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The bitumen imports at Tell Abraq — tracing the second-millennium BC bitumen industry in south-east Arabia

THOMAS VAN DE VELDE, PETER MAGEE & FREDERIC LYNEN

Summary
Bitumen was widely traded throughout the Arabian Gulf in prehistory and its movement in the Neolithic and Early Bronze Age is well studied. This article presents the results of new geochemical work conducted on bitumen from the mid-second millennium BC at Tell Abraq (Emirate of Sharjah, UAE) to determine the geological origin of the samples. This study uses Stable Carbon Isotope Analysis ($\delta^{13}C$) on the asphaltenes fraction and Gas Chromatography-Mass Spectrometry (GC-MS) on the saturated hydrocarbon fraction.

The Tell Abraq dataset offers a unique opportunity to understand trade and interaction as no bitumen from this period in south-eastern Arabia has ever been investigated. The mid-second millennium BC is one of immense change in the region. It is widely considered that south-eastern Arabia was disengaged from major economic interactions in the Arabian Gulf while Kassite influence in the central Gulf had drawn Bahrain (ancient Dilmun) into closer economic and political ties with Mesopotamia. The identification of Iranian bitumen at Tell Abraq illustrates that the situation in south-eastern Arabia was more complex than previously thought.

Keywords: Tell Abraq, bitumen, GC-MS, isotope analysis, Late Bronze Age

Introduction
Tell Abraq (Tall Abraq) is in the northern United Arab Emirates on the Arabian Gulf coast, on the border between the Emirates of Sharjah and Umm al-Quwain (Fig. 1). Our excavations at this key site have focused only on those areas contained within the Sharjah boundary limits. Before excavations began, the areas to be investigated were based on the results of previous excavations (Potts 1990; 1991; 1993; 2000) and the topography of the mound. In these areas, the most important deposits relevant to our research questions were located, that is, those that date between c.2000 and 500 BC.

Within this time frame, including Wadi Suq, Late Bronze Age and Iron Age I periods (c.2000 to 1100 BC), there is a contested understanding of chronology and material culture (Magee 1996; Magee & Carter 1999; Velde 2003). Previous excavations at Tell Abraq and Shimal in Ras al-Khaimah defined the Late Bronze Age and Iron Age I periods (Magee 1996; Velde 2003), but these excavations lacked $^{14}C$ dates. This lack of supportive chronological data is important because it is within this period that settlement appears to decline throughout south-eastern Arabia. Although some scholars have attributed this decline to the cessation of the copper trade in the Arabian Gulf (Cleuziou 1981; Edens 1992), the original excavations at Tell Abraq and subsequent research at K4 at Kalbā (Carter 1997) on the east coast of the Emirate of Sharjah indicated that large settlements were still occupied during these centuries. It is also clear that imported ceramics continued to form an integral part of the material culture and therefore that the inhabitants continued to engage economically with their neighbours throughout the Arabian Gulf and beyond. Our knowledge of this trade exists, although textual sources do not provide any details of this trade or even mention the toponym ‘Magan’, which earlier referred to south-eastern Arabia. Our excavations at Tell Abraq aim at further investigating this economic interaction by quantitatively assessing the artefactual record and conducting geochemical analysis to determine the origin of ceramics and other materials.

Although this work is still in progress, we are aware that ceramics were only one traded item. Indeed, ceramics, particularly plain wares, were most likely traded because of their contents rather than as vessels per se. One such material was bitumen, on which this paper focuses. Geochemical analyses provide the opportunity to assess the origins of this important material. In this paper we present the provisional analysis and results of this ongoing work.
Figure 1. A map showing the location of archaeological sites and bitumen seepages mentioned in the text.

