness of the carcass, a nearly complete mammoth indicating a very fast burial in the frozen ground, away from vultures and oxidation processes. As for the conditions of preservation since the Late Pleistocene, we might consider that they have been comparable for all specimens kept in permafrost with temperature varying between -15 and -30°C . This means that “class (2)” criteria may be disregarded as a whole in a comparative approach to Siberian mammoth DNA conservation. Recent preservation (3) is a parameter to be evaluated for different mammoths or different tissues submitted to several treatments.

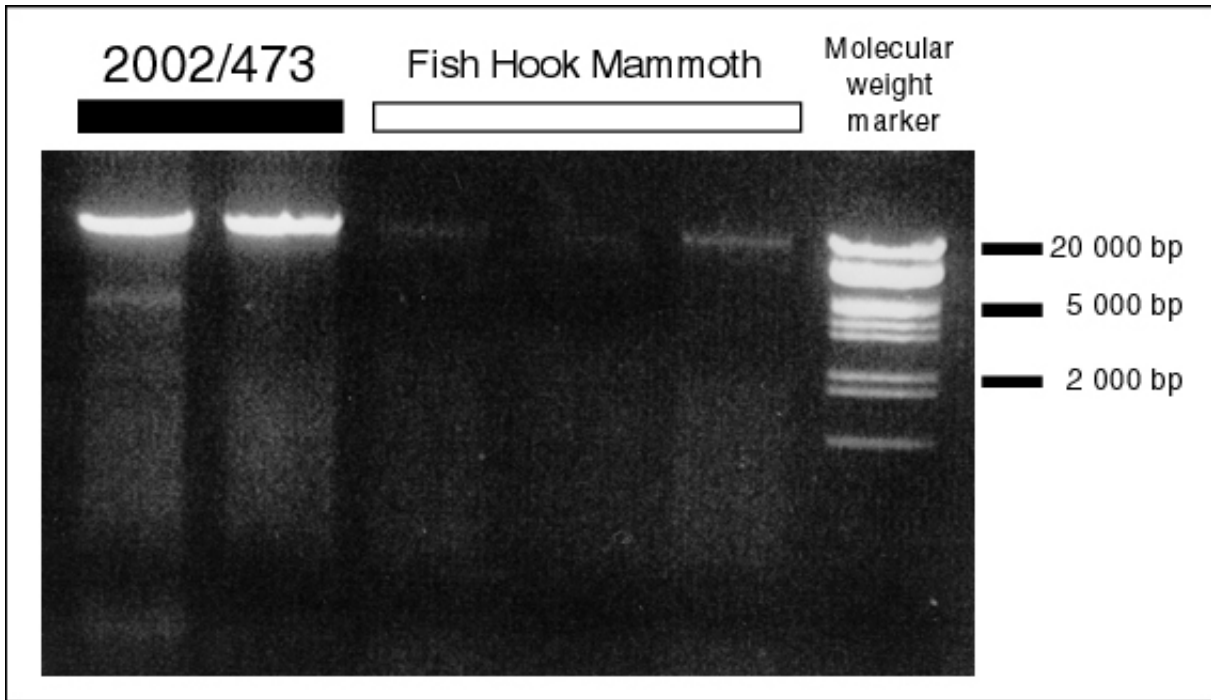
Material

Here we focus on the quality (in terms of maximal size of amplifiable mitochondrial DNA (Debruyne *et al.* 2003)) of the DNA to be retrieved from an isolated femur of a young mammoth collected near Lake Arilakh (East of Lake Taimyr) as reference 2002/473 by the CERPOLEX / Mammuthus programme. This specimen, the so-called Arilakh Mammoth, is dated ca. 50,000 BP (see below), like the complete carcass of the Lyakhov Mammoth preserved at the French National Museum of Natural History. Interestingly, a previous study has shown that no mtDNA fragment longer than 200 bps could be amplified from the Lyakhov Mammoth skeleton. Bone and bone marrow of specimen 2002/473 then have been collected in order to establish the range of mtDNA fragments we could retrieve.

Results

First, our analyses have confirmed that bone as well as marrow contain DNA of high molecular weight through a modified phenol/chloroform extraction protocol (Hassanin *et al.* 1998), although concentration appears to be slightly greater in bone (Figure 1). This template DNA has been submitted to PCR amplifications of different mitochondrial cytochrome *b* fragments ranging 100 bp up to 800 bp. Positive results have been observed for different fragment sizes up to 620 bp (that is to say, three-fold the maximum length obtained for the Lyakhov Mammoth). Expecting sequencing results on the fragments to discard the hypothesis of exogene contamination, we will not draw strong hypotheses to explain this pattern. However, we can propose a plausible explanation relative to the differential preservation of these mammoths. As previously advocated, it is likely that the initial burial of the Lyakhov mammoth proceeded in best conditions so that the limited results obtained for this specimen in comparison to 2002/473 should result from the differences in recent preservation of this material. While the Lyakhov Mammoth was excavated between 1908 and 1910 and kept in ambient conditions since then, the femur 2002/473 has been put back in frozen conditions just a few months after its discovery by a fisherman near Lake Arilakh. Samples taken from the bone and the marrow have been put in ethanol 70% prior to sending to the laboratory in France where they were kept at -20°C until treatment. Our preliminary results show how post-collection conservation of fossil material might play a decisive role in the recovery of exploitable DNA.

Figure 1



A piece of bone from the Arilakh Mammoth (2002/473) has been submitted to the Groningen Radiocarbon laboratory. We performed in total 4 measurements of the ^{14}C content. First, bone marrow was sampled. The sample material underwent standard chemical pretreatment (Mook and Stuiver 1983), and was combusted into CO_2 . A few ml of this CO_2 was first transformed into graphite and analysed by the AMS facility (Van der Plicht *et al.* 2000), because this way a first date could be obtained relatively quickly. This AMS analysis was done in duplo. The large gas sample was also measured by the proportional counters in the conventional laboratory (Van der Plicht *et al.* 1992). The usual datable fraction for bone, however, is bone collagen. From a piece of about 10 grams of bone, collagen was extracted following the method developed by Longin (Mook and Stuiver 1983). The results of the ^{14}C measurements are shown in table 1:

Table 1

lab nr.	method	material	^{14}C activity ($^{14}\text{a},\%$)	^{14}C age (T,BP)
GrA-21232	AMS	marrow	0.010 ± 0.100	>49,500
GrA-21293	AMS	marrow	0.000 ± 0.080	>51,700
GrN-27409	Conv.	marrow	0.231 ± 0.086	$48,800^{+3700}_{-2500}$
GrN-27520	Conv.	collagen	0.121 ± 0.068	>47,900

The errors quoted are 1sigma (1σ). The Radiocarbon ages are reported in BP, the timescale defined for ¹⁴C. It turns out that the measurements are very close to the detection limit (ca. 50,000 years) for the ¹⁴C method. Three measurements (both AMS marrow dates, and the collagen) show infinite age on the ¹⁴C timescale; one measurement (conventional marrow) shows a finite age. The problem is how to interpret these results: is the age of the mammoth around, say, 50,000 BP, or infinite on the ¹⁴C timescale (i.e., in theory any age above 50,000)?

In order to discuss this question, we first have to explain some ¹⁴C conventions. The Radiocarbon ages (T) are calculated from the so-called ¹⁴C activities (¹⁴a), which are the actually measured quantities. The ¹⁴C activity is the relative radioactivity, measured relative to the standard radioactivity, and ranges between 0 and 1 (or 0 and 100%; Mook and Van der Plicht 1999). The standard activity corresponds to 100% (which in turn corresponds to 1950 AD or 0 BP); the background corresponds to no activity, or 0%. These activities are also shown in the table. The activities are the result of a measurement, and therefore have a measurement error. The errors shown in the table are 1sigma (1σ) errors, which in statistical theory is a way of expressing that the chance that the true result is within the ±1σ range is 68%. One can also quote 2σ errors, which means that this chance is 95%.

The ¹⁴C ages T are calculated from the ¹⁴C activities ¹⁴a from the simple formula $T = -8033 \ln ^{14}a$, which is the inverse form of the exponential decay law of radioactivity. The number 8033 is $T_{1/2} / \ln 2$, with $T_{1/2} = 5568$ years (the conventional ¹⁴C half-life). For ¹⁴C ages which are not so old, the measured activity plus error $^{14}a \pm \sigma(^{14}a)$ easily translates into an age $T \pm \sigma(T)$. For old samples, however, the errors in T become asymmetric. This is, for example, the case for GrN-27409. For measurements close to the dating limit the error estimation becomes problematic. For example, the result for GrA-21232 is: $^{14}a = 0.01 \pm 0.10 \%$ (see Table 1), so that the 1σ range includes negative activities. These do not exist, and correspond to ages which are infinite. For this reason, the following convention has been agreed, based on the sigma value $\sigma(^{14}a)$ of the ¹⁴C activity ¹⁴a (Olsson 1989):

Table 2

when	...then take for ¹⁴ a	...to calculate age T
$^{14}a < 0$	$^{14}a^* = 2\sigma(^{14}a)$	$T > -8033 \ln ^{14}a^*$
$^{14}a < \sigma(^{14}a)$	$^{14}a^* = ^{14}a + 2\sigma(^{14}a)$	$T > -8033 \ln ^{14}a^*$
$^{14}a < 2\sigma(^{14}a)$	$^{14}a^* = ^{14}a + 2\sigma(^{14}a)$	$T > -8033 \ln ^{14}a^*$

$^{14}a > 2\sigma(^{14}a)$	$^{14}a \pm \sigma(^{14}a)$	$T = -8033 \ln ^{14}a$ $\sigma^+(T) = -8033 \ln (^{14}a - \sigma(^{14}a))$ $\sigma^-(T) = -8033 \ln (^{14}a + \sigma(^{14}a))$
$^{14}a \gg 2\sigma(^{14}a)$	$^{14}a \pm \sigma(^{14}a)$	$T = -8033 \ln ^{14}a$ $\sigma^+(T) = \sigma^-(T) = \sigma(T)$

Note that also when $\sigma(^{14}\text{a}) < ^{14}\text{a} < 2\sigma(^{14}\text{a})$, an age limit should be given despite the fact that $\sigma^+(\text{T})$ and $\sigma^-(\text{T})$ can be calculated. The reason is that for these cases $2\sigma(\text{T})$ is infinite because $^{14}\text{a} - 2\sigma(^{14}\text{a})$ is negative. The bottom part of table 2 is the "normal" situation where activities are not negative, and is included here for completeness. Following these conventions, the ^{14}C ages in Table 1 have been calculated based on the activities and their errors.

This convention had to be explained in order to further interpret the results measured for the Arilakh Mammoth. Normally, i.e., for ages which are not too old, the ages can be averaged when we have multiple measurements. The average age is then determined with better precision. For the Radiocarbon ages given in Table 1, this is obviously impossible. For such cases, one has to average the measured activities ^{14}a . From this averaged value one can then calculate the averaged ^{14}C age, again taking into account the conventions from Table 2. The final results for the Arilakh Mammoth are shown in Table 3. After calculating the weighted average for the 4 measured results, the resulting error now becomes significantly smaller. They averaged $^{14}\text{a} > 2\sigma(^{14}\text{a})$, so that the (average) ^{14}C age is now very old but finite. The calculated ages are rounded off to the nearest 100.

Table 3

	^{14}C activity (%)	^{14}C age (BP)
averaged result	0.096 ± 0.041	$55,800^{+4500}_{-2900}$

We conclude that the ^{14}C age of the Arilakh Mammoth is $55,800^{+4500}_{-2900}$ BP. The errors quoted are 1σ . This means that the probability that the true age lies within the range 52,900 - 60,300 BP is 68%. For 2σ (or 95% probability), this range is 50,900 - 71,300. Finally, we can state for completeness that the chance that the true age is older than 71,300 BP is 2.5%; also the chance that the true age is younger than 50,900 BP is 2.5%.

Late Pleistocene vegetation and climate in Taimyr lowland and the interaction between vegetation and megafauna

Several continuous sedimentological records from lakes were studied in order to reconstruct vegetation and climate of Late Pleistocene (Middle and Late Weichselian) and Holocene lowland Taimyr (Andreev *et al.* 2002, in press; Hahne and Melles 1997, 1999; Kienast *et al.* 2001; Niessen *et al.* 1999; Siegert *et al.* 1999). Those studies are of considerable value for understanding the environment of the Late Pleistocene fauna and the interrelation between fauna and vegetation (Guthrie 2001). The pollen diagrams from lake sediments show that most of Taimyr has been unglaciated since Middle Weichselian time. Based on geological data Möller *et al.* (1999) and Niessen *et al.* (1999) found no evidence for extended glaciation during the last glacial maximum. Only the northern and northwestern coastal lowlands were covered with a thin ice cap (Alexanderson *et al.* 2002). Dryness prevented the formation of large ice sheets (Svendsen *et al.* 1999). The vegetation during the Weichselian was dominated by taxa indicating dry, cold steppe conditions (mainly grasses and *Artemisia*). Tundra plants were of minor importance and mainly occurred at humid sites. During two less cold, more humid Middle Weichselian interstadials there was a temporary increase of Larch, Birch and Alder, but the pollen records during those phases still reflect a rather open

landscape. After the transition from the Late Weichselian to the warmer and more humid Holocene a remarkable and dramatic change took place. The herbaceous steppe vegetation declined and shrub and tree Birches and Alder expanded, together with tundra species.

