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NEUTRON ACTIVATION ANALYSIS AND THE LOCATION OF WASSUKANNI

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This work was done with support from the U.S.
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NEUTRON ACTIVATION ANALYSIS AND THE LOCATION OF WAŠŠUKANNI*

By Allan Dobel, Frank Asaro
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The capital cities of ancient empires always excite interest, the more so if such cities are 'lost', their locations remaining to be discovered. Ancient Mesopotamia, has, perhaps, more than its share of such famous lost cities. Among these, Akkad, Šubat-Enlil and Waššukanni are surely noteworthy; all of them promise their discoverers rich rewards.[1] One of these three has received the most attention, namely, the city of Waššukanni, capital of the Mitanni Empire which flourished in northern Mesopotamia during the mid-second millenium B.C.

Scholars attempting to fix its location have always utilized the scattered geographical references in the cuneiform documents of the Mitanni period. Those references led the investigators to agree that the most likely general area was within the triangle formed by the Khabur and Jaghjagh Rivers in the upper Jezirah of modern Syria. During the 1940's and 50's, the location of Waššukanni excited so much interest that at least three archaeologaical excavations made its discovery their primary objective.[2] These having failed to produce any evidence for an identification, the subject has laid fallow ever since, badly in need of fresh evidence.

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*The material presented in this article will be included in Chapter IV of Mr. Dobel's doctoral dissertation: Waššukanni and Problems in North Mesopotamian Geography, which is being prepared for the Department of Near Eastern Studies at the University of California-Berkeley.

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The search received new impetus with the realization that neutron activation analysis might well fill this need. This is an approach that is being used in a number of laboratories and is being intensively utilized at the Lawrence Berkeley Laboratory for pottery provenience studies. In the Berkeley procedure, the abundances of about 30 chemical elements in clay objects are measured with high precision and accuracy. These abundances, many of which are in the part-per-million range, form a chemical profile for each object; it is this profile which can be used to indicate the place of origin of clay objects. For the method as applied to identification of archaeological sites to be successful, two conditions must be met, which we may refer to as requirements:

(i) A number of clay objects from the unknown source must have very similar chemical profiles.

(ii) The likely source sites must have chemical profiles which can be distinguished from each other.

Since 1969 such procedures have been used successfully in determining the provenience of pottery excavated at various sites in the Near East.[3] Since epigraphic material in the second millennium B.C. was commonly of clay, documents too can be subjected to provenience analysis using neutron activation.

The First Requirement

In order to satisfy the first requirement it was decided to isolate, sample and test a group of cuneiform letters which could reasonably be thought to have been written from Waššukanni.

If a significant number of these proved to be homogeneous as to a profile of their chemical elements, a sampling of likely source sites would then be in order.

Since no published cuneiform letters actually state that they were written in Waššukanni, the Amarna correspondence of the Mitanni king, Tušratta, seemed to offer the best hope of supplying us with clay from that city. This correspondence consists of thirteen letters sent by Tušratta from Mitanni to Egypt where they were discovered at the capital city of the famous Pharaoh Akhenaten.[5] We assume that the majority of these letters were written by Tušratta from his capital, Waššukanni, on local clay.

The next step involved collecting samples of clay (100 mg each, the standard unit used at Lawrence Berkeley Laboratory in these analyses) from as many of the thirteen letters as possible. This was not an easy step inasmuch as museum officals are wisely reluctant to sanction destructive analysis of limited material. Nevertheless, the staffs of the Staatlich Museum, Berlin and the British Museum, London responded with a generosity for which we are very grateful, permitting the sampling of six of these letters, including the famous 'Mitanni letter' (EA 24) written in Hurrian. Neutron activation analysis of these samples was carried out by standard procedures at the Lawrence Berkeley Laboratory..

The process of sample preparation, neutron irradiation, gamma ray counting and statistical evaluation of data have been previously described (see footnote 3) and so will not be discussed here. Four of the tablets (EA 22, 24, 25 and 29) were

found to be remarkably homogeneous, and hence suitable for use in establishing the chemical profile, or fingerprint, of Waššukanni. A partial listing of their chemical abundances is shown by element in Table 1.

