

Analysis and Provenience of Minoan and Mycenaean Amber, III. Kakovatos

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IN 1907 Dörpfeld discovered three *tholoi* at Kakovatos¹ which he equated with Homeric Pylos. This identification has long since been abandoned, but the site retains considerable interest, not least because the amber “spacers” found there invite comparison to those from Germany and England.

The first preliminary report² mentions finds only from the largest *tholos*, later designated as Tholos A, among them “amber which in quantity and variety exceeds anything known so far from Mycenaean tombs. In addition to lentoid beads of various sizes—the largest will have served as sword pommels—there are flat rings with broad loops for suspension, as well as rectangular plates with multiple drillings.” The tomb was tentatively considered “contemporary with the older *tholoi* [at Mycenae] which immediately follow the shaft graves [also at Mycenae].”

In the full report Dörpfeld³ concluded that the large Tholos A was the most recent, Tholos B slightly older, and Tholos C the oldest, but that all fell into the period of the “second late Minoan style,” to which vases in all three *tholoi* belong. He based his assignment of relative age in part upon the fact that finds of amber and ivory are much more plentiful in Tholos A, while glass and stone predominate in the other two.

The *tholoi* are now assigned to LH II A, or 1500–1450 B.C.⁴

The amber finds from Kakovatos were finally described, though

¹ British War Office map series G.S.G.S. 4439/MDR 610 (1:100,000) square L.5 (Kiparissia), grid lines 514E/998N. Cf. R. Hope Simpson, *A Gazetteer and Atlas of Mycenaean Sites* (London 1965) no. 255.

² W. Dörpfeld (with description of finds by K. Müller), *AthMitt* 32 (1907) vi–xvi.

³ Dörpfeld, *AthMitt* 33 (1908) 294–317.

⁴ A. Furumark, *The Chronology of the Mycenaean Pottery* (Stockholm 1941).

still rather summarily, by Müller⁵ in 1909. We now present, with minimal annotations, his description of the amber finds, followed by an account of the amber we were able to see at the National Museum in Athens in the summer of 1966 and of the results of our analyses.

Tholos A: Beads

Müller reports:⁶

“Tholos A was especially rich in amber, both with regard to quantity and to shape. The greater part is comprised of beads. In spite of the vulnerability of the material, about 500 beads were preserved entirely or in large part. Shape and size vary considerably as shown in the illustration [Müller shows 10 beads on his Plate xv, nos. 10–18, 25, in natural size. Their diameters range from 5mm to 41mm]. The majority are lentoid and have sharp edges. Their convex surfaces vary in curvature. There also are—but only among the smaller beads—flat plates with rectangular cross-section. More frequent are medium-sized pieces of this kind with rounded edges. When beads of this kind are very thick relative to their diameters, they occasionally approach spherical shape but never quite attain it. The diameter of the drill holes also varies, both absolutely (in one case 8mm, usually between $5\frac{1}{2}$ and $1\frac{1}{2}$ mm) and relatively; in some smaller beads the ratio [of drill hole to diameter of the bead] is such that they appear as rings.

“The dimensions vary even more. The diameter increases continuously from 5 to 50mm, and from fragments one can infer center pieces of which the largest has a diameter of 85mm and a thickness of 21mm. [Depending on the curvature, a bead of these dimensions would have weighed between 40 and 80g.]

“No beads of such size have been found so far in Mycenaean contexts. None of the beads from the shaft graves [of Mycenae] measures more than 40mm. It is difficult to imagine such giant beads strung into necklaces, but there is

⁵ K. Müller, *AthMitt* 34 (1909) 269–328.

⁶ Müller, *op.cit.* (*supra* n.5) 278–79.

no alternative. One might think of pommels for daggers and swords [as Müller himself had done in 1907], but apart from the fact that they form a continuous series with the smaller beads, this is ruled out by the small drill holes—that of the largest piece measures barely 3mm—and the consideration that known pommels are never lentiform and were attached to the blade in a different manner.”

All the amber objects from Tholos A are registered in the National Museum of Athens under inventory no. 5688. A large number of beads and some of the more complex objects and fragments have been mounted on a board for exhibition in the Mycenaean Room. The beads have been strung into two necklaces; the first consists of 115 graduated beads of fairly large size ranging from 14mm diameter for the smallest to 42.5mm diameter and 20mm thickness for the largest center bead. Most of the beads are lentoid (in Beck's⁷ classification: Short Convex Bicone, group B.1.e.), though in many the curvature is so slight that they approach a bicone (Beck's Short Bicone, group B.2.e). A few of the smaller beads are discs, *i.e.*, they have parallel flat sides. Their edges may have been sharper once than they are now and the distinction between Müller's "flat plates with rectangular cross-section" (Beck's Cylinder Discs, group A.2.b or Short Cylinders, group B.2.b) and those with "rounded edges" (Beck's Barrel Discs, group A.1.b or Short Barrels, group B.1.b) may reflect differences in wear and weathering rather than in intentional, original shape.

The second necklace on the exhibition board consists of 291 smaller beads ranging in diameter from 5.5mm to 18.5mm. Again the larger beads are biconvex or biconical and the smaller ones, almost half of the total number, are discs with sharp or rounded edges.

In a cardboard box in the storeroom at the National Museum there are several hundred fragments, many of which are large enough to be recognizable as having been part of beads, pendants or spacers. To preserve the whole beads, samples were taken from eleven of the fragmentary beads. Their spectra, over the range from 7.5 to 9.5 μ , are shown in Figure 1 and the results of their analyses are listed in Table 1. By computer classification, ten of the eleven spectra were identified as those of Baltic amber; the exception, spectrum 1553 of sample 11, differs only minutely from the others but fails to meet the stringent computer test.

⁷ H. C. Beck, *Archaeologia* 77 (1927) 1-74.

