Available online at www.sciencedirect.com

SciVerse ScienceDirect

Geochimica et Cosmochimica Acta 75 (2011) 5951–5970

Geochimica et Cosmochimica Acta

www.elsevier.com/locate/gca

Nd and Sr isotope compositions in modern and fossil bones – Proxies for vertebrate provenance and taphonomy

Thomas Tütken [a,*], Torsten W. Vennemann [b], Hans-U. Pfretzschner [c]

[a] *Steinmann-Institut für Geologie, Mineralogie und Paläontologie, Poppelsdorfer Schloss, University of Bonn, 53115 Bonn, Germany*
[b] *Institut de Minéralogie et Géochimie, L'Anthropôle, 1015 Lausanne, Switzerland*
[c] *Institut für Geowissenschaften, University of Tübingen, Keplerstrasse 17, 72074 Tübingen, Germany*

Received 14 April 2010; accepted in revised form 17 July 2011; available online 26 July 2011

Abstract

Rare earth elements (REE), while not essential for the physiologic functions of animals, are ingested and incorporated in ppb concentrations in bones and teeth. Nd isotope compositions of modern bones of animals from isotopically distinct habitats demonstrate that the $^{143}Nd/^{144}Nd$ of the apatite can be used as a fingerprint for bedrock geology or ambient water mass. This potentially allows the provenance and migration of extant vertebrates to be traced, similar to the use of Sr isotopes. Although REE may be enriched by up to 5 orders of magnitude during diagenesis and recrystallization of bone apatite, *in vivo* $^{143}Nd/^{144}Nd$ may be preserved in the inner cortex of fossil bones or enamel. However, tracking the provenance of ancient or extinct vertebrates is possible only for well-preserved archeological and paleontological skeletal remains with *in vivo*-like Nd contents at the ppb-level. Intra-bone and -tooth REE analysis can be used to screen for appropriate areas. Large intra-bone Nd concentration gradients of 10^1–10^3 are often measured. Nd concentrations in the inner bone cortex increase over timescales of millions of years, while bone rims may be enriched over millenial timescales. Nevertheless, ε_{Nd} values are often similar within one ε_{Nd} unit within a single bone. Larger intra-bone differences in specimens may either reflect a partial preservation of *in vivo* values or changing ε_{Nd} values of the diagenetic fluid during fossilization. However, most fossil specimens and the outer rims of bones will record taphonomic $^{143}Nd/^{144}Nd$ incorporated *post mortem* during diagenesis. Unlike REE patterns, $^{143}Nd/^{144}Nd$ are not biased by fractionation processes during REE-uptake into the apatite crystal lattice, hence the ε_{Nd} value is an important tracer for taphonomy and reworking. Bones and teeth from autochthonous fossil assemblages have small variations of ± 1 ε_{Nd} unit only. In contrast, fossil bones and teeth from over 20 different marine and terrestrial fossil sites have a total range of ε_{Nd} values from –13.0 to 4.9 ($n = 80$), often matching the composition of the embedding sediment. This implies that the surrounding sediment is the source of Nd in the fossil bones and that the specimens of this study seem not to have been reworked. Differences in ε_{Nd} values between skeletal remains and embedding sediment may either indicate reworking of fossils and/or a REE-uptake from a diagenetic fluid with non-sediment derived ε_{Nd} values. The latter often applies to fossil shark teeth, which may preserve paleo-seawater values. Complementary to ε_{Nd} values, $^{87}Sr/^{86}Sr$ can help to further constrain the fossil provenance and reworking.

1. INTRODUCTION

Rare earth elements (REE) are important trace elements in petrology and geochemistry and have become increasingly important in archeology, paleontology, and taphonomy to help understand the processes, timing, and environment of fossilization of vertebrate remains (e.g., Henderson et al., 1983; Elderfield and Pagett, 1986; Toyoda and Tokanami, 1990; Trueman and Benton, 1997; Trueman, 1999; Reynard et al., 1999; Lécuyer et al., 2003; Trueman et al., 2004, 2006, 2011; Metzger et al., 2004; Patrick et al., 2004; Trueman et al., 2005; Labs-Hochstein and MacFadden, 2006; MacFadden et al., 2007; Suarez et al., 2007, 2010; Kohn, 2008; Tütken et al., 2008; Koenig

* Corresponding author. +49 (0) 228 736545.
E-mail address: tuetken@uni-bonn.de (T. Tütken).

0016-7037/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.gca.2011.07.024