TABLE 1

CHEMICAL ABUNDANCES IN FOUR TUŠRATTA TABLETS[a]

	Th	Cr	Hf	Cs	Sc	Fe%	Co	Eu
EA 22	4.44	355	2.39	3.67	18.07	4.91	32.12	.729
EA 24	4.88	352	2.35	3.45	18.42	4.88	33.05	.679
EA 25	5.67	338	2.65	3.72	17.59	4.60	30.36	.777
EA 29[b]	4.75	382	2.20	3.50	17.56	4.80	29.77	.743
EA 29	5.11	387	2.19	3.58	17.63	4.81	29.45	.750

[a]In this table and all tables and graphs below, the measurements are in parts-per-million unless percent (%) is indicated.

[b]EA 29 is listed twice because it was sampled a second time more deeply as a check against any surface contamination which might have resulted from the use of chemicals in the cleaning and care of the tablets at the museum. We found no evidence of any such contamination.

This information can be compressed into a composite profile by calculating the average abundance for each element together with its standard deviation (±). The result is the chemical fingerprint or profile to be used in searching for Waššukanni. (We have limited the number of elements to the eight measured by Davidson and McKerrell (see below).)

TABLE 2

THE TUŠRATTA PROFILE

Th	Cr	Hf	Cs	Sc	Fe%	Co	Eu
4.97 ±.46	363 ±21	2.35 ±.19	3.58 ±.11	17.85 ±.38	4.80 ±.12	30.9 ±1.6	.736 ±.036

The Second Requirement

Having successfully met the demands of our method's first requirement, the second was still to be faced. Establishing the Tušratta profile would not suffice, and, in fact, would be of no help at all if samples taken from areas across the Khabur triangle were all homogeneous. Since the Khabur headwater region comprises a geologically uniform plain of recent date, there was reason to fear that this was more than a theoretical possibility. These fears were allayed in unexpected fashion by T. E. Davidson and Hugh McKerrell's publication of their survey work in the Khabur region [Iraq 38 (1976), 45-56.]. Basing themselves on neutron activation analysis of 71 Halaf period pottery samples from nine Khabur basin sites as well as 39 samples of mud brick and clay from various river and wadi systems in the area, they reached a variety of conclusions. That which most concerns us here is found in their statement: "Within the Khabur region at least, clays seem to vary in composition over quite short distances, and this means that pottery sources can be located with considerable precision" (p.53).

In support of their conclusions, we are now able to offer corroborative evidence. One of the mounds, for which Davidson and McKerrell published a large sampling of neutron activation

measurements, is Tell Halaf. Only three kilometers away lies Tell Fakhariyah which has been excavated twice during the search for Waššukanni (see footnote 2). The Oriental Institute of the University of Chicago recently allowed Mr. Dobel to sample their Fakhariyah material. In all, fifteen pieces were tested: thirteen pottery sherds and two Middle Assyrian tablets. The pottery was of three types: Khabur ware, Mitanni ware, and the type designated in the publication as Transitional Khabur-Mitanni. Neutron activation analysis of this material is now complete, with the result that nine of the fifteen samples fall into a homogeneous pattern. This composite profile of Tell Fakhariyah material is similar to but distinguishable from that of Tell Halaf, as Table 3 (below) clearly shows.

This situation, of course, provides us with striking confirmation of the Davidson and McKerrell conclusion, and at the same time fulfills the demands of our second requirement with respect to the Khabur triangle.

TABLE 3

CHEMICAL PROFILES OF TELLS HALAF AND FAKHARIYAH[a]

Th	Cr	Hf	Cs	Sc	Fe%	Co	Eu
Tell Halaf[b]							
10.5	493	5.40	3.3	18.8	5.51	32.7	1.42[c]
±1.6	±140	±.89	±1.0	±1.5	±.55	±2.0	±.15
Tell Fakhariyah[d]							
8.89	273	4.79	4.27	16.48	4.67	23.67	1.282
±.53	±18	±.41	±.49	±.54	±.16	±.68	±.042

[a]The figures give a composite profile showing group mean values for each element together with their standard deviation (±).

[b]The Tell Halaf profile is based on the measurements of twenty samples published by Davidson and McKerrell (above, pp. 54-6), i.e., H1-H18 plus C10 and one marked Tell Halaf clay.

[c]It was not clear if Davidson and McKerrell used the initial value[3] of 1.448 ppm for the abundance of Eu in Standard Pottery or a revised value,[4] 1.291 ppm, which is used in the present work. If the former is true, their Eu abundances should be divided by a factor of 1.12 to correspond to the present work.

