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Database of residues of plant and animal origin analyzed with the InfraRed technique on replicas made of stone or bone

Introduction to database

The database collects a selection of replicas made of stone or bone on which significant residues were observed and spectroscopically analyzed with the InfraRed technique.
This database was sponsored by the Wenner-Gren Foundation (NY) as part of a project aiming to verify the presence of micro-residues at the working edges of lithic archeological items by means of a non invasive method.
To identify the nature of the micro-remains, a set of suitable replicas which worked fleshy tissues, hide, bone, antler, shells and a large variety of domestic and wild vegetables was analysed.
This database is a work in progress. We will constantly add new spectra of replicas acquired during our research projects.

Replicas

Replicas of artefacts made of flint, obsidian, bone have been employed in a large series of activities such as butchering, working hide, hard animal material, cutting of wild and domestic cereals, reeds, grasses, edibles, medicinal, dyeing plants.

Experimental

FT-IR analysis of artifacts: Unused parts and working edges of archaeological and experimental chipped artefacts have been studied by means of Fourier Transform Infrared (FTIR) microspectroscopy using the Hyperion 2000 (Bruker Optics) microscope at the DA□NE laboratories of the Istituto Nazionale di Fisica Nucleare, Frascati (Rome), Italy. Spectra were obtained cumulating at least 200 scans at a resolution of 2 cm^{-1} or better. In the following, spectra of unused part of the tools are reported in black.

References

ANIMAL RESIDUES

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PLANT RESIDUES

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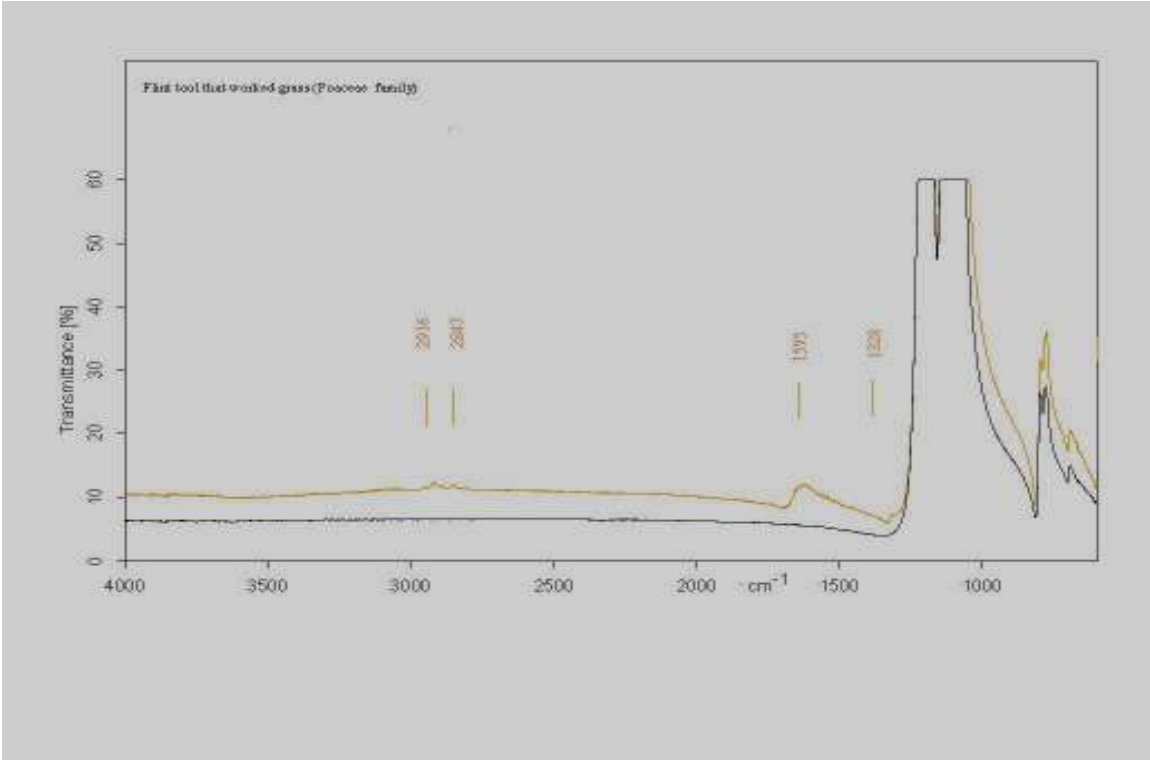
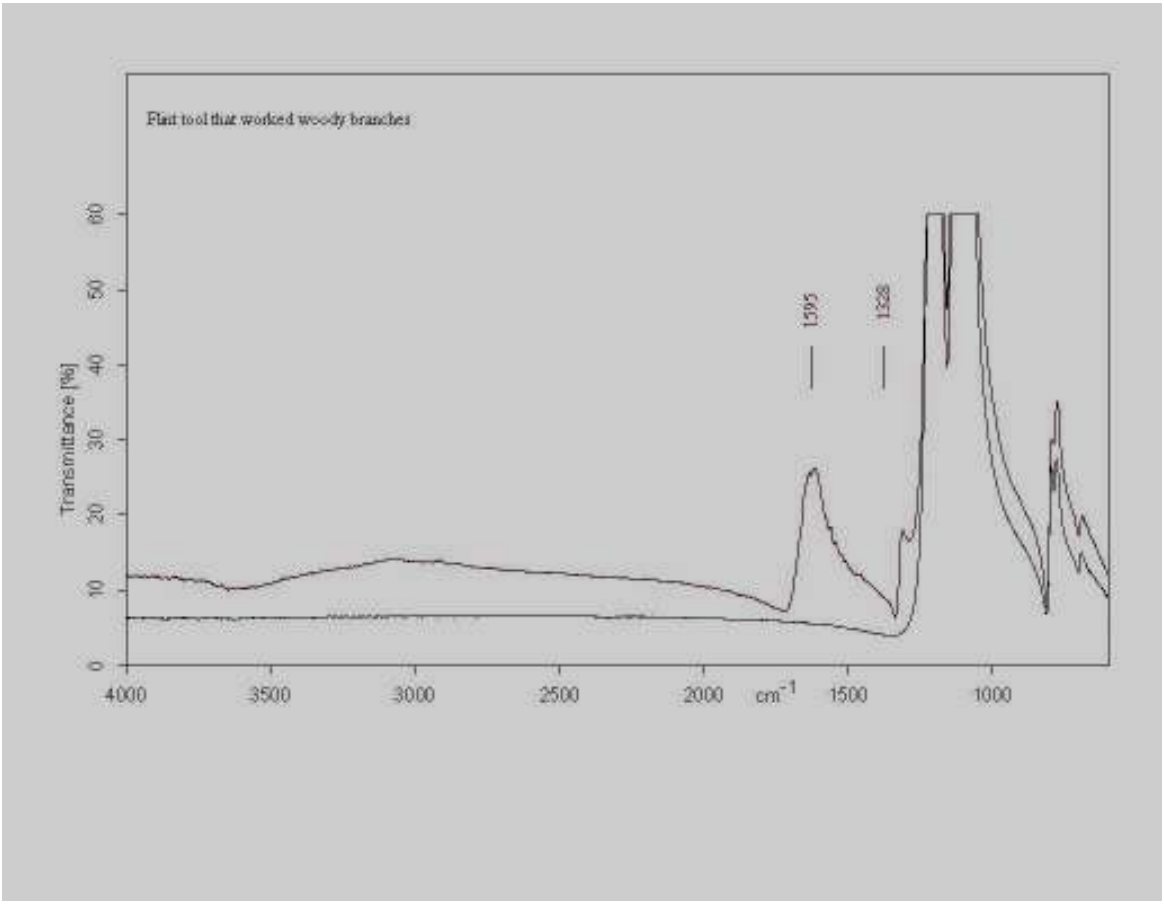
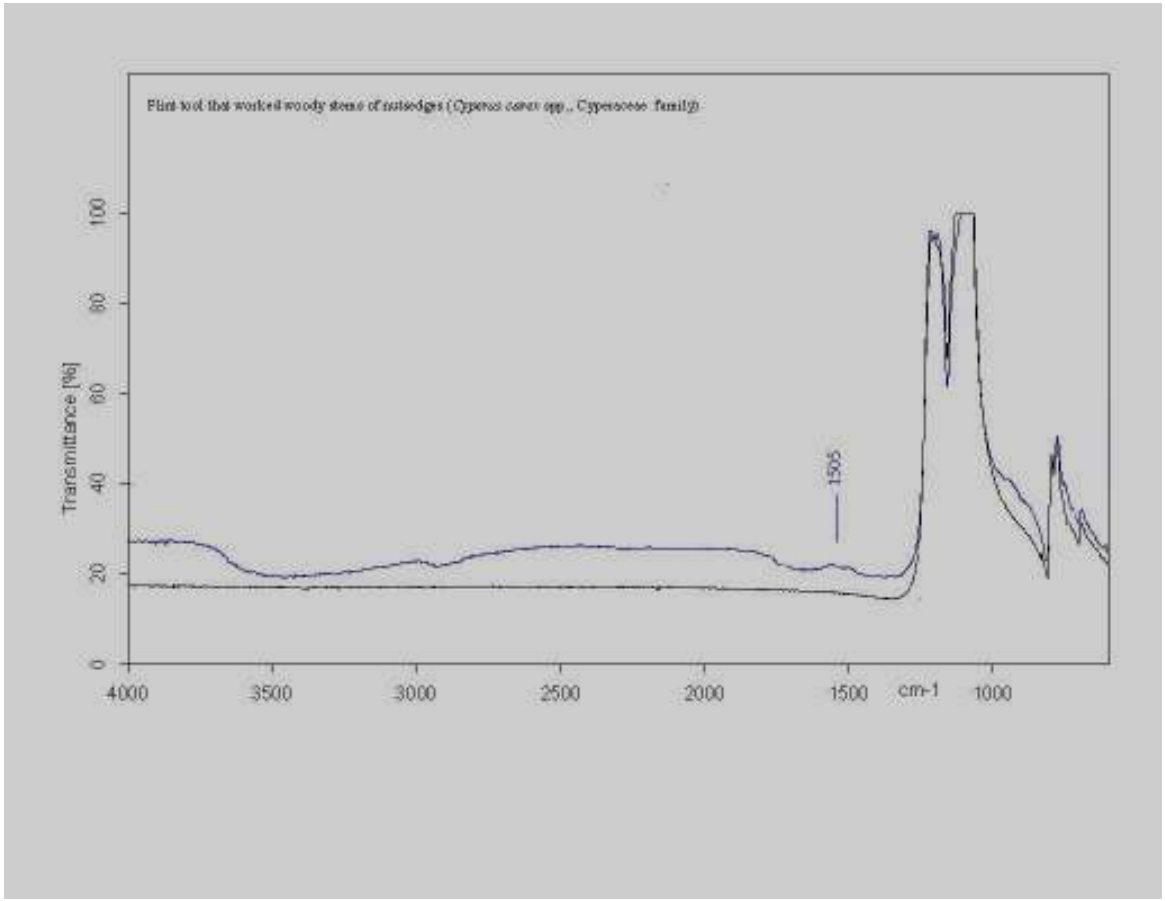
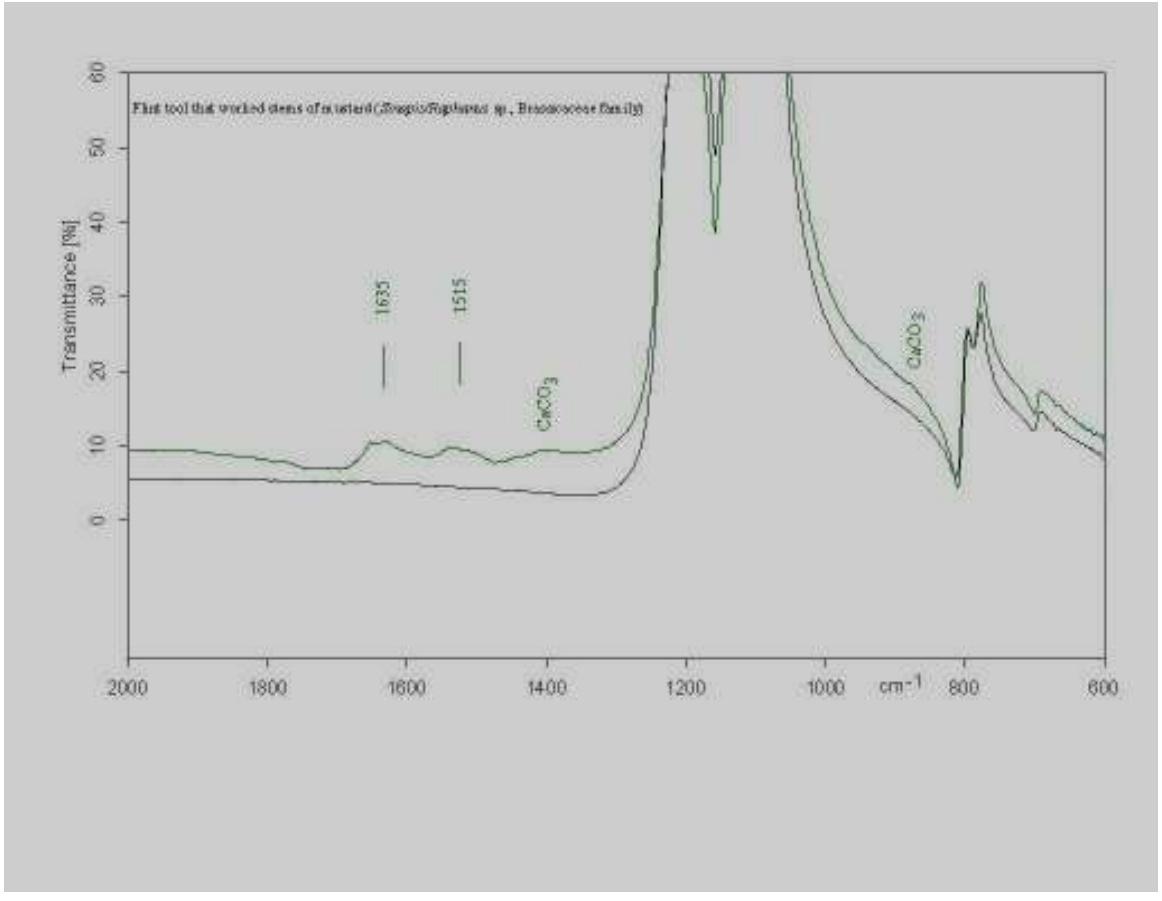
PLANT RESIDUES

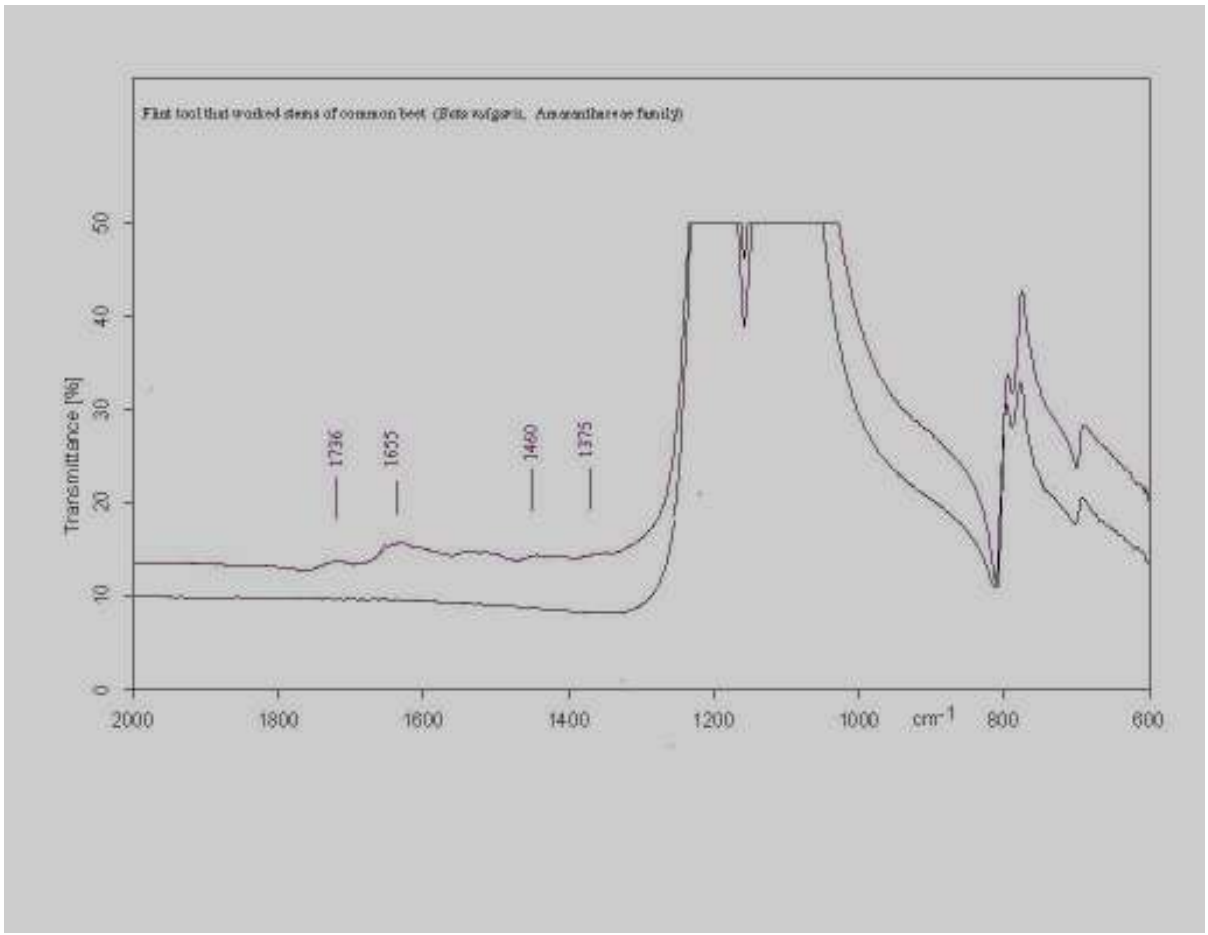
Wavenumber range (cm-1) of maxima	Proposed assignment
~ 3560	absorbed water weakly bound
3570 – 3450	valence vibration of H bonded O-H groups (intramolecular)
3400 – 3200	valence vibration of H bonded O-H groups
~ 3300	N-H stretching of proteins (Amide A)
~3100	N-H stretching of proteins (Amide B)
3000 – 2842	CH stretch in methyl and methylene groups
1730 – 1725	C=O valence vibration of acetyl or COOH groups
1738 – 1709	C=O stretch of unconjugated ketones, carbonyls and ester groups
~ 1700	C=O stretch of aldehydes or carboxylic acids
1690 – 1600	C=O stretching of proteins (Amide I)
1675 – 1655	C=O stretch of conjugated p-substituted aryl ketones
~1635	absorbed water
1605 – 1593	aromatic skeletal vibration
1515 – 1505	aromatic skeletal vibration
1576 – 1540	fatty acid salts carboxilate C-O stretching
1575 – 1480	C-N stretching + N-H bending of proteins (Amide II)
1470 – 1460	C-H deformation: asymmetric in -CH_3 and –CH_2
1430 – 1416	CH_2 scissoring
1375 – 1374	CH deformation vibration
1370 – 1365	aliphatic CH stretch in CH_3
1330- 1325	phenolic OH
1301 – 1229	C-N stretching + N-H bending of proteins
1282 - 1277	CH deformation
1235 – 1225	OH plane deformation
1162 – 1125	C-O-C asymmetric valence vibration
1110 – 1107	Ring asymmetric valence vibration
~1086	C-O deformation in secondary alcohols and aliphatic ethers
1060 – 1015	C-O valence vibration
930 – 925	Pyran ring vibration
895 - 892	defomation. Ring valence vibration C-H- out of plane
858 – 853	C-H out of plane
767 – 625	O-C-N- bending of proteins (Amide IV)
800 – 640	N-H bending out of plane (Amide V)
606 – 537	C-O bending out of plane (Amide VI)

