SOM4 - Reading and ploting Confocal data

Paixao et al. 2021. The Middle Paleolithic Ground Stones Tools of Nesher Ramla Unit V (Southern Lev

2021-03-17 13:00:51

Brief description of the script

This R markdown document reads, summarizes and plots data for: *Paixao et al. 2021. Functional analysis of the Middle Paleolithic Ground Stone Tools from Unit V of Nesher Ramla (Central Levante): the application of a multi-scale use-wear approach. Quaternary International*

The document contains includes plots of the quantitative surface texture analysis, using Confocal microcopy.

This R project and respective scripts follow the procedures described by Marwick et al. 2017.

To compile this markdown document do not delete or move files from their original folders. Please note that most of the tables and figures in this file do not match the numbering in the PhD dissertation manuscript.

For any questions, comments and inputs, please contact:

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Load data into R project

Imported files are in: '../analysis/raw_data'

Figures are saved in: '../analysis/plots'

Tables are saved in: '../analysis/derived_data'

```
# Load required libraries

library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.0 --

## v ggplot2 3.3.3     v purrr   0.3.4
## v tibble  3.1.0     v dplyr   1.0.5
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(utils)
library(knitr)
library(janitor)
```

```
##
## Attaching package: 'janitor'

## The following objects are masked from 'package:stats':
##
##     chisq.test, fisher.test
```

```
library(kableExtra)
```

```
##
## Attaching package: 'kableExtra'

## The following object is masked from 'package:dplyr':
##
##     group_rows
```

```
library(GGally)
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
```

```
library(doBy)
```

```
##
## Attaching package: 'doBy'

## The following object is masked from 'package:dplyr':
##
##     order_by
```

```
library(ggpubr)
library(tools)

# See your WD and update the following paths
# getwd()

# Load data from .csv
confocaldataarch <- read.delim("../raw_data/confocalarch/confocaldataarch.csv", header = T, ";")

data_file <- list.files("../raw_data/confocalarch", pattern = "\\.csv$", full.names = TRUE)
md5_in <- md5sum(data_file)
info_in <- data.frame(file = basename(names(md5_in)), checksum = md5_in, row.names = NULL)
```

Confocal micro surface texture data

Import and summarize data

```
# compute descriptive statistics

nminmaxmeanmedsd <- function(x){
    y <- x[!is.na(x)]
    n_test <- length(y)
    min_test <- min(y)
    max_test <- max(y)
    mean_test <- mean(y)
    med_test <- median(y)
    sd_test <- sd(y)
    out <- c(n_test, min_test, max_test, mean_test, med_test, sd_test)
    names(out) <- c("n", "min", "max", "mean", "median", "sd")
    return(out)
}

num.var <- 21:length(confocaldataarch)

confostatsarch <- summaryBy(.~sample + workedmaterial, data=confocaldataarch[c("sample", "workedmaterial

write_csv(confostatsarch, "../derived_data/confocalstats_arch.csv")
```

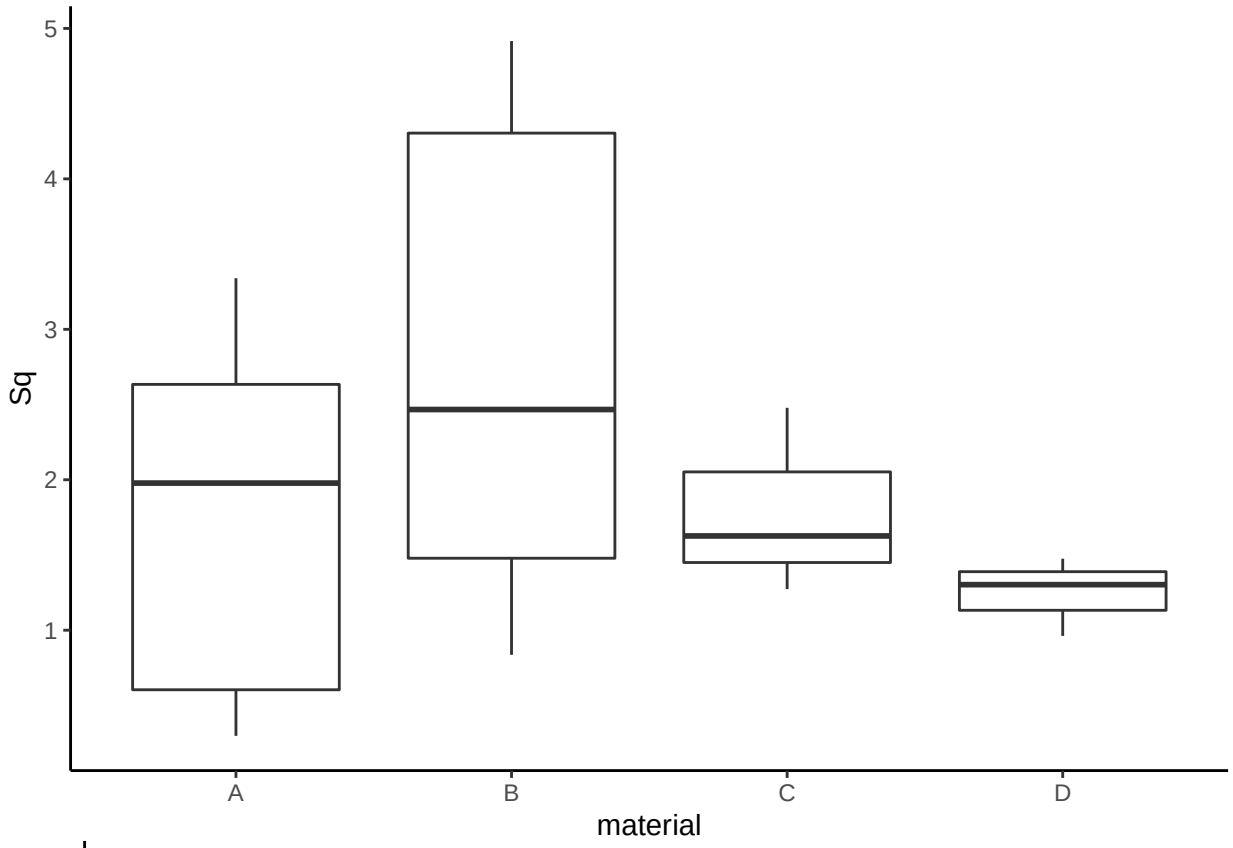
Plot all paramaters

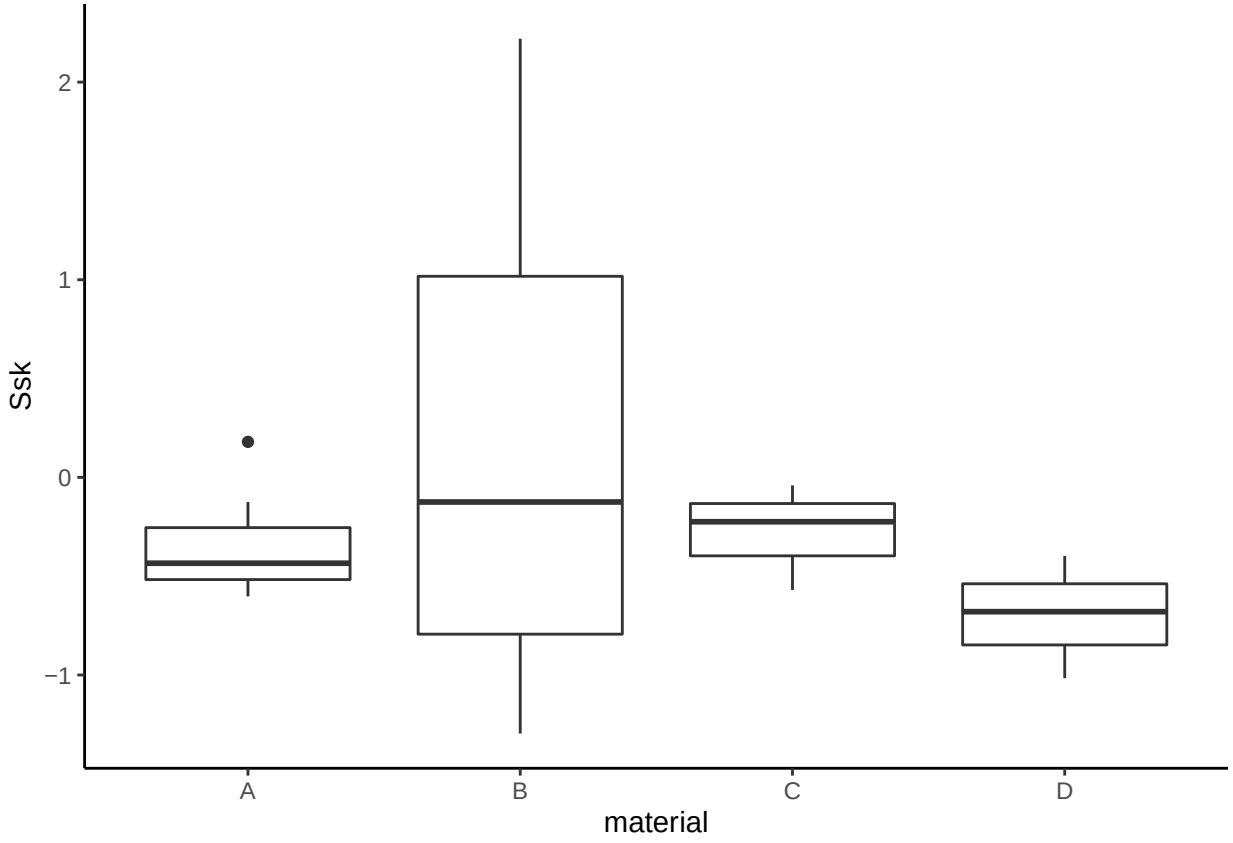
```
# Sample main dataset
# Only archaeological tools

confoarch <- filter(confocaldataarch, sample == "archaeological")

# Loop for plotting all surface texture parameters

for (i in num.var) cat("[",i,"] ", names(confoarch)[i], "\n", sep = "")
```

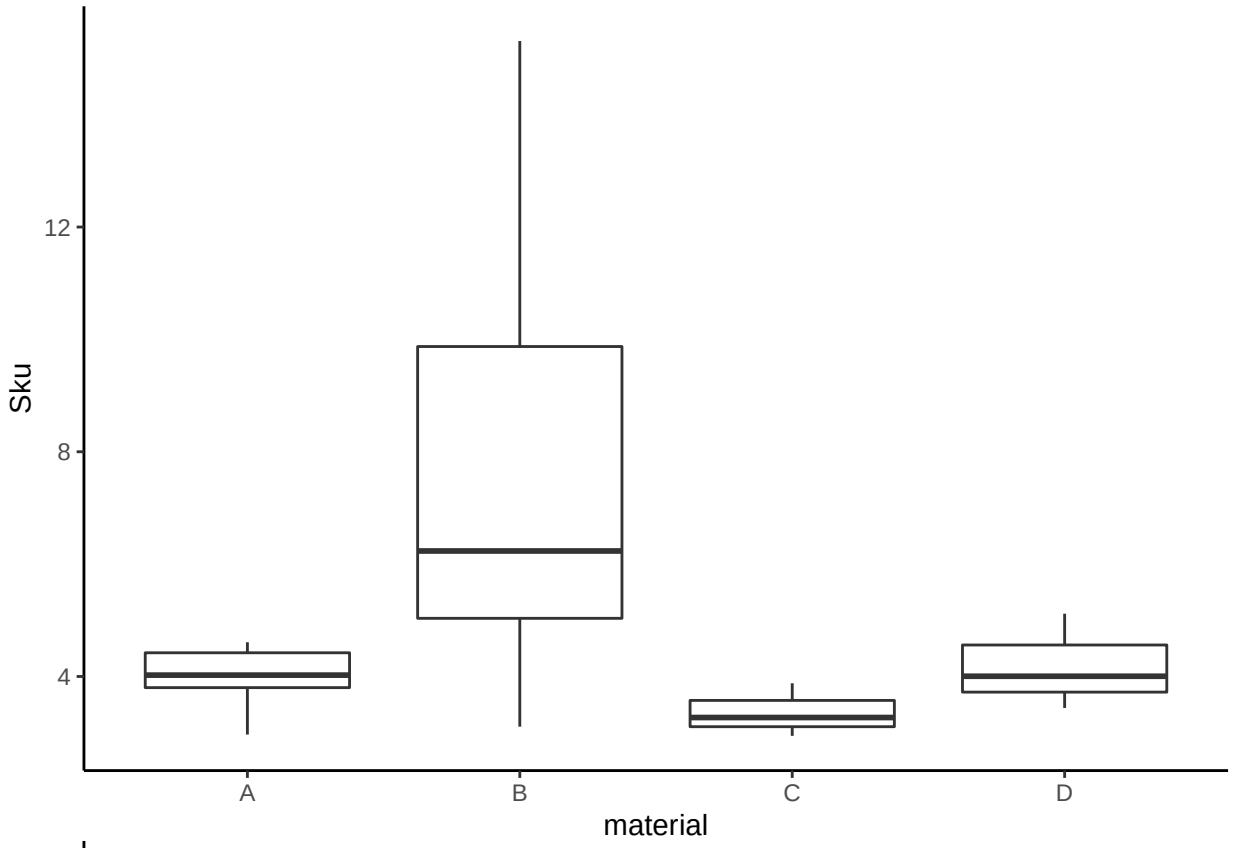
```
## [21] Sq
## [22] Ssk
## [23] Sku
## [24] Sp
## [25] Sv
## [26] Sz
## [27] Sa
## [28] Smr
## [29] Smc
## [30] Sxp
## [31] Sal
## [32] Str
## [33] Std
## [34] Sdq
```

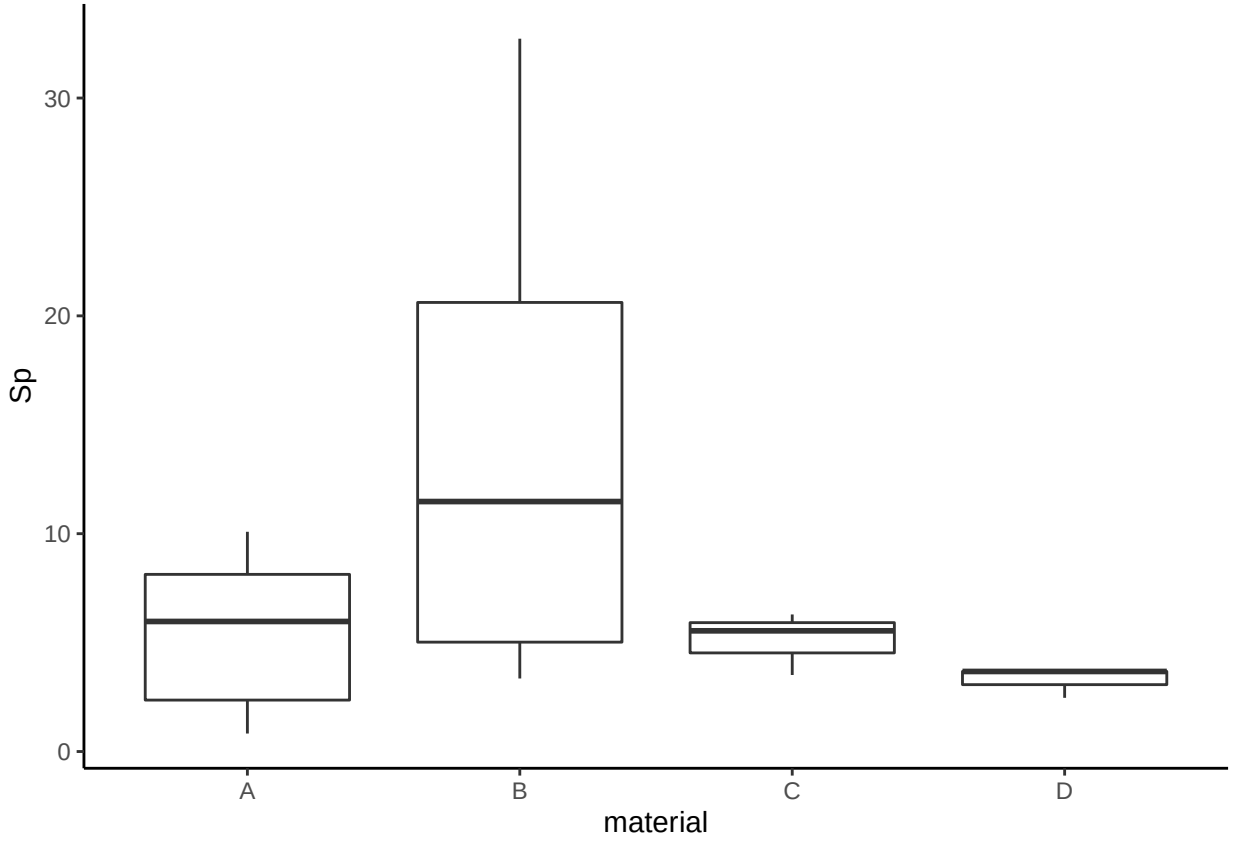
```
## [35] Sdr
## [36] VM
## [37] Vv
## [38] Vmp
## [39] Vmc
## [40] Vvc
## [41] Vvv
## [42] Vvv.1
## [43] Mean.depth.of.furrows
## [44] Mean.density.of.furrows
## [45] First.direction
## [46] Second.direction
## [47] Third.direction
## [48] Isotropy
## [49] Lengthscale.anisotropy.Sfrax.epLsar
## [50] Length.scale.anisotropy..NewEplsar.
## [51] Fractal.complexity.Asfc
## [52] Smfc
## [53] HAsfc9
## [54] HAsfc81
```

