

A BRONZE SITULA FROM TOMB 128, VALLE TREBBA: CHEMICAL EVIDENCE OF RESINATED WINE AT SPINA

(Con la tav. XXXVII f.t.)

Among the banqueting bronzes recovered in Tomb 128 of the Valle Trebba necropolis at Spina were two matching situlae, one of which (inv. 2323) preserves a rather amorphous mass of organic residue in the bottom (*tav.* XXXVII)¹.

The inhumation tomb, probably of a male, was marked by a concentration of «pietrame informe saldamente cementato»² and the skeleton, disposed E/W on a platform of oaken planks, lay c. 1.60 m. below the surface. According to the field notes and sketches of Francesco Proni, the funerary objects – Attic vases, Italic pottery, bronzes of various types including an impressive wine service, silver fibulae, and diverse iron, alabaster and wax objects – were disposed along both sides of the deceased, with the two situlae to the left of his feet³. To judge by the latest grave goods, the tomb was probably closed in the late fifth century, though certain objects date as early as c. 500-480 B.C.

The two situlae, of Giuliani-Pomes stamnoid-situla type C⁴, are not uncommon in the wealthier Etruscan tombs of the Po Valley, including those of Felsina and Marzabotto, and have been recovered throughout Etruria, often in necropoleis of cities linked to wine production such as Todi, Populonia, Volsinii and Chiusi.

¹ We are deeply grateful to Dr. Fede Berti, Director of the Museo Nazionale Archeologico di Ferrara, for permission to analyze the residue.

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On Tomb 128, see AURIGEMMA 1960, 46-62; MASSEI 1978, 10-12; and HOSTETTER 1986, 15-19, 32-33, 102-103, nos. 1-2, 8, 73. On bronze banqueting services, BOULOUMIÉ 1986, 63-79 and HOSTETTER 1991, 86-106.

² AURIGEMMA 1960, 46.

³ Not to the right of his right shoulder, as they are depicted in later redrawings by Aurigemma (1960, figs. on 46-47), in which the direction of the skeleton in relation to the grave goods appears to have been reserved.

⁴ GIULIANI-POMES 1957, 39-54. See also BOULOUMIÉ 1977, 31-32.

The grave goods from Tomb 128 and pertinent tomb groups elsewhere generally suggests that these two situlae date in the second half of the fifth century, and probably in the last quarter.

The organic residue amassed on one side of the base of the situla is blackish brown in color. The sample was taken by scraping away and discarding the surface material in one small area, then scraping further residue from beneath the surface. The inner core of the residue appears lighter, more amber in color than the surface, and gives off a slighty sweet aroma.

ANALYSIS

The analysis of this residue was first proposed by S. Aurigemma in 1960⁵ but at that time there were no analytical methods that could have given a reliable account of the composition of a complex organic mixture. Since then, the techniques of instrumental analysis have sufficiently advanced to allow the characterization of even minute amounts of organic archaeological remains. Infrared and nuclear magnetic resonance spectroscopy, various chromatographic techniques, and especially the combination of gas chromatography with mass spectrometry have been successful in identifying olive oil and wine⁶ and food residues⁷ in ceramics, the provenience analysis⁸ and chemical structure⁹ of fossil resins, and the composition of tars and pitches used as linings of transport amphorae and in nautical practice¹⁰.

The organic residue in the Spinetic situla was analyzed by gas chromatography – mass spectrometry. The sample was dissolved in diethyl ether and treated with an ethereal solution of diazomethane to convert free carboxylic acids to their methyl esters. The resulting solution was injected into a Hewlett-Packard Model 5995 Gas Chromatograph – Mass Spectrometer equipped with a Hewlett-Packard Model 9153C Workstation. The capillary column (15 m × 0.25 mm) had a stationary phase of RSC-150 poly(dimethylsiloxane). The initial column temperature was 100°, and was raised at the rate of 5° C/minute to 250° C. To improve data recovery, two total ion chromatograms were recorded: one covers the entire range (*fig. 1*: retention times 0-30 minutes) but shows only the high-molecular weight diterpenoid components which comprise more than 97% of the sample; another, at higher amplification, covers only the low range (*fig. 2*: retention times 0-18 minutes) to

⁵ AURIGEMMA 1960, 59.

⁶ CONDAMIN and FORMENTI 1976. See also BIERS and MCGOVERN 1990, *passim*.

⁷ ROTTLÄNDER 1990.

⁸ LAMBERT and FRYE 1972; BECK 1986.

⁹ MILLS, WHITE and GOUGH 1984/1985.