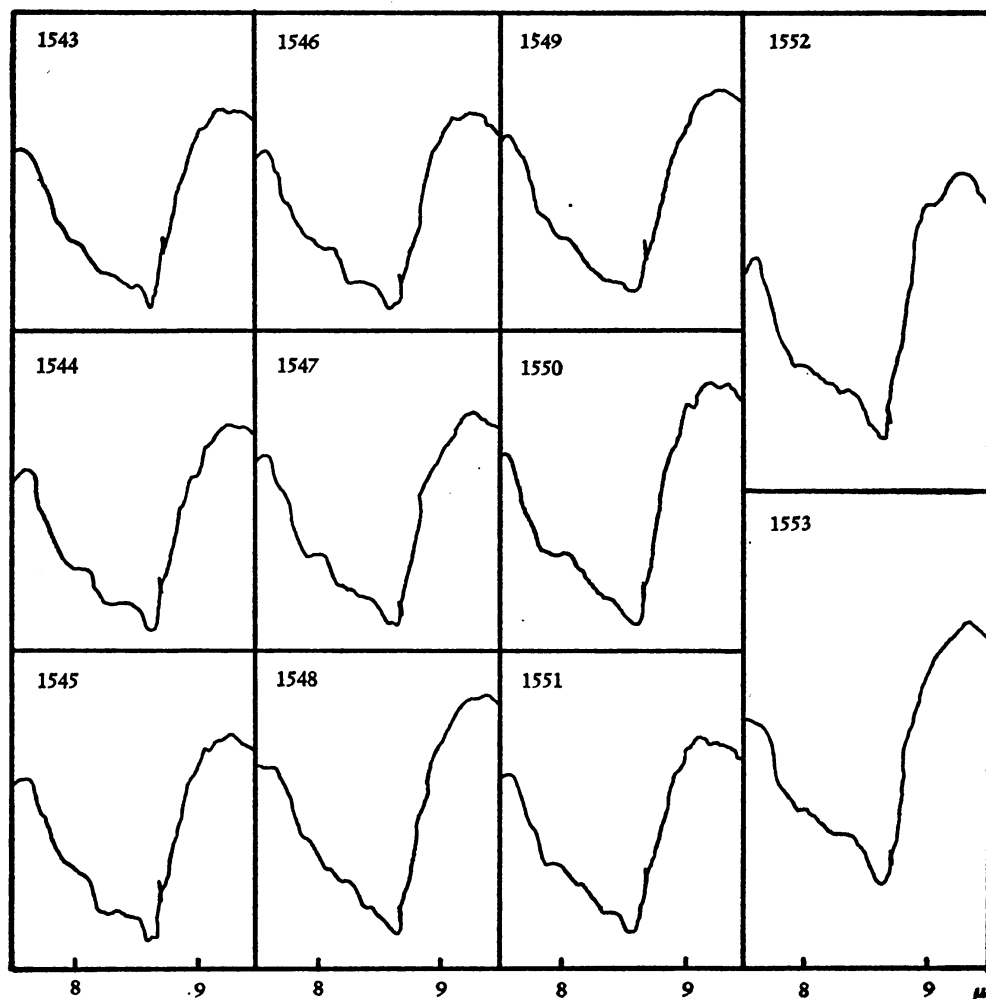


Figure 1. PARTIAL INFRARED SPECTRA OF AMBER BEADS. KAKOVATOS, THOLOS A

Tholos A: Pendants

Müller continues:⁸

“In addition to the beads, the tomb contained the remains of a particularly splendid necklace. Its members have the form of flat round plates with a very broad suspension tube along one side and a circular hole which is so placed that the ring has its greatest width opposite the tube. It [the ring] is tapered on both sides towards the periphery, terminating into a sharp edge. Three pieces have been preserved entire; there are fragments of 5–7 others. The largest, which will have been

⁸ Müller. *op.cit.* (*supra* n.5) 279–80.

the center piece, is 64mm high and nearly as wide with a thickness of 12mm; the smallest is 30mm high. The width of the ring increases to a maximum of 21mm in the former, and to 10mm in the latter.”

TABLE 1. SPECTROSCOPIC CLASSIFICATION OF AMBER FROM THOLOS A
AT KAKOVATOS

(Athens National Museum, inventory number 5688)

<i>Sample Designation</i>	<i>Spectrum Number</i>	<i>Computer Classification</i>	<i>Sample Designation</i>	<i>Spectrum Number</i>	<i>Computer Classification</i>
	<i>Beads</i>			<i>Unidentified Objects</i>	
1	1543	Baltic	A	1534	Baltic
2	1544	Baltic	B	1535	Baltic
3	1545	Baltic	C	1536	Baltic
4	1546	Baltic	D	1537	non-Baltic
5	1547	Baltic	E	1538	Baltic
6	1548	Baltic	F	1539	non-Baltic
7	1549	Baltic	G	1540	Baltic
8	1550	Baltic	H	1541	Baltic
9	1551	Baltic	I	1542	non-Baltic
10	1552	Baltic		<i>Spacers</i>	
11	1553	non-Baltic?	S	1529	Baltic
	<i>Pendants</i>		T	1533	Baltic
Q	1527	Baltic	U	1530	Baltic
R	1528	Baltic	V	1531	Baltic
1	1568	Baltic	W	1532	Baltic
2	1569	Baltic	1	1558	Baltic
3	1570	schraufite?	2	1559	Baltic
4	1571	schraufite?	3	1560	Baltic
5	1572	Baltic	4	1561	Baltic
6	1573	Baltic	5	1562	Baltic
7	1574	Baltic	6	1563	Baltic
8	1575	schraufite?	7	1564	Baltic
9	1576	schraufite?	8	1565	Baltic
10	1577	Baltic	9	1566	Baltic
			10	1567	non-Baltic?