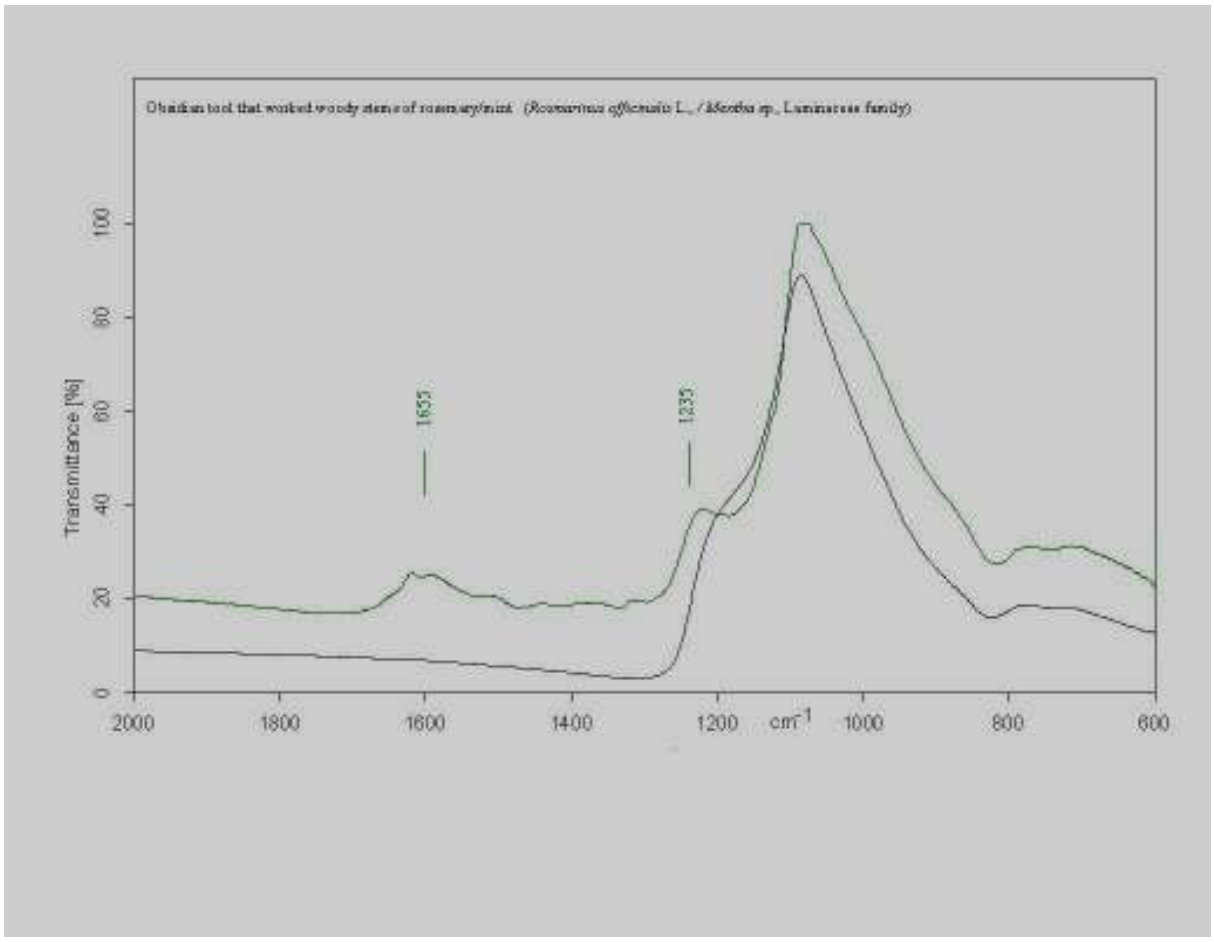

Flint tool that worked grass (Poaceae family)
Transmittance [%]
0
10
20
30
40
50
60
2916
2847
1595
1328
4000
3500
3000
2500
2000
cm-1
1500
1000

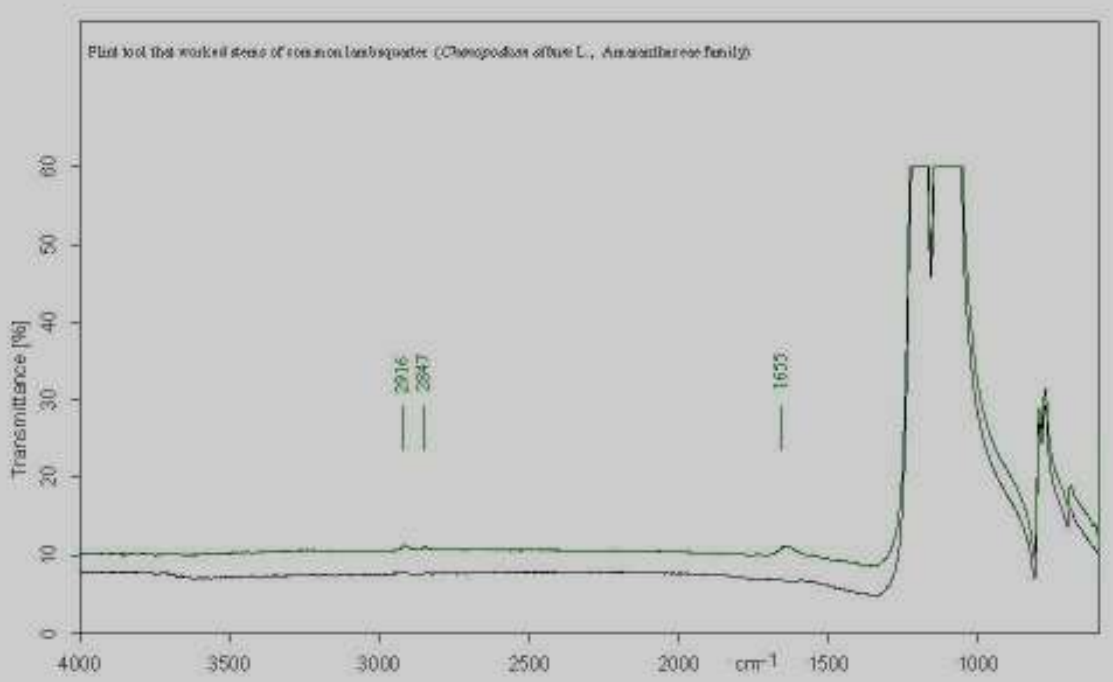

Flint tool that worked woody branches
Transmittance [%]
0
10
20
30
40
50
60
1595
1328
4000
3500
3000
2500
2000
cm-1
1500
1000

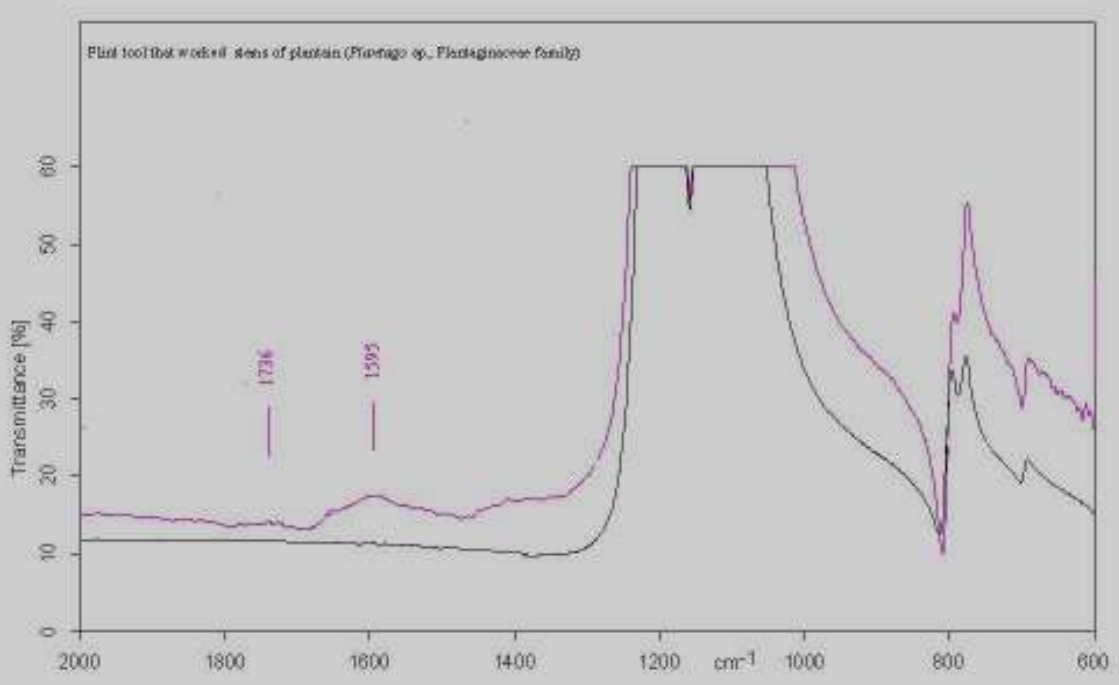

Flint tool that worked woody stems of nutsedges (Cyperus canus spp., Cyperaceae family)
Transmittance [%]
0
20
40
60
80
100
1505
4000
3500
3000
2500
2000
1500
cm-1
1000

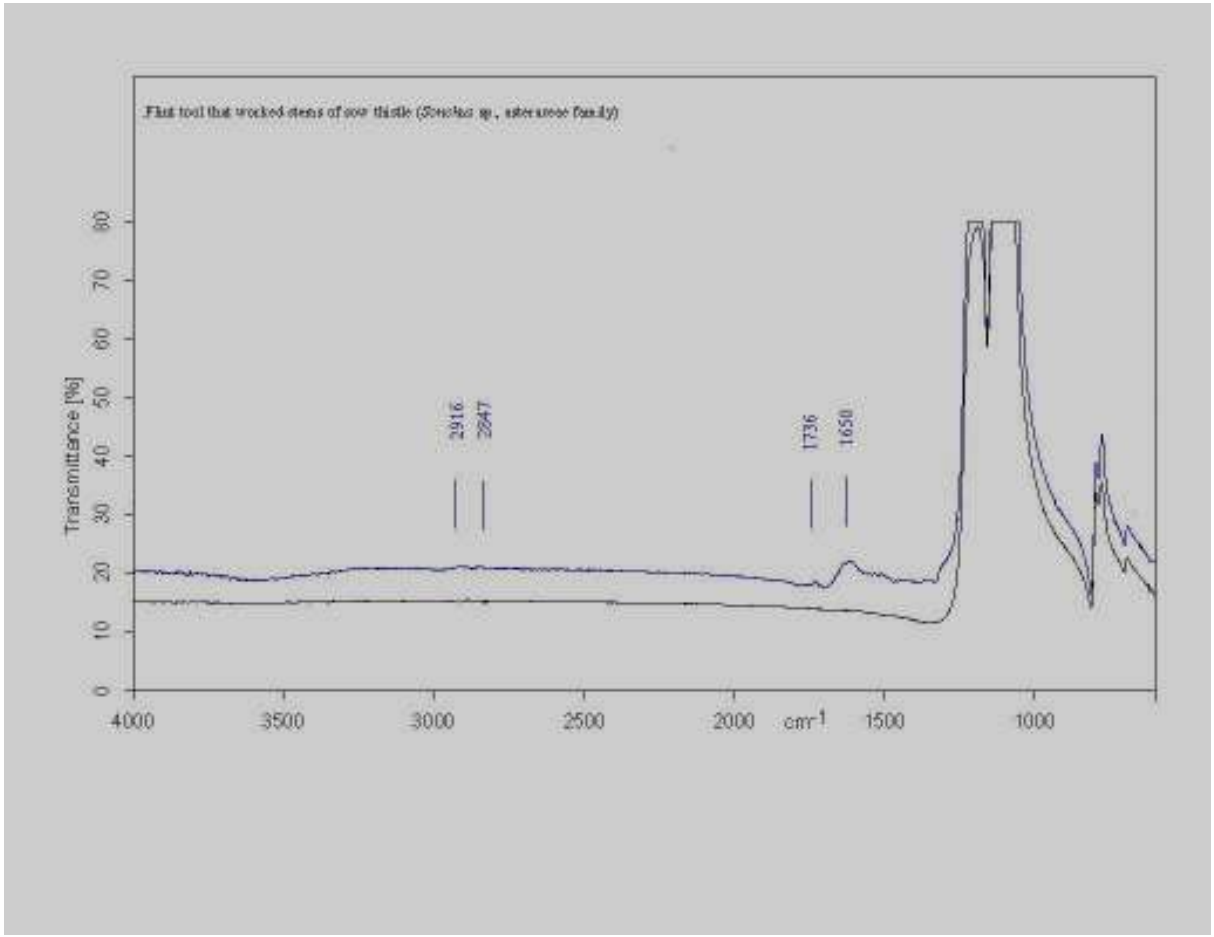

Flint tool that worked stems of mustard (Brassica/Raphanus sp., Brassicaceae family)
Transmittance [%]
0
10
20
30
40
50
60
1635
1515
CaCO3
CaCO3
2000
1800
1600
1400
1200
1000
cm-1
800
600

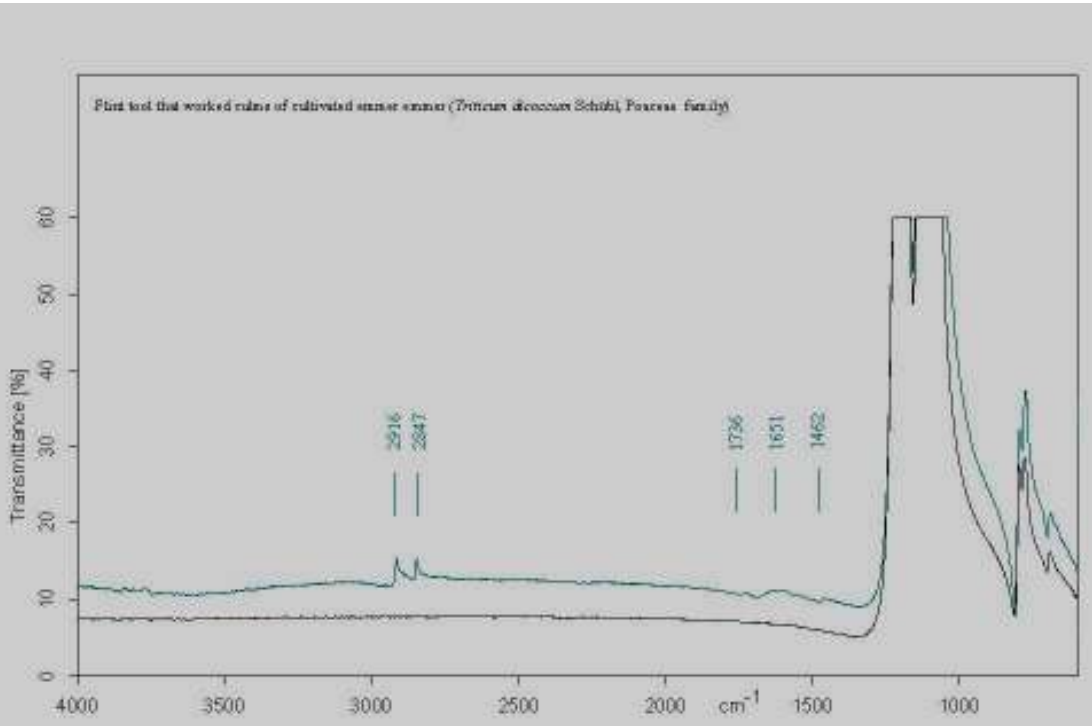

Flint tool that worked stems of common beet (Beta vulgaris, Amaranthaceae family)
Transmittance [%]
0
10
20
30
40
50
1736
1655
1460
1375
2000
1800
1600
1400
1200
1000
cm-1
800
600

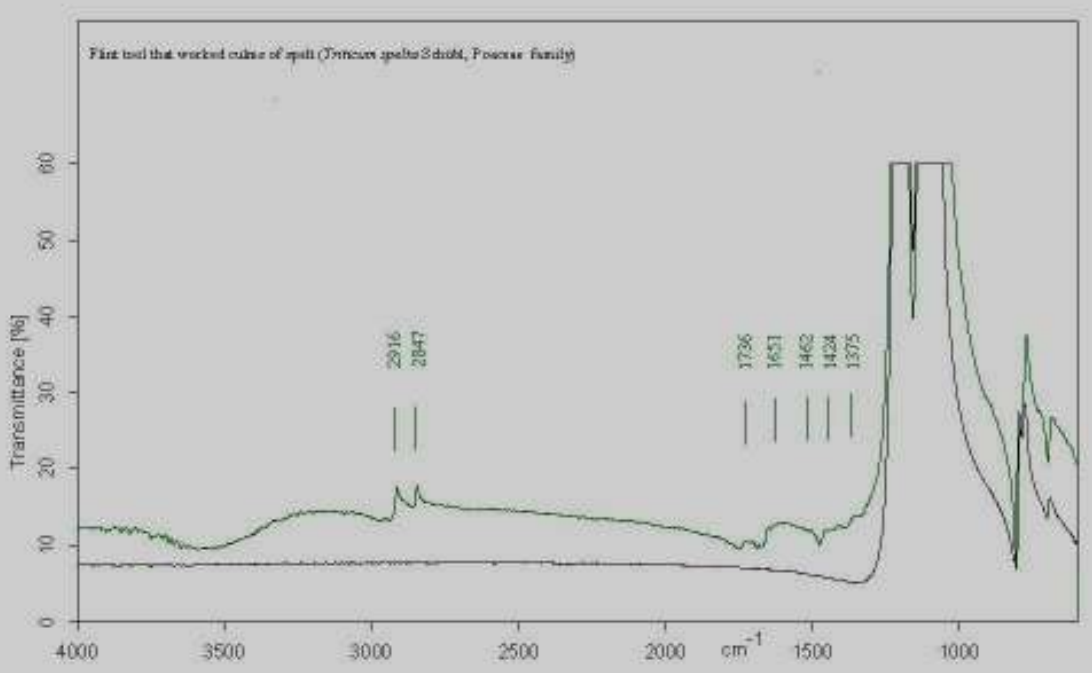

Obsidian tool that worked woody stems of rosemary/mint (Rosmarinus officinalis L. / Mentha sp., Lamiaceae family)
Transmittance [%]
0
20
40
60
80
100
1655
1233
2000
1800
1600
1400
1200
cm-1
1000
800
600

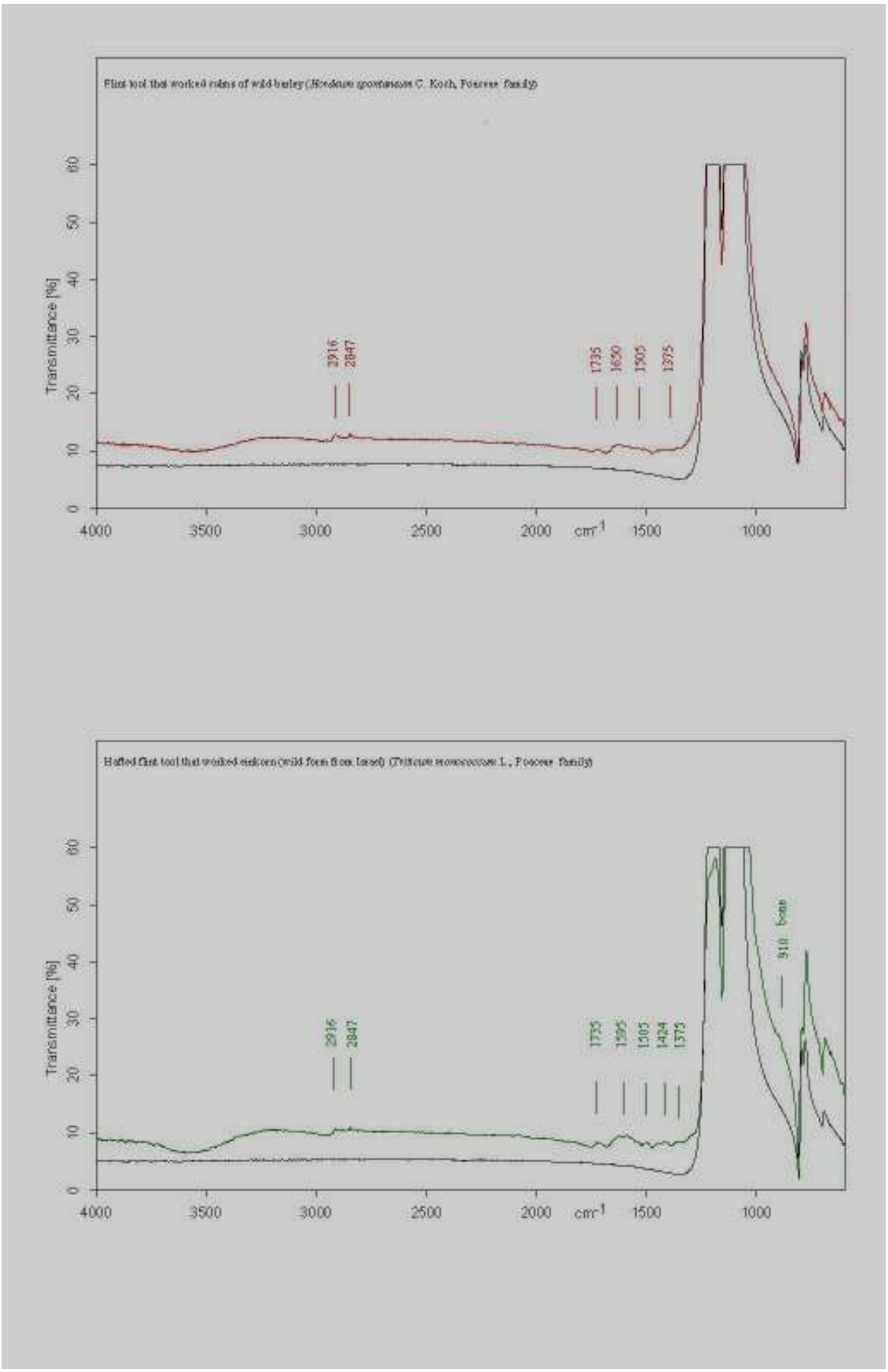

Flint tool that worked stems of common lambsquarter (Chenopodium album L., Amaranthaceae family)
Transmittance [%]
0
10
20
30
40
50
60
2916
2847
1655
4000
3500
3000
2500
2000
cm-1
1500
1000

