Digital Taphonomy: A new microphotogrammetric approach to geometric morphometrics

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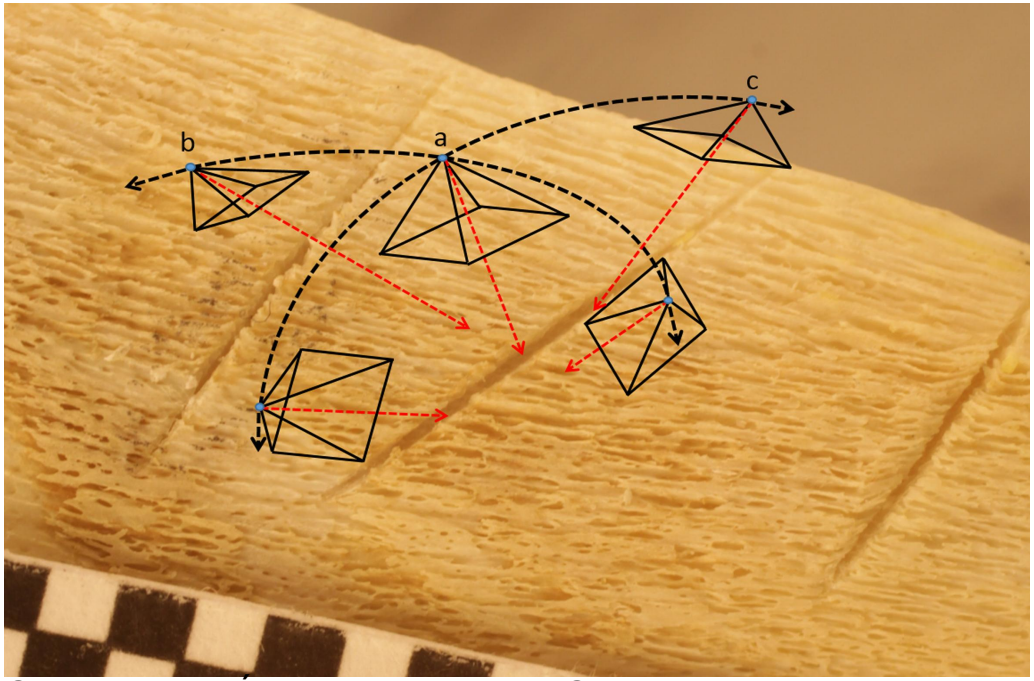
Introduction

- Studies about cut-marks has a great importance in taphonomic studies.
- Useful for open windows to human behaviour and resource exploitation strategies in the past
- Our work, try two things:
  - Faster and cheaper techniques to study cut-marks profiles.
  - Statistical and Geometrical Morphometrics to study their profiles.

- **Are we able to recognise the raw material of which the tool used to make the marks were made of?**

Macro-Photogrammetry



- Reflex camera + macro lens
- Agisoft PhotoScan

González, M. Á. M., Yravedra, J., González-Aguilera, D., Palomeque-González, J. F., & Domínguez-Rodrigo, M. (2015). Micro-photogrammetric characterization of cut marks on bones. *Journal of Archaeological Science*, *62*, 128-142.

IMAGE BASED MODELLING

INPUTS

IMAGES

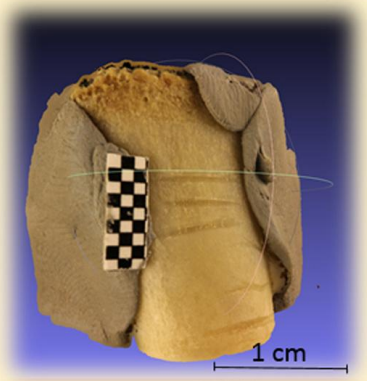
Field Work

PROCESSING

PW DATA PROCESSING

- Automatic extraction and matching
- Automatic hierarchical orientation
- Automatic 3D dense surface generation
- Scaling

RESULTS

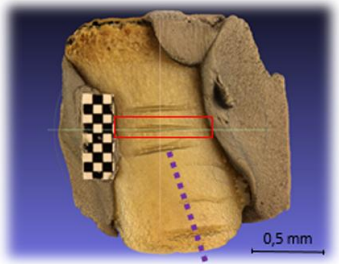


Self-Scaled 3D Model

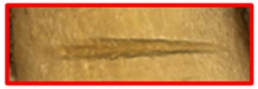
CROSS SECTIONS

Product derivative of photogrammetry:

- Digital Elevation Models (DEM)
- Orthophotography
- 3D Point Clouds
- 3D Model



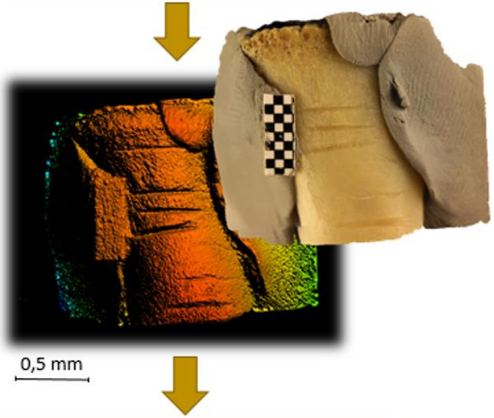
3D Model of bone



3D Model of cut mark

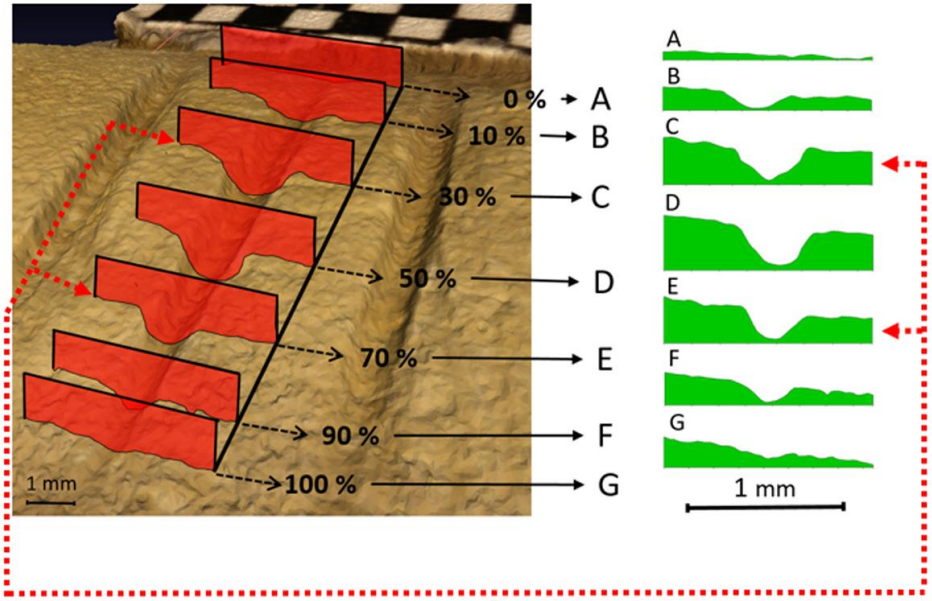
0,5 mm

INPUT DEM AND ORTHOPHOTOGRAPHY IN GLOBAL MAPPER

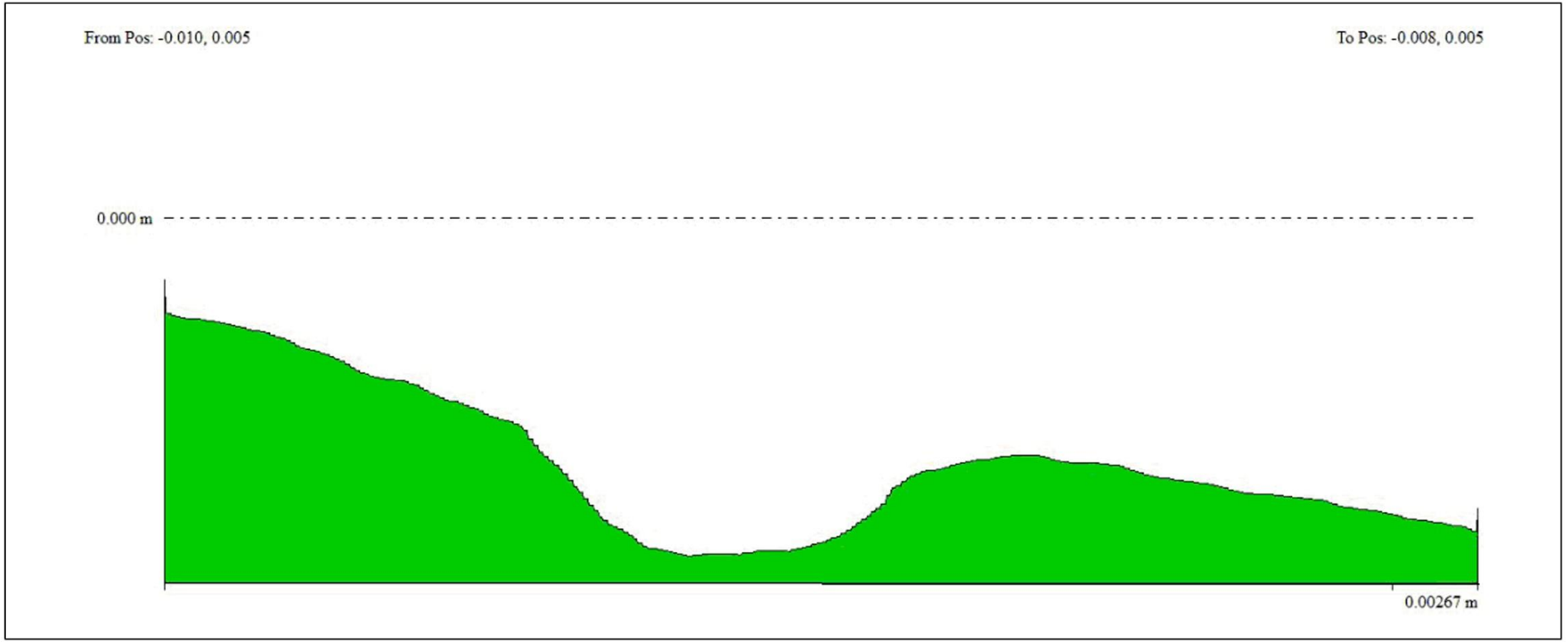


Cross sections from different relative positions along the cut mark.