[d]For Tell Fakhariyah the pieces tested were those published in C.W. McEwan et.al., Soundings at Tell Fakhariyah, (1957): Plate 36 nos. 116, 118, 129, 130, 131, Plate 38 nos. 110, 114, Plate 76 nos. XVI and X. Our neutron activation identification symbols for these samples are TLFH-3, -8, -9, -11, -12, -4, -5, -14, -15. The two tablets TLFH-14 and -15, from Tell Fakhariyah, had larger abundances of the element calcium than the pottery, and all other significant elements were reduced in abundance. These tablet abundances were normalized to those of the pottery with the element dysprosium to compensate for dilution by calcium carbonate and water. The six other samples tested from Tell Fakhariyah fell into three distinct chemical groups with profiles similar to the Halaf profile.

Waššukanni and Tell Fakhariyah

Having thus established the theoretical viability of our method, it remained to apply it in a practical site by site fashion. The first tell to be tested against the Tušratta fingerprint was, quite expectedly, Fakhariyah which has been, since the suggestion of D. Opitz in 1927, the site most frequently mentioned by scholars as the most likely location for Waššukanni.[6] In fact, the role played by Tell Fakhariyah in the literature has been of such prominence that even negative results would be significant. Table 4 compares the Tušratta profile with that of Fakhariyah.

TABLE 4

THE TUŠRATTA AND FAKHARIYAH PROFILES

	Th	Cr	Hf	Ni	Sc	Sm	Co	Eu
Tušratta	4.97 ±.46	363 ±21	2.36 ±.19	387 ±37	17.85 ±.38	2.79 ±.16	30.95 ±1.56	.736 ±.036
Fakhariyah	8.89 ±.53	273 ±18	4.79 ±.41	172 ±10	16.48 ±.54	4.79 ±.99	23.67 ±.68	1.282 ±.042

The differences between the groups are marked. The Tušratta profile, for example, shows twice as much nickel (Ni) as Fakhariyah, while having only half as much thorium (Th) and hafnium (Hf). Among the five remaining elements, only the scandium (Sc) abundances approach each other, and even these are not quite identical. Hence it can be stated that Tell Fakhariyah has been probed for a third time and has failed to produce any evidence which would substantiate its identification with Waššukanni.

This conclusion merely confirms what many scholars had begun to suspect. Thus it seems that Fakhariyah can be laid aside as a candidate, while the search for Waššukanni continues elsewhere.

The Khabur Triangle

Examining the triangle formed by the Khabur and Jaghjagh rivers would seem to be the next logical step. According to scholarly consensus , the evidence of the cuneiform record points in that direction. The Khabur triangle offers the additional

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advantage of being Davidson and McKerrell's area of concentration (p. 48). We could thus avail ourselves of their neutron activation results.