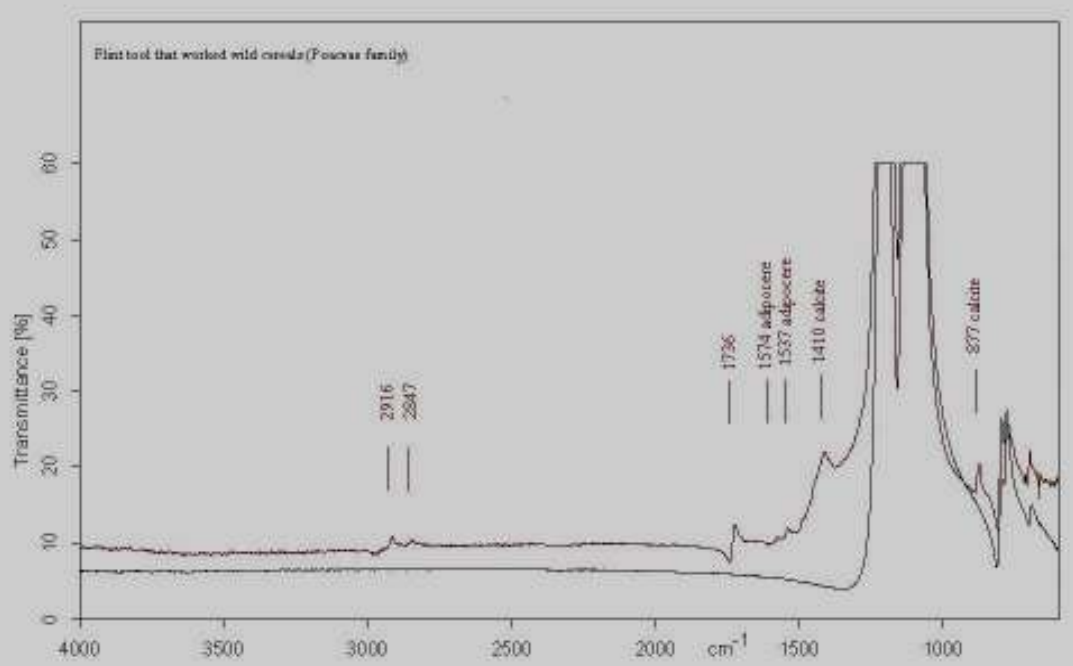

Flint tool that worked stems of plantain (Plantago sp., Plantaginaceae family)
Transmittance [%]
0
10
20
30
40
50
60
1736
1595
2000
1800
1600
1400
1200
cm-1
1000
800
600

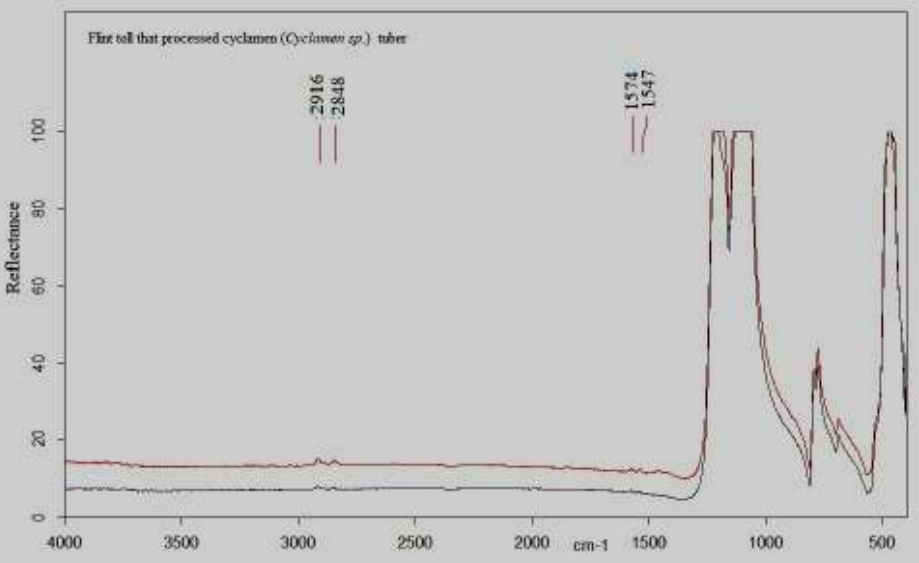

Flint tool that worked stems of sow thistle (Sonchus sp., asteraceae family)
Transmittance [%]
0
10
20
30
40
50
60
70
80
2916
2847
1736
1650
4000
3500
3000
2500
2000
cm-1
1500
1000

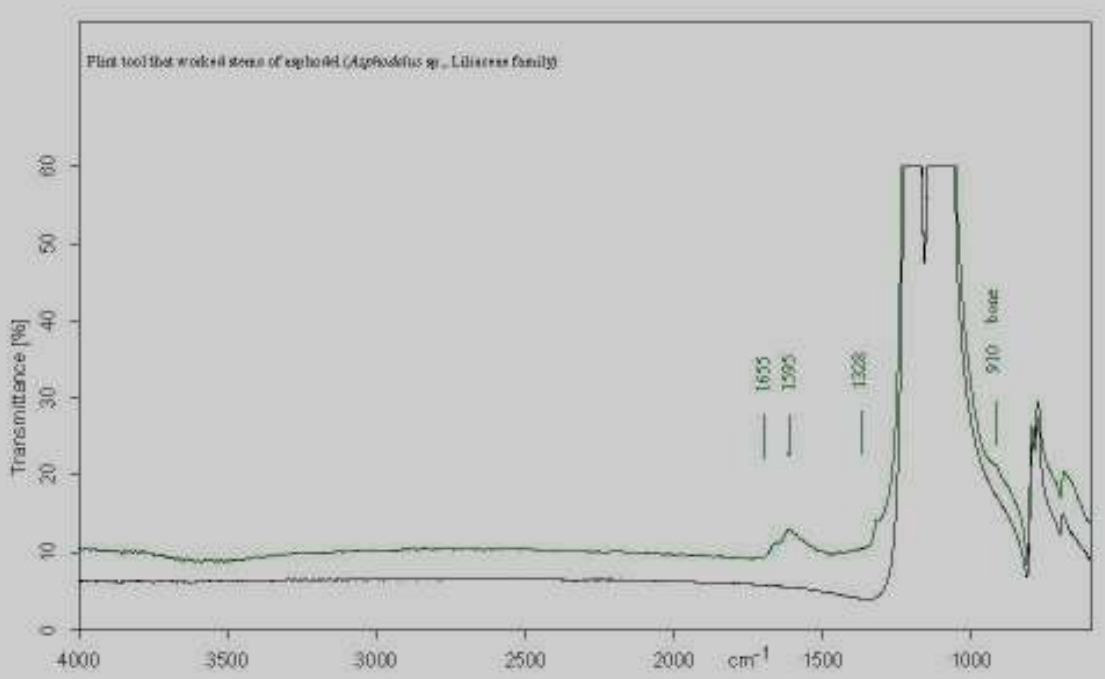

Flint tool that worked culms of cultivated emmer emmer (Triticum dicoccum Schübl, Poaceae family)
Transmittance [%]
0
10
20
30
40
50
60
2916
2847
1736
1651
1462
4000
3500
3000
2500
2000
cm-1
1500
1000

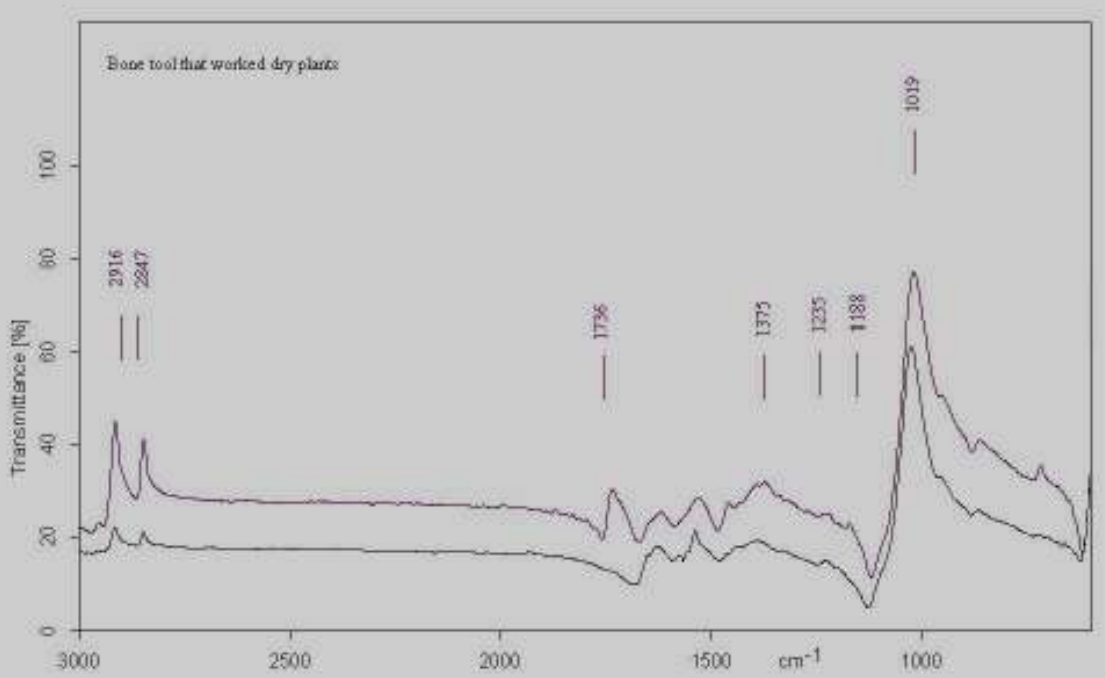

Flint tool that worked culms of spelt (Triticum spelta Schübl, Poaceae family)
Transmittance [%]
0
10
20
30
40
50
60
2916
2847
1736
1651
1462
1424
1375
4000
3500
3000
2500
2000
cm-1
1500
1000

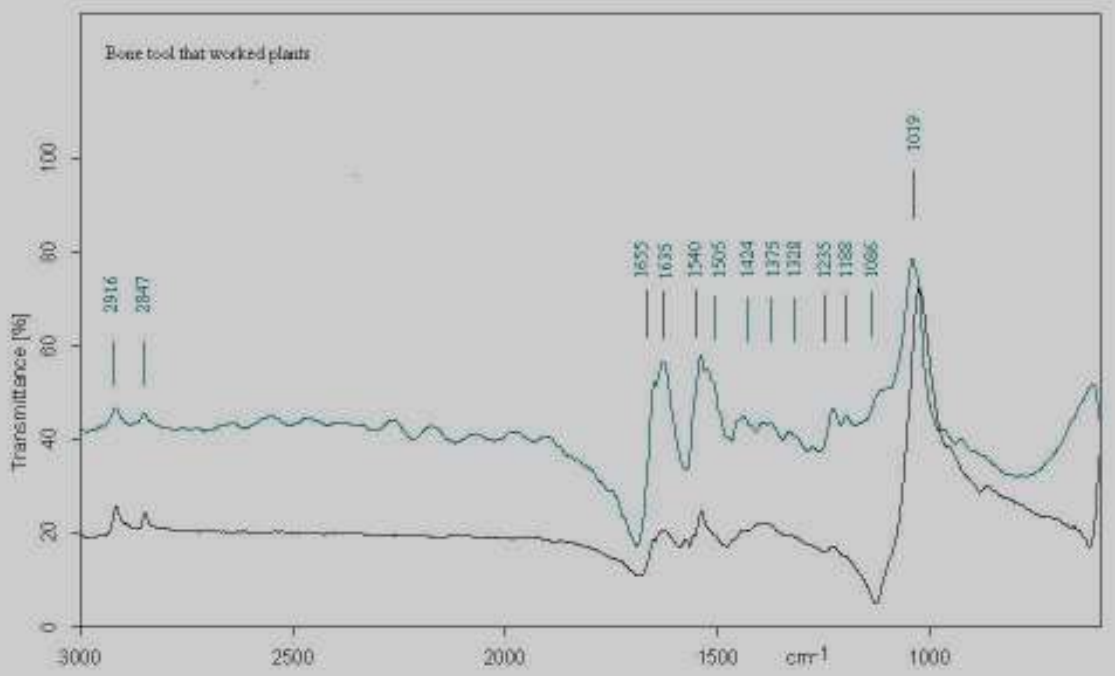

Flint tool that worked culms of wild barley (Hordeum spontaneum C. Koch, Poaceae family)
Transmittance [%]
0
10
20
30
40
50
60
2916
2847
1735
1650
1505
1375
4000
3500
3000
2500
2000
cm-1
1500
1000
Hafted flint tool that worked einkorn (wild form from Israel) (Triticum monococcum L., Poaceae family)
Transmittance [%]
0
10
20
30
40
50
60
2916
2847
1735
1595
1505
1424
1375
910
bone
4000
3500
3000
2500
2000
cm-1
1500
1000

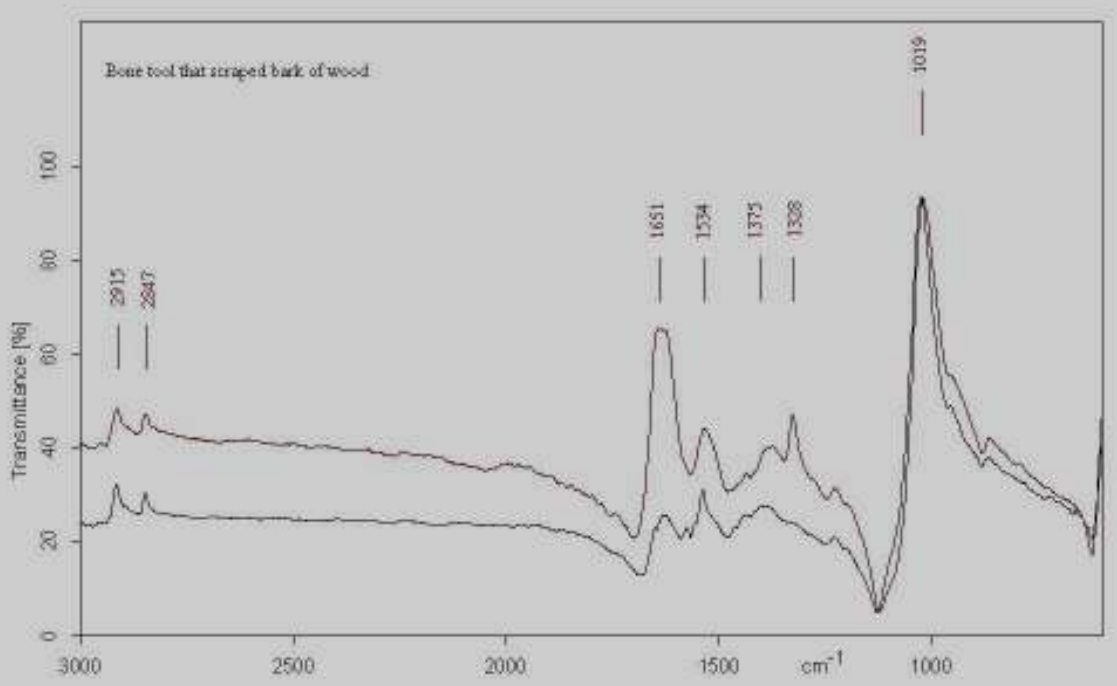

Flint tool that worked wild cereals (Poaceae family)
Transmittance [%]
0
10
20
30
40
50
60
4000
3500
3000
2500
2000
cm-1
1500
1000
2916
2847
1736
1574 adipocere
1537 adipocere
1410 calcite
877 calcite

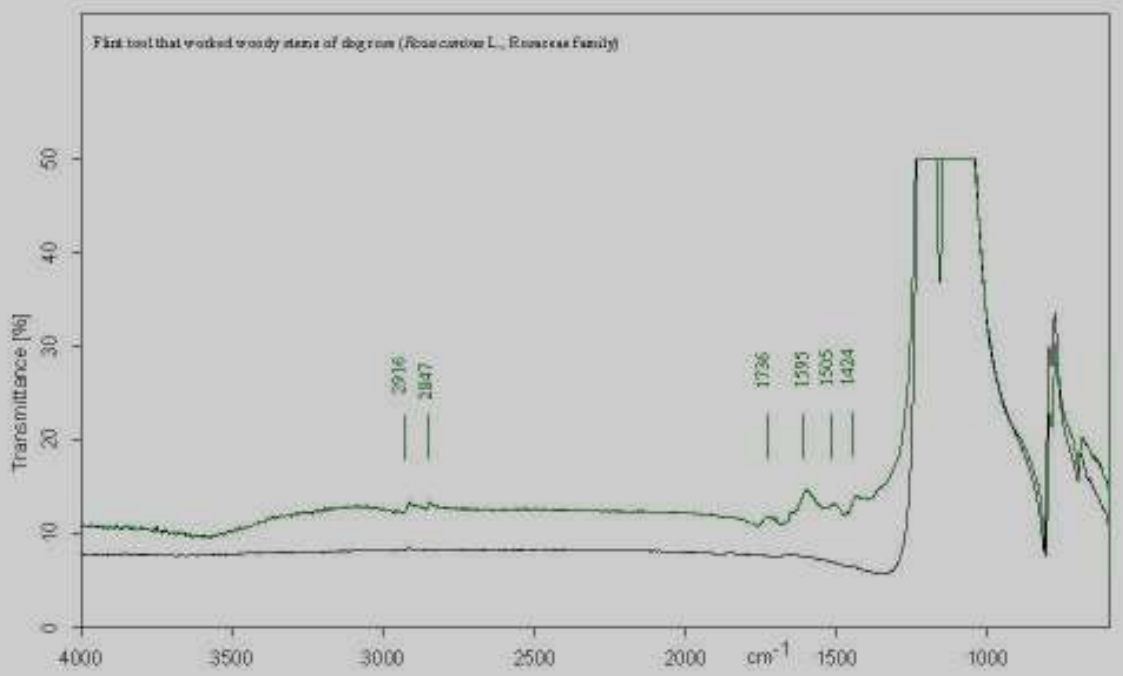

Flint tool that processed cyclamen (Cyclamen sp.) tuber
Reflectance
0
20
40
60
80
100
4000
3500
3000
2500
2000
cm-1
1500
1000
500
2916
2848
1574
1547