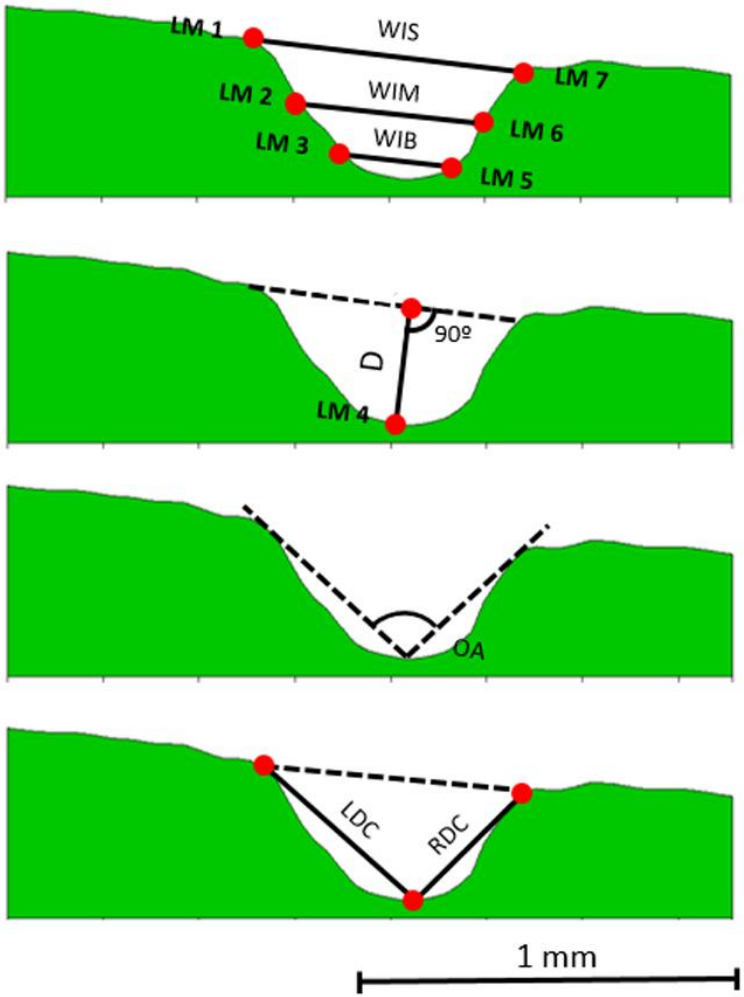
3D Model of bone.



Confidence area on which measurements can be taken (30%-70% of the groove).



- First attempts, profile to CAD, take scale, and measures manual to spreadsheet
- Working in R: package “Pandora” -> fast and easy; Possibility do morphometric tests.
- Input by menus: Site, name of mark, raw material of the tool (if knows), animal taxon...
- Input by mouse: scale and 7 Landmarks.
- Pandora calculates the measures and save all in a *.marks file



We measure on the profile:

WIS - Width of the incision at the surface

WIM - Width of the incision at the mean

WIB - Width of the incision at its bottom

D - Depth of the incision

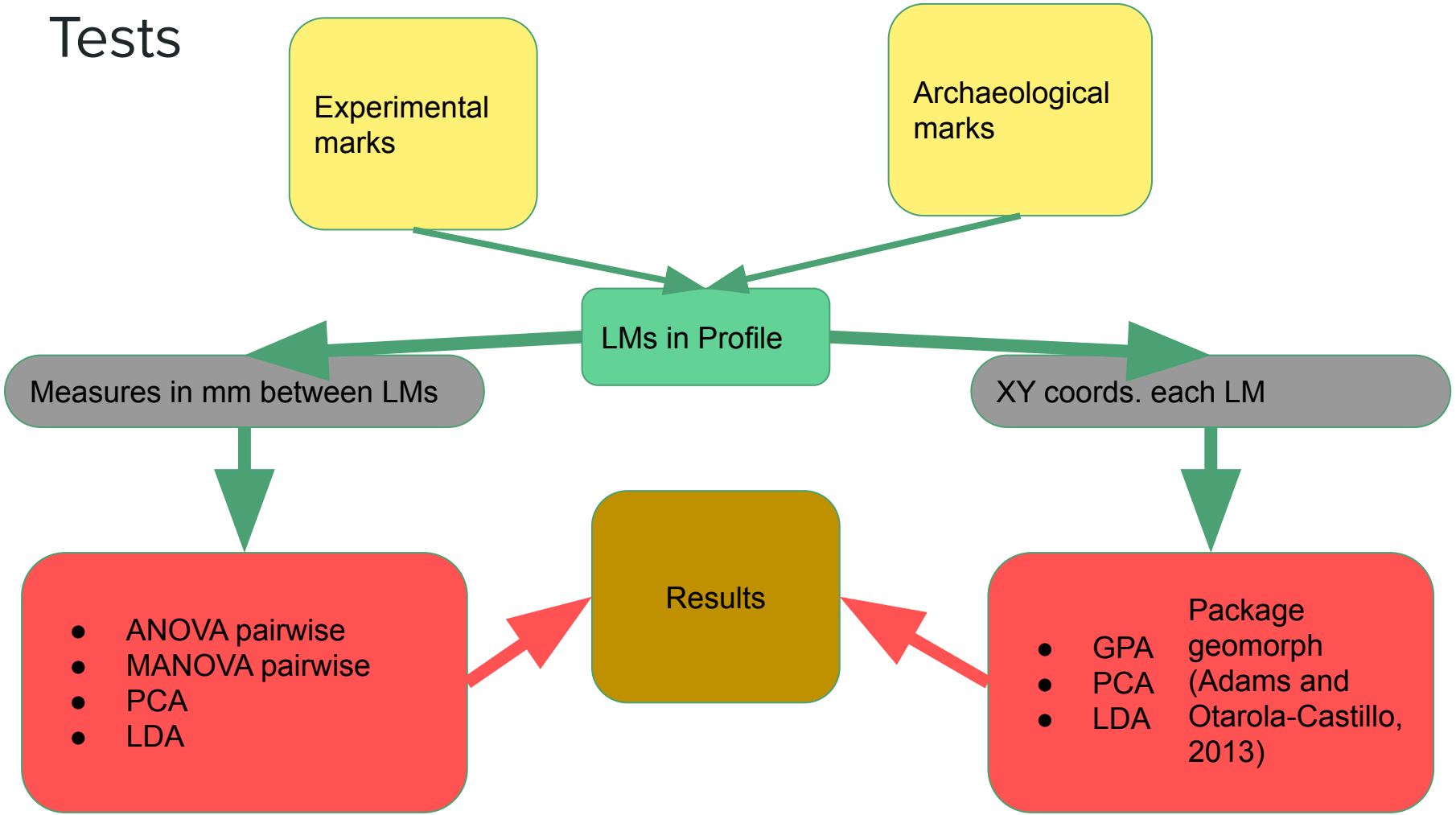
OA - Opening angle of the incision

LDC - Left depth of the incision convergent

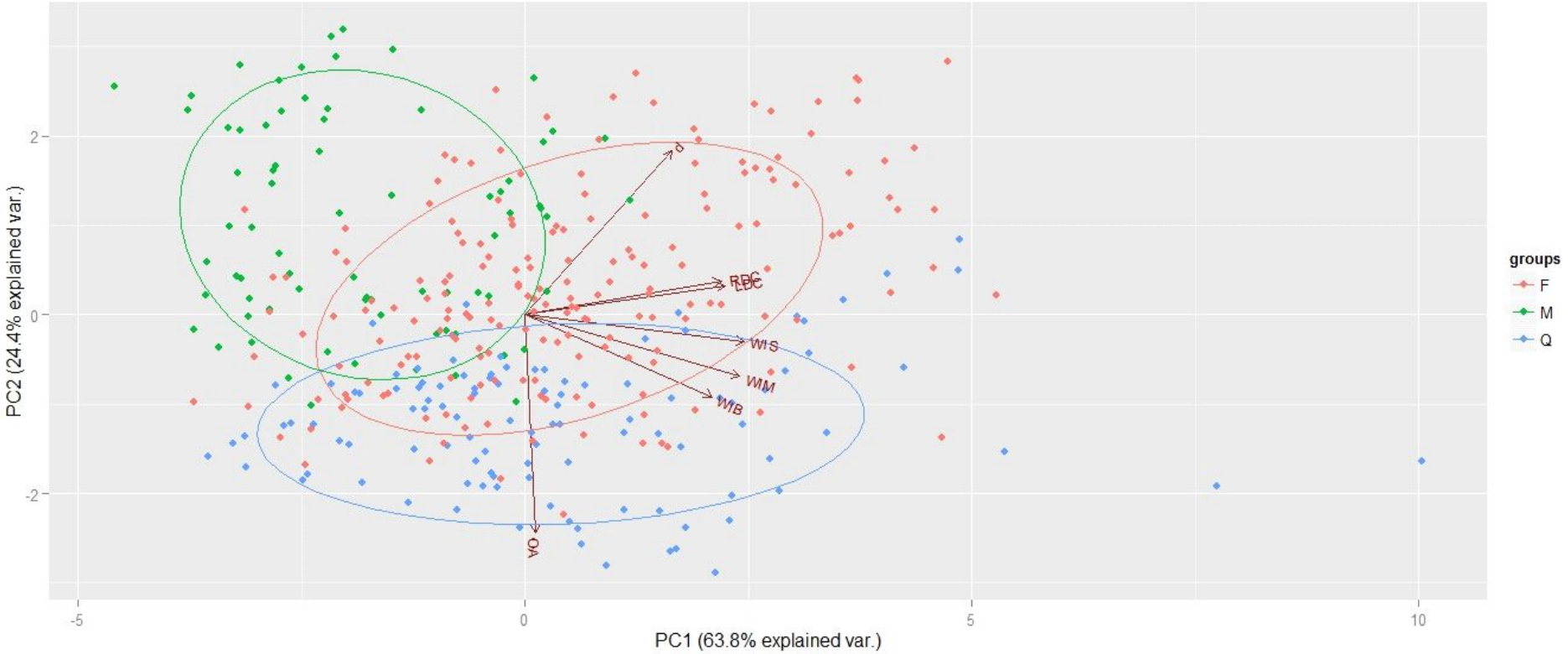
RDC - Right depth of the incision convergent