¹⁰ EVERSHED, JERMAN and EGLINTON 1985; ROBINSON *et al.* 1987; REUNANEN, EKMAN and HEINONEN 1989; BECK, SMART and OSSENKOP 1989; BECK and BORROMEO 1990.

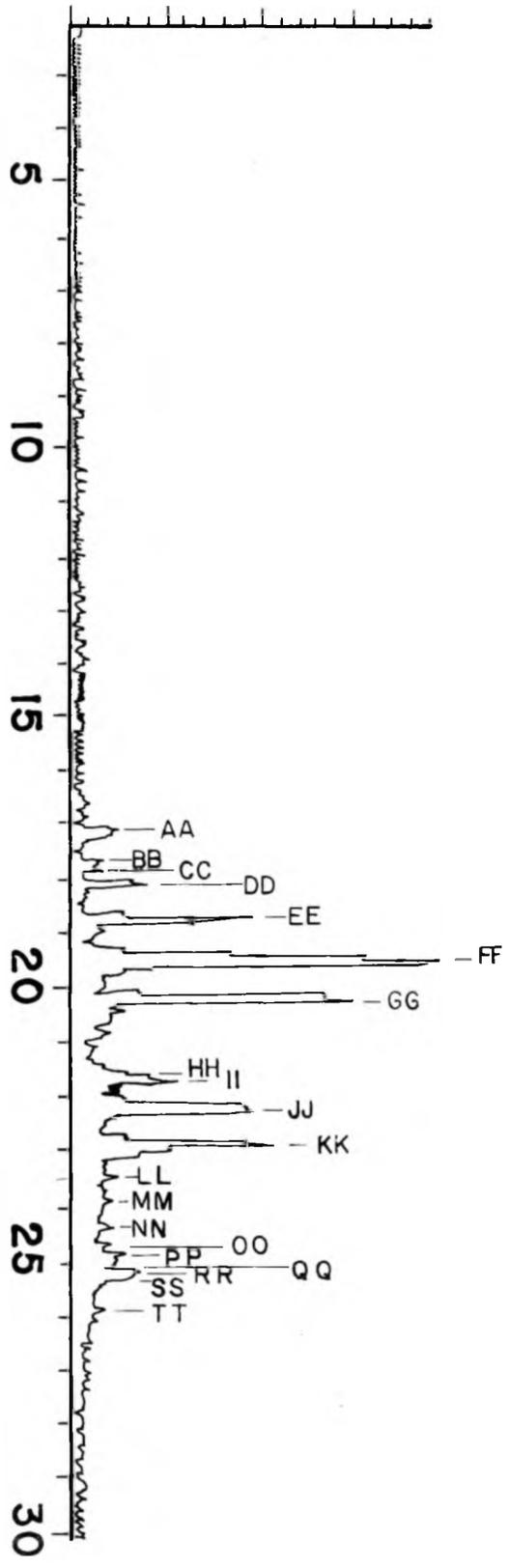


fig. 1 - Total ion chromatograms of Spinetec resin: TIC over entire range.

