Table DR1. Location, systematic attribution, sample number, sample type and oxygen isotope compositions of the fish fossil samples. (**d**) is for diagenesis suspected

Location	Taxon	Environment	Sample	Sample	d18O (PO4)
Toros-Menalla : 7 Ma					
TM 82	*Hydrocynus*	marginal waters	19-M82-h	4 teeth	20,19
	Hydrocynus	marginal waters	20-M82-h	6 teeth	19,70
TM 90	*Polypterus*	Swamp	30-M90-p	4 scales	20,90
	Polypterus	Swamp	31-M90-p	4 scales	19,23
TM 254	*Hydrocynus*	open waters	36-M254-h	5 teeth	16,40
	Hydrocynus	open waters	37-M254-h	6 teeth	18,06
TM 337	*Hydrocynus*	marginal waters	40-M337-h	5 teeth	18,29
	Hydrocynus	marginal waters	51-M337-h	33 teeth	18,58
	Tetraodon	marginal waters	49-M337-t	33 plates	19,36
TM 266	*Hydrocynus*	open waters	11-M266-h	n teeth	17,10
	Hydrocynus	open waters	12-M266-h	n teeth	18,05
	Hydrocynus	open waters	39-M266-h	6 teeth	18,12
	Hydrocynus	open waters	41-M266-h	33 teeth	16,08
	Hydrocynus	open waters	42-M266-h	33 teeth	16,62
	Hydrocynus	open waters	43-M266-h	33 teeth	16,90
	Hydrocynus	open waters	52-M266-h	33 teeth	17,06
	Tetraodon	open waters	48-266-t	38 plates	17,10
	Tetraodon	open waters	50-266-t	26 plates	18,44
TM 267	*Hydrocynus*	open waters	24-M267-h	5 teeth	15,86
	Hydrocynus	open waters	25-M267-h	8 teeth	16,43
Kossom Bougoudi : 5.5–5 Ma					
KB 03	*Hydrocynus*	open waters	7-B3-h	n teeth	18,94
	Hydrocynus	open waters	8-B3-h	n teeth	19,90
	Hydrocynus	open waters	44-B3-h	33 teeth	18,67
	Hydrocynus	open waters	45-B3-h	33 teeth	19,03
	Hydrocynus	open waters	53-B3-h	33 teeth	19,14
KB 07	*Hydrocynus*	open waters	26-B7-h	5 teeth	19,74
	Hydrocynus	open waters	32-B7-h	3 teeth	17,63
Kolle : 5–4 Ma					
KL 02	*Hydrocynus*	open waters	13-L2-h	n teeth	18,97
	Hydrocynus	open waters	14-L2-h	n teeth	20,24
	Hydrocynus	open waters	54-L2-h	33 teeth	19,16
KL 02 (channel)					
	Hydrocynus	marginal waters	15-L2c-h	n teeth	18,21 (d)
	Polypterus	marginal waters	29-L2c-p	4 scales	18,20 (d)
Koro-Toro : 3.5–3 Ma					
KT 13	*Hydrocynus*	open waters	9-T13-h	n teeth	19,57
	Hydrocynus	open waters	10-T13-h	n teeth	20,05
KT 12	*Hydrocynus*	open waters	16-T12-h	n teeth	19,76
	Hydrocynus	open waters	46-T12-h	33 teeth	19,58
	Hydrocynus	open waters	56-T12-h	33teeth	19,86
	Tetraodon	open waters	47-T12-t	30 plates	18,99
	Tetraodon	open waters	55-T12-t	23 plates	20,14

Appendix DR1. Sample preparation

Teeth (jaw teeth of *Hydrocynus*), tooth plates (beak elements of *Tetraodon*) and ganoid scales (*Polypterus*) were cleaned by ultrasonic cleaning in deionized water. Depending on the concerned fish, bulk analyses were performed on 10 to 33 teeth, on about 20 tooth plates from one or two beak elements, or on 5 to 10 scales. Well-preserved enamel was manually selected on each tooth by hand-picking following rough crushing in an agate mortar.

Appendix DR2. Oxygen isotope analysis of tooth enamel phosphate

Measurements of oxygen isotope ratios of apatite consist in isolating PO_4^{3-} using acid dissolution and anion-exchange resin, according to a protocol derived from the original method (Crowson et al., 1991) and slightly modified (Lécuyer et al., 1993). Silver phosphate was quantitatively precipitated in a thermostatic bath set at a temperature of 70°C. After filtration, washing with double deionised water, and drying at 50°C, 15 mg of Ag_3PO_4 were mixed with 0.8 mg of pure powder graphite. $^{18}O/^{16}O$ ratios were measured by reducing silver phosphate to CO_2 using graphite reagent (O'Neil et al., 1994; Lécuyer et al., 1998). Samples were then weighed into tin reaction capsules and loaded into quartz tubes and degassed for 30 minutes at 80°C under vacuum. Each sample was heated at 1100°C for 1 minute to promote the redox reaction. The CO_2 produced was directly trapped in liquid nitrogen to avoid any kind of isotopic reaction with quartz at high temperature. CO_2 was then analyzed with a GV Prism™ mass spectrometer at the Laboratory UMR CNRS 5125 'PEPS', University Lyon 1. Isotopic compositions are quoted in the standard δ notation relative to V-SMOW. Silver phosphate precipitated from standard NBS120c (natural Miocene phosphorite from Florida) was repeatedly analyzed ($\delta^{18}O = 21.67 \pm 0.18$; n = 15) along with the silver phosphate samples derived from the Neogene Chadian fish remains.

