Supporting Online Information

This document presents groundwater age dating methods (S1), $\Delta^{18}O_{late\text{-}glacial}$ calculation details (S2), inter-model simulation details (S3) and tabulated data and sources (S4).

S1. Groundwater age dating

Mean ^{14}C-based groundwater ages (*t*, the time elapsed since recharge) were calculated for each groundwater sample by accounting for the radioactive decay of ^{14}C and for the dissolution of ^{14}C-dead aquifer materials (Clark and Fritz, 1997):

$$t = -8033 \times ln\left(\frac{A}{q \times A_o}\right) \qquad \text{Equation S1.}$$

where *t* is the time elapsed since the groundwater sample recharged (i.e., groundwater age), *A* is the measured ^{14}C activity in a groundwater sample, A_o is the initial ^{14}C activity (~100 pmC) and *q* is a correction factor applied to account for the dissolution of aquifer material with zero ^{14}C (i.e., ^{14}C-dead). In cases where $\delta^{13}C$ data was available *q* was calculated as:

$$q = \frac{\delta^{13}C_{measured} - \delta^{13}C_{aquifer}}{\delta^{13}C_{recharge} - \delta^{13}C_{aquifer}} \qquad \text{Equation S2.}$$

where $\delta^{13}C_{measured}$, $\delta^{13}C_{aquifer}$ and $\delta^{13}C_{recharge}$ represent the carbon isotope composition of a groundwater sample, the aquifer and recharging groundwater. $\delta^{13}C_{aquifer}$ was set to 1.0±3.4 ‰ PDB (average ± 1 s.d.) as determined by $\delta^{13}C$ values of 16359 rock and sediment samples (Veizer et al., 1999). $\delta^{13}C_{recharge}$ was set to −12.6±4.3 ‰ PDB (average ± 1 s.d.) as determined by 120 groundwater samples having a ^{14}C activity of greater than 90 p.m.C. compiled in this study (i.e., recently recharged water bearing near-atmospheric radioactive activities; Burchuladze et al., 1989). *q* was set to 0.76±0.41 in cases where $\delta^{13}C_{measured}$ data were unavailable, as determined by the most common $\delta^{13}C$-based *q* values (q = 0.76±0.41 represents the average and

one standard deviation of all $\delta^{13}C$-based q values calculated in this compilation). Uncertainties in groundwater ages were calculated by Gaussian error propagation (calculated values of q exceeding 1 were set to a value of 1). The $\delta^{13}C_{recharge}$ and $\delta^{13}C_{aquifer}$ ranges do not encompass all possible geochemical scenarios, and likely introduce additional errors into our groundwater age dates.

Equivalent calendar year ages were estimated from ^{14}C-ages by applying a polynomial fit of compiled ^{14}C-to-calender age corrections (Reimer et al., 2013). Samples were then divided into two age categories: (i) the late-Holocene (^{14}C-based age of less than 5,000 calendar years before present, or having a ^{3}H activity of greater than 4 T.U., indicating modern recharge), or (ii) the late-glacial (^{14}C-based age of 20,000 to less than ~50,000 calendar years before present and samples with ^{14}C activities below analytical detection). An upper late-glacial limit of less than ~50,000 years before present was set because of limitations with ^{14}C age calculations, even though the most recent ice age extends to ~110,000 years before present (Lisiecki and Raymo, 2005). However, ^{14}C-based ages cannot distinguish ~50,000 year old water from much older groundwaters on the order of 10^5 years before present, meaning that some of the last glacial period groundwater samples may represent older glacial climates (e.g., ^{36}Cl-based versus ^{14}C-based ages presented by Kulongoski et al., 2004).

S2. $\Delta^{18}O_{late\text{-}glacial}$ calculation

$\Delta^{18}O_{late\text{-}glacial}$ values (defined as $\Delta^{18}O_{late\text{-}glacial} = \delta^{18}O_{late\text{-}glacial} - \delta^{18}O_{late\text{-}Holocene}$) were analyzed on an aquifer-by-aquifer basis. Comparisons of isotopic data for the late-glacial and the late-Holocene were made by subtracting median $\delta^{18}O$ and $\delta^{2}H$ values from each age group, with uncertainties representing error propagation of one standard deviation of $\delta^{18}O$ and $\delta^{2}H$ values for the two data groups (i.e., late-Holocene and last glacial period age groups). Samples were

omitted from our analysis if they exhibited an evaporative signature ($\delta^2H - 8\times\delta^{18}O$ of less than 0), contained a mixture of modern and late-glacial groundwater (^3H activity of greater than 1 tritium unit and a ^{14}C-age of more than 20,000 calendar years before present), were suspected to have mixed with intruding seawater (e.g., Geyh and Söfner, 1989; Bouchaou et al., 2008) or were presumed to have been recharged by subglacial meltwaters beneath the Fennoscandinavian (e.g., Karro et al., 2004) or the Laurentide (e.g., Grasby and Chen, 2005; Ferguson et al., 2007; Stotler et al., 2010) ice sheets (review by McIntosh et al., 2012).

Ice core and speleothem $\Delta^{18}O_{late\text{-}glacial}$ values were calculated by comparing $\delta^{18}O$ values from the late-Holocene (<5,000 years before present) and the latter half of the late-glacial (20,000 to ~50,000 years before present). A threshold of less than ~50,000 years before present was selected as an upper limit for the latter half of the last ice age $\delta^{18}O$ value for consistency with the groundwater records. Speleothem as $\Delta^{18}O_{late\text{-}glacial}$ values were corrected to account for different temperatures during the late-glacial relative to the late-Holocene that impact the water-calcite isotopic fractionation factor. Temperature-based H_2O-$CaCO_3$ fractionation factors were obtained from O'Neil et al. (1969) with temperatures calculated under the assumption that atmospheric temperatures are indicative of temperatures in the shallow subsurface. Temperatures for the late-Holocene were assumed to be equivalent to modern mean annual near surface temperatures (New et al., 2002), potentially introducing <1°C of error because of temperature change throughout the last 5,000 years (Marcott et al., 2013). Adding 1°C of added uncertainty into late-Holocene temperature equates to an added ±0.4 ‰ ($\delta^{18}O$) of uncertainty in the temperature-corrected difference between the late-glacial and the late-Holocene $\delta^{18}O$ values (O'Neil et al., 1969). Last glacial period temperatures were calculated by applying the temperature offset of the last glacial maximum (Figure 1; Annan and Hargreaves, 2013) to gridded values of modern mean annual air temperatures (New et al., 2002).

S3. Simulated precipitation $\delta^{18}O$

Simulated precipitation $\Delta^{18}O_{late\text{-}glacial}$ values compiled from five general circulation models are reported in this study. Table S1 describes model-specific parameterizations, input data and boundary conditions.

S4. Groundwater, speleothem and ice core isotope records

Tabulated paleowater isotope records of groundwater (Tables S2 to S3), speleothem (Table S4), glacier ice (Table S5) and ground ice (Table S6) records presented in the following supplemental tables.

S5. Groundwater $\delta^{18}O$ change over time

Figures S1 – S57 present groundwater $\delta^{18}O$ variations from the last ice age to present day for 57 globally-distributed aquifer systems (two ground ice records not included in this series of plots). Figures S1 to S57 are sorted by alphabetically by country title. Exact ages for Germany's Benker-sandstein aquifer are not available, however, the stable isotope data two data clusters are interpreted to be representative of late-Holocene and Pleistocene climate states (Figure S20, van Geldern et al., 2014). The most recent age end member for the late-glacial time period—usually set to 20,000 years before present—was set to 22,000 years before present for the Pannonian Basin to avoid samples with ^{14}C-ages between 20,000 and 22,000 years before present showing evidence of groundwater mixing (Figure S22; Varsanyi et al., 2011). Aleppo Basin (Syria) and Mahomet Aquifer (USA) groundwaters having a $\delta^{13}C$-based q values of less than 0.3 were not included in our analysis on the basis of highly uncertain groundwater ages at low values of q (Figures S44 and S55; Hackley et al., 2010; Al-Charideh, 2012; Stadler et al., 2012). Late-glacial to late-Holocene $\delta^{18}O$ and $\delta^{2}H$ shifts are shown in Figure S58 for 44 aquifers.

Table S1. Information for isotope enabled general circulation models compiled in this study

Model name:	**CAM3iso**	**ECHAM5-wiso**	**GISSE2-R, NINT**	**IsoGSM**	**LMDZ4**
Reference for model:	Collins et al., 2006	Roeckner et al., 2006	Schmidt et al., 2014	Kanamitsu et al., 2002	Hourdin et al., 2006
Reference for isotopic version:	Noone and Sturm, 2009; Sturm et al., 2010	Werner et al., 2011	LeGrande and Schmidt, 2009 *	Yoshimura et al., 2008	Risi et al., 2010
Forced or coupled simulation:	Forced	Forced	Coupled	Forced	Forced
Sea surface temperature forcing (if forced):	Monthly-mean anomalies from a LGM simulation by the CCSM3 coupled model (Otto-Bliesner et al., 2006)	Monthly-mean anomalies from GLAMAP reconstruction (footnote: LGM anomalies were calculated with respect to a pre-industrial simulation, and added to present-day observed SSTs from AMIP)	N/A	Monthly-mean anomalies from a LGM simulation by the IPSL coupled model (footnote: LGM anomalies were calculated with respect to a pre-industrial simulation, and added to present-day observed SSTs from AMIP)	Monthly-mean anomalies from a LGM simulation by the IPSL coupled model (footnote: LGM anomalies were calculated with respect to a pre-industrial simulation, and added to present-day observed SSTs from AMIP)
Sea ice forcing (if forced):	Same as SSTs	Same as SSTs	N/A	Same as SSTs	Same as SSTs
Climatological or inter-annual forcing:	Climatological (average over 100 years)	Climatological	N/A	Climatological (average over 30 years)	Climatological (average over 30 years)
Topography/ land ice:	Ice 5G (Peltier, 1994)	As advised by PMIP3 (Braconnot et al., 2012)	Ice 5.2G, with LIS of Licciardi et al. (1998)	Ice 5G (Peltier, 1994)	Ice 5G (Peltier, 1994)

Model name:	**CAM3iso**	**ECHAM5-wiso**	**GISSE2-R, NINT**	**IsoGSM**	**LMDZ4**
Aerosol:	Pre-industrial	None	NINT physics (Koch et al., 2011; Shindell et al., 2006) and includes a tuned aerosol indirect effect (AIE) following (Hansen et al., 2005)	None	None
Solar/orbital forcing:	PMIP2 protocol	PMIP3 protocol	PMIP3 protocol	PMIP2 protocol	PMIP2 protocol
Number of years:	15	12 years and last 10 years average	1500	30 years and last 20 years average	3
Horizontal resolution:	2.8° x 2.8°	1.1° x 1.1° (T106 spectral resolution)	Atmosphere: 2.0° x 2.5°; Ocean: 1.0° x 1.25°	1.8° x 1.8° (T62 spectral resolution)	2.5° latitude x 3.75° longitude
Vertical resolution:	26 levels	31 levels	Ocean: 26 levels; atmosphere: 40 levels, top at 0.1 mb	28 levels	19 levels
Seawater $\delta^{18}O$ (modern):	0 ‰, globally constant	LeGrande and Schmidt, 2006	0 ‰ mean, but coupled	0 ‰, globally constant	0.5 ‰, globally constant
Seawater $\delta^{18}O$ (LGM):	+1.1‰ with respect to present	+1‰ with respect to present	+1‰ with respect to present, but coupled	0 permil, globally constant; +1 per mille added after to account for seawater change	+1.2 ‰ with respect to present

* Last Glacial Maximum simulation described in Ullman et al. (2014)

Table S2. Groundwater datasets compiled in this study

Country	Aquifer	Citation(s)
Algeria	Great Oriental Erg: CI	Edmunds et al., 2003
Botswana	Kalahari: Ntane	Kulongoski et al., 2004
Botswana	Lokalane-Nakojane	Rahube, 2003
Burkina Faso	Taoudeni basin	Huneau et al., 2011
Chad	Chad aquifer	Edmunds, 2009
Egypt	Nubian aquifer	Shehata and Al-Ruwaih, 1999; Patterson et al., 2005; Edmunds, 2009
Mali	Mali aquifer	Edmunds, 2009
Morocco	Souss Plain	Bouchaou et al., 2008
Namibia	Omatako basin	Külls, 2000
Niger	Djardo-Bilma	Dodo and Zuppi, 1997; 1999
Niger	Irhazer: CI	Andrews et al., 1994; Edmunds et al., 2004
Niger	Iullemeden: CT	Le Gal La Salle et al., 2001; Beyerle et al., 2003
Nigeria	Chad basin	Maduabuchi et al., 2006
Senegal	Senegalese CT	Castany et al., 1974; Edmunds, 2009
South Africa	Uitenhage aquifer	Heaton et al., 1986
Tunisia	Kairouan Plain	Derwich et al., 2012
Zimbabwe	Zimbabwe aquifer	Larsen et al., 2002
Australia	Canning basin	Harrington et al., 2011
Bangladesh	Bengal basin	Aggarwal et al., 2000; Sikdar and Sahu, 2009; Majumder et al., 2011; Hoque and Burgess, 2012
China	Songnen Plain	Chen et al., 2011
China	North China Plain	Zongyu et al., 2003; Kreuzer et al., 2009
China	Yuncheng basin	Currell et al., 2010
India	Cuddalore sandstone	Sukhija et al., 1998
India	Tiruvadanai aquifer	Kumar et al., 2009
Indonesia	Jakarta basin	Geyh and Söfner, 1989
Israel	Israel coastal aquifer	Yechieli et al., 2009
Israel	Dead Sea rift valley	Gat and Galai, 1982; Mazor et al., 1995
Kuwait	Al-Raudhatain and Damman aquifers	Al-Ruwaih and Shehata, 2004; Fadlelmawla et al., 2008
Oman	Batinah coastal plain	Weyhenmeyer et al., 2000; 2002
Oman	Najd aquifer	Clark et al., 1987; Al-Mashaikhi et al., 2012
Syria	Aleppo basin	Al-Charideh, 2012; Stadler et al., 2012
Belgium	Ledo-Paniselian	Walraevens, 1990; Walraevens et al., 2001
Czech Rep.	Sokolov aquifer	Noseck et al., 2009
Denmark	Ribe Formation	Hinsby et al., 2001
France	Bathonian coast	Barbecot et al., 2000
France	Lorraine sandstone	Celle-Jeanton et al., 2009
France	Aquitaine basin	Le Gal La Salle et al., 1996
Germany	Benker-Sandstein	van Geldern et al., 2014

Country	Aquifer	Citation(s)
Hungary	Great Hungarian Plain	Stute and Deak, 1989
Hungary	Pannonian basin	Varsanyi et al., 2011
Italy	Emilia-Romagna Plain	Martinelli et al., 2011
Poland	S. Poland carbonates	Samborska et al., 2013
Poland	Malm limestone	Zuber et al., 2004
Portugal	Sado basin	Galego Fernandes and Carreira, 2008
Turkey	Kazan Trona Ore Field	Arslan et al., 2014
United Kingdom	Lincolnshire limestone	Darling et al., 1997
United Kingdom	Chalk aquifer	Darling and Bath, 1988; Dennis et al., 1997; Elliot et al., 1999
U.S.A.	Columbia Flood Bslts.*	Douglas et al., 2007; Brown et al., 2010
U.S.A.	Idaho Batholith	Schlegel et al., 2009
U.S.A.	Mahomet aquifer	Hackley et al., 2010
U.S.A.	Aquia aquifer	Aeschbach-Hertig et al., 2002
U.S.A.	High Plains: Central	Dutton, 1995; Clark et al. 1998
U.S.A.	High Plains: South	Dutton, 1995; Mehta et al., 2000
U.S.A.	San Juan Basin	Phillips et al., 1986
U.S.A.	Floridan aquifer	Clark et al., 1997
Brazil	Potiguar basin: Acu	Salati et al., 1974
Brazil	Botacatu: central	Gouvea da Silva, 1983
Russia	Bykovsky Peninsula**	Meyer et al., 2002
Canada	Near Dawson City***	Kotler and Burn, 2000

* Columbia Flood Basalt late-glacial groundwater may be glacial Lake Missoula floodwaters rather than regional precipitation (Brown et al., 2010).

** Ground ice record – comparison of ice wedge $\delta^{18}O$ values <1m from edge (Holocene) and inner-most (2.5m – 5m; Pleistocene) samples (horizontal ice wedge sample transect MKh-3).

*** Ground ice record – comparison of ground ice $\delta^{18}O$ values from the Dago Hill (Holocene) and Quartz Creek (Pleistocene) formations.

Table S3. Groundwater $\delta^{18}O_{late\text{-}Holocene}$ and $\delta^{18}O_{late\text{-}glacial}$ values

Country	Aquifer	Lon.	Lat.	$\delta^{18}O_{late-Holo.}$	$\delta^{18}O_{glacial}$	$\Delta^{18}O_{glacial}$
Australia	Canning basin	125	−17	−7.0±1.7	−7.4±0.5	−0.5±1.8
Indonesia	Jakarta basin	107	−6	−6.1±0.1	−6.0±0.5	0.1±0.5
Bangladesh	*Bengal basin	90	24	−4.9±1.1	−3.4±0.6	1.5±1.3
China	Songnen plain	125	46	−10.4±1.4	−10.2±0.4	0.3±1.5
China	*North China Plain	115	38	−8.5±0.5	−10.8±0.4	−2.3±0.6
China	Yuncheng basin	111	35	−8.7±1.3	−9.9±1.0	−1.1±1.7
India	*Cuddalore sandstone	80	11	−5.6±0.3	−4.9±0.6	0.7±0.7
India	*Tiruvadanai aquifer	79	10	−3.9±0.5	−5.6±0.3	−1.7±0.6
Algeria	*Great Oriental Erg: CI	6	32	−7.1±1.0	−8.4±0.3	−1.3±1.1
Botswana	*Kalahari: Ntane	25	−24	−4.8±0.0	−5.6±0.1	−0.8±0.1
Botswana	*Lokalane-Nakojane	22	−22	−6.0±0.0	−7.2±0.1	−1.2±0.1
Burkina Faso	*Taoudeni basin	−5	13	−5.1±0.6	−6.0±0.3	−0.9±0.7
Chad	*Chad aquifer	18	11	−3.9±1.2	−5.6±0.6	−1.7±1.3
Egypt	Nubian aquifer	29	26	−8.6±2.0	−10.4±0.3	−1.9±2.1
Mali	Mali aquifer	−7	15	−5.2±0.7	−6.5±0.5	−1.4±0.9
Morocco	Souss Plain	−7	33	−6.2±0.9	−6.3±0.6	−0.1±1.1
Namibia	Omatako basin	18	−20	−8.6±0.7	−9.0±0.1	−0.4±0.7
Niger	Djardo-Bilma	13	19	−7.8±4.0	−8.1±0.3	−0.2±4.0
Niger	*Irhazer: CI	7	17	−5.1±1.8	−7.3±0.8	−2.3±2.0
Niger	*Iullemeden: CT	3	14	−4.5±0.9	−7.3±0.3	−2.9±0.9
Nigeria	*Chad basin	13	12	−4.0±0.8	−6.2±0.5	−2.2±1.0
Senegal	Senegalese CT	−16	15	−6.1±0.7	−6.0±0.5	0.1±0.8
S. Africa	*Uitenhage aquifer	25	−34	−4.7±0.2	−5.4±0.1	−0.8±0.2
Tunisia	Kairouan Plain	10	35	−5.5±0.3	−5.7±0.5	−0.2±0.6
Zimbabwe	*Zimbabwe aquifer	28	−20	−5.9±0.4	−6.9±0.3	−1.0±0.5
Kuwait	Al-Raudhatain and Damman aquifers	48	30	−2.7±0.4	−4.5±0.4	−1.8±0.6
Oman	Batinah coastal plain	58	24	−2.4±1.2	−1.6±0.6	0.9±1.3
Oman	*Najd aquifer	54	18	−1.5±2.4	−4.7±0.7	−3.2±2.5
Syria	*Aleppo basin	37	36	−4.5±0.2	−7.2±0.8	−2.7±0.8
Belgium	Ledo-Paniselian	4	51	−6.5±1.6	−7.0±0.2	−0.5±1.6
Czech Rep.	Sokolov aquifer	13	50	−9.1±0.1	−9.5±0.4	−0.4±0.4
Denmark	Ribe Formation	9	56	−7.9±0.1	−8.8±0.5	−0.8±0.5
France	*Bathonian coast	0	49	−6.6±0.1	−7.1±0.1	−0.5±0.2
France	*Lorraine sandstone	7	49	−8.9±0.0	−10.0±0.4	−1.0±0.4
France	Aquitaine basin	0	46	−5.7±0.2	−6.7±0.5	−1.0±0.6
Germany	*Benkerstein	11	49	−9.3±0.2	−10.5±0.1	−1.3±0.2
Hungary	*Great Hungarian Plain	21	48	−9.6±0.0	−11.3±0.5	−1.7±0.5
Hungary	*Pannonian basin	20	46	−9.3±0.4	−13.0±0.3	−3.7±0.5
Italy	*Emilia Romagna plain	11	45	−8.3±0.5	−10.3±0.6	−1.9±0.8
Israel [x]	Israel coastal aquifer	35	32	−4.8±0.4	−4.6±0.1	0.3±0.4
Israel	*Dead Sea rift valley	35	31	−4.7±0.1	−6.6±0.5	−1.8±0.6

Country	Aquifer	Lon.	Lat.	$\delta^{18}O_{late-Holo.}$	$\delta^{18}O_{glacial}$	$\Delta^{18}O_{glacial}$
Poland	*S. Poland carbonates	19	51	−10.2±0.4	−11.4±0.8	−1.3±0.9
Poland	*Malm limestone	20	50	−10.2±0.4	−11.2±0.8	−1.0±0.9
Portugal	Sado basin	−9	38	−4.7±0.3	−4.7±0.1	0.0±0.3
Turkey	*Kazan Trona Ore Field	40	33	−9.3±0.8	−12.1±0.6	−2.8±1.0
U.K.	*Lincolnshire limestone	0	53	−7.8±0.1	−8.1±0.3	−0.3±0.3
U.K.	Chalk aquifer	−1	51	−7.4±0.0	−7.6±0.2	−0.2±0.2
Brazil	Potiguar basin: Acu	−37	−6	−1.8±1.2	−4.5±0.3	−2.7±1.3
Brazil	Botacatu: central	−49	−22	−8.9±1.4	−8.3±1.0	0.6±1.7
U.S.A.	*Columbia Flood Bslts	−119	47	−15.3±0.9	−18.0±0.6	−2.8±1.1
U.S.A.	*Idaho Batholith	−116	44	−16.5±0.7	−17.5±0.5	−1.0±0.8
U.S.A.	*San Juan Basin	−108	36	−12.0±0.6	−14.5±0.8	−2.5±1.0
U.S.A.	Mahomet aquifer	−89	40	−6.8±0.2	−7.2±0.5	−0.3±0.6
U.S.A.	*High Plains: Central	−101	38	−9.3±1.6	−12.0±0.9	−2.7±1.8
U.S.A.	*High Plains: South	−102	35	−6.3±0.7	−8.7±1.2	−2.4±1.3
U.S.A.	Aquia aquifer	−77	39	−7.0±0.2	−7.1±0.3	−0.1±0.4
U.S.A.	*Floridan aquifer	−82	32	−4.7±0.2	−3.7±0.4	1.0±0.4
Russia	Bykovsky Peninsula	129	72	−25.4	−30.8±1.3	−5.4±1.3
Canada	*Near Dawson City	−139	64	−26.1±0.8	−31.5±0.4	−5.5±0.9

* aquifers where $\delta^{18}O_{late-Holocene}$ values are statistically distinct ($p<0.05$) from $\delta^{18}O_{late-glacial}$ values (two tailed heteroscedastic t-test comparing $\delta^{18}O_{late-Holo.}$ values with $\delta^{18}O_{late-glacial}$ values). 34 of 57 (60%) groundwater records show a significant change in $\delta^{18}O$ from the late-Holocene (<5,000 calendar years before present) to the latter half of the last glacial period (>20,000 calendar years before present). Of the 34 aquifers having significant ($p<0.05$) shifts between the late-Holocene and the last glacial period, 31 aquifers have a $\Delta^{18}O_{late-glacial}$ values of less than zero (exceptions Bengal Basin (Bangladesh), Floridan Aquifer (USA) and the Cuddalore Sandstone (India)).

[x] Some samples show evidence of seawater intrusion and were excluded on the basis of total dissolved solids, where samples exceeding 2,000 mg/L were excluded.

Table S4. Speleothem $\delta^{18}O$ change from the late-glacial to the late-Holocene

Cave	Cntry.	Reference	Lon.	Lat.	$\Delta^{18}O_{late\text{-}glacial}$	Corr.[x]
Gunung Buda	Borneo	Partin et al., 2007	114.8	4.0	+2.0±0.3	−0.9±0.2
Botuverá Cave	Brazil	Cruz et al., 2005; Wang et al., 2007	−49.2	−27.2	−0.7±0.4	−0.9±0.2
Dongge [t]	China	Dykoski et al., 2005; Yuan et al., 2004	108.1	25.3	+2.6±0.5	−0.9±0.2
Hulu *	China	Wang et al., 2001	119.2	32.5	+1.6±0.3	−1.0±0.2
Jiuxian [t]	China	Cai et al., 2010	109.1	33.6	+1.3±1.9	−1.0±0.2
Yaman [t]	China	Yang et al., 2010	107.9	24.5	+2.7±0.5	−0.9±0.2
Soreq	Israel	Bar-Matthews et al., 2003	35.0	31.5	+2.3±0.2	−1.0±0.1
Peqin*	Israel	Bar-Matthews et al., 2003	35.2	32.6	+2.0±0.5	−0.9±0.2
Jerusalem W	Israel	Frumkin et al., 1999	35.2	31.7	+1.8±0.6	−1.0±0.2
NW South Island	New Zealand	Williams et al., 2010	172.0	−42.0	+0.4±0.2	−1.0±0.3
Cold Air Cave	South Africa	Holmgren et al., 2003	29.1	−24.0	+1.2±0.5	−1.0±0.1
Sofular	Turkey	Fleitmann et al., 2009	31.9	41.4	−4.7±0.2	−1.0±0.2
Fort Stanton*	U.S.A.	Asmerom et al., 2010	−105.3	33.3	−2.0±1.0	−1.0±0.2
Cave of the bells*	U.S.A.	Wagner et al., 2010	−110.8	31.8	−2.4±0.2	−1.0±0.2
Moomi*	Yemen	Shakun et al., 2007	54.0	12.5	+2.2±0.6	−0.9±0.2

* early Holocene value used (i.e., shift likely larger than shown)

[t] values from 15.0 ka used

[x] Calcite-water fractionation correction subtracted from raw observed $\Delta^{18}O_{late\text{-}glacial}$ to correct for the 4.0±0.8 °C colder climate (Annan and Hargreaves, 2013) at the last glacial stage (from O'Neil et al., 1969; modern temperatures from New et al., 2002; $\Delta^{18}O_{late\text{-}glacial}$ values in preceding column are shown in raw (i.e, uncorrected) form.

Table S5. Ice core $\delta^{18}O$ change from the late-glacial to the late-Holocene

Ice core	**Country**	**Reference**	**Lon.**	**Lat.**	**$\Delta^{18}O_{late\text{-}glacial}$**
Sajama	Bolivia	Thompson et al., 1998	−68.8	−18.1	−4.6±1.0
Huascaran	Peru	Thompson et al., 1995	−77.6	−9.1	−6.3±1.3
Qinghai-Tibetan	Tibet	Thompson et al., 1997	81.5	35.3	−0.6±2.8
Devon Island	Canada	Patterson et al., 1977	-82.3	75.3	−4.7±2.4
TALD Ice	Antarctica	Buiron et al., 2011	159.2	−72.8	−4.0±0.7
Byrd Glacier	Antarctica	Blunier and Brook, 2001	−119.5	−80.0	−5.9±0.9
Dome Fuji	Antarctica	Kawamura et al. 2007	39.7	−77.3	−3.6±0.9
Dronning Maud	Antarctica	EPICA Community, 2006	2.0	−75.0	−5.2±1.0
Law Dome	Antarctica	Pedro et al. 2011	112.8	−66.8	−6.7±0.7
Siple Dome	Antarctica	Pedro et al. 2011	−148.8	−81.7	−7.1±1.0
Renland ice core	Greenland	Vinther et al., 2008	−27.0	71.0	−3.9±1.0
NGRIP1	Greenland	Vinther et al., 2006	−42.3	75.1	−7.0±1.9

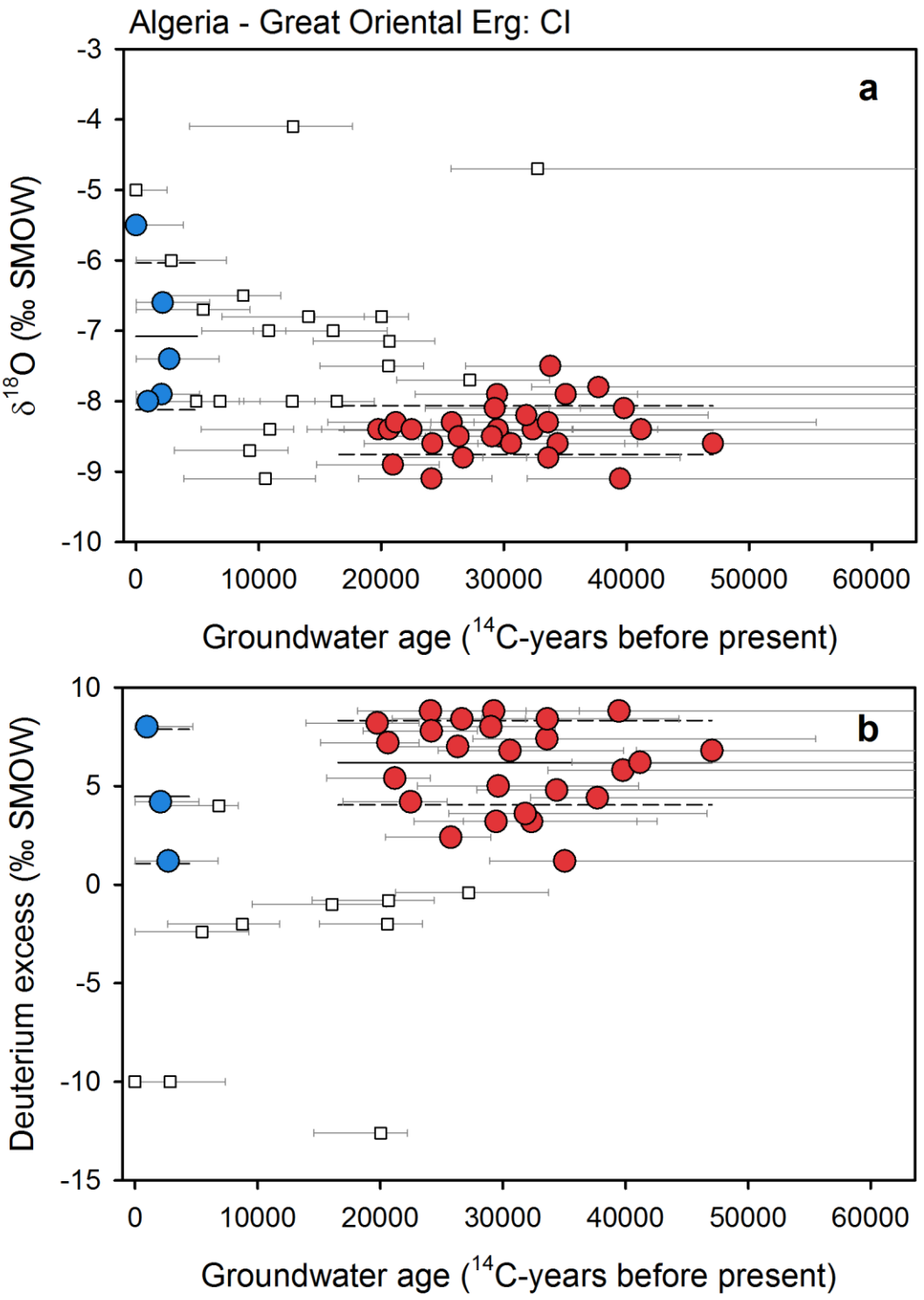

Figure S1. Groundwater isotope composition of the Great Oriental Erg (Continental Intercalaire) aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Edmunds et al., 2004).