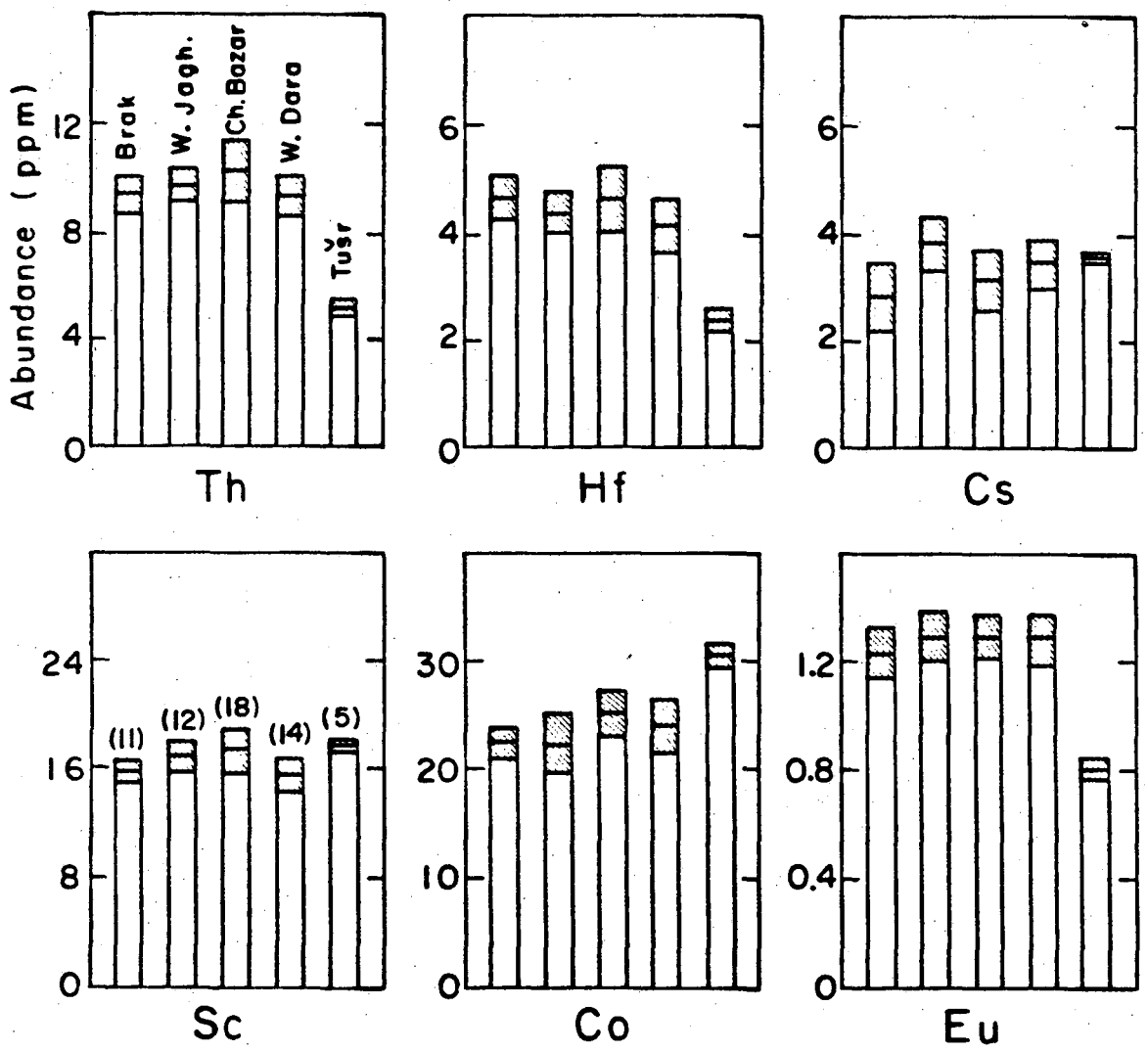
Before making comparisons, however, a problem of method must be faced. In order to better control the reference pottery for source sites which might be Waššukanni, it appeared initially that the Tušratta profile should only be compared to pottery samples of mid-second millennium provenance. Davidson and McKerrell, however, used either prehistoric Halaf ware or clay taken directly from river beds and mud bricks (p. 47). Since they were able to match samples of prehistoric pottery with modern clay samples (p. 53), it was deemed profitable to check their measurements against our Tušratta profile. The results of this comparison, however, were disappointing and surprising. Of the 110 samples published by Davidson and McKerrell, not one had a chemical profile resembling the Tušratta profile! Even though comparison is limited to the abundances of only eight published elements, the differences are clear. Thorium, for example, is consistantly lower by about half in the Tušratta tablets (4.9 as against a range of 8.5 - 13.2). The same is true for hafnium and europium.

Davidson and McKerrell concentrated their sample collecting along the Jaghjagh and the Wadi Dara. These two systems show composite profiles which are quite similar in general configuration. Our own analysis of Tell Fakhariyah material shows that it falls into the same overall pattern. On the basis of the published numbers, there appears to be a general uniformity

in the composition of the clays in the Khabur triangle, from Fakhariyah to the Jaghjagh. Davidson and McKerrell were able to distinguish specific clusterings within this area by means of computer-based taxonometric techniques (p. 50). No such sophistication is required to separate the Tušratta letters from this group. They stand clearly apart. Indeed, the difference is so marked as to make one wonder if any clay matching the Tušratta profile could be found within the Khabur triangle.

In illustration, the graph contrasts the Tušratta profile with composite profiles of pottery from Tell Brak and Chagar Bazar as well as with profiles of clay and mud brick from the Jaghjagh and the Wadi Dara.

Tušratta Profile Contrasted with
Khabur Triangle Profiles



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Notes on Graph:

1. The Th graph labels the five bars which appear in all six graphs. In the Sc graph, the actual number of samples represented by each bar is indicated.

