Reports

The Earliest Ice Age Dogs: Evidence from Eliseevichi 1[1]

MIKHAIL V. SABLIN AND
GENNADY A. KHLOPACHEV
Zoological Institute, Russian Academy of Sciences, Universitetskaya nab. 1, 199034 St. Petersburg, Russia. (*msablin@yandex.ru*)/*Museum of Anthropology and Ethnography, Russian Academy of Sciences (Kunstkamera), Universitetskaya nab. 3, 199034 St. Petersburg, Russia.* 24 I 02

Although some scientists have suggested that the first transformation from wolf to dog may have taken place more than 100,000 years ago (Vila et al. 1997), most archaeologists and palaeontologists believe that humans first tamed wolves before the end of the Pleistocene. The evidence of domestication has, however, been indirect (Benecke 1987). Fragments of bones of *Canis lupus* L. identified as early Holocene domestic dog have been reported from the Near East (Turnbull and Reed 1974, Davis and Valla 1978), central and northern Europe (Musil 1984, Nobis 1986, Street and Baales 1999), and Siberia (Pawlow 1930). No complete dog cranium has yet been found in a site earlier than 12,000 ^{14}C years B.P. The finds we report here, from the Upper Paleolithic site Eliseevichi 1 (central Russian Plain, Bryansk Region), have been dated to 13,000–17,000 ^{14}C years B.P.

Eliseevichi 1 is situated in the basin of the Dnieper River, on the Sudost River (the right tributary of the Desna) (lat. 53°10′ N, long. 33°40′ E). The cultural layer is located on the second alluvial terrace of the Sudost in eolian-diluvial Upper Pleistocene deposits. A large number of bones of the mammoth *Mammuthus primigenius* Blum were found among the food debris at the site. Remains of Arctic fox (*Alopex lagopus* L.) and reindeer (*Rangifer tarandus* L.) were also common (Kuzmina and Sablin 1993). The assemblage of animal bones from Eliseevichi 1 is typical of a cold-tolerant Upper Pleistocene fauna. Climate change to extremely cold and dry by the final phase of the Late Valdai stage of the last glaciation brought about an increase in the number of tundra species of mammals and a decrease in the number of steppe species.

Around 694 m^2 of cultural deposits were excavated by the Russian scientists K. M. Polikarpovitch (in 1930–40), V. D. Bud'ko (in 1960), and L. V. Grekhova (in 1970–80). The cultural deposits, including remains of at least eight mammoth-bone dwellings, were dated by the radiocarbon method, producing four dates that range from 15,620 ± 200 ^{14}C years B.P. to 17,340 ± 170 ^{14}C years B.P., five dates that range from 14,080 ± 70 ^{14}C years B.P. to 14,590 ± 140 ^{14}C years B.P., and two further dates of 12,630 ± 360 ^{14}C years B.P. and 12,970 ± 140 ^{14}C years B.P. (Velichko et al. 1997). The high frequency of the burin technique in the stone industry, the large quantities of worked mammoth tusk, and the tradition of bone carving in complicated geometric designs that characterize the material culture of the site are typical of other sites in the Desna River area. Eliseevichi 1 is usually categorized as Epigravettian or "Evolved Gravettian," but its culture has no analogues in the Desna River area or elsewhere. Special objects from this site include mammoth ivory "churingas," honeycomb-like ornaments, a particular type of realistically carved female figurine (Polikarpovich 1968), and small animal figurines made of limestone (Grekhova 1985, Khlopachev 1997). The majority of these finds came from the area of the site that was excavated in 1935 and 1936, and it was this area that yielded the skulls of the earliest dogs. A complete dog cranium (MAE 447/5298) was found 2.0 m southeast of the edge of the concentration of mammoth skulls in the excavation unit of 1935 that was later interpreted as the remains of dwelling (Polikarpovich 1968). It lay at a depth of 1.48 m in a hearth deposit in the middle of the cultural layer and was found in a dorsal position, with the nose tilted down in a southeasterly direction. The second skull was found outside the hearth deposit 7 m southwest of the first specimen in the 1936 excavation unit.