For understanding the high population density and final collapse of the Late Pleistocene megafauna of Taimyr, insight into the interaction between climate, vegetation and herbivores is essential (Guthrie 1990, 2001). The climate-induced transition from dry steppe to moist tundra at the start of the Holocene had strong effects on the life conditions of the large herbivores. Snow cover during winter was thin or even absent during the dry climate of the Late Weichselian, and thus food remained available for grazing animals. Thick snow cover was problematic for the herbivores after the transition to the Holocene. The change in humidity played another important role: the dryness of the Weichselian period had positive effects on the length of the growing season, while, after the transition to the Holocene, plant growth could only start during late spring, after the thick snow cover had melted. Intensive grazing during the Weichselian had strong effects on the vegetation, because of the accelerated nutrient cycling (recorded fungal spores point to high production of dung). In addition, grazing stimulates grass species (Poaceae) because they have their growing points just near their roots. Many tundra plants have their growing points at the end of their stems, for which reason those species are easily damaged by grazing. The moisture-demanding and less palatable tundra plants could expand only after the early Holocene decline of the herbivore population density. Wet conditions and low grazing pressure caused the development of thick (insulating) layers of plant remains on top of the soils, which hampered early and deep thawing of the soils and thus also resulted in nutrient-poor conditions. Climate change probably was not the only factor causing the crash of the megafaunal populations, but the effects of increased temperatures and precipitation - as is evident from the pollen records from Taimyr - will have been an important factor in the megafaunal collapse at the Pleistocene / Holocene boundary. The climate change at the start of the Holocene was a major factor in the observed vegetation change, but the climatic effect was amplified as a consequence of the reduced population density of large herbivores.

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SOME PRIMITIVE MAMMOTH TEETH FROM OLD CROW LOC. 47, NORTHERN YUKON

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Old Crow Locality 47 is located on the right bank of Old Crow River, 275 km by river above its confluence with Porcupine River, and a few km below the mouth of Surprise Creek, in Old Crow Basin, northern Yukon. It is an eroding river bluff about 2 km long and 24 m high. In 1981, two mandibular molars were found *in situ* in the fill of a small channel near the downstream end of the section. Their occlusal patterns are so similar that they are suspected to be the left and right lower molars of a single individual. In 1985, two maxillary molars with very similar occlusal patterns were found eroded out on the river bank at the same location, and these are suspected to be from the same individual mammoth.

The presence of enamel islets in plates 8-12, the low lamellar frequency (6.4), and high enamel thickness (2.2 mm) indicate a relatively primitive stage in mammoth development compared to most molars recovered from Old Crow Basin. Following Maglio (1973), they could be assigned to *Mammuthus armeniacus*. Following Kurtén and Anderson (1980), one would choose *M. columbi*. Using Agenbroad's (1984) scheme, the name would be *M. imperator*. After examining them at them at the XIIth INQUA Congress, S.D. Webb (1992) referred to them as *M. hayi*. From Churcher's (1986) study of Old Crow Basin mammoth teeth, one could choose *M. imperator*, *M. trogontherii*, or *M. armeniacus*. They are very similar to mammoth teeth from the Olyor Suite referred to the genus *Arctelaphas* (Sher 1986). Let's name that mammoth!

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THE MAMMOTH AND MAMMOTH FAUNA OF BELARUS

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Belarus is located between 56° 10' and 51° 16' north latitude and 23° 11' and 32° 47' east longitude. It covers a total of 207600 km². The remains of *Mammuthus primigenius* Blum. are found in more than 150 locations. The territory of Belarus was the central part of the European natural habitat of mammoth in the Pleistocene.

The most ancient remains of mammoth coincide with deposits of the end of the Middle Pleistocene. This record includes two finds from the localities Petrikov and Kobeljaki. In

the Petrikov locality the skeleton of a mammoth was found. It lay in Riss sandy deposits in a succession of river terrace deposits. The location Kobeljaki is situated in a high interstream area. It was formed due to erosion of Riss moraine. These beds are overlain by Wurmian loess.

Early Wurmian deposits with the mammoth remains comprise the other group of locations. The Rumlovka and Gralevo localities are typical. The remains are found in alluvial deposits of high river terraces.

The most abundant remains of mammoth are found in locations of the third group. Their geological age is Middle and Late Wurm. Deposits are of various genetic types.

An especially great concentration of remains is observed at stopping places of ancient humans. The absolute C¹⁴ ages are: for Smorgon remains – 37600-32900 and 19600-13500; and for Paleolithic stopping places – 26470-23430 (Kalinovsky, 1983).

The morphological parameters of teeth of *Mammuthus primigenius* are given in Table 1. The structure of all molar teeth is typical for mammoths. The characteristic features of this structure are high numbers of plates, narrow and high crowns, and thin and strongly folded enamel. Weak vertical partition of plates results in their forming an oval pattern on a chewing surface. These features can be primitive or progressive (V. V. Scheglova, 1961 and P.F. Kalinovsky, 1983), and that is the basis for distinguishing two subspecies of mammoth - *M. primigenius pavlowae* (early type) and *M. primigenius primigenius* (late type). The early type of mammoth is characterized by lower height of molar teeth, thick enamel, and lower numbers and frequency of plates on M₃³. For mammoths of the late type the opposite is found. One subspecies replaced another in the Middle Wurm. In Belarus the process of replacement did not have a precise geological boundary. This conclusion is made due to analysis of mammoth remains from well dated geological layers (vide Table 1).

In late-Riss deposits only remains of *M. primigenius pavlowae* are found. It is interesting that mammoth remains are not found in numerous sections of Eemian interglacial deposits in Belarus territory or in Poland (Kubiak, 1989). Here the remains of the forest elephant *Palaeoloxodon antiquus* Falcon are found. Mammoths of late type appeared in Belarus at the beginning of the Wurm. Originally the quantity of them was insignificant. In the Middle Wurm late-type mammoths amount to about 50 % and in the Late Wurm they prevailed.

The natural conditions of mammoth habitat have been researched in detail in Belarus. A mammoth skeleton from the Petrikov locality (Late Riss) contains humic sand in its stomach. Spore and pollen analysis was conducted on this humic sand. Obtained information is very valuable. The results of this analysis have revealed absolute domination of pollen of the Family Graminaeae, isolated grains of *Pinus* and *Alnus* pollen, and spores of *Sphagnum* and Polypodiaceae. It can be concluded that the local environment was made up of open landscapes with islets of woods. The mammal fauna of that time is found in many locations but it is of the same composition. Besides the mammoth, the fauna contained *Ochotona* cf. *pusilla* (Pall.), *Sorex* cf. *tundrensis* Merriam, *Lemmus sibiricus* Kerr., *Dicrostonyx simplicior* Fejfar, *Arvicola* cf. *terrestris* (L.), *Microtus* (St.) *gregalis* Pall., *M. oeconomus* Pall., and *Bison* sp. The composition of the fauna allows us to establish the character of biotopes: forest-tundra landscapes with different herb meadows on floodplains of rivers.

In the Early Wurm, Eemian wood vegetation became degraded. New rarefied forests of northern-taiga type with large zones of marshy tundras and dry steppes were formed and the canopy began to recover. The strong skins, meat and fat of mammoth were important to humans (San`ko, 1987). At that time the mammal fauna of Belarus contained: *Sorex cf. tundrensis* Merriam, *Neomys fodiens* (Penn.), *Ochotona cf. pusilla* (Pall.), *Spermophilus superciliosus* (Kaup.), *Arvicola aff. terrestris* (L.), *Lemmus sibiricus* Kerr., *Dicrostonyx cf. simplicior* Fejfar, *Lagurus* sp., *Microtus agrestis* (L.), *M. (St.) gregalis* (Pall.), *M. oeconomus* Pall., *Mustela nivalis* L., *Vulpes corsac* L., *Rangifer* sp., and *Mammuthus primigenius pavlowae*.

Thus evidence on both vegetation and faunal composition are important in reconstructing mammoth biotopes of the Early Valday.

Due to the middle and late Valdaian progressive cold snap a glacier was generated in northern Belarus 17000 years ago. Spore-pollen data allow us to conclude that dry periglacial tundra-forest-steppes gradually took the place of northern taiga forests. Besides mammoth, at that time the fauna of mammals contained *Ochotona cf. pusilla* (Pall.), *Spermophilus superciliosus* (Kaup.), *Dicrostonyx gulielmi* Sanf., *Lemmus sibiricus* Kerr., *Lagurus lagurus* Pall., *Microtus* (St.) *gregalis* (Pall.), and *M. ex. gr. arvalis-agrestis*.

In Middle and Late Valday time, mammoth became a game animal, the object of a regular hunt. A great quantity of mammoth remains is found in stopping places of Paleolithic humans (26470-23430 and 15660-14470). In the stopping place at Judinovo (Bryansk region, Russia) 30 skulls of mammoth were put tooth-ridge downwards to form the base of a human habitation. The long ribs were used to build interior walls of the house. Work instruments (e.g., needles, batons, scoops, arrow-heads) were made from mammoth tusks (Kalechits, 1984).

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Table 1. Measurements of molar teeth of *Mammuthus primigenius* Blum.

	Author							
	Materials of V.V. Scheglova, 1963	Materials of the authors	Materials of V.V. Scheglova, 1963	Materials of the authors		Materials of P.F. Kalinovsky, 1983		
	Locality							
	Petrikov	Kobeljaki	Rumlovka	Gralevo		Smorgon`	Pashino	Selische, Smorgon
	Tooth position							
	M ³	M ₃	M ₃	M ₁		M ₃ ³	M ₃ ³	M ³
				Left	Right			
Length of crown	251	--	274	156.5	156.0	265-290	142; 270	142-205
Width of crown	100	--	92	61.8	61.2	92-95	72; 100	71-89
Height of crown	211	--	121	--	--	120-150	93; 169	134-180
Number of plates	24	--	22	12	13	18-22	21; 24	21-25
Frequency of plates	6	6	7.5	9.5	10	6-7	7.5; 11	5.5-9.5
Thickness of enamel	2.0	.2	1.55	1.9	1.7	2.0-2.1	2.0; 1.2	1.6-2.2
Geological age	Q ₂ ²	Q ₂ ³	Q ₃ ²	Q ₃ ²	Q ₃ ²	Q ₃ ³	Q ₃ ⁴	Q ₃ ⁴

KOPACHIV – A NEW PALEOLITHIC CAMP OF MAMMOTH HUNTERS IN UKRAINE

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In summer, 2001, with the assistance of local inhabitants, a late Paleolithic human site was discovered in the village of Kopachiv, Kiev Region (in the area of the town of Obukhov), Ukraine. In the same years excavations were made at the site by researchers from the National Scientific Natural History Museum in Kiev (L. Rekovets, V. Nesin, A. Pashkov). The site is situated on the slope of a ravine with a well in the locality of Verem`e, about two kilometers west of the village. The slope of the ravine is filled with sub-aerial (loess-soil) deposits.

In the upper part of the excavation there is a layer of modern soil (up to one meter), and beneath that is loam (up to one meter thick) with numerous mole-hills. The loam lies on loesses up to eight (8) meters thick. The loesses are light in color, monolithic in structure, non-schistose, without carbonates. In the foot (base) of the loesses there are loams (about one meter thick) which rest on dark iron-rich sands with great erosion (about five meters thick). Under them there lies moraine made up of coarse-grained sand, pebbles and other inclusions (granites, chalcedony, clays, quartzites). At the base of these deposits there is a thin layer of dark sands, containing much manganese. All these alluvial and fluvial (fluvioglacial) deposits with great erosion lie on light-colored, plastic and structurally monolithic clays, the visible thickness of which is about five meters.

The cultural layer of the camp (site) was found in loess at a depth of about 3.5 meters. On the place of the cultured layer a skull of *Mammuthus primigenius* with the left tusk and molars (M3) a humerus, a tibia and a fragment of a tabular bone of this species were found. The right tusk of the mammoth had been withdrawn (removed) out of the alveolus (by man ?) and it has not been found so far.

The arrangement of the bones of the mammoth is compact and put in strict order. The humerus was placed perpendicularly under the middle part of the tusk. Probably it was a support when certain work was done on the tusk. The tibia was nearby, closer to the front part of the tusk.

The arrangement of the bones, the percussion marks on them, and polished areas on the bones testify to the fact that the site served as a place for making food, which is the most probable interpretation. There is every reason to believe that this place for working bones - ? was situated in the outlying part of the main camp (site), the traces of which have not been found for certain yet. However, there are data that show that tusks had previously been found near the place of the new discoveries.

The uniqueness of these finds lies in the fact that the remains include one of the largest individuals of *M. primigenius* from Ukraine. The skull belonged to a grown individual. Unfortunately, the skull is very poorly preserved (it was buried in loess !), so it was possible to study only its occipital part, the alveoli of the tusk, and molars (2 M3). The teeth have 22 enamel plates each, the width of each tooth is 105 mm. The length is 260 mm, the height of the crowns is 70 mm, the total height with roots is 160 mm. The enamel of the plates is noticeably crimped.

The left tusk is very well preserved, its outer length is 3050 mm, the inner length is 2450 mm, its curve is typical of the species of this age. The diameter of the tusk at its base is 210 mm, the diameter of the middle part is 175 mm, the distal part of the tusk is pointed, it has a typical beveled surface, which shows its functioning in conditions of snow-covered landscape. In the middle part of the tusk where the humerus is situated, traces of percussions and incisions (cuts) have been made with a sharp cutter. Similar traces of man's activity are also found on other bones. The absolute age of the bone remains is 13.2 ± 0.1 thousand years determined by C14, N 11200, Geol. Inst. Russ. Acad. of Scien.