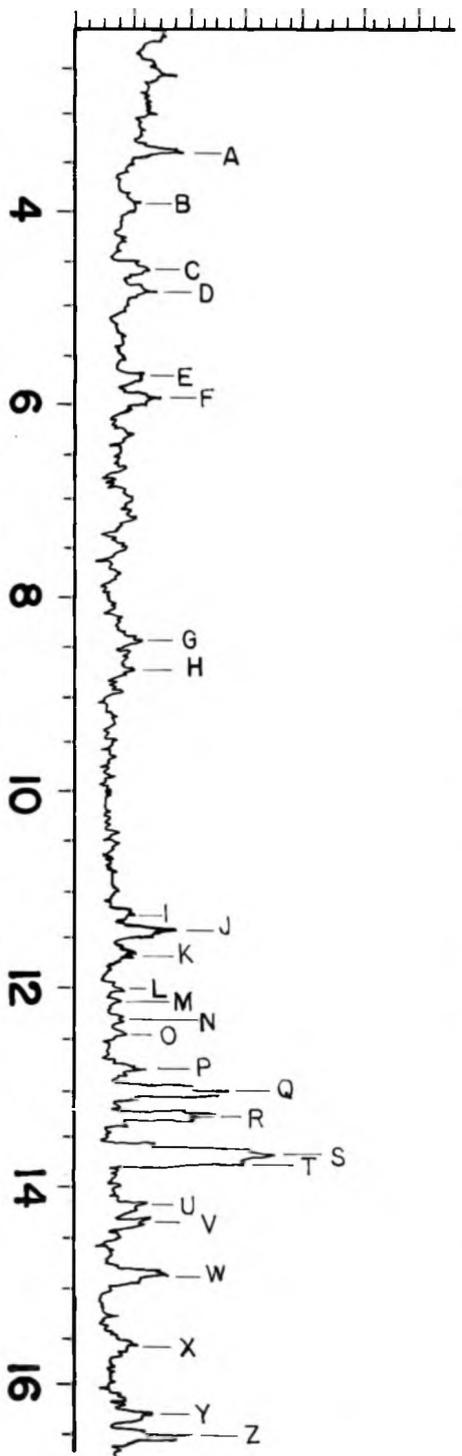


fig. 2 - Total ion chromatograms of Spinetec resin: Enhanced TIC of lower range.

reveal the minute amounts of monoterpenoids, sesquiterpenoids, and degradation products with low molecular weights. *Table 1* summarizes the analytical data. The first column lists the component peaks from A to Z for the low, and from AA to TT for the high range. The second gives the mass units of the molecular peak, i.e., the molecular weight, and, in parentheses, the intensity of that peak to the nearest integer. A question mark indicates that the assignment of the molecular peak is uncertain. The last column lists the 10-12 most prominent peaks in decreasing order of intensity, which is given in parentheses. *Table 2* presents the identification of the peaks A to Z and AA to TT as far as it has been possible to establish it, beginning with their molecular formulas. For fully identified components, the next column gives the common name rather than the more elaborate IUPAC name, but the next column adds the Chemical Abstracts Service Register Number for unambiguous identification. For components whose structures are not identified with certainty, a general description of their probable structure is provided. The last column lists the amount of each component calculated as a percentage of the 46 peaks. It should be pointed out that these percentages are based on total ion chromatogram and are rather less accurate than those obtainable with a flame-ionization detector. They are, however, more than adequate to support the arguments made. The identification of the components was aided by comparison to published reference spectra¹¹. Discrimination between epimers with very similar mass spectra was made by using their retention times taken from Mills¹².

RESULTS

The first 26 components (peaks A to Z in *fig. 2*) are present in exceedingly small amounts, ranging from 0.01% to 0.22%, and together comprise 2.85% of the total. Because these peaks are so small, their mass spectra are unreliable and their identification has been difficult. Eight of them yield no clearly recognizable molecular ions, so that no molecular formula could be established. The others, however, provide useful information even in those cases where the structures are uncertain. Peak A is methyl cumate, an oxidation product of a monoterpene with a menthane skeleton. Peak B is certainly a sesquiterpene, and peaks F and G are likely to be sesquiterpenoids. Peak P is methyl palmitate, an established constituent of pine resins. Peak D is the antioxidant added to commercial ether, and thus an extraneous contaminant¹³. The remaining twelve peaks are

¹¹ ZINKEL, ZANK and WESOLOWSKI 1971; *Mass Spectrometry Data Centre* 1983; MILLS, WHITE and GOUGH 1984/85; PHILP 1985; McLAFFERTY and STAUFFER 1989 (hard copy edition and CD-ROM computer version); REUNANEN, EKMAN and HEINONEN 1989.

¹² MILLS, WHITE and GOUGH 1984/85.

¹³ Introduced by the diethyl ether used to dissolve the samples.

degradation products of the original resin components. One of these, an alkyl-naphthalene (peak E) can be derived from a sesquiterpene. Four other, i.e., phenanthrene (peak H), two alkylphenanthrenes (peaks J and U), and deisopropyldehydroabietate (peak W) can only be obtained from tricyclic diterpene resin acids. Six have structures that more specifically indicate derivation from resin acids with the carbon skeleton of abietic acid: an abietatriene (peak V), an abietadiene (peak Y), two norabietatrienes (peaks Q and S), simonellite (peak X), and secodehydroabietate (peak Z). The mass spectrum of peak L closely resembles that of isophyllocladene, a diterpene hydrocarbon not reported from the genus *Pinus*; it can be seen as a rearrangement product of abietadiene.