The shape of these apparently unique pendants is illustrated by Müller on Plate xv, 22 and here in Figure 2.1. The mounted exhibit in the National Museum includes the upper half of a very large

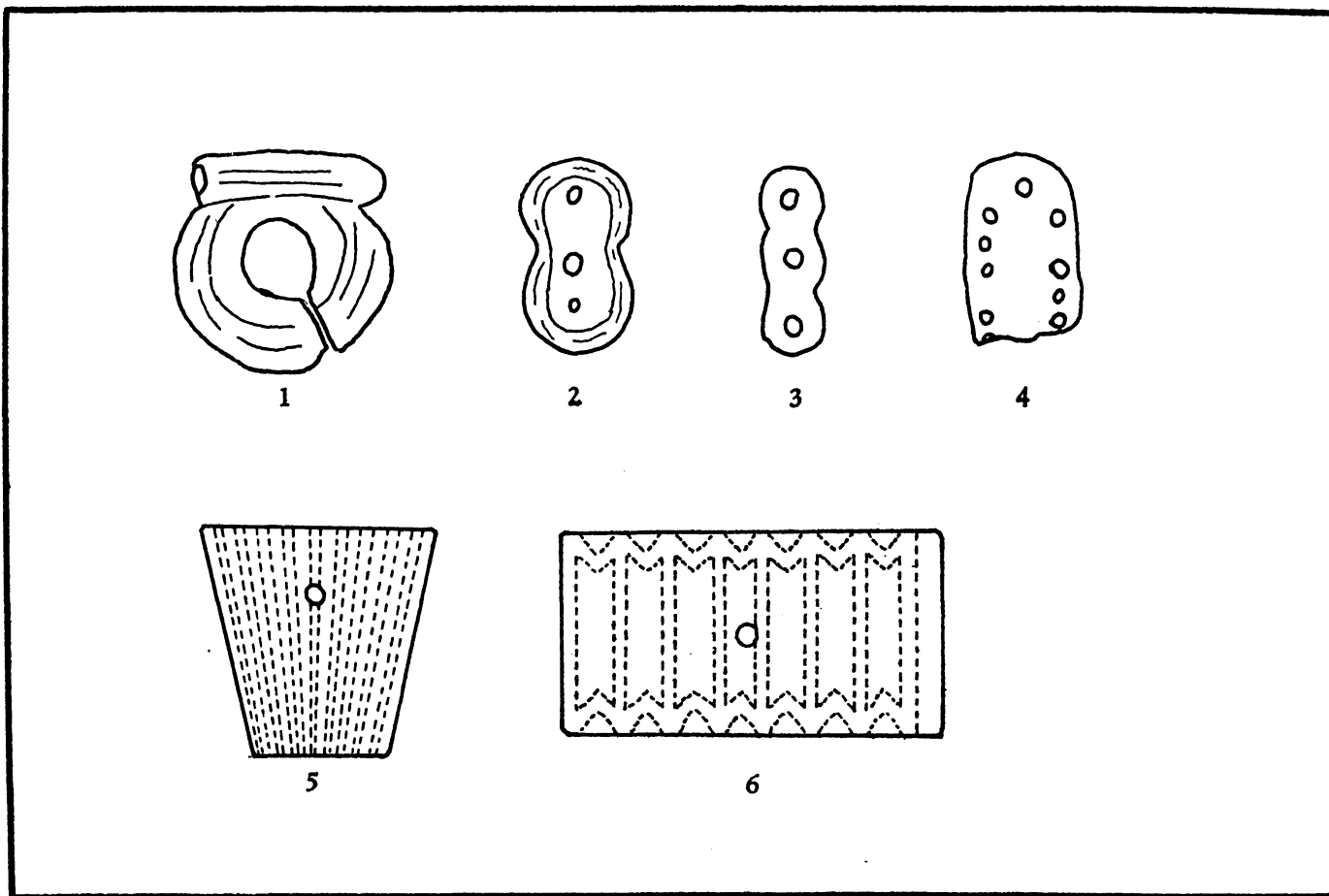


Figure 2. AMBER PENDANT, COMPLEX BEADS, AND SPACERS FROM KAKOVATOS, THOLOS A

specimen having a maximum preserved width of 61.5mm and a smaller whole pendant which is 36mm wide and equally high. Neither were sampled since many identifiable fragments of these pendants were found in the storeroom. From these we have collected twelve samples whose partial spectra are shown in Figure 3. The computer classification, summarized in Table 1, assigned eight of these spectra to Baltic amber. The other four spectra, nos. 1570, 1571, 1575, and 1576 differ markedly from those of Baltic amber in that the maximum absorption occurs at 8.2μ with a gradual or stepwise decrease to 8.7μ . We have never before found such a pattern in any sample of Baltic amber, no matter how badly deteriorated it was.