Our research makes it possible to note two very important peculiarities. First, a new paleolithic camp (site), Kopachiv, which is likely to be an outlying part of a late Pleistocene settlement, the age of which is 13 thousand years. Second, remains of a

comparatively large (or maybe the largest) individual of *M. primigenius* has been found in loess deposits of Ukraine for the first time.

WOOLLY MAMMOTHS FROM THE UPPER PALAEOLITHIC SITE OF VOGELHERD CAVE, GERMANY

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Vogelherd Cave is one of many Palaeolithic sites located in the extensive karst systems of the Lone and Ach Valleys in southwestern Germany. In addition to a variety of other cold climate taxa, remains of *Mammuthus primigenius* make up a large proportion of the Aurignacian archaeofauna at Vogelherd and represent a minimum of 28 individuals. New analysis of the Vogelherd mammoths shows selective deaths from all age groups with a slightly higher frequency of infants and juveniles. Skeletal element frequencies reflect a variety of possible uses of mammoth resources, including but not limited to building materials, fuel, and food. Although sparse mammoth remains are found in all nearby cave localities, the extensive assemblage of tusk portions, cranial and post-cranial skeletal elements, and >100 molars from Vogelherd distinguishes the site, which suggests a different use of this cave during the Aurignacian period and raises questions about its place in the regional settlement system. The role of fluctuating environmental conditions is also evaluated, as the high frequency of tooth pathologies in the Vogelherd mammoths might be an indication that periodic physiological stress from nutritional or vitamin/mineral deficiencies influenced the location of mammoth herds on the landscape, providing natural death sites to collect bone and/or possibilities for opportunistic hunting.

PALEOECOLOGICAL IMPLICATIONS OF TOOTH PATHOLOGIES IN *Mammuthus primigenius*: EXAMPLES FROM CENTRAL EUROPE

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Several forms of pathologies have been documented in the teeth of *Mammuthus primigenius* from the late Pleistocene archaeological sites of Kraków Spadzista Street (B), Poland and Vogelherd Cave, Germany. Linear furrows in the crown cement are the most frequent pathology and the high incidence of this tooth defect, 50% and 74% of the specimens respectively, warrants investigation into their etiology. One possible cause of the furrows is a developmental defect such as hypoplasia, due to periodic physiological stress. Other potential sources of the furrows include cement decay from infection or impaction of food material in the gums and resorption of tooth cement. Apart from cause, the morphology of the cement furrows reflects regular rhythms of seasonal or annual

formation. The Kraków Spadzista Street (B) molars also exhibit several cases of severe malocclusion and formational defects such as twisted or malformed lamellae.

Tooth pathologies are relatively common in fossil proboscideans from Eurasia, and periodic physiological stress as a possible cause could have broad implications for the life histories of these animals. Such defects may have also played a role in interactions between mammoths and humans in that weakened animals presented prehistoric hunter-gatherers with possibilities for opportunistic hunting or natural death sites where bones could be collected. Kraków Spadzista Street (B) and Vogelherd Cave offer a unique opportunity to evaluate the implications of tooth pathologies in mammoths.

LARGE MAMMAL TURNOVER, DIVERSITY AND ELEPHANT DISPERSAL IN THE WESTERN MEDITERRANEAN: THE ITALIAN AND IBERIAN PENINSULAS

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The large mammal successions that occurred during the Plio-Pleistocene on the Italian and Iberian peninsulas are correlated with climatic changes and compared with respect to patterns of mammalian species turnover, richness, and faunal composition. From the end of the Miocene, both peninsulas formed a kind of “cul de sac” where most of the Eurasian dispersal events that affected Western Europe ended. The peculiar morphology of the Italian peninsula and the presence of natural physical barriers affected the diffusion of several taxa and favoured local speciation. Additionally, Southern Europe was the refuge area for northern taxa during the Pleistocene glaciations. Therefore, their occurrence on the Italian or Iberian peninsula resulted from a previous route through France and central Europe, even if some dispersals from Africa were hypothesised (Palmqvist and Arribas, 2001)

On both the Italian and Spanish peninsulas, the most important faunal renewals took place at the transition from the early to middle Villafranchian (Early/Middle Pliocene), from the middle to late Villafranchian (latest Pliocene), and from early to middle Galerian (Early/Middle Pleistocene) Mammal Age transitions. The early-middle Villafranchian paleocommunity reorganisation can be correlated with the major pulse in the late Neogene glacial trend and with concurrent environmental changes taking place around 2.6/2.5 Ma. This reorganisation can be considered a starting point for the dispersal phases that occurred during the Middle and Late Pliocene. The first occurrence of the primitive elephant, *Mammuthus meridionalis gromovi*, was a bioevent characterising both the Italian and the Iberian peninsula. Mammoth was first recorded in Montopoli (Italy, Palombo, 1995 and references therein) and in Huélago (Spain, Sesé *et al.*, 2001).

During the middle Villafranchian (Late Pliocene), the forest taxa diminished greatly and several new herbivores, including large-sized taxa, appeared. The scarcity of *M. meridionalis* remains does not permit us to evaluate their morphological and biometrical range of variability.

Around 1.9-1.7 Ma (Olivola and Tasso FUs) in Italy both a turnover pulse and a clear increase in diversity can be detected. The structural change taking place at the beginning of the late Villafranchian is consistent with the climatic worsening that occurred around OIS 64-62, when grasslands became more extensive (Azanza *et al.*, in press a; Palombo, in press). While this phase was not as marked on the Iberian peninsula, the so-called “wolf event” has to be regarded not only as a dispersal phase but also as a true turnover. In Italy, during the Early Pleistocene when the average temperature decreased slightly and progressively, the structure of the faunal assemblages was characterised by more richness and diversity among carnivores than among herbivores. Nevertheless, in the herbivore guild, large and grazer taxa, most of which lived in open landscapes, prevailed. *Mammuthus meridionalis meridionalis* became a very common taxon. At the end of the Villafranchian some very large specimens occurred that were assigned by some authors to the local subspecies “*M. meridionalis vestinus*”. On the Iberian Peninsula open environments prevailed. A renewal was particularly evident among ruminants, while elephants were generally less well represented there than they were in Italy.

The transition from Early to Middle Pleistocene faunas represents a major community reorganization (dispersal followed by a turnover phase) that shows a significant and progressive rejuvenation coincident with the onset of 100 ka climate cyclicity and vegetation changes related to climate worsening. The end of the Early Pleistocene (early Galerian), and the early Middle Pleistocene (middle Galerian) were characterised by a marked large mammal renewal, which occurred in successive phases at a time of significant climatic and paleoenvironmental changes. In Italy, carnivores diminished despite the fact that new carnivore taxa appeared. Herbivores, on the other hand, progressively increased, and because new occurrences prevailed over extinctions, standing richness also increased (Azanza *et al.*, in press; Palombo, in press). *Elephas antiquus* and *Mammuthus trogontherii* were part of this faunal change. The former appears to have occurred somewhat earlier in Spain (Huéscar, about 900 ka, Sesé *et al.*, 2001) than it did in Italy (Ponte Galeria, about 750 ka). *M. trogontherii*, on the other hand, was first recorded in Northern Italy at Monte Tenda (estimated age approximately 800 ka), and later on the Iberian Peninsula at Cúllar de Baza (estimated age approximately 600 ka) (Sesé *et al.*, 2001).

During the rest of the Pleistocene, important faunal renewal cannot be detected. A moderate community reconstruction occurred at the Galerian/Aurelian transition. During the late Middle Pleistocene (OIS 9-7), mild interglacials characterised the Mediterranean area. In Italy there were extensive broad-leaf wooded areas, especially along the Tyrrhenian coast. The Italian fauna was dominated by *E. antiquus*, *Bos primigenius* and cervids, while *Mammuthus trogontherii* was very poorly represented (Palombo and Mussi, 2001). On the Iberian peninsula, however, and in accord with more continental climate conditions, the faunal complex was characterised by a major frequency of taxa inhabiting open and arid environments. Despite these favourable environmental conditions there was a relative scarcity of *M. trogontherii*.

In Italy, the climate worsening corresponding with OIS 6 favoured the widespread dispersal of some new taxa into the peninsula such as representatives of *Mammuthus*. *Mammuthus* were characterised by dental features very similar to those of *M. trogontherii*, but had more ipsicephalic skulls and a very wide dimensional range, which also included small individuals.

During the early Late Pleistocene, *Elephas antiquus* was the most common elephant in both peninsulas, and was recorded until the end of OIS 4 (Palombo, 1995) and OIS 5 (Made and Mazo, 2001) respectively.

During the last Glacial, middle Pleistocene taxa progressively disappeared, while some “cold” species occasionally reached both the Italian and Iberian peninsulas. In Spain, scanty *Mammuthus primigenius* remains were reported mainly from the late Glacial locality of the Cantabric coast (Made and Mazo, 2001). In Italy, a mammoth steppe environment was observed in the northern eastern Pianura Padana at about 34 ka (Gallini and Sala, 2001). During the coldest last glacial phases, *M. primigenius* was widely dispersed along the Adriatic coastal plain, reaching the southernmost part of the peninsula; while a few samples reached the latitude of Monte Circeo (Palombo, 1995).

Results of the analyses confirm that the most important faunal renewals, due both to originations/immigrations and extinctions + originations/immigrations, can be linked to major global climate changes. There is a relatively good agreement between the middle Villafranchian faunal complexes of both peninsulas, while early late Villafranchian sites are scarce in Spain. A clear provincialism could be detected during the Middle Pleistocene (Azanza *et al.*, in press b). Even if diffusion and population patterns of elephants in the Italian and Iberian peninsulas were quite similar (Table 1), the milder climate conditions characterising Italy during the last glacial, favoured a longer survival of *Elephas antiquus*, while the geographical position of the Iberian Peninsula seems to reduce the possibility of a widespread dispersal of *M. primigenius*, in spite of the continental climate of that area.

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***Mammuthus lamarmorai* (MAJOR, 1883) REMAINS IN THE MIDDLE PLEISTOCENE ALLUVIAL DEPOSITS OF CAMPU GIAVESU PLAIN (NORTH WESTERN SARDINIA; ITALY)**

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During the Pleistocene, endemic elephants were quite common taxa in unbalanced faunas of several Eastern and Western Mediterranean islands. Dwarfed elephants from Tylos, Crete, Cyprus, Sicily and Malta have been generally considered as paleoloxodontine, descended from the Middle and Late Pleistocene continental *Elephas* (*Palaeoloxodon*) *antiquus* Falconer and Cautley, 1847. The middle-sized *Mammuthus lamarmorai* (Major, 1883) from Sardinia constitutes the only exception. The Sardinia elephant has been known from very scanty remains. At the end of the XIXth century, some tarsal, carpal and long bones were recorded from the last Glacial eolian deposits outcropping at Fontana Morimonta (Gonnesa, South-Western Sardinia), first reported by Acconci (1881). On the basis of these bones, Major (1883), described the new species "*Elephas lamarmorae*", but did not figure it. Later, during the second half of the 20th century, two further molars were discovered: one in post-Tyrrhenian (post-OI stage 5)

breccias at Tramariglio (Alghero) (Malatesta, 1954), and the other in pre-Tyrrhenian (pre-OI stage 5, ?OIS 6) continental deposits at S. Giovanni in Sinis (Ambrosetti, 1972, Melis *et al.*, 2001).

The morphological and biometrical characters of the more complete, but very worn molar, from San Giovanni in Sinis suggest an attribution to the genus *Mammuthus*. Moreover, taking into account that in Sardinia elephant remains were not recorded from deposits older than latest Middle Pleistocene, it was supposed that the probable ancestor *Mammuthus trogontherii* (Pohlig, 1885) should have colonised the island during the latest Middle Pleistocene (Melis *et al.*, 2001).

More recently, we have learned of two specimens, so far unknown, collected at the beginning of the last century in alluvial deposits outcropping at Campu Giavesu (North-Western Sardinia)

These finds attest to the great relevance of the northern Sardinia area in understanding paleoenvironmental evolution during the Plio-Pleistocene. A unique geological history characterises the Campo Giavesu area, which has been affected by volcanic activity during the Pleistocene. The radiometric data (K/Ar method) of the basaltic lava flows belonging to different phases of the volcanic activity, enable us to clarify the geomorphological evolution of this area. The Cujaru volcanic activity (0.8 Ma bp, Beccaluva *et al.*, 1981) produced an important alluvial episode affecting the inner Coghinas river basin. According to the morphological reconstruction, this phase was followed by a reinstatement of drainage, even if for a short span of time, because of the reprise of the Austidu volcano's activity, which caused a complete fossilization of the river by lava flows. This condition gave rise to a progressive alluvial process along the drainage network of the stream.

The Campu Giavesu plain was formed by the M. Annaru-M. Poddighe volcanic episode (0.2 Ma bp, K/Ar method, Beccaluva *et al.*, 1981; older than 0.1-0.08 Ma bp, Ar/Ar method, Ginesu *et al.*, 2002) which blocked the river, whereas the basin was filled by colluvial sediments. The nature of deposits depends on the moderate drainage activity taking place during the Middle Pleistocene and continued also during the Upper Pleistocene. The morphological and depositional condition of the plain might favour the preservation of the elephant remains, in a swampy area originated by the establishment of a marsh in a river meander. Consequently, a late middle Pleistocene age could be hypothesised for the mammoth remains.

