Data Article

Human and faunal stable and radiogenic isotope data from four Bahraini and three Jordanian assemblages c. 5300 B.C. to 1500 AD

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\textbf{A B S T R A C T}

This dataset presents carbon, nitrogen, oxygen (carbonates and phosphates) and strontium data from human and faunal remains from that portion of seven assemblages from Jordan and Bahrain currently curated at the Smithsonian Institution’s National Museum of Natural History. Human remains from Bahraini assemblages include the Middle Islamic Period (c. 1,400-1,500 AD) cemetery associated with the Qal’at al-Bahrain fort (n=49) and the Early Dilmun City IIa-c Period (c. 2,350-1,800 BC) assemblages of Saar (n=31), Buri North (n=41) and Buri South (n=17). The Saar assemblage, at the time of sampling at the Smithsonian Institution, also included individuals recovered from isolated tombs outside the Saar mound field, with distinct alphanumeric or name designations. The Buri assemblage (also known as Hamad Town) also contained one individual labeled BE (Buri East). Assemblages from Jordan include Early Bronze Age IB (c. 3,550-3,150 BC) Bab edh Dhra (91 individuals selected of a total MNI of 274), the Iron Age IA (c. 1,250-1,100 BC) commingled cave burial assemblage from the Ba’Qa Valley (n=63), and the Late Roman (c. 200-300 AD) assemblage from Zabayar Za- hir edh-Diyab, also known as the Queen Alia International Airport assemblage (n=69). Not all individuals from whom a bone sample was taken had a suitable tooth to sample as well. A cumulative total of 13 faunal samples (bone and teeth; cattle and sheep) were also obtained from the Bahraini

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assemblages, all but two from the Bronze Age assemblages. Results in general are consistent with those from other assemblages from both locations regardless of time period, but they also complement and expand what is known about long-distance migration and dietary diversity and resilience across time within marginal desert environments (e.g., [11]; [16]; [7,8]).

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### Specifications Table

| Subject | Data Type | How | Description |
|---------|-----------|-----|-------------|
| Subject | Geochemistry and Petrology; Social Sciences; Archaeology; History | Type of data | Anthropology; Zooarchaeology; Stable and radiogenic isotope analysis; Carbon; Nitrogen; Oxygen; Strontium. |
| Specific subject area | Isotope Ratio Mass Spectrometry; Fourier Transform Raman for enamel diagenesis assessment. Carbon and nitrogen stable isotope data were obtained on a Thermo Delta V Advantage mass spectrometer coupled with an Elementar Isotope CUBE elemental analyser with a Confo IV interface. Oxygen (carbonates and phosphates) were obtained using a Thermo Delta V Advantage mass spectrometer coupled with a Thermo Gasbench II and a Thermo TC/EA mass spectrometer using a Confo IV gas interface. Strontium radiogenic isotope data were obtained via a Nu Instruments Multi-Collector ICP-MS. | How data were acquired | Raw |
| Data format | Tables, Figures | Parameters for data collection | Age and sex estimates were assessed using standard cranial and innominate criteria (adults) and dental eruption and epiphyseal union (subadults), as per White and Folkens [17], Bass [1], Brooks and Suchey [2], Lovejoy et al. [13], and Buikstra and Ubelaker [4]. Non-diagnostic long bone fragments were preferred due to an increased likelihood of collagen preservation. First molars were preferred, but when absent, second molars, third molars or anterior dentition were chosen. The amount of remaining enamel and evidence for no preservative treatment also affected tooth sampling. Regarding the EBIA Bab edh Dhra assemblage held by the Smithsonian Institution at the time of data collection, all discernible individuals present were assessed for age and sex against Ortner and Frohlich 2008, but only those with a paired bone and tooth sample available were ultimately analysed due to sample size and time and budget considerations. Summary data for numbers of samples of each type from each site is given in Table 1. A subsample of teeth from each assemblage was assessed for enamel diagenesis before proceeding with carbonate and phosphate chemistry (see below). Regarding faunal remains, eleven bone or molar enamel samples from domestic herbivores (cattle and goats) were selected from the Saar and Hamad Town assemblages and two faunal bone samples from Qal‘at al-Bahrain. Initially, all samples where photographed with labels and scales. All bone and enamel samples with adhering glue (assessed macro and microscopically using a 10x hand lens) were first subjected to several acetone washes. Dirt or staining was removed from the surface of every sample using a carbide bur attached to a Dremel hand drill, with larger calculus fragments saved in a labelled bag and dentin and enamel removed using a rotary blade attachment. Each whole bone fragment or tooth was lightly crushed in a mortar and pestle to separate individual portions for collagen, carbonates, phosphates, and strontium. Each smaller bone or enamel sample was then thoroughly pulverised in advance of wet chemistry (see below), and the mortar and pestle washed with acetone. |
| Description of data collection | (continued on next page) |
Value of the Data