Both crania are those of adult dogs. They resemble Siberian husky skulls in shape but are larger, with broad, flat frontals (fig. 1). The crista mediana and the lineae semicularis are strongly protruding, the braincases strongly (MAE 447/5298) or normally (ZIN 23781/24) vaulted, and the zygomatic breadths very large (table 1). The orbital angles are 46.5° (MAE 447/5298) and 47.0° (ZIN 23781/24). The premolars are compacted, diastemas between C^1 and P^1 being absent. Because Ice Age dogs were the same size as wolves (Musil 1984, Nobis 1986), smaller size cannot be used as evidence of domestication. Size reduction under domestication is of course well documented for dogs (Tchernov and Horwitz 1991, Morey 1992, Crabtree 1993), but it did not take place by active intervention of humans (encouraging cross-breeding between these dogs and wolves and by deliberate selection of their offspring). Ethnohistoric and ethnographic descriptions of Plains Amerindian dogs directly illustrate this point:

1. Sponsored by the Russian Fundamental Investigations Fund, # 01-06-80045a.

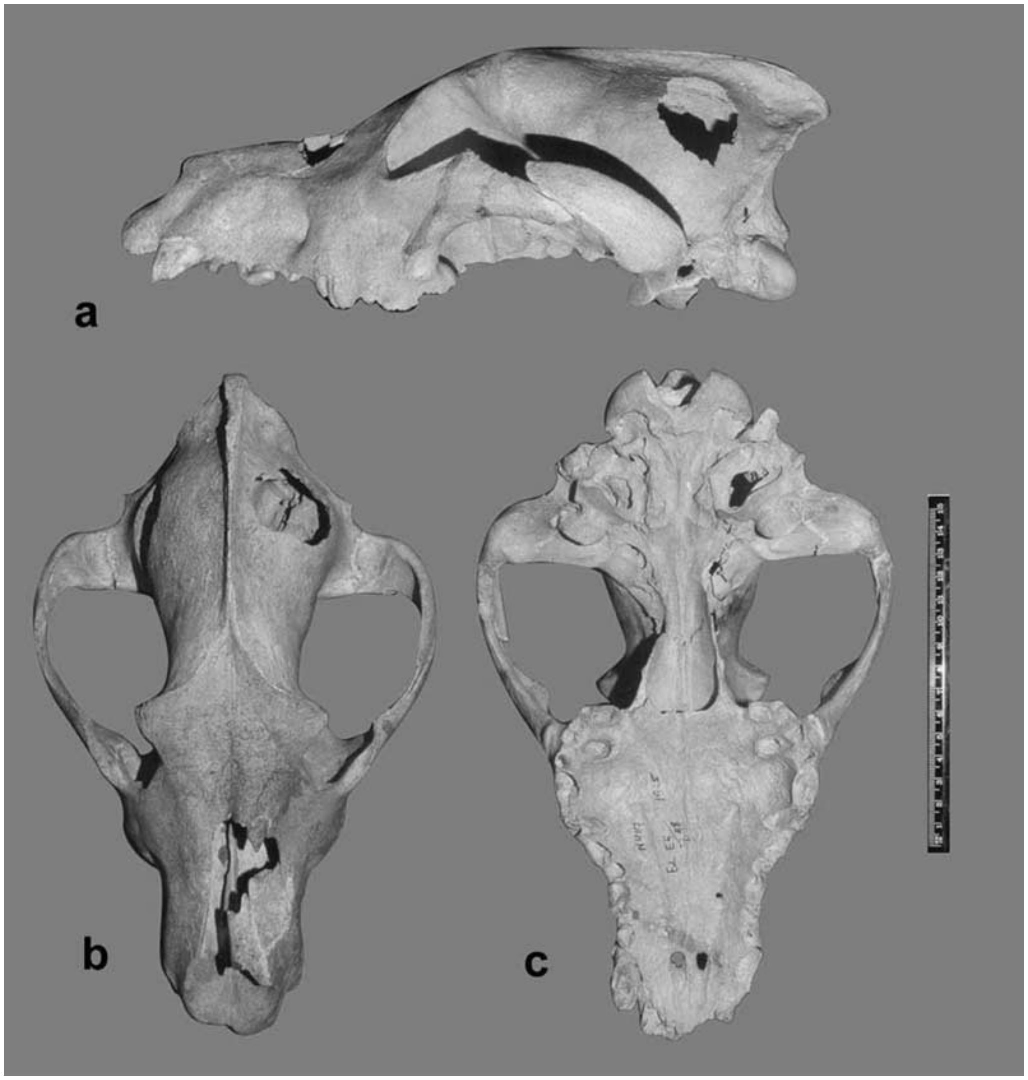

FIG. 1. *Dog cranium from Eliseevichi 1 (MAE 447/5298).* a, *lateral view, cutting off the occipital;* b, *dorsal view;* c, *palatal view.*