The samples recorded from Giavesu, belonging to two different individuals, consist of an almost complete upper molar, and of a fragment of a very worn one. The first is an M³ indicated by the lack of any evidence of pressure by a posterior tooth on the talon and the typical gradual reduction of height. The tooth has 15.5 plates (the anterior part of the molar is broken, consequently only the posterior side of the first plate is present) including talon, the first seven showing wear caused by use. The three anterior plates apparently belong to the same root. The molar shows an elongated shape, the maximum length is 225 mm, the height of the first unworn plate is 129 mm. The occlusal surface is ovoid, quite narrow, with a maximum width of 76,5 mm. Length and number of plates fall in the range of variability of "primitive" *Mammuthus trogontherii* M² (e.g. the teeth from Süssenborn, Guenther, 1969), whereas the average enamel thickness is slightly higher and the teeth are less hypsodont.

On the other hand, the last upper molar of *Mammuthus trogontherii* representatives is usually larger, whereas the M³ belonging to small specimens of *Mammuthus primigenius* (e.g., some teeth from Předmostí, Musil 1968) displays more advanced features and has more plates. Compared with the previous known molar from San Giovanni in Sinis, the occlusal surface of the tooth from Giavesu shows almost oval, not undulated enamel loops, that are regularly but less densely plicated, and show a greater value of average enamel thickness and a minor value of the lamellar index. Nevertheless, it differs from *Mammuthus meridionalis* of the Italian late Early Pleistocene basically in the higher number of plates and frequency index.

All things considered, according to enamel thickness, hypsodonty index, lamellar frequency and enamel loop morphology it seems more probable that the M³ from Giavesu constitutes a specimen of *M. lamarmorai* more archaic than the San Giovanni in Sinis one, as confirmed by the geological data. Moreover, the molar from Giavesu belongs to a *Mammuthus* moderately reduced in size.

On the basis of the occurrence of elephant remains in deposits of late Middle Pleistocene age, the hypothesis that the ancestor of the endemic elephants from Sardinia (an advanced representative of *Mammuthus meridionalis* or an archaic *Mammuthus trogontherii*) reached the island at the Early-Middle Pleistocene transition cannot be ruled out. Nevertheless, due to the scarcity of data, this hypothesis still has to be fully substantiated.

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MAMMOTH BONES AS RAW MATERIALS FOR DWELLING STRUCTURES: HUNTS OR COLLECTIONS?

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Strategies of mammoth procurement during the Palaeolithic are still actively debated, the principal hypotheses being hunting, scavenging and bone collecting. In particular, in the Gravettian and Epigravettian open-air settlements of Central and Eastern Europe, heaps of mammoth bones have been described as ruins of huts, especially in the Dniepr river valley of Ukraine but also in Moravia (Czech Republic) and Southern Poland.

This paper questions the origin of the mammoth bones for the purpose of building, in the broader perspective of mammoth procurement and treatment by Upper Palaeolithic people in Europe. Mammoth bones could have been picked up from accumulations of dry bones or from fossil bone deposits. The bone material could also have been taken from hunted or scavenged mammoths.

Methods are zooarchaeological analyses, which include the description of the taphonomic modifications and integrate the palaeoecological and archaeological data associated with mammoth bone assemblages.

The ways of mammoth bone procurement, their selection and potential processing in order to build dwelling structures will be studied. The selection and treatment of mammoth bones in terms of architectural potential will be discussed also: the potential use of the different anatomical elements (long bones, ribs, scapula/innominate, tusk and cranium) must be evaluated, notably in relation to their growth development. Furthermore, wooden materials may have been or had to be also used in association with mammoth bones.

Comparative analyses are carried out on bone materials from the circular structure described as a hut at Milovice G (Czech Republic) in relation to those from other mammoth sites, set by non-human factors or by anthropogenic activities, with or without evident dwelling structures.

THE RUBBING POST: A HYPOTHESIS FOR PLEISTOCENE FAUNA AGENCY IN THE FORMATION OF ANOMALOUS POLISHED ROCK SURFACES IN NEVADA

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A preliminary investigation of anomalous polished surfaces on a siliceous rock outcrop in the northern Edna Mountains, Nevada suggests extinct, late-Pleistocene fauna rubbing as the agent responsible for the modified rock. Concentration of both superficial polish and altering polish on accessible locations of the outcrop from 1 to 2.5 meters above the current ground surface indicate that rubbing activity responsible for the most intensive polish must have resulted from fauna considerably larger than members of the Holocene and introduced fauna found within the region. The regional geomorphology supports the hypothesis that the rock outcrop is stable relative to the surrounding surface elevation, and polish presently found 2+ meters above the surface could have formed 2+ meters above the surface 10,000 years ago. Successful lichen re-colonization over much of the polish suggests a prehistoric age for the polish. Paleo-environmental reconstruction suggests that the rock outcrop lies within two kilometers of a region of high biotic stability and productivity during the Pleistocene-Holocene transition. This study considers geological, meteorological, and cultural alternatives for the anomalous polish and suggest further research for determining age and agency of the phenomena at The Rubbing Post.

RED-BREASTED GOOSE (*Rufibrenta ruficollis* Pall., 1769) ABOVE THE HEADS OF MAMMOTHS IN EUROPE

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Red-breasted Goose is a rare monotypic species with peculiar migration routes (Tugarinov, 1929, 1937). Nowadays it breeds in a few restricted areas in the tundras of northern Siberia (Yamal, Gydan and Taimyr Peninsulas) and winters in the western Mediterranean (Italy), western coast of Black Sea and Balkans, Caspian and Aral seas and Euphrates marshes in Iraq (Snow and Perrins, 1998). Red-breasted Goose does not have obvious phylogenetic links to other modern geese (Tugarinov, 1929; Danilov, 1969; Ploeger, 1968) and its Pleistocene records are very scarce (Tyrberg, 1998). My research and analyses of the Pleistocene history and migration routes of the Red-breasted Goose were stimulated by discovery of bone remains in Medvezhya cave and Grotto Bolshoi Glukhoi on the western slopes of the Ural Mountains, far beyond the modern migration route of the species. Both caves are well known and yielded detailed stratigraphy, radiocarbon dates and rich faunal assemblages (Kuzmina, 1971; Kuzmina and Sablin, 1991; Guslitser and Pavlov, 1993; Potapova, 1990, 2000)

Remains of the Red-breasted Goose from the Riss deposits at Grays Tharrock in England (Ipswich, possibly IS 7; Harrison and Walker, 1977), Voigschedt in Germany (about 200,000 – 750,000 y.BP; Janossy, 1965), Quartaccio (Middle Pleistocene; Bedetti, 2001) and Loreto á Venoza (200,000-750,000 y.BP; Cassoli, 1978, 1980) in Italy, are the earliest records of the species. Thus, the modern paleontological data show evidence for the evolution of the species in the Western Palearctic.

Location of the Middle Pleistocene sites where the species remains were found, strongly indicates the existence of a migration route between the northern and southern parts of Western Europe. Red-breasted Goose migrated from southern England and northern Germany to Italian coasts in a northwest – southeast direction between 53/53° n.l. and 41° n.l., almost between the same breeding and wintering areas for the Brant, *Branta bernicla*, Barnacle Goose, *B. leucopsis* and White-fronted Goose, *Anser albifrons* in the Middle and Late Pleistocene (Sutherland, 1984).

Red-breasted Goose possibly inhabited Western Europe since the Early Pleistocene through the Riss epoch. Shortly after that, probably at the beginning of Riss-Würm interglacial, the West-European population went extinct, since there are no post-Riss records in the former breeding grounds of the species in northern Europe.

In the “East”, the remains of the Red-breasted Goose dated as Late Pleistocene (Early-Late Valdai) were found along the western slopes of Urals mountains, on the riverbanks of the lower Ural River, Binagady tar pit on Apsheron Peninsula in Transcaucasia (Burchak-Abramovich, 1975) and Sudan in Africa (Ballmann, 1980). This is solid evidence that a Caspian-Iranian migration route for the species existed at least since the Early Valdai epoch, and the migration of the species occurred along the west side of the Ural Mountains. The existence of an “Eastern European” part of the migration route is an indirect indication of the presence of Red-breasted Goose breeding range in tundra closely adjacent to the northern Urals, which might have been extended to the tundra of the North Dvina River basin during maximum (Late Valdai) glaciation. According to paleontological data from Medvezhya cave, the tundra west of the northern Urals was a breeding area of the White-fronted Goose, *Anser albifrons*, Graylag Goose, *Anser anser*, Rough-legged Hawk, *Buteo lagopus* and Gray Plover, *Squatarola squatarola* and is now far south of their modern ranges. Remains of the Red-breasted Goose from Medvezhya cave belong to birds from the “East- European” population.

Paleontological records (Janossy, 1965; Cassoli, 1978, 1980; Harrison and Walker, 1977; Bedetti, 2001) show that since the Early-Middle Würm the wintering areas of Red-breasted Goose expanded from the Caspian sea (and perhaps, the Aral sea) to the west, into the Mediterranean islands, Bulgaria, Hungary, and the coast of northern and southern Italy. Thus, the latitudinal migration route of the species, which starts at the Caspian sea and ends along western Mediterranean coasts (Isakov, 1979), has a relatively recent origin.

By the end of the Pleistocene, during the postglacial, Red-breasted Goose range retreated to tundra of the northern Siberia, shifting the East-European migration route further to the east, along the Ob' and Irtysh Rivers.

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SPECIMEN COLLECTION AND METHODS OF MAMMOTH BONE PRESERVATION AT THE HOT SPRINGS MAMMOTH SITE, HOT SPRINGS, SOUTH DAKOTA

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The Mammoth Site, the locality for many bones of the Columbian mammoth, *Mammuthus columbi*, was discovered in the summer of 1974. The site, located on a hilltop in the southern part of the Black Hills, appears to be a former sinkhole filled with warm artesian water, which became the deadly trap for at least 49 Columbian and three woolly mammoths. The deposits accumulated during approximately 700 years, 26,000 years ago (Agenbroad, 1994; Laury, 1994). Since then, substantial efforts have been made to salvage the site and preserve the precious collection of bones.

From the time of discovery, the bones left *in situ*, as well as those removed from the bone bed, were subjected to a variety of treatment methods, preservatives and conditions of storage. These included application of Glyptal, Butvar 98/Methanol, Butvar 98/Ethanol, Butvar 76/Acetone, Vinac/Acetone, Elmer's glue, and some others (Anderson *et al.*, 1994). Bones left *in situ* were subsequently covered by backfill (1974-1979), a temporary plywood shed was erected above the permanently exposed bones (1980-1986), and finally, the permanent building was constructed (1986). In 1996 the building was equipped with an HVAC system and a thermo-hydrograph to keep track of temperature and humidity fluctuations, significantly improving the conditions of storage and stability of the bones in the bone bed. Analyses of records are presented in this paper, with comparisons with other paleontological sites in the USA.

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MAMMOTH (*Mammuthus primigenius*) IN THE PERIGLACIAL FAUNAS OF UKRAINE

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Mammoth faunas of the second half of the Pleistocene of Ukraine have been studied thoroughly on the basis of numerous discoveries of the remains of the typical genera in various taphonomic types of burials. These faunas are practically always characterized by the presence of *Mammuthus primigenius*. In localities connected with camps (stands) of ancient man (Mezin, Mazhirich, Pushkari, Zhuravka, Gontsy, Dobranichevka, Lypa IV, Molodova and others), this species almost always dominates in its number of remains. In river-bed deposits of the Dnieper River this genus is also predominant. There is a smaller quantity (number) of its remains in loesses, fossilized soils and cave grotto deposits.

The qualitative composition of attendant genera is very consistent for certain landscape-climate zones of Ukraine and contiguous territories. For example, in the northern part of Ukraine (the central part of the Russian Plain), the periglacial zone with ecologically mixed theriofauna (mammal fauna) is considered today to be a natural-historical association. At that time specific conditions prevailed, with a particular set of species. Those conditions differed morphologically and therefore supported a taxonomically different mammal fauna than in other areas where we find closely related forms. *Mammuthus primigenius*, *Dicrostonyx gulielmi*, and *Microtus gregalis* prevailed there; *Alopex lagopus*, *Rangifer tarandus*, *Ovibos moschatus*, and *Lemmus sibiricus* were less consistently represented. Other species including *Spermophilus*, *Lagurus lagurus*, *Allactaga jaculus*, *Ochotona spelaeus*, and *Equus latipes* were predominant among the inhabitants of the steppe. Polyzonal species, mostly Carnivora, were not very representative.

The central part of Ukraine, including its western regions, made up a special ecological zone (cold forest-steppe) during the late Pleistocene, which bordered on the periglacial zone. As before, *Mammuthus primigenius*, *Rangifer tarandus*, *Spermophilus*, and Lagurini were dominant. The peculiarity of the theriofauna of this zone is that species of polyzonal ecological landscapes appeared: many Carnivora, Cervidae, Muridae,

Microtus arvalis and forest forms. In this case the qualitative composition of the mammoth theriofauna changed to include fewer northern forms and an increased role of polyzonal species (species with wide ecological plasticity). Such a fauna is to some degree transitional between the more northern typical periglacial mammoth fauna and the more southern steppe fauna where remains of *Bison priscus* prevail.