![Map of archaeological sites and bitumen seepages](image)

<table>
<thead>
<tr>
<th>Bitumen ID</th>
<th>TA ID</th>
<th>Subnr</th>
<th>Locus</th>
<th>Remarks</th>
<th>Chronological comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA01</td>
<td>15024</td>
<td>1</td>
<td>6278</td>
<td></td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA02</td>
<td>15191</td>
<td>1</td>
<td>6362</td>
<td></td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA03</td>
<td>13337</td>
<td>0</td>
<td>5647</td>
<td></td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA04</td>
<td>13177</td>
<td>0</td>
<td>5549</td>
<td>Two date stone imprints, shell, and barnacle inclusions</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA05</td>
<td>15083</td>
<td>0</td>
<td>6302</td>
<td>Vegetal imprints visible, possible date stone imprint</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA06</td>
<td>15078</td>
<td>0</td>
<td>6302</td>
<td>Body sherd with bitumen on its exterior</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA07</td>
<td>15240</td>
<td>0</td>
<td>6362</td>
<td></td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA08</td>
<td>13521</td>
<td>0</td>
<td>5732</td>
<td></td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA09</td>
<td>15087</td>
<td>0</td>
<td>6302</td>
<td>Shell fragments visible</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA10</td>
<td>13287</td>
<td>0</td>
<td>5628</td>
<td>Tiny shell fragments visible</td>
<td>disturbed</td>
</tr>
<tr>
<td>TA11</td>
<td>15086</td>
<td>0</td>
<td>6302</td>
<td>Vegetal imprint visible</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA12</td>
<td>13336</td>
<td>0</td>
<td>5647</td>
<td></td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA13</td>
<td>11224</td>
<td>1001</td>
<td>5112</td>
<td>Mesopotamian body sherd with bitumen on its exterior</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA14</td>
<td>11181</td>
<td>1014</td>
<td>5095</td>
<td>Rim sherd with bitumen on its interior</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA15</td>
<td>12414</td>
<td>1007</td>
<td>5422</td>
<td>Mesopotamian body sherd with bitumen on its interior</td>
<td>2000–1500 BC</td>
</tr>
<tr>
<td>TA16</td>
<td>1011</td>
<td>6278</td>
<td>Mesopotamian storage jar rim with bitumen on its interior</td>
<td>1500–1100 BC</td>
<td></td>
</tr>
<tr>
<td>TA17</td>
<td>14225</td>
<td>1</td>
<td>6062</td>
<td>Body sherd with bitumen, shell inclusions</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA18</td>
<td>13437</td>
<td>0</td>
<td>5721</td>
<td>Shell inclusions and barnacles visible</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA19</td>
<td>14095</td>
<td>1007</td>
<td>5974</td>
<td>Mesopotamian body sherd with bitumen covering its interior</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA20</td>
<td>13444</td>
<td>0</td>
<td>5695</td>
<td>Body sherd with bitumen on its interior</td>
<td>1500–1100 BC</td>
</tr>
<tr>
<td>TA21</td>
<td>1001</td>
<td>6416</td>
<td></td>
<td>Rim sherd with bitumen on interior, exterior and upper rim</td>
<td>1500–500 BC</td>
</tr>
</tbody>
</table>

Figure 2. Bitumen samples from Tell Abraq. Bitumen ID is the identification code given to samples for this specific research; the TA ID (Tell Abraq ID), Subnr and Locus correspond to the Tell Abraq database. Any noteworthy remarks concerning the samples are also given.
Archaeological samples

Bitumen samples have been taken from various deposits in our current excavations. One of the priorities was sampling the bitumen present on several pottery fragments of both imported Mesopotamian and locally made pottery of the Late Bronze Age. Nine such samples have been analysed and, additionally, twelve other samples were selected based on their context and the number of bitumen finds in a locus. Additionally, preference was given to bitumen samples available in large quantity, thus avoiding having to use the entire sample for analysis. Any samples with noteworthy features have been photographed and documented in the catalogue (Figs 2 & 3).

Figure 3. These photographs show some of the more extraordinary samples in the dataset. Samples TA13, 14, 16, and 21 all represent pottery from which bitumen was scraped for analysis. Samples TA13 and TA16 were recovered from imported Mesopotamian pottery, whereas the vessels from which samples TA14 and TA21 were retrieved represent indigenous pottery. Sample TA04 is a lump of bitumen on which barnacles are visible, indicating the use of bitumen in a marine context. Cuneiform, anthropological, and archaeological evidence has indicated the use of this specific material for the caulking of boats to waterproof the hulls. Similar bitumen samples were retrieved from Ra‘s al-Jinz/RJ2 and H3/al-Sabiyah (Connan et al. 2005).
Methodology

The methods used to fingerprint archaeological bitumen have been tried and developed by J. Connan and A. Nissenbaum (Nissenbaum et al. 1984; Rullkötter & Nissenbaum 1988; Rullkötter, Spiro & Nissenbaum 1985; Connan 1999; Connan & Deschesne 1992a; 1996).