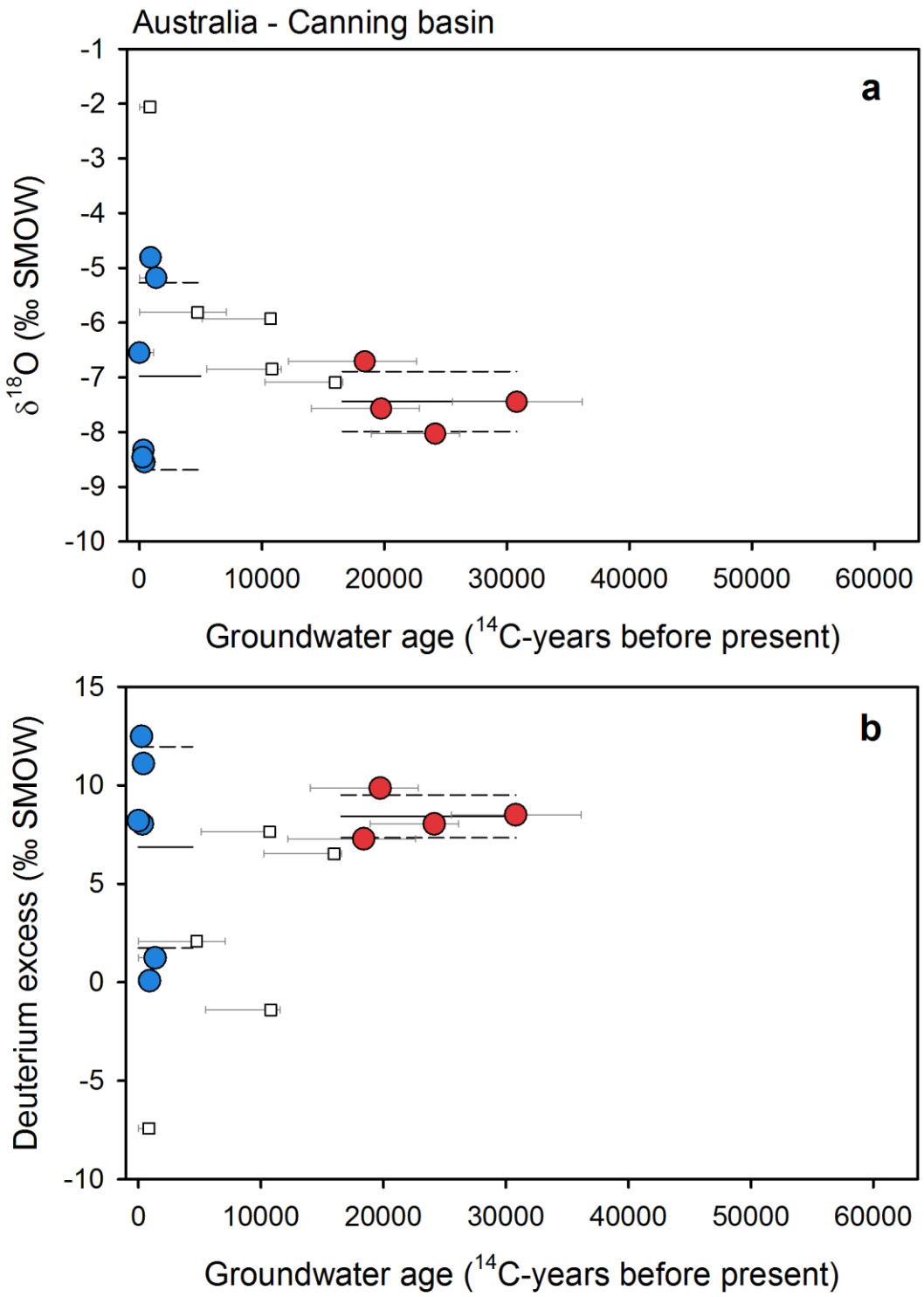

Figure S2. Groundwater isotope composition of the Canning basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Harrington et al., 2011).

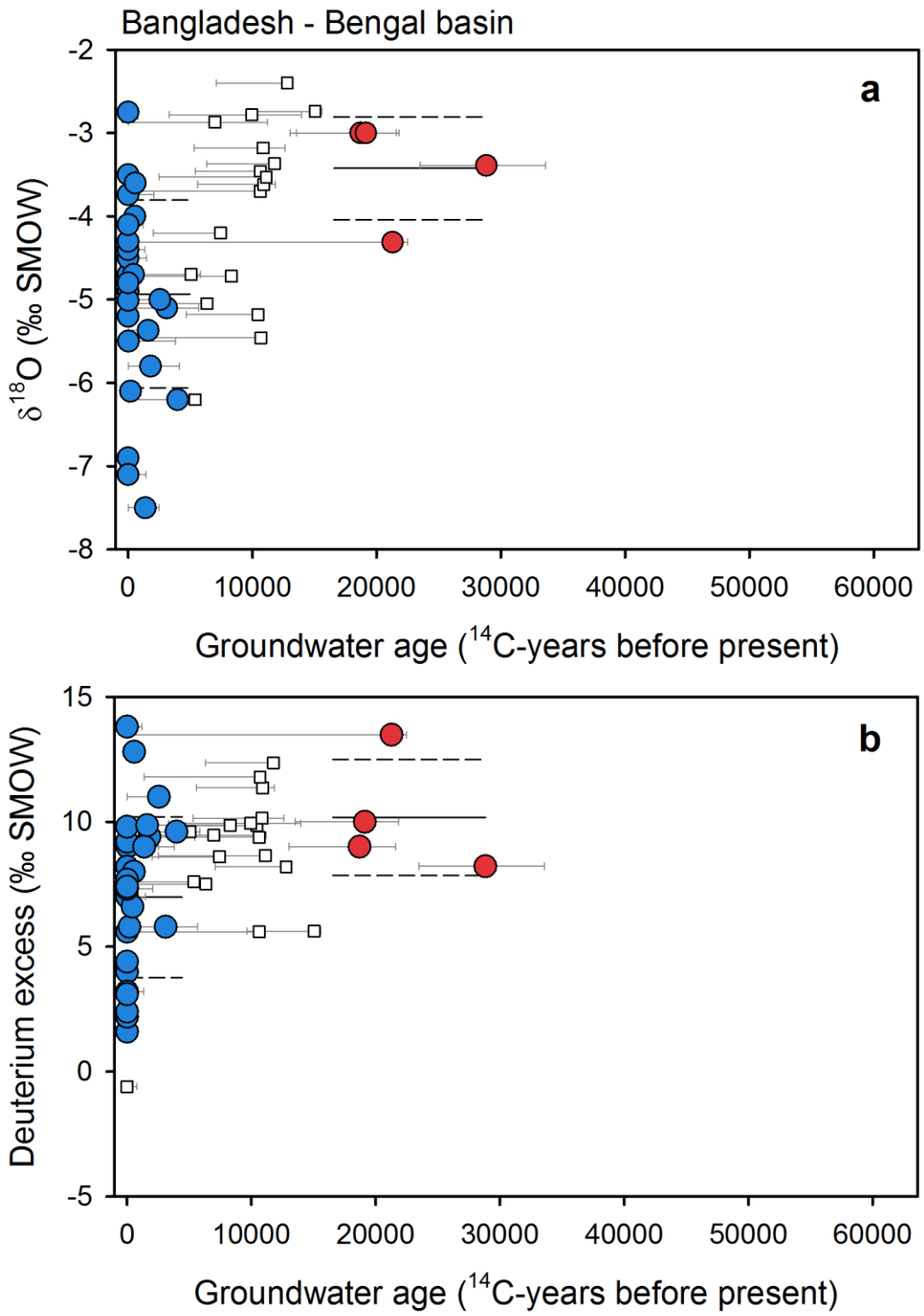

Figure S3. Groundwater isotope composition of the Bengal basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark average (solid line) and 1 s.d. (dashed lines) for each group (Aggarwal et al., 2000; Sikdar and Sahu, 2009; Majumder et al., 2011; Hoque and Burgess, 2012).

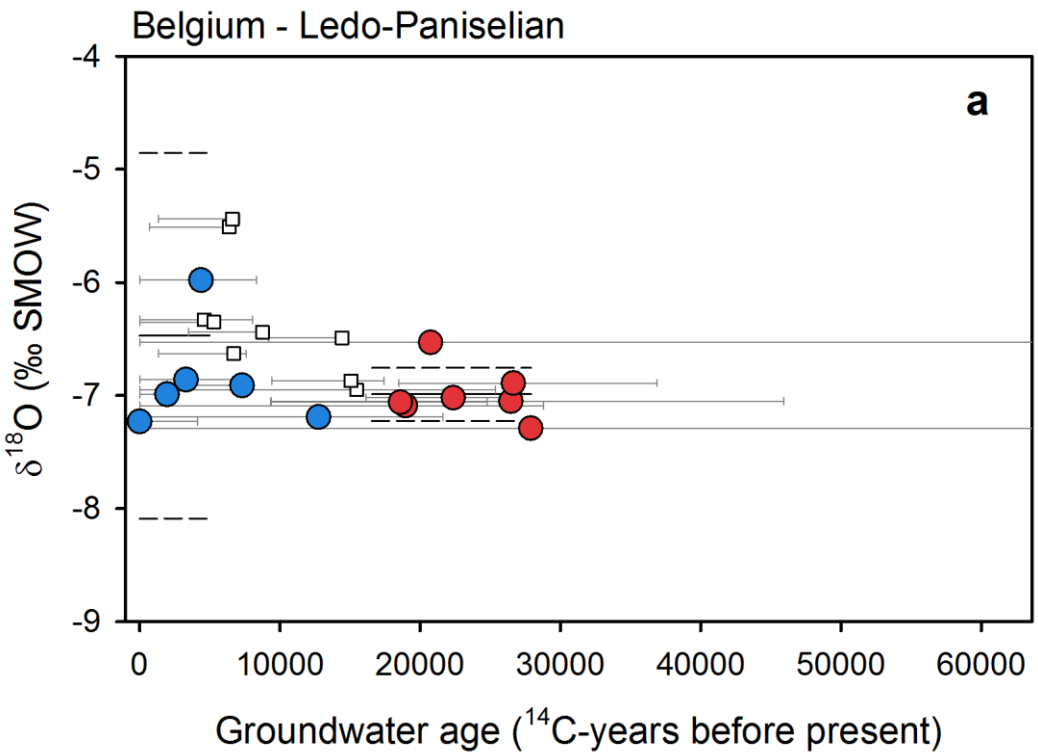

Figure S4. Groundwater isotope composition of the Ledo-Paniselian aquifer. Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Walraevens, 1990; Walraevens et al., 2001).

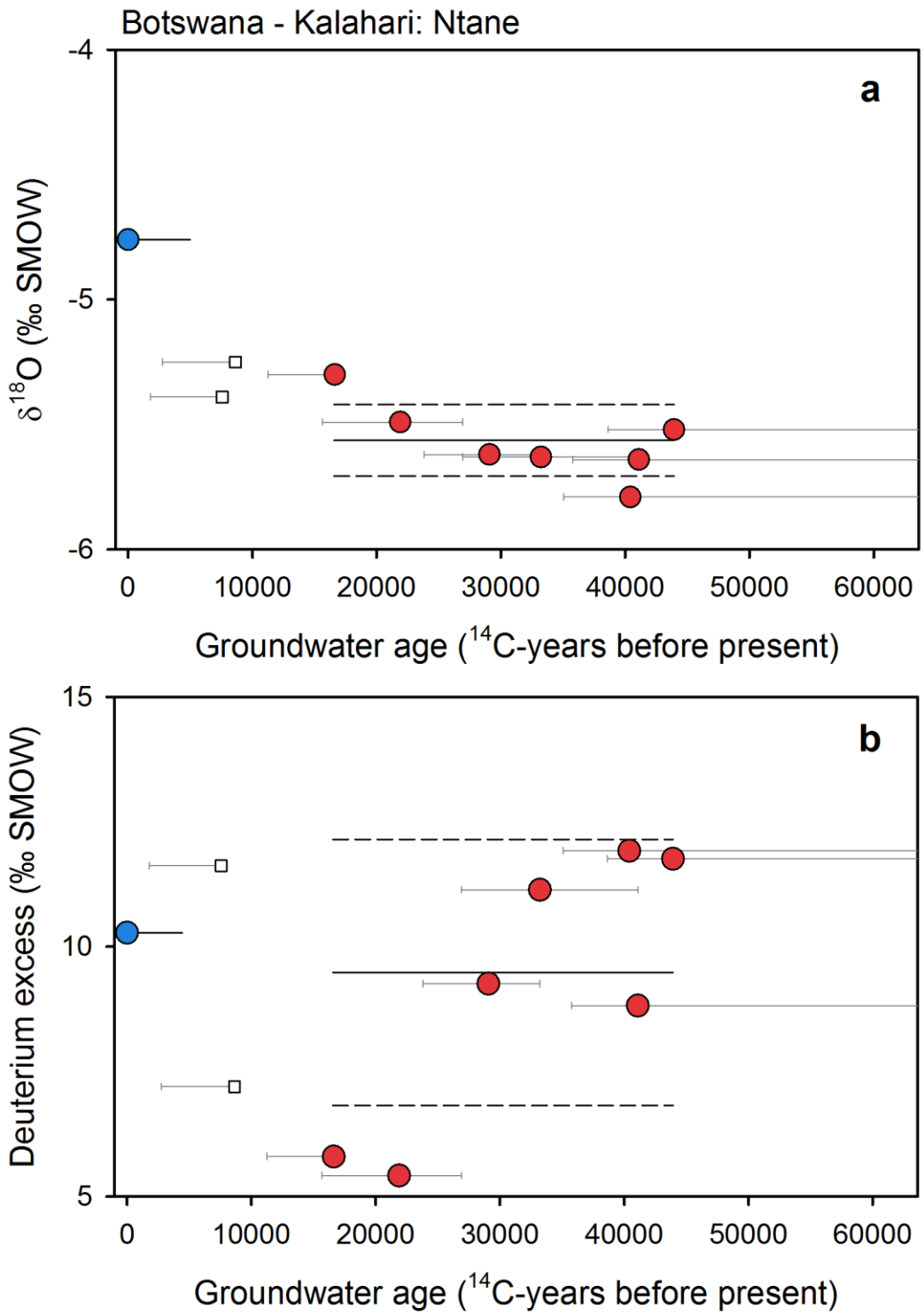

Figure S5. Groundwater isotope composition of the Ntane Sandstone aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Kulongoski et al., 2004).

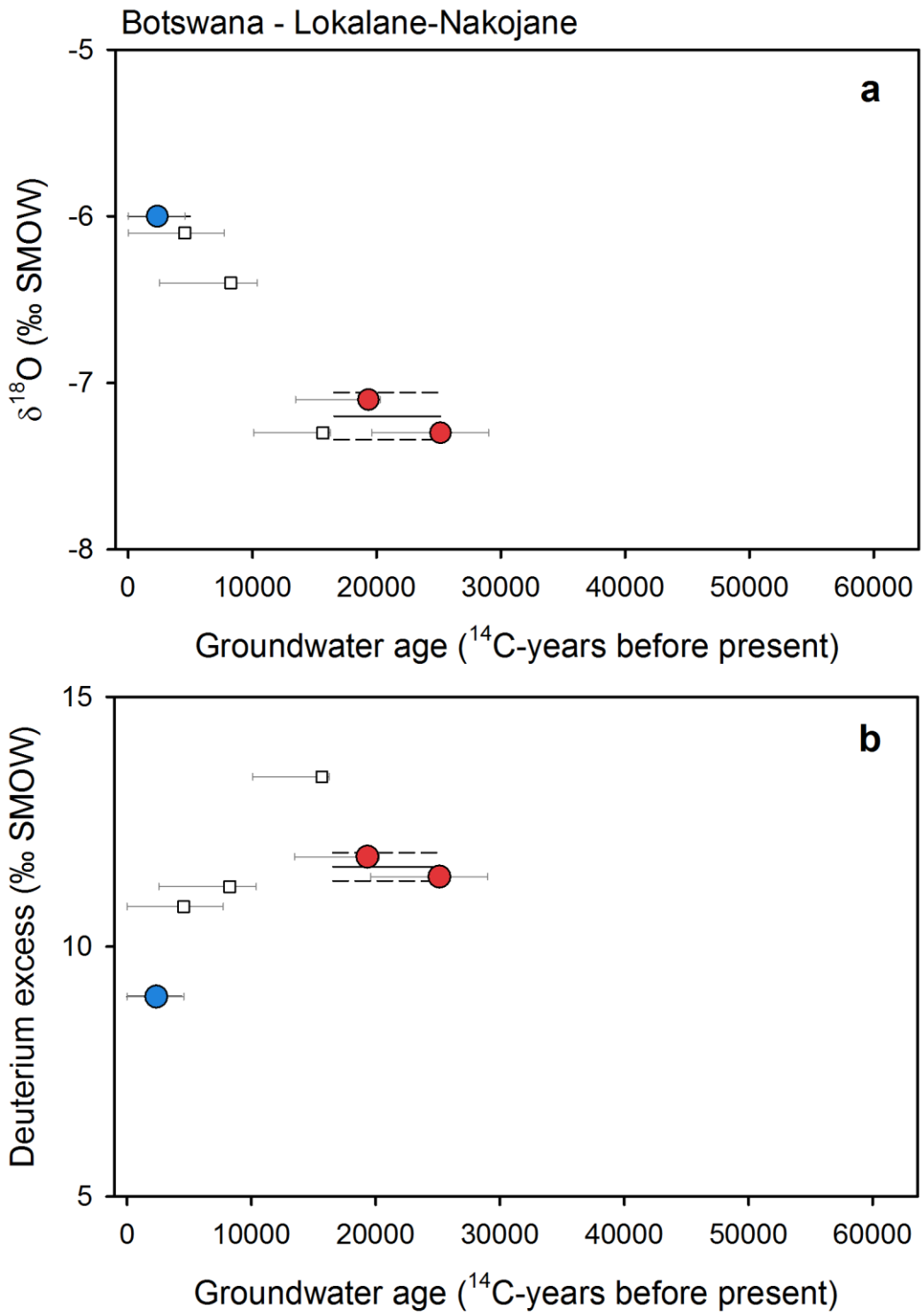

Figure S6. Groundwater isotope composition of the Lokelane-Nakojane aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Rahube, 2003).

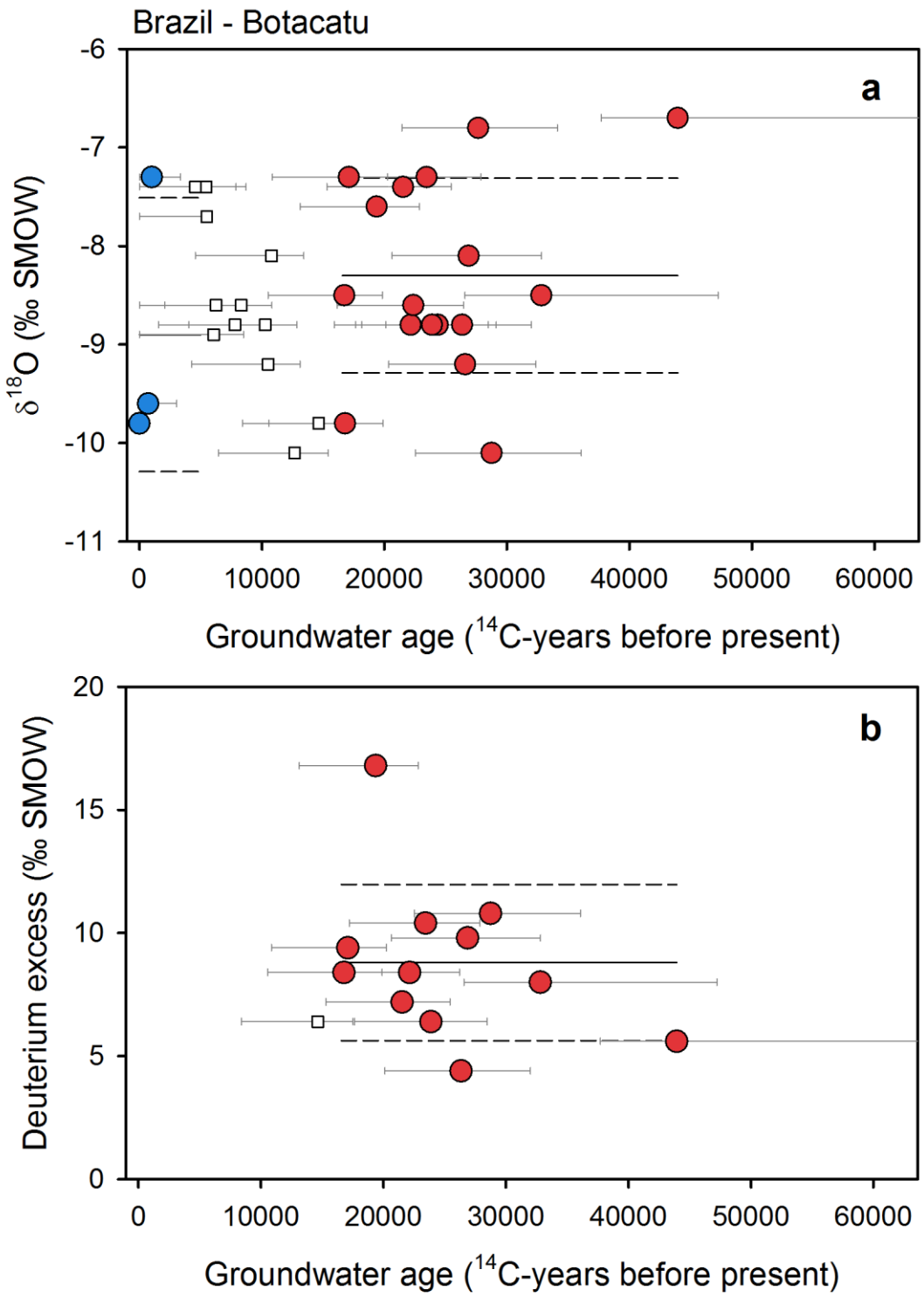

Figure S7. Groundwater isotope composition of the Botacatu aquifer system. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Gouvea da Silva, 1983).

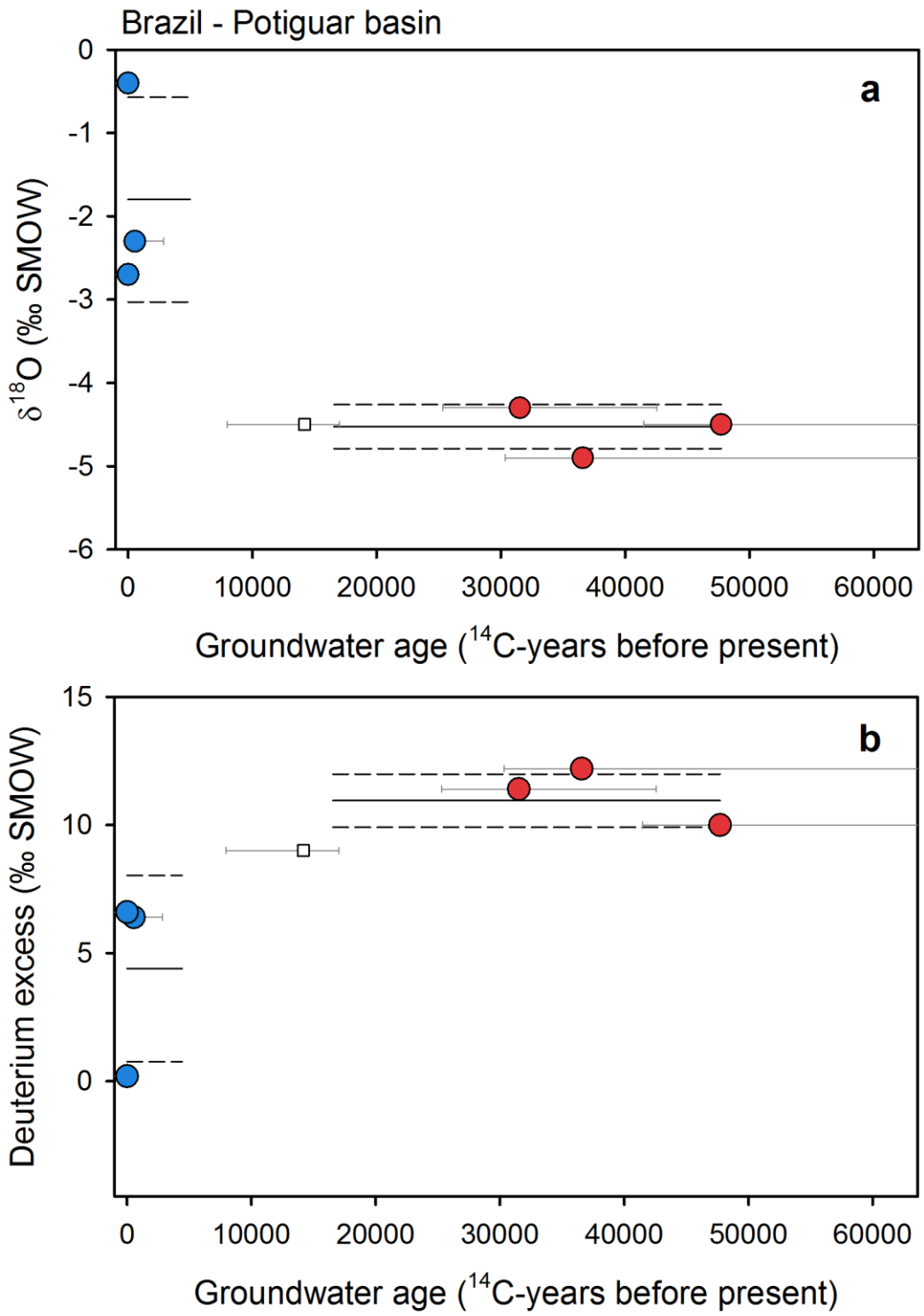

Figure S8. Groundwater isotope composition of the Potiguar basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Salati et al., 1974).

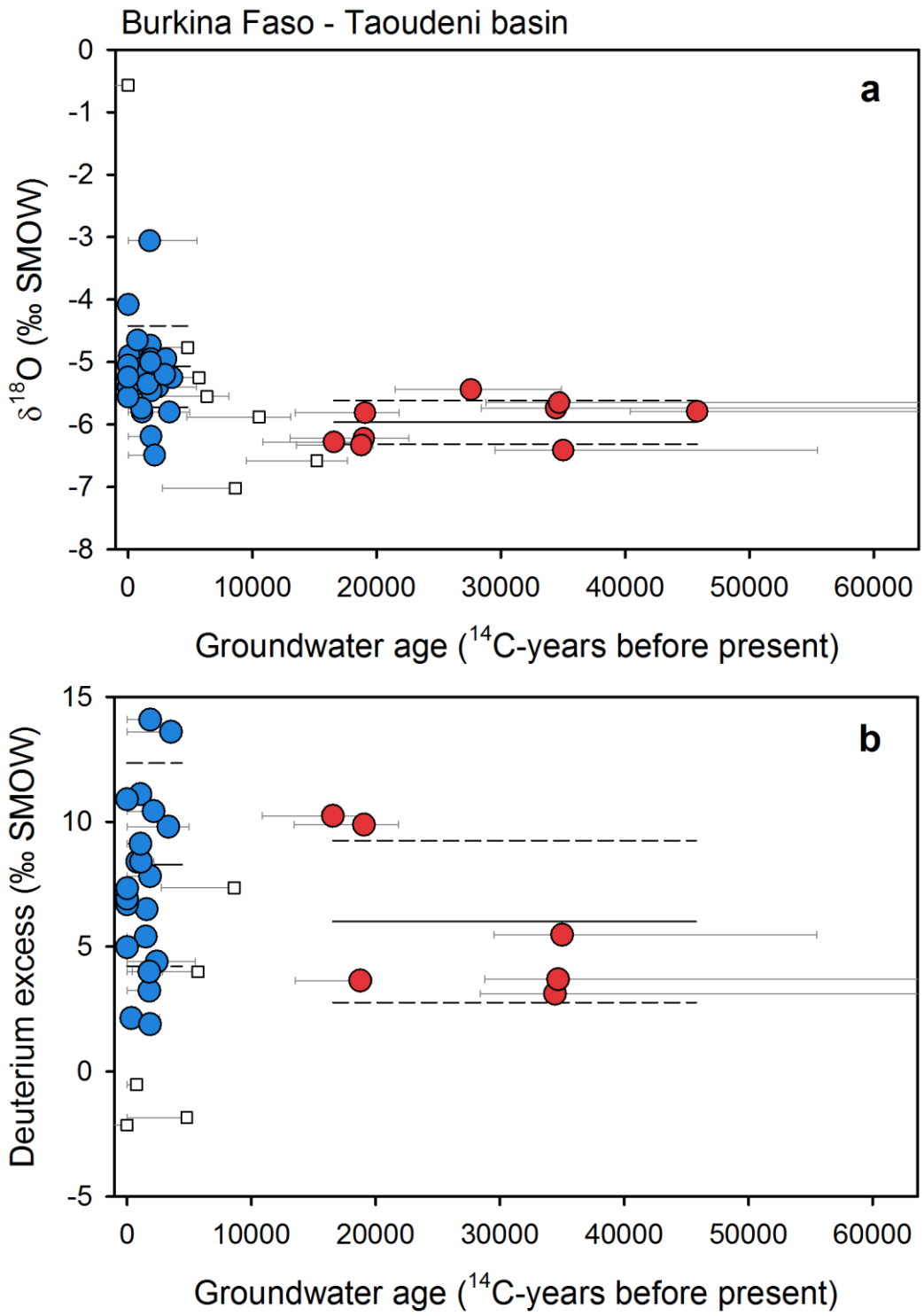

Figure S9. Groundwater isotope composition of the Taoudeni basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Huneau et al., 2011).