At that time in the southern part of Ukraine open steppe predominated. The number of *Mammuthus primigenius* was small (insignificant). The species *Bison priscus*, *Rangifer tarandus*, *Equus latipes*, *Microtus arvalis* – *socialis* groups, *Marmota bobac*, and *Spermophilus* dominated. The qualitative composition of the mammoth fauna noticeably changed at the expense of the predominance of steppe species, as well as abundance of the remains of *Rangifer tarandus*, especially in the western part of Ukraine. Conditions for the existence of this species were probably optimal; which is also indicated by the palynological data. There are no *Dicrostonyx* or *Lemmus* and very few *Mammuthus primigenius*, *Microtus gregalis*, *Alopex lagopus*, *Gulo gulo*, or *Lagopus lagopus* in this landscape zone.

A peculiar composition of theriofauna was characteristic of the territory of the Crimea. Here *Saiga tatarica*, *Alopex lagopus*, *Vulpes corsac*, and Cervidae prevailed. Other species including *Mammuthus primigenius*, *Coelodonta antiquitatis*, and *Capreolus* were absent.

Coelodonta antiquitatis, *Megaloceros giganteus*, *Equus latipes*, and *Arvicola terrestris* as well as Carnivora were poorly presented in the mammoth theriofauna of all landscape-climatic zones of Ukraine.

Changes in the qualitative composition of the mammoth fauna, generally progressing from north to south, were accompanied by an increase in the role of arid steppe species and weakening of the role of arctic forms. In the meridional direction (from east to the west) there was a noticeable increase of the number of polyzonal, forest and near-water species of the theriofauna.

The number of remains of *Mammuthus primigenius* in the north was almost invariable, while in southern Ukraine they are nearly absent. Progressing from east to west, the role and importance in the biocenose of typical steppe species (*Spermophilus*, Spalacidae, Lagurini, *Saiga*) are considerably diminished. Such dynamic trends in the quantity (number) of mammoth, were caused by the landscape-climatic zone character that existed in the late Pleistocene. It showed itself in the fact that in the southern outlying part of the Valdai glacier (near glacial zone) there existed periglacial tundra-steppe with an evolutionarily formed complex of species where *Mammuthus primigenius*, *Dicrostonyx* and *Lagurus* dominated. These (and other) species had special morphological adaptations to these special conditions, which have no equivalent today. All the theriofauna was quite different taxonomically from previous and contemporary associations, as well as from that from the more southern landscape zones – a cold forest-steppe with polyzonal species, and a steppe with predominant xerophytic species, as demonstrated by data on the dynamics of the vegetation which made up (served as) the main forage reserve for mammoths and other herbivorous animals (Velichko, 1973; Bibikova, Belan, 1999; Rekovets, 1985; Puchkov, 1989; and others).

A PALYNOLOGICAL APPROACH TO THE STUDY OF MEGAHERBIVORE EXTINCTION IN THE HUDSON VALLEY

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Four sites in Lower New York State comprise a landscape-level study using stratigraphic pollen and charcoal particle analysis, including the distinctive spores of a dung fungus, *Sporormiella*, as a proxy for megaherbivore biomass. Microfossil stratigraphies combined with AMS bone collagen dates suggest that mastodons and other components of the Pleistocene megaherbivory regime underwent population collapse well before the time of extinction. Rapid population decline is followed by an order of magnitude rise in stratigraphic charcoal concentrations interpreted as the replacement of herbivory by fire. Both developments occur in advance of the Younger Dryas cooling event in the Northeast. The same sequence has been observed recently in a suite of late Holocene stratigraphic records from Madagascar, where megafaunal extinction also followed human arrival. Two stages of the human transformation of the regional landscape are inferred in both cases. Overhunting of large game compromises an ecology controlled by keystone megaherbivores. The rise in stratigraphic charcoal that frequently follows human arrival may reflect human-caused and/or natural fires accentuated by accumulating fuel loads in the absence of a megaherbivory regime. The inferred sequence of events is consistent with the hypothesis that humans precipitated these extinctions by setting in motion a process of ecosystem failure driven by the synergistic interactions of overhunting and landscape transformation.

ELEPHANT MITOCHONDRIAL DIVERSITY AND THE PHYLOGENY OF MAMMOTHS

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The phylogenetic placement of the woolly mammoth, *Mammuthus primigenius*, relative to the extant African genus *Loxodonta* and to the Asian elephant, *Elephas maximus*, has been subject to debate. Some morphological reports have held that the mammoth was more closely related to Asian elephants, while recent studies of mitochondrial DNA sequences have placed the mammoth closer to extant African elephants. We have examined mitochondrial DNA from elephants in a geographically widespread set of 21 locations in Africa, including both forest and savanna elephants. We identified a diverse set of loxodont mitochondrial sequences. This very diverse group of sequences is being used to resolve phylogenetic relationships within the Elephantidae. (Funded in part by DHHS#N01-CO-12400.)

MAMMOTH HUNTERS AND ICE AGE DOGS

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A large number of bones of the mammoth *Mammuthus primigenius* Blum. were found among the food debris at the Upper Palaeolithic site Eliseevichi 1. The site is situated in the basin of the Dnieper River, on the Sudost River (right tributary of the Desna River) in Russia and previously dated to 13.000 – 17.000 ¹⁴C BP. At Eliseevichi 1, the main prey by far was mammoth (mostly young animals), while the arctic fox *Alopex lagopus* L. and the reindeer *Rangifer tarandus* L. are far less common. This very likely indicates a specialised mammoth hunters' camp in which the bones were also used for construction. The assemblage of animal bones from the site is a typical cold tolerant Late Pleistocene (Dryas I) fauna. The mammoth bones used to build the dwellings could have come from animals hunted over a long span of time. A large number of artworks made from mammoth tusk, and a tradition of bone carving featuring complicated geometrical ornament, are characteristic of the material culture of the Eliseevichi 1 site. The majority of these mammoth ivory objects are from the same excavation units where the skulls of Ice Age dogs were found (Sablin and Khlopachev, 2002). Both dogs were adult when they died. No doubt, the dogs also played a part as a meat animals. Holes were made in the sides of the skulls from Eliseevichi 1 site so that the brain could be removed. We suggest that the dogs looked like present-day Tibetan mastiffs or Caucasian sheep-dogs. The dogs had a much wider palate and shorter rostrum than Siberian huskies and Great Danes. The reconstructed withers height is about 70 cm. Therefore, the dogs belonged to a very strange and dangerous heavy hunting/guarding breed. The Upper Palaeolithic central Russian Plain was peopled after 18,000 yr. BP by hierarchically organised groups. That hierarchisation was related to an increase in environmental variability and unpredictability. High-status individuals have been able to partially control labour, exchange, and ritual behaviour (Soffer, 1985). An unequal distribution of resources, social and economic asymmetry would create social conflict. In this context it can be assumed that the large wolf-like dogs were used to guard not only against predators. Their presence on the site may indicate the high social status of the inhabitants.

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OSTEOMETRIC COMPARISON OF THE POSTCRANIAL SKELETON IN FOSSIL REPRESENTATIVES OF THE FAMILY ELEPHANTIDAE FROM CHOSEN EUROPEAN LOCALITIES

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The subject of this study is variation of the postcranial skeleton in representatives of the family Elephantidae in Europe. Fossil elephants are represented in Europe by two contemporaneous phylogenetic lines. The mammoth lineage included three main nominal species: the southern mammoth (*Mammuthus (Archidiskodon) meridionalis* (Nesti)), the steppe mammoth (*M. trogontherii* (Pohlig)) and the woolly mammoth (*M. primigenius* (Blumenbach)). The only representative of the second line is the forest elephant (*Palaeoloxodon antiquus* (Falconer and Cautley)). Mammoths of the first lineage were adapted to open biotopes, while the second line included inhabitants of woodlands.

Three species from five localities were measured in this study. Samples were chosen in such a way as to show representatives of three European elephant species from important localities. The species *Mammuthus trogontherii* was left out of the study because of its small minimum count of excavated postcranial bones at appropriate sites. *M. meridionalis* comes from Upper Valdarno (late Villafranchian) in Italy, which is the type locality of this species. The sites Milovice and Předmostí (Czech Republic) and Spadzista (Poland) from the Upper Pleistocene provided *M. primigenius* remains. The remains of *P. antiquus* studied here are housed in Bilzingsleben (East Germany) and they were found in opencast near Frankleben, dating to the middle Pleistocene. Several individuals of this species from Upper Valdarno were also included in the investigation, but in contrast to *M. meridionalis*, these bones come from younger layers (Middle Pleistocene).

Species determinations of elephants usually focus on characters of their skulls, lower jaws and primarily molars. Diagnostic features of the postcranial skeleton are much more difficult to analyze. The present study gives results of a detailed study of the postcranial skeleton. The osteometric analysis of the whole postcranial skeleton was undertaken and the individual species and both genders were compared. The obtained data were compared with published data. Gender determination was carried out using characters of the pelvis and long bones. In the postcranial skeleton, pelvis morphology is the most obvious anatomical feature for sex determination, in that the female's pelvis has a relatively larger pelvic aperture than the pelvis of males. The most reliable indicator of sex in the pelvis is the ratio of the aperture width and the acetabulum length. Distinguishing both sexes using long bones is based on their different size, because epiphyses in males fuse at a greater age and their total growth is much greater. Therefore it is necessary to use bones with fused epiphyses for separating females and immature males.

Some differences were found in the structure of individual carpal bones and in ratios between some carpal bones and the long bones of the forelimbs. These differences can be roughly assumed to reflect changes in the heightening of carpal bones of the distal

row in *P. antiquus*. The proportions between segments in limbs are related to feeding behavior, to speed of locomotion and to endurance. Whether these changes are really caused by different functional load and feeding is problematic. However further study of larger samples is needed to solve this question.

PLEISTOCENE EVOLUTION OF BERINGIAN BISON

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Throughout the Late Pleistocene (LP), bison were one of the most abundant species of large mammal in both eastern and western Beringia. Despite this abundance, very little is known about their taxonomic relationships or evolutionary history. We present a mitochondrial DNA analysis of >350 permafrost bison bones collected across Beringia and central North America, ranging from >160 ka BP - modern. The molecular phylogeny does not correlate with previously published morphological phylogenies for bison. Surprisingly, bison genetic diversity in LP Siberia appears to be a subset of that in Alaska, indicating the possibility of a recent dispersal westwards across the Bering land bridge. In contrast, bison populations in eastern Beringia were genetically diverse, and ranged as far south as Wyoming prior to the last glacial maximum. Following the deglaciation of western Canada, Beringian bison do not appear to have traveled southward through the ice-free corridor. Instead, modern bison evolved from bison that had migrated into central North America before the coalescence of the Laurentide and Cordilleran ice sheets.

TUNDRA-STEPPE ENVIRONMENT IN ARCTIC SIBERIA AND THE EVOLUTION OF THE WOOLLY MAMMOTH

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Introduction

The new concept of woolly mammoth evolution (Lister and Sher, 2001) suggests that the high latitudes of the Siberian Arctic played an important role in the origin of this species (*Mammuthus primigenius*) and its predecessors (of the *Mammuthus trogontherii* level). It is based on morphological comparison of independently dated mammoth samples from Siberia and Europe. The Siberian samples cover the time span of about 1.2 million years. It was shown that the same levels of evolutionary advancement were achieved by mammoths in Arctic Siberia and in Europe but not simultaneously - in Siberia always a few hundred thousand years earlier. It has been suggested that the more advanced Siberian mammoths could repeatedly interact with the populations in the lower latitudes, which would explain a complex pattern of fast morphological innovations in the European mammoths, alternating with the periods of stasis, and sometimes the apparent coexistence of two populations of different level of evolutionary advancement. The supporting background for this model is the early development in the Siberian Arctic of a kind of "periglacial", or tundra-steppe, environment (northern grassland on permafrost), driving the evolution of the woolly mammoth for which it is thought to have provided optimal conditions. This paper presents a more detailed analysis of that environment, evidenced in the last (Weichselian) cold phase, and then examines the relations of key earlier mammoth samples of different ages (Lister and Sher, 2001) to the insect and pollen record.

The mammoth's environment in the Weichselian of the Siberian Arctic

For the period of the last 50 ka in the Laptev Sea area we have established a correlation between the mammoth's radiocarbon chronology and the character of environment, shown by the composition of fossil insect faunas, with additional support from other proxy evidence (Sher *et al.*, 2001; Schirmermeister *et al.*, 2002). This evidence comes from a very detailed and dated multi-proxy record of the environment in the Mamontovy Khayata section on the Bykovsky Peninsula (Lena River Delta), obtained during the work of the Russian-German Expedition "Laptev Sea System-2000" (1998-2002). This record is compared with the large collection of radiocarbon dates on mammal bones from the Laptev Sea area, from Taimyr to the New Siberian Islands (Sher *et al.*, 2003).

The long record of the Late Pleistocene environment in the Bykovsky section, covering the time span from the lower limit of radiocarbon (50-60 ka or more) to about 12 ka, shows the continuous existence of treeless, grass-and-herb dominated vegetation, and plant and insect communities of tundra-steppe type. Fossil insects, however, as the most sensitive indicators of the past environment, allow us to distinguish at least four periods

in the evolution of the tundra-steppe biome, and presumably the climate, during that time (Table 1). Those changes are well illustrated by two characteristics in the composition of fossil insect assemblages. The first is the proportion of true steppe species, that currently do not occur in tundra; even a few percent of these species indicates summer temperatures higher than present (Alfimov *et al.*, 2003). The second, sum of xerophilic insects, both those currently common in the Arctic (dry tundra inhabitants) and those uncommon or absent there (Kuzmina, this volume), is a proxy indicator of the total extent of various biotopes which were relatively dry, and at the same time better heated, than common modern wet tundra habitats.