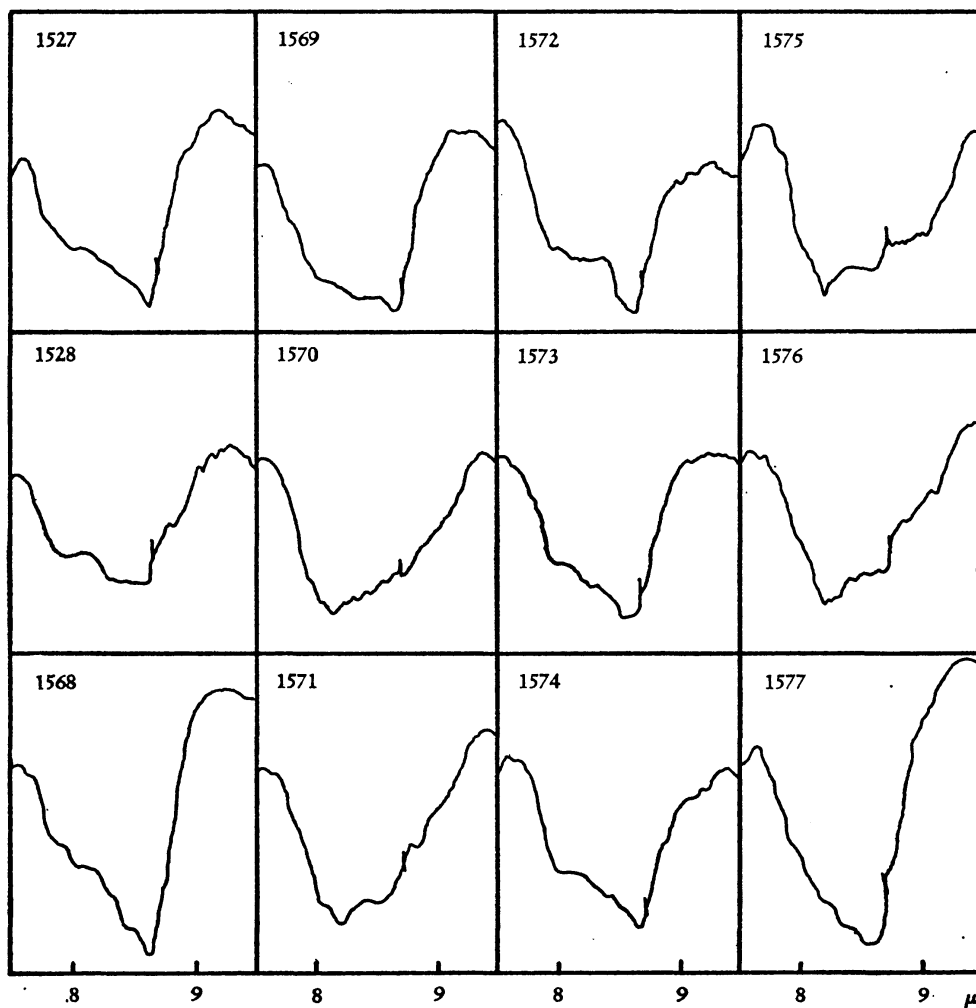


Figure 3. PARTIAL INFRARED-SPECTRA OF AMBER PENDANTS.
KAKOVATOS, THOLOS A

Nor can this unexpected result be laid to contamination, since none of the fragments tested seem to have received any conservation treatment beyond cleaning. The pattern of these four samples is, in fact, the same which we have found in mineralogical specimens of schraufite, a fossil resin native to the Balkans and perhaps to the Lebanon. The computer, which has "seen" spectra of authentic schraufite, promptly classified the spectra of these four pendant fragments as schraufite. The evidence is suggestive but far from conclusive. It invites the notion that some of the pendants may have been made of fossil resins nearer to hand than the Baltic deposits, which in turn suggests local manufacture. But since the majority of the pendants, as of all the other amber objects in Tholos A, are unquestionably of Baltic amber, such an assignment, even if it is correct, does not alter the fact that Mycenaean Kakovatos participated in the amber trade in the Middle Bronze Age.

Tholos A: Various Beads

We return to Müller's description:⁹

"There is further a tubular bead (11mm long, 6mm diameter) and several curious pieces which look like combinations of simple beads. In three specimens two beads with beveled edges appear to be joined (Plate xv, 20; length 27 to *ca.* 45mm) [Figure 2.2]; as two of them have three drillholes, they may have served as links between a single and a double-stranded chain. The third with only two drillholes, as well as a piece which combines three flat beads (Plate xv, 19; length 26mm) [Figure 2.3], may have served to hold several chains together. A similar purpose, possibly to hold the strands of a tassel, can be suspected for a flat piece (Plate xv, 21; width 16mm, thickness 9mm, remaining length 25mm) [Figure 2.4]. It is semicircular at the preserved narrow side, and ten drillholes follow its rounded edge at irregular intervals."

One of the double beads (Figure 2.2), the triple bead (Figure 2.3), and the fragment with ten holes (Figure 2.4) are now part of the mounted exhibit in the National Museum. Because of their uniqueness, we have not taken samples from them. Instead we insert here the analyses of nine fragments of unidentified amber objects from the

⁹ Müller, *op.cit.* (*supra* n.5) 280.

store room. Their partial spectra are shown in Figure 4. Computer classification, as summarized in Table 1, showed six of them to correspond to Baltic amber; the other three (spectra 1537, 1539 and 1542) did not meet the computer's requirements for Baltic amber, but