- Archaeologists and historians are the main researchers who would benefit from these datasets or their contextualized analysis.
- The carbon, nitrogen and oxygen data will aid research that aims to further investigate human subsistence and water procurement in marginal desert environments over time.
- The strontium and oxygen data will aid research that aims to better understand if people or material culture, or both, moved from core to periphery along trade routes.
- The δ18Op data from the Bab edh Dhra represents the only isotopic data currently available from the EBIA shaft tomb assemblage.
- Faunal oxygen and strontium values from the Bahraini assemblages would contribute to efforts to refine local baselines. Combined δ18Omw has a mean of +3.2 ± 3.1‰, while strontium has a mean of 0.708343 ± 0.000087.

1. Data Description

This data article presents in more depth the raw data provided on the landing page (https://doi.org/10.48530/isoarch.2021.003). A description of the larger IsoArcH data management project to which this article contributes is provided in Salesse et al. [14]. Figure 1 is a map of Bahrain showing approximate site locations. Figure 2 is a map of Jordan showing approximate site locations. The IsoArcH form contains general information about each site, demographic and/or mortuary data on each individual sampled, both human and faunal, and reference to key publications discussing excavation history and any previous bioarchaeological or isotopic research. The dataset includes the isotope proxies δ13C, δ15N, δ18O and 87Sr/86Sr. Carbon and nitrogen isotope data were obtained from the organic fractions of bone and dentin and the mineral fraction of enamel. Oxygen (carbonate and phosphate) values were obtained from the mineral fraction of dentin as well as enamel, and strontium from enamel only. The Excel sheet available at the landing page essentially represents nested datasets that could be reimported into a statistical package such as SPSS. Not all individuals for whom bone was sampled also had a tooth sampled, and not all assemblages provided complete, or any, bone, or dentin collagen data (see below). Carbon and nitrogen isotope ratio data from bone and dentine collagen from Zabayir Zahir ed-Diyab (QAIA) that the author collected have been included with permission in a PhD dissertation at University of Pittsburgh [16], currently under embargo. The dissertation also includes carbon and oxygen isotope data from incremental enamel samples and bone apatite.

2. Experimental Design, Materials and Methods

A summary of the dataset according to site name, location, and time period, as well as sample numbers for bone, dentin and enamel per assemblage is provided in Tables 1 and 2. Every assemblage sampled during this research except for EBIA Bab edh Dhra was sampled in its entirety (i.e., every set of remains that could be reliably assigned to one individual and was associated with one box and one label had at least a bone sample taken; a tooth sample as well if
Fig. 1. Map of Bahrain showing approximate site locations. Courtesy of d-maps.com. Original at https://d-maps.com/carte.php?num_car=27885&lang=en.
Table 1
Summary of geographic location, chronological period and total sample size for each assemblage