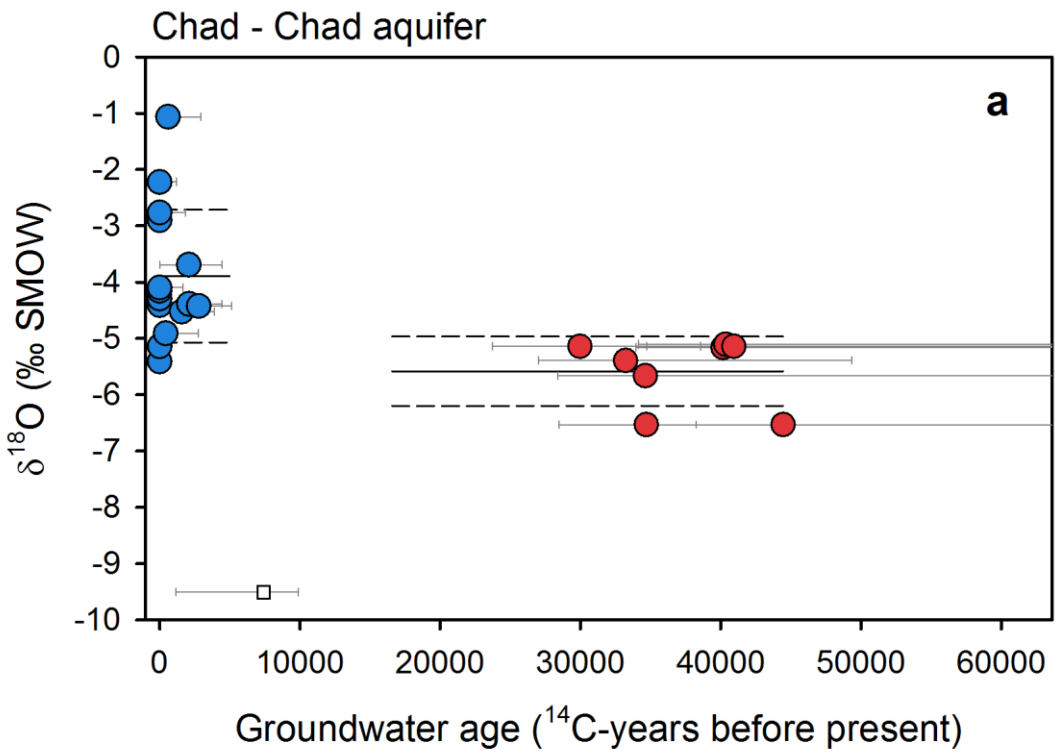

Figure S10. Groundwater isotope composition of the Chad aquifer (in Chad). Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Edmunds, 2009).

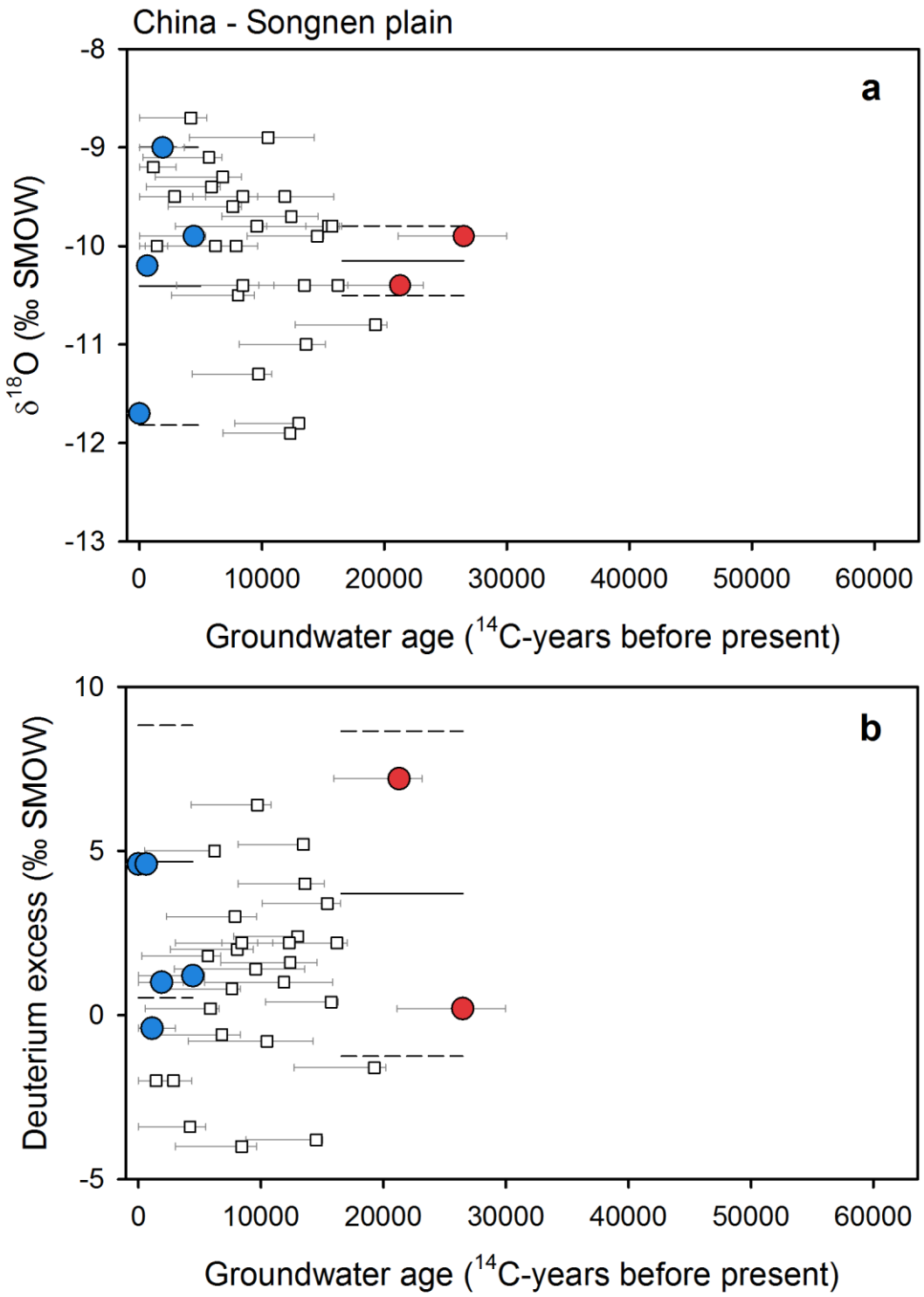

Figure S11. Groundwater isotope composition of the Songnen Plain. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Chen et al., 2011).

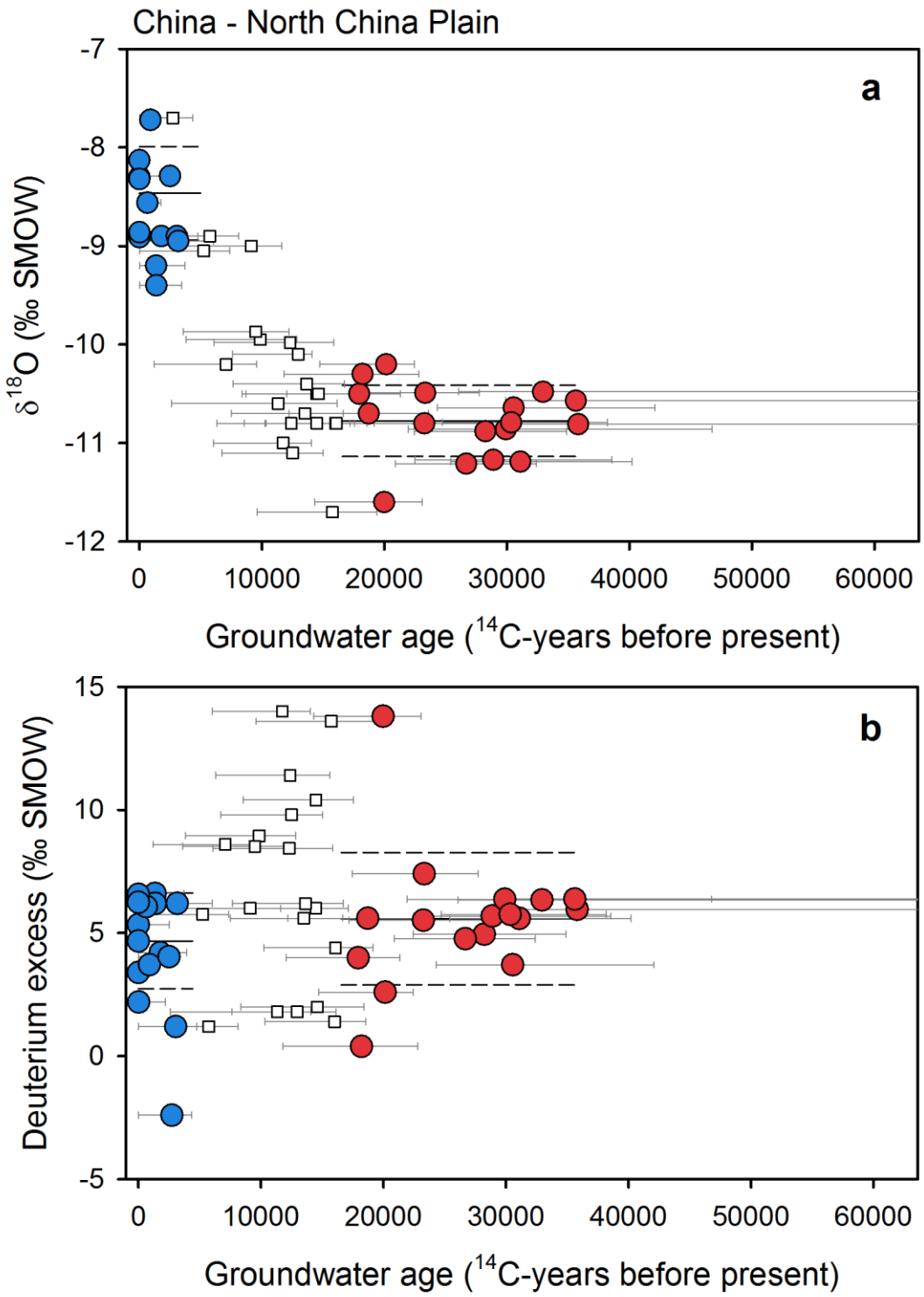

Figure S12. Groundwater isotope composition of the North China Plain. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Zongyu et al., 2003; Kreuzer et al., 2009).

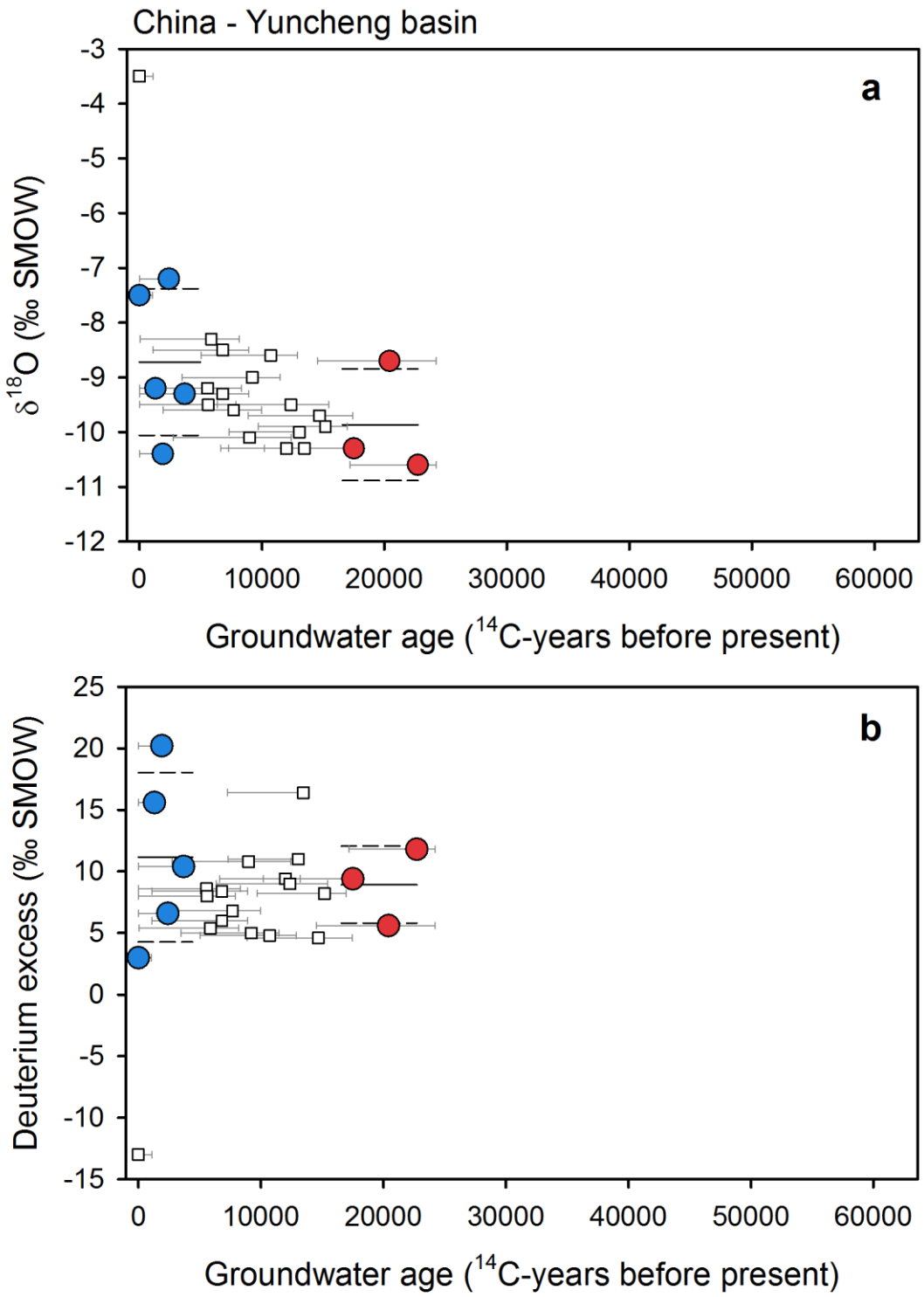

Figure S13. Groundwater isotope composition of the Yuncheng basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Currell et al., 2010).

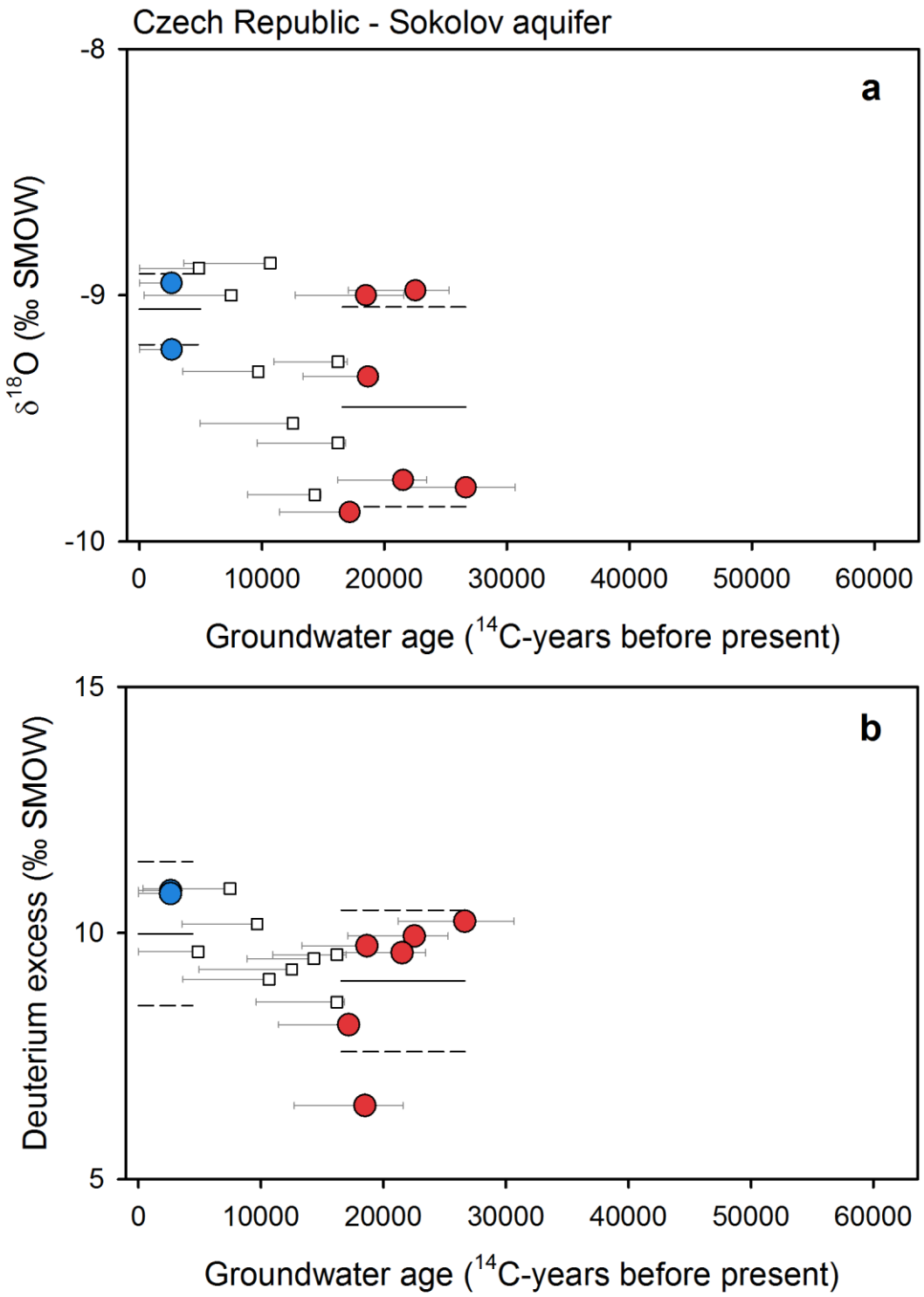

Figure S14. Groundwater isotope composition of the Sokolov aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Noseck et al., 2009).

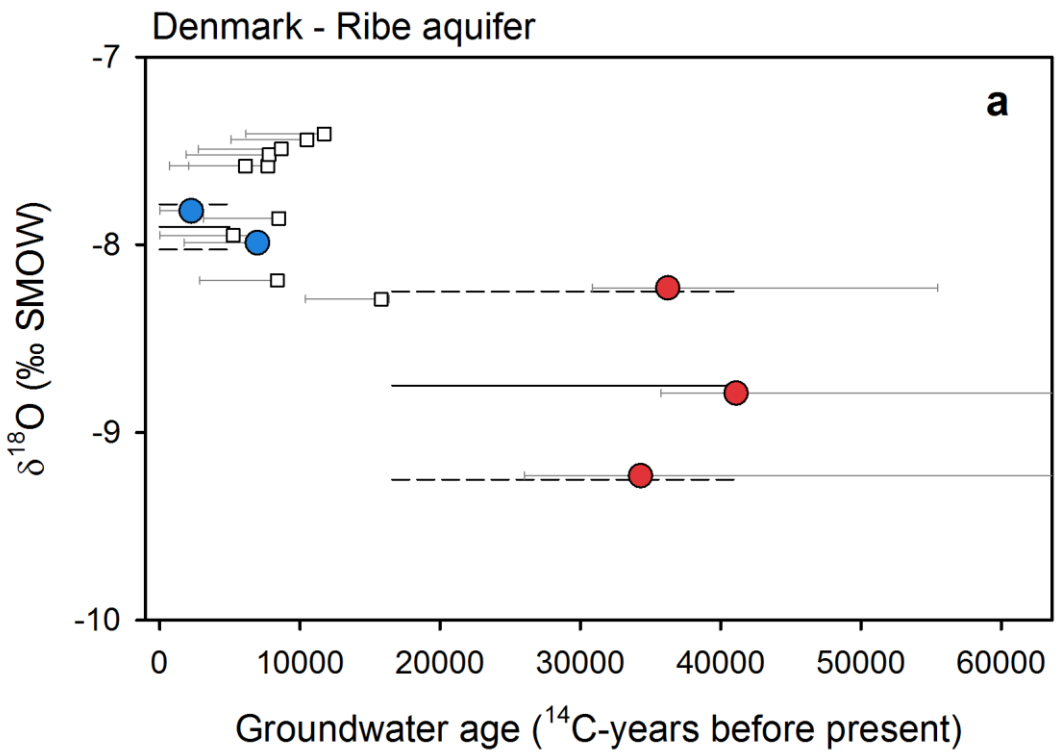

Figure S15. Groundwater isotope composition of the Ribe aquifer. Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Hinsby et al., 2001).

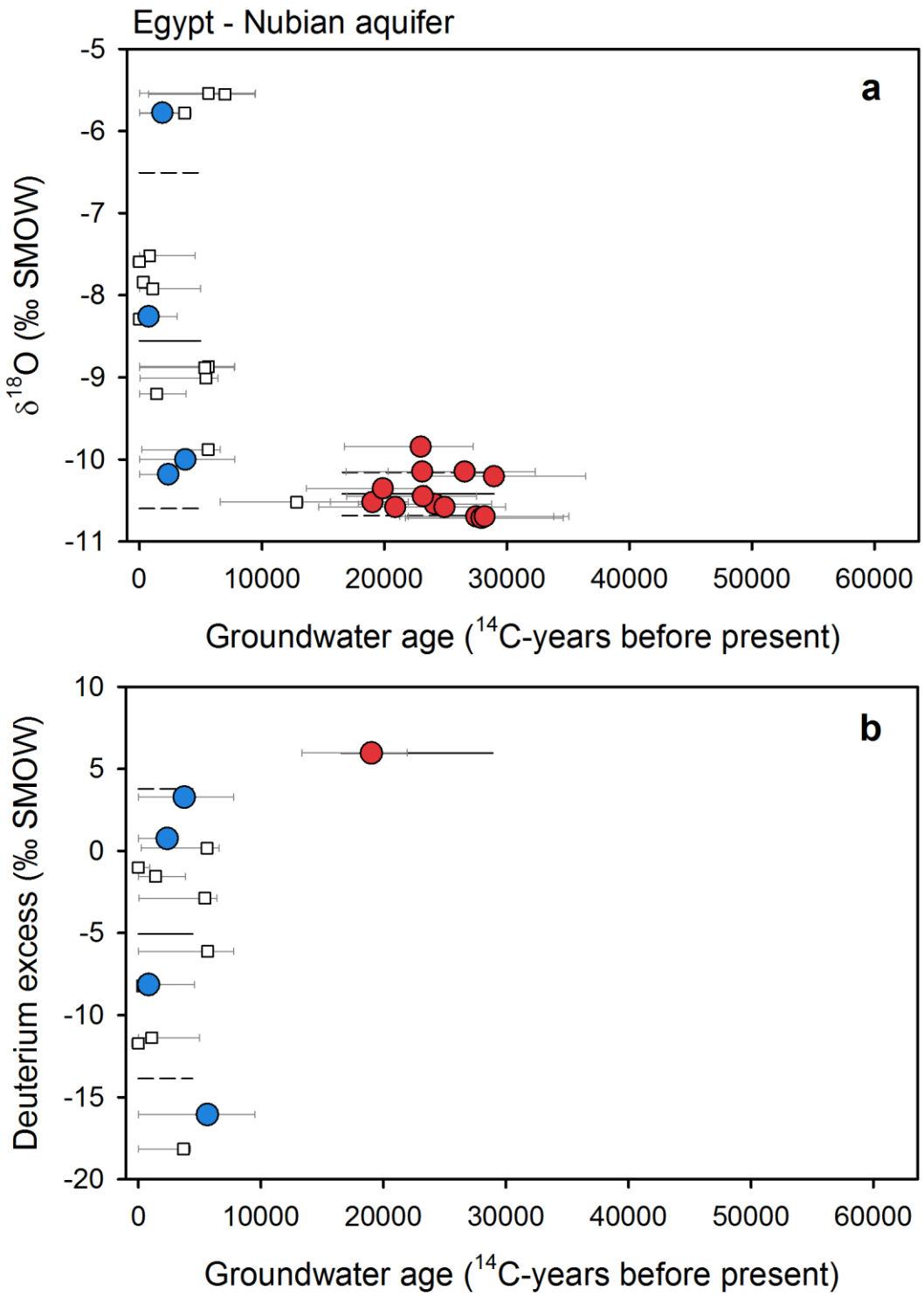

Figure S16. Groundwater isotope composition of the Nubian aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Shehata and Al-Ruwaih, 1999; Patterson et al., 2005; Edmunds, 2009).

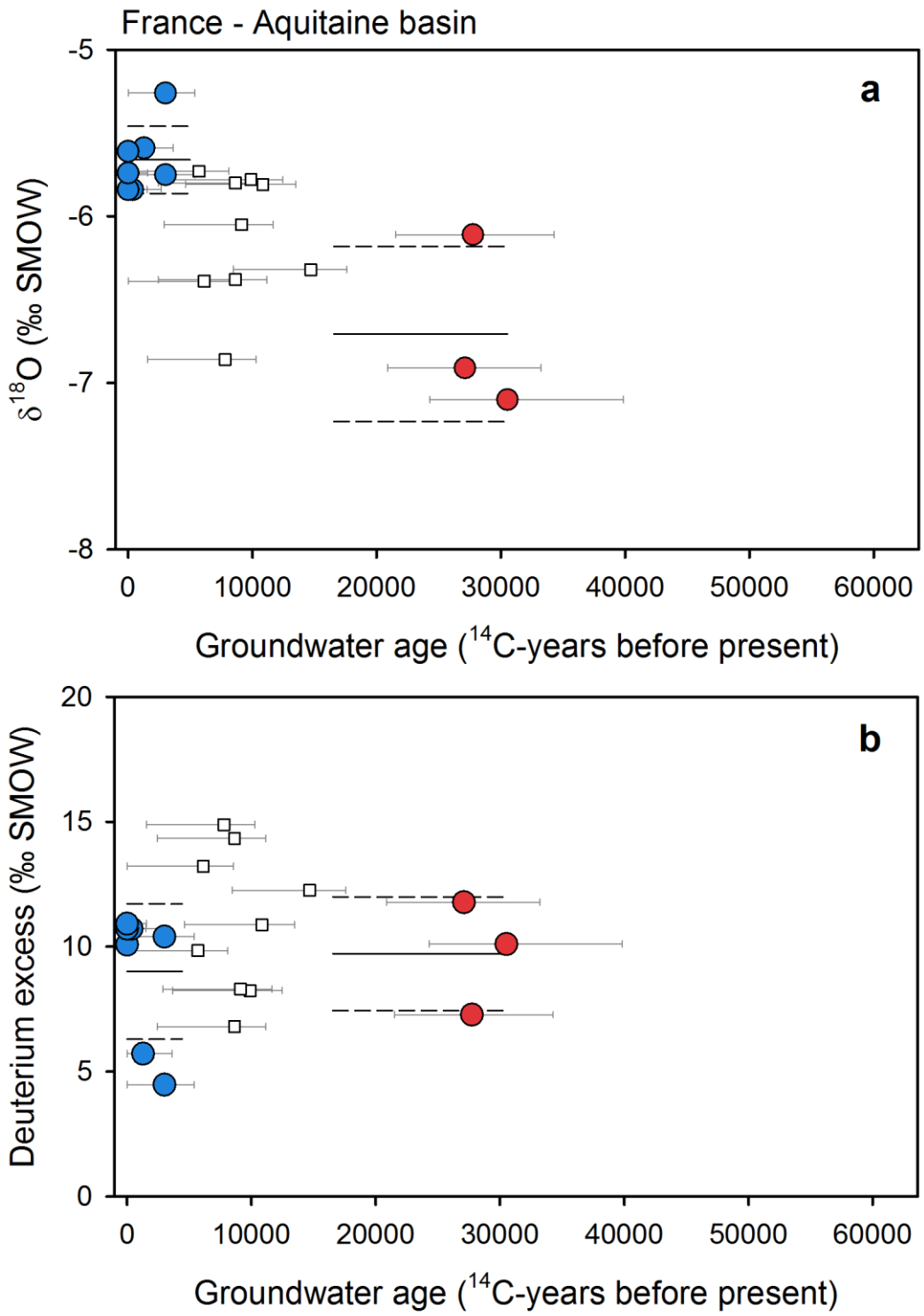

Figure S17. Groundwater isotope composition of the Aquitaine basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Le Gal La Salle et al., 1996).