> The dogs, whose flesh is eaten by the Sioux, are equally valuable to the Indians. In shape they differ very little from the wolf, and are equally large and strong. . . . Their voice is not a proper barking, but a howl, like that of the wolf, and they partly descend from wolves, which approach the Indian huts, even in the daytime, and mix with the dogs. [Maximilian 1906:310]

> Usually, there were from seven to ten puppies in a litter. As we wanted only big dogs, and those of the first litter never grew large, we always killed them sparing not even one. From the second litter, we kept three or four of the puppies with large heads, wide faces, and big legs, for we knew they would be big dogs; the rest we killed . . . . Our old breed of dogs all had straight wide faces, heavy, but not short legs, and ears that stood erect like those of a coyote. The dogs were about the size of a wolf. [Buffalo-Bird-Woman, quoted in Wilson 1924:204]

There is little doubt that the same hybridization and deliberate selection for large, strong (i.e., wolflike) dogs took place in the Ice Age and that Upper Pleistocene dogs were remarkably like wolves in terms of size.

Relative to wolves, most dogs exhibit a shortening of the anterior end of the cranium (the snout) associated with a broad palate (Lawrence 1967, Riesenfeld and Siegel 1970, McLoughlin 1983, Olsen 1985). Therefore, a wide palate, coupled with a short rostrum, has been used as an effective criterion for the identification of domestication (Morey 1994). Shortening of the snout in dogs relative to wolves is the clearest single trait distinguishing the two.

TABLE 1
Measurements (mm) of Two Dog Crania from Eliseevichi 1

Measurements	Specimens: MAE 447/5298	Specimens: ZIN 23781(24)
Total length	240.0	256.0
Condylobasal length	226.0	236.0
Basal length	213.5	223.0
Basicranial axis	–	60.2
Basifacial axis	158.5	168.0
Neurocranial length	124.0	–
Upper neurocranial length	117.0	122.0
Viscerocranial length	116.0	–
Facial length	132.0	146.0
Greatest length of the nasals	85.4	–
"Snout" length	99.0	100.0
Palatal length	113.0	127.4
Alveolar length M^2–C^1	99.7	104.4
Alveolar length M^2–P^1	81.6	92.0
Alveolar length M^2–P^4	43.8	45.7
Alveolar length M^2–M^1	22.5	24.1
Alveolar length P^3–P^1	38.5	41.4
Alveolar length P^4	23.7	27.2
Crown length P^1	–	9.6
Crown length P^2	–	15.3
Crown length P^3	–	17.4
Crown length P^4	–	27.3
Crown length M^1	–	19.0
Crown length M^2	–	9.3
Crown breadth P^4	–	14.5
Crown breadth M^1	–	20.4
Crown breadth M^2	–	13.5
Greatest diameter of the auditory bulla	27.9	28.0
Greatest mastoid breadth	85.3	85.2
Breadth dorsal to the external auditory meatus	84.2	85.3
Greatest breadth of the occipital condyles	49.7	50.0
Greatest breadth of the foramen magnum	24.0	21.0
Height of the foramen magnum	21.3	19.7
Greatest breadth of the braincase	73.0	68.0
Zygomatic breadth	145.7	~148.0
Least breadth of skull	43.0	~52.0
Frontal breadth	64.4	66.0
Least intraorbital breadth	46.4	47.0
Greatest palatal breadth	87.5	~91.0
Least palatal breadth	50.4	~51.6
Breadth at the canine alveoli	52.4	~55.6
Greatest inner height of the orbit	36.4	36.0
Skull heigth	76.0	78.4
Skull height without the sagittal crest	67.0	62.6
Height of the occipital triangle	64.0	64.5

NOTE: For similar or identical measurements see Van den Driesch (1976).