The major components of the Spinetic resin are represented by the peaks AA to TT in Table 2. They include two more degradation products of abietic acid derivatives: peak AA is retene, and peak BB is an abiatetriene isomeric with peak V. The next group of compounds are unchanged diterpene resin acids: pimaric acid (peak CC; 0.72 %), sandaracopimaric acid (peak DD; 2.05%), isopimaric acid (peak EE; 6.82%), and abietic acid peak (peak GG; 14.12%). A total of 23.71% of unchanged resin acids is remarkable in a material that must have suffered considerable post-depositional changes in two and one half millenia; if we add the dehydroabietic acid (a disproportionation product of abietic acid) of peak FF (23.13%), the total percentage of the diterpene resin acids rises to 46.84 and the ratio of abietic structures over pimaric/isopimaric structures is almost 4:1, as is the case in recent pine resins. The remainder of the components of the Spinetic resin are oxidation products of the original resin acids. Most prominent among these is the 7-oxo-dehydro-abietic acid (peak KK; 11.03%). For the other oxidation products we have been able to establish the molecular composition, but the structures are tentative. There are three isomeric monohydroxy-derivatives (peaks HH, NN and QQ; total 4.32 %) and one apparent trihydroxy-derivative (peak TT; 1.27%) of the original doubly unsaturated resin acids. More prominent are the oxidation products of the more stable triply unsaturated dehydroabietic acid: three monohydroxy-derivatives (peaks II, JJ and LL; total 18.63%), and two dihydroxy-derivatives (peaks OO and PP; total 3.75%). Finally, three components have the compositions of hydroxy-oxo-dehydro-abietic acids (peaks MM, RR and SS; total 9.32%). Together, the thirteen oxidation products comprise nearly half (48.32%) of the total ion chromatogram.

Thus, the Spinetic resin consists predominantly of unchanged diterpene resins acid and of their oxidation products, the predominant structural type being that of abietic acid. Degradation products that are known to result from heating and that comprise a large portion of tars and pitches¹⁴ account for less than five

¹⁴ ROBINSON *et al.* 1987; REUNANEN, EKMAN and HEINONEN 1989; BECK, SMART and OSSENKAMP 1989; and BECK and BORROMEO 1990.

percent of the resin. At the time of its use, the resin was a fresh pine resin, and was probably added to impart a resin flavor to wine, even though no traces of wine (i.e., pigments or tannin) were detected.

DISCUSSION

The persistence of pine resin in ancient *retsina* has been questioned on the grounds that the diterpenoid components would be insufficiently soluble in wine and the mono- and sesquiterpenoid components would have been lost by evaporation¹⁵. The latter is certainly true; the former is irrelevant if the resin was left in the wine, as could be the case (Dioscorides V, 34 Wellman). The present analytical evidence can leave no doubt that the Spinetic *situla* contained fresh pine resin. The absence of more than minimal amounts of thermal degradation products conclusively rules out the use of pine pitch either as a deliberate addition or as the incidental results of storing wine in pitch-lined vessels. The coating of the interior surfaces with pitch, common and necessary to render porous clay amphorae impermeable, is not applicable to a seamless metal vessel. It is possible that the *situla* could have been lined in order to prevent acidic wine from assuming a somewhat disagreeable metallic taste, or at least to mask that taste, but this, too, would appear unlikely given the amount and the concentration of the pine resin present¹⁶. For this same reason, the addition of the resin solely as a conservation agent is perhaps unlikely¹⁷.

The addition of resin or pitch to wine is well attested in ancient Greece and Italy, the commonly stated intentions being to flavor wine, either because the taste of resin was itself desirable or to disguise or improve the taste of a poor vintage, to conserve, or to line permeable clay amphorae¹⁸.

¹⁵ SHACKLEY 1982.

¹⁶ TCHERNIA 1990, 67, on the boiling of new wine (*defrutum*) in copper cauldrons, causing the wine to assume an unpleasant taste.

¹⁷ On the treatment of wine with pitch, for taste and conservation, including the antiseptic effect exerted by resin in wine, see TCHERNIA 1990, 67-73.

¹⁸ On the varied use of pine resins and pitches, including discussion of the many ambiguities in the ancient terms, see ANDRÉ 1964, 86-97 and, more recently, TCHERNIA 1990, 65-74. For collected selected sources on wine, CHEVALLIER 1990, 3-13.