The analytical protocols used in the present research were built on the principles and techniques that have been used in the past with high accuracy and great success (Van de Velde, forthcoming, a; forthcoming, b; 2016; Van de Velde & Bodé, forthcoming; Van de Velde et al. 2015).

Bitumen consists of several complex mixtures of molecules, some of which hold information concerning its geological origin. To select archaeological samples, two different techniques exist, each developed for a specific chemical fraction (Fig. 4). The first fraction containing information on the source of the bitumen is the asphaltenes. These can be defined as the heaviest components of petroleum fluids that are insoluble in light n-alkanes (e.g. hexane) but soluble in organic compounds (e.g. dichloromethane). Carbon Isotope Analysis (expressed as $\delta^{13}C$) of this fraction reveals information on the geological origin of the sample. The second technique makes use of biomarkers. These are, in essence, molecular fossils — complex organic compounds derived from the original organic material the bitumen is formed from, which have a certain specificity for geological origin. These biomarkers are generally analysed using gas chromatography/mass spectrometry. Identification of compounds is achieved by employing SIM mode (Selective Ion Monitoring), specifically the mass to charge ratio 191 (m/z 191) that is useful when identifying biomarkers in bitumen samples for the purpose of sourcing the material (see Fig. 7).

Generally, archaeological bitumen is a mixture consisting of pure bitumen to which a temper (most commonly sand) is added. Prior to analysis, the organic content — the bitumen — needs to be isolated from its matrix. To achieve this, a sample was crushed and solvent extraction was used ($\text{CH}_2\text{Cl}_2$: methanol, 4:5 ratio). This was done either automatically, by employing an Accelerated Solvent Extractor ( Dionex ASE 350), or manually. In the latter case, a solvent was added to the sample, which was put in an ultrasonic bath (for 10 to 20 minutes) after which the sample was put in a centrifuge prior to recuperation of the liquid fraction holding the dissolved bitumen.

For asphaltenes isolation, the obtained solution was dried initially by using a rotovapor followed by nitrogen blowing. Hexane was added to the sample and the liquid fraction removed, leaving the asphaltenes. This operation was repeated several times to be sure that no coprecipitated molecules were trapped in the asphaltenes fraction. Standard column chromatography was used for the separation of chemical fractions prior to GC-MS analysis as described by Peters, Walters and Moldowan (2005). A column packed with silica and pentane — $\text{CH}_2\text{Cl}_2$ (3:1) — was used as a solvent. The eluted fraction was recovered and used for GC-MS analysis.

For the GC-MS analysis, a Hewlett Packard 6890–5973 GC-MS system equipped with an Agilent Technologies HP-5MS column (30 m x 0.25 mm ID, 0.25 µm) was used with helium as a carrier gas with a gas flow of 1.5 ml/min. One microlitre of the saturated hydrocarbon fraction dissolved in $\text{CH}_2\text{Cl}_2$ was injected (in split-less mode). The oven temperature was increased gradually from 40° to 250°C at 6°C per minute, and from 250° to 300°C at 2°C per minute.

The carbon isotopic composition of the asphaltene fraction was determined using an elemental analyser (ANCA-SL, PDZ Europa, UK), coupled to an isotope ratio mass spectroscope (IRMS Sercon 20–22). The isotopic composition of natural samples (i.e. not synthetic isotopic enrichment) was reported relative to an international reference, using the so-called ‘$\delta$’ scale typically expressed in ‰.

$$\delta^{13}C = \frac{\left[\frac{^{13}C}{^{12}C}\right]_{\text{sample}} - \left[\frac{^{13}C}{^{12}C}\right]_{\text{VPDB}}}{\left[\frac{^{13}C}{^{12}C}\right]_{\text{VPDB}}}$$

**Figure 4.** A flowchart of the sample preparation and analysis.
For C the international reference was Vienna Pee Dee Belemnite (VPDB), which had a carbon isotopic ratio $\delta^{13}C$ of 0.0111802 ($\pm$ 0.0000028).