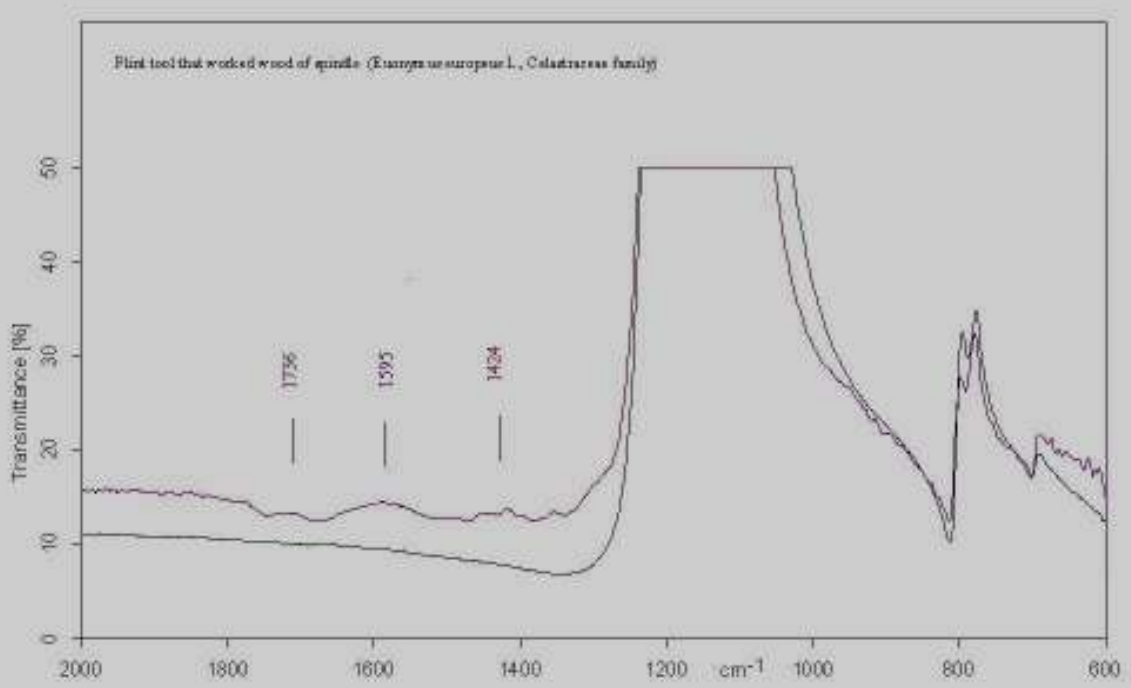

Plant tool that worked stems of asphodel (Asphodelus sp., Liliaceae family)
Transmittance [%]
0
10
20
30
40
50
60
1655
1595
1308
910
base
4000
3500
3000
2500
2000
cm-1
1500
1000

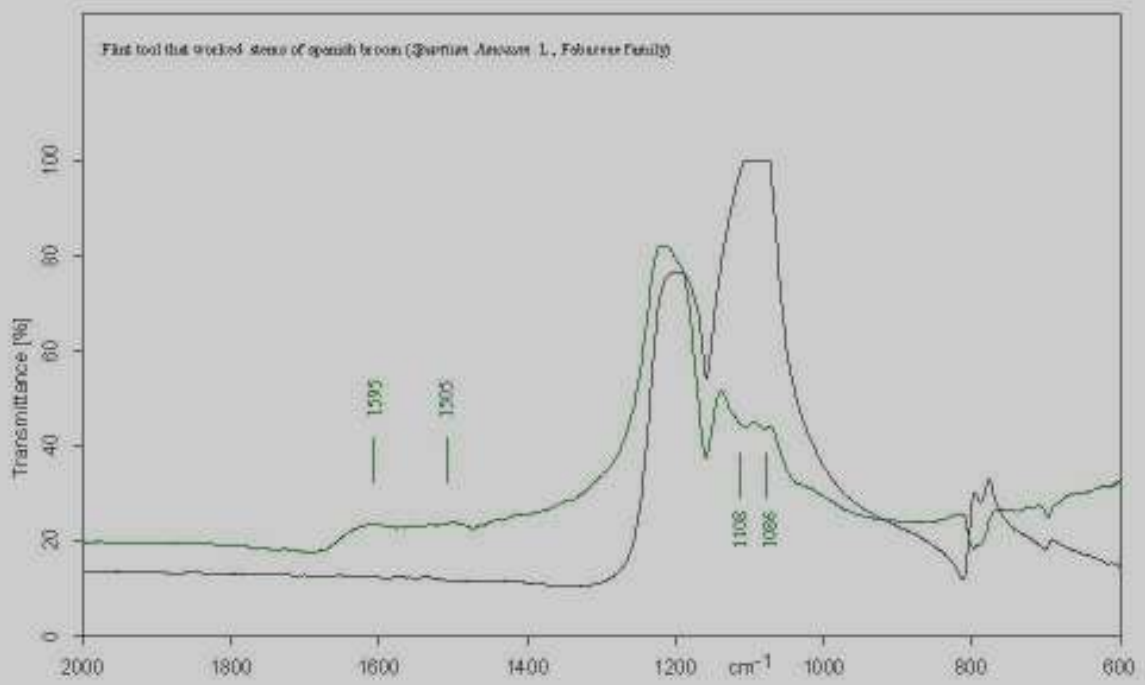

Bone tool that worked dry plants
Transmittance [%]
0
20
40
60
80
100
2916
2847
1736
1375
1235
1188
1019
3000
2500
2000
1500
cm-1
1000

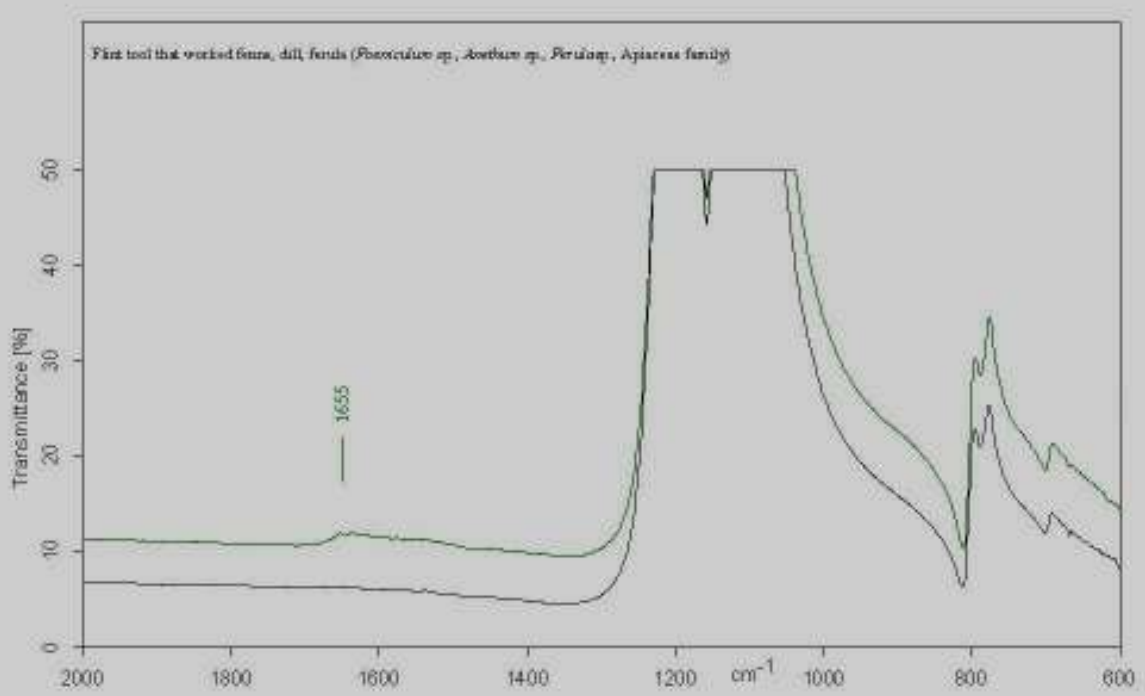

Bone tool that worked plants
Transmittance [%]
0
20
40
60
80
100
2916
2847
1655
1635
1540
1505
1424
1375
1318
1235
1188
1086
1019
3000
2500
2000
1500
cm-1
1000

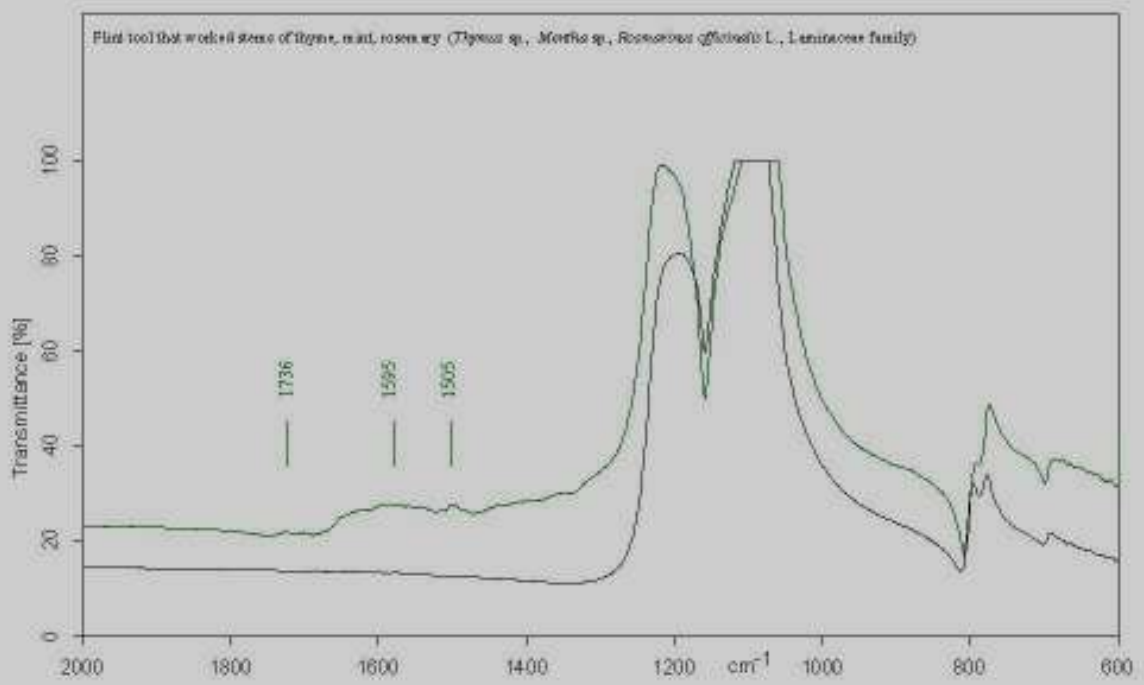

Bone tool that scraped bark of wood
Transmittance [%]
0
20
40
60
80
100
2915
2847
1651
1534
1375
1308
1019
3000
2500
2000
1500
cm-1
1000

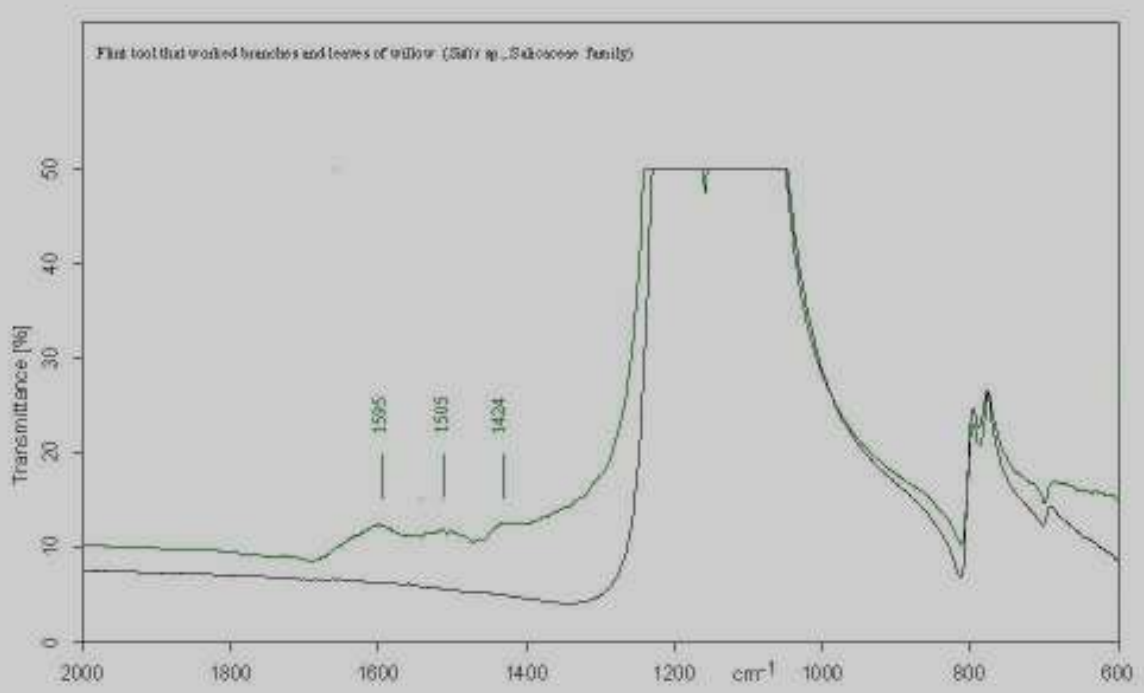

Flint tool that worked woody stems of dog rose (Rosa canina L., Rosaceae family)
Transmittance [%]
0
10
20
30
40
50
2916
2847
1736
1595
1505
1424
4000
3500
3000
2500
2000
cm-1
1500
1000

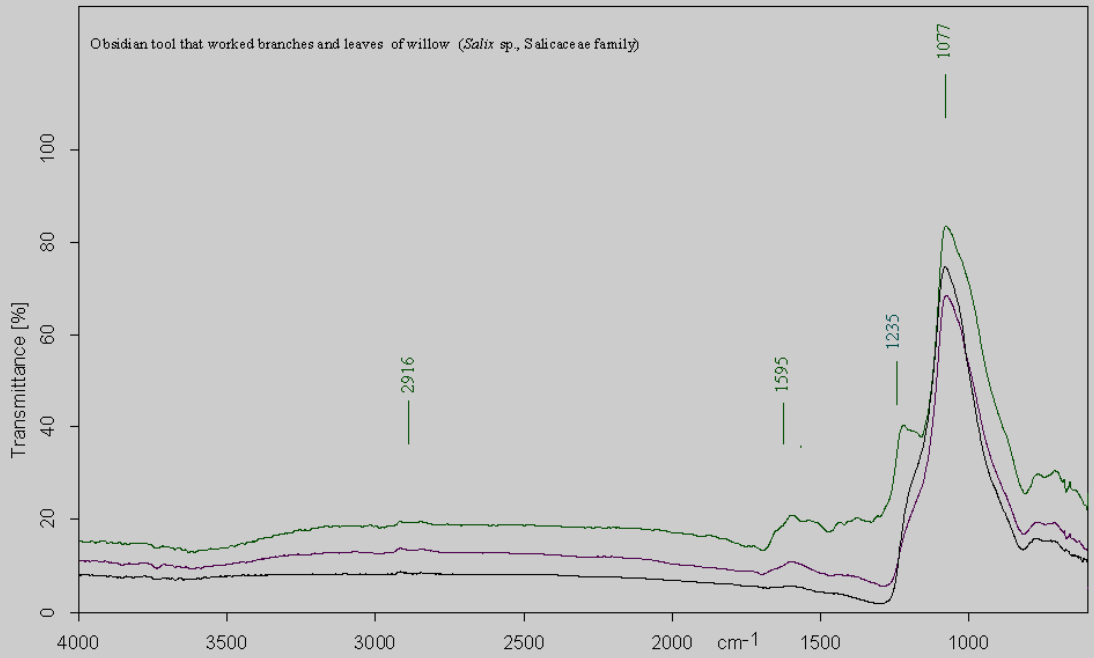

Flint tool that worked wood of spindle (Euonymus europaeus L., Celastraceae family)
Transmittance [%]
0
10
20
30
40
50
1736
1595
1424
2000
1800
1600
1400
1200
cm-1
1000
800
600

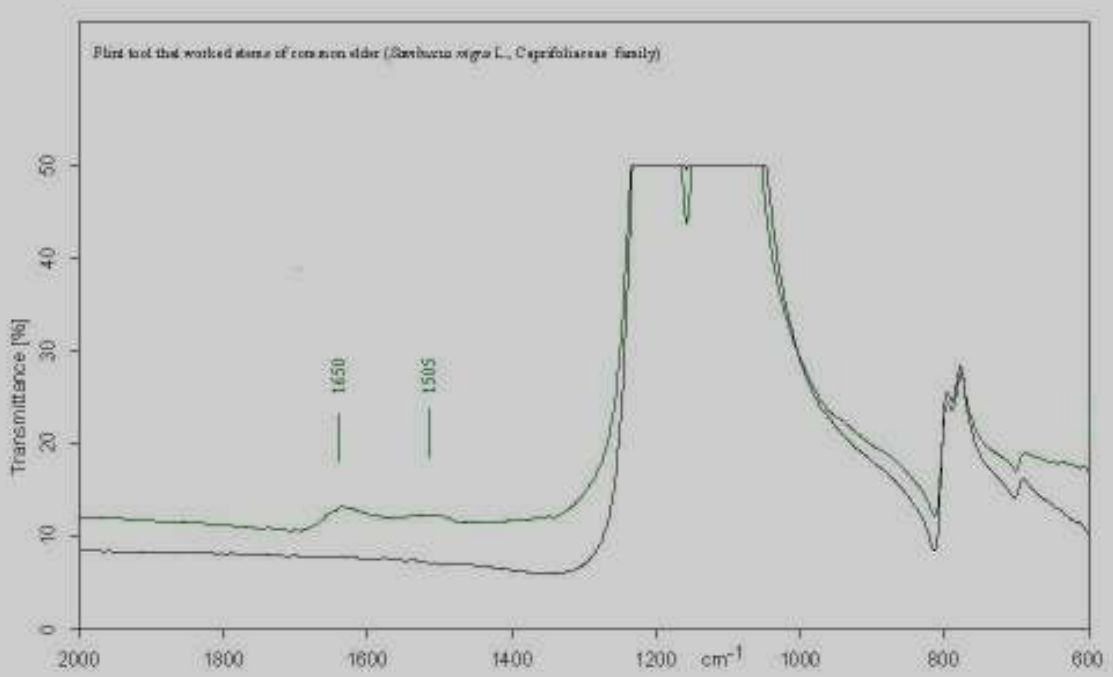

Flint tool that worked stems of spanish broom (Spartium Anthoxum L., Fabaceae Family)
Transmittance [%]
0
20
40
60
80
100
1595
1505
1108
1086
2000
1800
1600
1400
1200
cm-1
1000
800
600

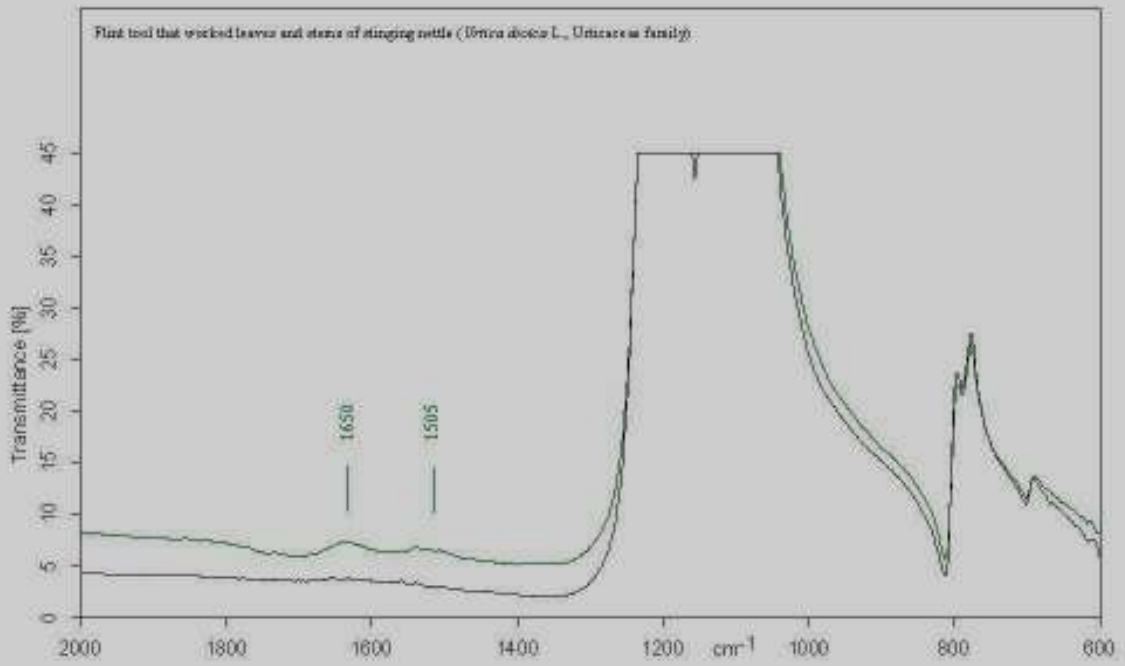

Flint tool that worked ferns, dill, ferula (Pteridium sp., Anethum sp., Ferulago, Apiaceae family)
Transmittance [%]
0
10
20
30
40
50
1655
2000
1800
1600
1400
1200
cm-1
1000
800
600