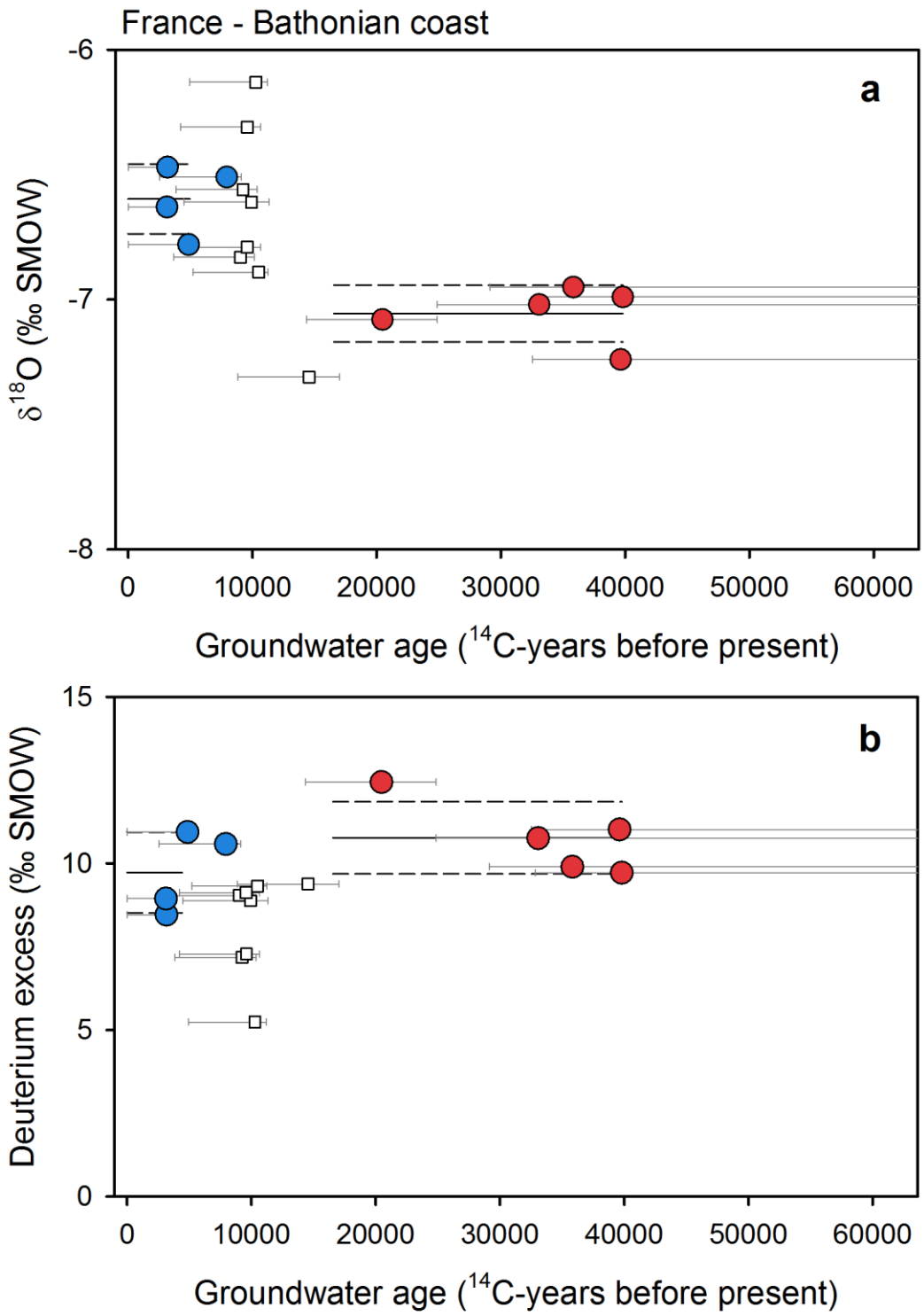

Figure S18. Groundwater isotope composition of the Bathonian coastal aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Barbecot et al., 2000).

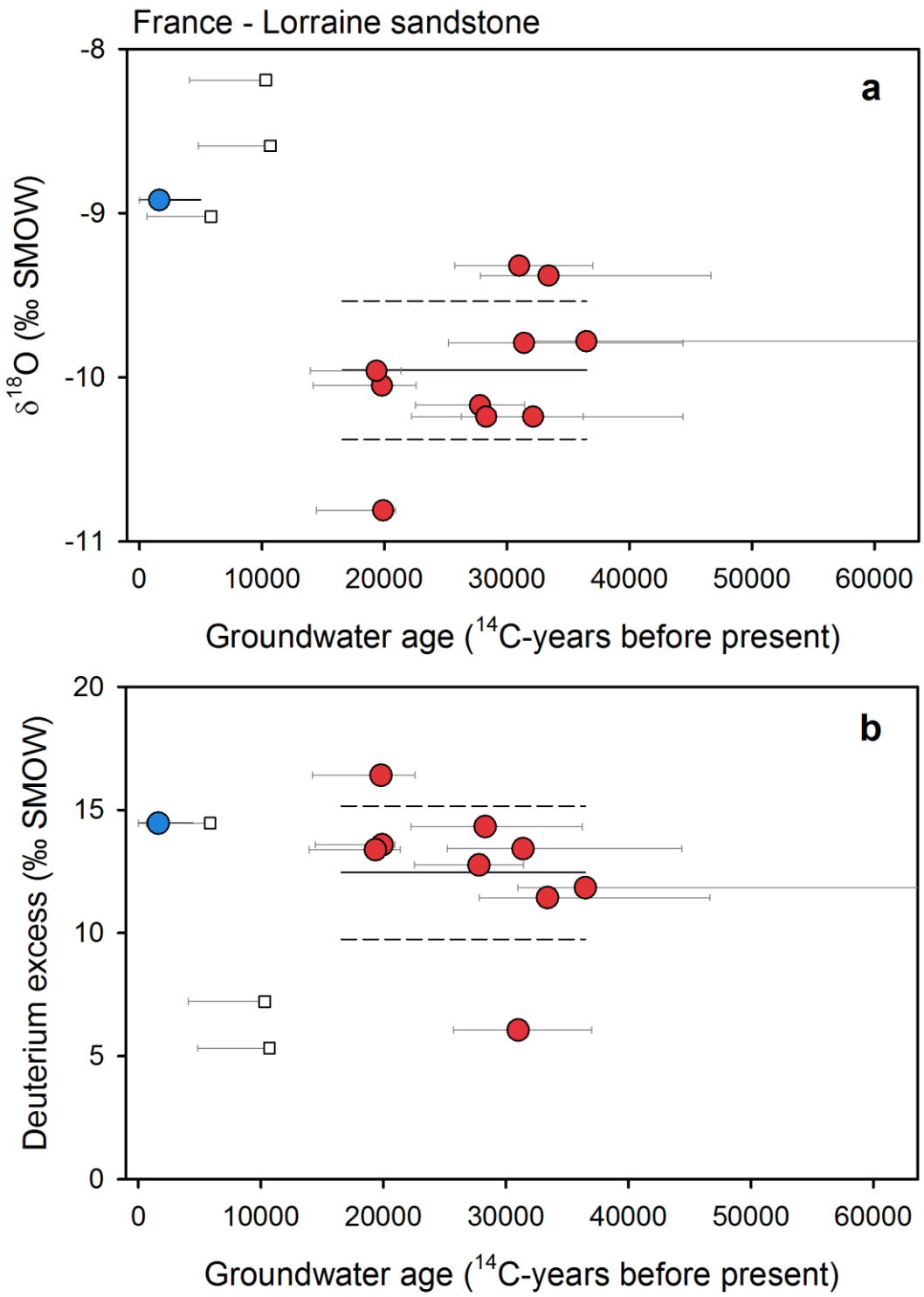

Figure S19. Groundwater isotope composition of the Lorraine sandstone aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Celle-Jeanton et al., 2009).

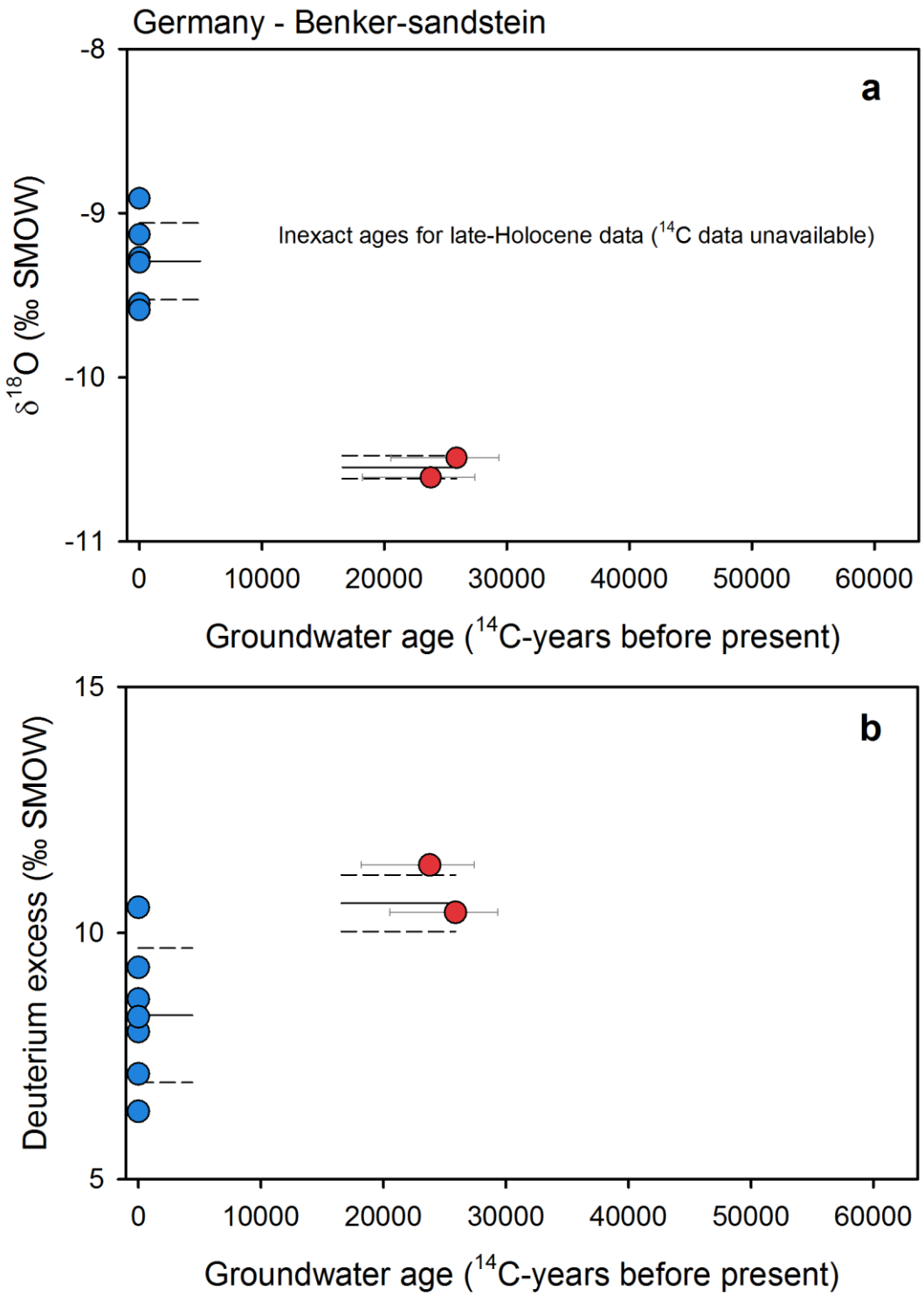

Figure S20. Groundwater isotope composition of the Benker-sandstein aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (van Geldern et al., 2014).

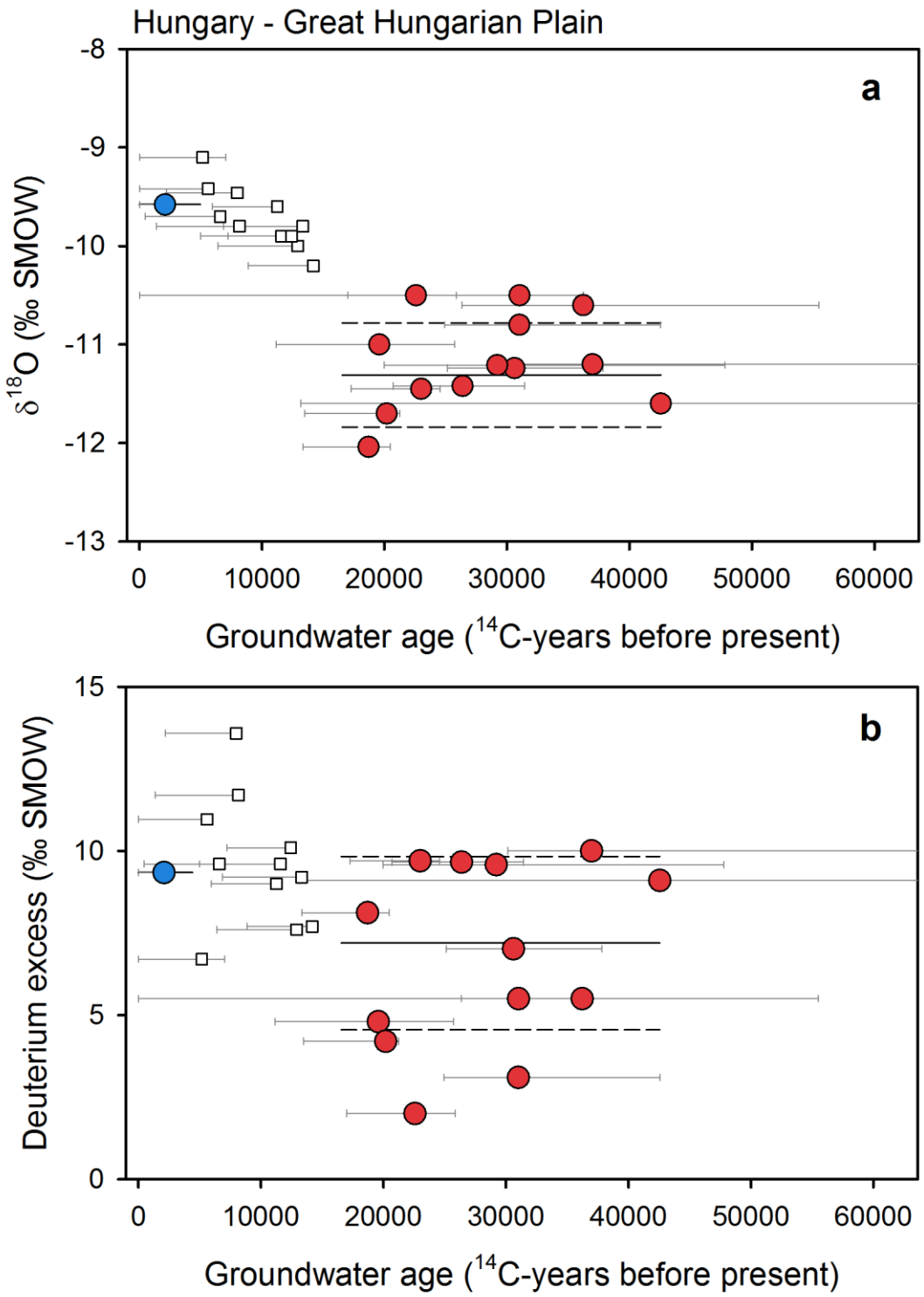

Figure S21. Groundwater isotope composition of the Great Hungarian Plain. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Stute and Deak, 1989).

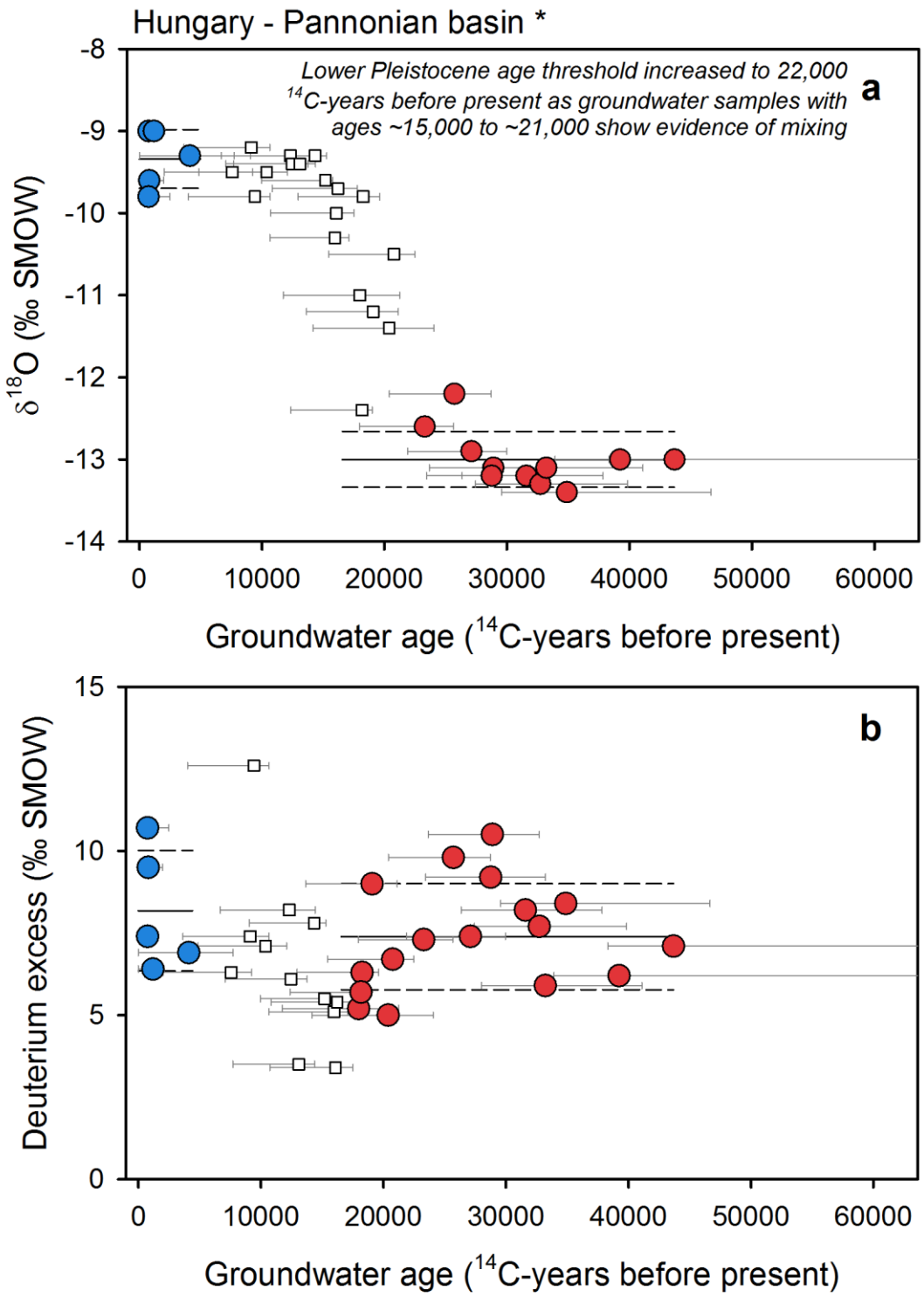

Figure S22. Groundwater isotope composition of the Pannonian basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Varsanyi et al., 2011).

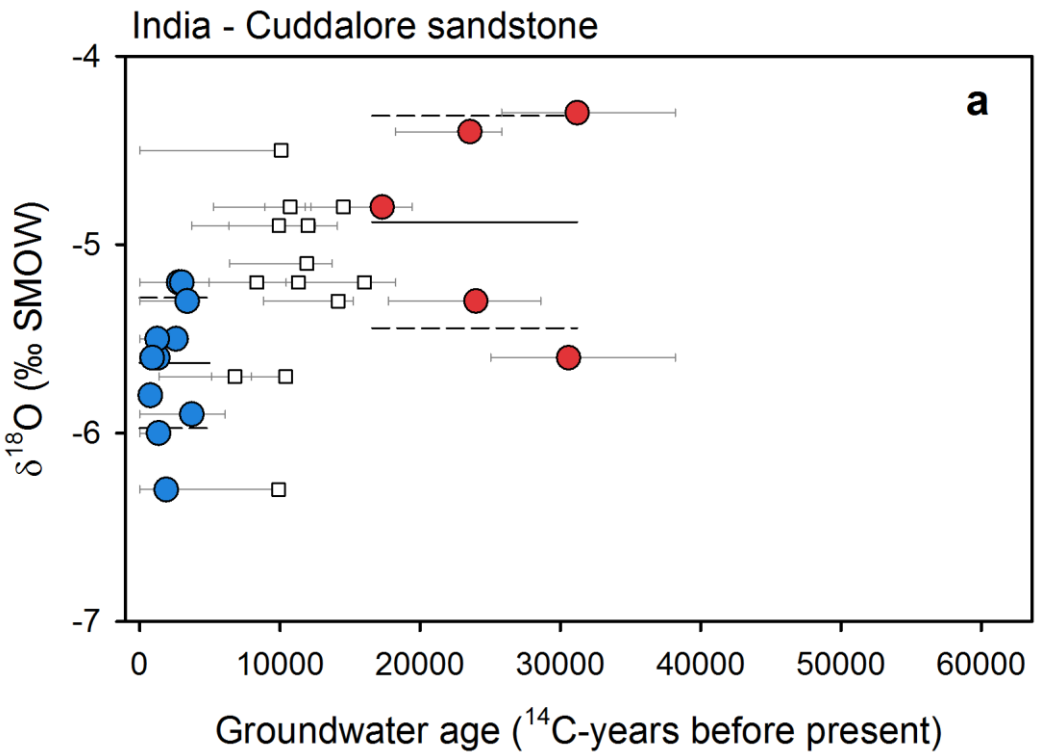

Figure S23. Groundwater isotope composition of the Cuddalore sandstone aquifer. Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Sukhija et al., 1998).

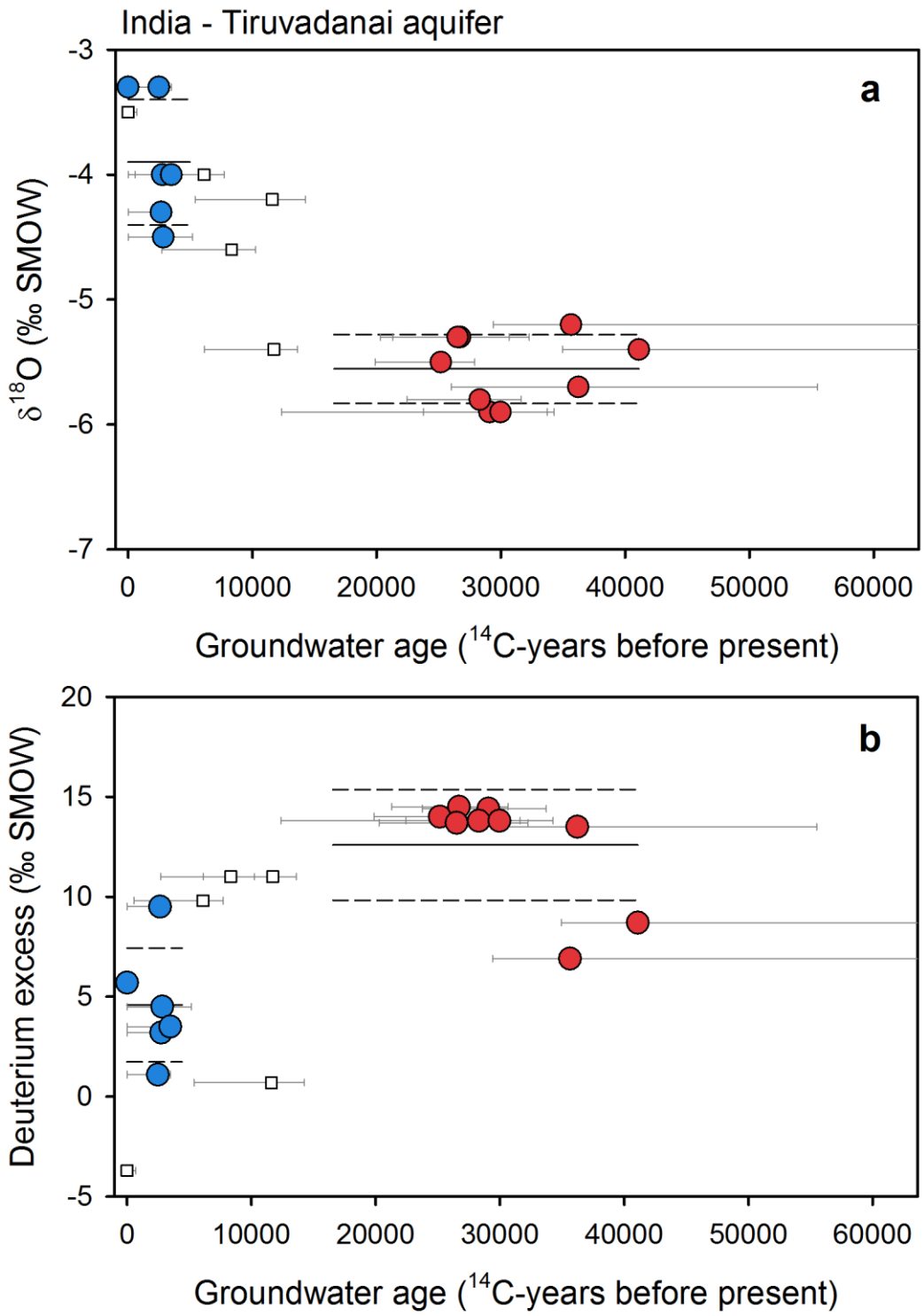

Figure S24. Groundwater isotope composition of the Tiruvadanai aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Kumar et al., 2009).

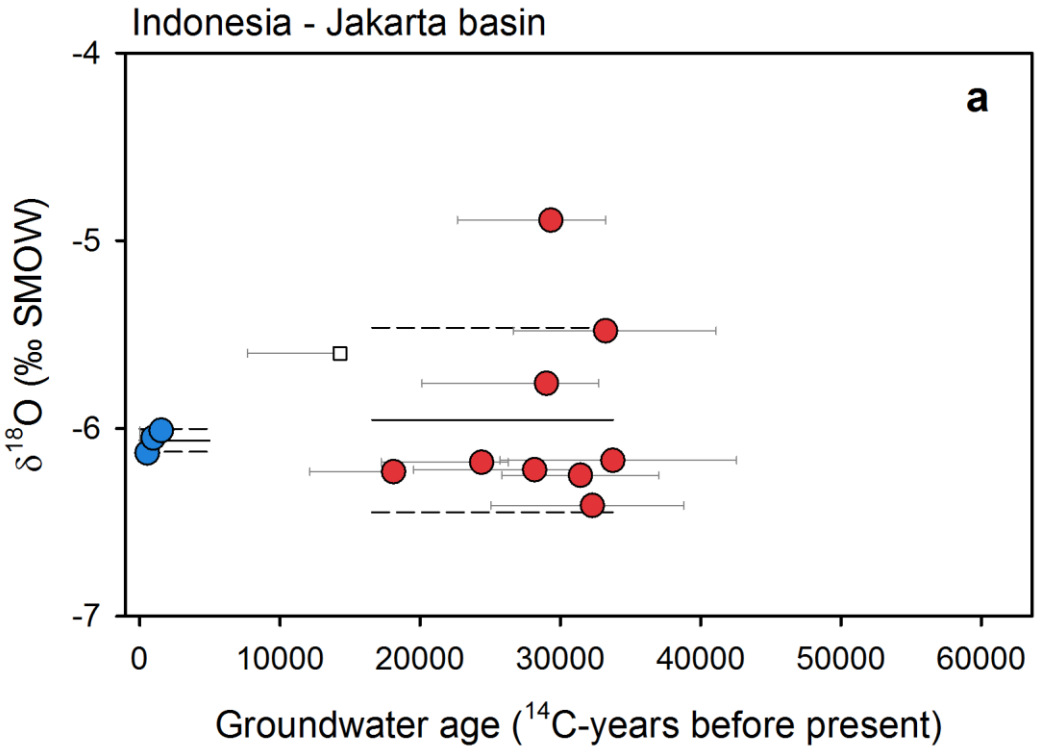

Figure S25. Groundwater isotope composition of the Jakarta aquifer. Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Geyh and Söfner, 1989).

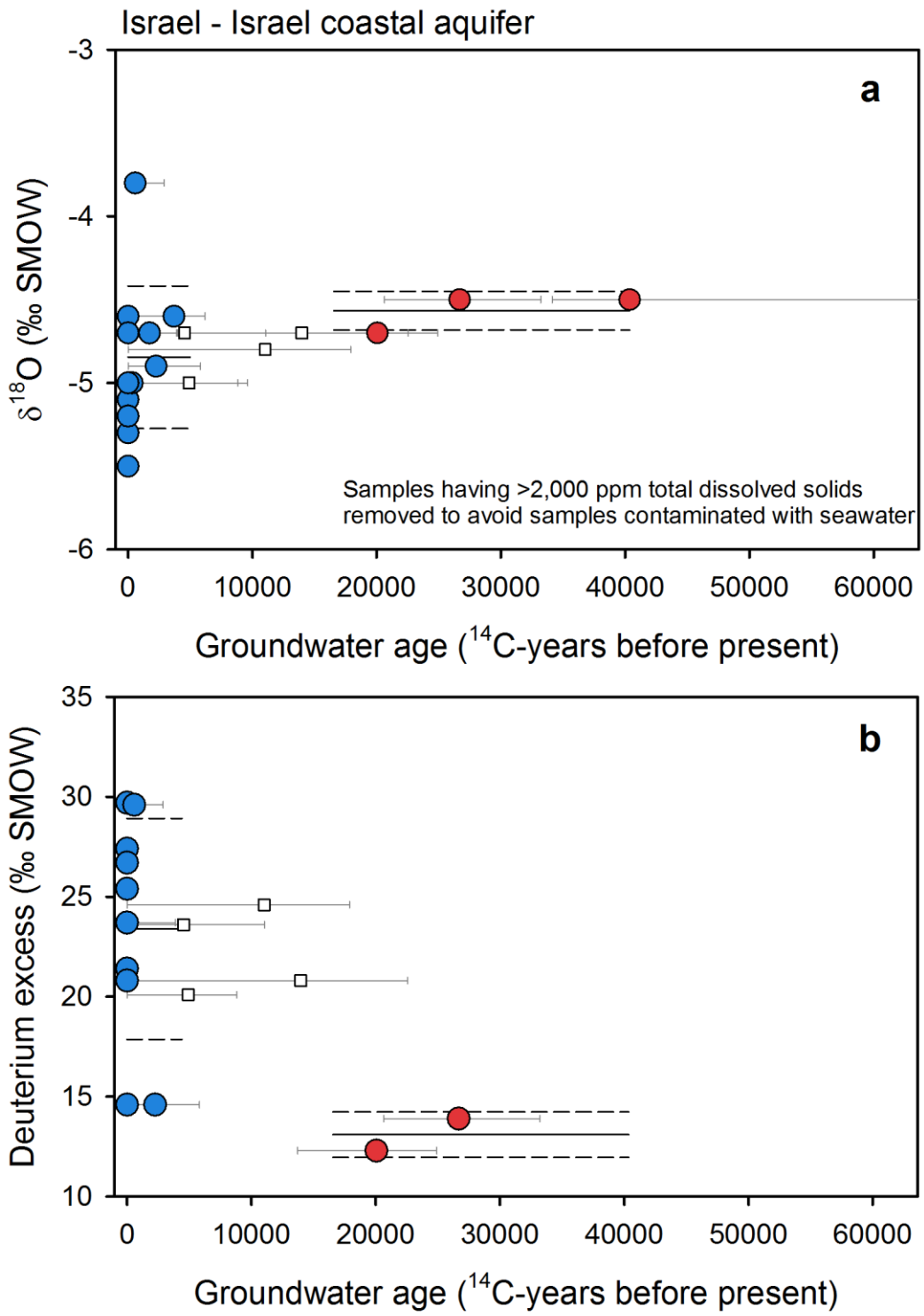

Figure S26. Groundwater isotope composition of the Israel coastal aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Yechieli et al., 2009).