The ratio of greatest palatal breadth to condylobasal length of both these finds was compared with that for recent wolves from northern Europe ($N = 16$), southern Europe ($N = 5$), the Caucasus ($N = 12$), Central Asia ($N = 13$), the Middle East and northern India ($N = 14$), China ($N = 20$), southern Siberia ($N = 8$), northern Siberia ($N = 18$), the Far East ($N = 14$), and North America ($N = 12$) and that for Siberian huskies ($N = 36$) and Great Danes ($N = 2$), the Siberian husky being a typical cold-tolerant breed and the Great Dane a large guarding breed. The measurements for wolves and dogs were taken by the first author from the collection of the Zoological Institute, Russian Academy of Sciences. Additional data on wolves came from Pocock (1935). The difference in this ratio between wolves and Siberian huskies is highly significant ($P < 0.001$), and the difference between the wolves and the dogs from Eliseevichi 1 is apparent (table 2). The Ice Age dogs from Eliseevichi 1 differ from all recent wolves and have much shorter muzzles than Siberian huskies and Great Danes (fig. 2). The crania from Eliseevichi 1 were almost as large as those of northern wolves and Great Danes, but the extremely wide palate, coupled with the extremely short rostrum, is very unusual. The reconstructed withers height is about 70

TABLE 2
Ratio of Greatest Palatal Breadth to Condylobasal Length in Wolves, Modern Dogs, and Eliseevichi 1 Crania

	N	Range	Mean	S.D.
Wolves	132	0.309–0.369	0.339	0.013
Siberian huskies	36	0.328–0.384	0.358	0.013
Great Danes	2	0.377–0.380	–	–
Eliseevichi 1 dogs	2	0.386–0.387	–	–

NOTE: For wolves and Siberian huskies, $t = 7.673$ ($P < 0.001$).

cm. Therefore, the Eliseevichi 1 dogs represent a heavy breed.

The early dogs from Eliseevichi 1 may have played an important role in the development of human hunting technology and strategy. In an environment in which wolves and humans were competing for food, it is not difficult to surmise how an alliance could have been formed between them. Social structures and behaviour patterns are closely similar because both species evolved in response to the needs of communal hunting. Dogs also doubtless served as food animals. For the Neolithic and the Bronze Age, dog skulls whose braincase had been opened by removing the occipital (Bokonyi 1974) have often been found. A hole had been made in the side of the skull MAE 447/5298 from Eliseevichi 1 site so that the brain could be removed (fig. 1).

Because of the lack of fossil material, it is still impossible to say where the domestication of the dog began.

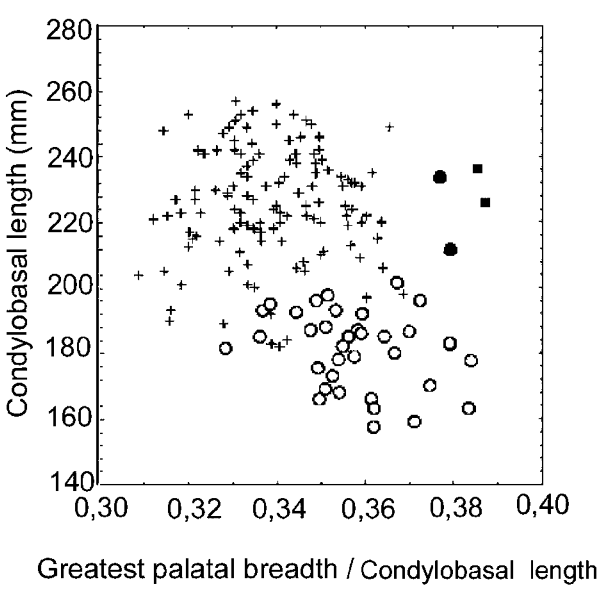

FIG. 2. *The ratio of greatest palatal breadth to condylobasal length compared with condylobasal length.* ○, *Siberian huskies* (N = *36*); +, *wolves* (N = *132*); •, *Great Danes;* ■, *Eliseevichi 1 dogs.*

Some researchers suggest that it may have taken place in the Middle East (Clutton-Brock 1995), but genetics cannot pinpoint the location of the ancestral wolf population. For this reason and on the basis of information from other genetic studies, the idea of a single locus of domestication is not supported (Morell 1997). It seems probable that humans tamed wolf pups in many parts of the world and therefore that several subspecies of wolf contributed to the ancestry of the dog. We suggest that the specimens of dogs reported here were domesticated *in situ* from local northern wolves.

References Cited

BENECKE, N. 1987. Studies on early dog remains from northern Europe. *Journal of Archaeological Science* 14:31.

BÖKÖNYI, S. 1974. *History of domestic mammals in central and eastern Europe.* Budapest.

CLUTTON-BROCK, J. 1995. "Origins of the dog, domestic and early history," in *The domestic dog.* Edited by James Serpell, pp. 8–20. Cambridge: Cambridge University Press.