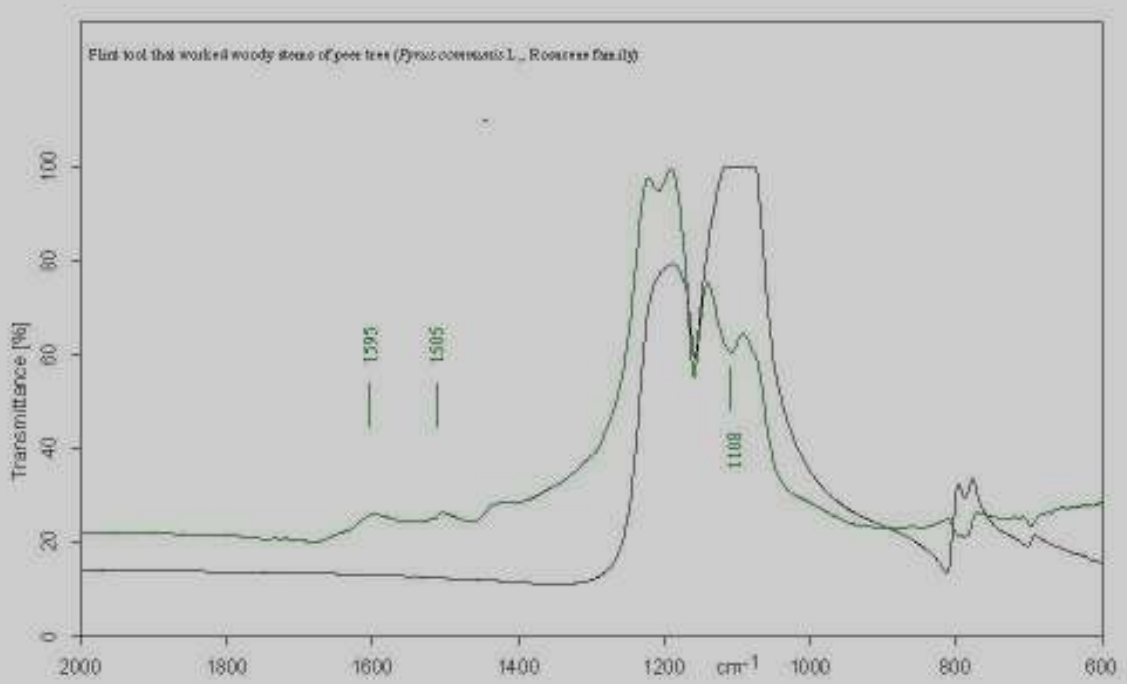

Flint tool that worked stems of thyme, mint, rosemary (Thymus sp., Mentha sp., Rosmarinus officinalis L., Lamiaceae family)
Transmittance [%]
0
20
40
60
80
100
1736
1595
1505
2000
1800
1600
1400
1200
cm-1
1000
800
600

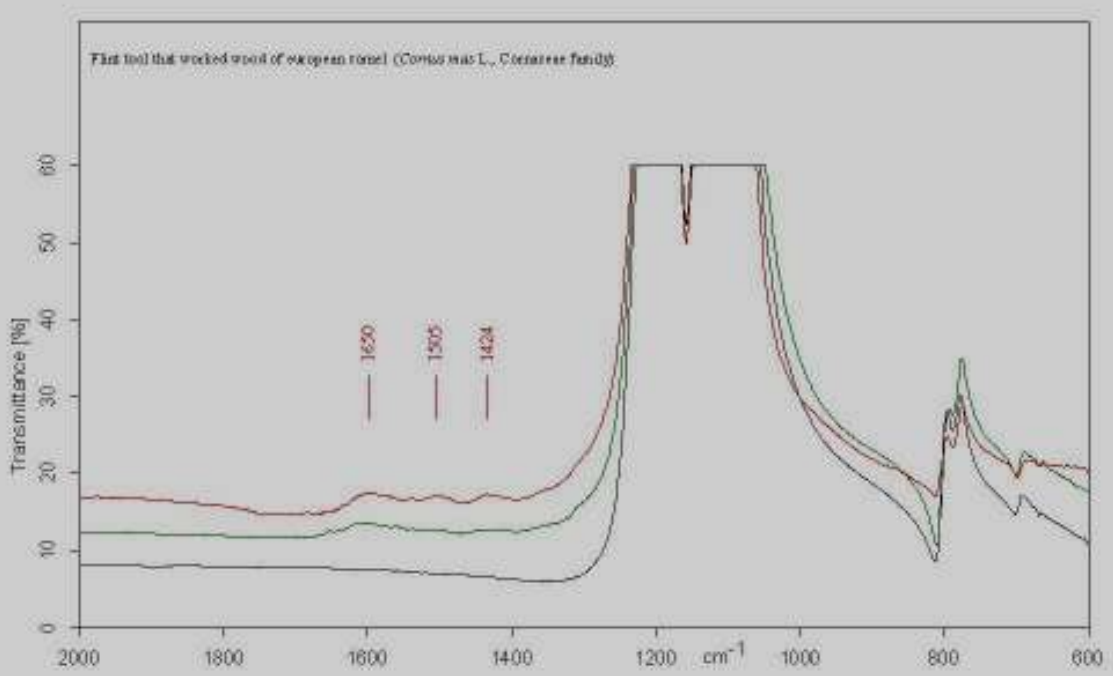

Flint tool that worked branches and leaves of willow (Salix sp., Salicaceae family)
Transmittance [%]
0
10
20
30
40
50
1595
1505
1424
2000
1800
1600
1400
1200
cm-1
1000
800
600

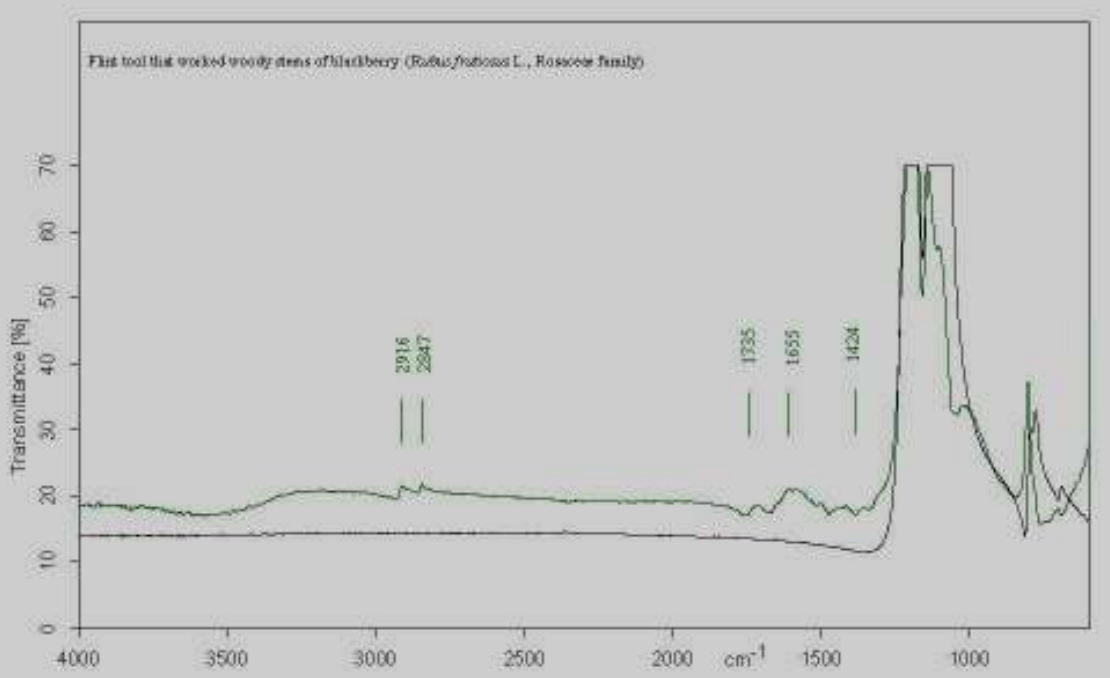

Obsidian tool that worked branches and leaves of willow (*Salix* sp., Salicaceae family)
Transmittance [%]
0
20
40
60
80
100
2916
1595
1235
1077
4000
3500
3000
2500
2000
cm-1
1500
1000

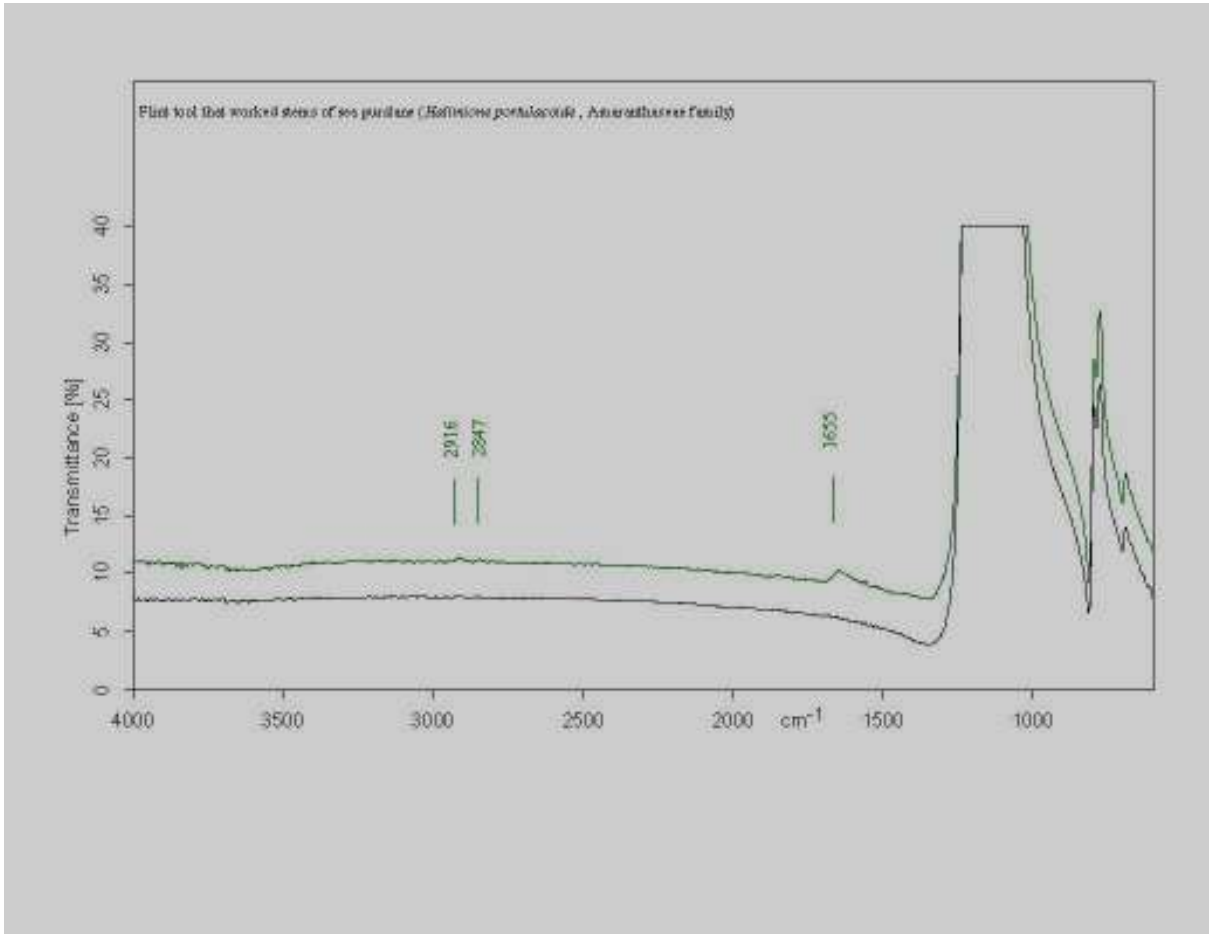

Transmittance [%]
0
10
20
30
40
50
1650
1505
2000
1800
1600
1400
1200
cm-1
1000
800
600


Flint tool that worked leaves and stems of stinging nettle (Urtica dioica L., Urticaceae family)
Transmittance [%]
0
5
10
15
20
25
30
35
40
45
1650
1505
2000
1800
1600
1400
1200
cm-1
1000
800
600


Flint tool that worked woody stems of pear tree (Pyrus communis L., Rosaceae family)
Transmittance [%]
0
20
40
60
80
100
1593
1505
1108
2000
1800
1600
1400
1200
cm-1
1000
800
600

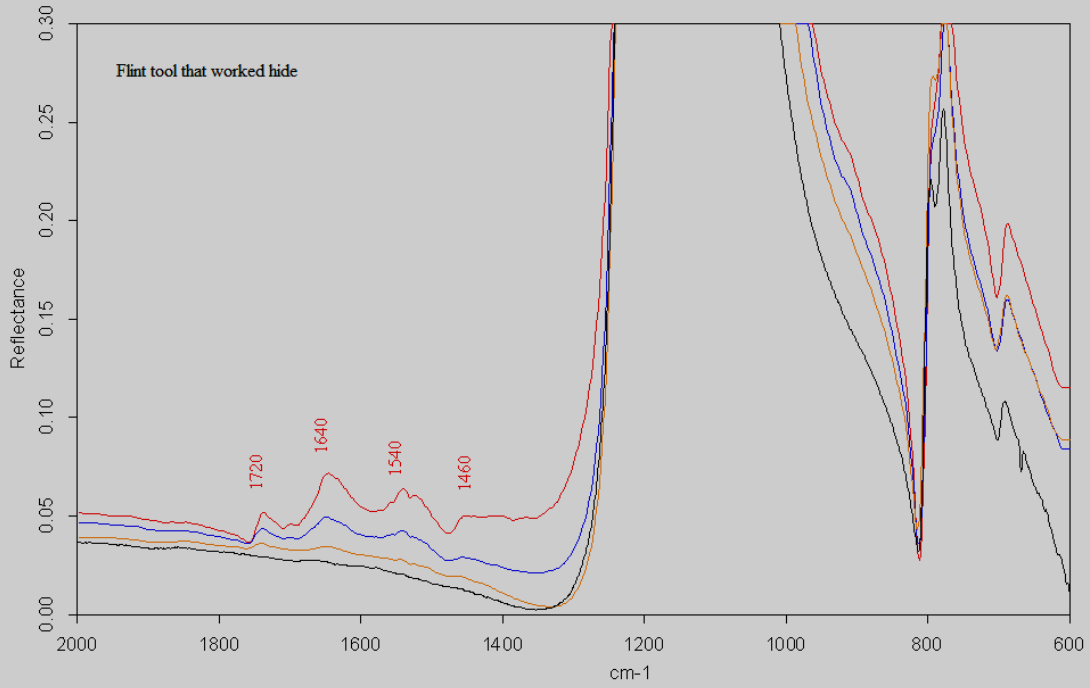

Flint tool that worked wood of european cornel (Cornus mas L., Cornaceae family)
Transmittance [%]
0
10
20
30
40
50
60
1650
1505
1424
2000
1800
1600
1400
1200
cm-1
1000
800
600

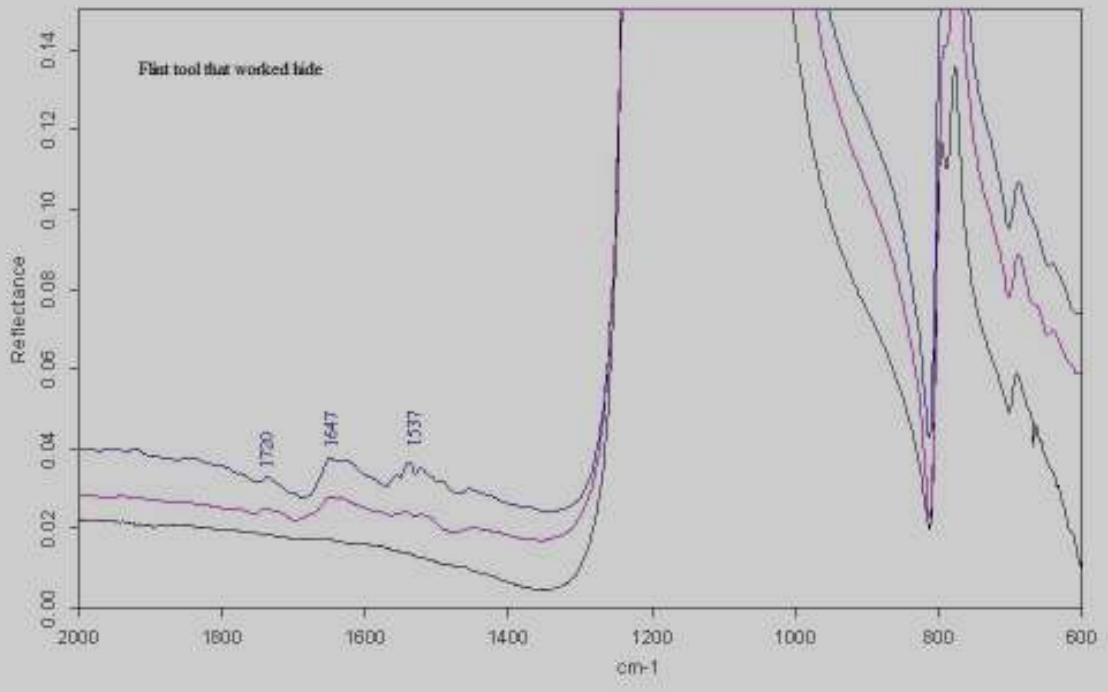

Flint tool that worked woody stems of blackberry (Rubus fruticosus L., Rosaceae family)
Transmittance [%]
0
10
20
30
40
50
60
70
2916
2847
1735
1655
1424
4000
3500
3000
2500
2000
cm-1
1500
1000

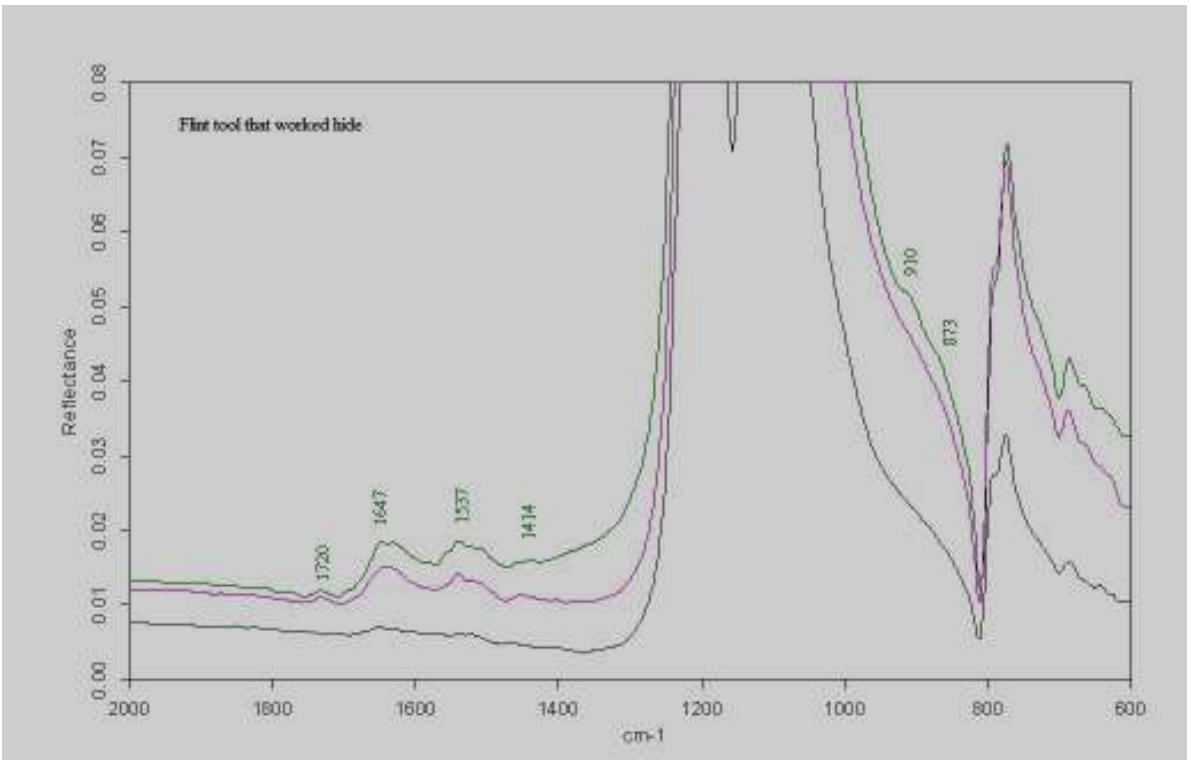

Plant tool that worked stems of sea purslane (Sesuvium portulacastrum , Aizoaceae Family)
Transmittance [%]
0
5
10
15
20
25
30
35
40
2916
2847
1655
4000
3500
3000
2500
2000
cm-1
1500
1000