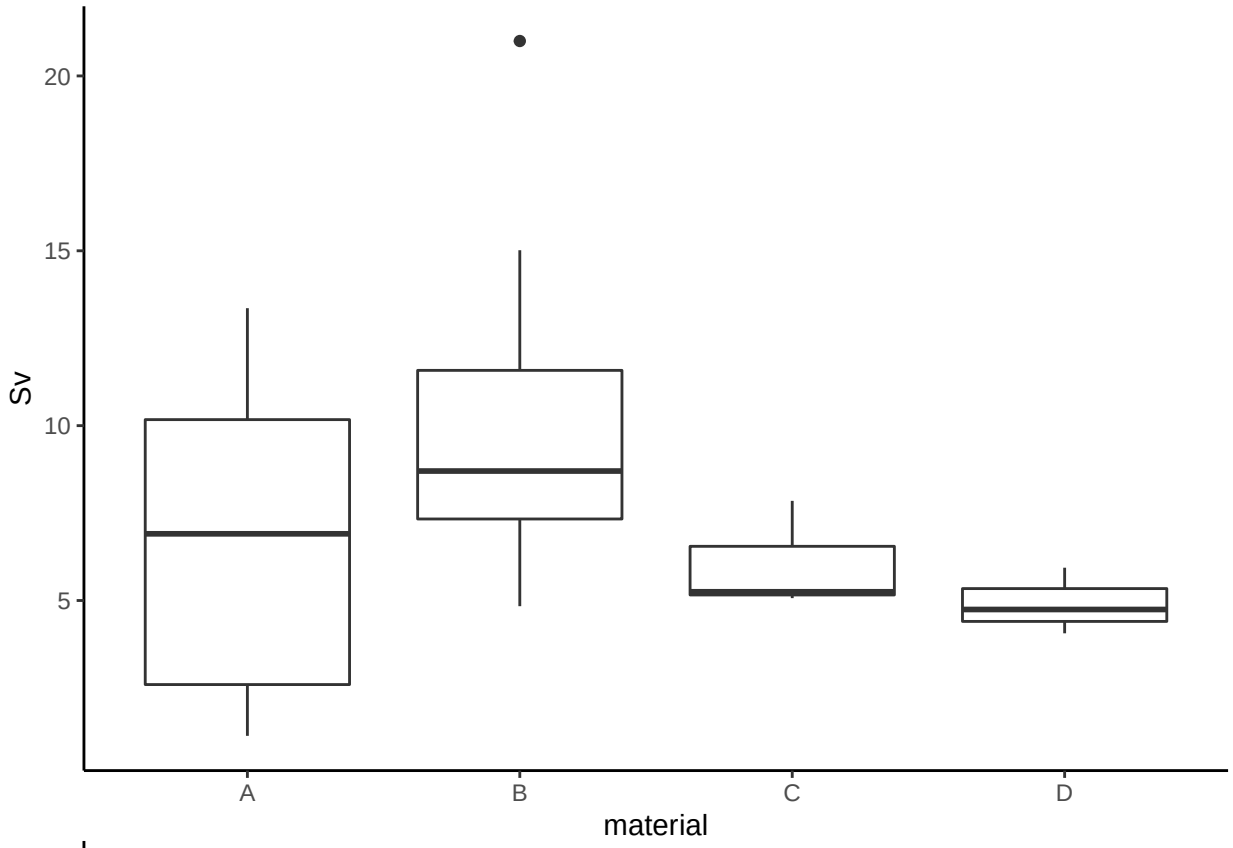
```
for (i in num.var) {
  p <- ggplot(data = confocaldataarch, aes_string(x = "workedmaterial", y = names(confoarch)[i])) +
         geom_boxplot() +
         # geom_line(aes(group = motion)) +
         theme_classic() +
         # facet_wrap(~ sample) +
         labs(x = "material", y = gsub("\\.", " ", names(confoarch)[i])) +
         scale_colour_hue(h = c(25,225))
  print(p)

  # saves the plots
  file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_plot_",
                     names(confoarch)[i], ".pdf")
    ggsave(filename = file_out, plot = p, path = "../plots", device = "pdf", width = 26,
           height = 21, units = "cm" )
}
```