| Site Reference | Site Name                  | Country   | Latitude       | Longitude      | Min Date | Max Date | Total n (bone) | Total n (tooth) |
|----------------|----------------------------|-----------|----------------|----------------|----------|----------|----------------|-----------------|
| S              | Saar                       | Bahrain   | 26° 11'48 N   | 50° 29'08 E    | 2,350 BC | 1,800 BC | 31             | 15              |
| BN             | Hamad Town North           | Bahrain   | 26° 6'46 N    | 50° 30'50 E    | 2,350 BC | 1,800 BC | 42             | 18              |
| BS             | Hamad Town South           | Bahrain   | 26° 6'46 N    | 50° 30'50 E    | 2,350 BC | 1,800 BC | 17             | 7               |
| QAB            | Qal‘at-al-Bahrain          | Bahrain   | 26° 14'01 N   | 50° 31'14 E    | 1,450 AD | 1,550 AD | 44             | 29              |
| BED            | Bab edh-Dhra               | Jordan    | 31° 25'092 N  | 35° 53'75 E    | 3,550 BC | 3,150 BC | 91             | 91              |
| BQ             | Baqah Valley Caves        | Jordan    | 31° 56'59 N   | 35° 55'58 E    | 1,250 BC | 1,100 BC | 60             | 34              |
| QAIA           | Zabayir Zahir ed-Diyab     | Jordan    | 31° 72'22 N   | 35° 98'64 E    | 200 AD   | 300 AD   | 69             | 27              |
Table 2
Statistical summary of human isotope data

| Site                        | δ13C bone Mean ± 1 S.D. | δ13C dentin Mean ± 1 S.D. | δ13C enamel Mean ± 1 S.D. | δ15N bone Mean ± 1 S.D. | δ15N dentin Mean ± 1 S.D. | δ18O bone Mean ± 1 S.D. | δ18O enamel Mean ± 1 S.D. | δ18Op enamel Mean ± 1 S.D. | 87Sr/86Sr enamel Mean ± 1 S.D. |
|-----------------------------|-------------------------|---------------------------|---------------------------|-------------------------|---------------------------|-------------------------|---------------------------|---------------------------|--------------------------------|
| Saar                        | N/A                     | N/A                       | -11.7 ± 0.3               | N/A                     | N/A                       | N/A                     | N/A                       | N/A                       | 27.6 ± 0.85                  |
| Hamad Town North            | -24.3 ± 2.76            | -20.9 ± 1.3               | -10.9 ± 1.39              | N/A                     | 7.95 ± 6.12                | 8.2 ± 6.25               | N/A                       | N/A                       | 28.5 ± 1.91                  |
| Hamad Town South            | N/A                     | N/A                       | -11.0 ± 0.8               | N/A                     | N/A                       | N/A                     | N/A                       | N/A                       | 20.7 ± 0.8                  |
| Qal‘at-al-Bahrain           | -16.6 ± 0.99            | N/A                       | -11.5 ± 1.94              | N/A                     | 13.8 ± 2.1                | N/A                     | N/A                       | N/A                       | 28.7 ± 1.9                  |
| Bab edh-Dhra                | N/A                     | N/A                       | N/A                       | N/A                     | N/A                       | N/A                     | N/A                       | N/A                       | 19.5 ± 0.64                  |
| Baqah Valley Caves          | -19.1 ± 0.9             | -19.0 ± 0.4               | -10.0 ± 2.1               | -8.9 ± 0.8              | 10.0 ± 1.5                | 8.5 ± 0.9                | 26.0 ± 6.1                | 27.8 ± 4.5                 | 19.9 ± 1.8                   |
| Zabayir Zahir ed-Diyab      | -18.4 ± 1.09            | -18.3 ± 0.5               | -11.4 ± 0.7               | -10.9 ± 0.4             | 10.7 ± 0.7                | 11.3 ± 1.1               | 29.5 ± 1.8                | 28.5 ± 1.7                 | 20.0 ± 1.1                   |

Note: N/A indicates data not available.
available and with a corresponding antimere). Eight individuals (five from Qal’at al Bahrain and three from the Baqah Valley Caves assemblage) are represented by only a tooth sample due to the high degree to fragmentation or missing elements.