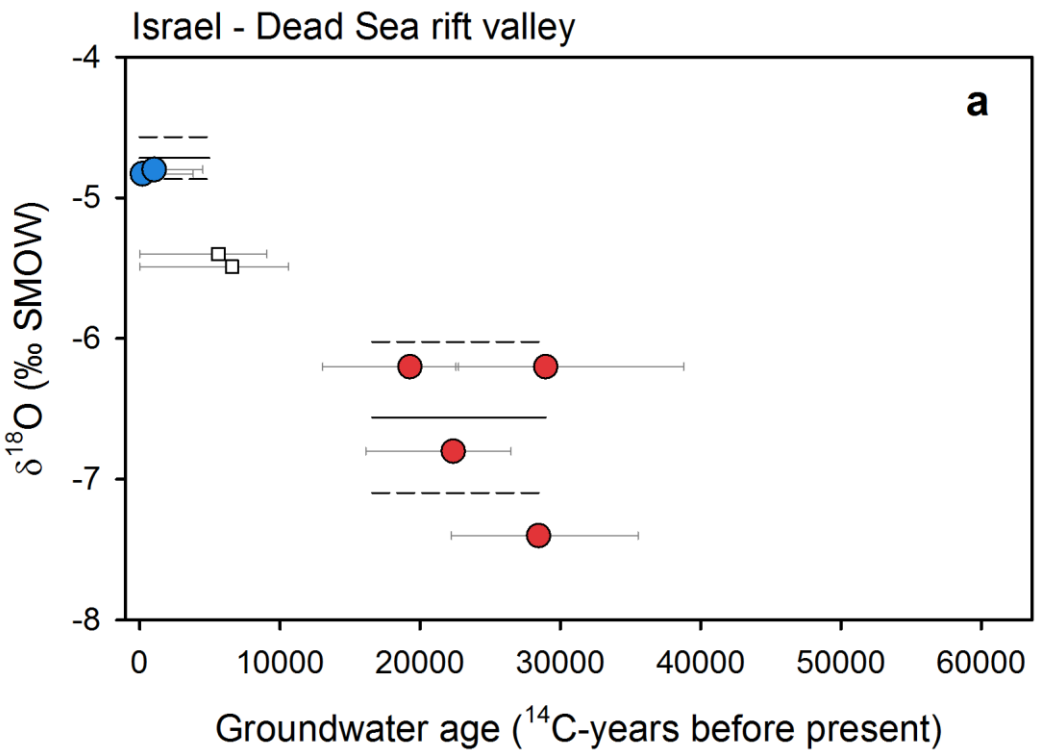

Figure S27. Groundwater isotope composition of the Dead Sea Rift aquifer. Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Gat and Galai, 1982; Mazor et al., 1995).

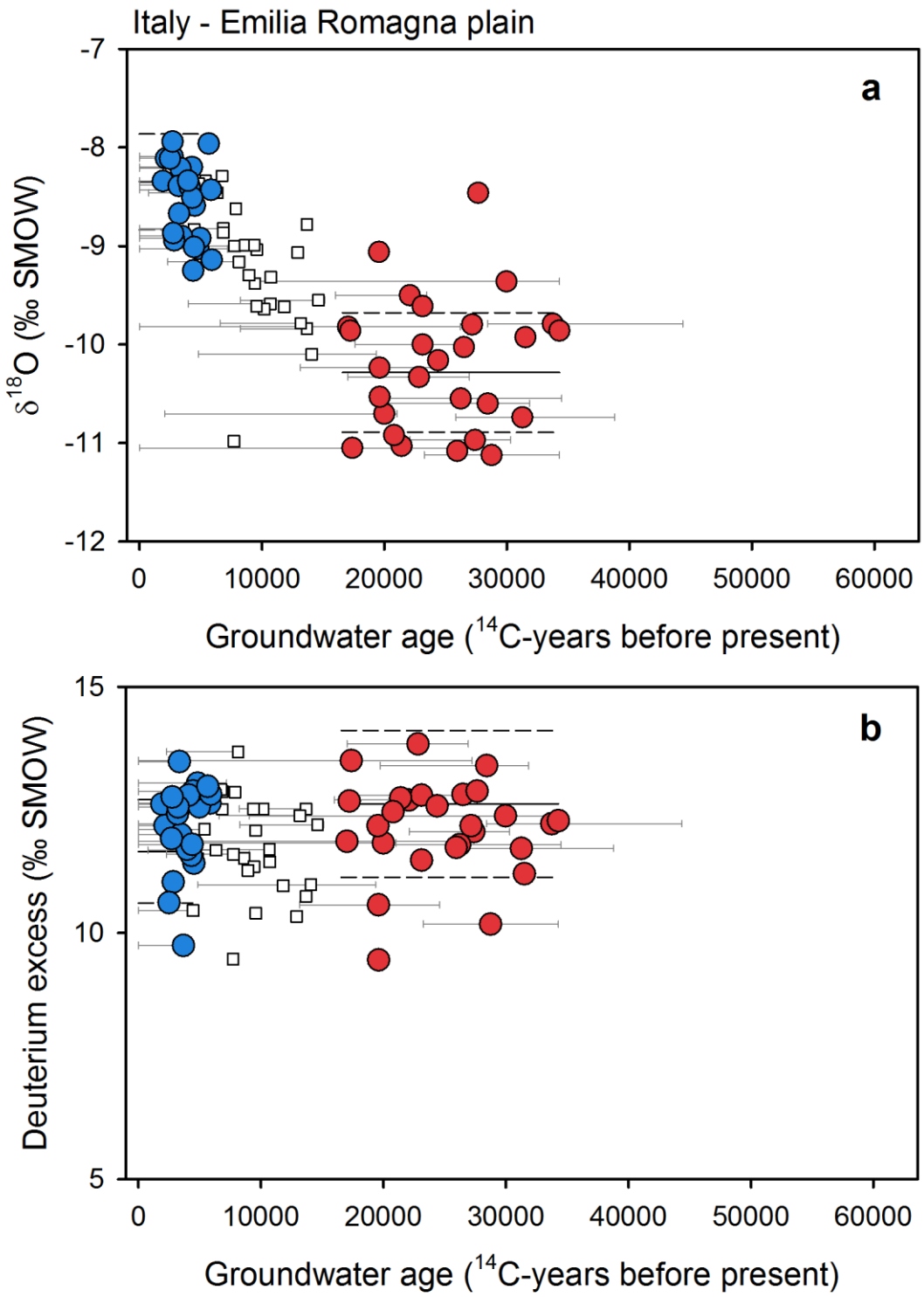

Figure S28. Groundwater isotope composition of the Emilia Romagna Plain. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Martinelli et al., 2011).

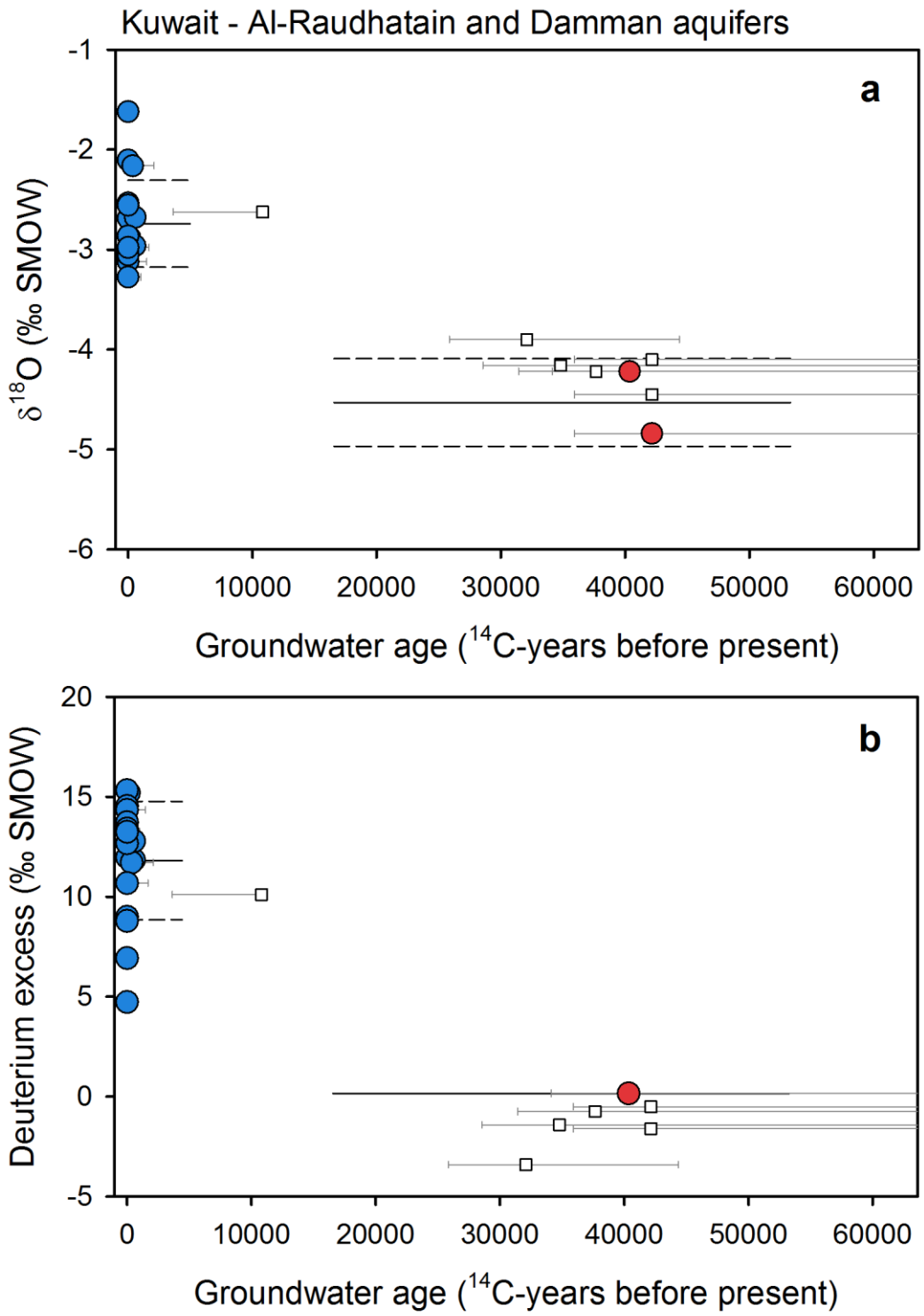

Figure S29. Groundwater isotope composition of the Al-Raudhatain and Damman aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. The average (solid line) and 1 s.d. (dashed lines) are shown for each group (Al-Ruwaih and Shehata, 2004; Fadlelmawla et al., 2008).

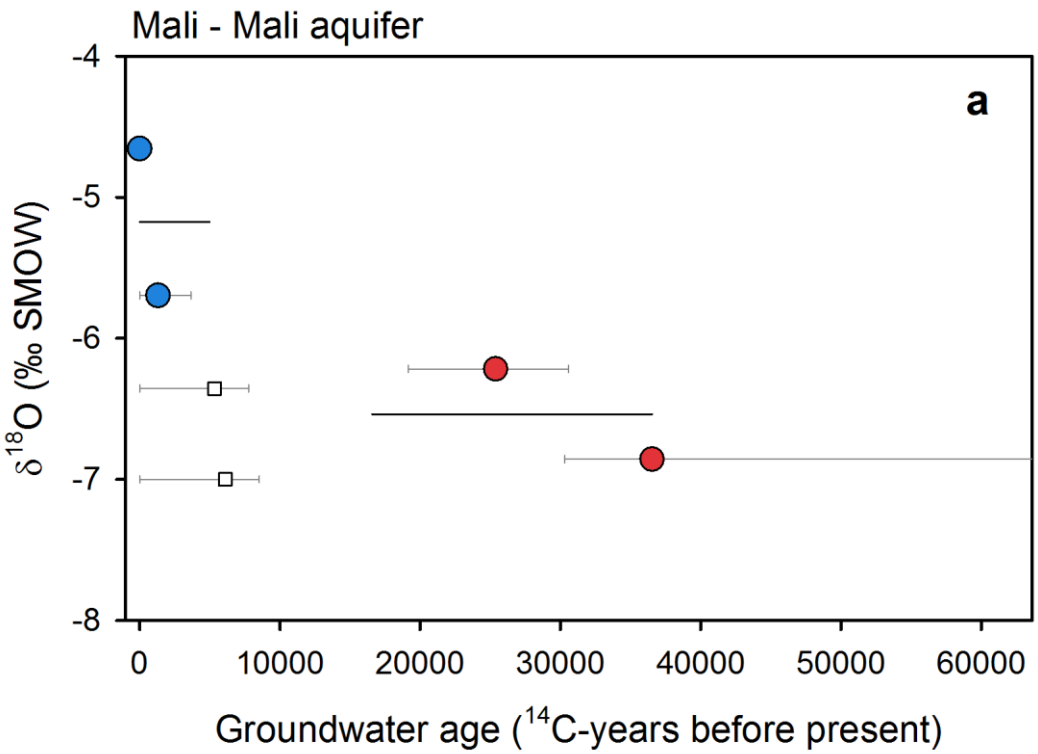

Figure S30. Groundwater isotope composition of the Mali aquifer. Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Edmunds, 2009).

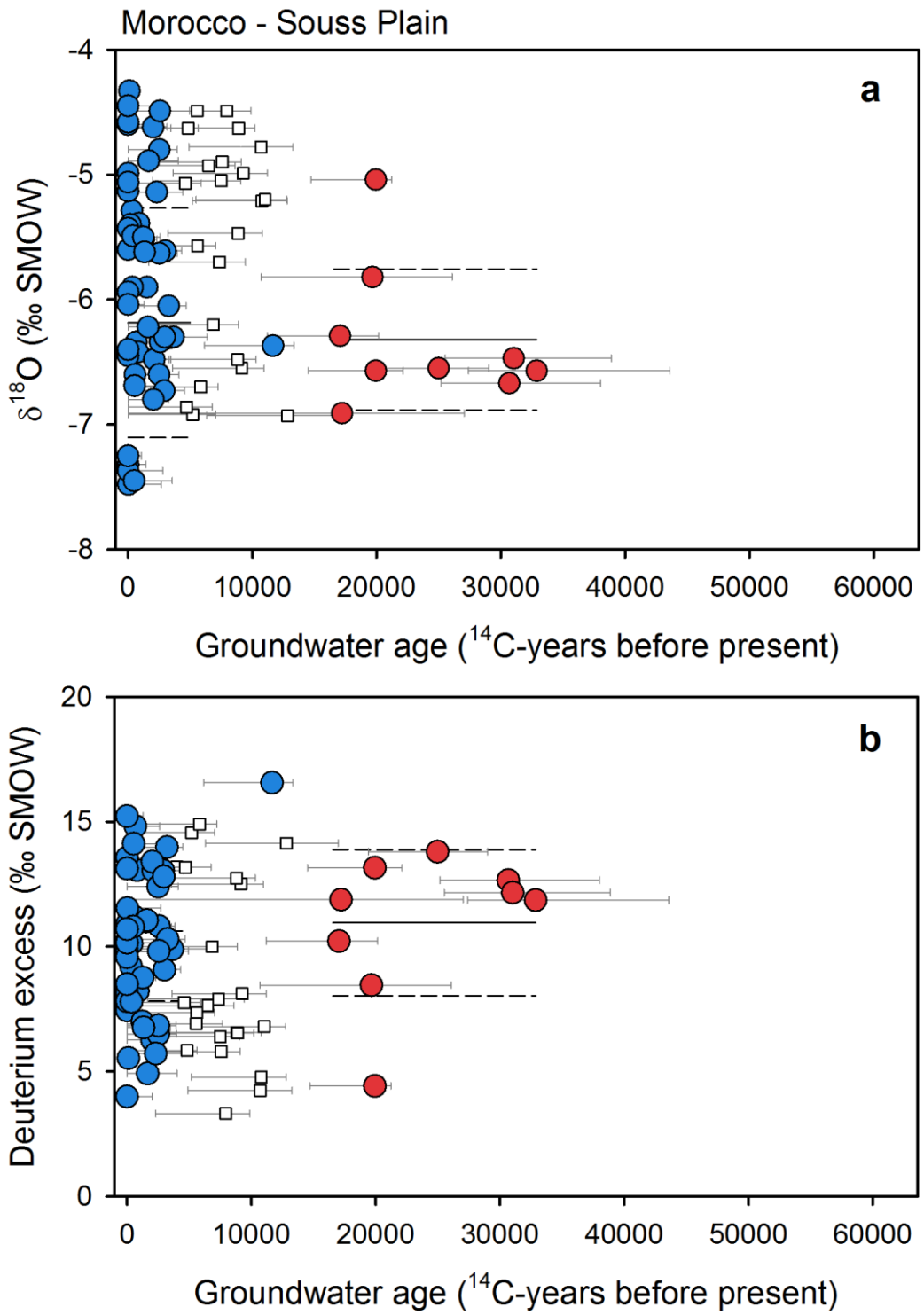

Figure S31. Groundwater isotope composition of the Tadla basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Castany et al., 1974).

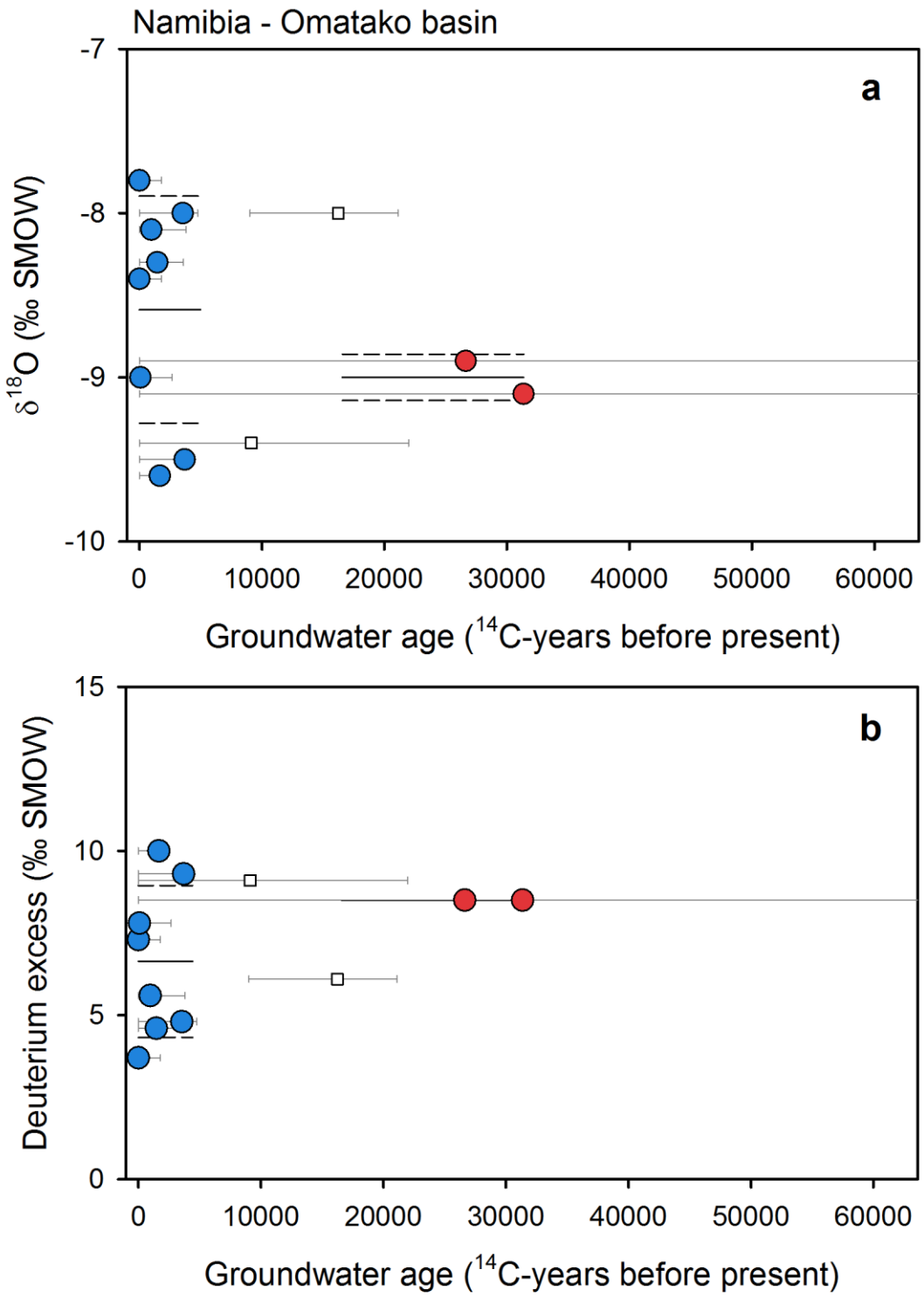

Figure S32. Groundwater isotope composition of the Omatako basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Külls, 2000).

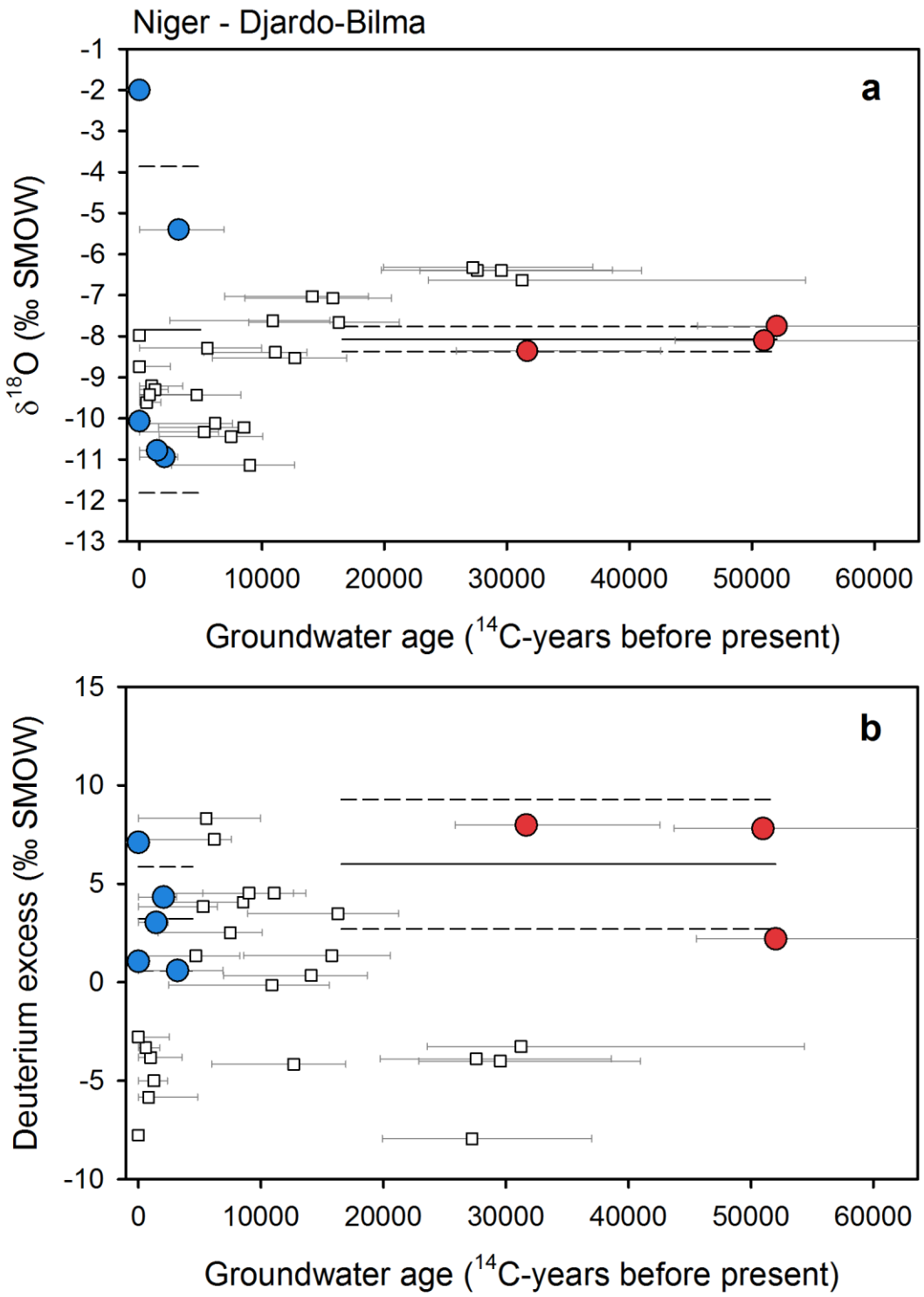

Figure S33. Groundwater isotope composition of the Djardo-Bilma basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Dodo and Zuppi, 1997; 1999).

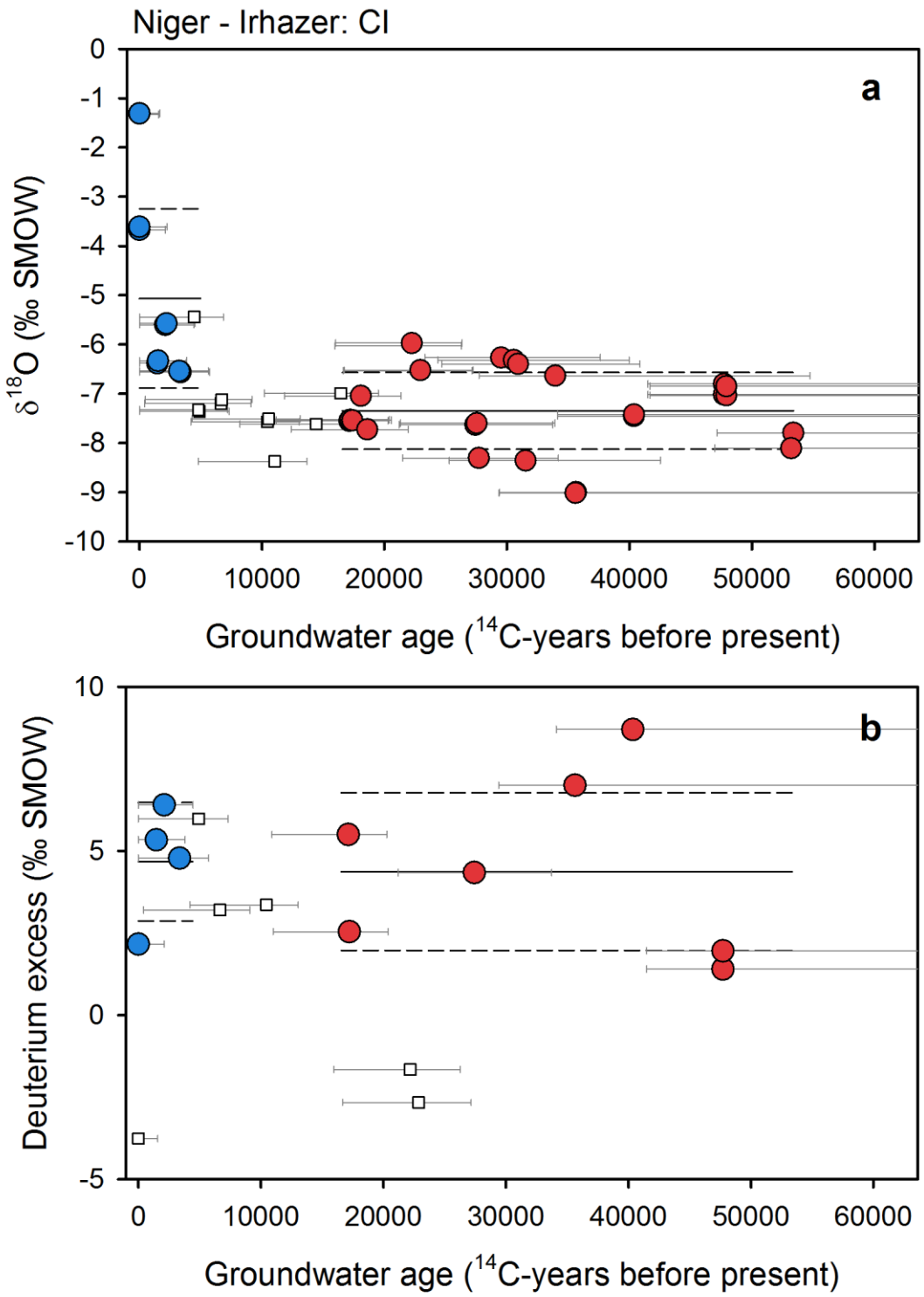

Figure S34. Groundwater isotope composition of the Irhazer aquifer (Continental Intercalaire). Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Andrews et al., 1994; Edmunds, 2004).