2. The data for the first four bars (Brak, Wadi Jaghjagh, Chagar Bazar and Wadi Dara) were taken from Davidson and McKerrell, pp. 54-6. The specific samples represented by each bar are:

Brak:	B1-B11
Wadi Jaghjagh:	82, 83, 84, 85, 89, 107, 811, 66, 81, 102, 21 and 101
Chagar Bazar:	C1-C9, D1, D2, D4, D10, D14, D23, D25, D30 and the sample labeled Chagar Bazar clay
Wadi Dara:	44, 45, 54, 53, 52, 51, 55, 94, 93, 91, 97, 910, 98 and 56

3. The abundances for each element in these four groups were averaged and the root mean square deviation calculated. This latter is represented by the shaded area on each bar.

4. Since only eight elements were available for comparison, it is impressive that the Tušratta group differed so clearly from the others with respect to four: Th, Hf, Co and Eu. Two of the available elements (Cr and Fe) were excluded from the graph for reasons of space. Like Cs and Sc, they were generally homogenous in all five groups.

If a match seems unlikely to be found within the Khabur triangle, where, then, is one to be found? The tells running in an east-west line across the wadis which drain the northern slopes of the Jebel 'Abd al-'Aziz and Jebel Sinjar might present clay profiles differing in character from those of the Khabur triangle (whose wadis drain the Mazi Dağ and the Midyat Dağ). The middle Khabur contains Mitanni sites according to an unpublished survey of Prof. W. Röllig (private communication) and hence requires

examination. The suggestion of Tell Hamükar, made by Dr. W.J. van Liere in 1963,, might seem more attractive now.[7] Certainly, this area between the Jaghjagh and the Tigris must be probed. Finally, the Midyat Dağlari should be considered; it should be noted that Profs. A. Goetze and M. Mallowan long espoused consideration of this area around Mardin.

Wherever Waššukanni may lie, continued application of an archaeological prospecting technique using neutron activation analysis seems to offer the best hope for discovery.

Ackowledgements

A sincere word of thanks is due Dr. Liane Rost and Frau Dr. Klengel-Brandt in Berlin as well as Dr. Edmond Sollberger in London for the interest and confidence their generosity with samples demonstrated. Dr. Michal Artzy did the actual sample collecting in Berlin, thereby placing us in her debt as well.

In Chicago, it is a pleasure to thank Prof. Hans Güterbock, Dr. Gustavus Swift, Curator of the Oriental Institute Museum and his staff, especially Barbara Hall and Al Leonard for their help with the Fakhariyah material.

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Footnotes

[1]For Akkad, see H. Weiss, "Kish, Akkad and Agade," JAOS 95 (1975), 434-453. For Šubat-Enlil and Waššukanni, the best summary is still the article by B. Hrouda, "Waššukanni, Urkiš, Šubat-Enlil," MDOG 90 (1958), 22-35.

[2]C.W. McEwan's excavation at Tell Fakhariyah in 1940 (Soundings at Tell Fakhariyah, (Chicago, 1957)) was followed by A. Moortgat's at the same site in 1955 and 1956 (Archäologisch Forschungen der Max Freiherr von Oppenheim-Stiftung im nördlichen Mesopotamien, 1955, and ibid., 1956 (Köln und Opladen, 1957 and 1959)). J. Lauffray's 1955 excavation at Tell Chuera has never been published.

[3]I. Perlman and Frank Asaro, "Pottery Analysis by Neutron Activiation," Archaeometry 11 (1969), 21-52. For a recent application of neutron activation analysis to archaeological problems see M. Artzy, I. Perlman and F. Asaro, "Alašiya of the Amarna Letters," JNES 35 (1976), 171-182.

[4]I. Perlman and Frank Asaro, "Pottery Analysis by Neutron Activation," Science and Archaeology. (MIT Press, Cambridge, Massachusetts, edited by Robert H. Brill, 1971), 181-195.

[5]J.A. Knudtzon, Die El-Amarna Tafeln, nos. 17-29, cited hereafter as EA plus number.

[6]D. Opitz, "Die Lage von Waššugganni" ZA 37 (1927), 299-301.

[7]W.J. van Liere, "Capitals and Citadels of Bronze-Iron Age Syria in their Relationship to Land and Water," AAS 13 (1963), 120.

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