LW II - the latest part of the Late Weichselian (=Wisconsin), 15-12 ka (from here on - uncalibrated radiocarbon ages) - demonstrates the last and brief flourishing of tundra-steppe communities. In the pollen record, it is marked by the prevalence of grasses and various herbs, such as Caryophyllaceae, Compositae, and *Artemisia*. Insect assemblages are marked by the highest proportion of all kinds of xerophilic species (averaging 78%), including thermophilic steppe elements (av. 4.2%). This fauna existed in a highly continental and very dry climate with relatively warm summers. Preliminary evaluation of summer temperature (T_{VII}) by the Mutual Climatic Range (MCR) method on fossil insects suggests that it was a few degrees higher than present (Sher *et al.*, 2002). The MCR analysis for the 13-14 ka old insect fauna in the Lower Kolyma (Alfimov *et al.*, 2003) reconstructs T_{VII} as 3° higher than present.

LW I - the early Late Weichselian, ca. 24-15 ka - was very different. The proportion of all xerophilic insects drops to 10%, steppe insects are totally absent between 23 and 19 ka, and arctic tundra species dominate in most assemblages. Spore-pollen spectra are peculiar for the highest Weichselian content of *Selaginella rupestris* spores. At the same time, they retain high diversity and abundance of various herb families, and the plant macrofossils show a high proportion and diversity of xerophilic plants (Kienast *et al.*, 2001). According to fossil insects, summers were colder than in LW II, but probably still at least as warm as today (Sher *et al.*, 2002).

MW II - the second half of the Middle Weichselian, ca. 34-24 ka. Insect assemblages are of intermediate character between LW II and LW I. Steppe species are almost always present, although the sum of xerophiles averages only 30%. The general interpretation of the ecological composition of the insect faunas is that summers in this period were still dry, but warmer than during LW I. Pollen spectra still combine high levels of various herbs with a large amount of *Selaginella* spores.

MW I - the first half of the Middle Weichselian, ca. 48 (or more) to 34 ka - shows notable variation in the composition of insect assemblages, but generally they have a more xeric and thermophilic appearance than during MW II and LW I. Average proportions of xerophilic species are about 60%, and steppe species are constantly present. Spore-pollen spectra show the highest, though variable, values of *Artemisia* and Caryophyllaceae, but less of Compositae, and very low amounts of *Selaginella*.

Thus, the insect assemblages in the Mamontovy Khayata section demonstrate a significant variation with time, apparently related to changes in summer temperature and humidity. The studied part of the Middle Weichselian (MW I and MW II), despite some variations, reveals a clear trend from warmer to cooler summers, demonstrated by the gradual decrease of relatively thermophilic xerophiles and increase in the proportion of arctic tundra insects. The insect assemblages allow us to consider the MW I

environment as a relatively "warm" variant of tundra-steppe, while the MW II one was "cool" tundra steppe. This cooling trend reached its maximum during LW I (LGM). The dominance of pollen of grass and various herbs, along with the high amount of *Selaginella* spores and the abundance of arctic willow weevil *Isochnus arcticus*, invite a parallel with the modern Wrangel Island environment. A very sharp increase in summer temperature took place around 15 ka, and the LW II environment can be labeled as the "warmest" tundra-steppe for this Arctic region. Permafrost studies and ground ice isotopic analyses show much colder winter temperatures than present during the deposition of the whole Bykovsky Ice Complex (Meyer *et al.*, 2002). Thus, all kinds of proxy evidence indicate the retention of very high continentality of climate through most of the Weichselian succession.

The collection of ^{14}C dates on mammal bones from the Laptev Sea area has amounted to 380 dates, obtained in the course of the Russian-German Expedition and from published sources; 233 of them are for mammoths, while other species received many fewer dates (including about 60 for horses, 40 for musk oxen and 30 for bison) and do not provide statistically reliable series.

The following distribution of the number of mammoth dates against the timescale can be seen. The number of finite dates on bones older than 40-42 ka is generally low (average 2.8 dates per 1,000 years) for technical reasons (infinite dates are not considered). After that time, the number of dated mammoth bones is more or less steadily high (av. 7.6 per 1,000 years) until about 25 ka, i.e. during the available part of MW I and most of MW II. Then it starts to decrease progressively during the whole LW I with a minimum at 16-17 ka (2 dates). It should be noted, however, that even during the peak of the LGM (18-20 ka BP) mammoth still inhabited the whole area of the Laptev Shelf Land, including the present northernmost islands and Severnaya Zemlya. The number of mammoth dates sharply jumps up after 15 ka, and stays at high levels (av. 7.4 in 1,000 years) until 10,000 y BP, i.e., during LW II. This period (the Late Sartanian) was the last interval with abundant dated records of woolly mammoth (the latest dated mammoth fossils in the region come from the interval 10,000-9,600 y BP, and are so far known from the Taimyr Peninsula only). Interestingly, the same period is marked by the highest number of ^{14}C dates on *Saiga* fossils in Beringia as a whole (Guthrie *et al.*, 2001), while no dated record of that antelope is known between 25 and 16 ka, i.e., during LW I.

The chronological variations in the number of radiocarbon dates is subject to many factors, such as collecting biases, occurrence of sediments of a certain age, changes in taphonomic conditions, etc. In our case, however, we can assume that the changing number of radiocarbon dates broadly reflects former mammoth abundance for the following reasons. The distribution of dates has similar pattern in four large areas around the Laptev Sea, with varying geology and collecting history; an increasing number of dates through almost 15 years of research (Sher and Sulerzhitzky, 1991; Lavrov and Sulerzhitzky, 1992) has not changed the major features of that pattern; and the sedimentary characteristics of continuous successions, such as Bykovsky, show no major shifts which might imply serious changes in taphonomic conditions, e.g. their worsening during the LGM. Finally, comparison of the mammoth radiocarbon chronology in the Laptev Sea area with the environmental record on the Bykovsky Peninsula shows a correlation between the number of mammoth dates, the proportion of xerophilic insects, and the presence of steppe species.

Both of the peaks in the number of mammoth dates correspond to periods with a relatively high proportion of xerophilic insects and the presence of steppe species. A high diversity of insect fauna implies a richer vegetation mosaic, including more extensive areas with better heat supply, occupied by presumably more productive grassland. The number of mammoth dates starts to decrease at the same time as the proportions of those insect groups, reaching its lowest point soon after the period of total absence of steppe species. This pattern allows us to infer that all varieties of tundra-steppe insect assemblages indicate environments tolerable to the woolly mammoth, but that the less diverse insect faunas of the LGM, lacking the most thermophilic beetle species, may suggest less productive, probably just sparser, vegetation, and large grazers seem to have responded by reducing their numbers.

Early to Middle Pleistocene environments and mammoth evolution

It is interesting to apply this model of relationships between insect faunas (as environmental proxies) and mammoth populations, to the Early and Middle Pleistocene samples used by Lister and Sher (2001) in their study of mammoth evolution (<http://www.sciencemag.org/cgi/content/full/294/5544/1094/DC1> for site details). We have examined insect samples from the same sites where most of the key mammoth fossils were found (Table 1).

All insect and mammoth localities in Table 1 have pollen records. In agreement with the insect evidence, they mostly portray grass- and herb-dominated vegetation, although a more complex variation of pollen spectra is observed, especially in the ancient samples. The earliest recorded appearance of steppe insects in northeastern Siberia comes from even older horizons (ca. 1500-2000 ka) (Sher, 1997; Kiselyov, 1981), but no proboscidean fossils of that age have so far been found there. For the subsequent at least 1-1.5 million years, the evolution of mammoths in Arctic Siberia was inseparably linked with a tundra-steppe environment, represented in the fossil record by insect, plant and pollen remains. That resulted from the high continentality of the climate that supported mostly treeless grassland vegetation with various cryoxerophilic and some steppe elements. The periods of decreased continentality (increasing humidity and extensive formation of boggy terrain) were relatively short, and did not result in total disappearance of tundra-steppe communities, just in some reduction of their spatial distribution (Kiselyov, 1981). As far as we know, none of those periods is comparable to the early Holocene with its devastating effect on the tundra-steppe biome. None of our model samples was found to correspond to a more impoverished insect fauna, similar to that of LW I, although this does not mean that such periods of climate and environment did not occur earlier.

Table 1. Insect assemblages corresponding to evolutionarily important mammoth samples from northeastern Siberia (based on Kiselyov, 1981, 1994; Kuzmina, 2001; Sher *et al.*, 2003, and geological publications cited in these papers). The Bykovsky succession, though providing no morphologically important mammoth fossils, is correlated with the "Ice Complex" sample from a wide region, from which the latest mammoth samples (Lister and Sher, 2001) were drawn.

Mammoth samples from Lister and Sher (2001)	Corresponding insect assemblages	Locality	Important mammoth specimens in situ	Age, ka	Sum of xerophilic insects, %	Proportion of true steppe species, %
"Ice Complex"	LW II, 6 samples	Bykovsky		12,5-15	78.0	4.2
	LW I, LGM, 4 samples	Bykovsky		19-22	10.4	0.0
	MW II, 4 samples	Bykovsky		ca 25-30	29.7	2.9
	MW I, 4 samples	Bykovsky		ca 42-48	58.5	2.8
	The base of the Ice Complex (series ANV & ANN, 7 samples)	Achchagiy-Allaikha, Lower Indigirka	+	ca 150-200	58.9	9.0
"Late Middle Pleistocene"	Utkin Beds, 4 samples	Maliy Anyuy River, Kolyma Lowland	+	ca 200-400	60.0	5.4
	Khomus Suite, lower part, 1 sample (6000 insect individuals)	Bolshoy Khomus-Yuryakh R., Indigirka Lowland		ca 400-600	64.4	14.0
"Late Olyorian"	Akanian Horizon, Loc. 35, 2 samples from the mammoth site	Bolshaya Chukochya R., Kolyma Lowland	+	ca 700-800	52.6	3.1
"Early Olyorian"	Chukochyan Horizon, Loc. 23, 4 samples	Bolshaya Chukochya R.	+	1000-ca 1200	59.7	2.5
	Chukochyan Horizon, Loc. 6, 4 samples	Krestovka R., Kolyma Lowland	+	ca 1000-1400	75.6	9.3

Permafrost made a very early appearance in Arctic Siberia (at least 2.5 million years ago), and a peculiar, extremely continental climate, with very cold winters and short, but relatively warm and dry summers, supported continuous tundra-steppe communities. The long existence of mammoth in this environment resulted in its successful adaptation to these habitats. Under such conditions, they reached successive stages of morphological advancement much earlier than their southern relatives. During certain periods of the Pleistocene, when similar (periglacial) environments developed in temperate latitudes, the northern mammoths had the potential for southward and westward dispersals. Our analysis supports the idea that the arctic Siberian mammoths repeatedly contributed to the evolutionary advancement of the whole lineage in Eurasia (Lister and Sher, 2001), and probably in North America too.

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SYSTEMATIC POSITION OF THE CAVE LION (*Panthera spelaea*)

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The large lion-like cat is one of the important members of the Mammoth fauna, which was widespread during the late Pleistocene in northern Eurasia and America. The history of the lion-like cats dates back to the Villafranchian with the earliest record in the African locality Laetoli at ca. 3.5 Ma. The earliest European occurrence of this group of felids is established in the Italian site Isernia dated at about 0.7 Ma (Turner and Antón, 1997). Unfortunately, the relationships of the middle Pleistocene European lion *Panthera fossilis* and the late Pleistocene *P. spelaea* are currently not clear because of the insufficient knowledge of the ancient form.

The cranial morphology and systematic position of Eurasian cave lion have been debated over a long time. The majority of studies showed close affinities of *P. spelaea* with the extant lion, rather than the tiger. Moreover, the European paleontologists have treated *P. spelaea* as a subspecies of *P. leo*, whereas the Russian students usually distinguished it as a separate species.

In the present study, remains of *P. spelaea* from the Upper Pleistocene deposits of the Smolensk area (Russian Plain) and northern Kolyma lowland (Northern Siberia) are compared and discussed. This material is represented by new complete skulls of adult males with almost equal basicranial lengths of 307 mm for the Smolensk specimen and 305 mm for the Kolymian one.

The discussion is based on the detailed morphological and the metrical cranial analysis. It suggests a close affinity of the two studied forms from geographically distant regions

and casts doubt on the definition of the northeastern population of *P. spelaea* as a separate subspecies as done by Baryshnikov and Boeskorov (2001).

Our study fits well the lion-like nature of *P. spelaea*. The comparison with *P. tigris* reveals more advanced features of the tiger relative to both *P. leo* and *P. spelaea*. In the cranial morphology of the tiger these characters are the long nasals, temporal crests joining anteriorly to the fronto-parietal suture, the sagittal crest well-developed with posterior dorsal margin elevated up to the nuchal line, posterior lacerate and condiloid foramina located in one cavity, P4 with well-developed preparastyle, and reduced M1. In its turn, *P. tigris* retains some primitive conditions including long and elliptic form of incisive foramina and moderately inflated bullae.

Really, *P. leo* and *P. spelaea* share numerous characters. In both forms the separation of the posterior lacerate and condylar foramina is rather clear and wide, which points to its primitive condition. In this character the lions are distinct from most recent felids. However, the analysis shows that the living lion is advanced relative to *P. spelaea* in its markedly more inflated and anterolaterally expanded bulla, more complex configuration of the zygomatic-maxillary suture, U-shaped (rather than V-shaped as in cave lion) frontal-maxillary suture, P3 with more developed additional second cusp, upper carnassial with preparastyle and distinct cusp on the its protocone bulge. On the other hand, *P. spelaea* has some features that seem more advanced than the conditions known in the extant lion. These are the widened nasal bones and reduced cusp on the protocone bulge of P4.