Among them: DIOSCORIDES (V, 34 Wellman) relates that resinated (*ρητινίτης*) wine was made in many countries, but especially in Galatia, where wine grows sour unless mixed with resin (*πέυκη*), which may mean any pine, but especially the Corsican pine *Pinus laricio*, the stone pine *Pinus pinea*, and the Aleppo pine *Pinus halepensis* (M. G. LIDDELL, R. SCOTT, H. STUART JONES and R. MCKENZIE, *Greek-English Lexicon* (9th ed.), s.v. *πέυκη*); the recommended amount to be added is put at one half *hemina* (four ounces) to an amphora (six gallons). Dioscorides (V, 38 Wellmann) also speaks of *οἶνος πικρότης*, usually translated as pitch wine, but which is probably wine mixed with fresh

The literary evidence regarding wine from Etrusco-Italic territory, resinated or otherwise, derives primarily from later sources. Strabo (4.6.2) and Pliny (*N.H.* XIV, 124) both state that the Ligurians mixed their rather harsh wine with pitch. Bouloumié has described the regions of Etruria in which fine and less fine wines were produced¹⁹. One of the latter was Veii, whose vintage contrasts with those of other regions for its poor reputation and its evident need of doctoring. Horace (*Sat.* II, 3, 143-144) and Martial (*Epigr.* I, 103, 9; II, 53, 4; III, 49, 1) both allude to the inferior quality of wine from Veii, while Persius (*Sat.* V, 147-148 Lee) is the most abusive in his comment: «*Veientanumque rubellum / exhalet uapida laesum pice sessilis obba*», or, «a squat beaker reeking of the little Veientine rosé spoiled by rotten pitch»²⁰.

In Etruria, as elsewhere, the production of *vinum picatum* is corroborated by archaeological evidence. Etruscan amphorae recovered undersea off the Midi preserve traces of pitch on their walls²¹, and Etruscan and Italic bronze situlae and stamnoi preserving traces of resin or pitch have been found in Etruscan and Italic burials and, further north, in Celtic graves of roughly the mid-fifth century, evidently the residue from *vinum picatum*²². According to Bouloumié, the presence of these residues within Etruscan bronze vessels recovered in northern Alpine regions where Etruscan wine amphorae are lacking, suggest that wine there was commonly transported in skins which did not require inner coatings of pitch – and hence that the addition of resin or pitch to wine in the bronze vessels was done solely for the sake of the particular flavor it imparted.

In the city of Spina, the presence of imported resinated wine is attested by resin or pitch-lined sherds of Corinthian amphorae. The analysis of the lining, «incrostazioni nerastre e vischiose, tenacemente attaccate alla parete»²³ on c. 150 of these sherds has shown it to be coniferous resin, possibly of Aleppo Pine (*Pi-*

resin because his prescription of washing the 'pitch' with sea-water or brine until it is white leaves no doubt that this is fresh resin, and not pitch in our sense of the word. *πίσσα* (Attic *πίτρα*) may mean either fresh resin or the black pitch made from it. In this recipe, the amount added is one or two ounces for eight *congi* = one amphora.

Cato (*de agri cultura* 110, 113) describes how the odor and aroma of wine can be improved, although it is uncertain whether the word used for pitch (*picatus*, from *pix*), refers to fresh resin or to the pitch made from it. Pliny (*N. H.* XIV, 122-123) lists a wide variety of resins that were added to wine – including terebinth, mastic, cypress resin, cedar resin, white 'Arabian resin', resin of Judaea, Syrian resin, resin of Colophon, and a pitch-pine resin called *psagdas*.

¹⁹ BOULOUMIÉ 1983, 165-178.

²⁰ Translation: M. PARCA.

²¹ BOULOUMIÉ 1983, 170; BOULOUMIÉ and LIU 1976, 211-217.

²² BOULOUMIÉ 1978, 7 and *passim*, and BRAVAR, 1983, 138. See, too, BOULOUMIÉ 1985, 167-178.

²³ On the walls rather than in the bottom, hence clearly a lining rather than an addition intended only to flavor: DESANTIS 1989, 104, note 18.

nus halepensis), which is found more or less around the entire rim of the Mediterranean Sea²⁴.

Evidence for viticulture at Spina exists in the form of the bundles of vine twigs and shoots commonly used in the reclamation of swampy terrain in the port city²⁵. Evidence for local resinated wine at Spina – albeit circumstantial and late – is offered by Pliny (*N. H.* XIV, 124), who relates that the new wine of the Po Valley was flavored with resins, probably drawn from local pines which evidently grew in the dunes along the coastline²⁶. Whether the Spinetic situla and, as Desantis suggests, the locally produced amphorae from the emporium contained local wine cannot be known. If they did, one may recall the nectar-sweet Adriatic wine, evidently exported to Greece, mentioned by Antiphilus (*A. P.* 6, 257, 2) in the first century A. D., and the vintages Pliny (*N. H.* XIV, 67) says were produced *mox ab intimo sinu maris Hadriana* – a description which has been considered as a possible generic appellation for wine from the Upper Adriatic rather than from Adria alone²⁷. Whatever the case, the residue contained in the situla from Tomb 128 of Valle Trebba clearly shows that fresh pine resin was either mixed or intended to be mixed with (local?) wine, probably in order to achieve a particular coniferous bouquet.