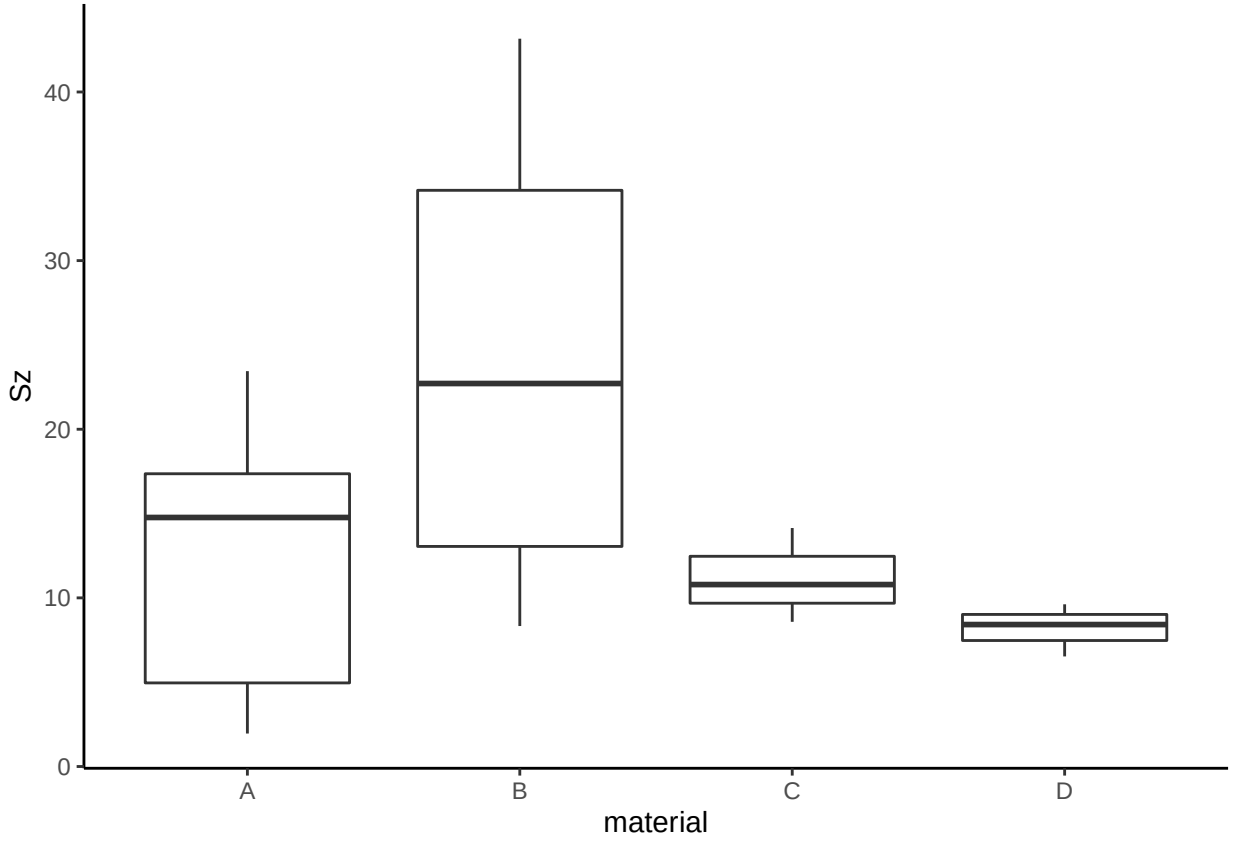

5
4
3
2
1
Sq
A
B
C
D
material

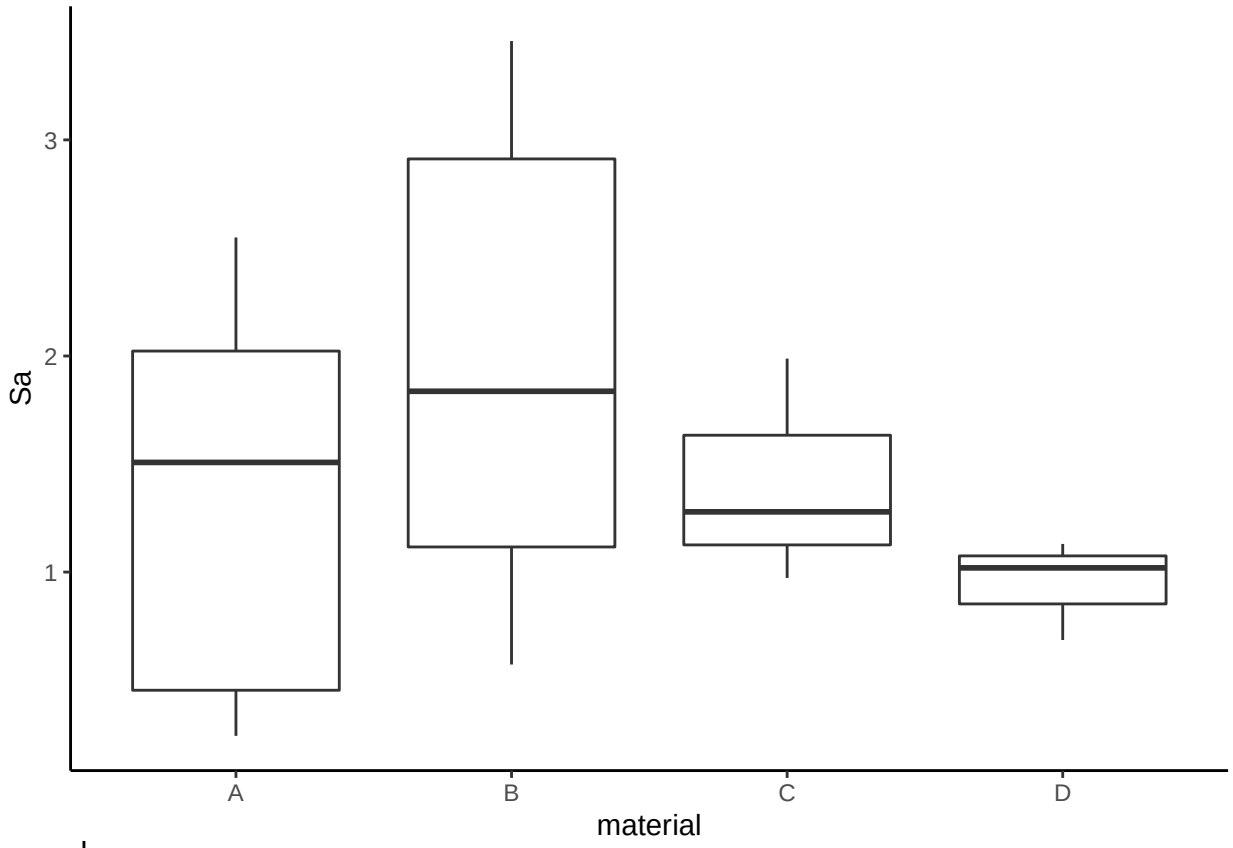

2
1
0
−1
Ssk
A
B
C
D
material

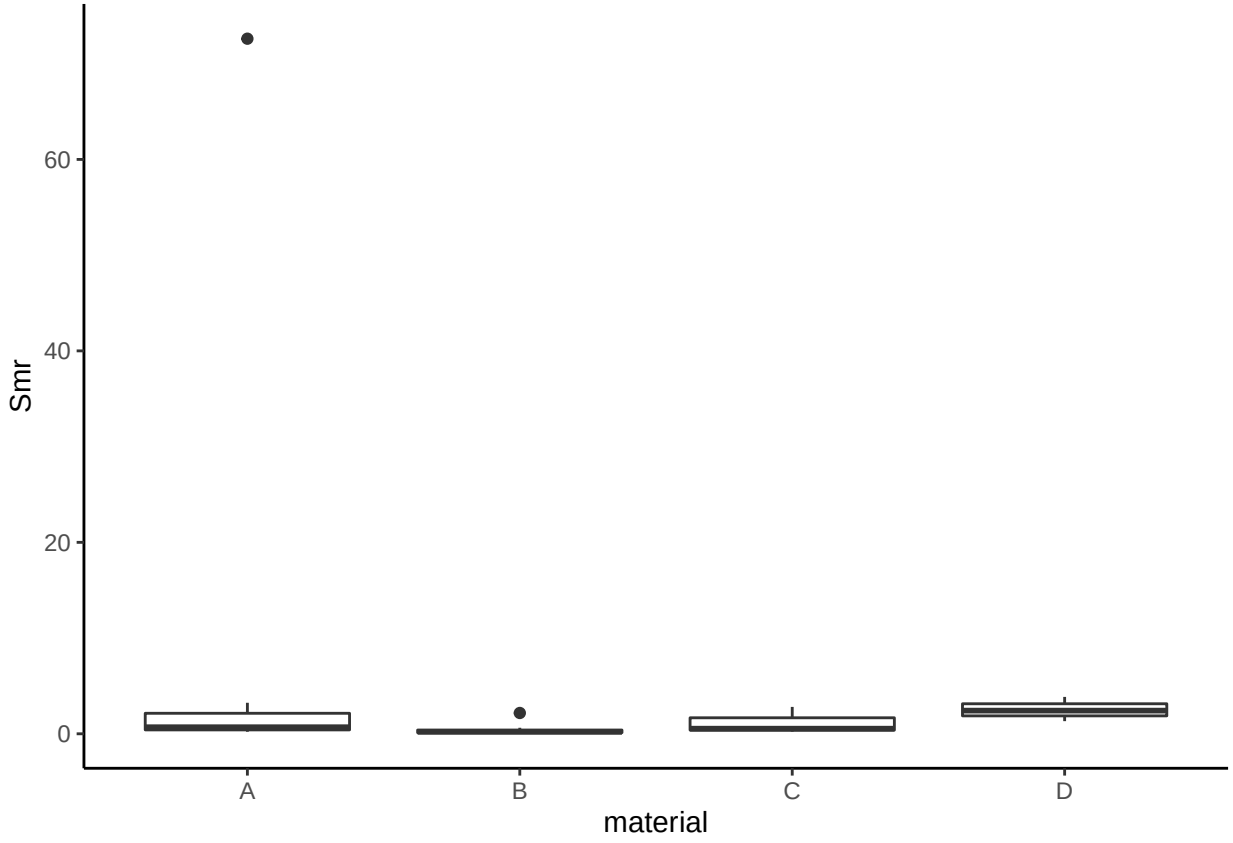

Sku
12
8
4
A
B
C
D
material

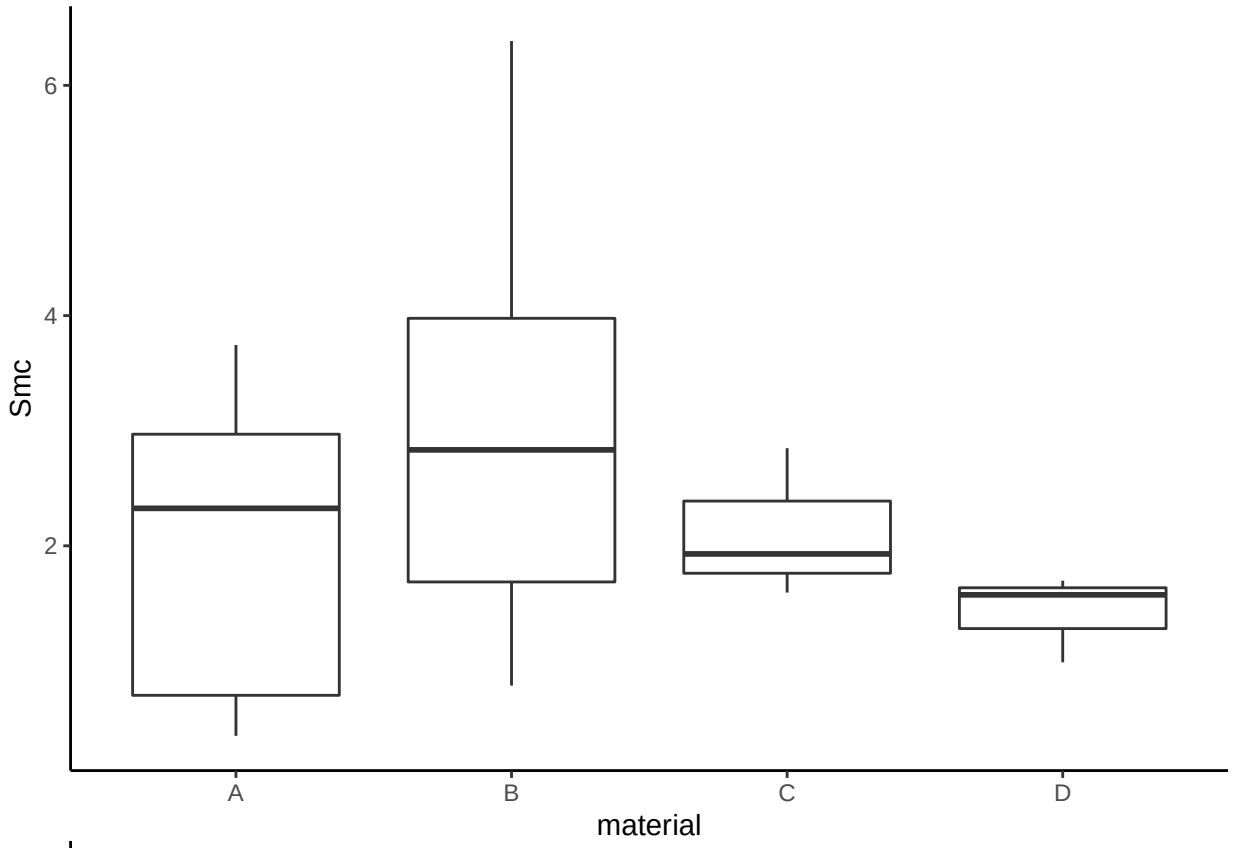

Sp
30
20
10
0
A
B
C
D
material

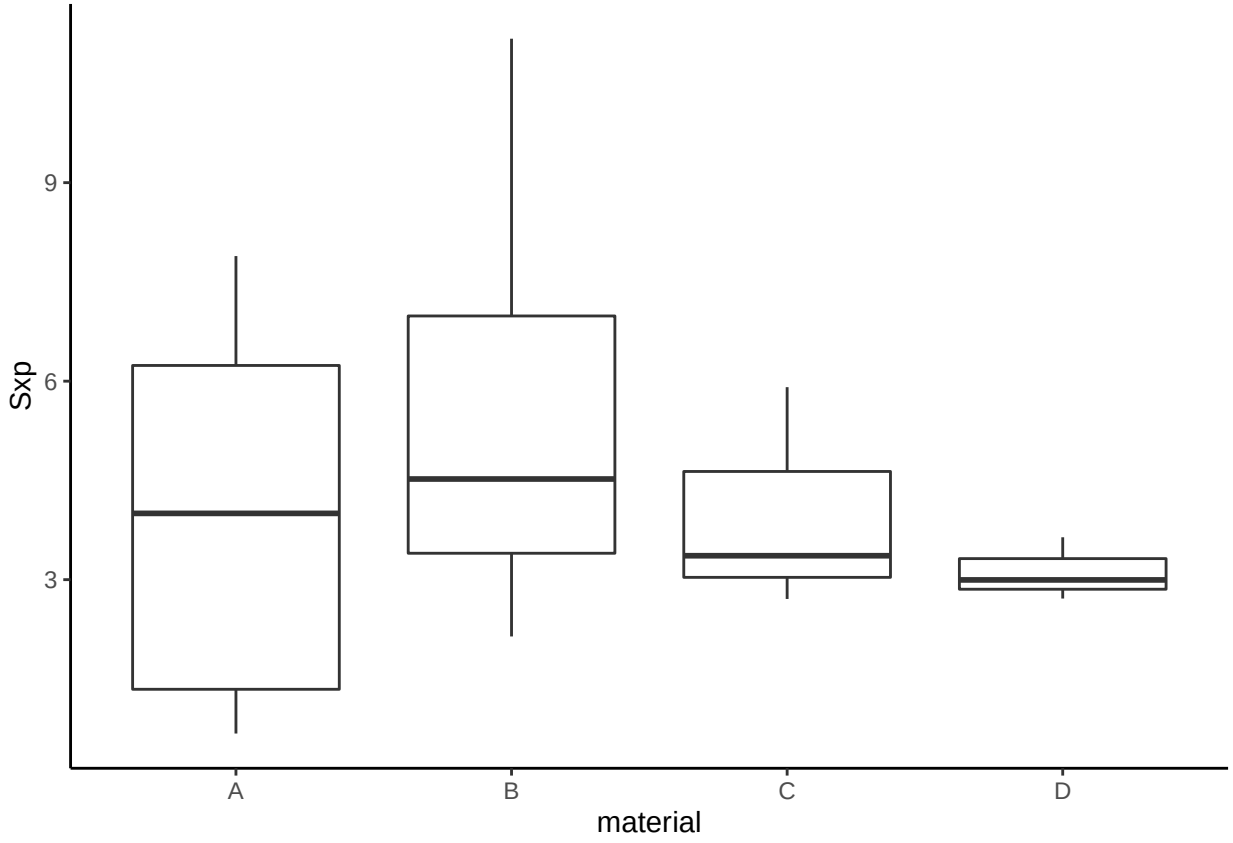

20
15
10
5
Sv
A
B
C
D
material

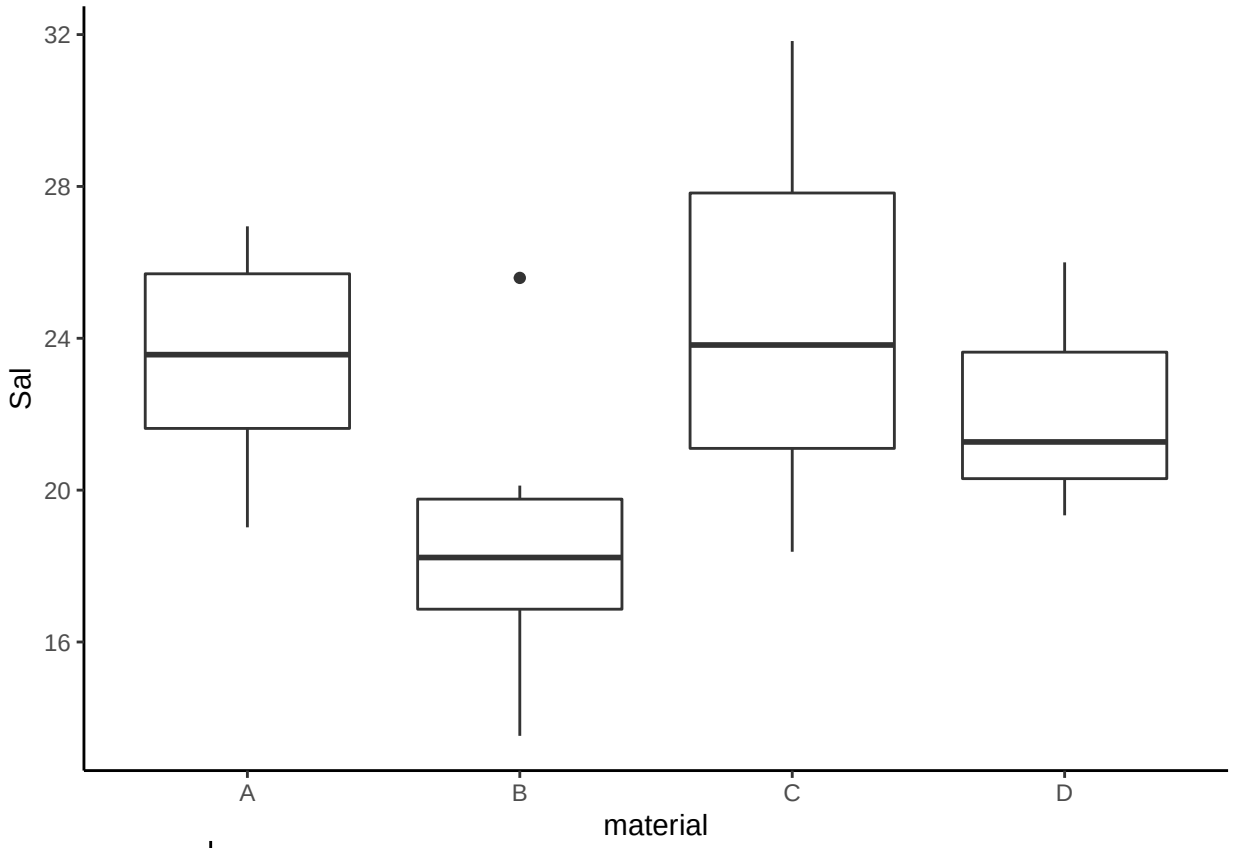

40
30
20
10
0
Sz
A
B
C
D
material

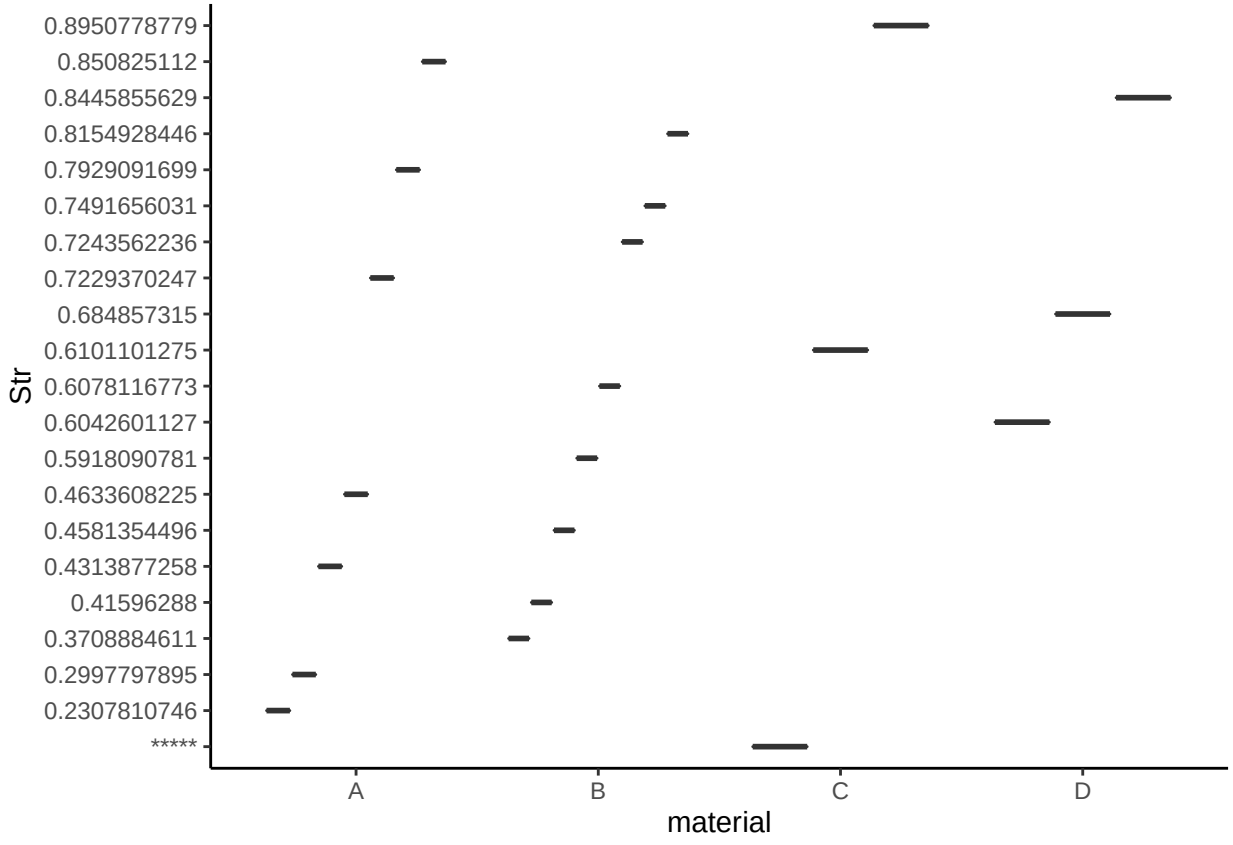

Sa
3
2
1
A
B
C
D
material

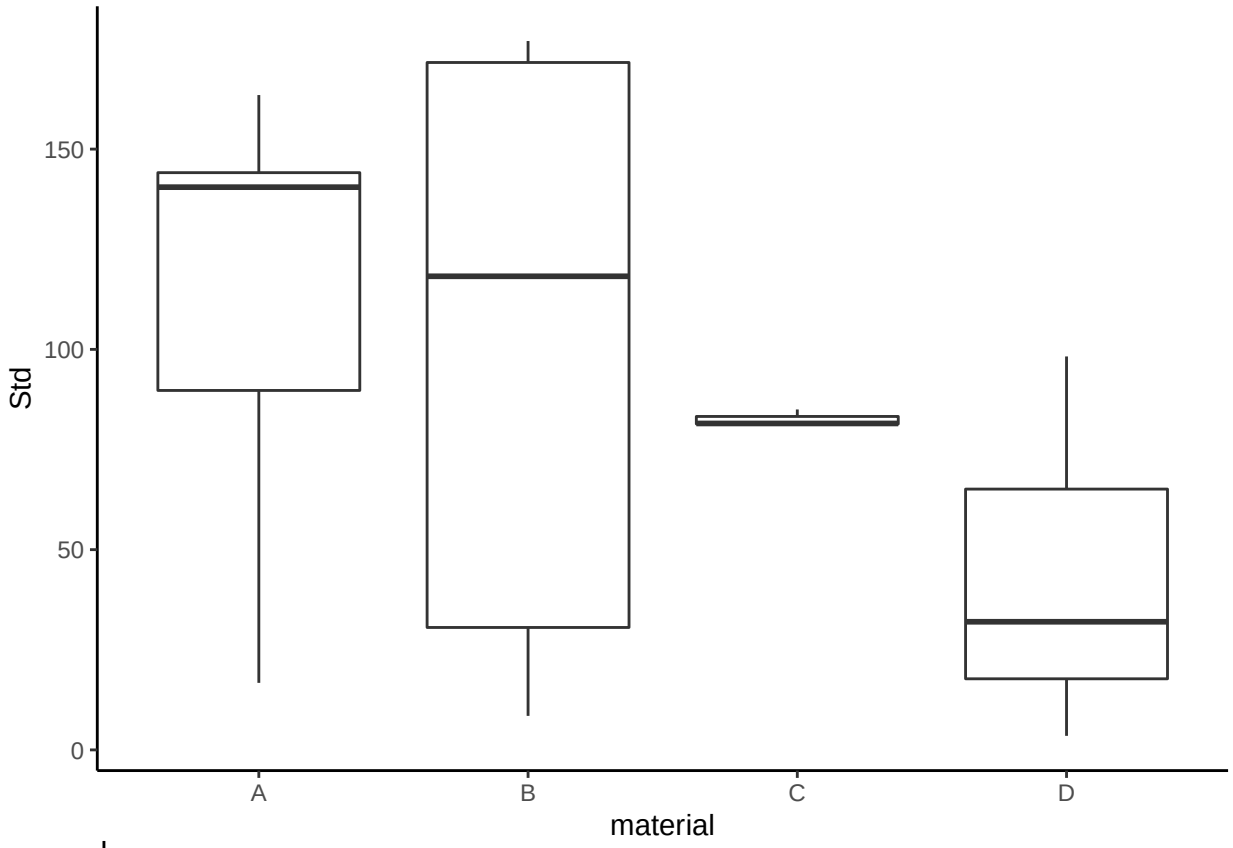

Smr
60
40
20