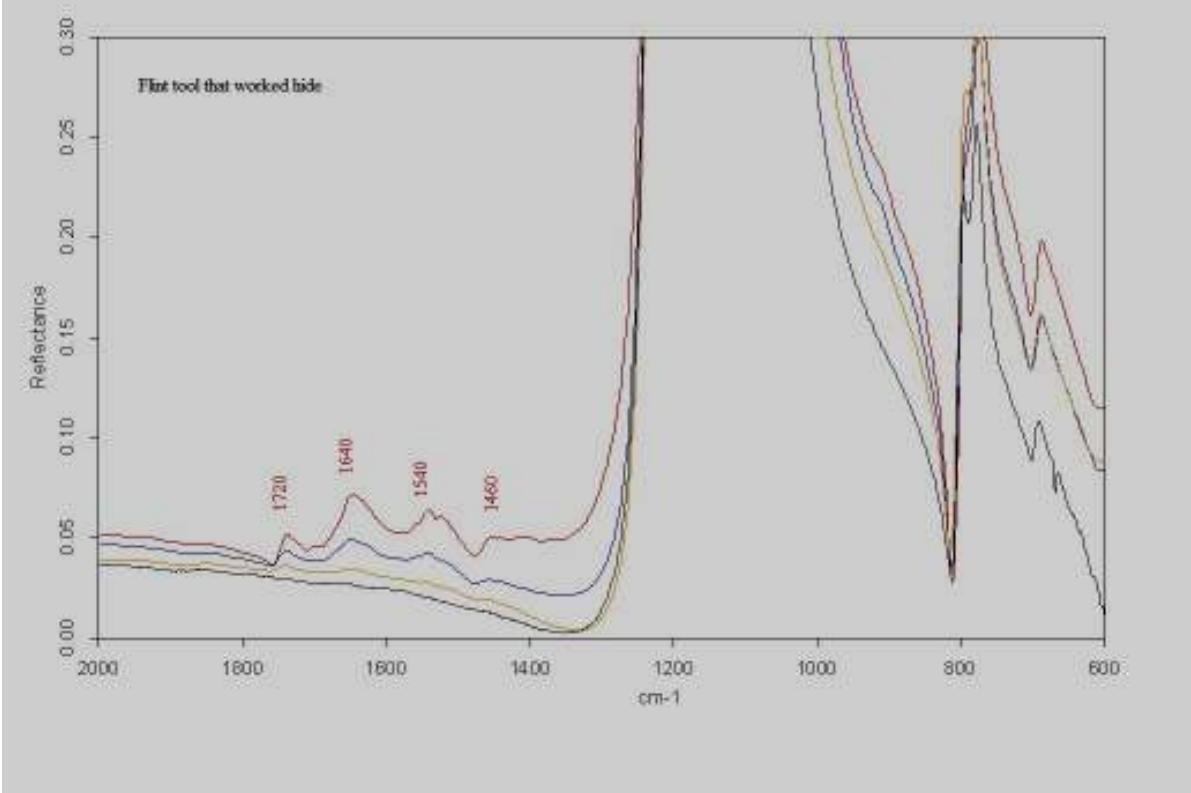
ANIMAL RESIDUES

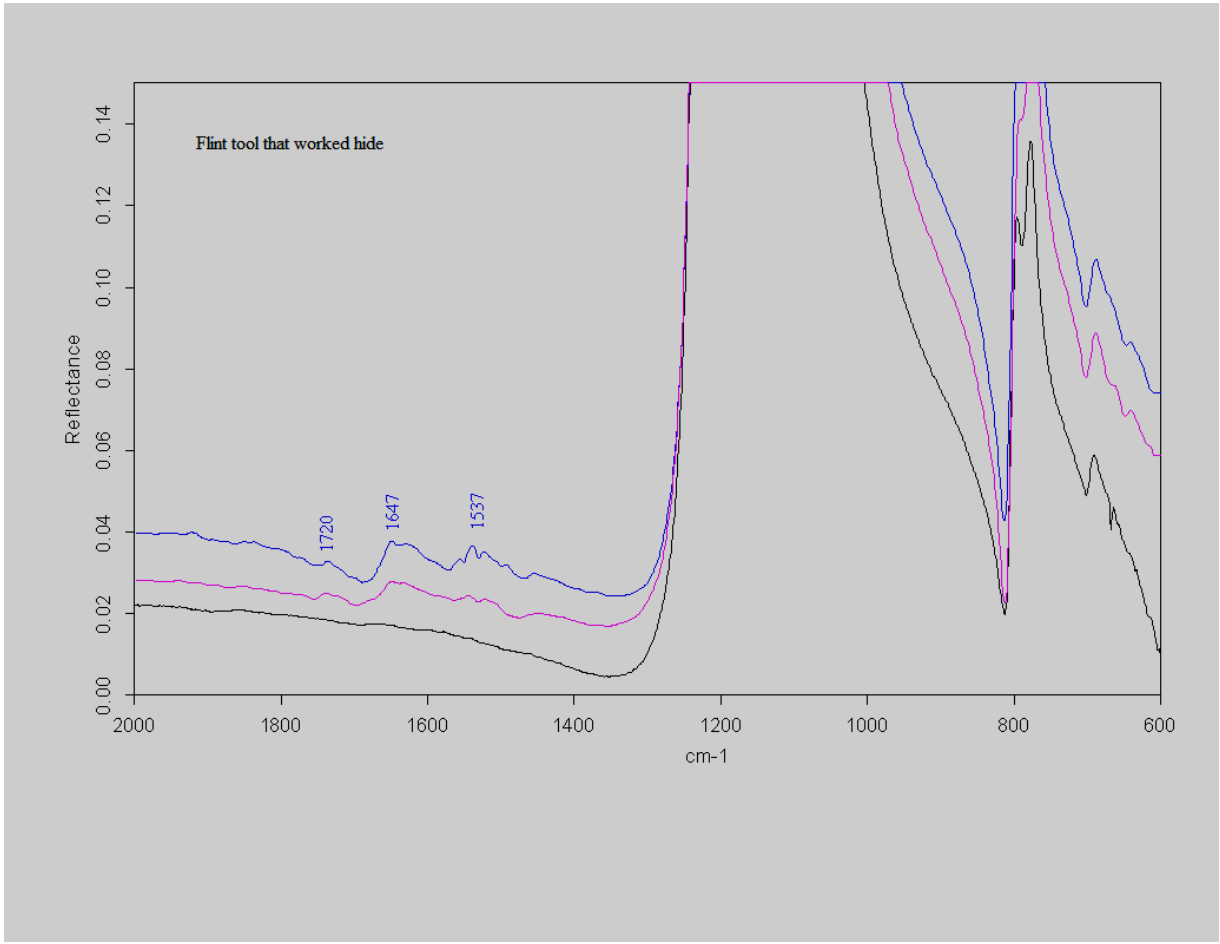
Wavenumber range (cm-1) of maxima	Proposed assignment
~ 3560	absorbed water weakly bound
3570 – 3450	valence vibration of H bonded O-H groups (intramolecular)
3400 – 3200	valence vibration of H bonded O-H groups
~ 3300	N-H stretching of proteins (Amide A)
~3100	N-H stretching of proteins (Amide B)
3000 – 2842	CH stretch in methyl and methylene groups
~ 1735	C=O stretching of esters
1720 – 1710	C=O stretching of triacylglycerols
~ 1640	C=O stretching (amide I) of proteins
1573	fatty acid calcium salt carboxilate C-O stretching (adipocere)
~ 1540	NH + CN stretching of proteins (amide II)
1537	fatty acid calcium salt carboxilate C-O stretching (adipocere)
~ 1460	CH_2 and CH_3 deformation of proteins
1414	C=O stretching of calcite
~ 1030	Si-O stretching of kaolinite
~ 914	Si-O stretching of kaolinite
~ 910	PO_4^{3-} stretching of apatite (bone)
877	CO_3^{2-} stretching of calcite
~ 660	Al-Si-O bend of kaolinite

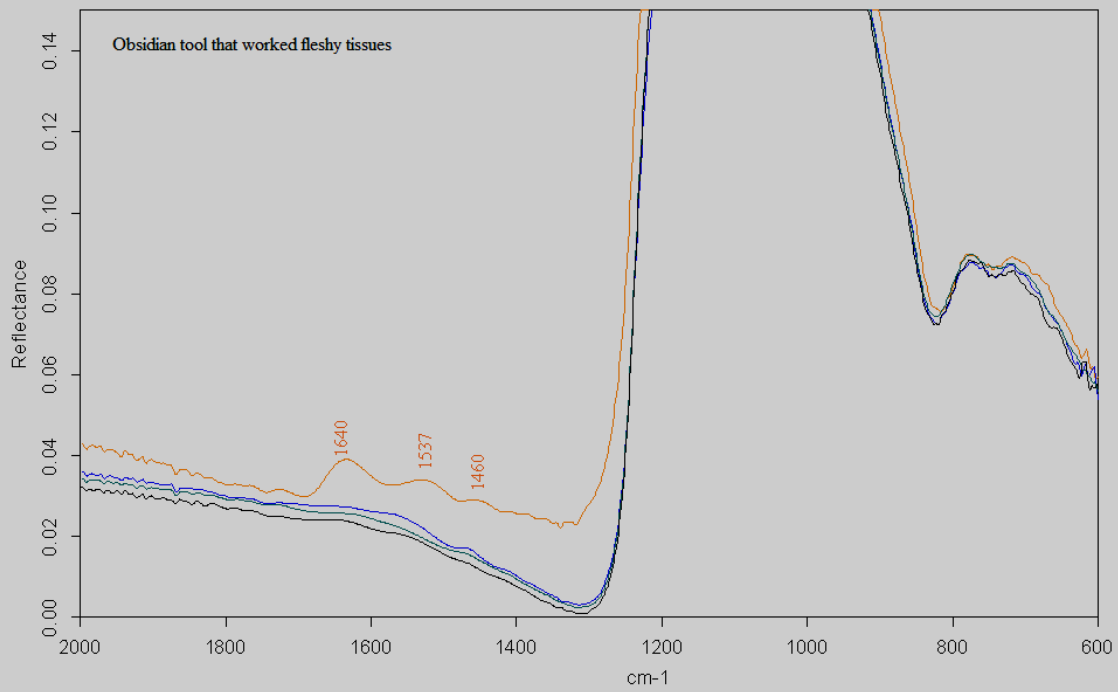

Flint tool that worked hide
Reflectance
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1720
1640
1540
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

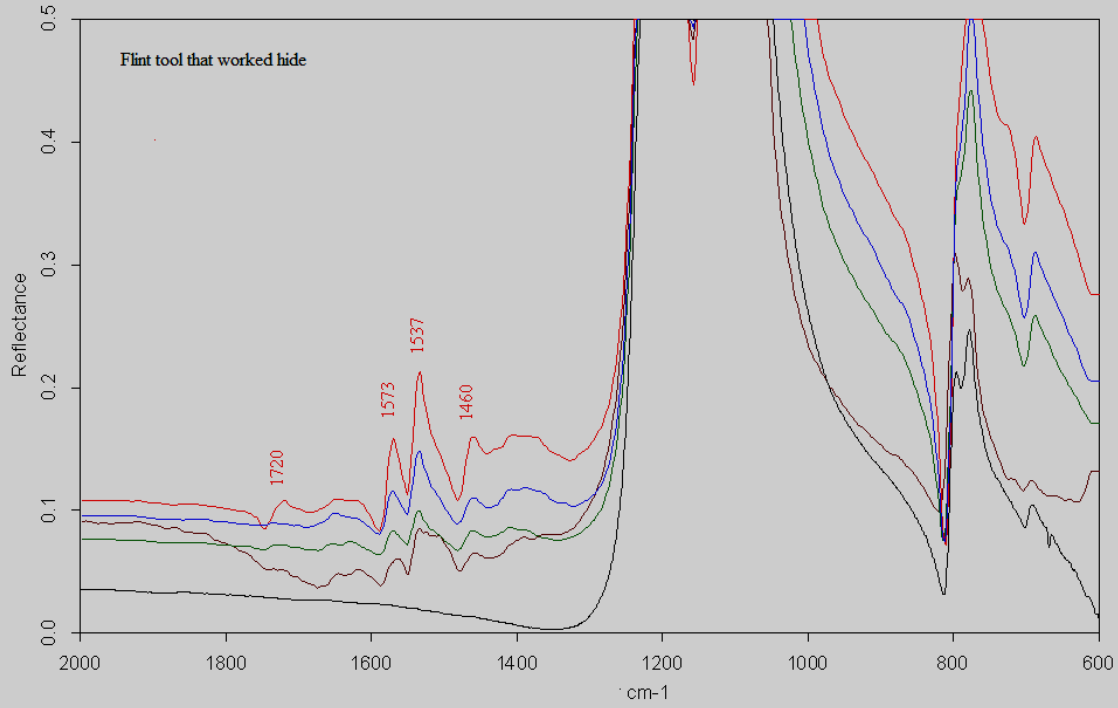

Flint tool that worked hide
Reflectance
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
1720
1647
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1

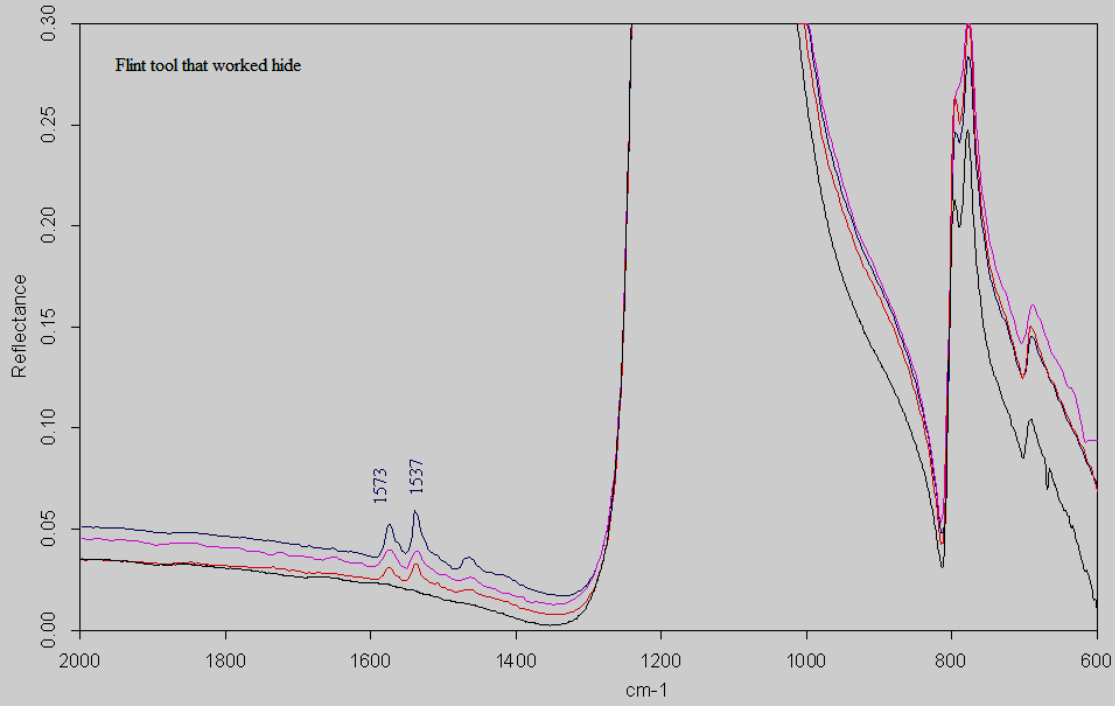

Flint tool that worked hide
Reflectance
0.00
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
1720
1647
1537
1414
910
873
2000
1800
1600
1400
1200
1000
800
600
cm-1

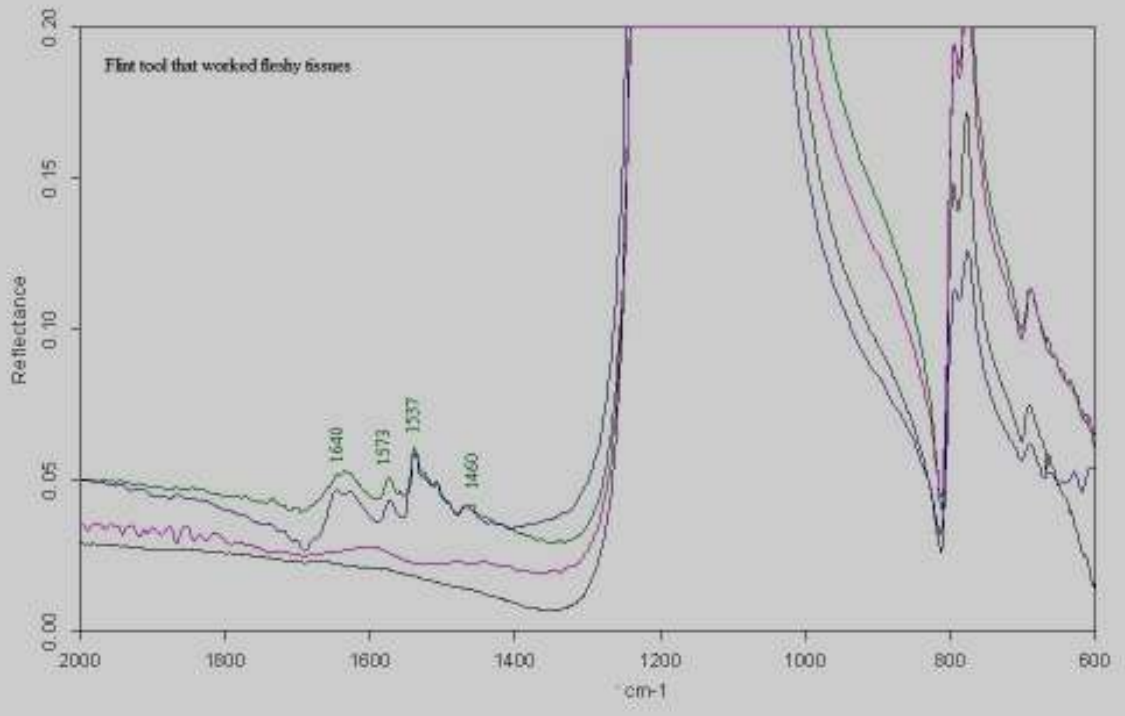

Flint tool that worked hide
Reflectance
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1720
1640
1540
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