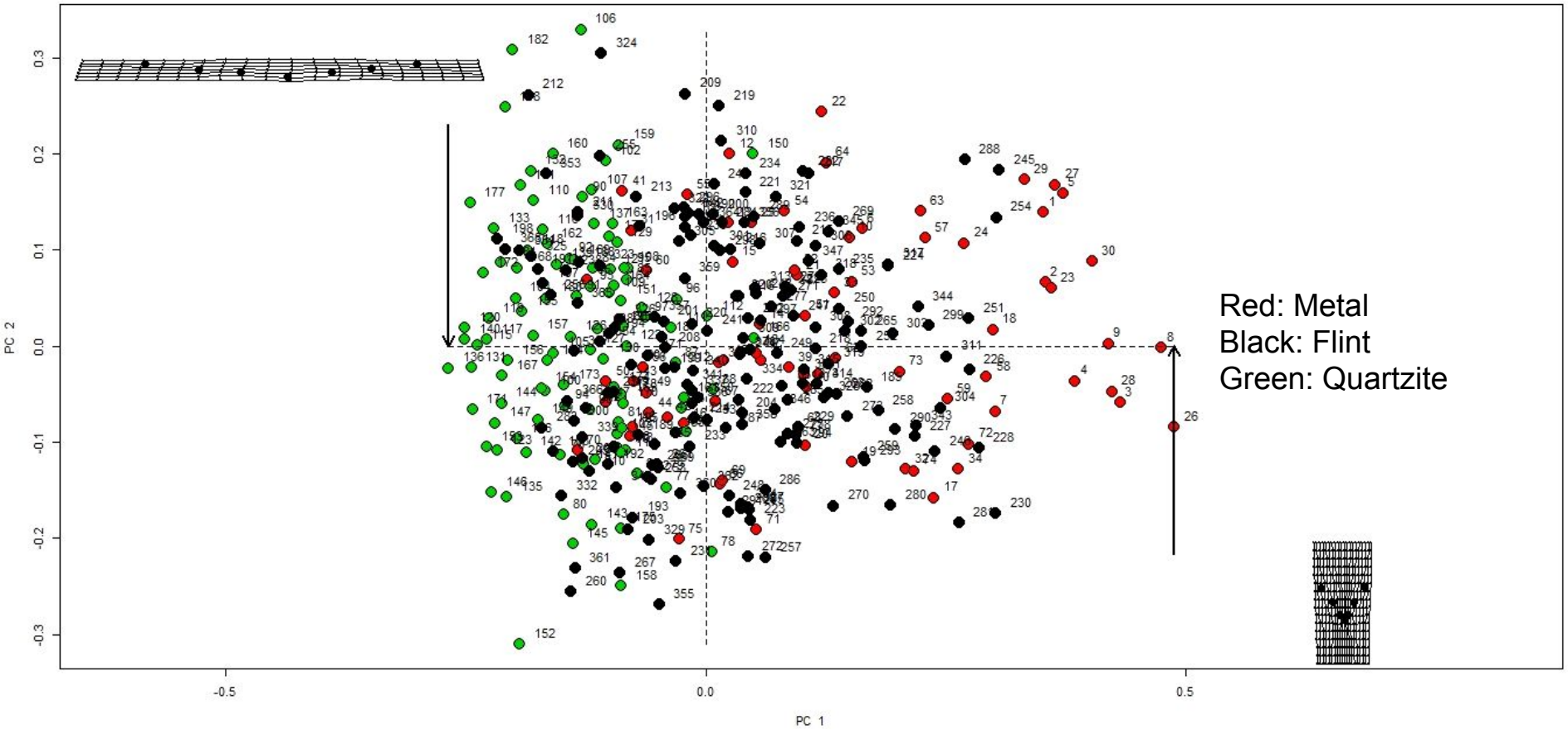
SI - Absolute value of: LDC - RDC

Tests


Experimental marks
Archaeological marks
LMs in Profile
Measures in mm between LMs
XY coords. each LM
ANOVA pairwise
MANOVA pairwise
PCA
LDA
Results
GPA
PCA
LDA
Package geomorph (Adams and Otarola-Castillo, 2013)