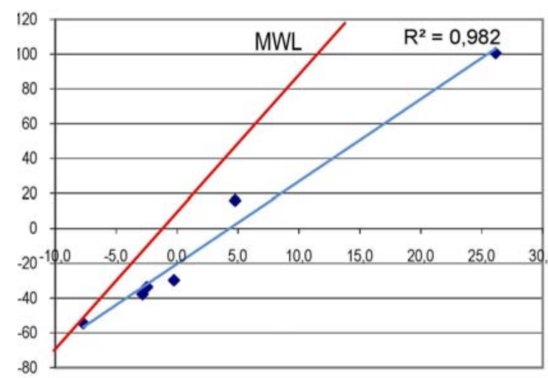
Appendix DR3. $\delta^{18}O$ and δD composition of six water samples collected in February 2006 in Chad

Aliquots of 200 µl of water were automatically equilibrated at 40°C with CO_2 and H_2 and analyzed using a MultiPrep™ system on line with a GVI IsoPrime™ dual inlet IRMS. Internal reproducibilities were typically ±0.03‰ for $\delta^{18}O$ and ±0.5‰ for δD. External reproducibilities of $^{18}O/^{16}O$ and D/H measurements were established at about ±0.1‰ and ±1‰, respectively, by scaling raw data to the "true" isotopic ratios of SMOW, SLAP and GISP international standards.

The measurements are presented below in a table giving the name sample and their location, and in the diagram δD=f ($\delta^{18}O$) showing the samples (blue spot), the regression line (blue line) and also the Meteoric Water Line (MWL) in red. Note the Deuterium and ^{18}O enrichment of the residual water collected in a drying pond (Guileba, TCH_W5)

Sample	Location	$\delta^{18}O$ ‰ SMOW	SD	δD ‰ SMOW	SD
TCH_W1	well ≈15°LatN (desert, Salal)	4.77	0.05	16.1	0.03
TCH_W2	well ≈16°LatN (desert, TM)	–2.46	0.05	–33.6	2.0
TCH_W3	well ≈16°LatN (desert, TM)	–0.26	0.04	–29.7	1.0
TCH_W4	well ≈16°LatN (desert, TM)	–2.83	0.06	–37.7	0.5
TCH_W5	pound ≈13.3°LatN (Guileba)	26.14	0.08	100.6	1.3
TCH_W6	well ≈13.3°LatN (Guileba)	–7.69	0.01	–54.4	2.7

Note: The wells in Salal and Guileba are those of the village; the wells in the desert were dug by OO and MHT (about 2 m deep) close to three different sites in the Toros-Menalla area (TM).



Appendix DR4. Diagenesis

Isotopic exchange under inorganic conditions has little effects upon the oxygen isotope composition of phosphate, even at geological scale (Kolodny et al., 1983; Lécuyer et al., 1999). Well-preserved and unbroken teeth were preferentially selected to isolate tooth enamel that is considered as the most robust biomineral for preserving pristine oxygen isotope ratios. Although no method is available to demonstrate definitely whether the oxygen isotope composition of tooth phosphate was affected by diagenetic processes, several arguments are in favor of the preservation of the primary isotopic record. Based on the clustered phosphate chemical yields close to 40% measured during the wet chemistry procedure, the original stoechiometry of tooth enamel was preserved. A strong argument supporting the preservation of the oxygen isotopic record is provided by the relation observed between the size of water bodies and the mean $\delta^{18}O$ values of fish teeth that lived in the contemporaneous late Miocene sites from Toros–Menalla. If early diagenetic processes had occurred, they would have most likely homogenised $\delta^{18}O_p$ values of all vertebrate remains whatever the physiology and ecology of the corresponding taxa. It appears on the basis of our data set that diagenetic effects – if they occurred – were weak enough to preclude the resetting of the original oxygen isotope compositions of fossil fishes. However, two samples from a same peculiar horizon in KL2 (Otero et al., 2009) were excluded from the dataset because they do not match any of these criteria (Table DR1).

Bibliography

Crowson, R.A., Showers, W.J., Wright, E.K., and Hoering, T.C. 1991, A method for preparation of phosphate samples for oxygen analysis: Analytical Chemistry, v. 63, p. 2397-2400.

Kolodny, Y., Luz, B., Navon, O., 1983, Oxygene isotopes variations in phosphate of biogenic apatites: I. Fish bone apatite, rechecking the rules of the game Ethiopia: Earth and Planetary Science Letter, v. 64, p. 398-404.

Lécuyer, C., Grandjean, P., and Sheppard, S.M.F., 1999, Oxygen isotope exchange between dissolved phosphate and water at temperatures <135°C: inorganic versus biological fractionations: Geochimica Cosmochimica Acta, v. 63, p. 855-862.

Lécuyer C, Grandjean, P., Barrat, J.A., Nolvak, J., Emig, C. Paris, F., and Robardet, M., 1998, $\delta^{18}O$ and REE contents of phosphatic brachiopods: a comparison between modern and lower Paleozoic populations: Geochimica and Cosmochimica Acta, v. 62, p. 2429-2436.

Lécuyer, C., Grandjean, P., O'Neil, J.R., Capetta, H., and Martineau, F., 1993, Thermal excursions in the ocean at Cretaceous-Tertiary boundary (northern Marocco): $\delta^{18}O$ record of phosphatic fish debris: Palaeogeography Palaeoclimatology Palaeoecology, v. 126, p. 235-243.

O'Neil, J.R., Roe, L.J., Reinhard, E., and Blake, R.E., 1994, A rapid and precise method of oxygen isotope analysis of biogenic phosphate: Israel Journal of Earth Science, v. 43, p. 203-212.

Otero, O., Pinton, A., Mackaye H.T., Likius, A., Vignaud, P., and Brunet, M., 2009, First description of a Pliocene ichthyofauna from Central Africa (site KL2, Kolle area, Eastern Djurab, Chad): what do we learn?: African Journal of Earth Science, v. 54, p. 62-74.