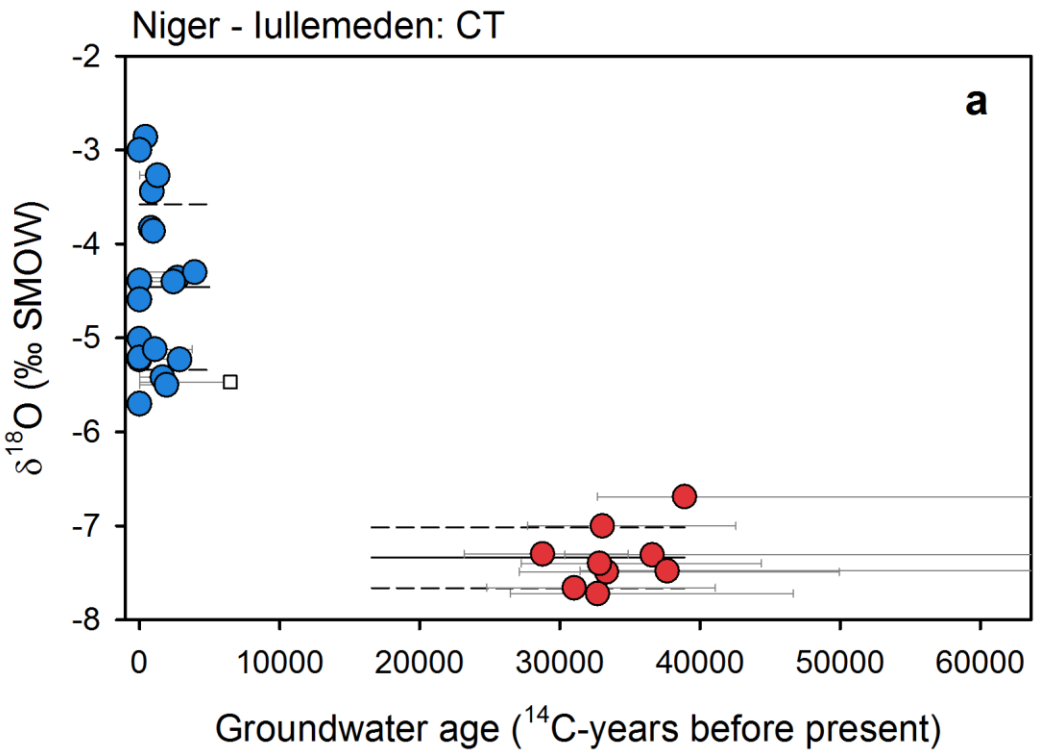

Figure S35. Groundwater isotope composition of the Iullemeden aquifer (Continental Terminal). Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Le Gal La Salle et al., 2001; Beyerle et al., 2003).

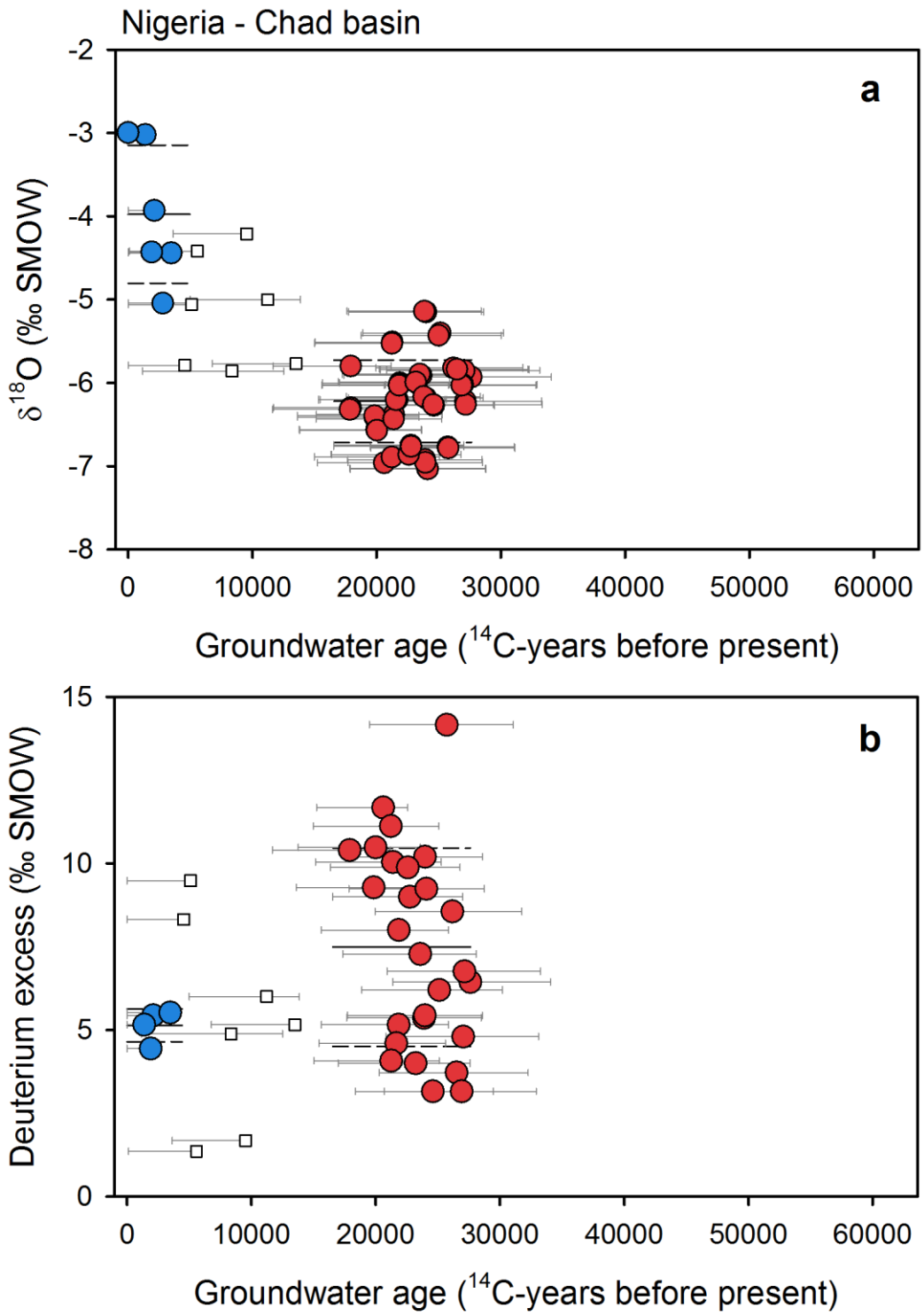

Figure S36. Groundwater isotope composition of the Chad aquifer (in Nigeria). Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Maduabuchi et al., 2006).

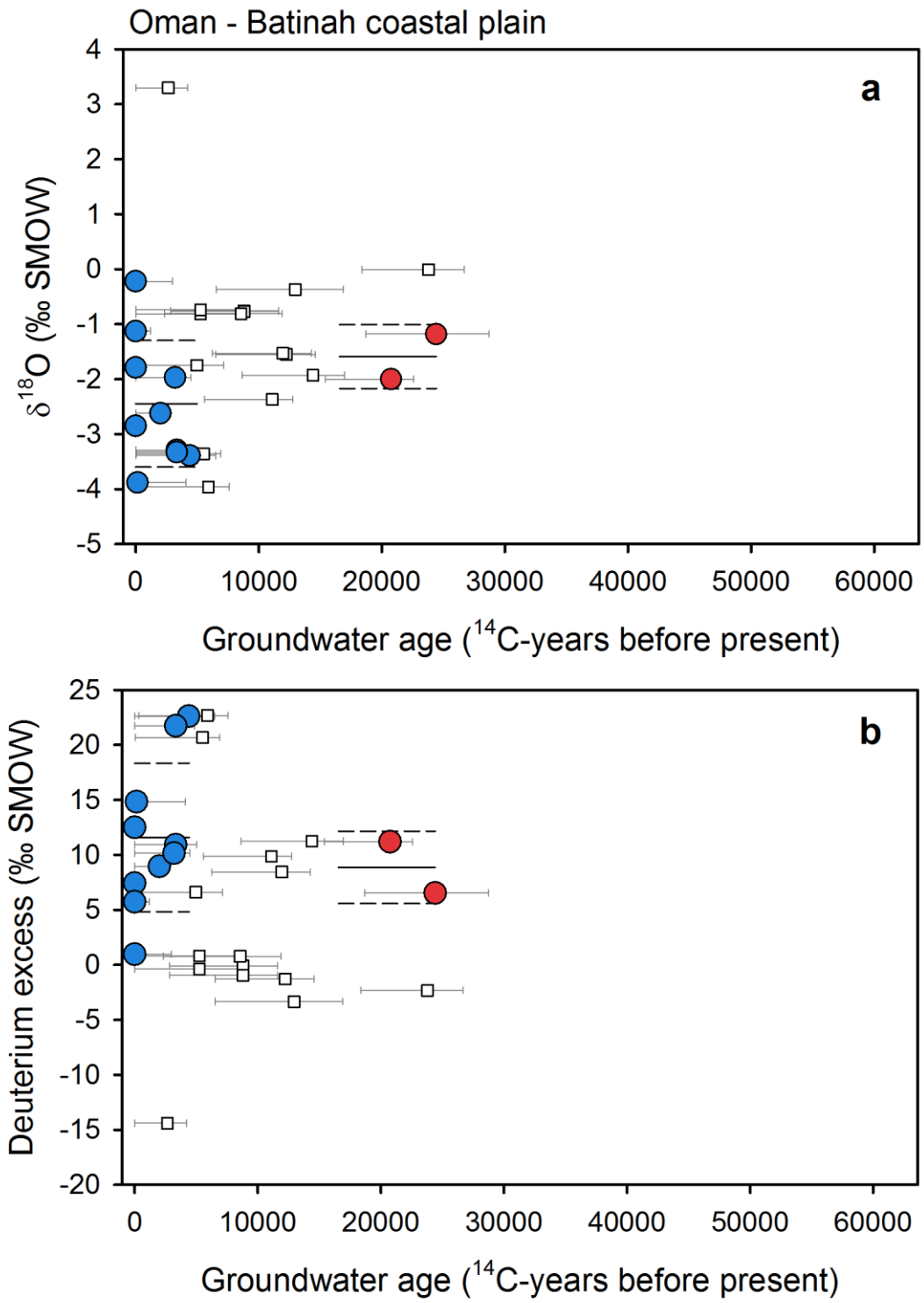

Figure S37. Groundwater isotope composition of the Batinah coastal aquifer system. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Weyhenmeyer et al., 2000; 2002).

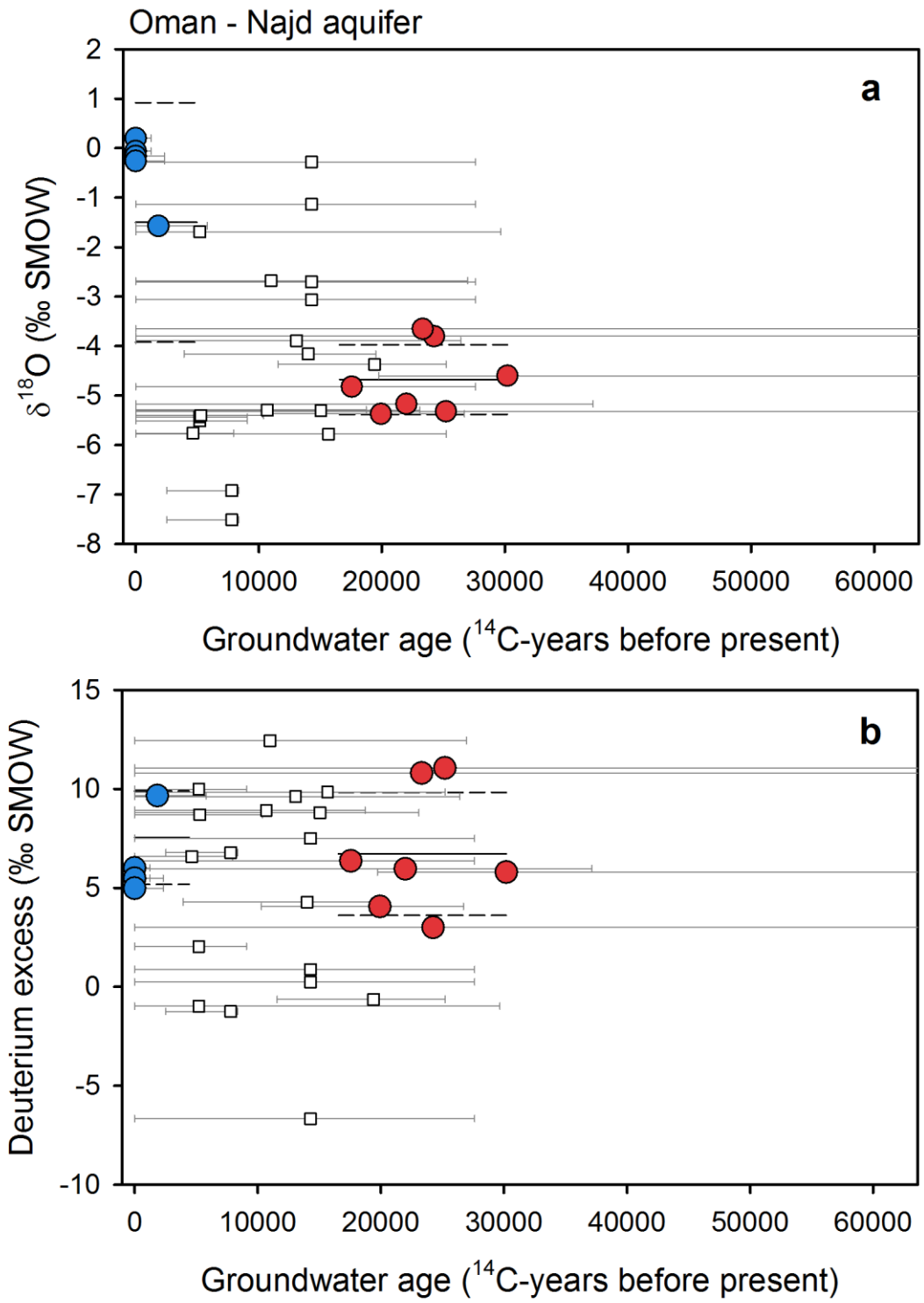

Figure S38. Groundwater isotope composition of the Najd aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Clark et al., 1987; Al-Mashaikhi et al., 2012).

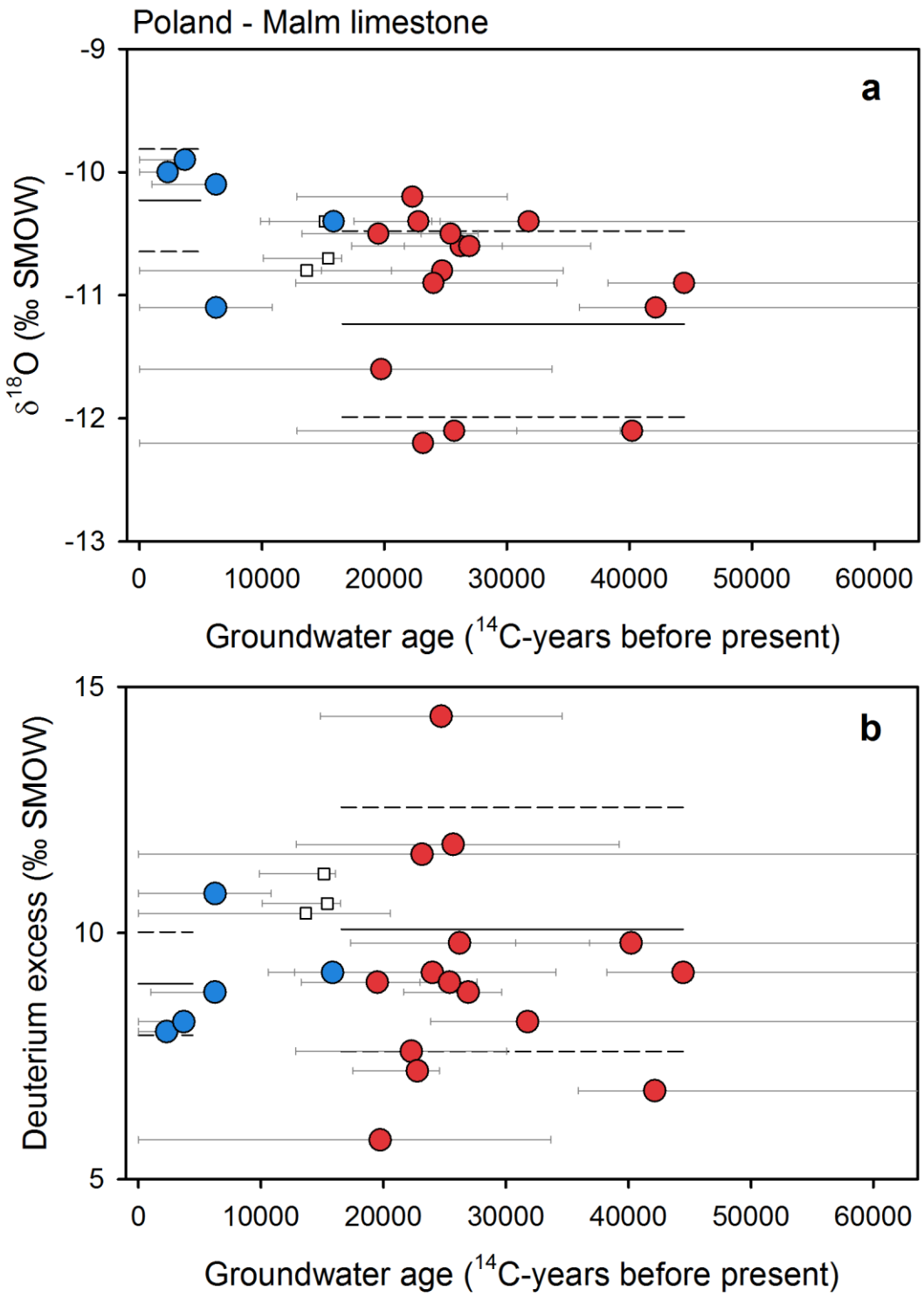

Figure S39. Groundwater isotope composition of the Malm limestone aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Zuber et al., 2004).

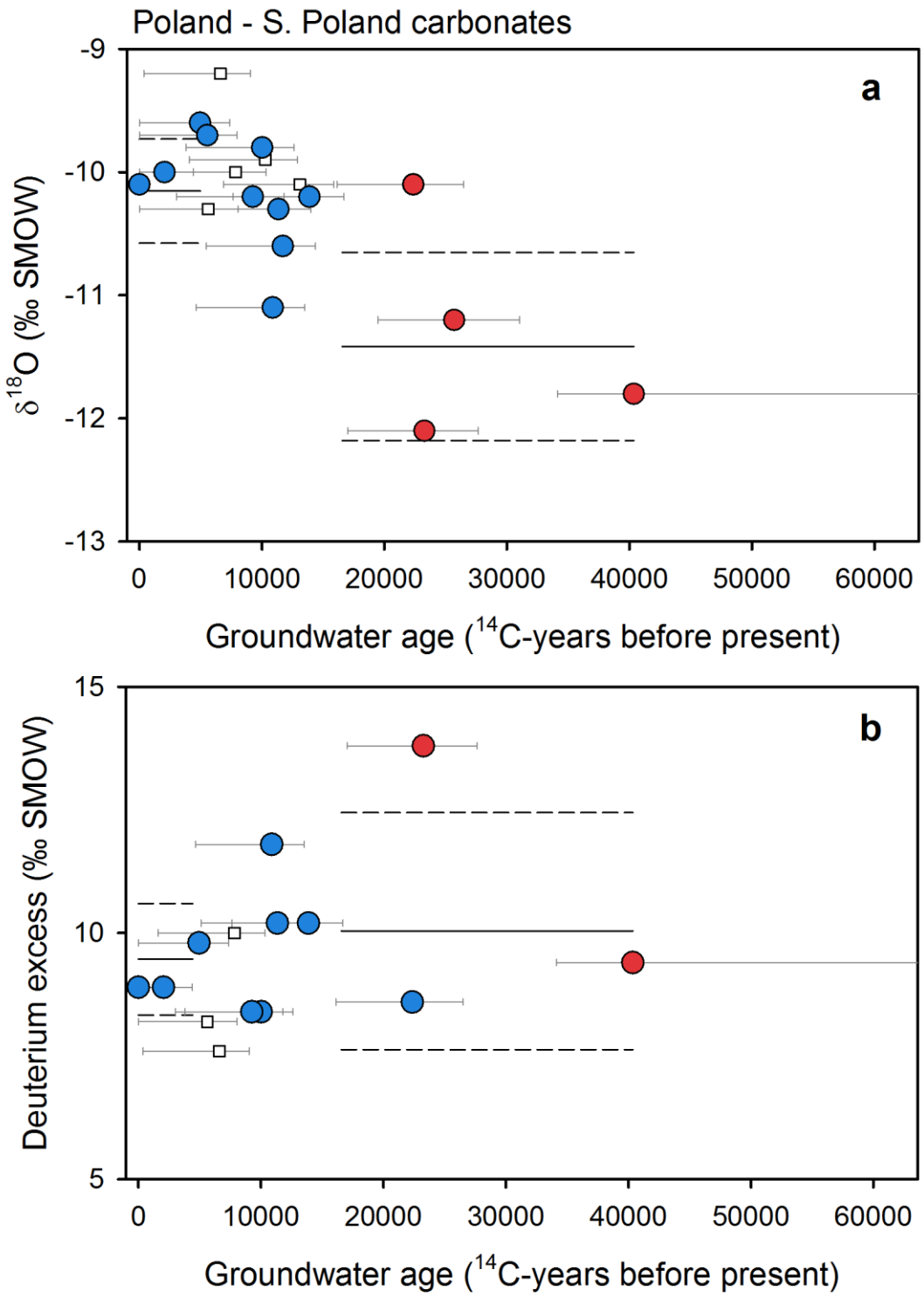

Figure S40. Groundwater isotope composition of the carbonate aquifer system of southern Poland. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Samborska et al., 2013).

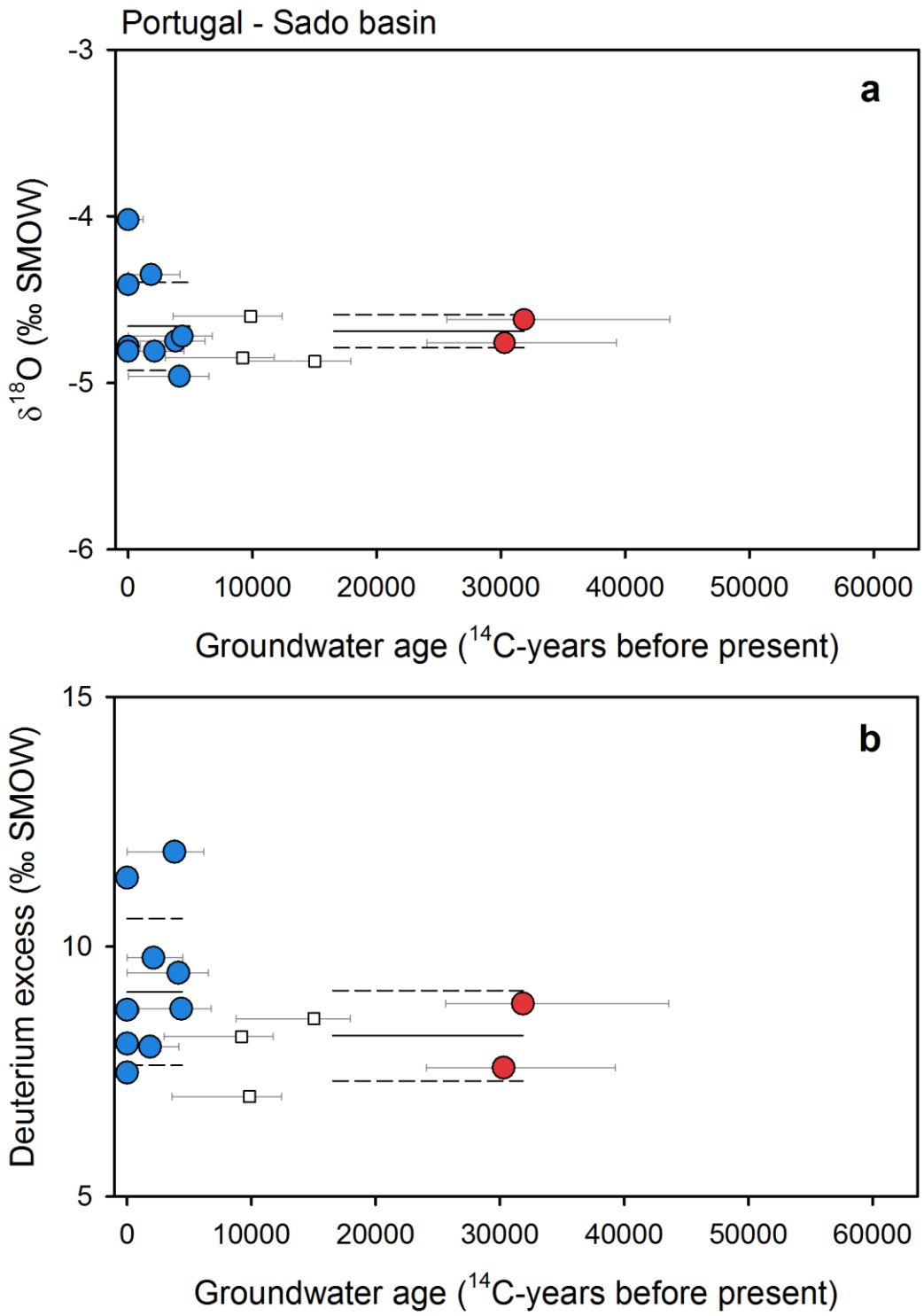

Figure S41. Groundwater isotope composition of the Sado basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Galego Fernandes and Carreira, 2008).

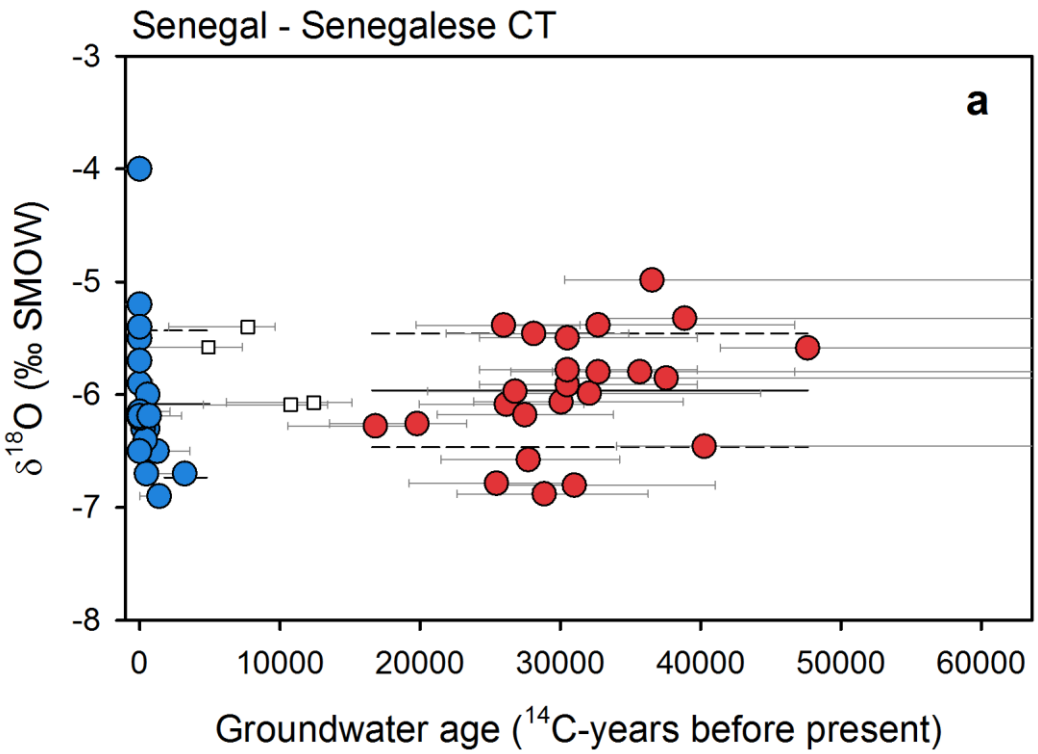

Figure S42. Groundwater isotope composition of the Senegalese Continental Terminal aquifer. Groundwater $\delta^{18}O$ plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Castany et al., 1974; Edmunds, 2009).