A total of 184 additional skeletons of varying levels of preservation from the EBIA Bab edh Dhra assemblage currently held by the Smithsonian Institution were not sampled in this study. This was due to time, budget, and facility access considerations (especially as a visiting researcher at the University of Maryland), as well as the decision to attempt to obtain the most complete multi-proxy data possible for those individuals most able to be securely age and sex estimated and who provided paired bone/tooth samples. Time available to the project did not allow Sr values to be obtained from the enamel samples, and the $\delta^{18}$O obtained is primarily from adult individuals. Every individual with associated faunal remains was sampled. Faunal remains were located in separate small boxes within the larger box or tray containing the human skeleton that shared the same burial identification number. Most boxes of faunal remains con-

Fig. 2. Map of the Southern Levant showing approximate site locations within the modern Hashemite Kingdom of Jordan. Courtesy of d-map.com. Original from https://d-maps.com/carte.php?num_car=5408&lang=en.
tained only either bone fragments or molars suitable for sampling, but three BN/BS individuals had associated boxes of faunal remains containing both bone and enamel. However, it is not clear that storage within the same box or on the same shelf corresponds to excavation from the same mortuary context.

Regarding “wet chemistry” protocol and analytical methods, collagen extraction was performed according to a modified Longin [10] method. Samples were weighed (∼100-500mg), sonicated in ultra-pure water to remove sediments and salts, rinsed copiously, and dried (60°C). Samples were then demineralized in 0.6M hydrochloric acid at 4°C with acid changed daily until the reaction ceased. The crude collagen extract was rinsed in ultra-pure water and dried (60°C). The residue or pseudomorph was then soaked in 0.125M sodium hydroxide for 18 hours at room temperature (∼23°C) to remove humic and fulvic acids, followed by copious rinsing in ultra-pure water. The remaining collagen was denatured in 0.03M hydrochloric acid in a 95°C water bath for 18 hours. The supernatant was decanted and freeze-dried to produce a pure collagen extract. Approximately 500 μg was combusted in a Costech 4010 Elemental Analyzer coupled to the mass spec via a Confllo IV interface. Collagen was corrected against acetonilide and urea standards calibrated to USGS40 and USGS41.

Enamel diagenesis was also assessed using Fourier transform Raman spectroscopy at the Smithsonian Museum Conservation Institute. A randomly selected subsample (n=5) was chosen from each assemblage and evaluated for carbonate and phosphate integrity using methods detailed in Thomas et al. [15]. Structural carbonates were extracted from hydroxyapatite using modified methods of Bryant et al. [3]. Initially, approximately 20-35mg of powder was weighed out. Organic material was removed by soaking the powder in 2-3% sodium hypochlorite for 18 hours at room temperature (∼23°C). The supernatant was discarded, and samples were rinsed copiously in ultra-pure water and dried (60°C). Secondary carbonates potentially deposited during burial were removed by soaking in 1M acetic acid buffered with 1M calcium acetate for exactly 4hrs. Samples were rinsed and dried (60°C). Approximately 5mg was acidified in concentrated phosphoric acid (SC-1.92) for 24 hours at 25°C before running samples via a GC Pal and Gasbench II interface. Carbonates were corrected against LSVEC and NBS-19 carbonates.

Phosphate extraction from hydroxyapatite was carried out as per Dettman et al. [5]. Approximately 10-20mg of powdered enamel sample was weighed out. Phosphate ions were liberated by soaking powder in 2M hydrofluoric acid for 18 hours at room temperature (∼23°C). The supernatant was diluted, isolated, and buffered with 20% ammonium hydroxide. Addition of 2M silver nitrate solution facilitated the precipitation of silver phosphate. The silver phosphate was isolated, rinsed in ultra-pure water, and dried (60°C). Oxygen values were converted from carbonates to phosphates using the enamel-specific equation in France and Owsley [6], and from phosphates to meteoric water using equations in Longinelli et al. [12] for human samples and Kohn [9] for faunal. Approximately 600 μg were thermally decomposed on a Thermo Temperature Conversion Elemental Analyzer connected via a Confllo IV. The data were corrected against USGS34 and USGS35 nitrates.