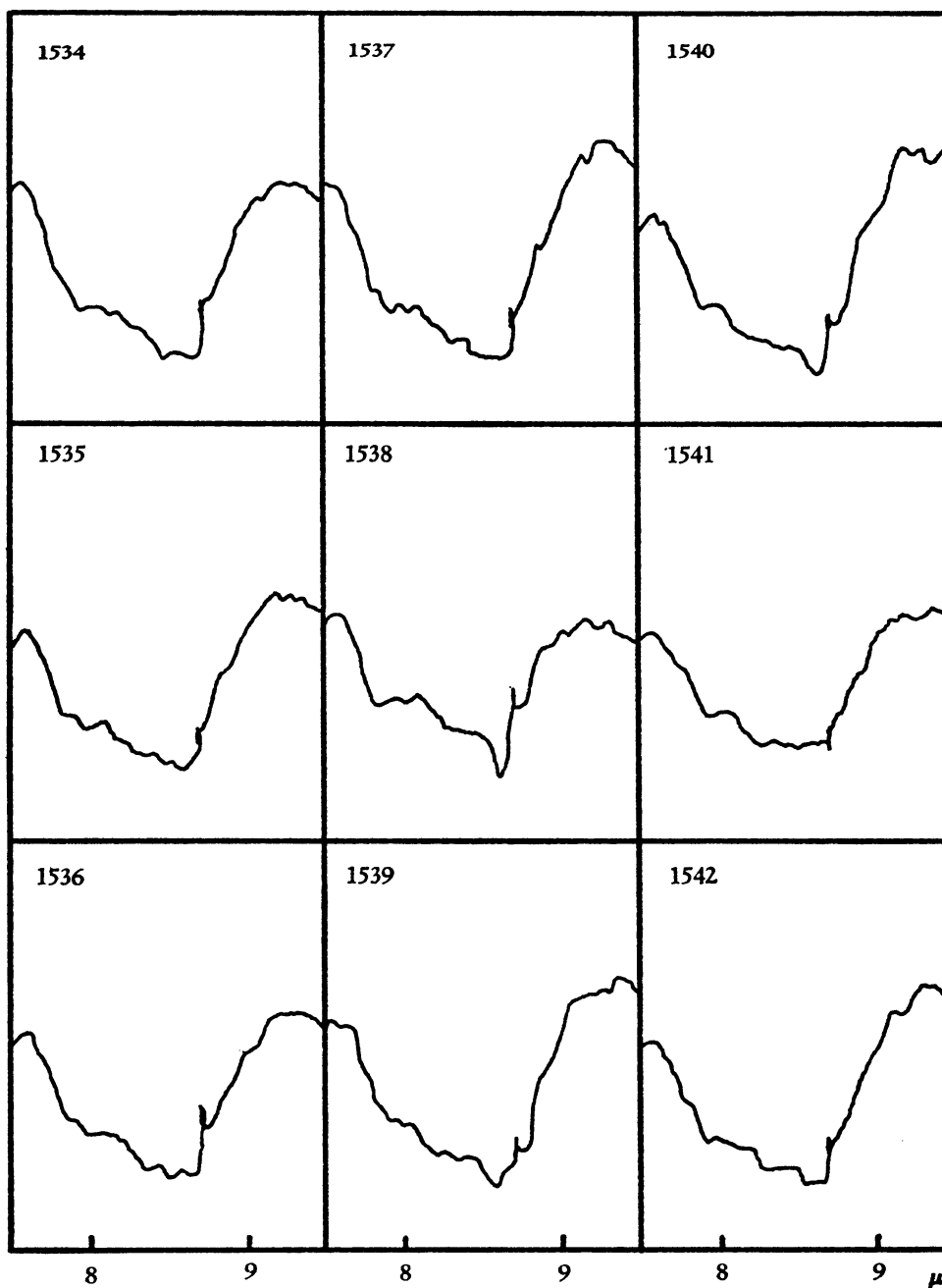


Figure 4. PARTIAL INFRARED-SPECTRA OF UNIDENTIFIED AMBER OBJECTS.
KAKOVATOS, THOLOS A

inspection shows that, unlike the fragments of some of the pendants discussed above, they show no unusual features and are most likely only Baltic amber samples which have weathered beyond the point where computer classification of infrared spectra is possible.

Tholos A: Spacers (Schieber)

The most interesting amber objects from Tholos A are described thus by Müller:¹⁰

“Finally two series of ornaments deserve to be emphasized of which at least one example of each could be reconstructed reliably. The first is a trapezoid plate (7mm thick and 40mm high) with a [transverse] hole and nine [longitudinal] radiately arranged drillings of which the central one passes through the [transverse] hole. The other plate is rectangular, 75 by 38mm with a thickness of 9mm; both its principal surfaces slope slightly towards the narrow ends. It, too, has a [transverse] central hole and in addition 8 parallel [longitudinal] drillings. So far it is reminiscent of the agate platelets [also found in Tholos A]. From the end of each drilling, however, there is a further drilling [actually two except for the first and last] approaching the neighboring drilling at an angle of 45° until it meets the [angular] drilling approaching from it. How were these curious pieces used? One can immediately imagine strings passing through the many drillings, so that here, too, we are faced with members of a necklace. The central [transverse] holes could then have held precious stones to decorate the surface. Yet this explanation does not account for the numerous oblique drillings along the edges of the rectangular pieces. These drillings may have had no purpose other than to reflect light and thus to enliven the [appearance of the] surface. That would of course be equally the case if strings had been passed through them, giving these ornaments a particularly splendid effect.”

In the later German literature these extraordinary objects (Figures 2.5 and 2.6) are called ‘Schieber’, a word which conveys little of their function in that language and less in translation. In English they are sometimes called ‘spacer beads’, but that term should be reserved for the small cylinder discs which are sometimes found separating

¹⁰ Müller, *op.cit.* (*supra* n.5) 280–81.

larger and more or less spherical beads from one another in a necklace. The 'Schieber' are beads only in the broad sense that they have drill holes for stringing; since their purpose was to separate the strands of a multiple necklace from one another, rather than the beads of a single strand, we call them simply 'spacers'.

The spacers from Kakovatos are clearly related to similar ones from western and northern Europe. Merhart¹¹ first compared them with ten spacers from six tumuli of the South German Tumulus Culture (*Hügelgräberkultur*) and found them sufficiently alike to conclude, "that the spacers of Kakovatos are imports from the North will remain a certainty even if the amber used to make them should not be Baltic as is commonly assumed."¹²

Merhart did not extend his view to the amber spacers reported in England by Stukeley,¹³ Hoare,¹⁴ Thurnam¹⁵ and others during the past two centuries. Much later, Milojcic considered the newly discovered spacers of Grave O in Grace Circle B at Mycenae, which dates to about 1525 B.C.¹⁶ He acknowledged the implications of these finds to the dating of the South German Tumulus Culture, and he compared them as well to the spacers of the English Wessex culture, but concluded that only those from Lake, Wiltshire, correspond closely, while the rest are "helpless imitations."

A different view of the relationships between the spacers from Greece, Germany and England has been taken by Hachmann.¹⁷ In an exhaustive investigation, he compared spacers from seven sites in England and forty sites in southern Germany (including Hesse, the middle Rhine, Alsace, Württemberg and Bavaria) with the spacers from Kakovatos and Mycenae, and concluded that the Greek spacers derive from England rather than from South Germany and that the earliest Greek spacers are substantially older than the oldest datable spacers in southern Germany.

The first conclusion is subject to some restrictions: Hachmann himself points out¹⁸ that the spacers from Kakovatos and Mycenae

¹¹ G. von Merhart, *Germania* 24 (1940) 99–102.

¹² von Merhart, *op.cit.* (*supra* n.11) 101.

¹³ W. Stukeley, *Stonehenge* (London 1740) 45 and Plate xxxii.

¹⁴ R. C. Hoare, *The Ancient History of Wiltshire* (London 1812–21).

¹⁵ J. Thurnam, *Archaeologia* 43 (1871) 500ff.

¹⁶ V. Milojcic, *Germania* 33 (1955) 316–19.