CRABTREE, P. J. 1993. Animal domestication in the Near East and Europe. *Advances in Archaeological Method and Theory* 5:201–45.

DAVIS, S. J. M., AND F. R. VALLA. 1978. Evidence for domestication of the dog 12,000 years ago in the Natufian of Israel. *Nature* 276:608–10.

GREKHOVA, L. V. 1985. "Mammoth figurine from Eliseevichi site" (in Russian), in *The history and culture of Eurasia: Archaeological data,* pp. 4–6. Proceedings of the State Historical Museum 60.

KHLOPACHEV, G. A. 1997. "Eliseevichi 1 and Gravettian sites within central Russia: Cultural contacts (based on the study of Upper Palaeolithic art)," in *Cultural interaction in contact zones,* pp. 7–20. St. Petersburg.

KUZMINA, I. E., AND M. V. SABLIN. 1993. Arctic foxes of the Late Pleistocene from the Upper Desna (in Russian). *Proceedings of the Zoological Institute, Russian Academy of Sciences* 249:93–104.

LAWRENCE, B. 1967. Early domestic dogs. *Zeitschrift für Saugetierkunde* 32:44–59.

MC LOUGHLIN, J. C. 1983. *The canine clan: A new look at man's best friend.* New York: Viking Press.

MAXIMILIAN, A. P. 1906. Travels in the interior of North America. *Early Western Travels* 22:5–393.

MORELL, V. 1997. The origin of dogs: Running with the wolves. *Science* 276:1647–48.

MOREY, D. F. 1992. Size, shape, and development in the evolution of the domestic dog. *Journal of Archaeological Science* 13: 119–45.

———. 1994. The early evolution of the domestic dog. *American Scientist* 82:336–47.

MUSIL, R. 1984. "The first known domestication of wolves in central Europe," in *Animals and archaeology,* vol. 4, *Husbandry in Europe.* British Archaeological Reports International Series 227.

NOBIS, G. 1986. Die Wildsaugetiere in der Umwelt des Menschen von Oberkassel bei Bonn und das Domestikationsproblem von Wolfen im Jungpaläolithikum. *Bonner Jahrbucher* 186:367–76.

OLSEN, S. J. 1985. *Origins of the domestic dog: The fossil record.* Tucson: University of Arizona Press.

PAWLOW, M. 1930. Mammifères posttertiaires trouvés sur les bords du Volga près de Senguiley et quelques formes provenant d'autres localités. *Annual of the Russian Palaeontology Society* 9:1–42.

POCOCK, K. R. 1935. The races of *Canis lupus. Proceedings of the Zoological Society of London* 2:646–86.

POLIKARPOVICH, K. M. 1968. *Palaeolithic of the Upper Dnieper* (in Russian). Minsk.

RIESENFELD, A., AND M. I. SIEGEL. 1970. The relationship between facial proportions and root length in the dentition of dogs. *American Journal of Physical Anthropology* 33:459–32.

STREET, M., AND M. BAALES. 1999. "Pleistocene/Holocene changes in the Rhine fauna in a Northwest European context," in *The Holocene history of the European vertebrate fauna: Modern aspects of research.* Edited by N. Benecke, pp. 9–38. Rahden: Verlag Marie Leindorf.

TCHERNOV, E., AND L. HORWITZ. 1991. Body size diminution in primeval domesticates: Unconscious selection in primeval domesticates. *Journal of Anthropological Archaeology* 10:54–75.

TURNBULL, P. F., AND C. A. REED. 1974. The fauna from the terminal Pleistocene of Palegavra Cave, a Zarzian occupation site in northeastern Iraq. *Fieldiana: Anthropology* 63(3): 81–146.

VELICHKO, A. A., L. B. GREKHOVA, Y. N. GRIBCHENKO, AND E. I. KURENKOVA. 1997. *Early man in the extreme environmental conditions: Eliseevichi 1 site.* Moscow.

VILA, C., P. SAVOLAINEN, J. E. MALDONADO, I. R. AMORIM, J. E. RICE, R. L. HONEYCUTT, K. A. CRANDALL, J. LUNDEBERG, AND R. K. WAYNE. 1997. Multiple and ancient origins of the domestic dog. *Science* 276:1687–89.

VON DEN DRIESCH, A. 1976. *A guide to the measurement of animal bones from archaeological sites.* Peabody Museum of Archaeology and Ethnology, Harvard University, Bulletin 1.