0
A
B
C
D
material

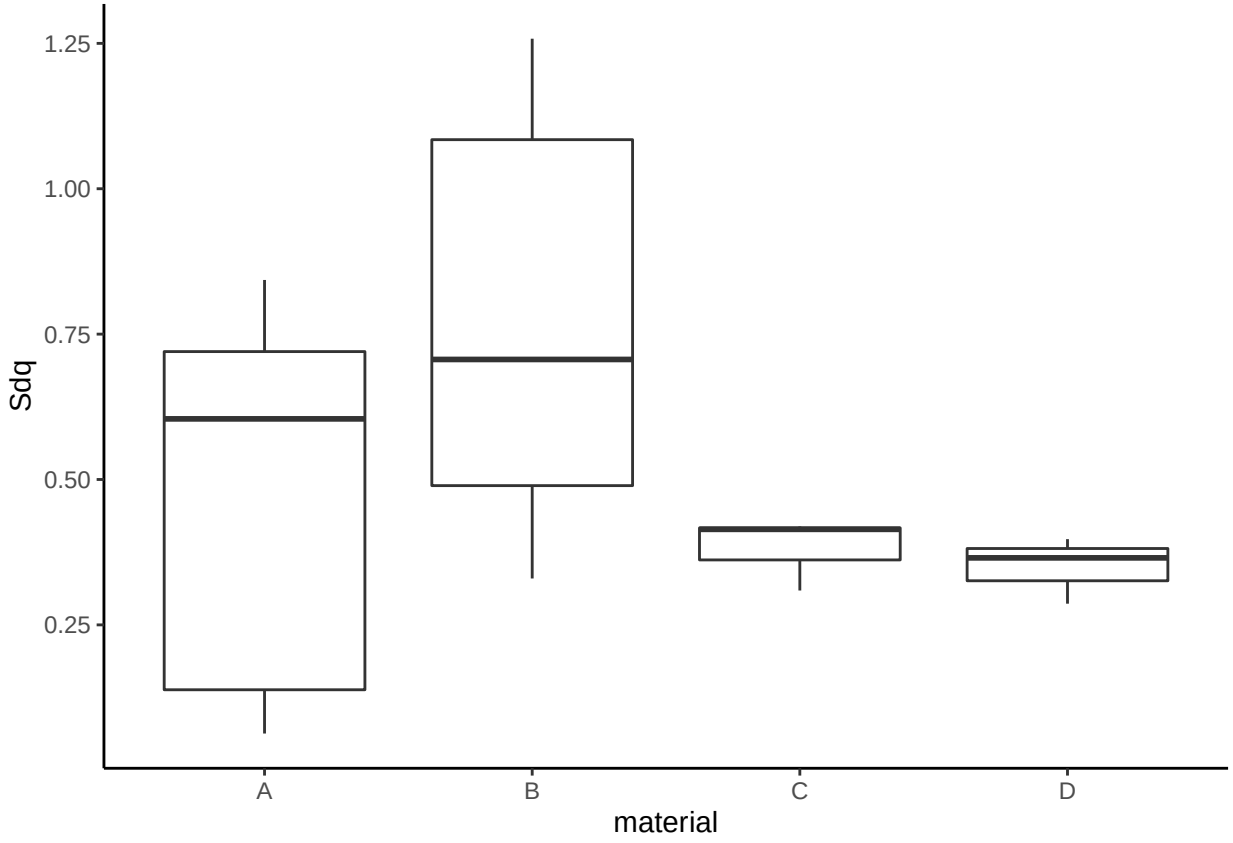

Smc
6
4
2
A
B
C
D
material

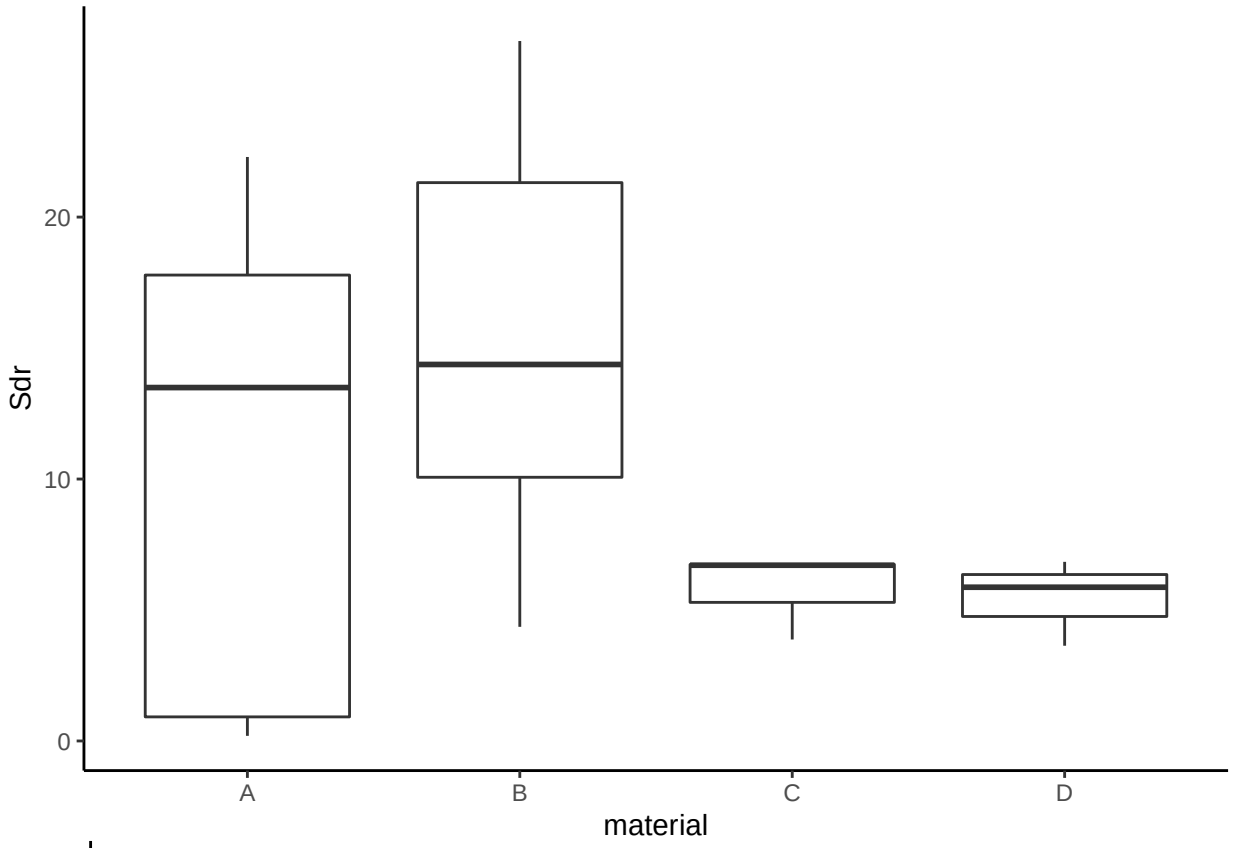

Sxp
9
6
3
A
B
C
D
material

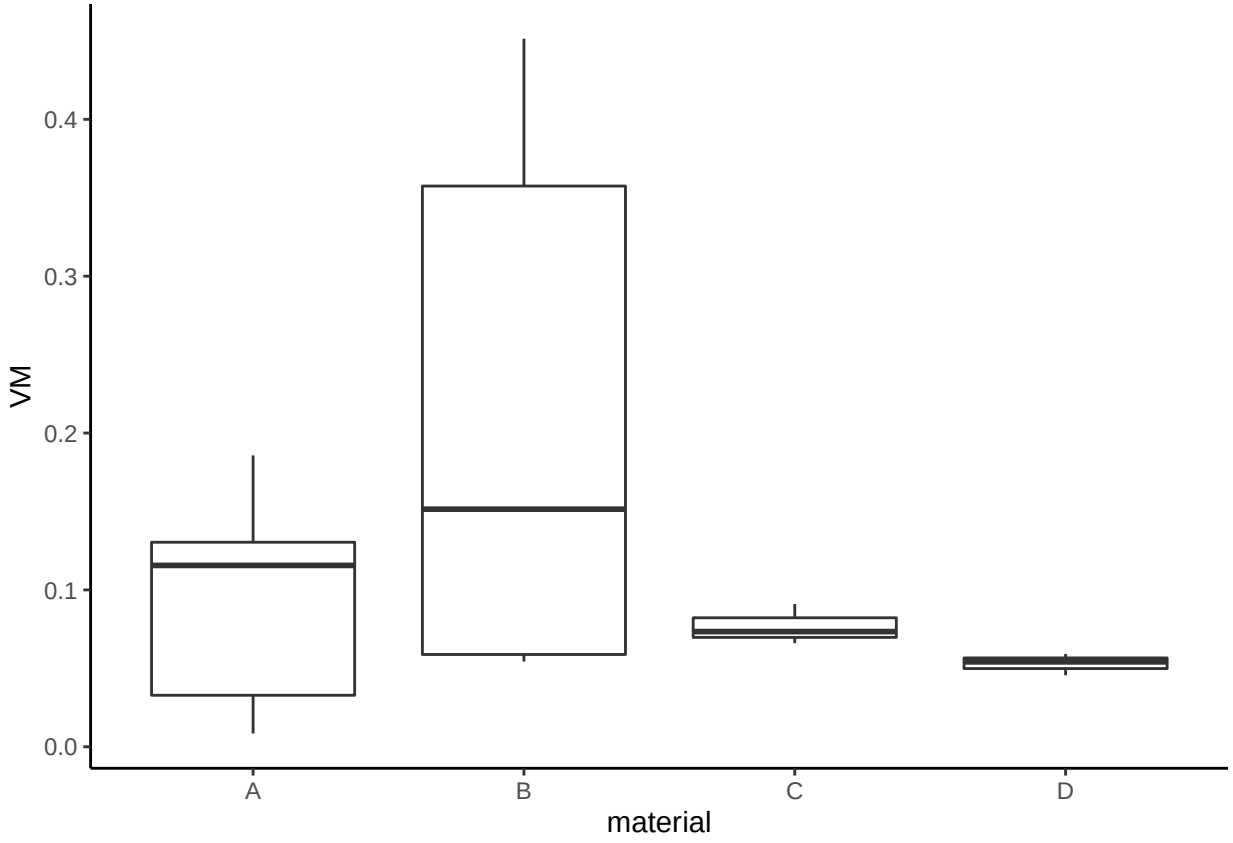

32
28
24
20
16
Sal
A
B
C
D
material

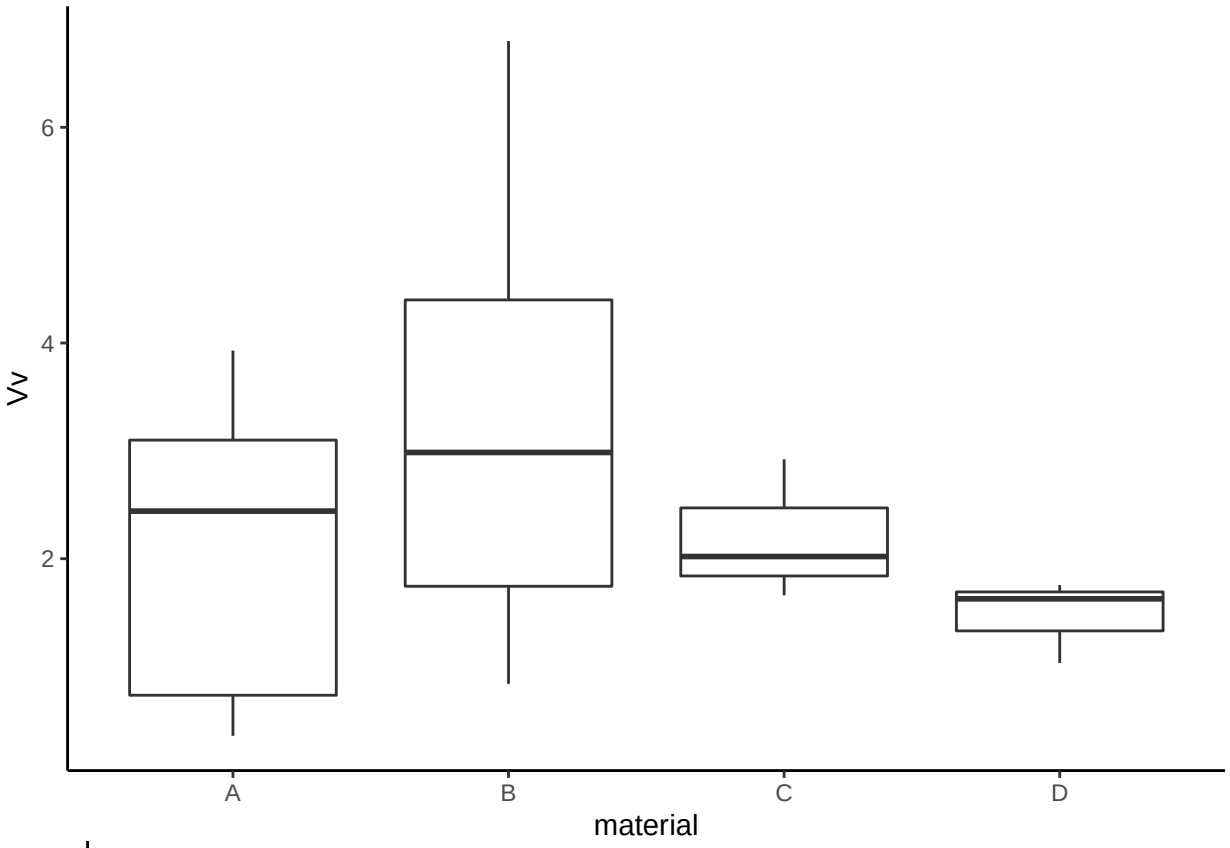

0.8950778779
0.850825112
0.8445855629
0.8154928446
0.7929091699
0.7491656031
0.7243562236
0.7229370247
0.684857315
0.6101101275
0.6078116773
0.6042601127
0.5918090781
0.4633608225
0.4581354496
0.4313877258
0.41596288
0.3708884611
0.2997797895
0.2307810746
*****
Str
A
B
C
D
material