A comparison of the cranial series of *P. atrox* from Rancho La Brea (Merriam and Stock, 1932) with the Eurasian skulls shows their close affinity. However, the American form can be distinguished by larger size, greater width across the postorbital constriction, the presence of the third root in P3, and a trend to a single root condition in M1 and posterior lacerate and condylar foramina placed in one cavity. All these features of the form from Rancho La Brea are likely derived.

To sum up the above given arguments, we consider *P. spelaea* a distinct species, which is well distinguished from the living lion.

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ADVANCES IN THE ICE AGE BIOSTRATIGRAPHY OF EASTERN BERINGIA

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Ongoing studies of mammalian faunas have led to the beginnings of a biostratigraphic framework for the Ice Age (>2.6 Ma – 10,000 yr) of Eastern Beringia, the largely unglaciated area of Yukon and Alaska. Dates for four of these faunas are drawn from tephrochronologic studies by John Westgate (University of Toronto) and colleagues. Here I consider the assemblages in order from youngest to oldest.

At Thistle Creek in the southernmost part of the Klondike Goldfields, three pre-Wisconsinan units make up about 10 m of section, including 14 tephras. The Old Crow tephra (~140,000 yr) underlies units Organic 2 and Organic 3, and these beds represent the last interglacial in the area (~125,000 yr, MIS 5). At this horizon we find the tundra vole *Microtus oeconomus* and the chestnut-cheeked vole *Microtus xanthognathus*, possibly one other small *Microtus*, the white-footed mouse *Peromyscus*, collared lemming *Dicrostonyx*, ground squirrel *Spermophilus*, horse *Equus* and caribou *Rangifer*. An older unit at Thistle Creek, Organic 1, has near its base the Gold Run tephra, recently dated by Westgate at 708,000 yr (Westgate, pers. comm., 2003). This record of an older interglacial preserves Morlan's "*Microtus* sp. X", a slightly larger *Microtus*, the lemmings *Dicrostonyx* and *Lemmus*, ground squirrel *Spermophilus*, pika *Ochotona*, hare *Lepus*, and a large horse *Equus*. Dating of a loessal layer apparently at the top of Organic 1 is being investigated: this stratum has produced a metacarpal of the sheep *Ovis dalli*.

At Fort Selkirk, along the Yukon River near the mouth of the Pelly River, a fauna has been collected from loessal sediments beneath a tephra more than 1.48 Ma old, and above a lava flow 1.83 Ma old. One of the most primitive *Microtus* species, *M. deceitensis*, is well represented in this fauna, which also includes heather vole, collared, brown, and bog lemmings, ground squirrel, bat, pika, hare, weasel, and caribou. This is a full-glacial assemblage of the Early Pleistocene.

Comparison of Fort Selkirk *Microtus deceitensis* teeth with the sample from Cape Deceit, Seward Peninsula, western Alaska (Storer, in press), shows that the Cape Deceit population is evolutionarily less advanced and presumably is the older of the two. The Cape Deceit fauna is correlated with the Olduvai normal subchron, about 1.8 Ma old and presumably latest Pliocene.

At locality CRH-94, on the Old Crow River in northern Yukon, the Little Timber tephra has been dated at 2.29 Ma, and the fauna from surrounding beds will indicate conditions during a Pliocene interglacial near the start of the Ice Age. Recovery of fossils from concentrate is just beginning.

RADIOCARBON DATING: IMPLICATIONS FOR PALEOENVIRONMENTAL STUDIES OF MEGAFUNA

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Traditionally bone was the least preferred material for ^{14}C dating. Our experience shows that large mammal bone is one of the best materials for certain radiocarbon dating, if even a small portion of the original carbon of collagen remains. We have abundant evidence for this statement. Experiments demonstrate excellent agreement of dates for different parts of a single bone, for different skeletal elements of a single animal and for portions of a single bone with different degrees of preservation. Another strong evidence is the good agreement of ^{14}C dates with stratigraphical data. Sporadically inaccurate dates can be obtained, but they can be eliminated if it is possible to get a suitable set of dates.

Mass dating is a good source of information for certain megafaunal characteristics (such as age, distribution, spatio-temporal fluctuations and others).

REPLACEMENT OF *Mammuthus primigenius* AND *Palaeoloxodon naumanni* ACCOMPANYING CLIMATE CHANGE IN JAPAN

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In the Japanese Islands, two kinds of proboscidean fossils, *Mammuthus primigenius* and *Palaeoloxodon naumanni*, are known from Late Pleistocene sediments. *P. naumanni* has been found from Hokkaido, Honshu, Shikoku and Kyushu Islands, and also from the seabed off the coast. In contrast, *M. primigenius* has been found only from Hokkaido. Therefore the distributions of these species overlap in Hokkaido. However, as a result of investigating in detail those ages of occurrence, *P. naumanni* has been found from the sediment dated at ca. 120,000 y.BP and 30,000 y.BP, and *M. primigenius* has been found from the sediment dated at ca. 60,000-40,000 y.BP and 20,000 y.BP.

It has been considered that *P. naumanni* inhabited Hokkaido ca. 120,000 y.BP, which oxygen isotope analysis indicates to have been stage 5e, the warmest period in the last interglacial epoch. From the plant macrofossils and pollen analysis of the horizon from which *P. naumanni* was excavated, it was assumed that cool-temperate forest composed of deciduous broad-leaved trees (*Quercus* sp., *Juglans mandshurica*, *Corylus* sp., *Alnus japonica*, *Magnolia kobus*, *Staphylea bumalda*, *Styrax obassia*, *Styrax japonicus* and *Fagus crenata*) and conifers (*Abies sachalinensis* and *Picea glehni*) was present. *Styrax japonicus* and *Fagus crenata* are presently found in the temperate zone southward from the southern-end of Hokkaido (Yano, 1972, 1978). This indicates that

ca. 120,000 y.BP in this area climate was warmer than at present. Another *P. naumanni* fossil was found from a horizon dated at ca. 30,000 y.BP. Some comparatively warm spells were identified by an increase in *Abies* and *Ulmus* during ca. 34,000-26,000 y.BP (Hoshino and Kosaka, 1978; Igarashi *et al.*, 1990; Ono and Igarashi, 1991).

On the other hand, it is clear that *M. primigenius* was found ca. 60,000-40,000 y.BP. and 20,000 y.BP in Hokkaido. In those ages forest taiga dominated by *Picea glehni* and *Picea jezoensis* and comprising also *Pinus pumila*, *Larix gmelini* and *Larix kamtschatica* were present even in the southern part of Hokkaido (Igarashi *et al.*, 1989).

These data show that the replacement of two kinds of Proboscidea in the northern part of the Japanese Islands took place under, and were probably driven by, conditions of climate change in the Late Pleistocene.

A WOOLLY MAMMOTH (*Mammuthus primigenius*) EXCAVATION ON A COLLEGE CAMPUS IN WESTERN ILLINOIS, USA

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Students at Principia College, a four-year liberal arts college, are participating in a paleontological dig as part of a geology field course that meets an all-college science requirement. Remains of a mammoth have been found that presumably are those of a woolly mammoth, *Mammuthus primigenius*, based on its geological age placement and depositional environment. The excavation site is on the Principia College campus, located on the bluffs of the Mississippi River at Elsah, Illinois, USA, near the confluence of the Illinois, Mississippi, and Missouri Rivers. The site is a high upland area about 0.4 km from the edge of the bluffs in an open area surrounded by dormitories.

The Principia mammoth was found at a depth of about 2 m within a highly leached, yellow-brown loess unit known regionally as the Peoria Silt (late Wisconsin Episode). Total loess thickness (Peoria and Roxana Silts) at the site is about 9.5 m. Lower Carboniferous limestone forms the bedrock, which is estimated to be 1 to 2 m deeper. The mammoth is a mature male, estimated to have been (1) 39 to 43 years of age (AEY) based on its teeth, (2) about 3.3 m in height at the shoulders based on the length of the humerus, and (3) living about 17,500 (¹⁴C) years ago based on its stratigraphic position within the Peoria Silt. The skull is inverted and, except for the M³s and ventral proximal portions of the tusks, still unexcavated. The tusks and M³s are intact, as the skull also appears to be. The mandible is missing. Limb bones, ribs, and vertebrae appear to be somewhat rearranged on a flat paleosurface, indicating only minor disturbance of the remains.

Students come to understand the scientific process through their participation in all aspects of this scientific research project. They gain background information about mammoths, the Pleistocene Epoch, and other mammoth excavations from videos and the literature. Readings are from books written for the general public and scientific books and articles on details of mammoths such as osteology and theories of extinction. Field trips to other excavation sites and museums have enriched the Principia project. Experts in vertebrate paleontology at the Illinois State Museum and in Quaternary geology at the Illinois State Geological Survey have guided various aspects of the project, including planning the excavation, digging and sampling techniques, identifying bones, and understanding the geology. Students learn to actively participate in discussions with geologists about (1) observations at the dig site; (2) data collection methods; (3) hypotheses development for various aspects of the mammoth—his demise, his state of preservation, the time period in which he lived; and (4) hypotheses testing based on new observations and data.

Students have many opportunities to share their growing knowledge with site visitors—both spontaneous drop-ins and scheduled school groups and news reporters. Students also participate in site management and are excited to make real-life decisions and implement them: to protect the pit from rain, manage crowds, and decide how to bury the bones for the winter. The students take pride in keeping the site clean and organized. Their final task is to write a progress report to a hypothetical funding agency. This report includes a review of the literature pertinent to our site, a section on methods of study, our findings and their scientific significance, a discussion of various hypotheses being considered, and our progress in testing them.

PERMAFROST PROCESSES AS A FACTOR OF MAMMOTH FAUNA CONSERVATION (NOVAYA SIBIR ISLAND)

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Preservation rates of the remains of members of the mammoth fauna depend on their burial conditions and further stay in deposits. Such conditions are determined by the geological structure of the area and processes which rework the deposits. Within the permafrost area, specific cryogenic processes are developed. Their nature and intensity are strongly influenced not only by composition of deposits, but their ice content and ice distribution in them as well. Thus, cryogenic processes depend considerably on climatic conditions.

On Novaya Sibir Island (Novosibirskie Islands archipelago) frozen quaternary deposits are widespread across most of the area. They are composed of various facies of the Middle Pleistocene and older marine deposits. Their volume ice content is up to 50%. They are overlapped with high ice content (80-90%) loam and sandy loam deposits with syngenetic ice wedges. Ice wedge width is ca. 2,5-3 m, and ground block dimension between them is 5-15 m. Such deposits are known as Ice-Complex (IC), and they are widespread on the Novosibirskie islands and within the Northern Yakutia lowlands. On Novaya Sibir Island discoveries of mammoth fauna remains are connected with IC (P.

Nikolskiy, pers. comm).

The IC thickness is determined by top relief of underlying marine deposits. Within the paleovalleys which dissect marine deposits, IC thickness is 10-20 m, and only 2-5 m between them. In some places the IC is eroded and underlying marine deposits crop out. Within the paleovalleys the IC deposits are mostly alluvial-type, and on the watersheds, slope processes could also influence their formation.

At the Late Pleistocene-Holocene boundary (11 - 10,5 BP according to the series of ¹⁴C dates) the IC deposits started to thaw due to formation of thermokarst lakes, thermal planation and thermoerosion. These processes removed the IC deposits completely from watersheds or reduced them to their modern thickness. Now the IC deposits are mostly preserved in the southern part of the island, whereas marine deposits form the topography of the northern part.

Due to low thickness of the IC on watersheds and prevalence of thermal planation processes, IC degradation caused the formation of dome-type (not cone-type) thermokarst mounds. Many mammoth skeletons were redeposited *in situ* and partly removed. Thus on the Novaya Sibir (and probably on the Faddeevskiy) island there are many mammoth skeleton burials on watersheds.

On watershed slopes and within river valleys fauna remnants were removed and there are almost no whole skeletons except in small rills, where skeletons have just been exposed by erosion.

After the complete IC thawing, enclosed bones were protected *in situ* or redeposited on the surface of the marine deposits. Skeleton burials are possible in favorable conditions, but due to their high ice content, marine deposits are subjected to solifluction and mud flows (rapid solifluction). These processes led to further removal of bones mostly into rill and river valleys. Then bones were transported along river beds towards the sea shore, where secondary piles of mixed bone material were formed as a result of coastal processes.

Thus, due to peculiarities of IC bedding containing mammoth fauna remnants and various cryogenic activities, there are many skeleton burials on IC-composed watersheds and isolated bone occurrences on the slopes and river valleys.