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²⁴ DESANTIS and SEDDA 1989, 124-127, with distribution of Aleppo pine in *fig. 1d*. The suggestion of Aleppo Pine is based only on a apparent visual similarity in the spectra of the resins analyzed to those of modern Aleppo Pine. Unfortunately, Desantis and Sedda do not individually identify the sherds examined, which disallows any rough dating of the vessels' coatings. On the process of coating clay vessels with pitch, TCHERNIA 1990, 66.

²⁵ UGGERI 1984, 42, who also points out that grape vines were also present at inland Iron Age settlements, like that of Fontanellato (Modena), where it would be more difficult to hypothesize Greek imports.

²⁶ UGGERI 1984, 41-42.

²⁷ FOGOLARI and SCARFI 1970, 43.

Table 1 - Mass Spectra of 46 components of Spinetic resin

Peak	MW (Int)	Fragments and (Intensities)
A	178(44)	163(100) 91(53) 119(42) 59(37) 41(36) 103(33) 77(33) 131(29) 147(28) 78(21) 117(19)
B	204(7)	41(100) 58(81) 59(75) 55(64) 43(44) 56(42) 45(40) 67(36) 69(35) 42(30) 91(28)
C	180?(11)	43(100) 179(73) 59(37) 77(22) 91(18) 163(16) 135(15) 105(15) 76(14) 146(13) 131(13)
D	220(34)	205(100) 57(45) 41(34) 58(33) 206(24) 55(19) 145(18) 127(17) 45(15) 129(14) 69(14)
E	184(47)	169(100) 141(28) 153(27) 170(23) 155(20) 152(20) 115(18) 128(17) 165(12) 139(12) 68(12)
F	206(43)	41(100) 109(94) 83(85) 55(77) 107(69) 108(50) 67(47) 91(41) 53(39) 135(38) 79(36)
G	212(9)	43(100) 153(33) 135(30) 41(25) 71(18) 197(17) 11(16) 55(13) 83(10) 79(10) 110(9)
H	178 (100)	176(22) 179(18) 76(15) 151(12) 150(11) 88(11) 152(10) 89(10) 57(10) 60(7) 49(7)
I	212?(14)	41(100) 134(85) 92(67) 181(61) 43(58) 69(45) 123(44) 91(41) 107(37) 55(36) 197(35) 119(35)
J	192 (100)	191(61) 134(47) 92(37) 41(29) 189(26) 193(23) 55(20) 190(19) 117(17) 159(16) 91(15)
K	242?(17)	41(100) 135(93) 145(71) 131(70) 205(67) 227(61) 123(58) 43(51) 143(49) 94(47) 157(44)
L	272(25)	120(100) 134(92) 119(79) 145(75) 173(74) 71(73) 51(71) 83(62) 82(62) 41(61) 97(59)
M	192?(7)	41(100) 43(91) 55(59) 69(40) 59(38) 91(38) 42(36) 81(34) 44(33) 95(31) 67(31)
N	252?(32)	119(100) 43(29) 121(28) 59(28) 133(27) 83(24) 107(21) 91(21) 123(20) 78(20) 55(19)
O	154?(12)	55(100) 41(83) 57(78) 111(57) 43(57) 82(55) 53(55) 106(43) 97(43) 70(42) 68(41)
P	270(23)	74(100) 43(58) 41(58) 55(35) 143(28) 75(25) 254(21) 213(19) 157(18) 69(18) 42(18)
Q	256(29)	241(100) 159(98) 43(63) 41(40) 185(25) 117(22) 55(20) 143(19) 129(17) 91(15) 105(12)
R	276(11)	239(100) 197(53) 41(49) 43(47) 275(45) 257(37) 55(35) 81(30) 254(26) 67(23) 141(21) 177(17)