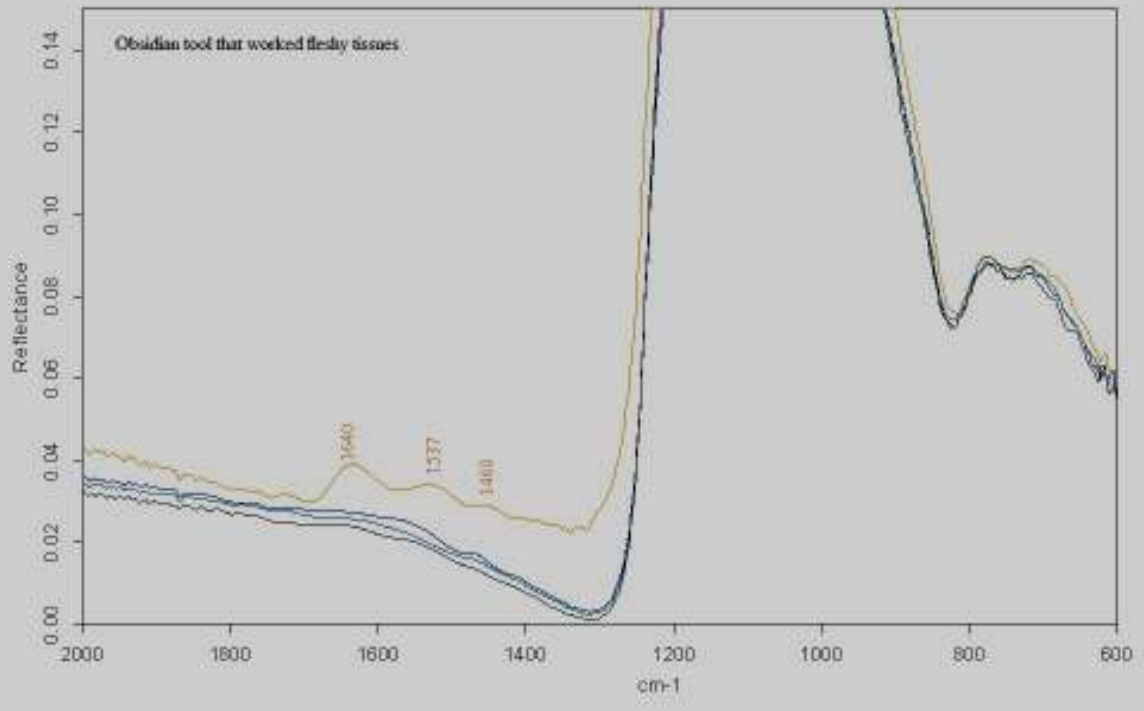

Flint tool that worked hide
Reflectance
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
1720
1647
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1

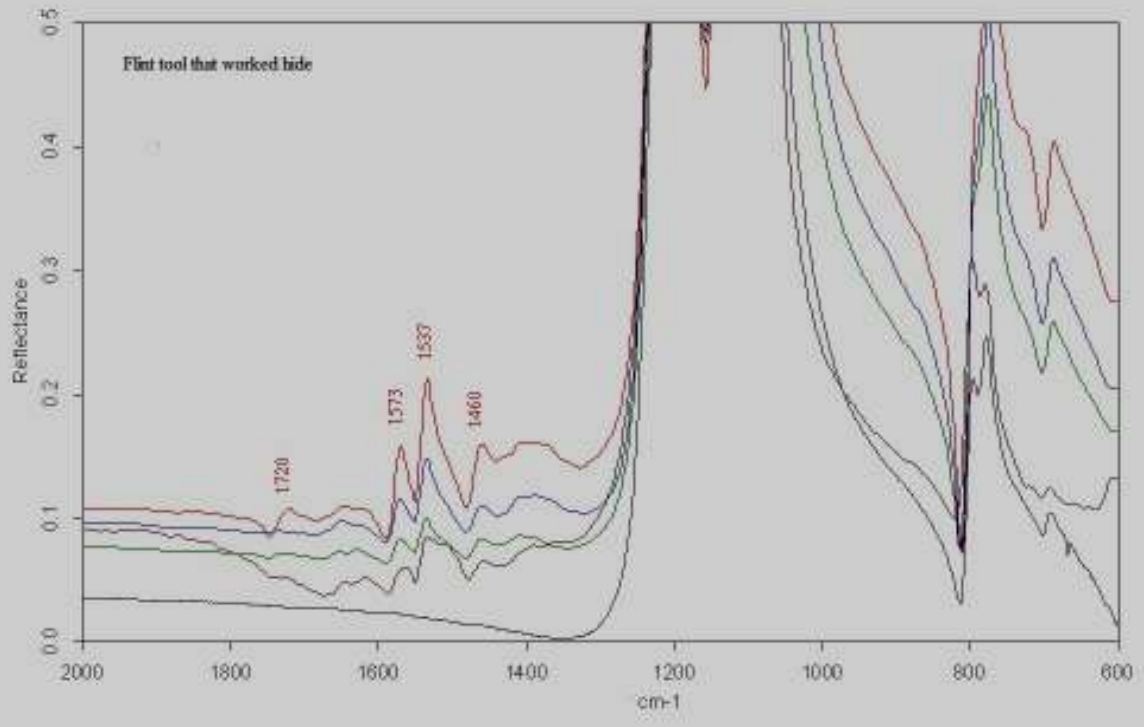

Obsidian tool that worked fleshy tissues
Reflectance
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
1640
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

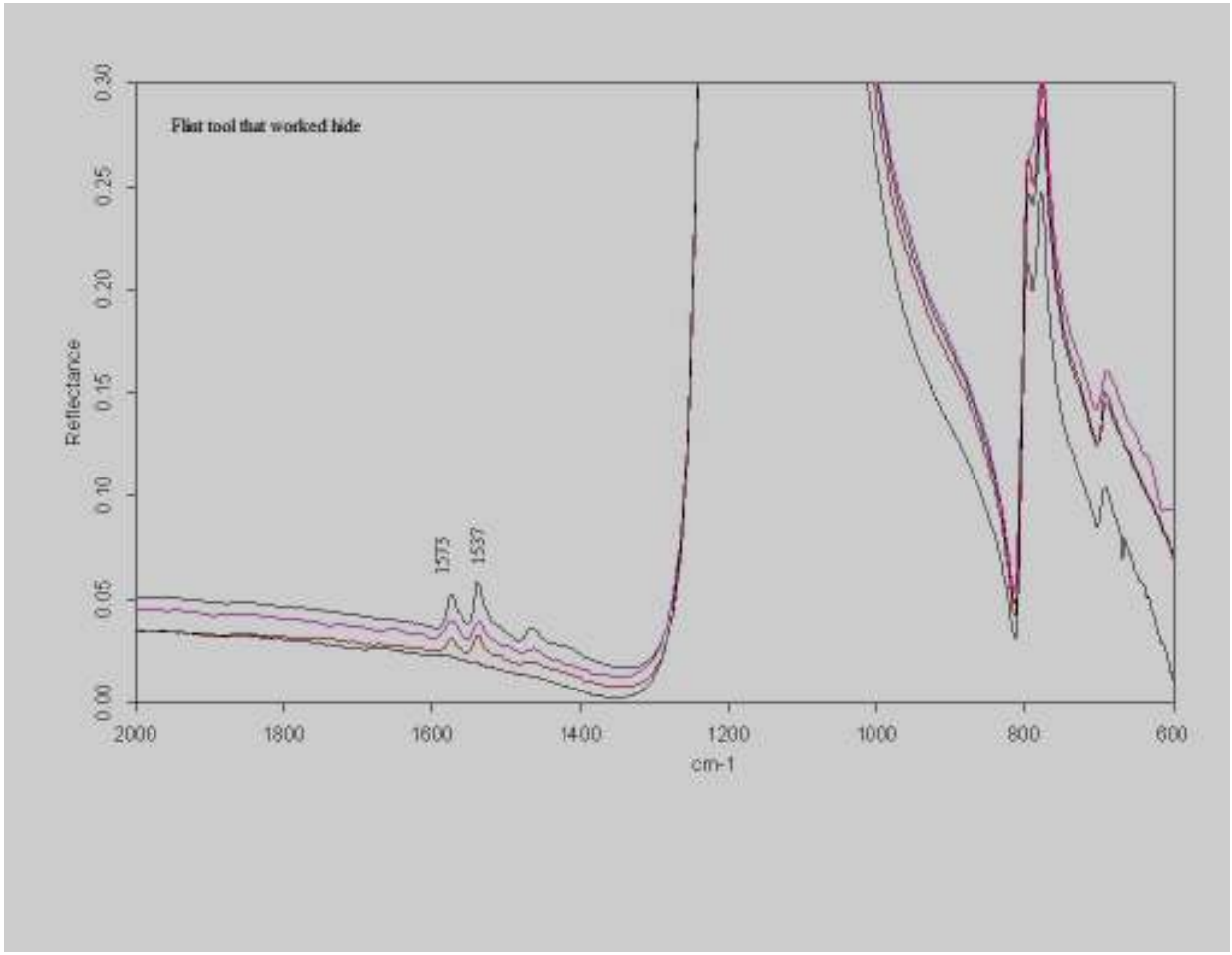

Flint tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1720
1573
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

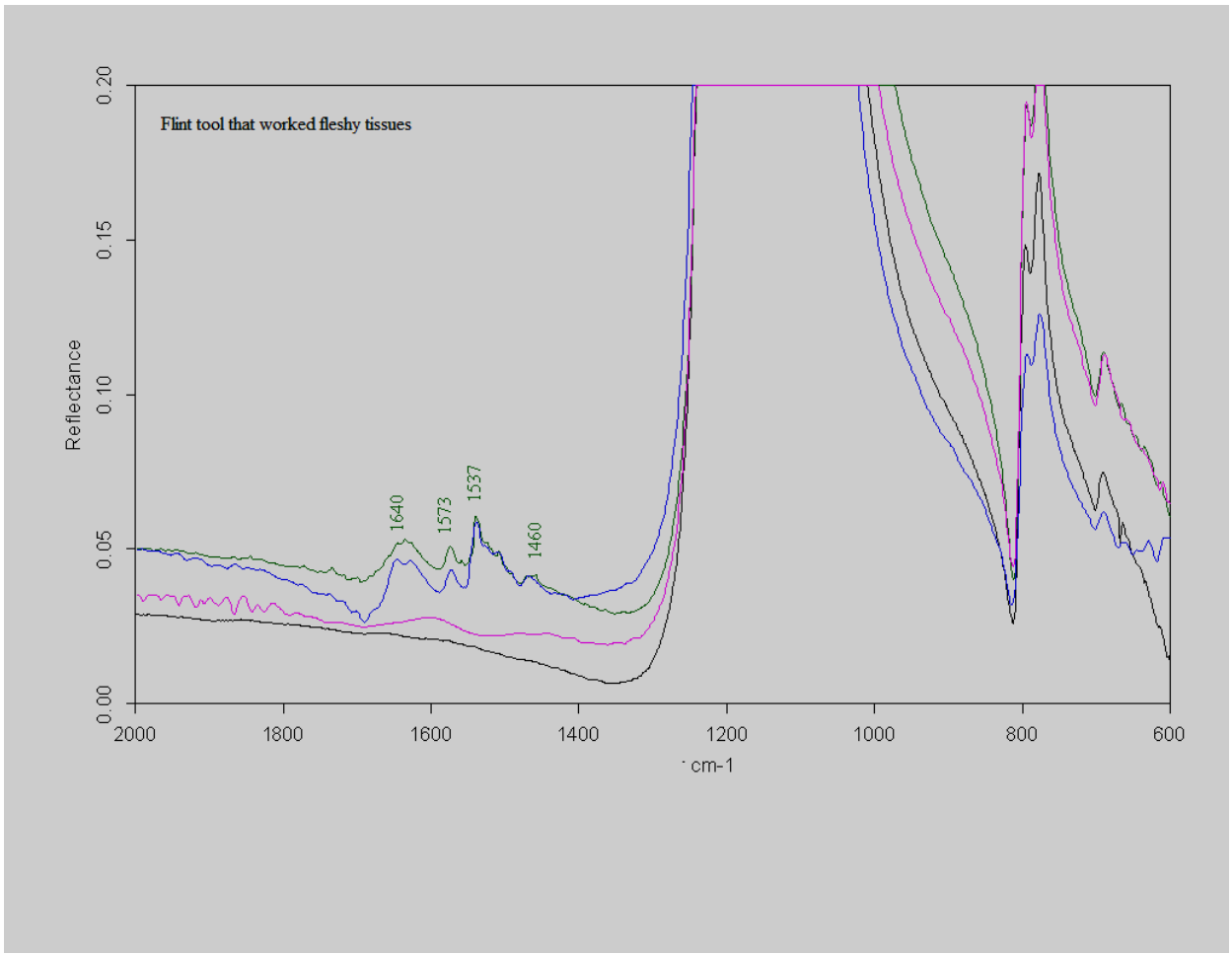

Flint tool that worked hide
Reflectance
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1573
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1

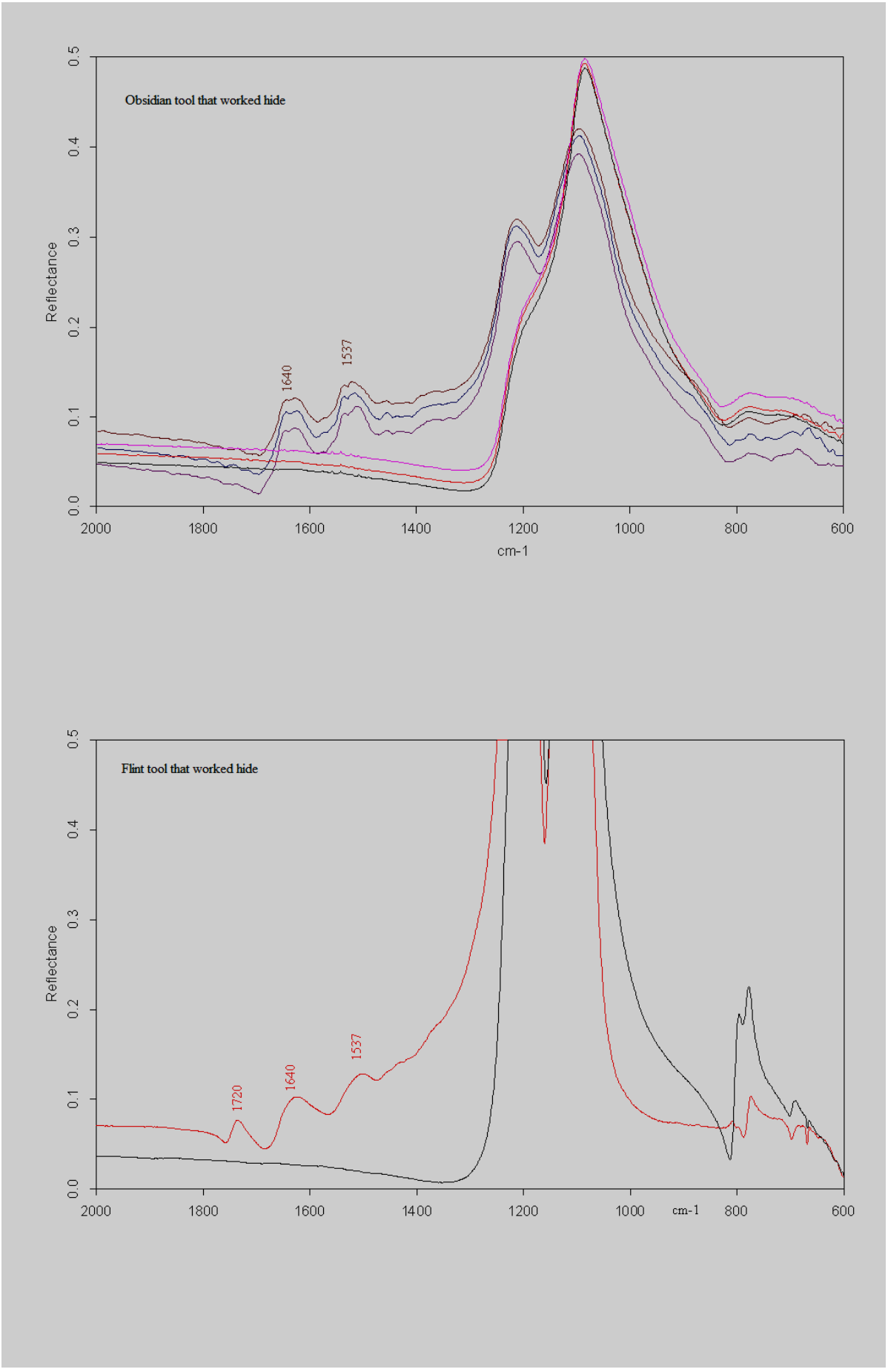

Flint tool that worked fleshy tissues
Reflectance
0.00
0.05
0.10
0.15
0.20
1640
1573
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

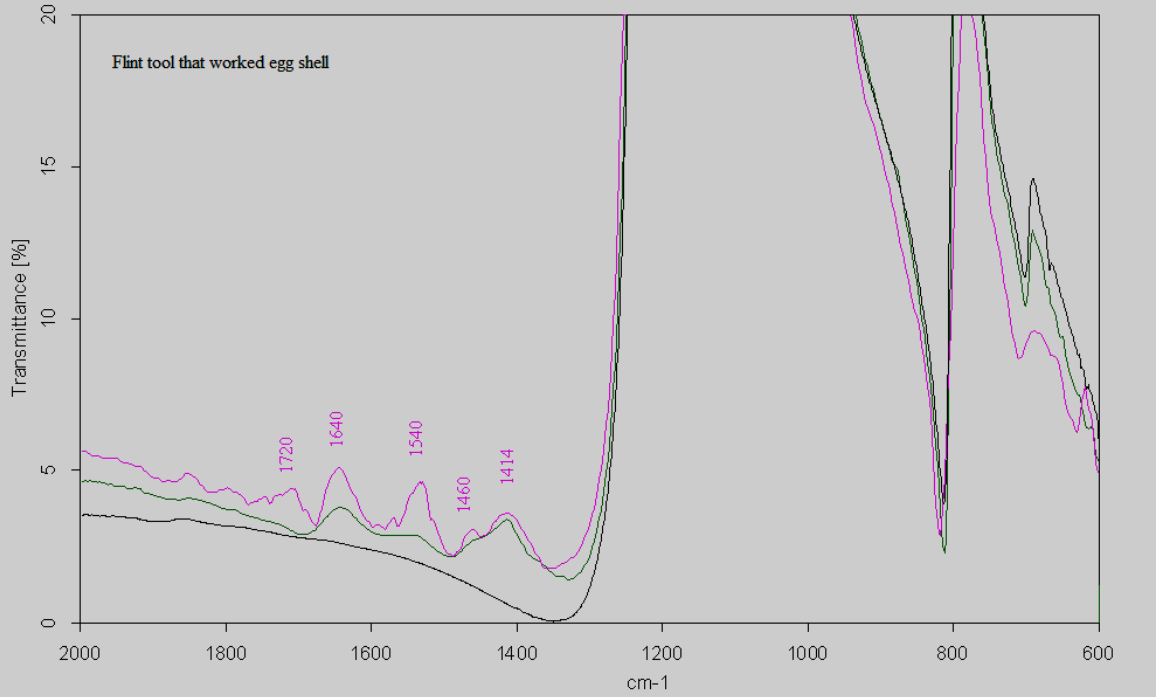

Obsidian tool that worked fleshy tissues
Reflectance
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
1640
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

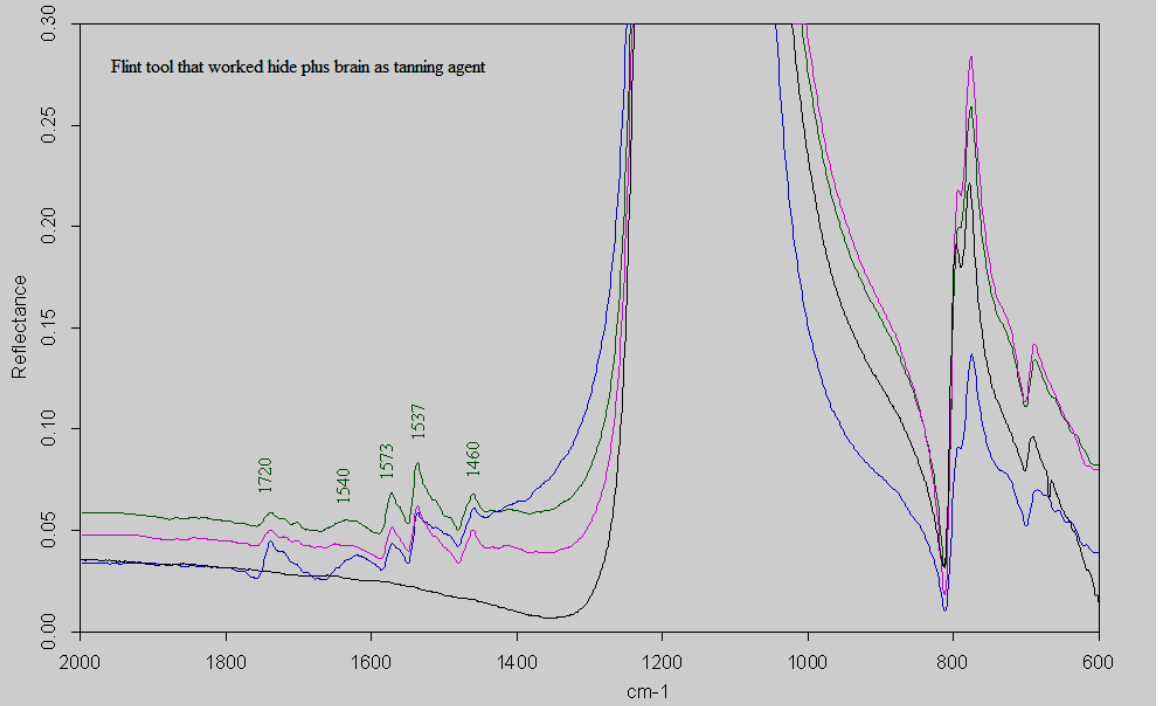

Flint tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1720
1573
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