To prepare for strontium column chemistry, powdered enamel and bone samples were run through the structural carbonate extraction chemistry above to remove secondary carbonate and secondary strontium. Approximately 10-20 mg was digested overnight in a 1:5 solution of 30% hydrogen peroxide and concentrated nitric acid, where the former was added 10 minutes prior to the latter to instigate reaction. The solution was transferred to a Teflon beaker and dried on a hotplate. Syringe columns (1 mL volume) filled with Eichrom Sr-spec resin (100-150 μm mesh) were conditioned with three 400 μL rinses of 3M nitric acid. Dried sample residues were reconstituted in 200 μL of 3M nitric acid and loaded on the columns. Calcium, rubidium, and rare earth elements were eluted and discarded using sequential rinses of 3M nitric acid (200 μL), 7M nitric acid (600 μL), and 3M nitric acid (100 μL). Strontium was collected with four aliquots (200 μL each) of 0.05M nitric acid. The collected solution was dried and reconstituted in 4 mL of 2% nitric acid, with subsequent dilutions of 2% nitric acid added as needed. NBS987 (Sr carbonate), NBS 1486 (bone meal), and an in-house Sr reference solution (UMd-1) were included in each batch at 50ppb (average ca. 4V of total Sr signal).
Masses at 84, 85, 86, 87 and 88 were measured in alternate L3-H4 Faraday cups. Three blocks of data were gathered per analysis, with 10 measurements per block, each 10 seconds. Potential interferences from $^{84}\text{Kr}$ and $^{86}\text{Kr}$ on $^{84}\text{Sr}$ and $^{86}\text{Sr}$ were determined by measuring these masses whilst aspirating pure nitric acid. Instrument fractionation was accounted for by the measurement of $^{88}\text{Sr}/^{86}\text{Sr}$ and correcting assuming a true value of 8.3786. Measurement at mass 85 allowed a correction for the potential interference of $^{87}\text{Rb}$ on $^{87}\text{Sr}$ by assuming a natural ratio of rubidium isotopes. The mean $^{87}\text{Sr}/^{86}\text{Sr}$ value over 10 months of analysis for NBS 987 was 0.71050 (certified value 0.71034), and for NBS 1486 was 0.70950 (literature value [GeoRem] 0.70931) Standard error for NBS 987 over 10 months was 78ppm. The literature difference in the $^{87}\text{Sr}/^{86}\text{Sr}$ value between the two reference materials (0.00103) is close to that determined in these analyses (0.00100) with a correction to the raw data made.

**Ethics Statement**

The data presented above was obtained from human and faunal remains of deceased individuals from archaeological excavations or salvage projects carried out in Bahrain and Jordan. The remains sampled are currently housed at the Smithsonian Institution, Department of Anthropology, National Museum of Natural History as permanent loans with original permission for this arrangement given by the Departments of Antiquities, Kingdom of Bahrain and Hashemite Kingdom of Jordan. No permits were seen or made available to the author either while applying for the Postdoctoral Fellowship under which this research was conducted, nor after commencing work, nor after departure. However, the sampling plan (including assemblages selected, categories of isotopic data sought, and permission for destructive analyses) was drafted in conjunction with the project’s advisors and approved by the selection committee. No living human subject data, animal experiment data, or data from social media platforms is presented.

**CRediT Author Statement**

**Damien Huffer:** Conceptualization, Methodology, Data Curation, Writing – original draft, Writing - review & editing.

**Declaration of Competing Interest**

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The author declares that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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