Peak	MW (Int)	Fragments and (Intensities)
S	256(36)	241(100) 159(98) 41(37) 185(35) 43(34) 117(23) 242(22) 128(21) 129(20) 55(20) 206(18) 143(17)
T	276(19)	43(100) 275(75) 257(68) 41(62) 67(41) 81(40) 206(38) 95(26) 191(24) 79(23) 53(21) 91(19)
U	220(66)	205(100) 202(36) 178(31) 189(24) 190(22) 206(21) 165(20) 145(20) 221(18) 211(18) 71(18) 47(15)
V	270(44)	255(100) 41(88) 43(88) 193(79) 250(63) 55(60) 173(54) 237(46) 159(45) 57(41) 178(39) 235(37)
W	272(27)	197(100) 223(40) 238(34) 181(26) 257(25) 195(20) 141(20) 131(18) 129(18) 117(18) 165(16) 41(16)
X	252(46)	237(100) 220(49) 205(44) 195(27) 191(21) 253(17) 153(16) 101(16) 171(14) 165(14) 179(13)
Y	272(35)	43(100) 239(55) 146(45) 187(37) 197(32) 117(31) 219(30) 131(30) 71(30) 41(30) 133(28) 183(27)
Z	316(30)	146(100) 187(60) 101(50) 133(46) 41(43) 91(35) 92(34) 117(29) 55(26) 43(24) 284(23) 123(21)
AA	234(84)	219(100) 204(35) 203(28) 173(24) 189(22) 220(21) 202(21) 235(16) 191(14) 211(14) 41(14) 102(13)
BB	270(52)	255(100) 173(55) 256(25) 199(25) 129(22) 115(18) 213(17) 128(17) 147(15) 271(15) 141(15) 157(14)
CC	316(50)	121(100) 180(44) 257(36) 93(35) 301(30) 79(29) 133(23) 68(23) 55(23) 122(21) 106(21) 44(21)
DD	316(41)	121(100) 301(36) 91(28) 41(26) 79(23) 257(23) 55(22) 120(16) 119(16) 81(16) 77(16) 107(15)
EE	316(58)	241(100) 257(59) 256(58) 41(54) 105(43) 91(43) 79(43) 55(39) 81(32) 67(30) 121(29) 119(29)
FF	314(22)	239(100) 299(22) 240(20) 43(13) 41(11) 141(7) 315(6) 155(6) 143(6) 129(6) 117(6) 58(6)
GG	316(100)	256(96) 241(59) 41(49) 257(45) 105(40) 91(39) 213(37) 121(32) 317(30) 185(28) 131(27) 55(27)
HH	332(100)	247(63) 41(53) 43(52) 121(48) 239(37) 79(32) 262(29) 146(28) 131(27) 107(26) 211(25) 174(25)
II	330(23)	237(100) 312(39) 238(22) 195(19) 162(15) 43(14) 197(10) 167(8) 253(7) 145(6) 141(6) 41(6)
JJ	330(35)	315(100) 255(78) 43(61) 316(30) 237(23) 59(21) 256(19) 197(12) 312(10) 41(10) 331(8) 273(8)

Peak	MW (Int)	Fragments and (Intensities)
KK	328(83)	253(100) 254(29) 329(25) 269(21) 296(18) 43(18) 268(17) 41(15) 213(14) 211(13) 128(11)
LL	330(68)	255(100) 147(33) 331(28) 271(23) 257(20) 256(20) 163(20) 254(18) 149(18) 227(17) 78(17) 71(17)
MM	344(66)	329(100) 269(37) 128(32) 123(32) 345(21) 147(20) 161(18) 318(16) 155(16) 43(16) 330(13)
NN	332(28)	247(100) 307(45) 43(33) 41(31) 271(20) 229(19) 147(19) 201(18) 181(18) 171(18) 159(18)
OO	346(13)	331(100) 253(51) 328(25) 59(25) 332(17) 195(17) 235(13) 329(12) 269(12) 250(11) 128(11) 92(11)
PP	346(24)	331(100) 43(53) 332(32) 253(31) 329(19) 328(19) 195(18) 235(17) 178(16) 155(16) 171(15) 131(15)
QQ	332(21)	331(100) 43(31) 149(23) 303(21) 271(11) 121(11) 304(8) 129(8) 289(7) 143(6) 49(6)
RR	344(8)	305(100) 245(42) 306(34) 123(27) 253(15) 187(14) 43(14) 289(13) 237(13) 329(12) 107(12) 71(12)
SS	344(8)	329(100) 330(31) 43(26) 269(13) 187(8) 331(5) 203(5) 145(5) 213(4) 157(3) 41(3)
TT	364(29)	318(100) 271(36) 319(35) 95(23) 43(22) 59(20) 346(18) 121(16) 255(15) 105(14) 290(12) 53(12)

Table 2 - Identification and quantification of resin components.