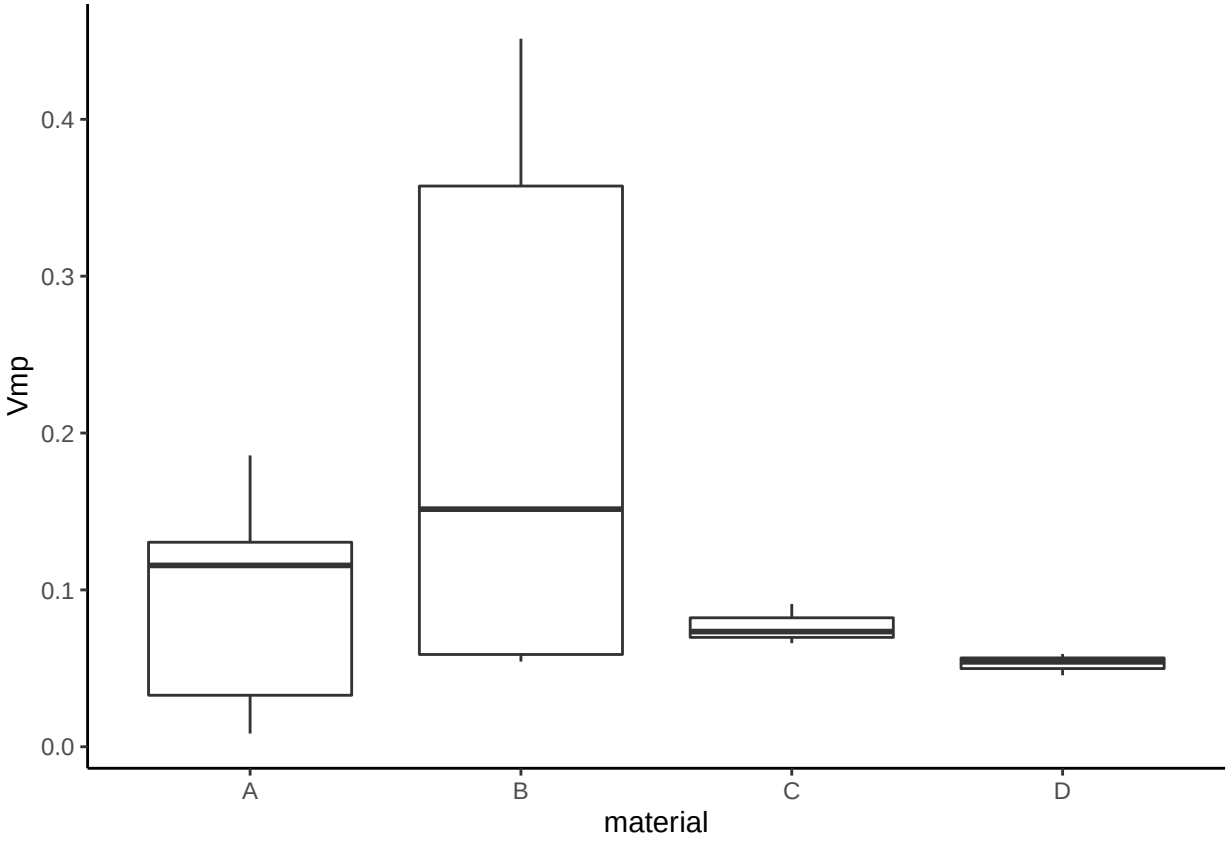

Std
150
100
50
0
A
B
C
D
material

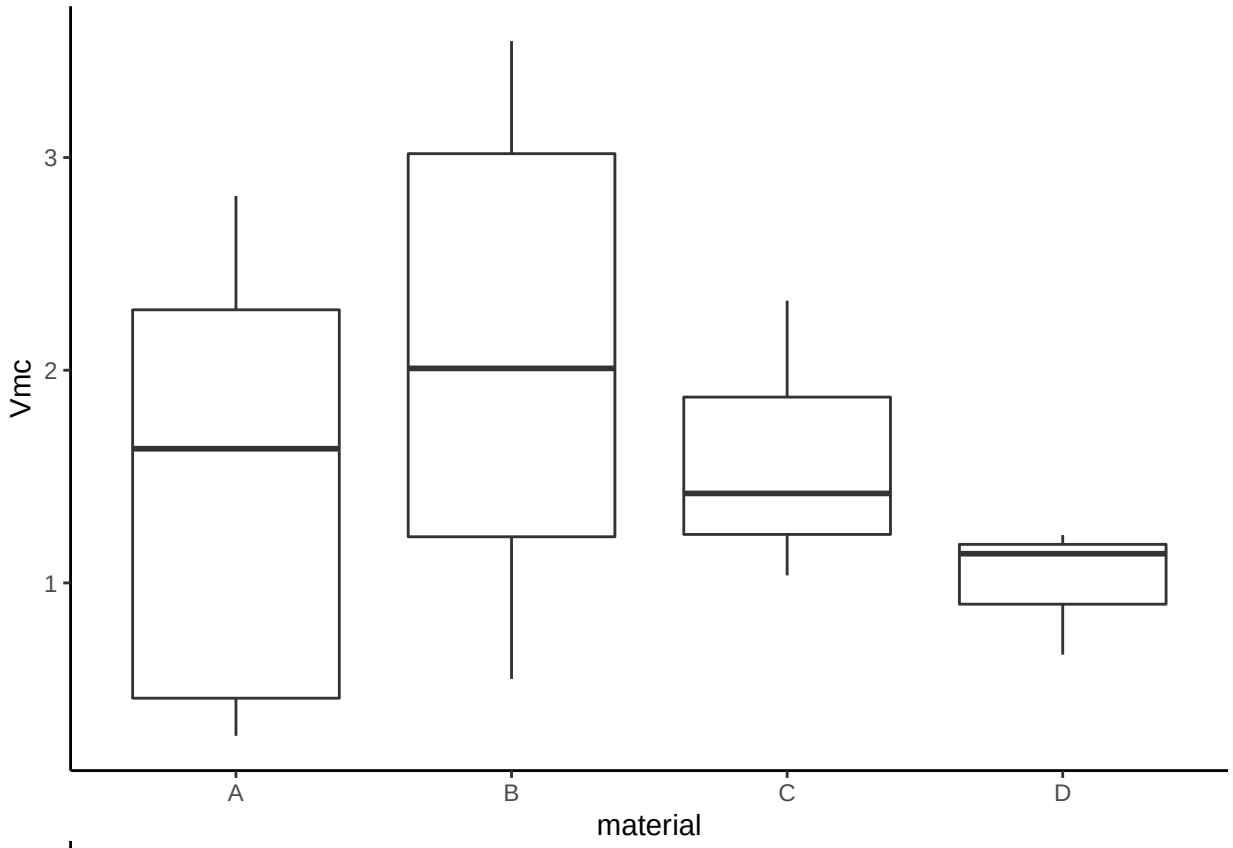

Sdq
1.25
1.00
0.75
0.50
0.25
A
B
C
D
material

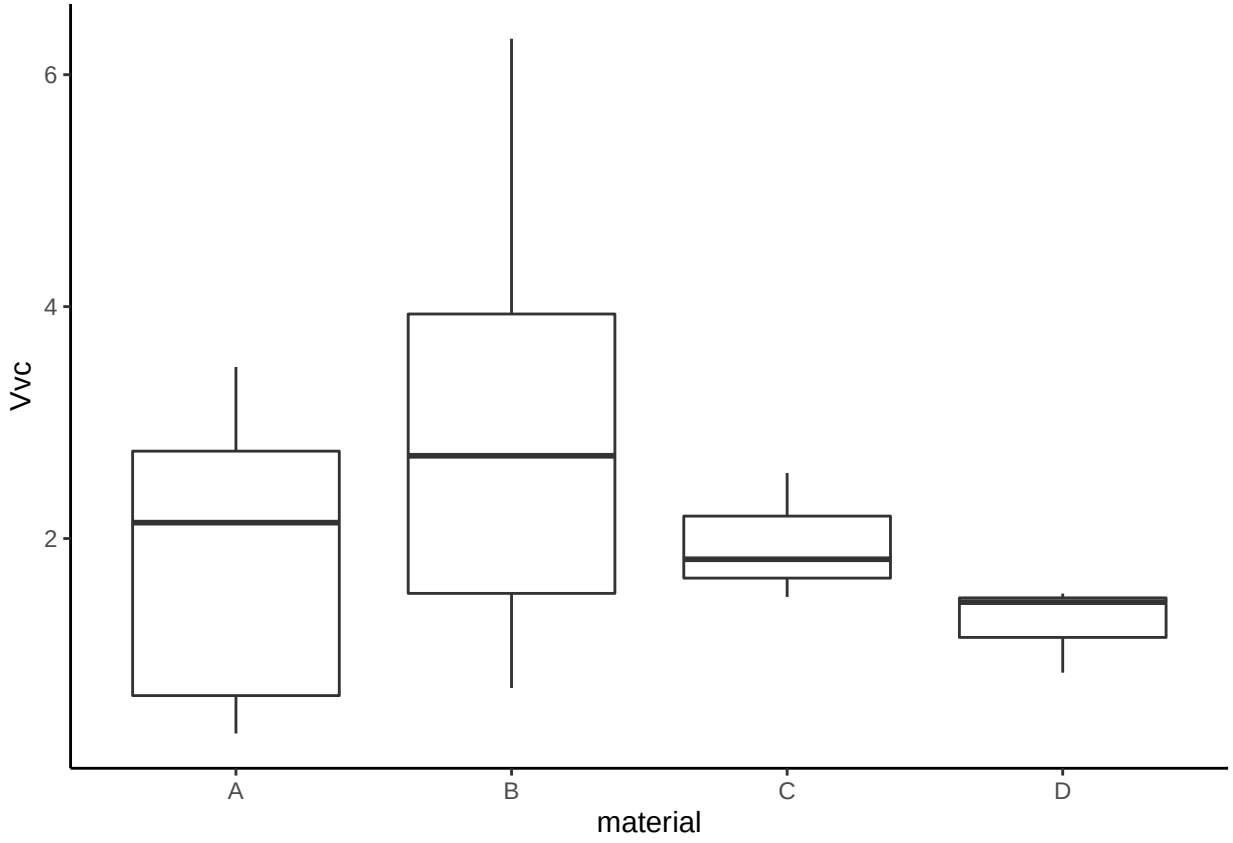

Sdr
20
10
0
A
B
C
D
material

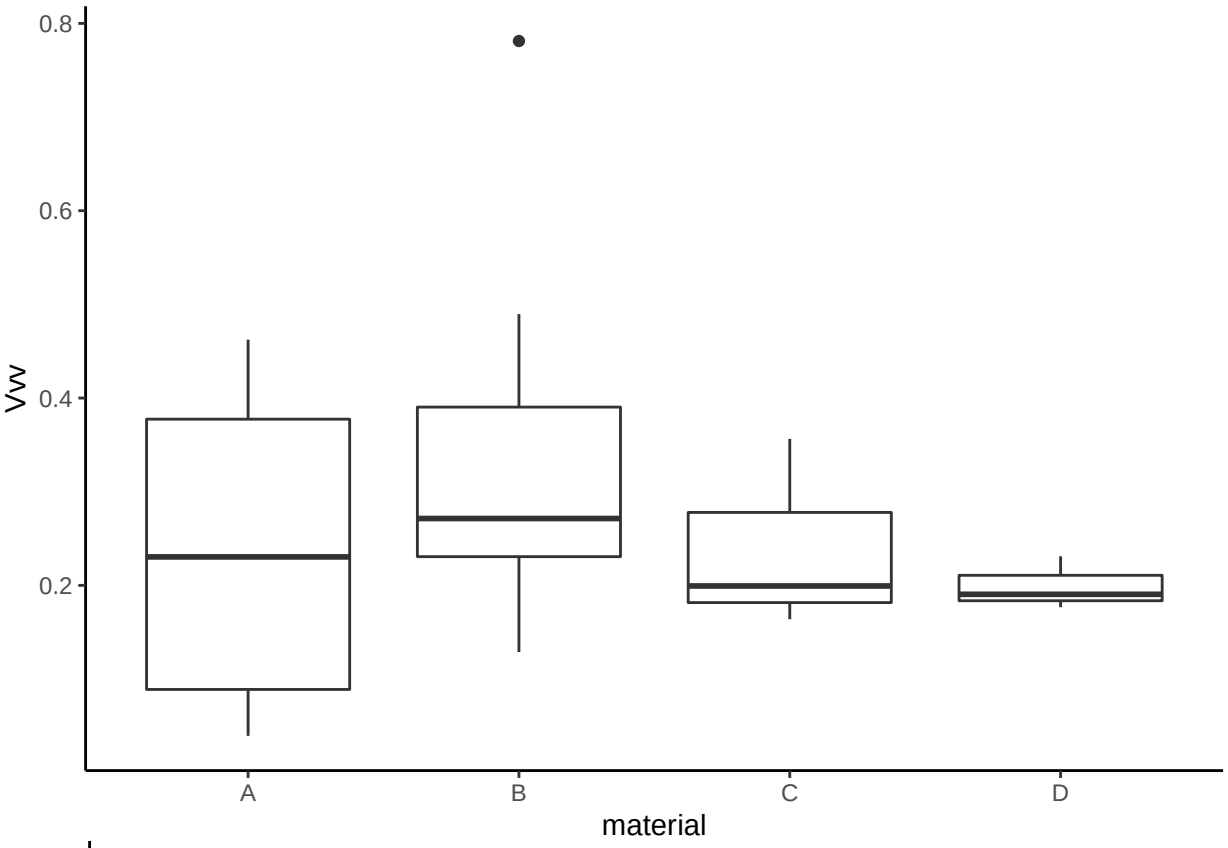

VM
0.4
0.3
0.2
0.1
0.0
A
B
C
D
material

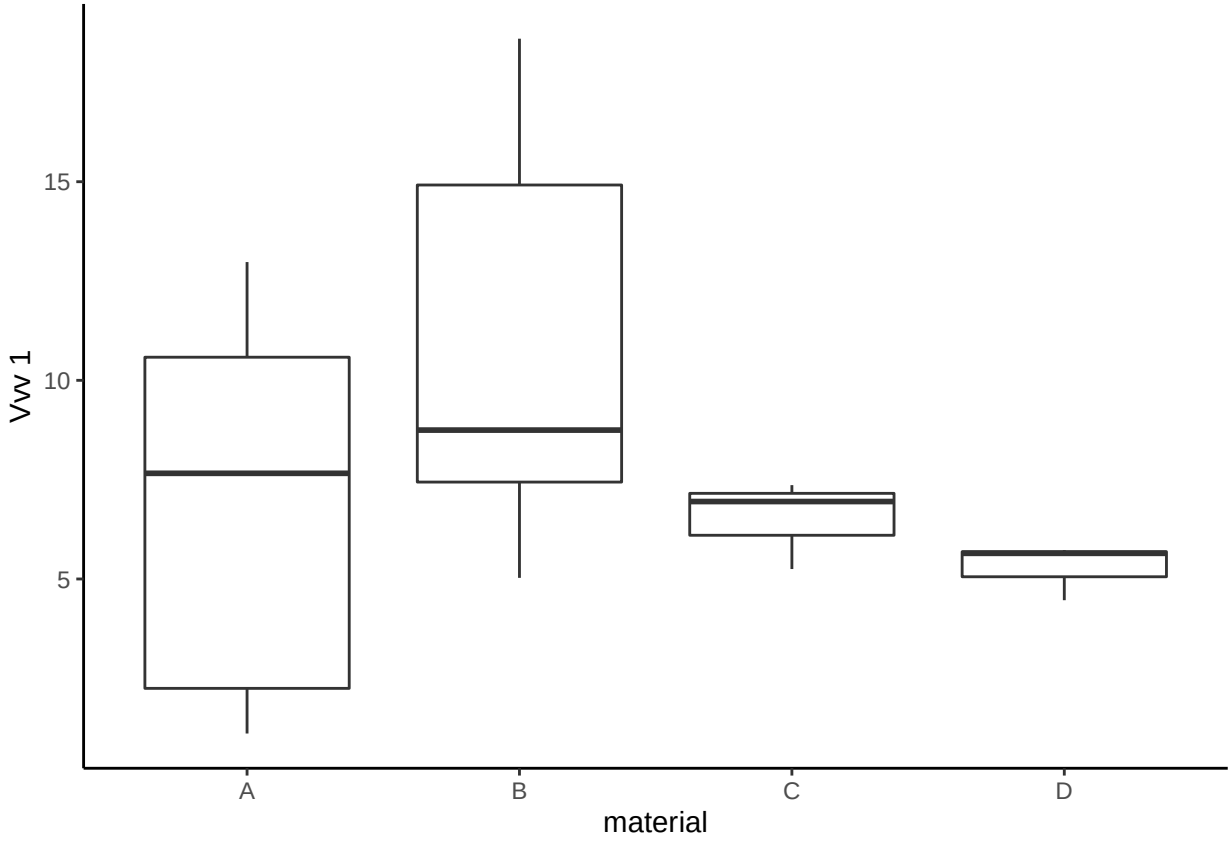

Vv
6
4
2
A
B
C
D
material

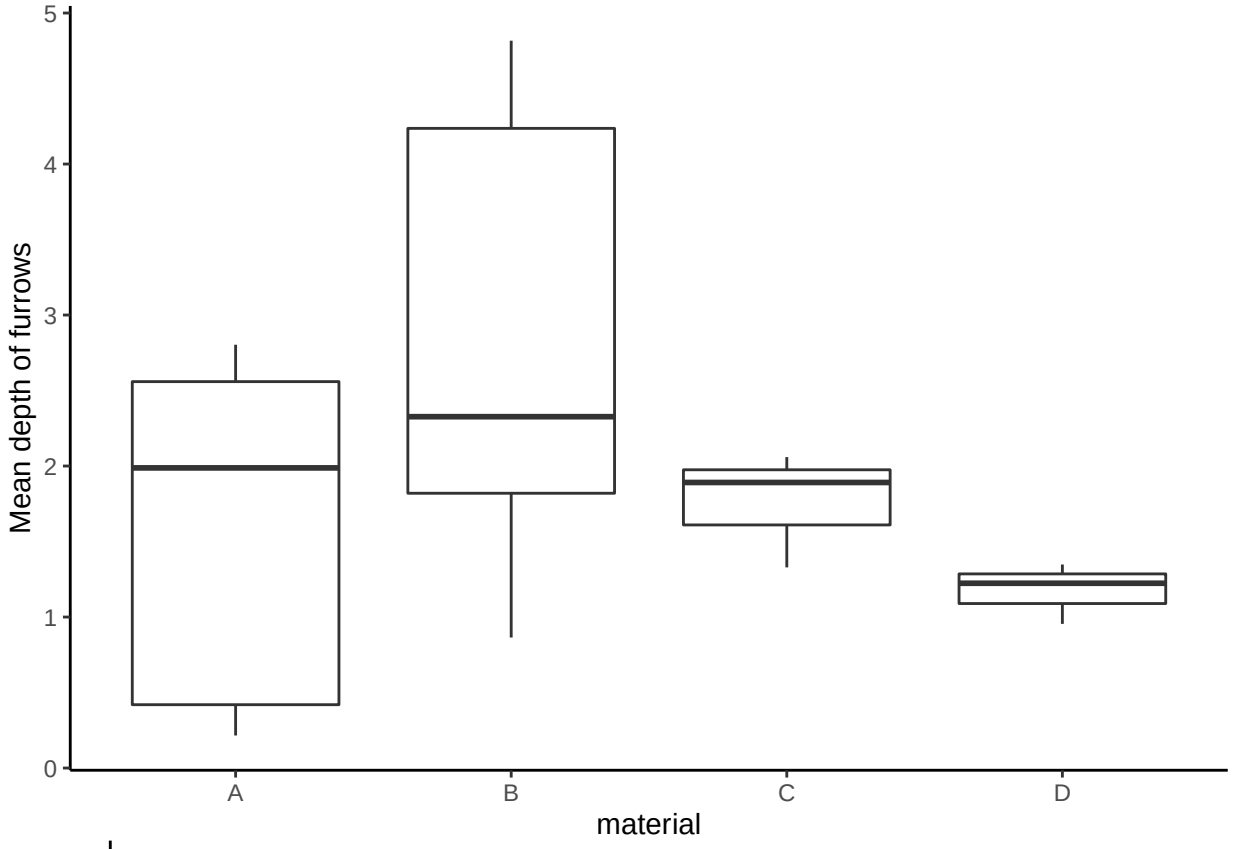

Vmp
0.4
0.3
0.2
0.1
0.0
A
B
C
D
material

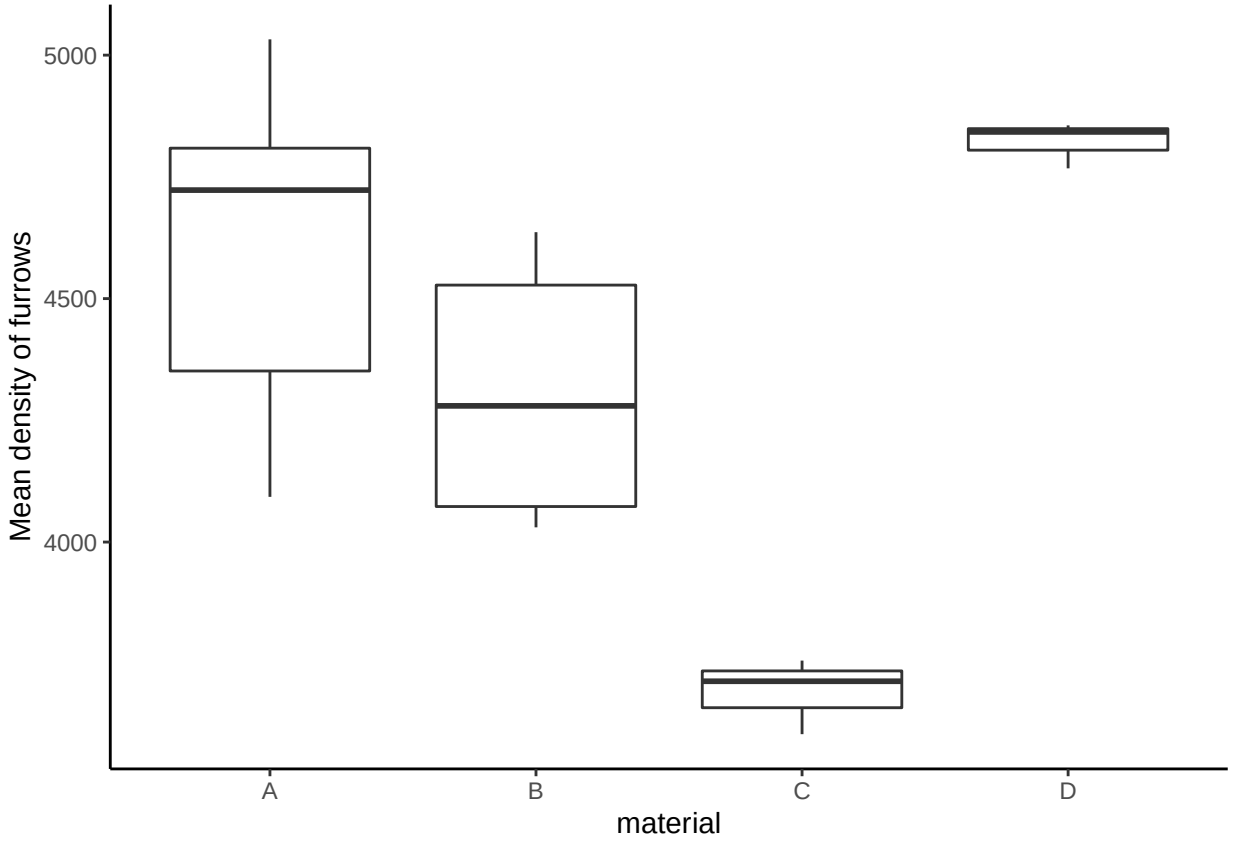

Vmc
3
2
1
A
B
C
D
material

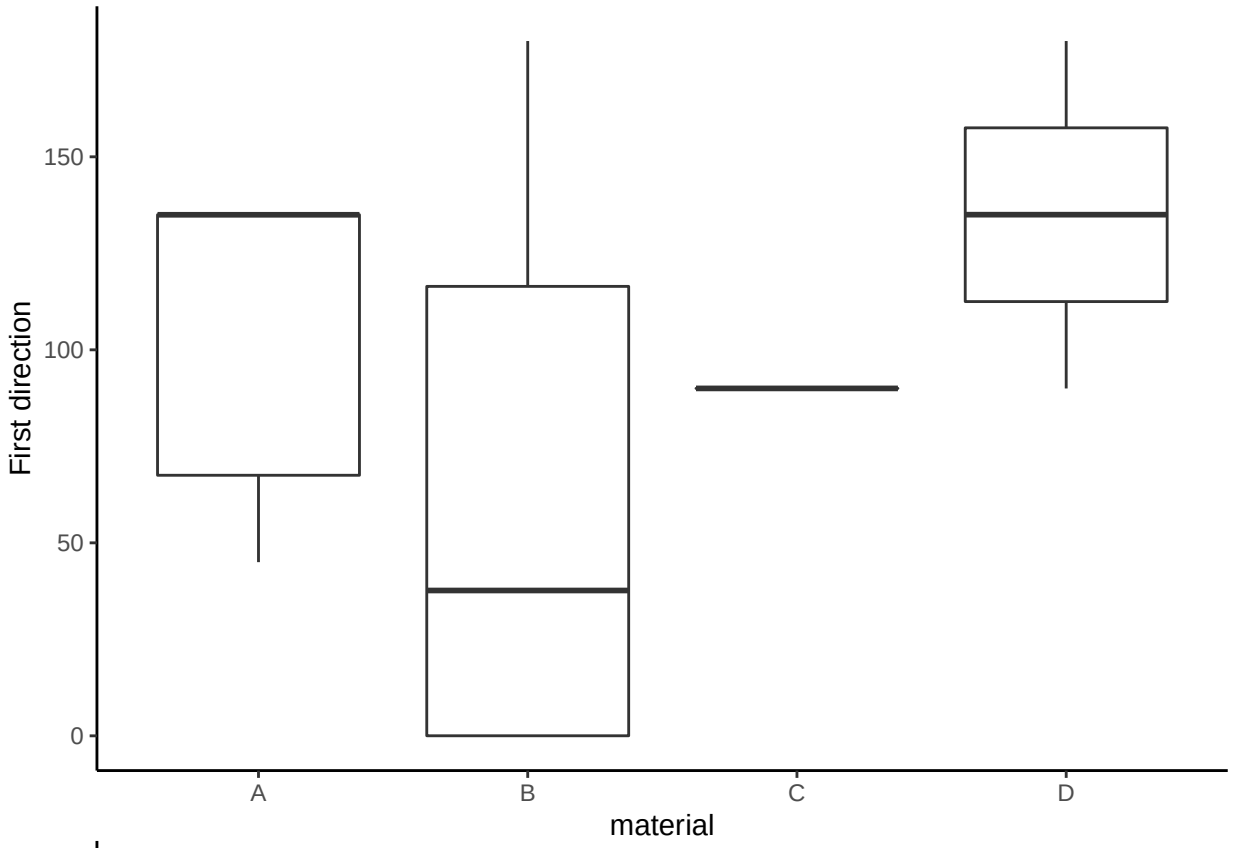