¹⁷ R. Hachmann, *Bayerische Vorgeschichtsblätter* 22 (1957) 1–36.

¹⁸ Hachmann, *op.cit.* (*supra* n.17) 13.

correspond closely not only to *some* spacers from England (Upton Lovell,¹⁹ Oakley Down,²⁰ and Huntiscarth (Knowes of Trotty),²¹ but also quite as closely to *some* South German spacers (Hundersingen-Weidenhang,²² Mehrstetten,²³ Melchingen-Hakenrain,²⁴ Upflamör-Lautrieb,²⁵ and Wilsingen-Stockacker²⁶). The spacer from Koblach, Vorarlberg, Austria, should be included in this group.²⁷ Hachmann's relative dating of the German spacers is of necessity limited and vague. As Miss Sandars has pointed out,²⁸ the fact that the first appearance of such spacers in Greece must now be dated to 1600 B.C. or even earlier does not make it necessary to try to date the German specimens to an equally early period; the evidence as reviewed recently by Professor Piggott²⁹ shows "that Aegean, and largely Mycenaean, interest in the west and northwest was not an episode of short duration, but something continuous throughout the whole of the Late Helladic period."

The decision whether the Mycenaean amber spacers with complex borings correspond more closely to those of the English Wessex culture or to those of the South German tumulus culture cannot be made with any finality. Moreover, one may doubt whether it is profitable to champion either relationship. The more important fact is that these spacers are obviously all related, and that we can now add amber spacers from Andrup near Esbjerg on the west coast of Jutland.³⁰

Seen as a whole the distribution of these spacers supports a view of Mycenaean connections with the north of Europe which is now gaining ground:³¹ sea-traffic from Greece to the western Mediter-

¹⁹ W. Cunnington, *Archaeologia* 15 (1806) 127 or 129; Thurnam, *op.cit.* (*supra* n.15) 501; Hachmann, *op.cit.* (*supra* n.17) fig. 12:45, 46.

²⁰ Hoare, *op.cit.* (*supra* n.14) 238.

²¹ S. Piggott, *ProcPS* 4 (1938) fig. 13A; Hachmann, *op.cit.* (*supra* n.17) fig. 2.

²² G. Kraft, *Die Kultur der Bronzezeit in Süddeutschland* (Augsburg 1926) 123 no. D26; Hachmann, *op.cit.* (*supra* n.17) 34 and fig. 11:5-13.

²³ Kraft, *op.cit.* (*supra* n.22) 125 no. E11; Hachmann, *op.cit.* (*supra* n.17) 34 and fig. 9:16.

²⁴ Kraft, *op.cit.* (*supra* n.21) 117 no. B21; Hachmann, *op.cit.* (*supra* n.17) 35 and fig. 9:30.

²⁵ Kraft, *op.cit.* (*supra* n.22) 19 no. C8,5; Hachmann, *op.cit.* (*supra* n.17) and fig. 11:15,21.

²⁶ Kraft, *op.cit.* (*supra* n.22) 120 no. 24,2; Hachmann, *op.cit.* (*supra* n.17) 35 and fig. 10:25,26.

²⁷ N. K. Sandars, *Antiquity* 33 (1959) 292-95, does so include it.

²⁸ Sandars, *op.cit.* (*supra* n.27) 294.

²⁹ S. Piggott, *Sbornik Narodniho Muzea v Praze*, SER. A, 22 (1966) 117-25.

³⁰ E. Lomberg, *Antiquity* 41 (1967) 221-23.

³¹ E. G. J. Bouzek, *Památky Archeologické* 57 (1966) 242-76; Piggott, *op.cit.* (*supra* n.29); K. Randsborg, *Acta Archaeologica* 38 (1967) 1-27.

anean, whence an overland route along the Rhone–Rhine valleys leads to England and Scandinavia. The South German spacers then could have emanated from Alsace eastwards;³² although a separate (and possibly later) connection between Jutland and southern Germany is an alternative possibility that may help to solve the problems in the chronology of the German spacers.

But the evidence for a land route across eastern Europe is by no means negligible. Finds of Mycenaean origin or affinity, as summarized most recently by Sulimirski,³³ leave little doubt that there was a lively traffic between the Aegean and the Danube Basin between the eighteenth and thirteenth centuries B.C. Whether the concentration of such finds in Denmark during this period is necessarily a direct extension of this thrust remains a question to which Sulimirski's map gives no clear answer. But it would be most unreasonable to deny that some exchange will likely have taken place across the narrow and well-populated gap which remains between central Europe and Jutland.

The choice between a western sea route and an eastern land route is therefore one it might be wiser to reject than to make. There is no reason why the two should be mutually exclusive. There is an analogy to such a solution in Hencken's compelling analysis of the distribution of the Herzprung shields of later times.³⁴ He showed that the V-type shields spread from the Aegean by a western sea route *via* Spain to Ireland, while the U-type shields traveled by an overland route from the head of the Adriatic to Denmark and thence to Ireland. This overland route is, of course, the main Iron Age amber route; Navarro³⁵ has shown that it was of little if any consequence until about 1000 B.C., and thus it cannot be drawn upon to map the Mycenaean amber trade.

To repeat, we are not suggesting that Hencken's Herzprung paper describes the trade routes of a period which lies 600 to 800 years farther in the past, but we do think that it provides the model for the

³² F. A. Schaeffer's opinion (*Les Tertres funéraires préhistoriques dans la Forêt de Haguenau* I [Haguenau 1926] 262) that the Alsatian amber is likely of Italian provenance is based on the most tenuous chemical evidence and should be ignored until a spectral analysis of these finds has been made.

³³ T. Sulimirski, in *Teki Historyczne* (London 1966–68) 3–27.

³⁴ H. Hencken, *AJA* 54 (1950) 295–309.

³⁵ J. M. de Navarro, *GeogrJ* 66 (1925) 481–507.

kind of pincer movement which seems to fit the evidence for the amber trade in Late Mycenaean times. The western prong would have reached across the length of the Mediterranean and then across France to Wessex and ultimately to Jutland. The eastern prong would have led up the Danube and reached Denmark across Germany.