Peak	Formula	Identity	CAS Registry	Percent
A	C 11 H 14 O 2	methyl cumate	[20185-55-1]	0.06
B	C 15 H 24	a sesquiterpene, possibly longifolene	[475-20-7] ?	0.08
C	?	unidentified sesquiterpenoid or degradation product		0.01
D	C15 H 14 O	2,6-di-tert.-butyl-4-methylphenol CONTAMINANT	[128-37-0]	0.03
E	C 14 H 16	2-methyl-7-isopropyl-naphthalene	[40459-00-5]	0.06
F	C15 H 26	probably a dihydro-sesquiterpene		0.11
G	C15 H 32	probably an acyclic sesquiterpane		1.19
H	C14 H 10	phenanthrene	[85-01-8]	0.08
I	?	C 15 H 32 sesquiterpene or C 16 H 20 phenanthrene derivative		0.12
J	C15 H 12	1-methylphenanthrene (or 2-methyl isomer?)	[832-69-9]	0.15
K	?	unidentified compound of uncertain molecular weight		0.18
L	C20 H 32	perhaps phylloclad-15-ene = 15-kaurene	[511-85-3]	0.06
M	?	unidentified compound of uncertain molecular weight		0.07
N	?	unidentified compound of uncertain molecular weight		0.07
O	?	unidentified compound of uncertain molecular weight		0.10
P	C 17 H 34 O 2	methyl palmitate	[112-39-0]	0.07
Q	C19 H 28	18-norabietatriene	[19407-17-1]	0.15
R	?	Isomer of peak T		0.06
S	C 19 H 28	19-norabietatriene	[19407-18-2]	0.15
T	?	Isomer of peak R		0.15
U	C 17 H 16	7-ethyl-1-methylphenanthrene	[19353-76-5]	0.18
V	C 20 H 30	abieta-8,11,13-triene	[19407-28-4]	0.17
W	C 18 H 24 O 2	methyl deisopropyldehydroabietate	[3650-04-2]	0.22

Peak	Formula	Identity	CAS Registry	Percent
X	C ₁₉ H ₂₄	simonellite	[27530-79-6]	0.17
Y	C ₂₀ H ₃₂	unidentified abietadiene		0.06
Z	C ₂₁ H ₃₂ O ₂	methyl secodehydroabietate	[41298-29-7]	0.14
AA	C ₁₈ H ₁₈	retene	[483-65-8]	1.32
BB	C ₂₀ H ₃₀	an abieta- or primara-triene		0.66
CC	C ₂₁ H ₃₂ O ₂	methyl pimarate	[3730-56-1]	0.72
DD	C ₂₁ H ₃₂ O ₂	methyl sandaracopimarate	[1686-54-0]	2.05
EE	C ₂₁ H ₃₂ O ₂	methyl isopimarate	[1686-62-0]	6.82
FF	C ₂₁ H ₃₀ O ₂	methyl dehydroabietate	[1235-74-1]	23.13
GG	C ₂₁ H ₃₂ O ₂	methyl abietate	[127-25-3]	14.12
HH	C ₂₁ H ₃₂ O ₃	a methyl hydroxyabietate ? cp. peaks NN and QQ		1.73
II	C ₂₁ H ₃₀ O ₃	a methyl hydroxydehydroabietate ? cp. peaks JJ and LL		4.22
JJ	C ₂₁ H ₃₀ O ₃	a methyl hydroxydehydroabietate ? cp. peaks II and LL		12.21
KK	C ₂₁ H ₂₈ O ₃	methyl 7-oxodehydroabietate	[17751-36-9]	11.03
LL	C ₂₁ H ₃₀ O ₃	a methyl hydroxydehydroabietate ? cp. peaks II and JJ		2.20
MM	C ₂₁ H ₂₈ O ₄	a methyl hydroxy-7-oxodehydroabietate ? cp. peaks RR and SS		1.43
NN	C ₂₁ H ₃₂ O ₃	a methyl hydroxyabietate? cp. peaks HH and QQ		0.86
OO	C ₂₁ H ₃₀ O ₄	a methyl dihydroxydehydroabietate? cp. peak PP		2.51
PP	C ₂₁ H ₃₀ O ₄	a methyl dihydroxydehydroabietate ? cp. peak OO		1.23
QQ	C ₂₁ H ₃₂ O ₃	a methyl hydroxyabietate ? cp. peaks HH and NN		1.73
RR	C ₂₁ H ₂₈ O ₄	a methyl hydroxy-7-oxodehydroabietate ? cp. peak MM and SS		1.43
SS	C ₂₁ H ₂₈ O ₄	a methyl hydroxy-7-oxodehydroabietate ? cp. peaks MM and RR		6.46
TT	C ₂₁ H ₃₂ O ₅	a methyl trihydroxyabietate?		1.27

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Bronze situla inv. 2323, Tomb. 128, Valle Trebba, with organic residue in bottom.