Vvc
6
4
2
A
B
C
D
material

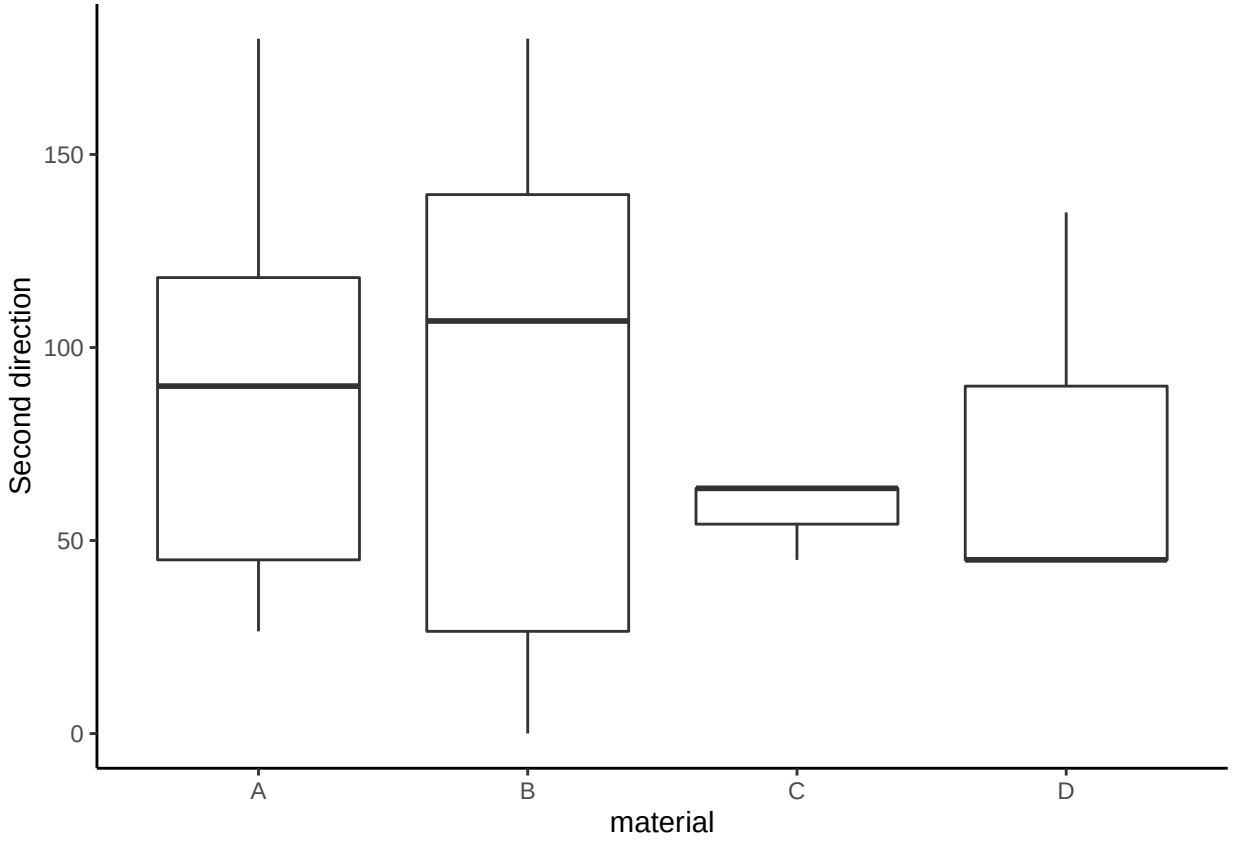

0.8
0.6
0.4
0.2
Vw
A
B
C
D
material

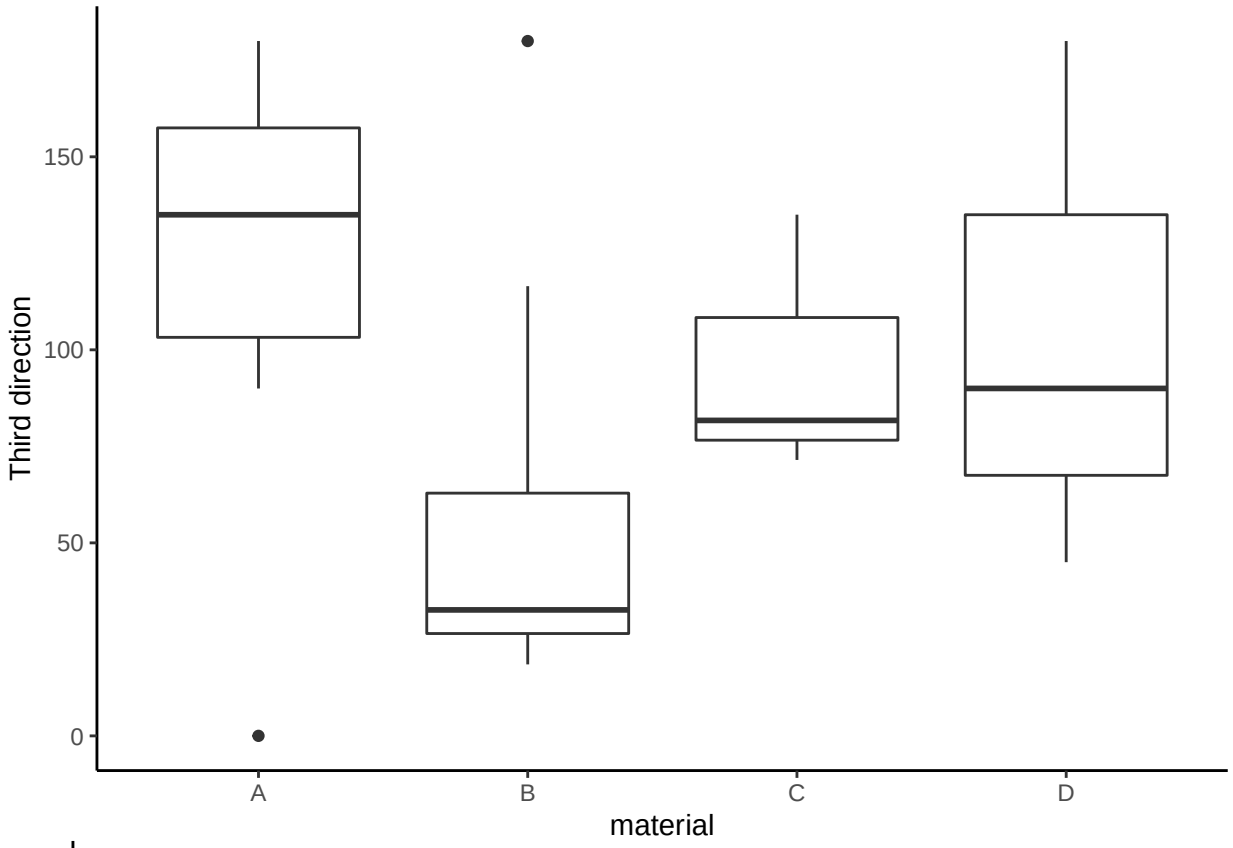

15
10
5
Vw 1
A
B
C
D
material

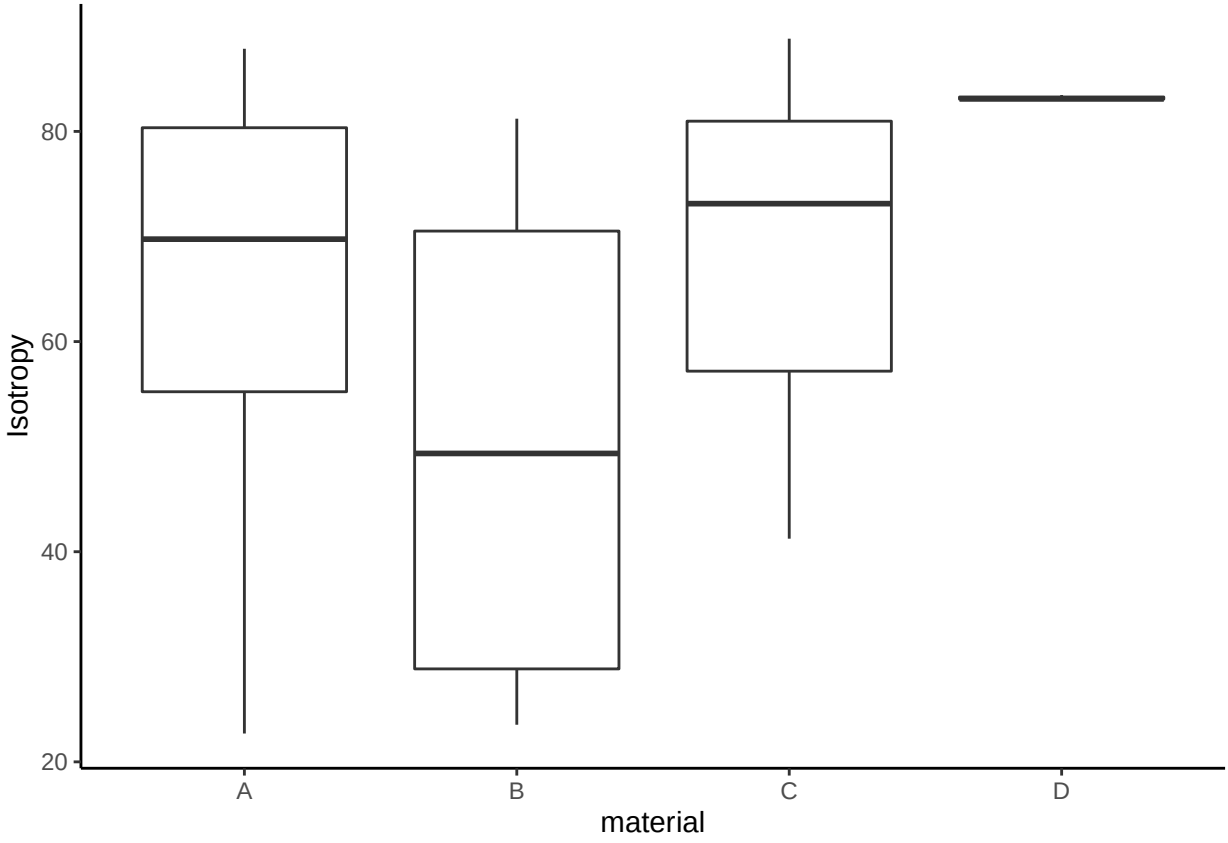

Mean depth of furrows
5
4
3
2
1
0
A
B
C
D
material

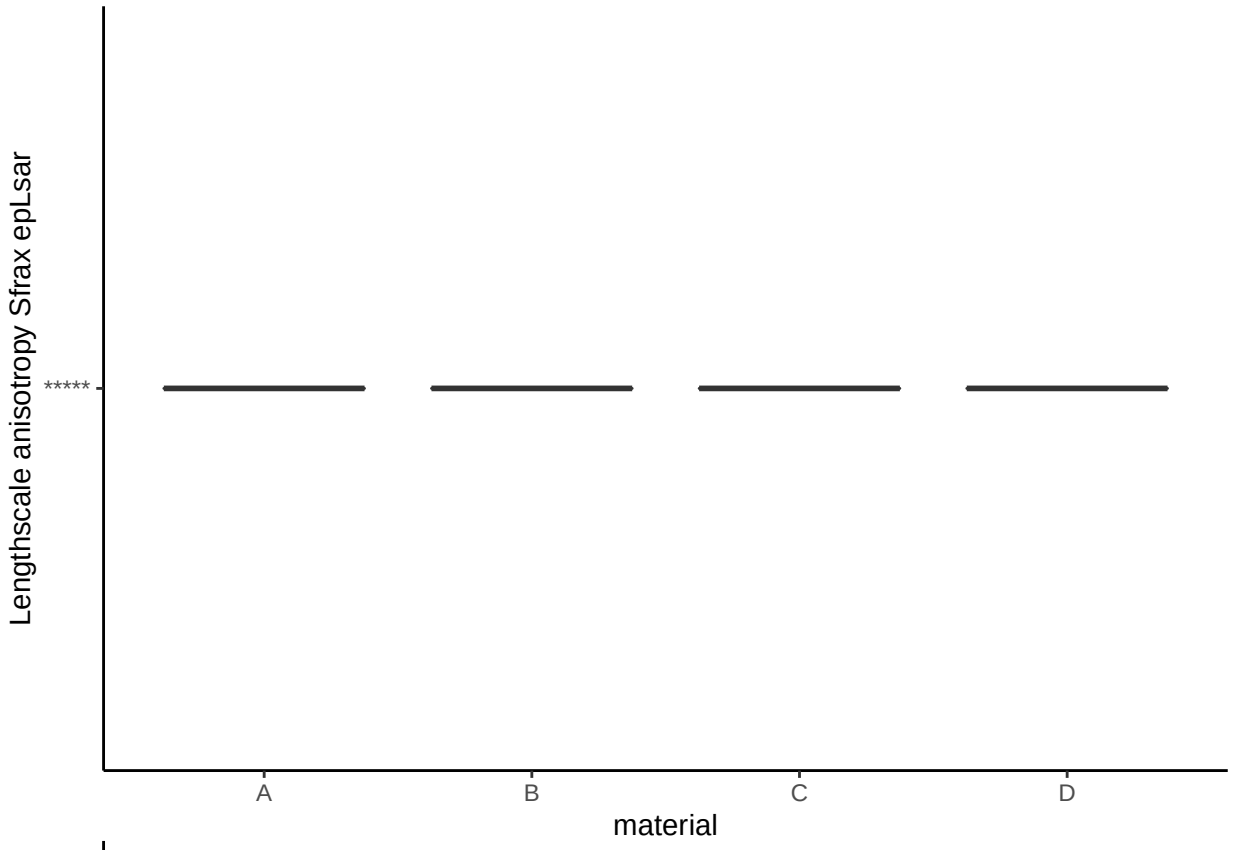

Mean density of furrows
5000
4500
4000
A
B
C
D
material

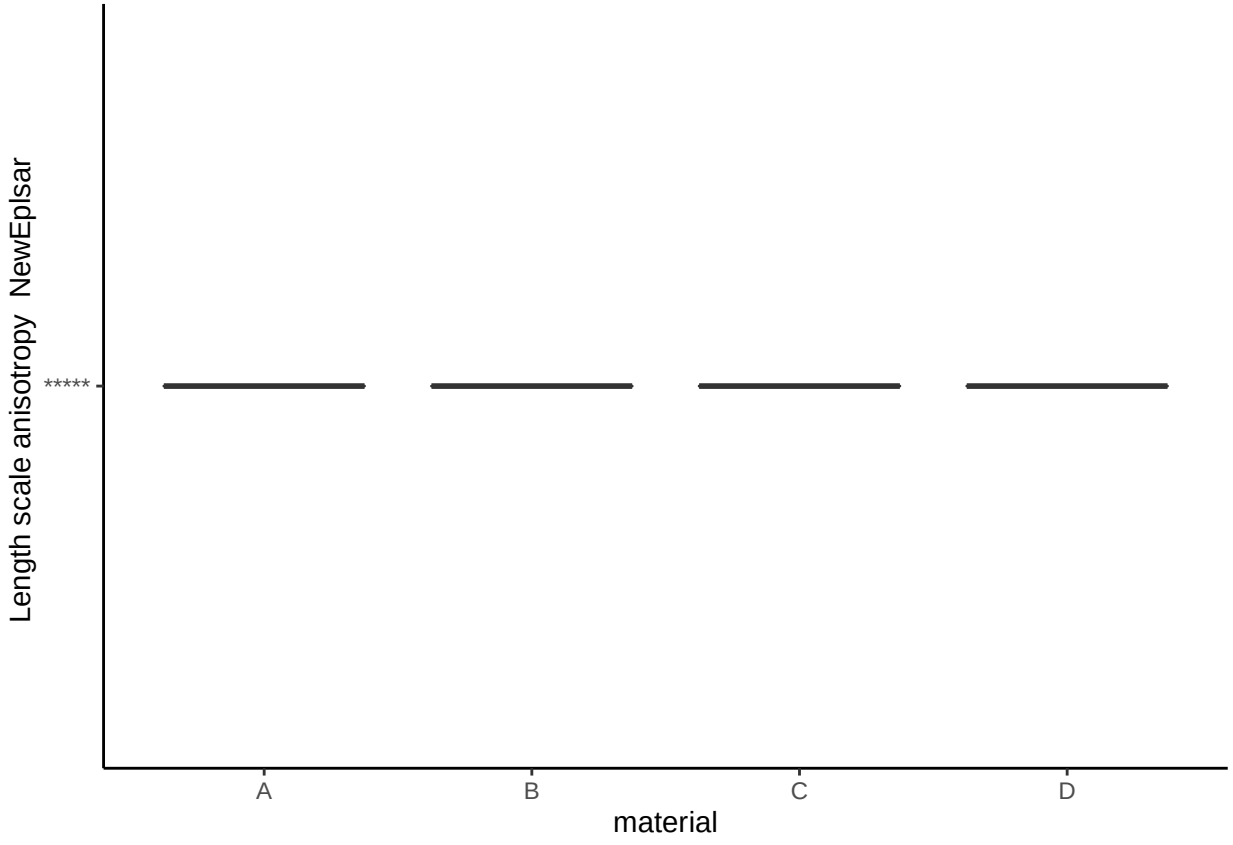

First direction
150
100
50
0
A
B
C
D
material

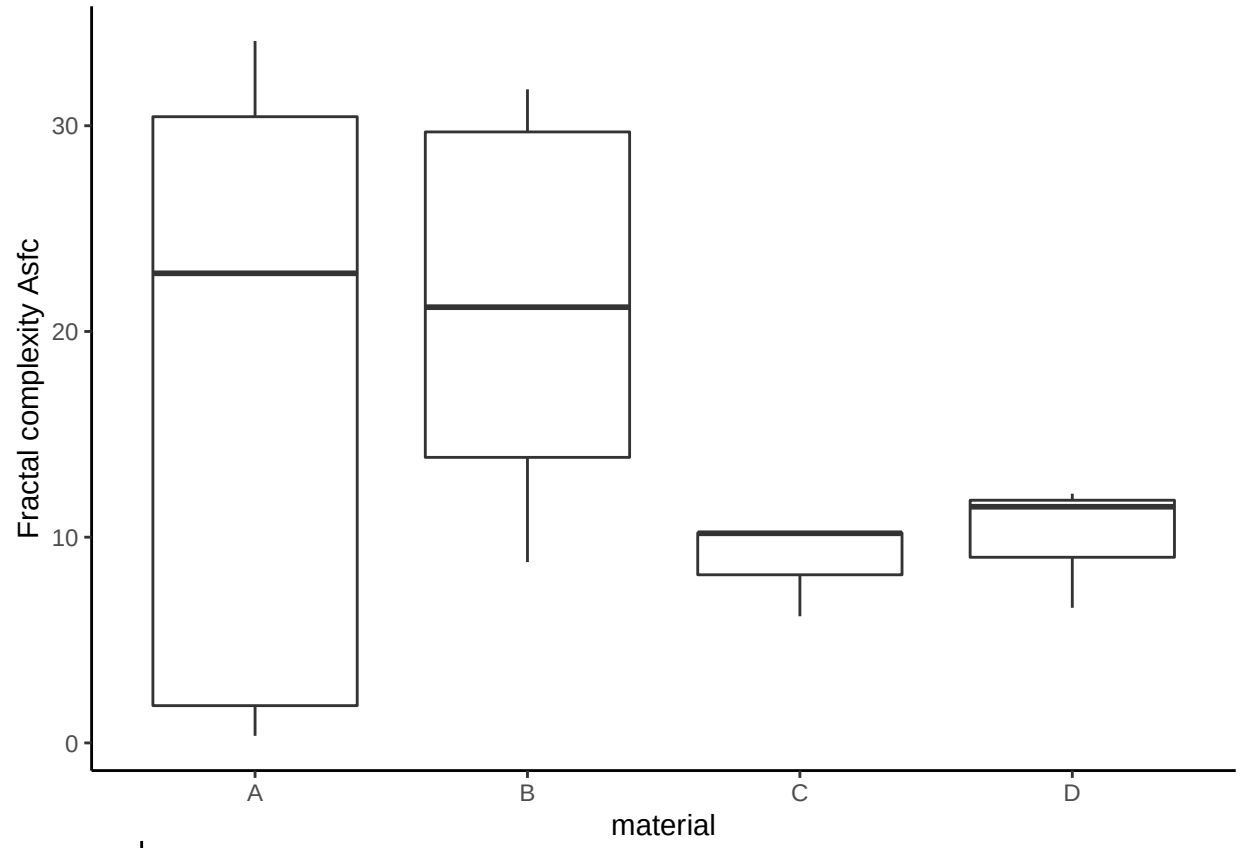

Second direction
150
100
50
0
A
B
C
D
material