Whether the two routes were entirely synchronous, overlapped, or succeeded each other is a question which would merit further examination. It is tempting to hope that the problems which have arisen from the amber spacers found in France, South Germany, Austria and Bohemia could be much reduced by considering that some of them may be offshoots of the western route while others emanate from the eastern one.

We return to the simpler matter of analyzing the amber of the Kakovatos spacers.³⁶ Two large fragments are mounted on the board for exhibition in the National Museum. No samples have been taken from these. Five more large pieces were found in storage. They are listed in Table 1 as S, T, U, V and W. S is a roughly rectangular fragment (height 32mm; width 20mm; thickness 9mm) which retains one complete boring and one along each edge of fracture. T is a trapezoidal end-spacer (height 23mm; maximum width 21mm; thickness only 5mm) which appears essentially complete. Since it is smaller and has only four radiately arranged borings, it cannot be the end-piece described and pictured by Müller or even have likely been part of the same assembly. U is also apparently complete, rectangular (height 27.5mm; width 20mm; thickness 8.5mm), and with three parallel borings. V is a large fragment of a rectangular piece (height 32.5mm; width 30mm; thickness 9mm) with three parallel borings. W is another fragment of a rectangular plate (height 23mm; width 23mm; thickness 9mm) with two intact parallel borings and one along the edge of fracture.

Samples from these five spacers and from ten unmarked small fragments of spacers were analyzed. As shown in Figure 5 and Table 1, fourteen of these samples give spectra which the computer classified as those of Baltic amber; the exception, spectrum 1567 of spacer sample 10, differs only very slightly from the others and fails the computer test by a hair.

³⁶ Spectral analyses of the spacers from Grave *Omicron*, Circle B, of Mycenae will be reported in the next paper of this series.

Tholos B

Müller³⁷ lists only “one small bead of amber,” but gives neither a description nor an illustration. We have not been able to find it in the National Museum at Athens. For a possible but unverifiable identification of this bead, see *infra*.

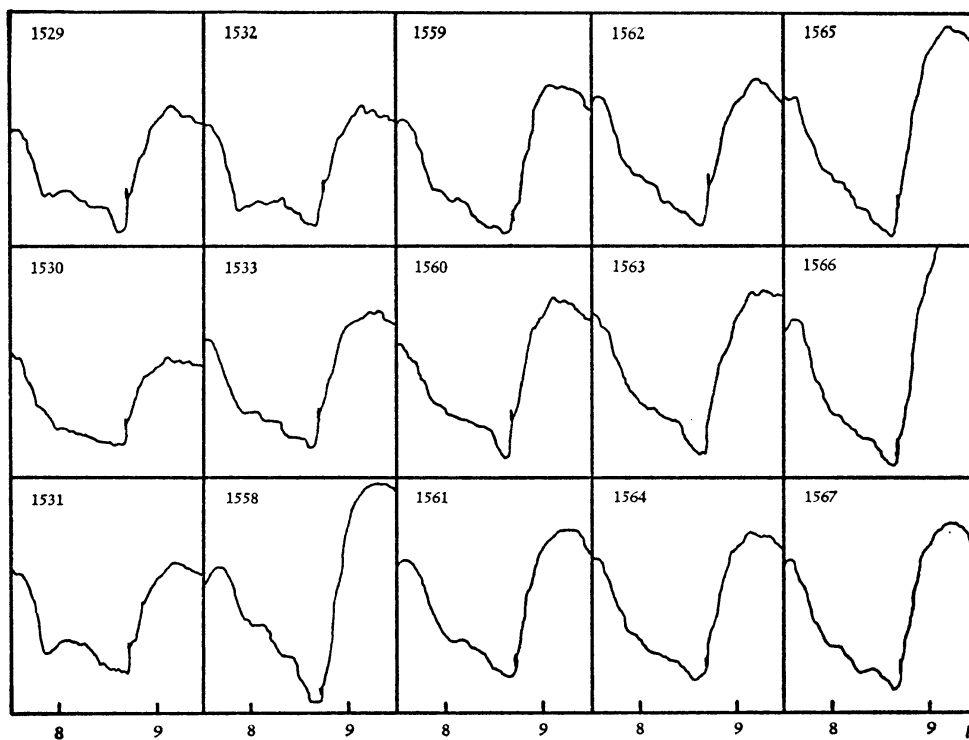


Figure 5. PARTIAL INFRARED-SPECTRA OF AMBER SPACERS.
KAKOVATOS, THOLOS A

Tholos C

Müller³⁸ describes “seven small and one larger drilled amber beads in the form of very flat plates. Diameters 8–12mm and 20mm, respectively.”

Mounted on a small board in the National Museum, together with seven amethyst beads, a plane-convex disc of rock crystal, a gold button and fragments of gold leaf and bronze, there are four amber beads. Three of them are more or less uniform in shape and size:

³⁷ Müller, *op.cit.* (*supra* n.5) 295.

³⁸ Müller, *op.cit.* (*supra* n.5) 301.

cylinder discs with diameters of 8–10mm. The fourth is a distinctly oval drilled bead with a short axis of 17mm and a long axis of 20mm. Found unmounted in a box labeled “Tholos C” were another four amber beads and some unidentifiable fragments. Three of the beads are again cylinder discs with diameters of 9–11mm, quite like the three mounted beads. The fourth unmounted bead has a diameter of 20mm and is somewhat irregular in shape, rather suggestive of an octagon with alternately long and short sides. We have thus six small and two large beads, rather than seven small and one large bead as listed by Müller. It is possible that one of the small beads has been broken into the unidentifiable fragments found. The unlisted larger bead may then actually be the one which Müller described from Tholos B.