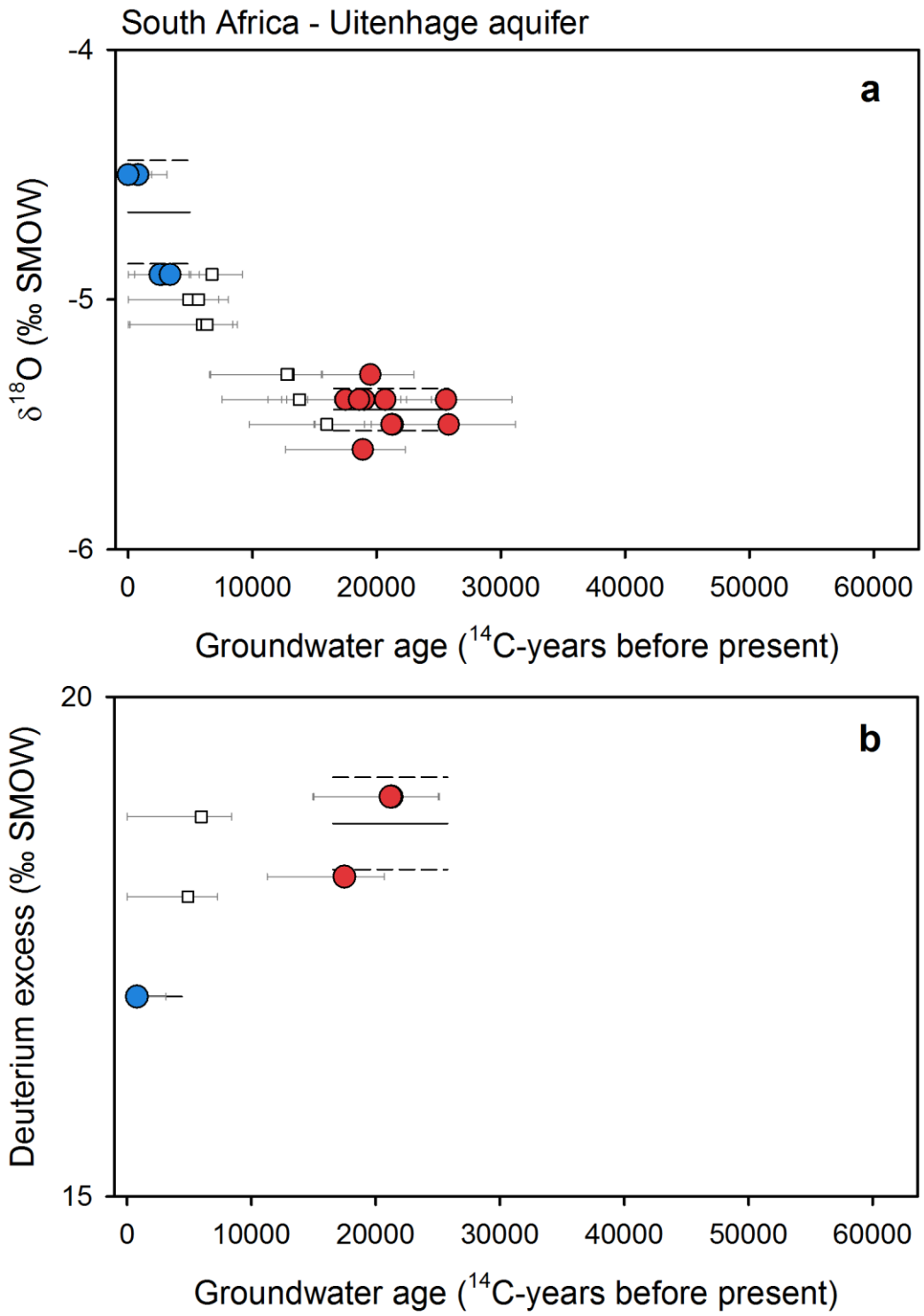

Figure S43. Groundwater isotope composition of the Uitenhage aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Heaton et al., 1986).

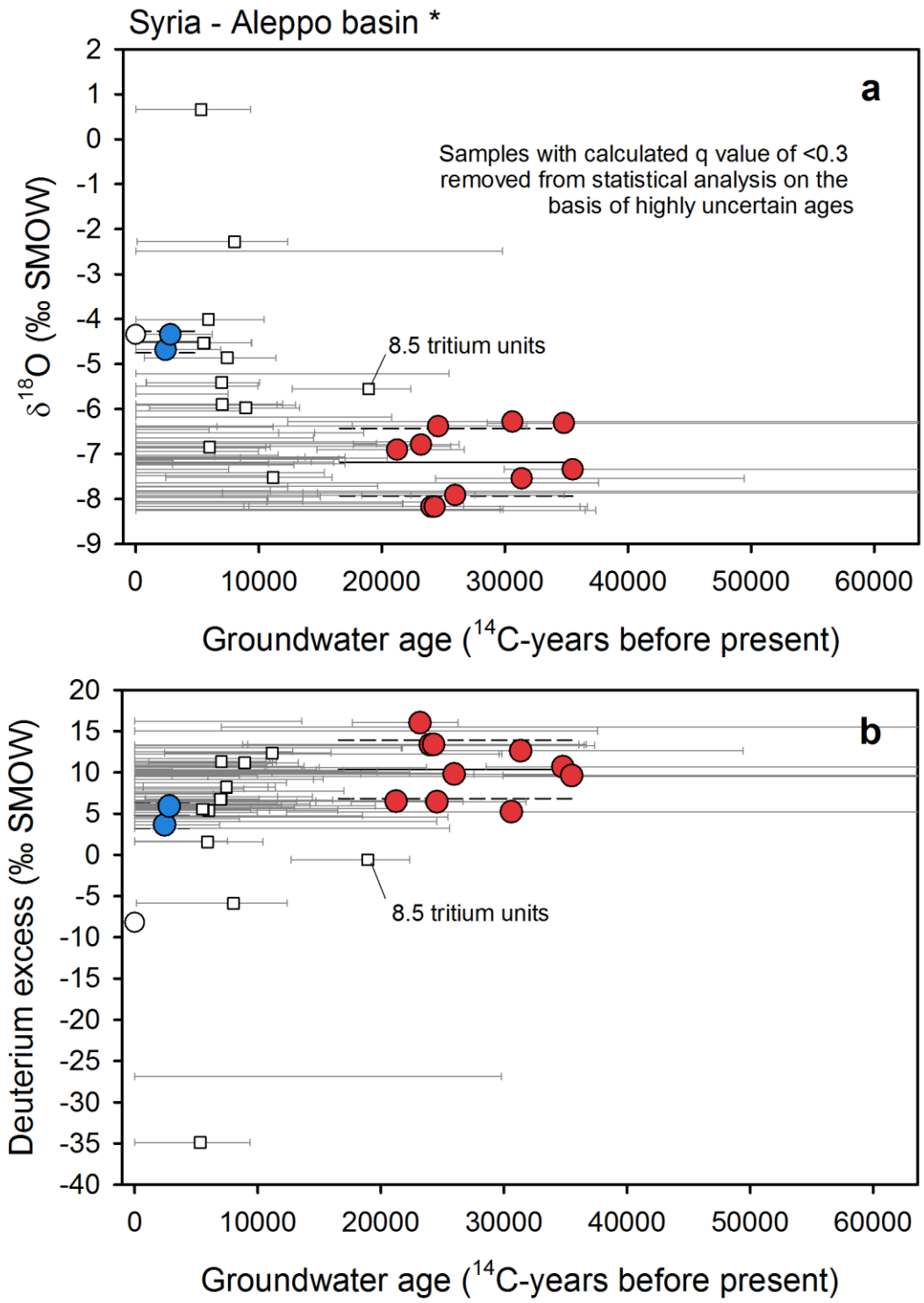

Figure S44. Groundwater isotope composition of the Aleppo basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Al-Charideh, 2012; Stadler et al., 2012).

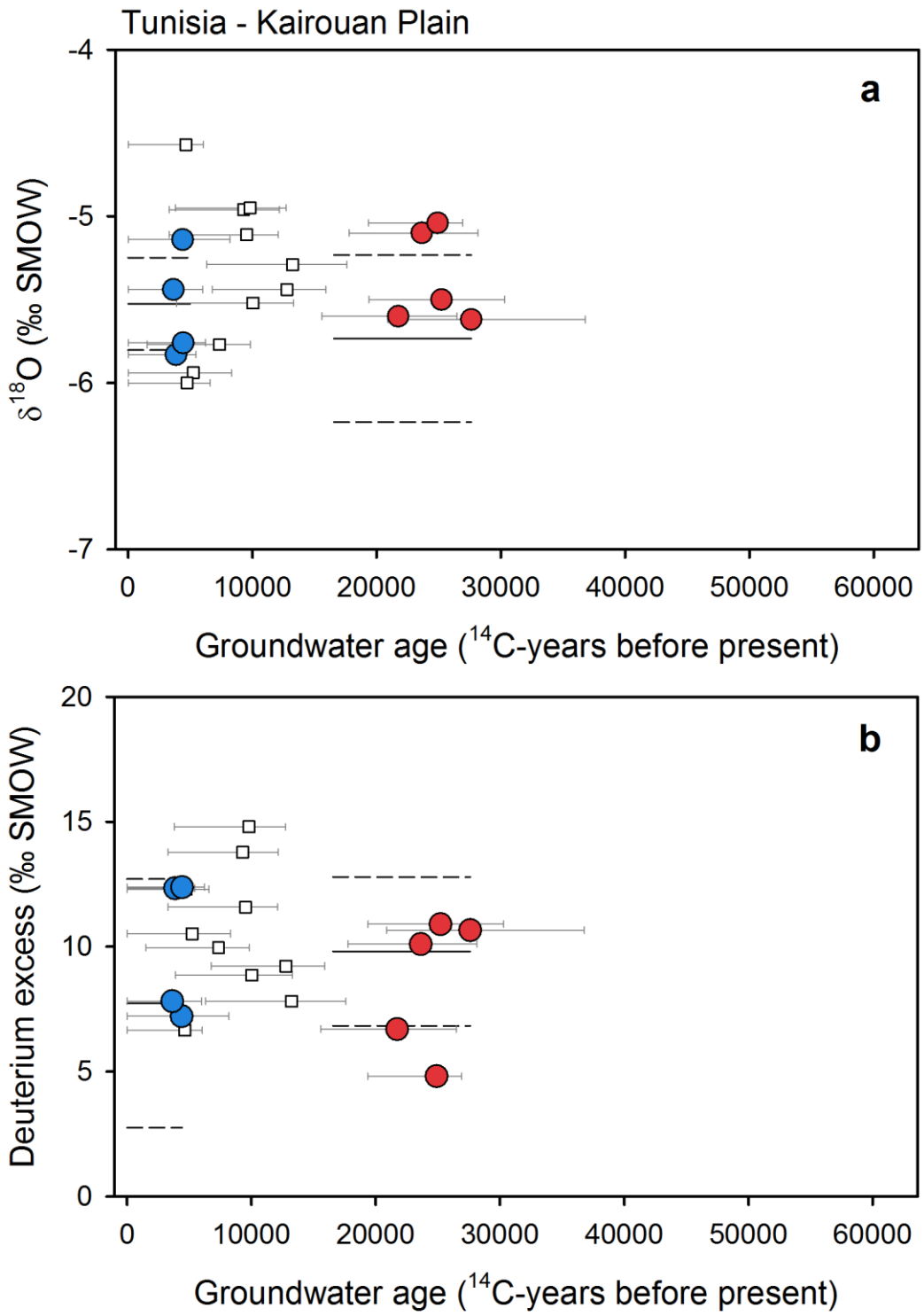

Figure S45. Groundwater isotope composition of the Kairouan Plain. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Derwich et al., 2012).

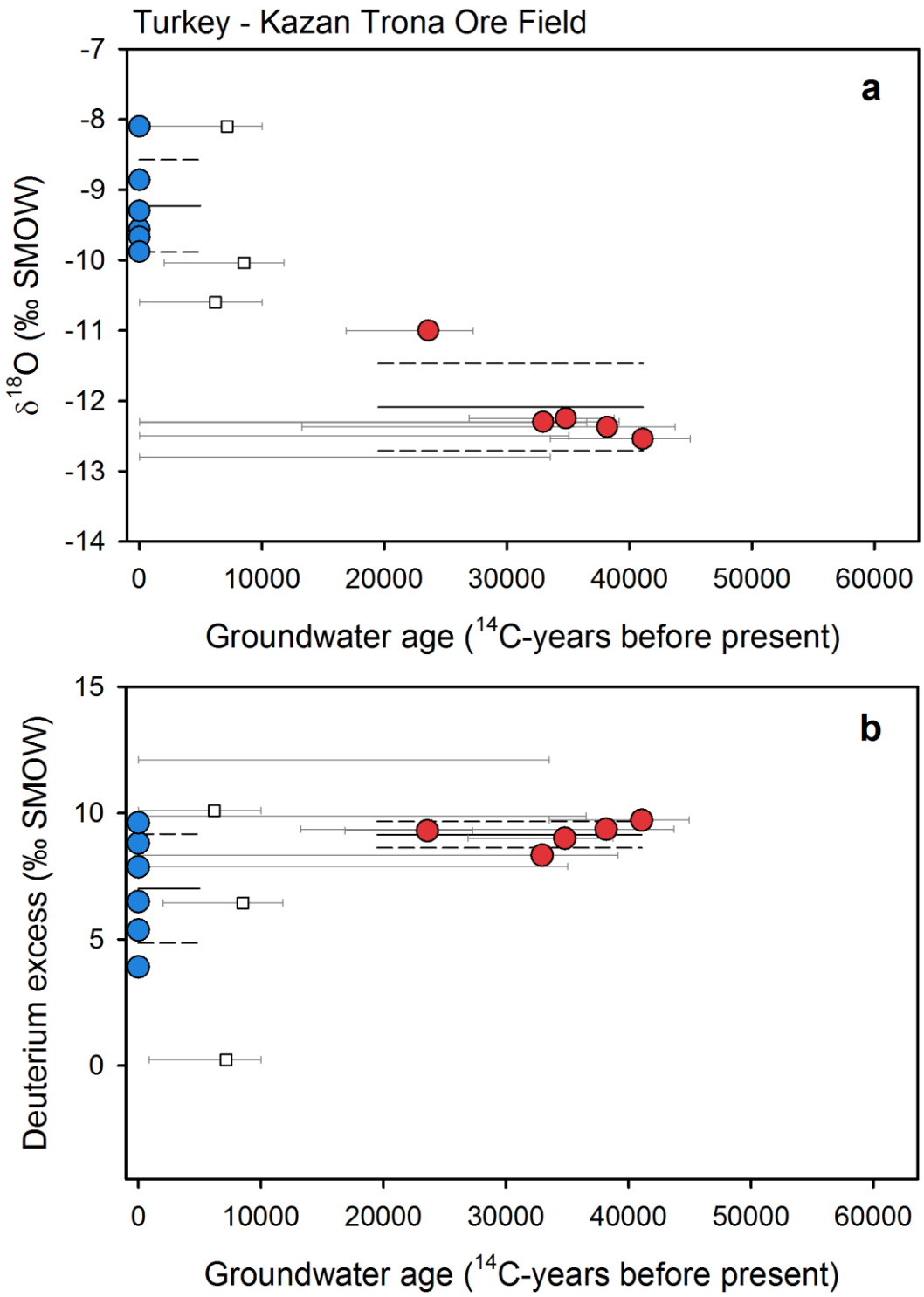

Figure S46. Groundwater isotope composition of the Kazan Trona ore field aquifer system. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Arslan et al., 2014).

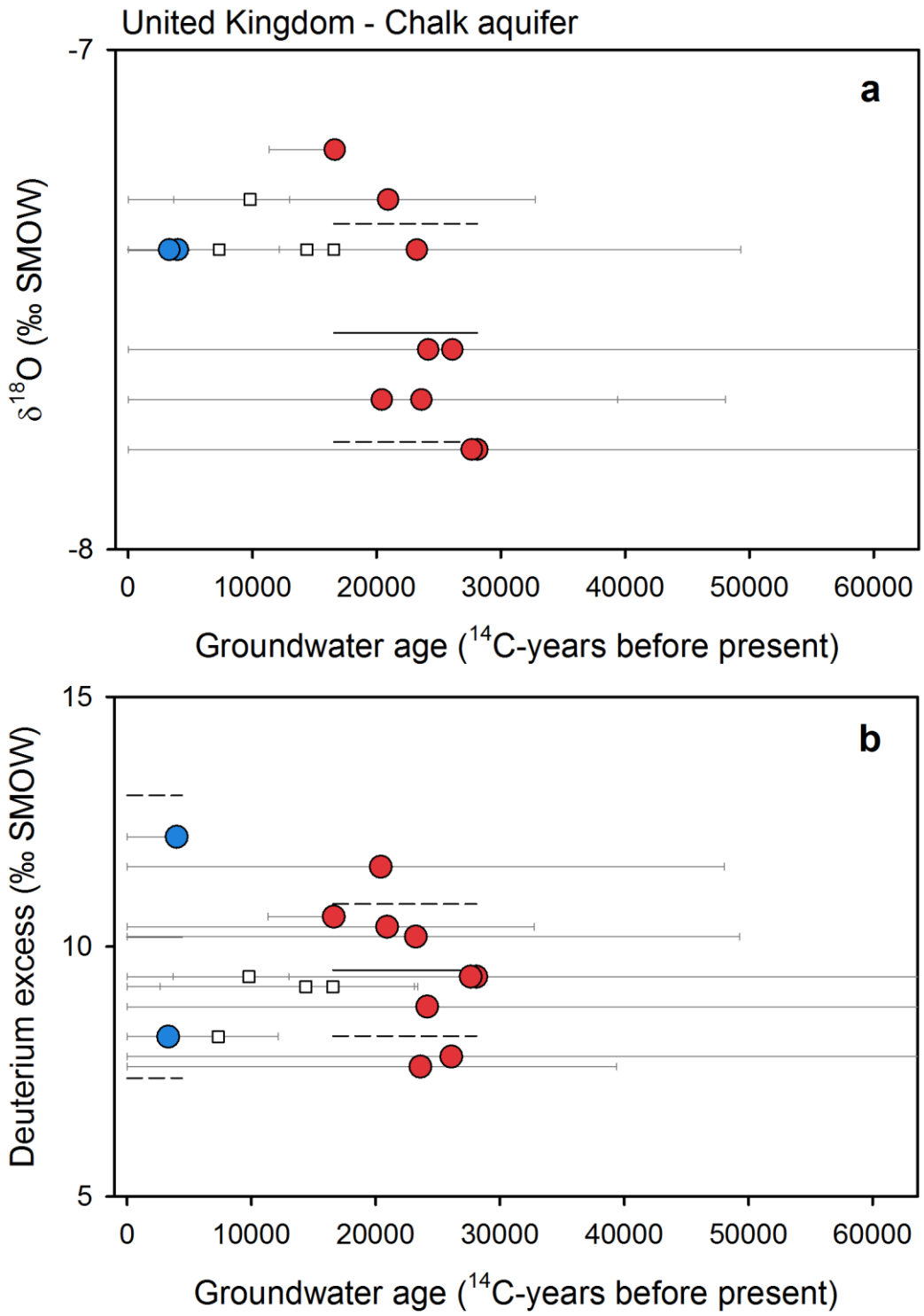

Figure S47. Groundwater isotope composition of the Chalk aquifer (in the United Kingdom). Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and 1 s.d. (dashed lines) for each group (Darling and Bath, 1988; Dennis et al., 1997; Elliot et al., 1999).

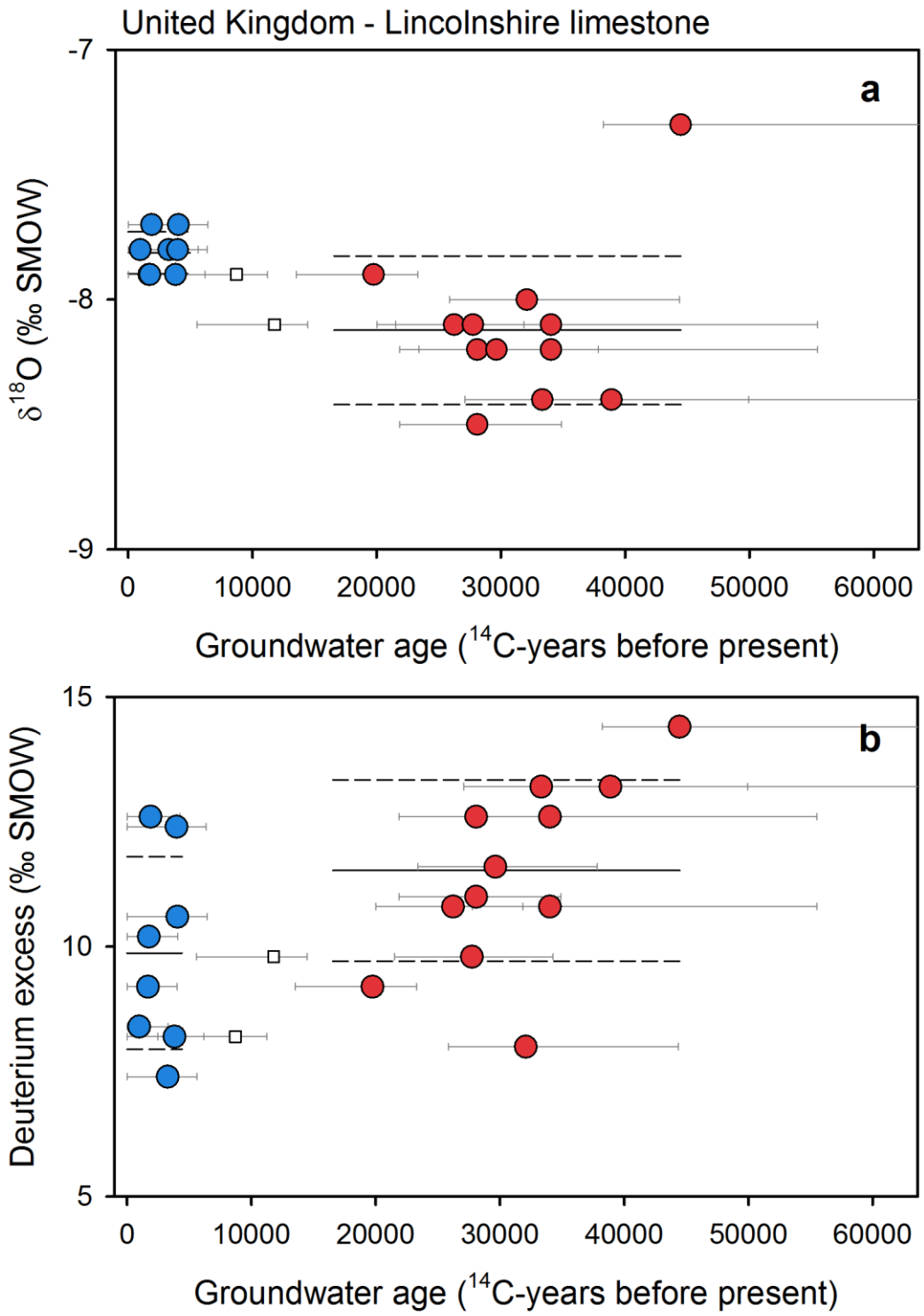

Figure S48. Groundwater isotope composition of the Lincolnshire limestone aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Darling et al., 1997).

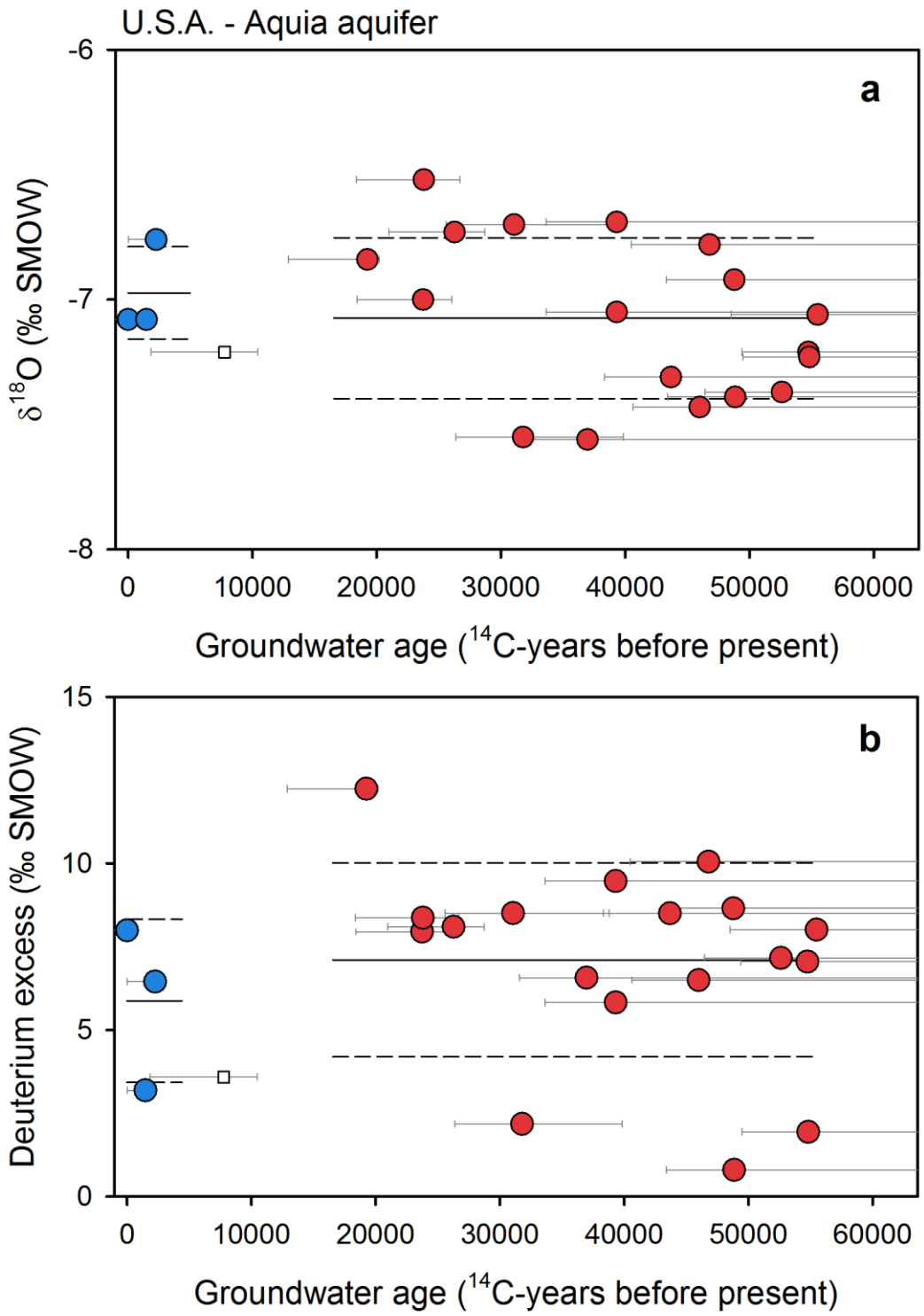

Figure S49. Groundwater isotope composition of the Aquia aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Aeschbach-Hertig et al., 2002).

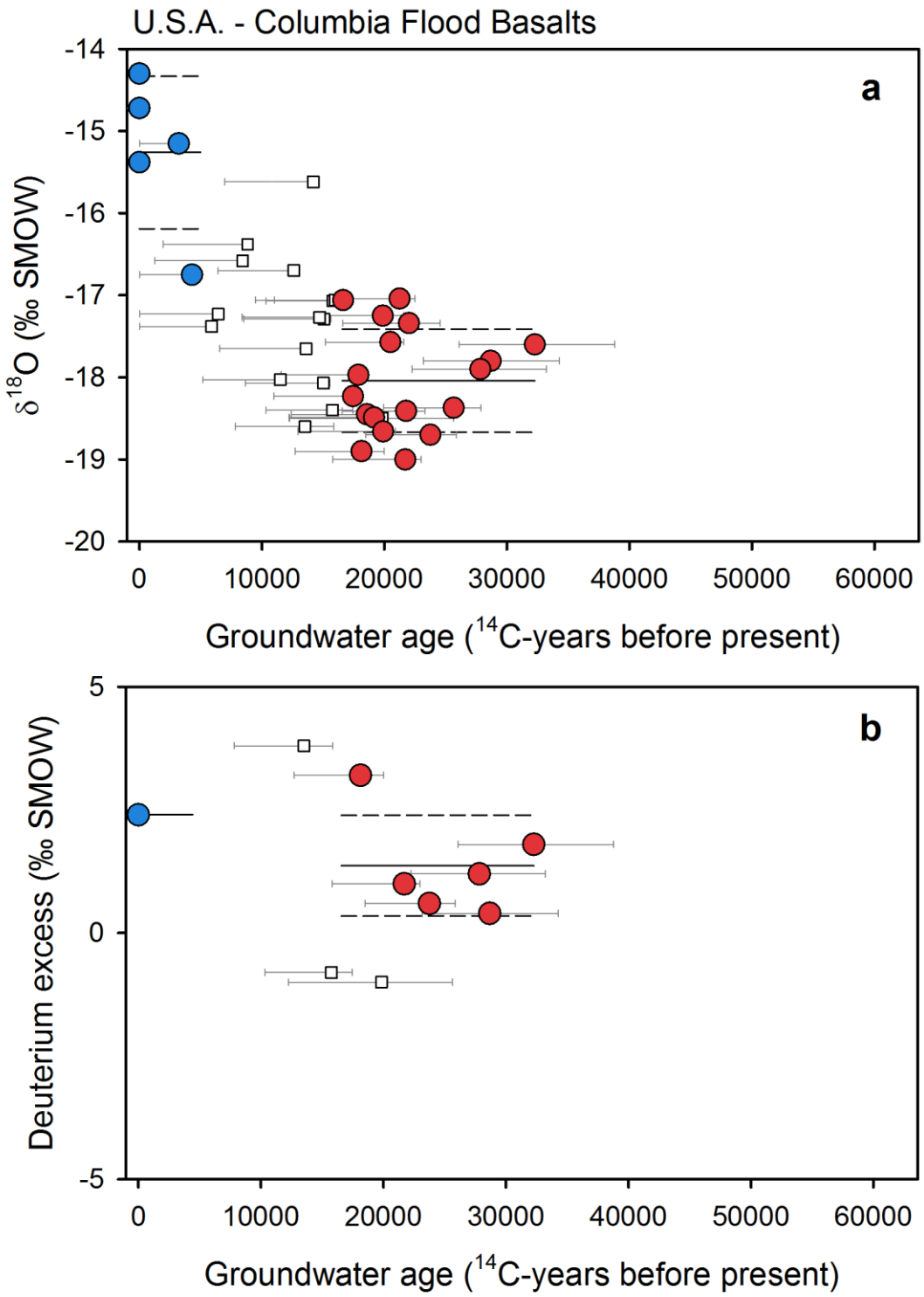

Figure S50. Groundwater isotope composition of groundwaters in the Columbia Flood Basalts. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Douglas et al., 2007; Brown et al., 2010).