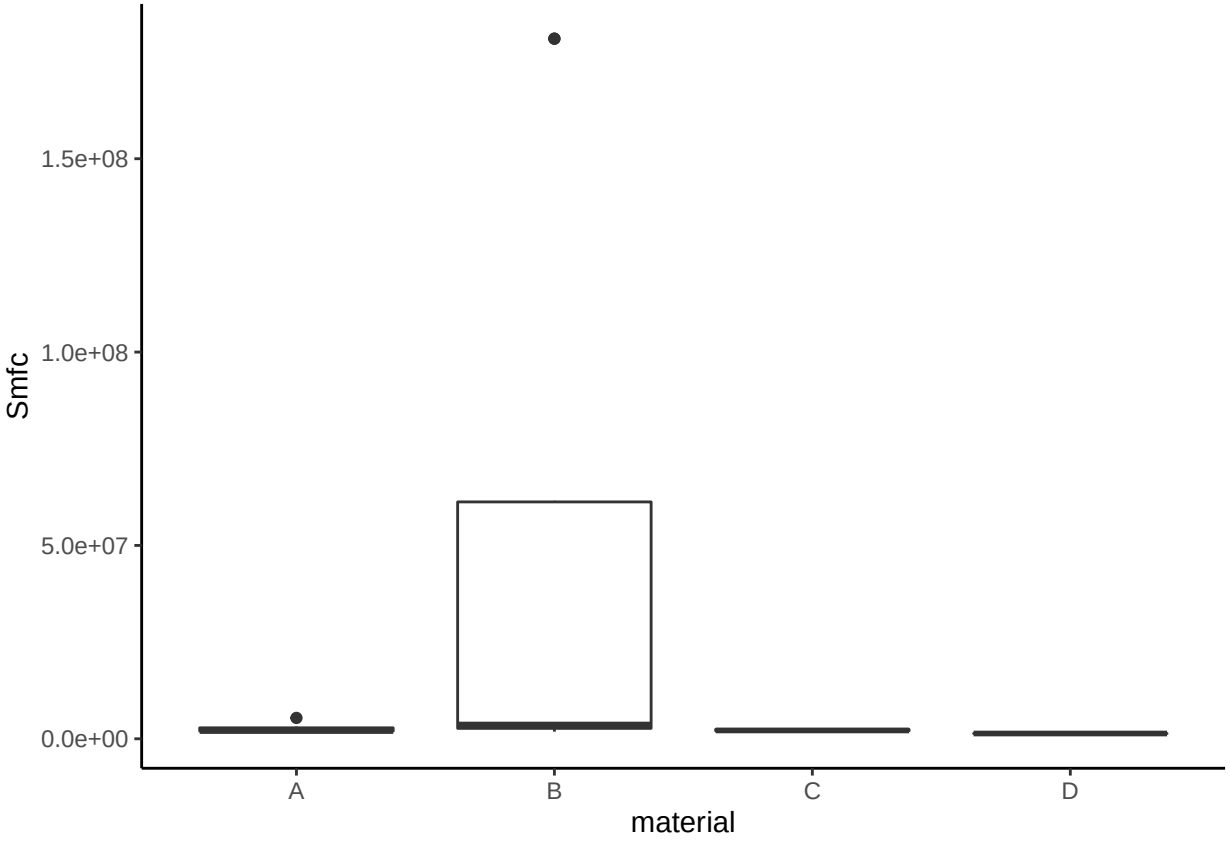

Third direction
150
100
50
0
A
B
C
D
material

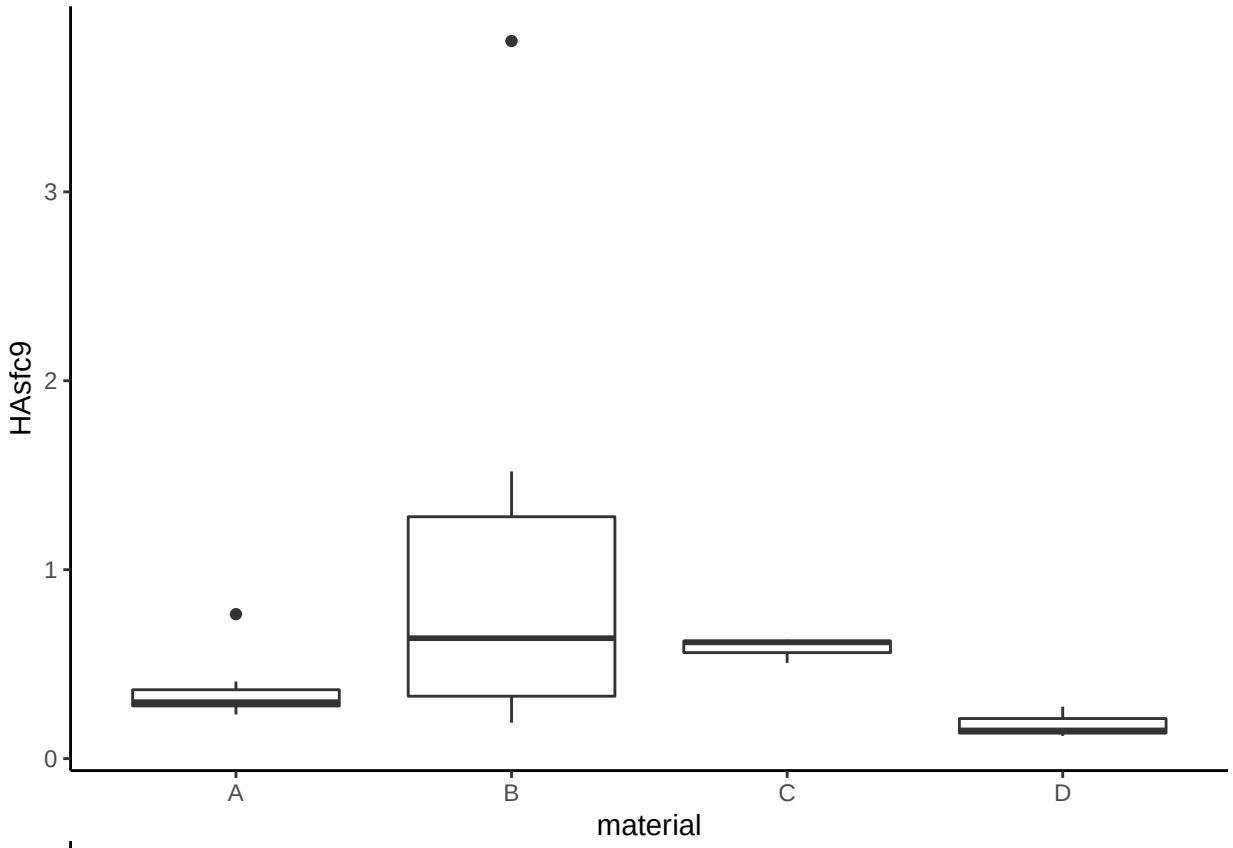

Isotropy
80
60
40
20
A
B
C
D
material

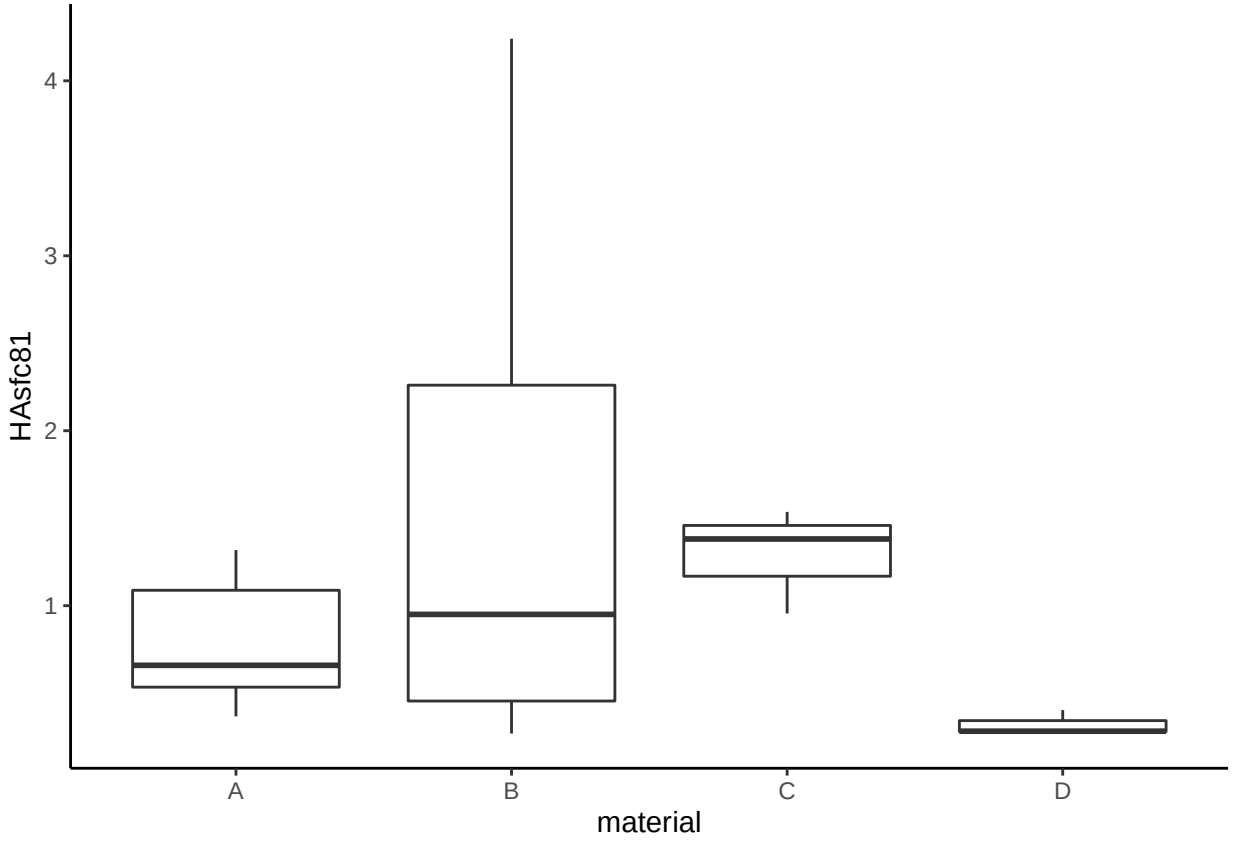

Lengthscale anisotropy Sfrax epLsar
*****
A
B
C
D
material


Length scale anisotropy NewEplsar
*****
A
B
C
D
material


Fractal complexity Asfc
30
20
10
0
A
B
C
D
material

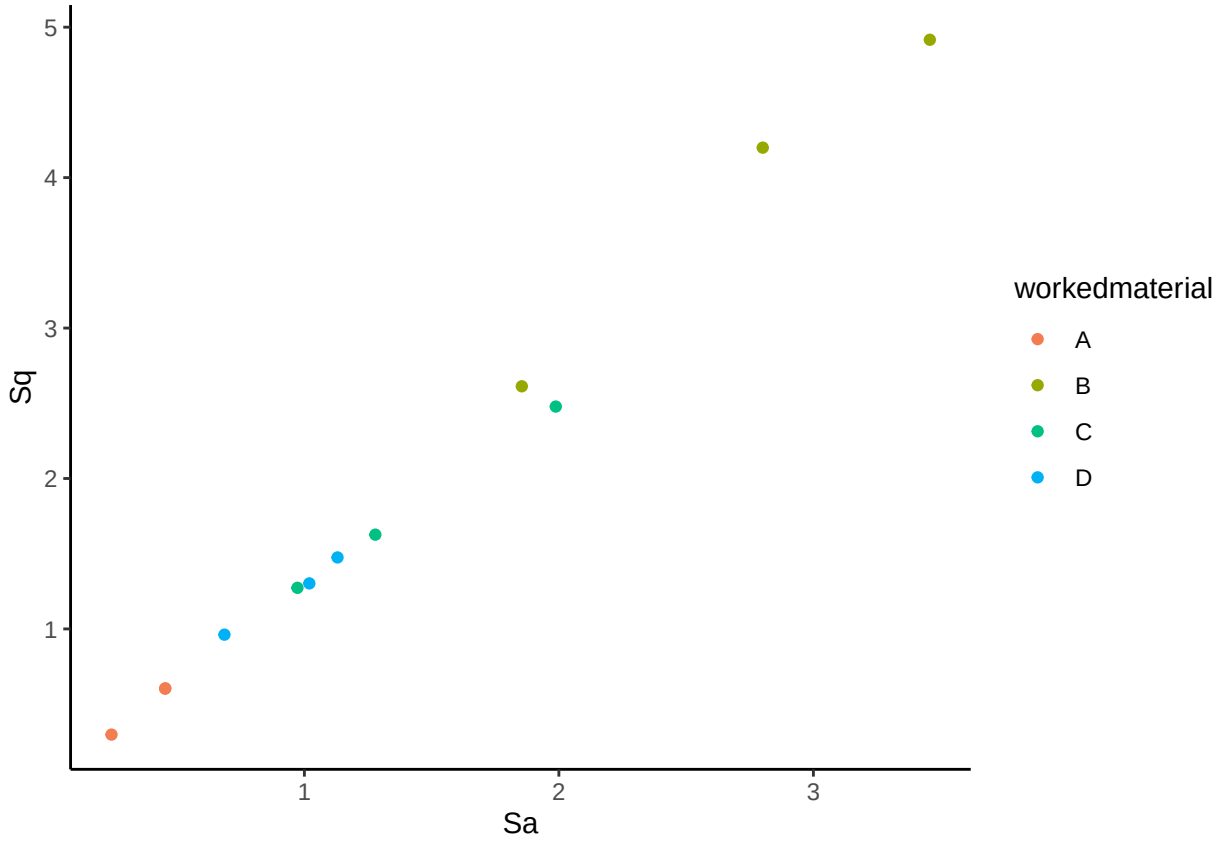

Smfc
1.5e+08
1.0e+08
5.0e+07
0.0e+00
A
B
C
D
material


HAsfc9
3
2
1
0
A
B
C
D
material


HAsfc81
4
3
2
1
A
B
C
D
material