WILSON, G. L. 1924. The horse and the dog in Hidatsa culture. *American Museum of Natural History, Anthropological Papers* 15:123–311.

Prehistoric Migration in Europe: Strontium Isotope Analysis of Early Neolithic Skeletons

R. ALEXANDER BENTLEY, T. DOUGLAS PRICE, JENS LÜNING, DETLEF GRONENBORN, JOACHIM WAHL, AND PAUL D. FULLAGAR
Institute of Archaeology, University College London, 31-34 Gordon Square, London WC1H 0PY, U.K. (*r.bentley@ucl.ac.uk*) (Bentley)/*Department of Anthropology, University of Wisconsin–Madison, Madison, Wis. 53706, U.S.A.* (Price)/*Johann-Wolfgang-Goethe University, Frankfurt, Germany* (Lüning and Gronenborn)/*Landesdenkmalamt Baden-Württemberg, Konstanz, Germany* (Wahl)/*Department of Anthropology, University of North Carolina, Chapel Hill, N.C. 27599, U.S.A.* (Fullagar). 23 I 02

The term Linearbandkeramik (LBK) is traditionally used to describe the first farmers of central Europe and the pottery they introduced approximately 7,500 years ago. Radiocarbon dates for the LBK suggest a rapid spread into central Europe from its origin on the Hungarian Plain. The geographic homogeneity of LBK artifacts and architecture, along with domesticated plants and animals with origins in southwestern Asia, seems to be reflective of a "wave" of colonization by migrating farmers, who may also have brought Indo-European languages and genes (Childe 1929, Quitta 1964, Ammerman and Cavalli-Sforza 1984, Bogucki 1988, Lüning, Kloos, and Albert 1989, Kreuz 1990, Price, Gebauer, and Keeley 1995, Price 2000, Troy et al. 2001).

An alternative view is that the LBK spread through the adoption of agriculture by the indigenous hunter-gatherers (Tillmann 1993, Whittle 1996) or a combination of colonization and indigenous adoption (Gronenborn 1999, Zvelebil and Lillie 2000). Indigenous people along and west of the Rhine River may have made "La Hoguette" pottery before the LBK era (Jeunesse 1987, Lüning, Kloos, and Albert 1989). In western Germany, flint tools from the earliest LBK exhibit continuity with preceding Mesolithic forms, and many are made of flint quarried from areas populated only by Mesolithic groups at that time (Mauvilly 1997, Gronenborn 1999). Mitochondrial DNA (mtDNA) studies support the case for indigenous adoption (Richards et al. 1996, 2000), although such evidence is indirect because the mtDNA has come from modern Europeans.

The two views have been difficult to resolve through architecture or artifacts because ideas or trade items can spread without people's migrating. To examine human mobility directly, we measured strontium isotopes in human skeletons from three LBK cemeteries in southwestern Germany. Strontium substitutes for calcium in the hydroxyapatite mineral of skeletal tissue, and strontium isotopes in prehistoric human teeth and bones provide a geochemical signature of the place of residence. The $^{87}Sr/^{86}Sr$ values in natural rocks vary from older granites, with $^{87}Sr/^{86}Sr$ ratios typically above 0.710 and as high as 0.740, to younger basalts, with lower $^{87}Sr/^{86}Sr$ ratios around 0.703 to 0.704. These differences, all in the third decimal place, are easily detected by thermal ionization mass spectrometry (TIMS), with which $^{87}Sr/^{86}Sr$ can be measured with a typical precision of 0.00001 or better.

Because of their large atomic mass, strontium isotopes retain the same $^{87}Sr/^{86}Sr$ ratio as they pass from weathered rocks through soils to the food chain (Hurst and Davis 1981, Beard and Johnson 2000). Even if there were some mass-dependent fractionation of strontium along biogeochemical pathways, it would be corrected for upon measurement by mass spectrometry, as strontium ratios are normalized to the constant value of $^{86}Sr/^{88}Sr$ in natural rocks (Beard and Johnson 2000). In other words, strontium isotopic signatures faithfully make their way from local geologic materials ultimately into the human skeleton.

One can identify migrant individuals who moved between geologic regions by comparing the isotope signature in adult teeth, composed between four and twelve years of age, with that in the bones, with characteristic turnover times varying between 6 and 20 years for different bones of the body (Parfitt 1983, Ericson 1985, Price et al. 1994, Grupe et al. 1997, Grupe, Price, and Söllner