Metal VS Flint VS Quartzite

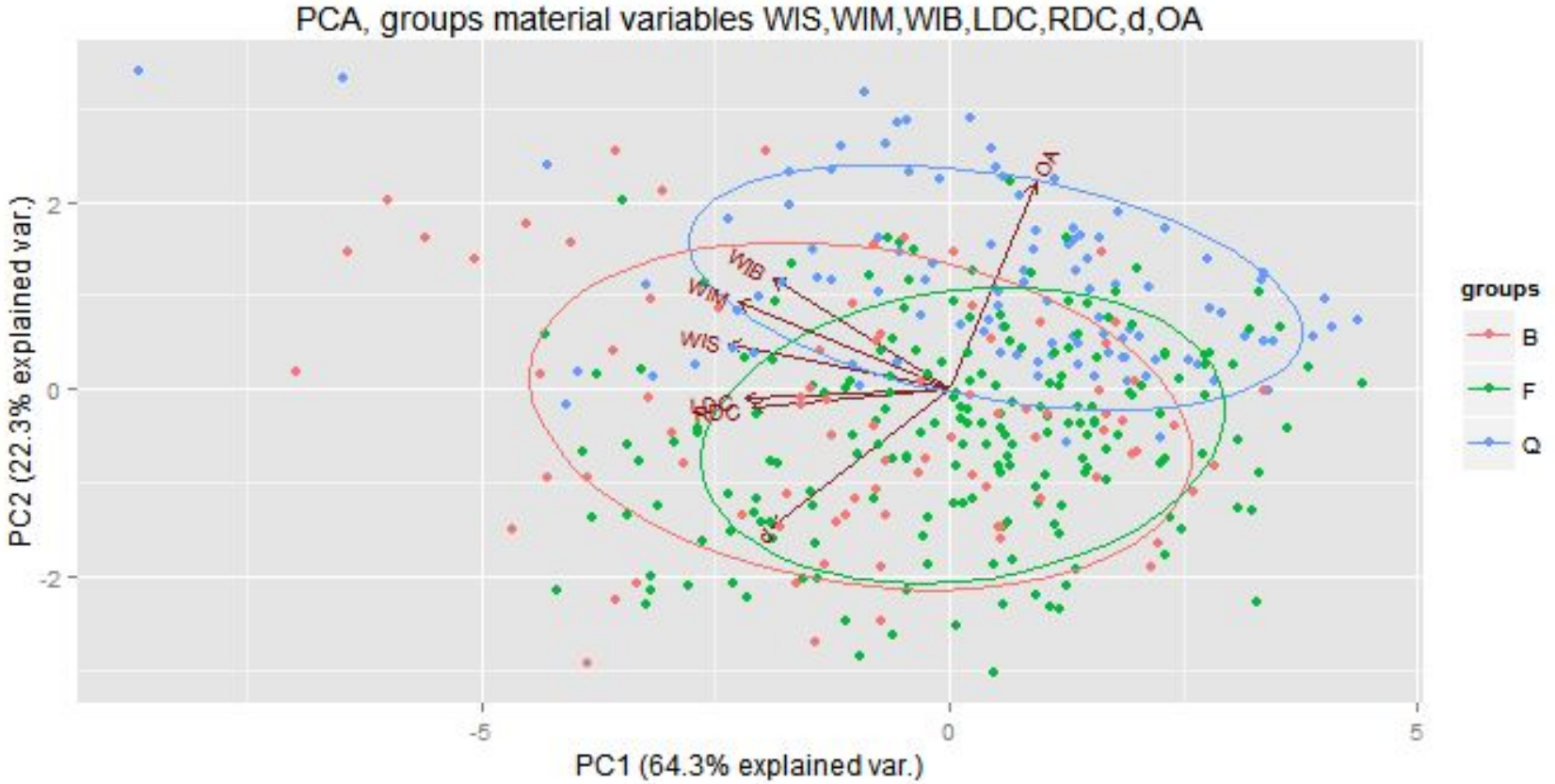



Red: Metal
Black: Flint
Green: Quartzite
PC 1
PC 2
-0.5
0.0
0.5
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3

Results: Flint VS Quartzite VS Basalt

MANOVA Pairwise:

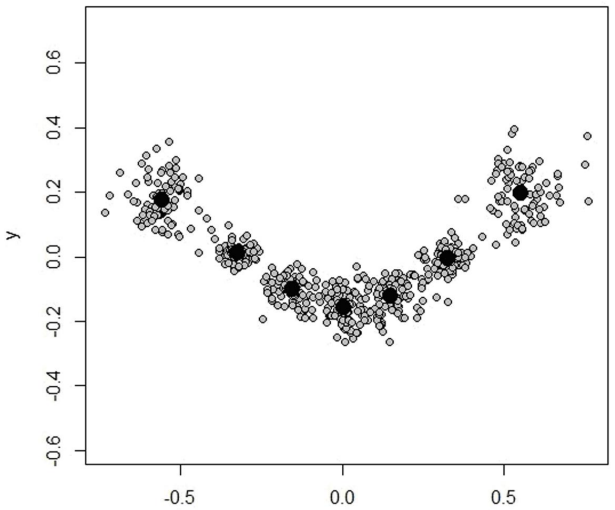
"F Q"	"7.06482071842748e-28"
"B Q"	"6.16912152827254e-21"
"B F"	"0.00004824190222222198"


PCA, groups material variables WIS,WIM,WIB,LDC,RDC,d,OA
PC2 (22.3% explained var.)
PC1 (64.3% explained var.)
2
0
-2
-5
0
5
OA
WIB
WIM
WIS
LDC
RDC
d
groups
B
F
Q

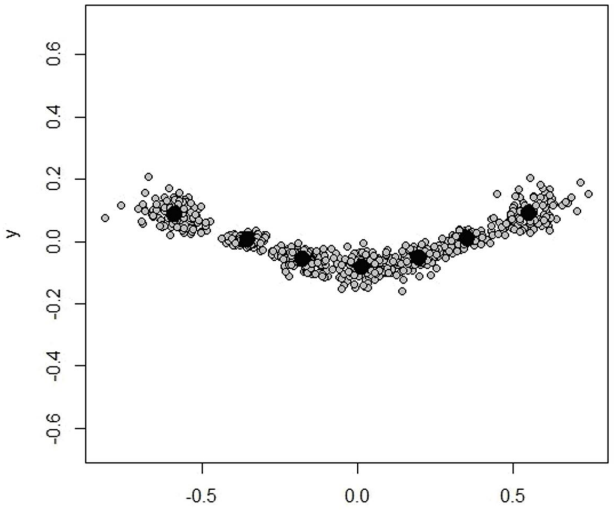
LDA measures Confusion matrix:

B	F	Q
0.000000	0.994709	0.000000

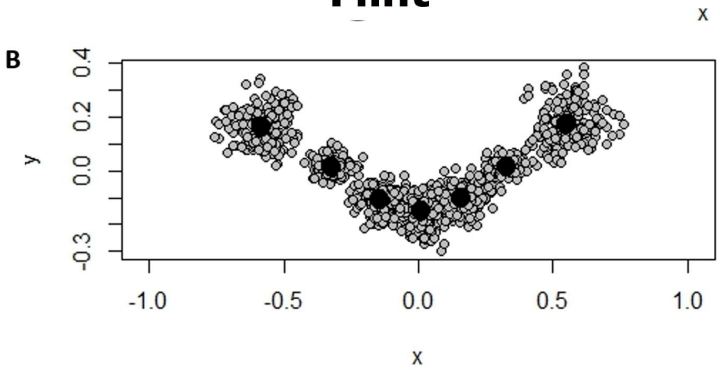
Basalt



Quartzite



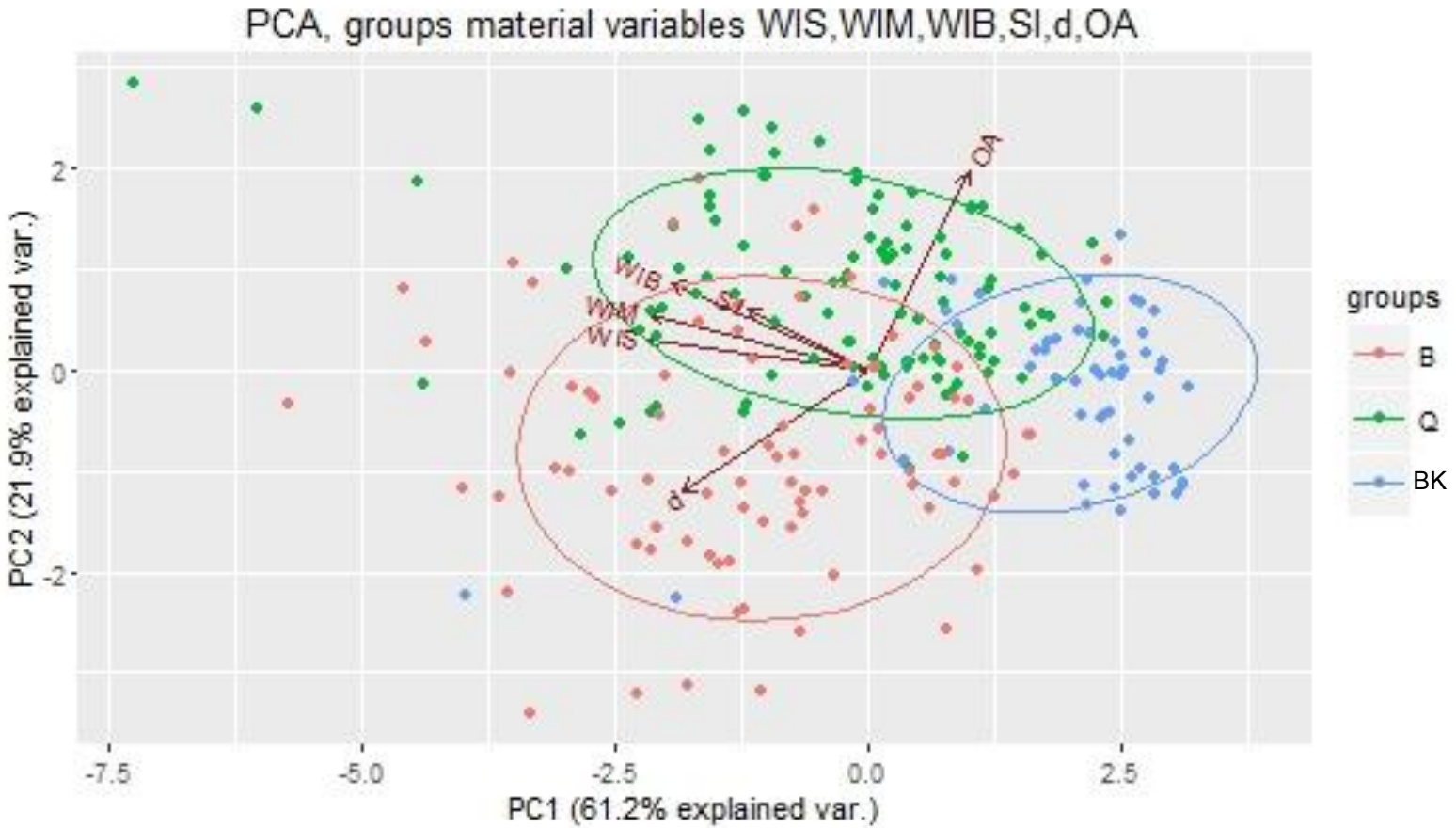
Flint

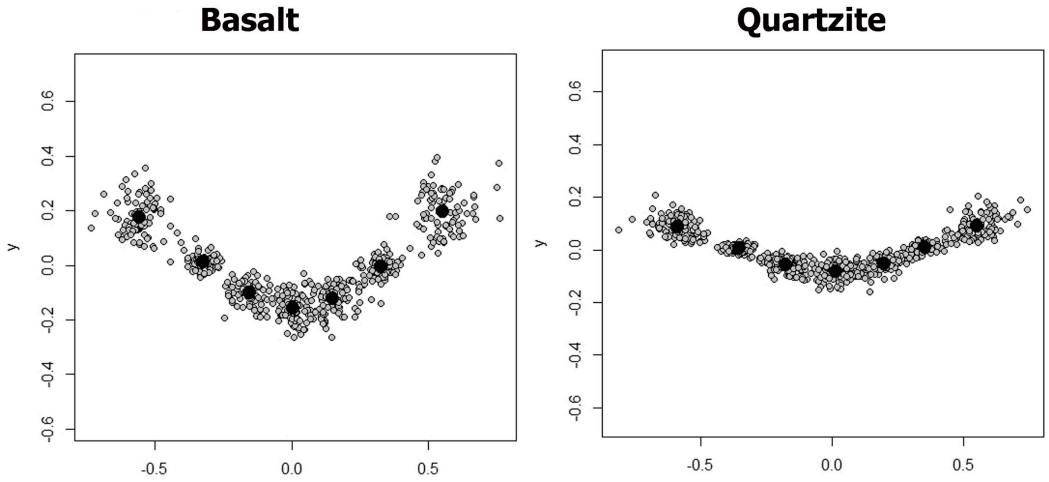


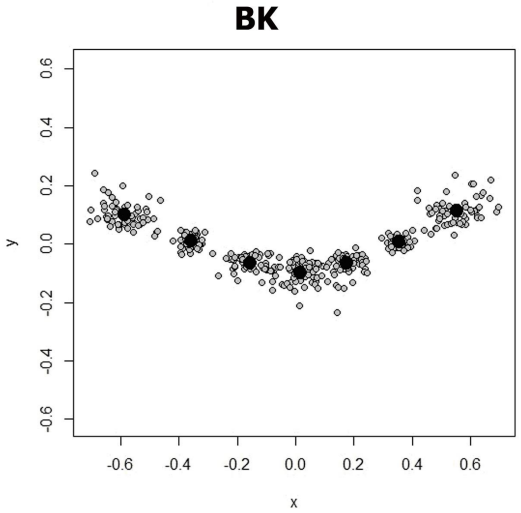
LDA GPA Confusion matrix:

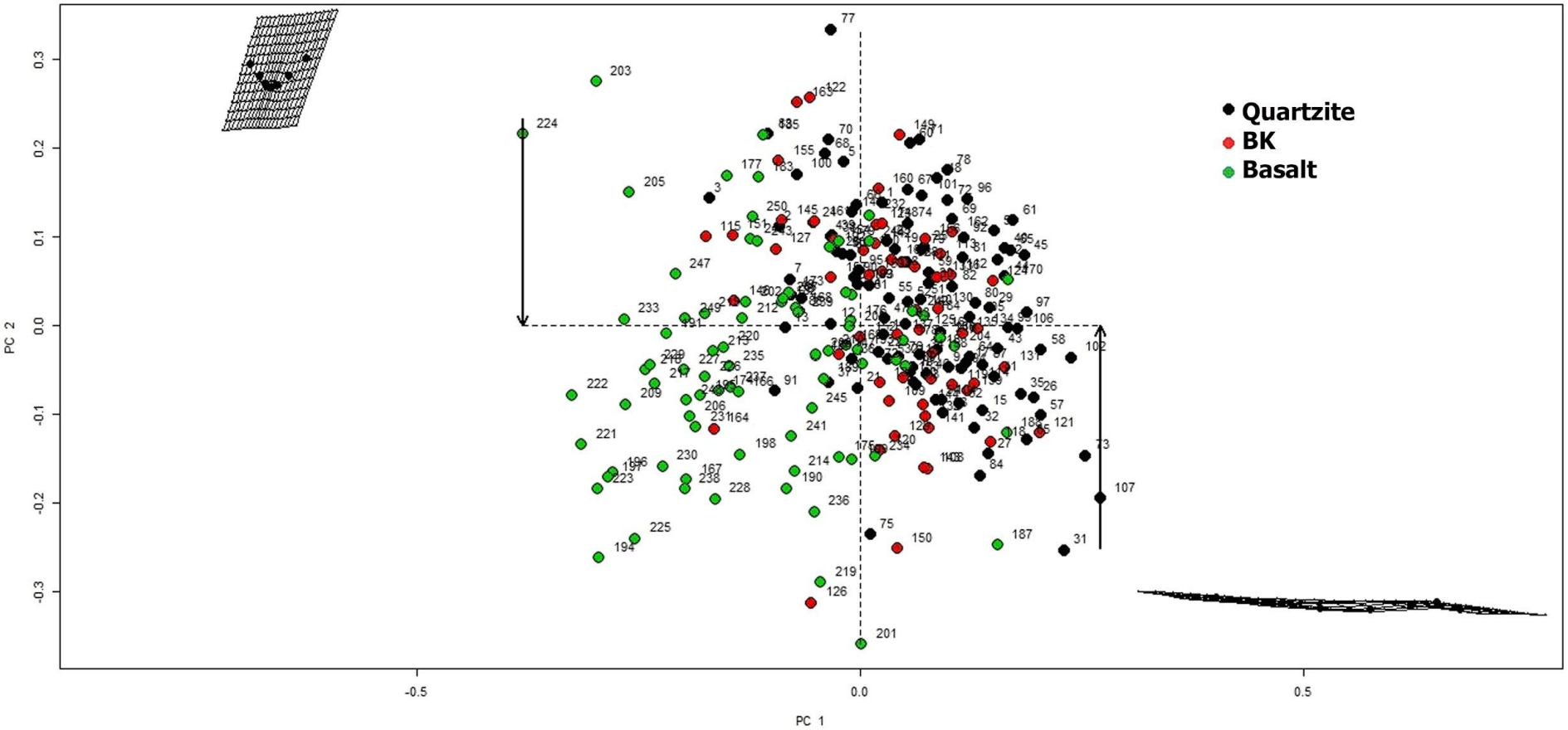
F	Q	B
0.7460317	0.7102804	0.3882353

Results: BK (Olduvai Gorge, Tanzania)




Basalt
Quartzite
y
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
-0.5
0.0
0.5


BK
y
x
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6


Quartzite
BK
Basalt
PC 1
PC 2
-0.5
0.0
0.5
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3

Conclusions

- It’s possible to analysis cut-marks in bones using a reflex camera, macro lens and photogrammetry software.
- It’s possible to apply this method to study marks in field. Sometimes it’s no possible (or really expensive) to export materials where a SEM ir.
- It’s possible to study all the marks of one site, and study large databases, and is even faster using package Pandora.
- It’s possible recognise raw material of the tool used to do the marks. For this, works better geometrical morphometric test than classical statistical tests using distance measures.
- This is ONLY the first steps to use computer 3D models, statistical tests and morphometrics test to study marks in bones. Is the beginning of Digital Taphonomy.