We have analyzed samples from each of the four unmounted beads. These are listed as samples A–D in Table 2. Eight of the unidentified fragments are also listed in this table as Samples A¹–H¹. Partial spectra of all twelve samples are shown in Figure 6. Computer classification identifies eight of the twelve spectra as those of Baltic amber. Of the exceptions, spectrum 1516 shows extensive deterioration, spectrum 1519 shows reverse absorption like spectra 1570 and 1571 in Figure 3, and spectrum 1520 fails the test because of a minutely positive slope between 8.2 and 8.4 μ , but is otherwise visually recognizable as a typical Baltic amber spectrum.

TABLE 2. SPECTROSCOPIC CLASSIFICATION OF AMBER FROM THOLOS C
AT KAKOVATOS

<i>Sample Designation</i>	<i>Spectrum Number</i>	<i>Computer Classification</i>
A	1515	Baltic
B	1516	non-Baltic
C	1517	Baltic
D	1518	unclassifiable
A ¹	1519	schraufite?
B ¹	1520	non-Baltic?
C ¹	1521	Baltic
D ¹	1522	Baltic
E ¹	1523	Baltic
F ¹	1524	Baltic
G ¹	1525	Baltic
H ¹	1526	Baltic

Figure 6 contains one partial spectrum which is wildly erratic: spectrum 1518 shows intense, broad absorption between 9 and 10 μ which completely destroys any resemblance to *any* fossil resin spectrum. This is probably caused by a major inorganic impurity, *i.e.*, dirt. The computer, precisely following its program written for resin spectra, was unable to cope with this glaring difference and pronounced the spectrum as one of Baltic amber. This is an instructive example of the obvious but easily forgotten limitations of the computer approach: the gain in objectivity is of necessity a loss of judgement, and an amber spectrum should not be entrusted to the computer without a previous check for gross impurities.

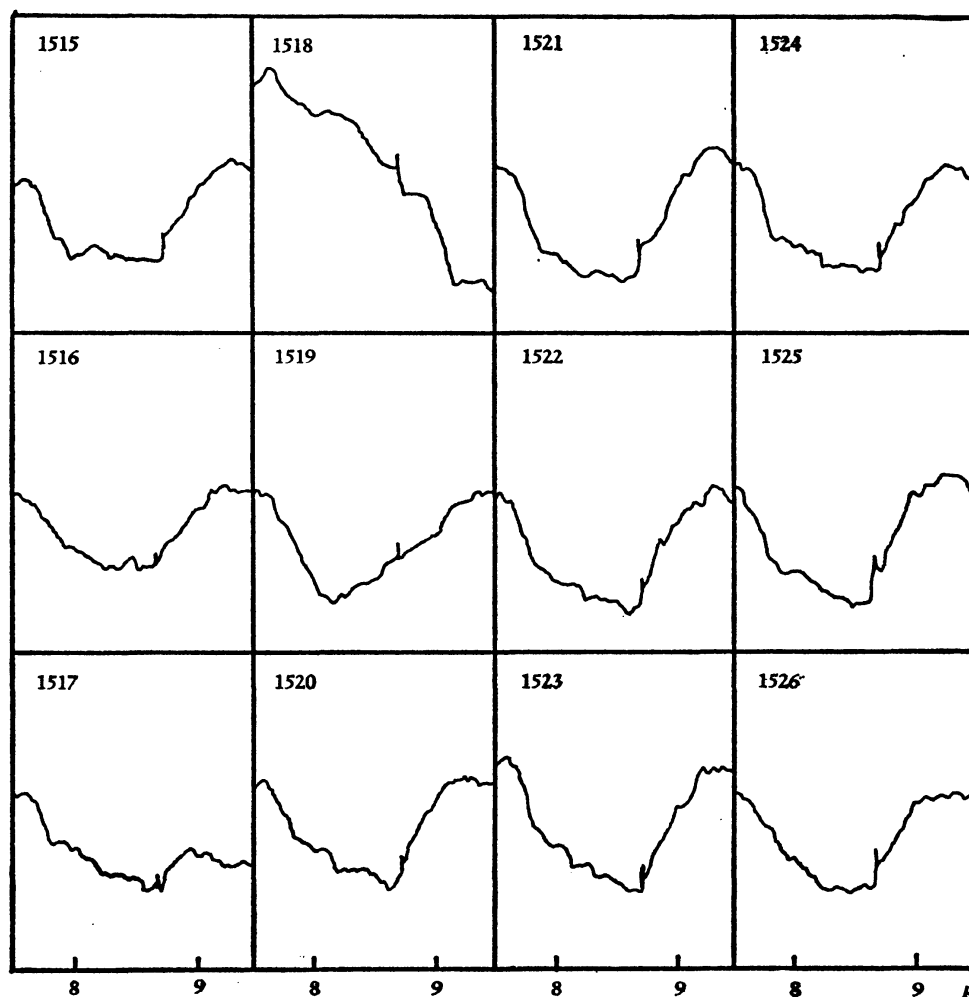


Figure 6. PARTIAL INFRARED-SPECTRA OF AMBER BEADS. KAKOVATOS, THOLOS C

Conclusion

Of the 59 samples of amber from the *tholoi* of Kakovatos, 46 have been identified as Baltic amber, five (spectra 1570, 1571, 1575, 1576 and 1519) may be schraufite of Balkan or eastern Mediterranean origin, and eight are unidentifiable because of extensive deterioration, though three of these are so similar to spectra of Baltic amber that their failure to pass the computer test is not significant.

This establishes that at least the raw material of most if not all of the amber from Kakovatos must have been imported. The amber can only have come from northern Europe, since the number and size rules out southern Russia, where occasional pieces of Baltic amber occur naturally.³⁹ Our findings thus agree with those of Jonas,⁴⁰ who had analyzed one of the Kakovatos beads by an indirect and questionable⁴¹ adaptation of the succinic acid test.

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³⁹ C. W. Beck, *GRBS* 7 (1966) 209–11.

⁴⁰ R. Jonas, *Schriften der Physikalisch-Ökonomischen Gesellschaft zu Königsberg* 49 (1908) 351–68.

⁴¹ Beck, *op.cit.* (*supra* n.39) 197–200.