### Analytical results

Specific chemical compounds from the m/z 191 terpane fingerprint obtained by GC-MS analysis were identified and quantified (see Figs 7 & 9). The compounds that were targeted specifically are 18α(H),21β(H)-22,29,30-trisnorhopane (code: Ts), 7α(H),21β(H)-22,29,30-trisnorhopane (code: Tm), 17α(H),21β(H)-hopane (code: C30αβ-hopane or C30), 22R-17α(H),21β(H)-30-homohopane (code: 31R) and Gammacerane (code: GCRN).

Considering the organic nature of bitumen samples, it is an extremely complex task to produce results based on quantities of individual molecules; molecular ratios are therefore used which provide far more reliable results, the most relevant of which are Ts/Tm and Gammacerane/C30αβ-hopane. These, in combination with the values retrieved from EA-IRMS analysis, allow the origin of the archaeological samples to be identified. Several samples were discarded from the dataset because the too low quantities of samples led to unreliable results. No reliable molecular fingerprint could therefore be obtained for samples TA15, 17, and 19 due to weathering, while no isotopic values were measured for samples 14, 20, and 21 due to limited sample size. When looking at the isolated dataset (Fig. 6), most samples show a similar Ts/Tm ratio, whereas their $\delta^{13}C$ seems to differ quite visibly. Two clusters may be identified in this: a first cluster (Group A) of three samples (TA3, TA4, and TA5) exhibiting a lower $\delta^{13}C$ ($<-27.5$) and a larger cluster (Group B) containing higher $\delta^{13}C$ values. Samples TA01 and TA06 are outliers from both Groups. The $\delta^{13}C$ values of all samples are considered as too high for the bitumen belonging to the Hit area (Fig. 5). They are, however, consistent with an origin in south-western Iran or northern Iraq.

GC-MS analysis of the samples did not reveal the presence of oleanane, a chemical compound that is limited to oils originating from the Padbeh source rock formation in south-west Iran. The lack of this compound in all samples rules out many of the known bitumen seepages in south-west Iran as possible suppliers for Tell Abraq. The plots in Figure 8 shows the major chemical characteristics of the Tell Abraq bitumen along with other, non-oleanane-containing samples from both archaeological sites (Ra’s al-Jinz, Saar [Sār in Bahrain]) and seepages (Sarkan and Sultan). These specific references were chosen because of the possible positive matches they could provide. Unfortunately, the main cluster of samples from Tell Abraq does not correlate either with seepage or with any other archaeological samples. The samples exhibiting a low Ts/Tm value are very reminiscent of the bitumen from the Sultan seepage, but their $\delta^{13}C$ falls rather in the range of bitumen from the Sarkan seepage. Thus, the two most likely candidates for the source of this bitumen can be ruled out. The $\delta^{13}C$ value does not agree with similar data from Iraqi seepages, therefore we can at least determine these samples as coming from Iran. However, the data from the bitumen from Saar (Sār) exhibits the same problem (Connan et al. 1998). This is due to the lack of reference data and up to now, no systematic survey and sampling campaign has ever been undertaken specifically for the purpose of fingerprinting archaeological bitumen.

![Figure 5](image1.png)

**Figure 5.** $\delta^{13}C$ value ranges of the major bitumen extraction areas.

![Figure 6](image2.png)

**Figure 6.** $\delta^{13}C$ vs. Ts/Tm values of the Tell Abraq dataset.
The small cluster of samples (TA03, TA04, and TA05) shows different $\delta^{13}$C values than the main cluster, offering a different possibility with reference to their origin. On first examination of the data, these bitumen samples might be imported either from the Sultan seepage in Iran or from northern Iraq. Statistical analysis (Hierarchical Clustering, Furthest Neighbour, and Ward’s Method with Squared Euclidean distance) seems to favour an Iraqi origin for sample TA05 and a Sultan origin for the other two samples. We are, however, dealing with highly complex organic samples meaning that deviant samples are not an exception to the rule. It should therefore not be ruled out that sample TA05 also came from the Sultan seepage. The Gammacerane/C$_{30}$αβ-hopane ratio tends to agree with this conclusion as it shows a value typical for bitumen from this seepage (Fig. 8). Considering the Iranian origin of all other samples from Tell Abraq, this seems the most likely option.