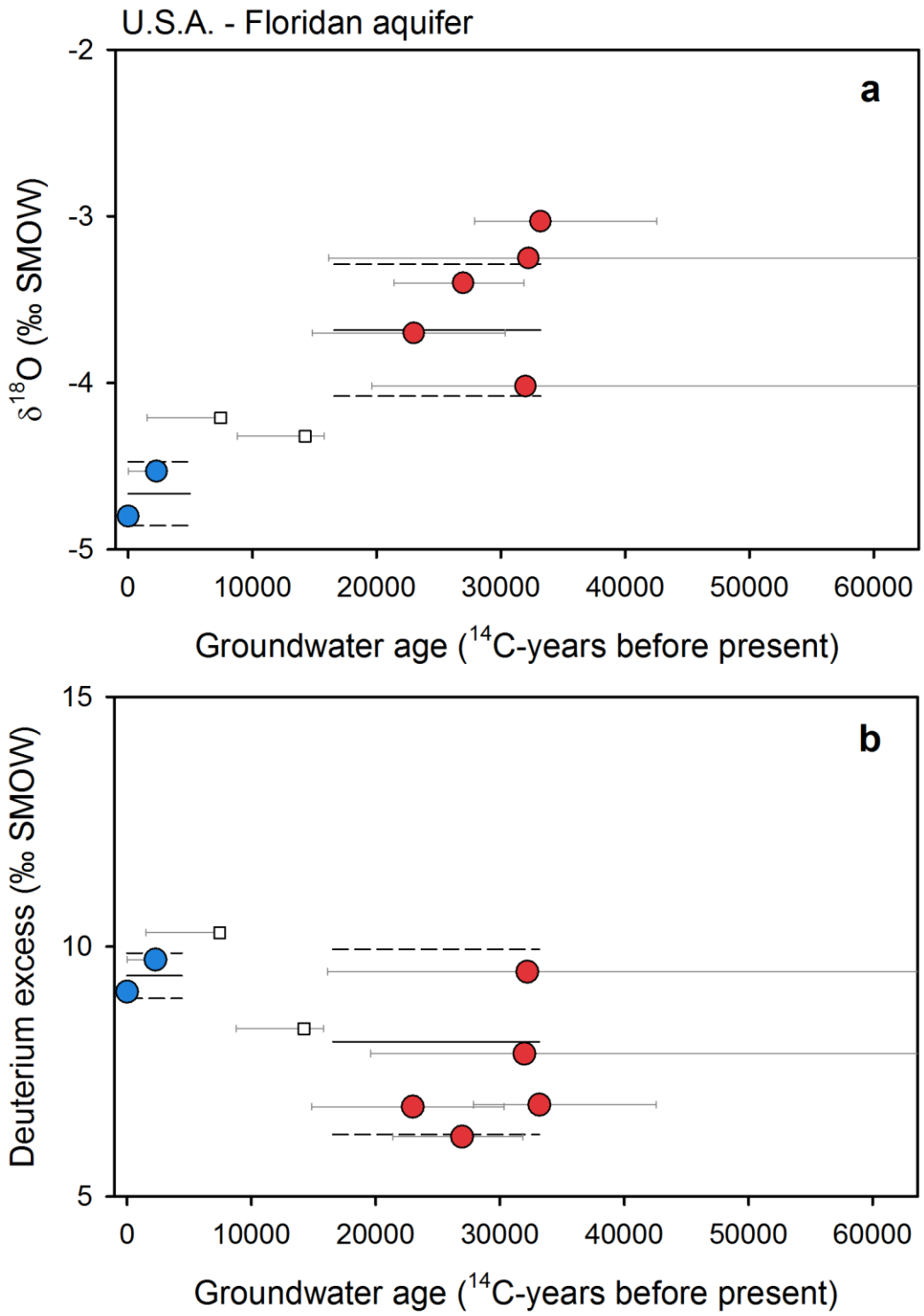

Figure S51. Groundwater isotope composition of the Floridan aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Clark et al., 1997).

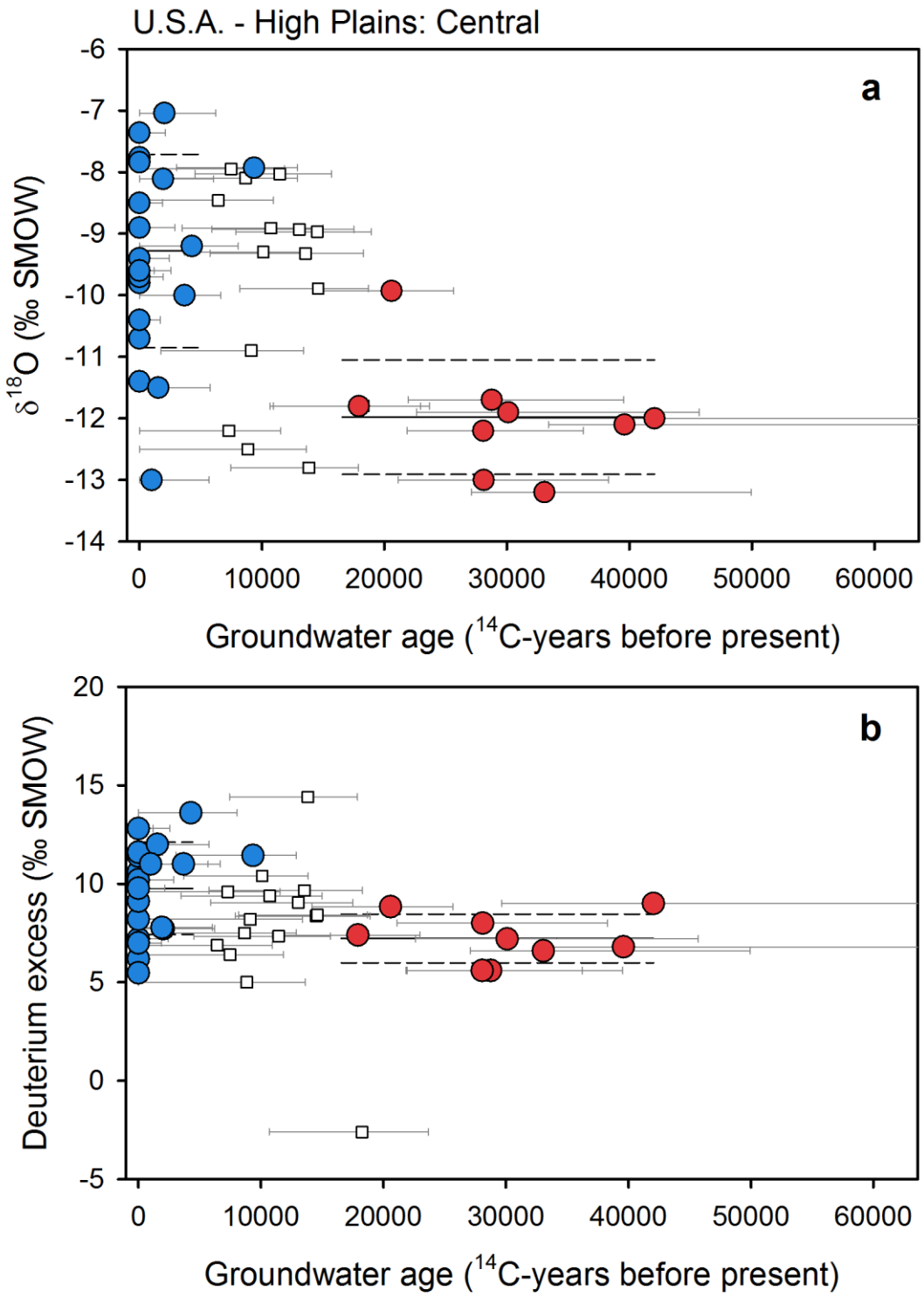

Figure S52. Groundwater isotope composition of the central High Plains aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Dutton, 1995; Clark et al. 1998).

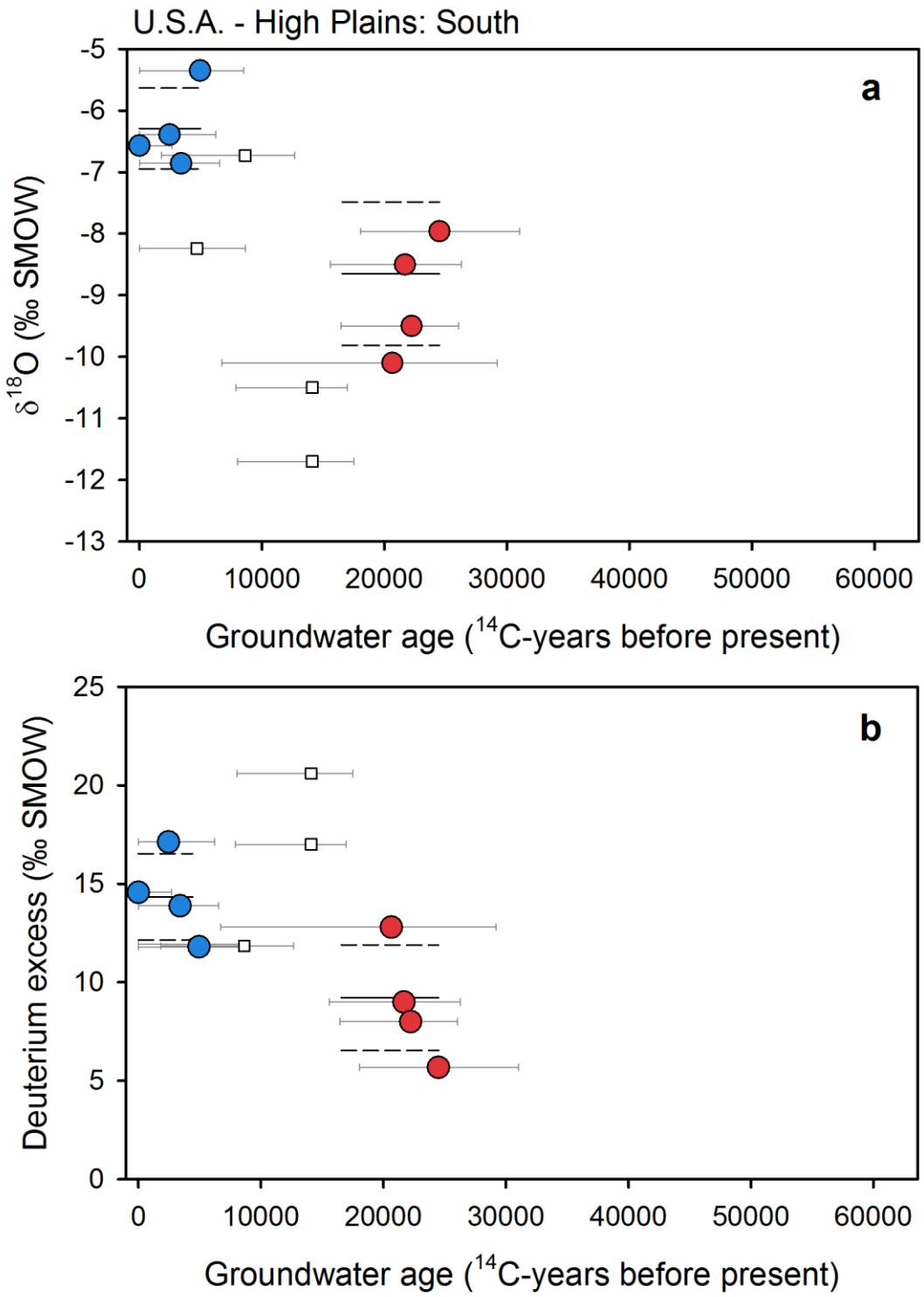

Figure S53. Groundwater isotope composition of the southern High Plains aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Dutton, 1995; Mehta et al., 2000).

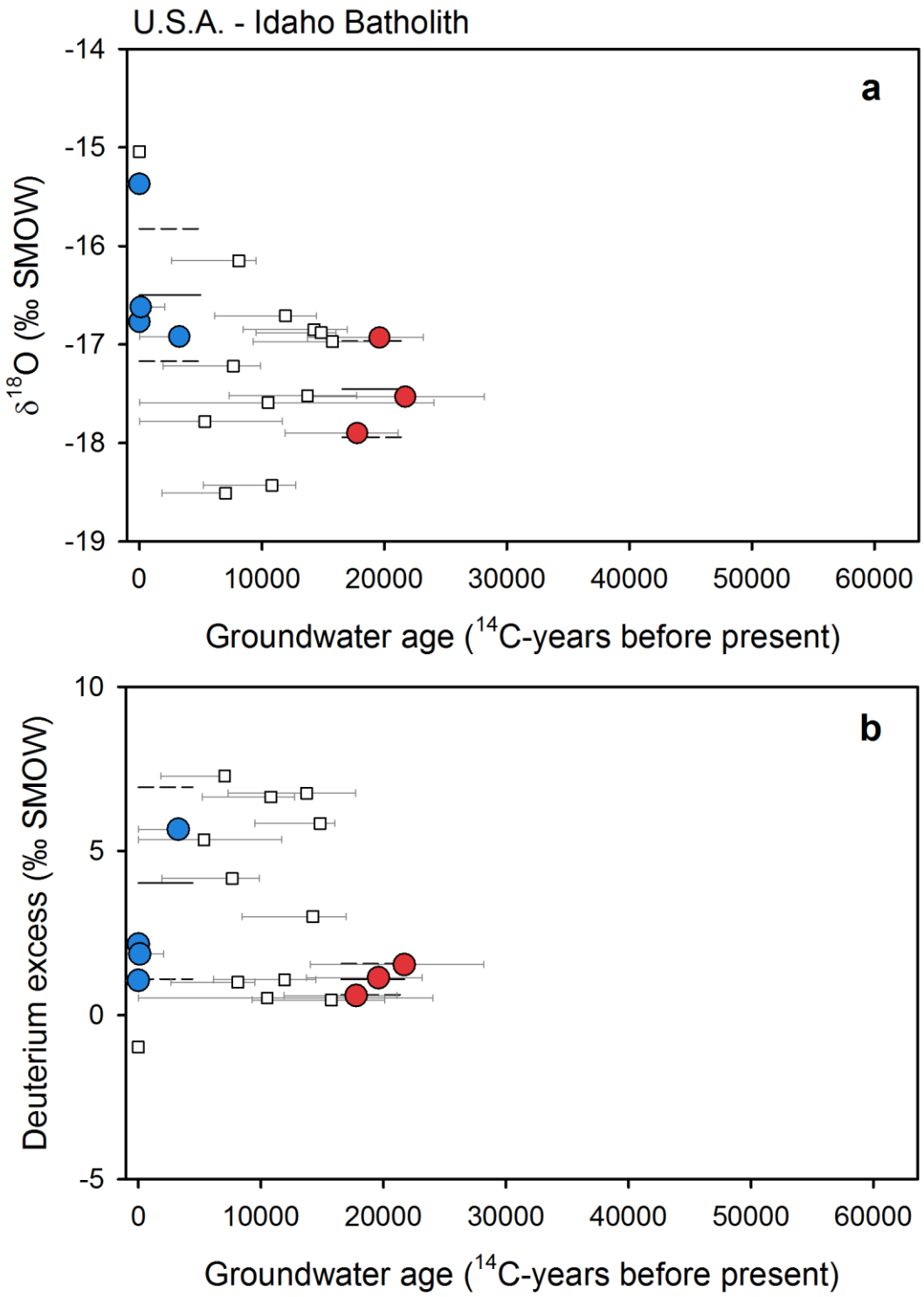

Figure S54. Groundwater isotope composition of the Idaho Batholith aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Schlegel et al., 2009).

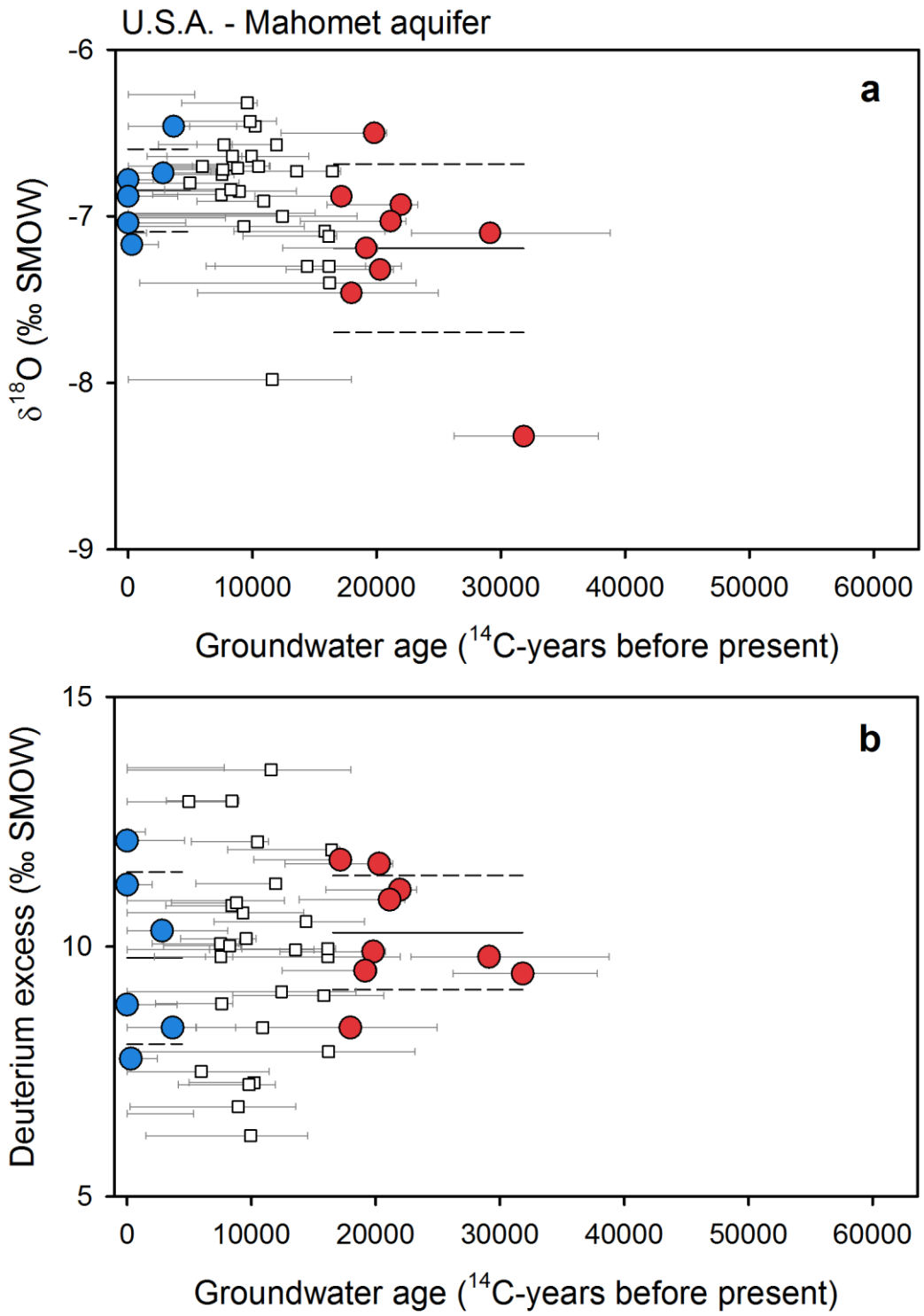

Figure S55. Groundwater isotope composition of the Mahomet aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Hackley et al., 2010).

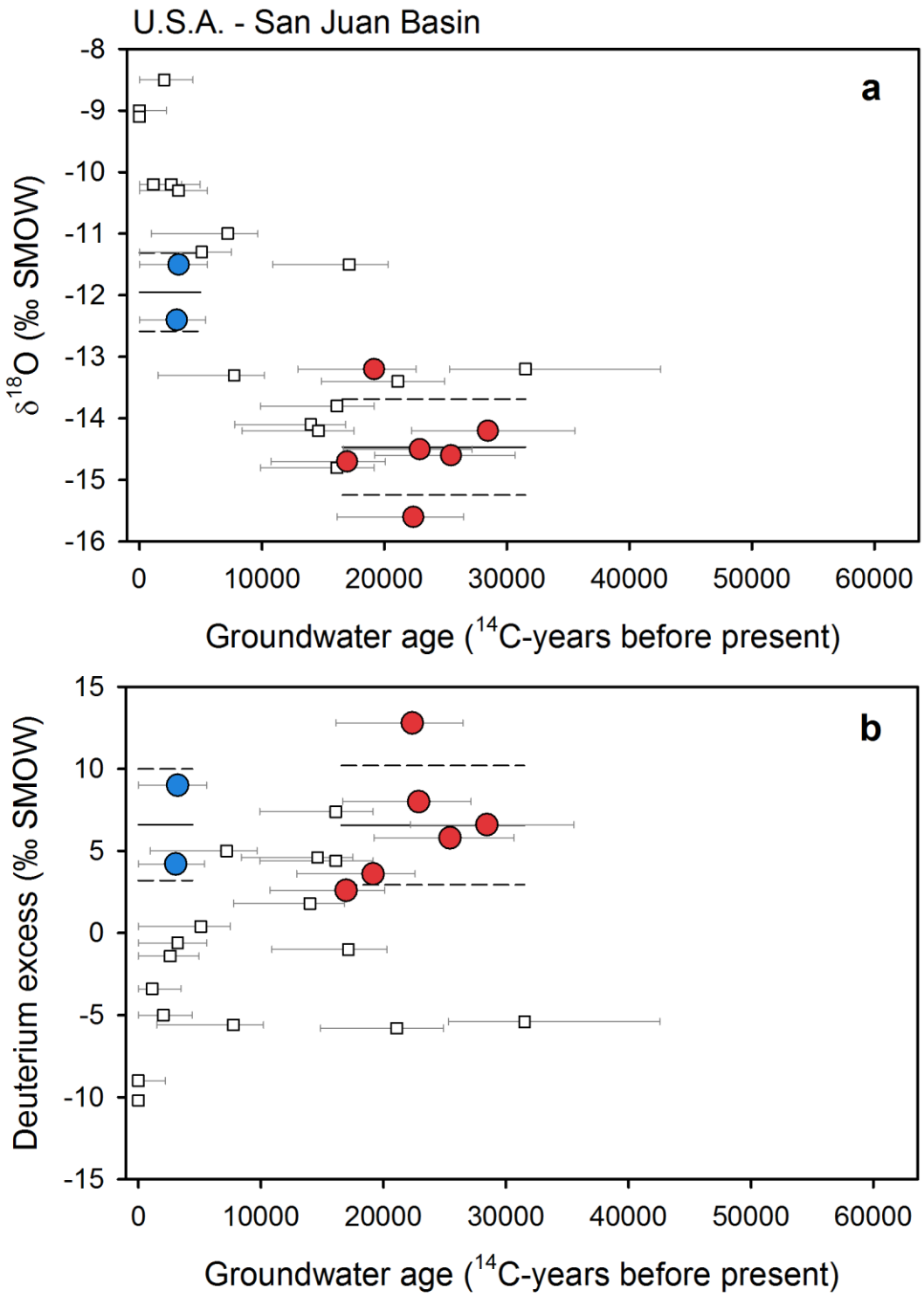

Figure S56. Groundwater isotope composition of the San Juan basin. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Phillips et al., 1986).

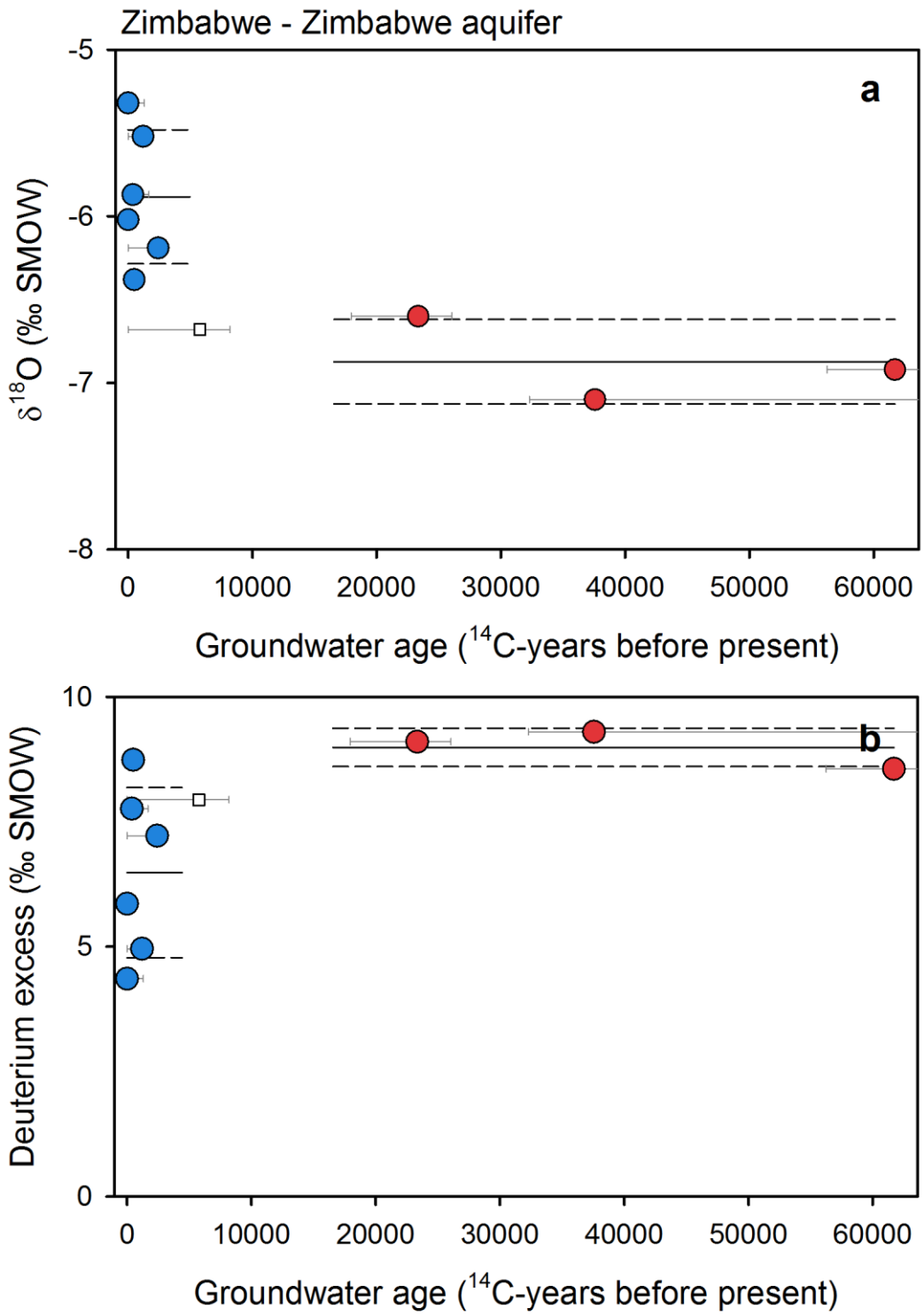

Figure S57. Groundwater isotope composition of the Zimbabwe aquifer. Groundwater $\delta^{18}O$ (a) and deuterium excess (b) plotted against corrected ^{14}C ages for late-Holocene (blue circles) and late-glacial (red circles) groundwaters. Lines mark the average (solid line) and one standard deviation (dashed lines) for each age group (Larsen et al., 2002).

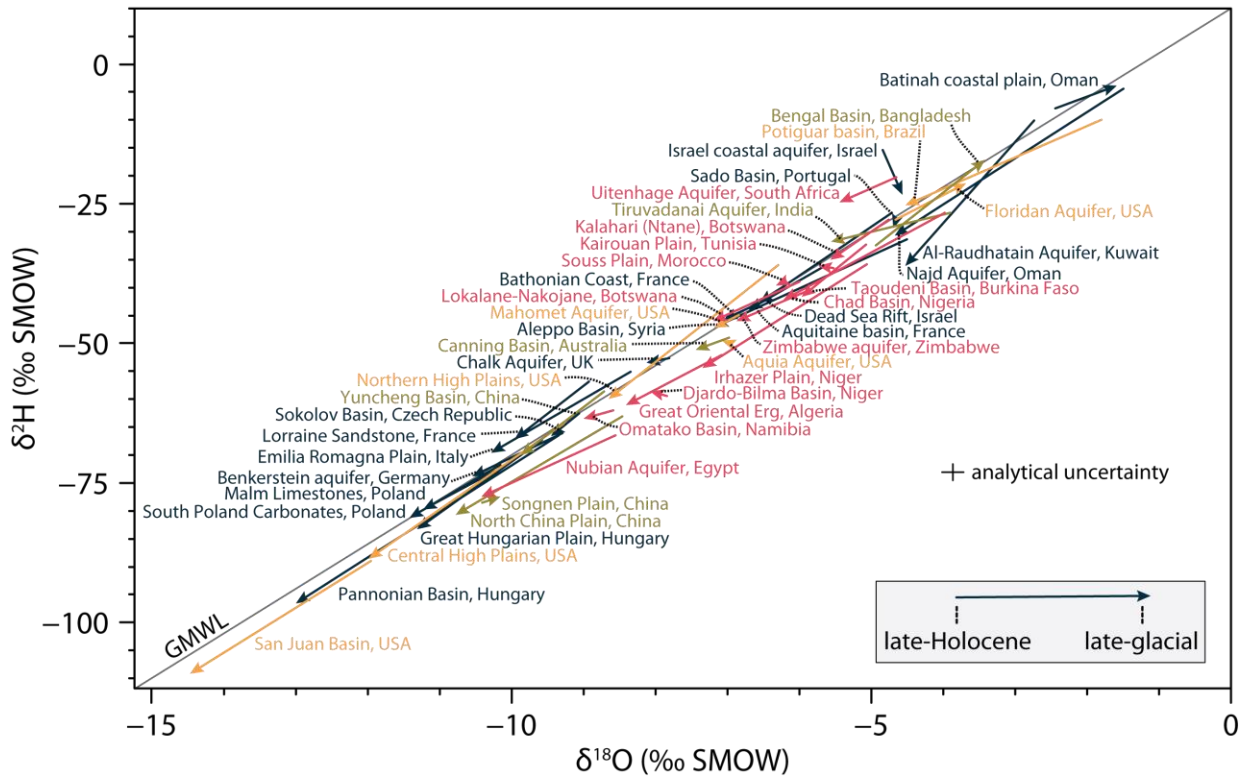

Figure S58. $\delta^{18}O$ and $\delta^{2}H$ values of late-glacial and late-Holocene groundwaters. Each arrow represents one aquifer, the arrow marks the average late-Holocene isotope composition (start of the arrow) and the average late-glacial isotope composition (end of the arrow). Each arrow is labelled (short dashed black lines). Aquifers are color coded by region: Asia, Australia and Oceania (green), Africa (red), North and South America (yellow) and Europe and the Middle East (dark blue). The global meteoric water line is shown as a dark black line (Craig, 1961). Groundwater data shown here was compiled from publications cited in Table S2.

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