MAMMOTH FAUNA FROM THE MAINLAND ADJACENT TO WRANGEL ISLAND

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Recently we started reconnaissance paleogeographical and paleozoological explorations on the territory of Western Chukotka. Documentation of the habitat conditions of mammoths and mammoth fauna, and determination of mammoth extinction

time with disintegration of the mammoth complex of mammals on the mainland territories directly adjacent to Wrangel Island, were the main aims of these investigations. Such study will help to reconstruct the means of colonization of mammoth on Wrangel Island in the Holocene, and to understand the reason for its absence on the island in the interval between 12 and 8 thousand years ago. Probably the Holocene refugium of mammoths on the mainland will be found. The valleys of Kuvet and Pegtymel Rivers, the coast of the East Siberian Sea as far as Billings Cape (Valkarai lowland), and Chaun Bay with Ayon Island (Chaun-Rauchua lowland) were surveyed. These regions were selected considering the bathymetry of the bottom of the East-Siberian Sea, because Wrangel Island separated from these regions of the mainland at the last moment. As a result of our expeditions a large collection of the animal remains from Western Chukotka was collected and some radiocarbon dates from the Pegtymel River mammoth materials were obtained. Addition of the new materials from the mainland to the existing vast paleontological collection supplements it with valuable new specimens. It is interesting to note that between the western coast of Chaun Bay and Valkarai lowland we found principally different situations relating to collection of bone remains. Bones of mammoths and other animals are very rare in the Valkarai lowland (lower Pegtymel River), in spite of a continuous series of radiocarbon dates from below-cutoff dates until 12500 BP, which demonstrates the constant presence of mammoth during the end of the Late Pleistocene. Within the limits of the Chaun-Rauchua lowland the situation is different, because there the friable deposits of the glacial complex, 50-60 m thick, include numerous bone remains. Probably this is connected not only with taphonomical factors but also with a very high quantity of animals in this region. However, we could not provide a continuous set of dates from our collection from this lowland, which include 6 species of mammals. Some dates show the age of Sartan glaciation.

ARCTIC EXPEDITIONS OF ZOOLOGICAL INSTITUTE FOR MAMMOTHS (1970-2000). PHOTO ALBUM

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Following the traditions of Russian scientists of the 18th and 19th centuries the Zoological Institute of the Russian Academy of Sciences (RAS) went on expeditions in search of mammoth cemeteries in the Asian Arctic in the 20th century as well. In 1948 a complete mammoth skeleton was excavated in Tajmir and in the same year the Mammoth Committee was established at the Presidium of RAS with academician E.N. Pavlovskij as chairman.

In 1970 the Zoological Institute took part in the complex expedition to the river Bereljoh in the river Indigirka basin to study the tremendous mammoth cemetery, and then continued similar research in the 1980s and 1990s in the basins of rivers Khatanga, Indigirka, Shandrin, Kolima and on the shore of East Siberian Sea.

Our album includes photos from six mammoth sites from the Asian Arctic, their modern landscapes and information on their topography, geomorphology, stratigraphy, paleoecology and taphonomy and also some moments of the camp expedition life.

PUBLIC INVOLVEMENT IN EXCAVATION AND PREPARATION OF THE STONEGATE MAMMOTH, PARKER, COLORADO: ONE OF THE OLDEST MAMMOTHS (*Mammuthus columbi*) RECORDED IN COLORADO

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In mid-July 2002, Terrabrook Development Company called the Denver Museum of Nature & Science to their construction site in Parker, Colorado. They believed that some heavy machinery had uncovered a mammoth tusk. Bart Weis confirmed that a 17-foot tusk had been uncovered. The tusk was in two pieces. The Terrabrook Development Company said, "We want to do the right thing and take what ever time is needed to excavate the tusk". The Terrabrook Company donated machinery, security, and labor to help in the excavation and transport back to the museum.

After the tusk was excavated, the museum crew surveyed the surrounding area for more mammoth remains. Paleontologically trained museum volunteers worked 10, 10-hour days in 90-degree heat to map and excavate a total of 28 bones, including a complete mammoth palate with both M³s intact. Up to five hundred people a day came to the site to watch the museum excavate the mammoth. Local, national and international news crews descended on the site, and the story made it in newspapers from Alaska to Vermont and Mexico to Germany. Preparations of the mammoth bones have been in view of the public with an accompanying video of the excavation at the Stonegate Mammoth locality. To date only a few of the jackets have been opened and prepared and the mammoth appears to be transitional between *Mammuthus imperator* and *M. columbi*.

All the bones were lying on a fine sand and gravel bed of the Louviers alluvium. The Louviers alluvium dates from 50,000 to 200,000 BP. The preliminary conclusion is that the mammoth skull with the tusk still attached tumbled into an old stream channel of Cherry Creek. On the skull's last tumble the tusk came dislodged and broke in two. Lack of enamel on the teeth suggests extensive transport.

NEW DATA FROM THE GRAVETTIAN HUNTING AND BUTCHERING SITE KRAKÓW SPADZISTA STREET (B) (POLAND)

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The Kraków Spadzista Street (B) site is one of six Aurignacian and Gravettian sites located on the rocky prominence connected with St. Bronisława hill in Kraków. It is one of the more well-known Gravettian sites in Europe and the largest mammoth bone accumulation in Poland. During 17 seasons of excavations that uncovered 150 m² of the site, approximately 7000 woolly mammoth bones and teeth were collected. The radiocarbon dates of this site clustered around 23 – 24 ky BP. As of year 2002, the

remains of 86 mammoths had been found. The Kraków Spadzista (B) site represents a mammoth butchering locality and probably a mammoth hunting site as well. However, it is not yet possible to distinguish the mammoths killed by Gravettian hunters from those that died naturally and then were scavenged by people. It is possible that Paleolithic hunters focused on the mammoths as their prey because the animals were weak due to environmental stress. Suggestion of weakened physical condition of the mammoth population is evident in the large proportion of tooth pathologies. Nearly 50% of all mammoth teeth from Kraków Spadzista Street (B) show furrows in the crown cementum. In other parts of the mammoth skeleton, we recorded only isolated bones with pathologies.

Recent investigations by archaeologists from Jagiellonian University provide insight into the spatial organization of the Gravettian complex at the site. In addition to the mammoth bone utilization zone, two other distinct zones were recognized, including activity areas for stone tool curation and polar fox procurement and another area for all stages of stone tool production and curation, interpreted as a base camp.

MAMMOTHS, HORSES AND MUCKS – OH MY! : PALEOENVIRONMENTS OF LAST CHANCE CREEK, YUKON TERRITORY

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Placer mining in the Klondike goldfields of west-central Yukon Territory has yielded thousands of late Pleistocene faunal remains. Fossils are often recovered from the base of "muck" deposits, the unconsolidated, fine-grained, ice-rich silt found in valley bottom sites overlying gold bearing gravel. The Yukon "mucks" may be analogous to Siberian *Yedoma* silt dating to the Duvanny Yar interval. Temporal and spatial association between megafauna and paleoecological data makes these sites ideal for addressing questions of late Pleistocene plant productivity, faunal diversity and climates in eastern Beringia.

Two discoveries at Last Chance Creek placer exposures are the focus of multi-proxy paleoecological investigation. In 1993, the mummified partial carcass of a small Pleistocene horse (*Equus lambei*) complete with stomach contents was recovered at the base of the "muck". An AMS radiocarbon age places the horse at 26,280 ±210 yr BP (Beta-67407, Harington and Eggleston-Stott, 1996). In 2002, an exceptionally well-preserved, complete tusk of a mature woolly mammoth (*Mammuthus primigenius*) was recovered from gravel and peat near the base of the "muck". Sedge (*Carex*) seeds from the peat yielded an AMS radiocarbon age of 25,700 ±400 yr BP (Zazula *et al.*, 2003). Pollen, plant and arthropod macrofossil analyses on the horse stomach, surrounding sediment and peat associated with the mammoth tusk were conducted. Our work

indicates megafauna at Last Chance Creek inhabited a local mosaic of xeric steppe or grassland, with diverse herbs (*Papaver*, *Draba*, *Potentilla*, various Caryophyllaceae) and *Artemisia*, that included isolated stands of birch and alder shrubs and trees. Sedge-willow meadows were present in the valley bottoms, with small groves of spruce. Data from west-central Yukon indicate that spruce survived in valley bottoms until the onset of late Wisconsinan glaciation. Shortly thereafter, climatic conditions became conducive to the deposition of loess in valley bottoms, forming the "mucks" and undoubtedly influencing the composition of local vegetation.

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THE FIRST DIRECT EVIDENCE OF MAMMOTH HUNTING IN ASIA (LUGOVSKOYE SITE, WESTERN SIBERIA)

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Lugovskoye is the rich and extensive site preserving Late Pleistocene mammalian fossil remains and the northernmost Paleolithic site in Western Siberia (the vast northwestern region of Asia). The genesis of this occurrence of mammal remains can be explained by a unique combination of a natural trap and a "beast solonetz". Sites of this sort attracted Paleolithic people, providing them with an opportunity for scavenging of animal remains or/and for hunting weak animals or those stuck in shifting ground (Derevianko *et al.*, 2000; Leshchinskiy, 2001). At the Lugovskoye locality this is evidenced by stone tools found at the site as well as by a mammoth vertebra (*Mammuthus primigenius* Blum.), hit by a spear or javelin with a composite (lithic inserts) point



Figure 1. A vertebra of *Mammuthus primigenius* Blum. pierced with a spear or javelin.

Traces of human activity and fossil remains were localized within the deposits of a spring which cuts the first fluvial terrace (above flood-plain) and flows into the Ob's tributary*. The main evidences of human activity were recovered from a nearby spring channel 190 - 205 meters upstream from the spring mouth. All of the Paleolithic artifacts (271 specimens) and numerous mammoth bone and tooth fragments were obtained through screening of sediments from the stream's bottom (top of layer 2) in an area of approximately 10 sq. m. The site's lithic industry is defined as blade-based. Tools form 14.8% of the artifact assemblage comprising retouched bladelets, grattoirs, borers, and chisel-like tools. A sample of mammoth teeth (found within the same layer as lithic artifacts) has yielded an absolute date of $10,820 \pm 170$ yr BP (SOAN-4943, conventional C14).

A mammoth vertebra pierced with a projectile weapon of Paleolithic humans was recovered from the same layer as the main collection of artifacts but approximately 60 meters downstream. The find was located among fossil remnants of a lower bone-bearing horizon at 0,3 - 0,4 meters below the top of ground deposits. A vertebra was buried partially (upper part) in the base of a peat lens (total thickness is up to 0,2 meters) and mainly in underlying thin-laminated sandy-clayey deposits (total thickness is more than 1 meter). The majority of available radiocarbon dates (obtained from bones) indicates a Late Sartan age (16,5 - 10 kyr) of layer 2. However, sedimentation of the layer's top, probably, took place in the early Holocene. This possibility is based on a date ($9,685 \pm 95$ yr BP, SOAN-4941) received from a peat lens overlapping a vertebra.

* More details about fauna composition and taphonomy: Maschenko, E.N., Pavlov, A.F., Zenin, V.N., Leshchinskiy, S.V., and Orlova, L.A. The Lugovskoe site: relations between the mammoth assemblage and the Late Palaeolithic Man - in this volume.

A small vertebral fragment was tested with radiocarbon analysis (the AMS-system), which produced the date of $13,465 \pm 50$ yr BP (KIA 19643). The “calibrated” (calendar) age was calculated with the use of “CALIB rev 4.3” as cal 14,225 yr BC. Consequently, the encounter between mammoth and man may have occurred about 16,200 years ago, i.e., in the beginning of the second half of the Sartan cryochron. Moreover, isolated dates of 18 and 30 kyr BP from the same layer evidence a process of post-depositional wash-out erosion of site deposits and re-deposition of some remains (including bone and teeth fragments from overlying layer 1 of stream bottom deposits).

A thoracic vertebra (7 - 9?) of an adult (over 22 years) mammoth female with a cone-shaped aperture and inserts of light-green quartzite stuck in the bone (Figures 1, 2) is a unique find of the Lugovskoye collection. The lesion is situated on the right side of the vertebra's body at the level of its median. Measurements of the aperture: depth - 24 mm; minimum diameter - 7 mm; maximum diameter - 9 mm. The longitudinal margin of the stuck lithic insert (previously fixed in the composite projectile point) displays blunting and steep retouch. The insert is 7 mm wide and 1,9-2,4 mm thick. Morphologically and dimensionally, the Lugovskoye insert is similar to inserts of a bone point from the Talitskogo site (radiocarbon age, 18.7 kyr) in the Urals and to an insert from the Volchiaya Griva site (radiocarbon age, 17 – 11 kyr) located at a natural fossil mammal locality ("beast solonetz") in Western Siberia.



Figure 2. A penetrating aperture in the mammoth vertebra with adhering quartzite inserts.

Judging by the developed technique of composite tools and by morphological characteristics of the artifacts, the Lugovskoye lithic industry may be placed within the second half of the Sartan cryochron (ca 16,5 - 10 kyr BP), which is in good concordance with available radiocarbon dates. However, this does not exclude the possibility of finding earlier industries at the Lugovskoye site.

A mammoth bone with a lesion made with an Upper Paleolithic projectile weapon (a spear or a javelin) is the second find of this sort in the vast territory of Eurasia and the first one in Asia. It evidences the fact the humans directly hunted a mammoth presumably stuck in a natural trap. The depth of the lesion on the bone is suggestive of a spear-throwing device used for big game hunting.

This research was carried out within the framework of the project "Initial Human Colonization and Settling of Eurasia: Formation and Evolution of Paleolithic Cultures, Correlation of Mechanisms of Cultural Adaptation with Climate Fluctuations" (Institute of Archaeology and Ethnography, Siberian Branch, Russian Academy of Sciences) and with the financial support provided by the Russian Foundation for Fundamental Research (projects 02-04-48458; 03-05-65252).

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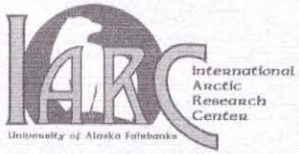
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