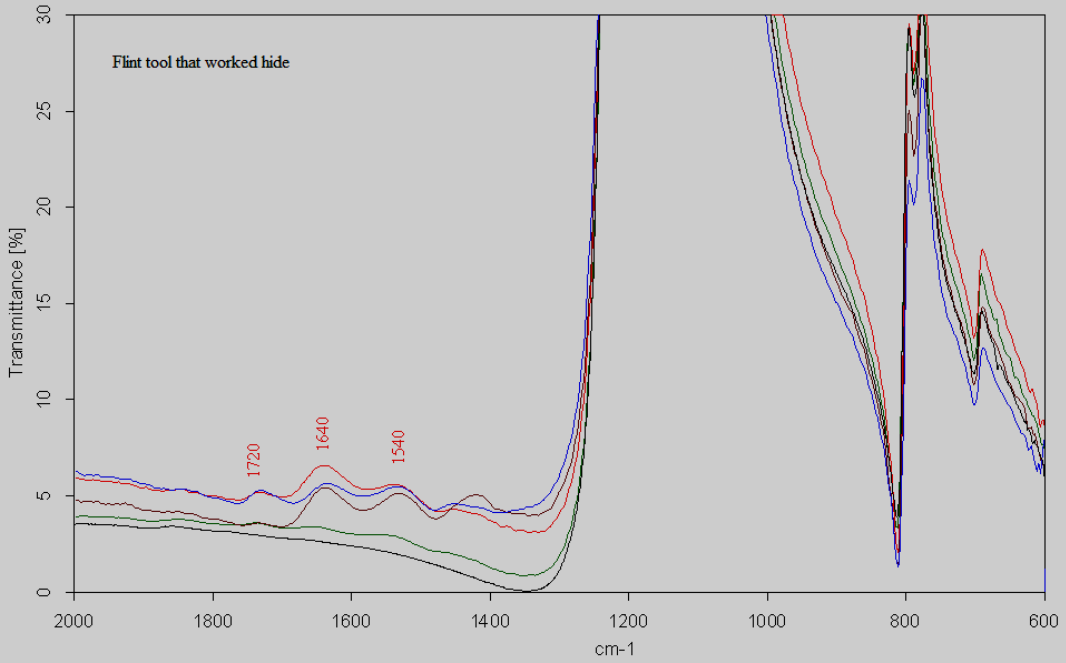

Flint tool that worked hide
Reflectance
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1573
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1

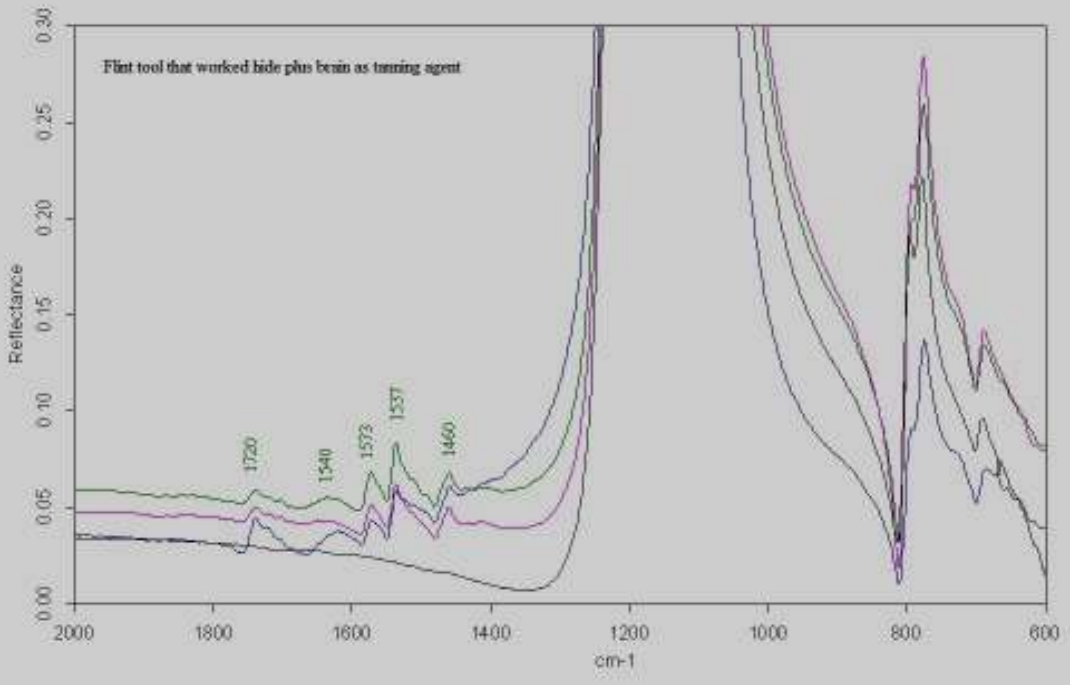

Flint tool that worked fleshy tissues
Reflectance
0.00
0.05
0.10
0.15
0.20
1640
1573
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

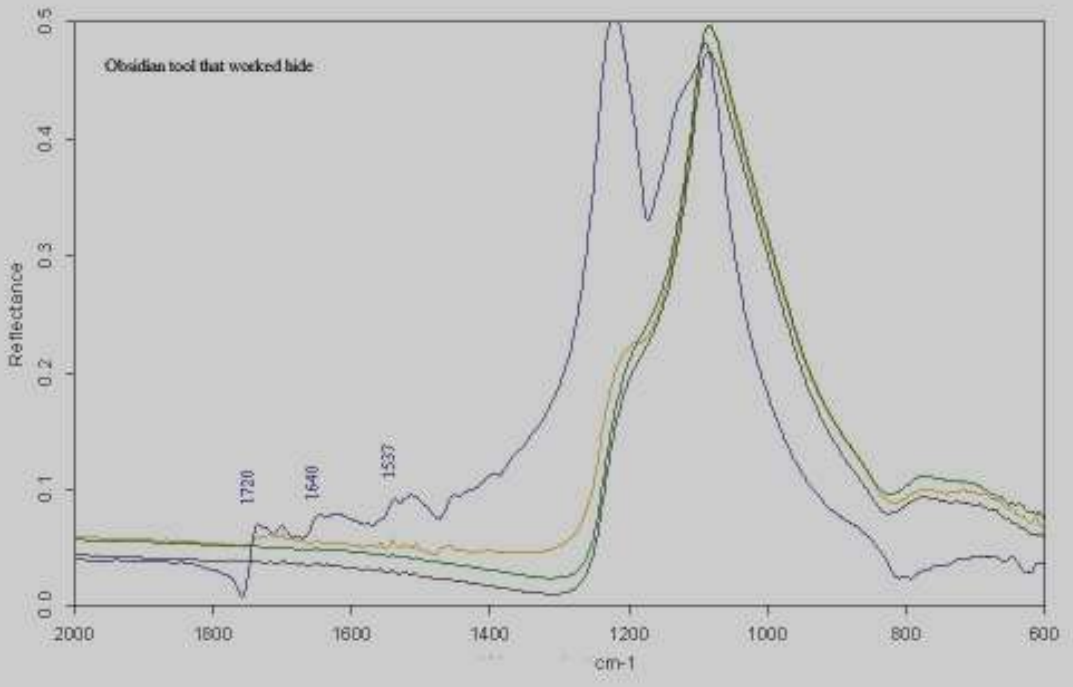

Obsidian tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1640
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1
Flint tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1720
1640
1537
2000
1800
1600
1400
1200
1000
cm-1
800
600

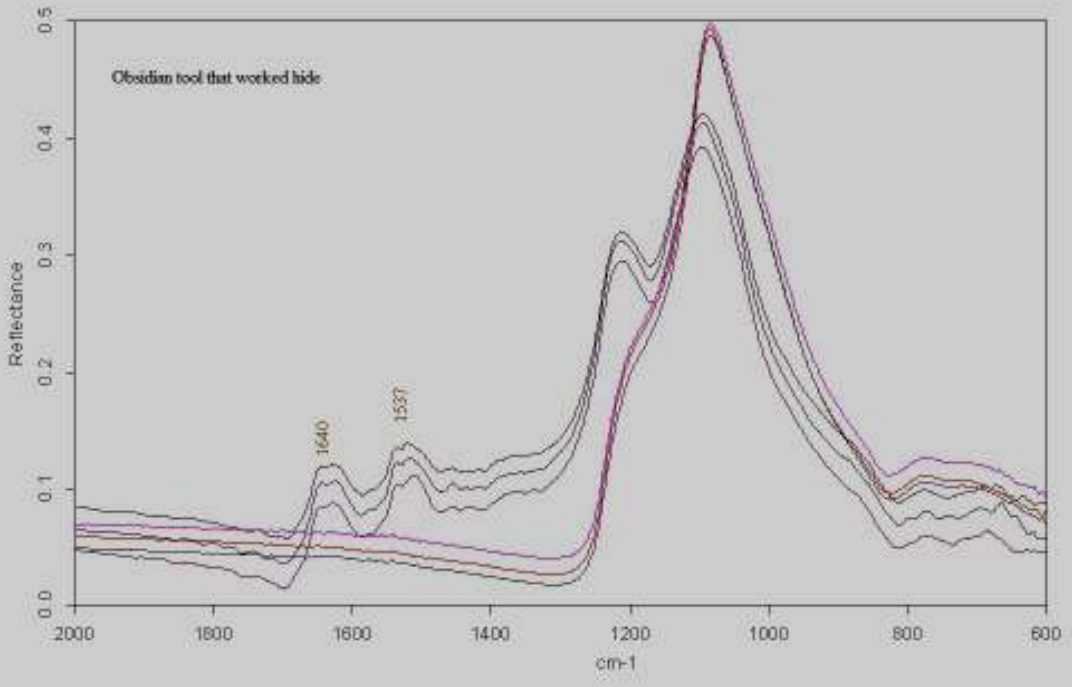

Flint tool that worked egg shell
Transmittance [%]
0
5
10
15
20
1720
1640
1540
1460
1414
2000
1800
1600
1400
1200
1000
800
600
cm-1

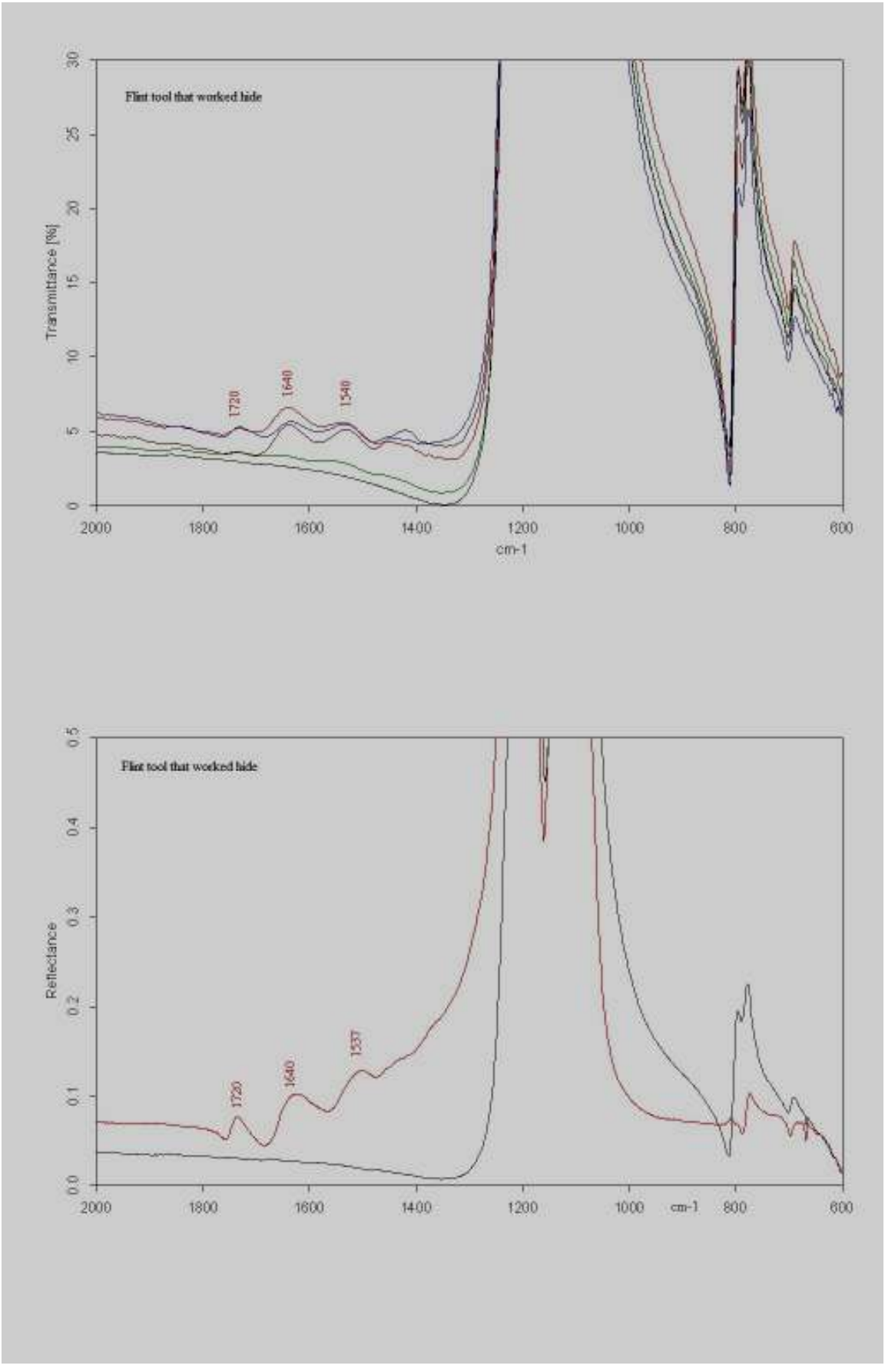

Flint tool that worked hide plus brain as tanning agent
Reflectance
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1720
1540
1573
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1

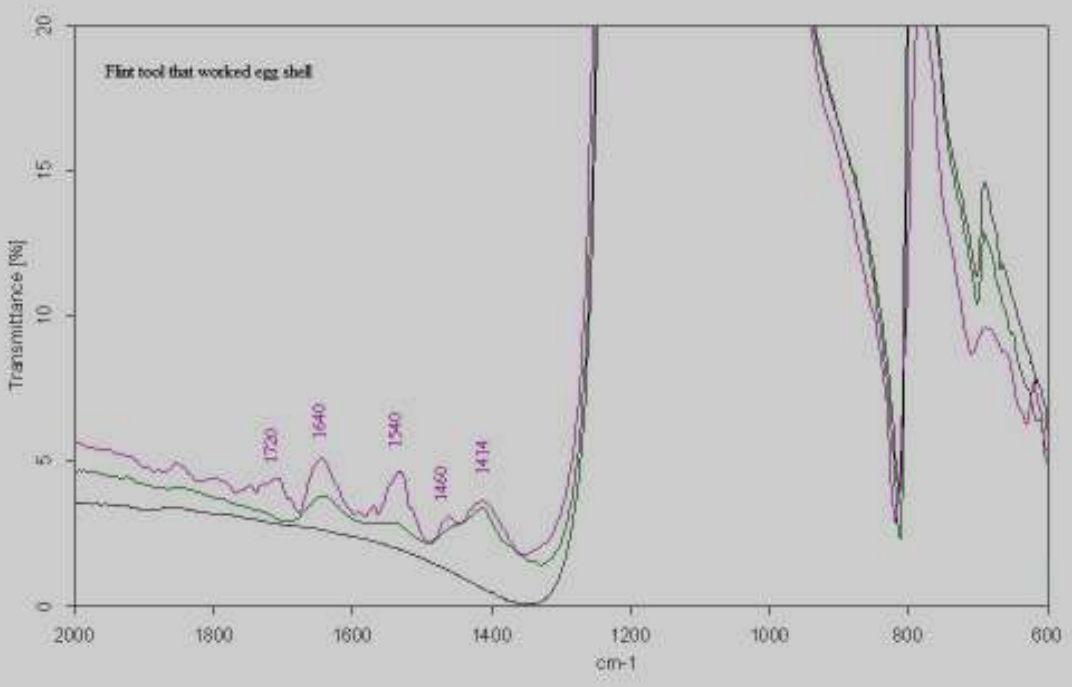

Flint tool that worked hide
Transmittance [%]
0
5
10
15
20
25
30
1720
1640
1540
2000
1800
1600
1400
1200
1000
800
600
cm-1

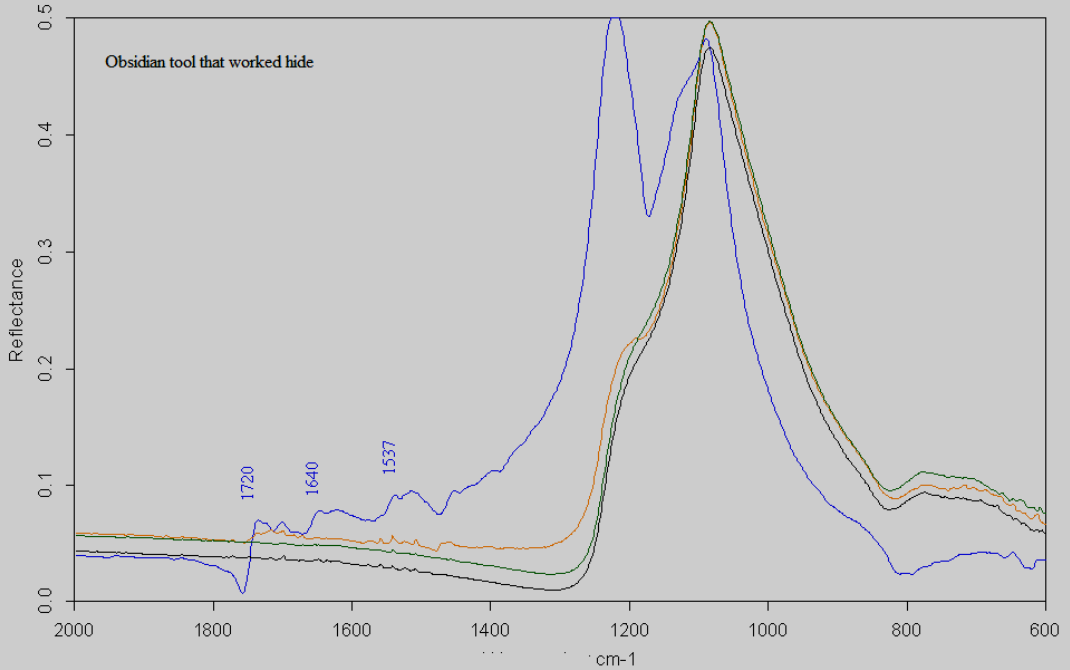

Flint tool that worked hide plus bean as tanning agent
Reflectance
0.00
0.05
0.10
0.15
0.20
0.25
0.30
1720
1540
1573
1537
1460
2000
1800
1600
1400
1200
1000
800
600
cm-1


Obsidian tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1720
1640
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1


Obsidian tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1640
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1


Flint tool that worked hide
Transmittance [%]
0
5
10
15
20
25
30
1720
1640
1540
2000
1800
1600
1400
1200
1000
800
600
cm-1
Flint tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1720
1640
1537
2000
1800
1600
1400
1200
1000
cm-1
800
600


Flint tool that worked egg shell
Transmittance [%]
0
5
10
15
20
1720
1640
1540
1460
1414
2000
1800
1600
1400
1200
1000
800
600
cm-1


Obsidian tool that worked hide
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
1720
1640
1537
2000
1800
1600
1400
1200
1000
800
600
cm-1