Samples TA01 and TA06 may be identified as true outliers in the dataset or alternatively as coming from another source area. Statistical analysis favours the interpretation that sample TA06 came from the same source as the main cluster of samples. The remarkably higher Ts/Tm ratio of sample TA01 is quite likely to be attributed to sample condition (low in quantity and weathered) rather than an indicator of another source area.

Some samples were not subjected to isotopic screening due to a very low quantity of available material.

**Figure 7.** Typical chromatograms for each cluster in the dataset. TA03 is exemplary for the small deviant cluster whereas TA10 represent samples from the main cluster. The marked molecules are 18α(H)-22,29,30-trisnorneohopane (C$_{27}$H$_{48}$) (Ts), 17α(H)-22,29,30-trisnorhopane (C$_{29}$H$_{48}$) (Tm), 17α,21β-hopane (C$_{30}$H$_{52}$) (C$_{30}$αβ-hopane), 22R-17α(H),21β(H)-homohopane (C$_{31}$H$_{54}$) (31R), and Gammacerane (C$_{30}$H$_{52}$).
specifically TA14, TA20, and TA21. Other chemical parameters obtained through GC-MS place these samples in the same range as all other samples in the dataset. Without the $\delta^{13}$C value, however, it is impossible to determine whether these samples belong in the main cluster of samples, or rather in the outliers formed by samples TA03, TA04, and TA05. Whatever the case, this bitumen also came from south-west Iran.

### Putting the Tell Abraq bitumen in an Arabian Gulf perspective

At around 5000 BC, the Gulf witnessed its first long-distance imported bitumen with the appearance of the material at Dosariyah (Dawsariyyat al-Jubayl). Like various other Mesopotamian settlements, such as Tell el-ʿOueili and Tell el-Sawwan (Tal al-Šawwān), the material comes from the seepages in northern Iraq (Connan & Deschesne 1992b; Connan, Breniquet & Huot 1996; Van de Velde 2015; Van de Velde et al. 2015). Although very few bitumen datasets are available for the third millennium BC, it is clear that bitumen from these seepages continued to be employed at Raʾs al-Jinz, Umm an-Nar, and possibly also Umm al-Namel (Umm al-Naml) during the second half of the third millennium (Connan et al. 2005; Connan & Carter 2007). Significant changes in bitumen

<table>
<thead>
<tr>
<th>Sample</th>
<th>$\delta^{13}$C</th>
<th>Ts/Tm</th>
<th>GCRN/C$_{30}$</th>
<th>GCRN/31R</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA01</td>
<td>-26.59</td>
<td>0.32</td>
<td>0.22</td>
<td>0.52</td>
</tr>
<tr>
<td>TA02</td>
<td>-27.71</td>
<td>0.12</td>
<td>0.21</td>
<td>0.61</td>
</tr>
<tr>
<td>TA03</td>
<td>-27.74</td>
<td>0.12</td>
<td>0.21</td>
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**Figure 8.** Plots of the main chemical characteristics of the Tell Abraq bitumen combined with other reference data.

**Figure 9.** The main chemical characteristics used for the geochemical sourcing of the Tell Abraq samples. The abbreviation GCRN stands for the chemical compound Gammacerane, whereas C$_{30}$ is the short notation for the compound C$_{30}\alpha\beta$-hopane.
Thus, if Iranian and Mesopotamian bitumen were both simultaneously traded and prepared for seaborne trade in southern Mesopotamia, they would have mingled and we would now see bitumen of both types appear in the archaeological record of Dilmun and Failaka. Previous analysis has indicated that this is not the case, nor is there any attestation of Hit bitumen in south-eastern Arabia in our analysis. We could therefore hypothesize that the Iranian bitumen did not travel to southern Mesopotamian ports of trade prior to entering the Gulf, and that its distribution was presumably focused on the Iranian littoral of the Gulf. Unfortunately, this side of the Arabian Gulf is fairly unknown, although both survey and excavations have established Elamite occupation and the presence of bitumen on the Bushehr peninsula (Carter et al. 2006; Pézard 1914). It is not hard to imagine ancient Liyan as a link in a chain of settlements and harbours along the Iranian littoral of the Gulf. Evidently, one of the links in this network would then have been responsible for bridging south-east Arabia and Elamite Iran.

A remarkable find is the presence of bitumen on the inside of four samples of pottery, which we assume, from its fabric, to be south Mesopotamian. In two cases, bitumen was used for lining the interior of the vessels (TA15 and TA19); in one case (TA16) the bitumen is presumably a remnant of storing or processing, whereas in the other the bitumen appears as an amorphous blob on the exterior of the sherd (TA13). Unfortunately, sample size was too small in the cases of TA15 and TA19 to deliver reliable results. For the other samples, TA13 and TA16, we suggest an Iranian origin of the bitumen.

Explaining this observation is challenging since the most obvious solution, that the Iranian bitumen travelled in Mesopotamian vessels, seems to be contradicted by the fact that the bitumen from mid-second-millennium BC Failaka and Bahrain is sourced to Mesopotamia, not Iran. Several scenarios present themselves:

a. Our identification of the pottery as Mesopotamian is incorrect. This is unlikely as south Mesopotamian fabric is unique and stands out as macroscopically different from locally produced ceramics, but we will need to confirm the origin of these vessels through geochemical analysis.

b. There was a functional connection between Mesopotamian vessels on the one hand, and bitumen on the other. One might imagine that these were connected with ship-borne transport, for example. In the repertoire of locally produced ceramics from south-eastern Arabia, there is no
torpedo-shaped, round bottomed vessel which would be suitable for maritime transport.

c. The absence of Iranian bitumen from Failaka and Bahrain is an artefact of prior analysis. In other words, there was Iranian bitumen transported to these places but the analysis did not reveal it, perhaps because of chronological reasons or sampling strategy. The material from Tell Abraq dates to a specific time frame in which Iranian bitumen was transported throughout the Arabian Gulf in Mesopotamian vessels.

d. The bitumen from Tell Abraq, while not matching known sources in Iraq, comes from a source in or close to Iraq, which is not in the reference database.

e. It is a simple remnant of inhabitants of Tell Abraq working with Iranian bitumen (heating, reusing, mixing…) in whatever container or vessel was available — in the case of sample TA16, a Mesopotamian transport vessel.

For the moment, we can decisively conclude that the bitumen trade to Tell Abraq represents a different trading pattern from that evident in the middle of the second millennium BC at sites in the central and northern Gulf. It is likely that this relates to the broader economic and political conditions that existed in the Gulf at this time (Potts 2006). Potts has argued a coexistence of Kassite and Elamite spheres of influence sustained and respected through interdynastic alliance. In this scenario, Elamites would deliberately not intervene or operate in the western part of the Gulf, and Kassites would leave eastern Arabia unhindered for their Elamite partner. The results of the analyses conducted on the bitumen from Tell Abraq, combined with data from other bitumen-related research, could contribute to this hypothesis.

Conclusions

Twenty-one archaeological samples from various excavation seasons and operations from Late Bronze Age contexts at Tell Abraq were subjected to geochemical analysis in order to determine their geological origin. Unfortunately, several samples had to be discarded because of the low quality of the data after analysis due either to weathering or to a sub-optimal quantity of the sample. For all other samples, chemical parameters pinpoint to a south-west Iranian origin, but without being able to identify specific known seepages in most cases. Three samples deviate quite widely from the main body of samples and clearly came from another source, in this case the Sultan seepage in south-west Iran. The results of the analyses on the Tell Abraq bitumen add to the existing knowledge concerning the bitumen trade, in the sense that we have previously underestimated the importance of Iranian bitumen and the role that the seepages in Elamite lands played in the second-millennium BC petroleum industry.

References


The bitumen imports at Tell Abraq