Scatterplots of selected variables combined by “Worked material” and “Motion”

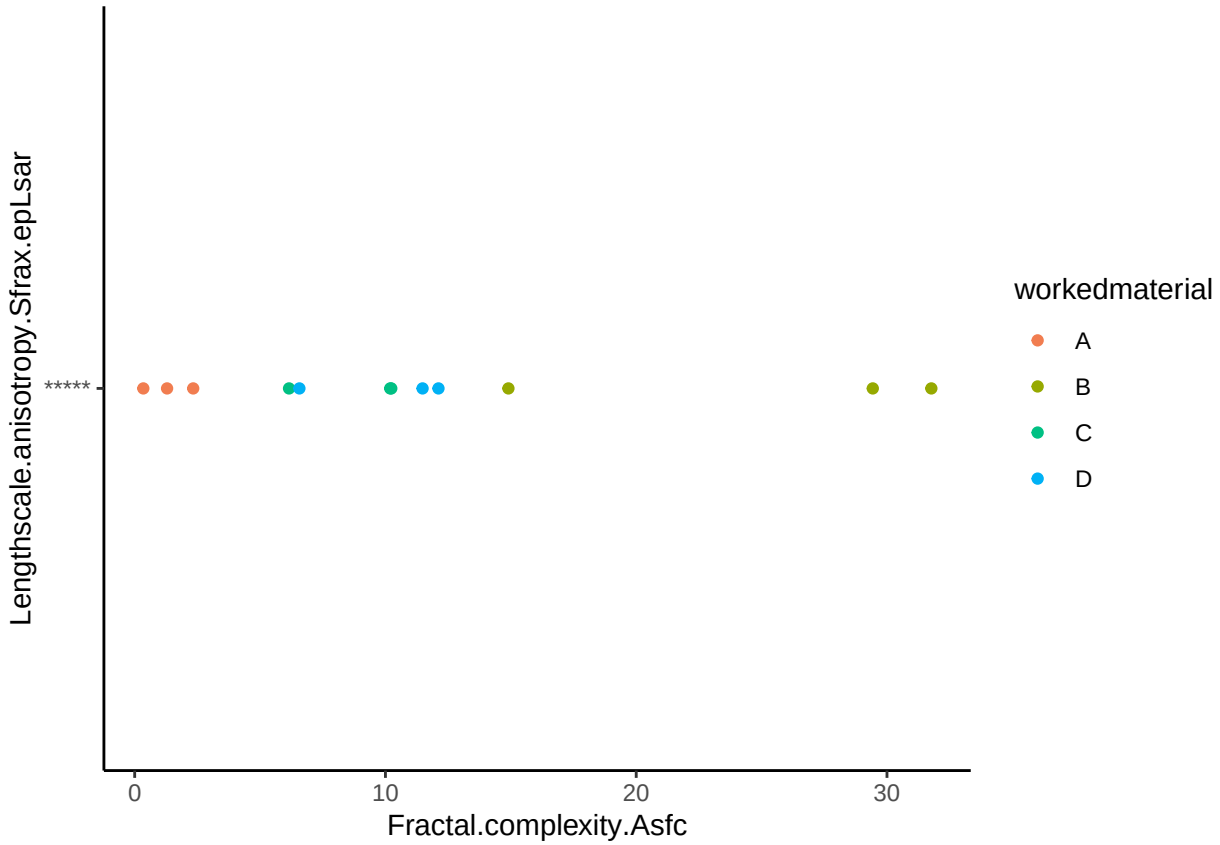
```
# Only archaeological
# Sa vs. Sq

Sa_Sq <- ggplot(data = confoarch) +
         geom_point(mapping = aes(x = Sa, y = Sq, colour = workedmaterial)) +
         theme_classic() +
         labs(colour = "workedmaterial") +
          scale_colour_hue(h = c(25, 230))
print(Sa_Sq)
```




```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_Sa-Sq", ".pdf")
ggsave(filename = file_out, plot = Sa_Sq, path = "../plots", device = "pdf")
```

```
## Saving 6.5 x 4.5 in image
```

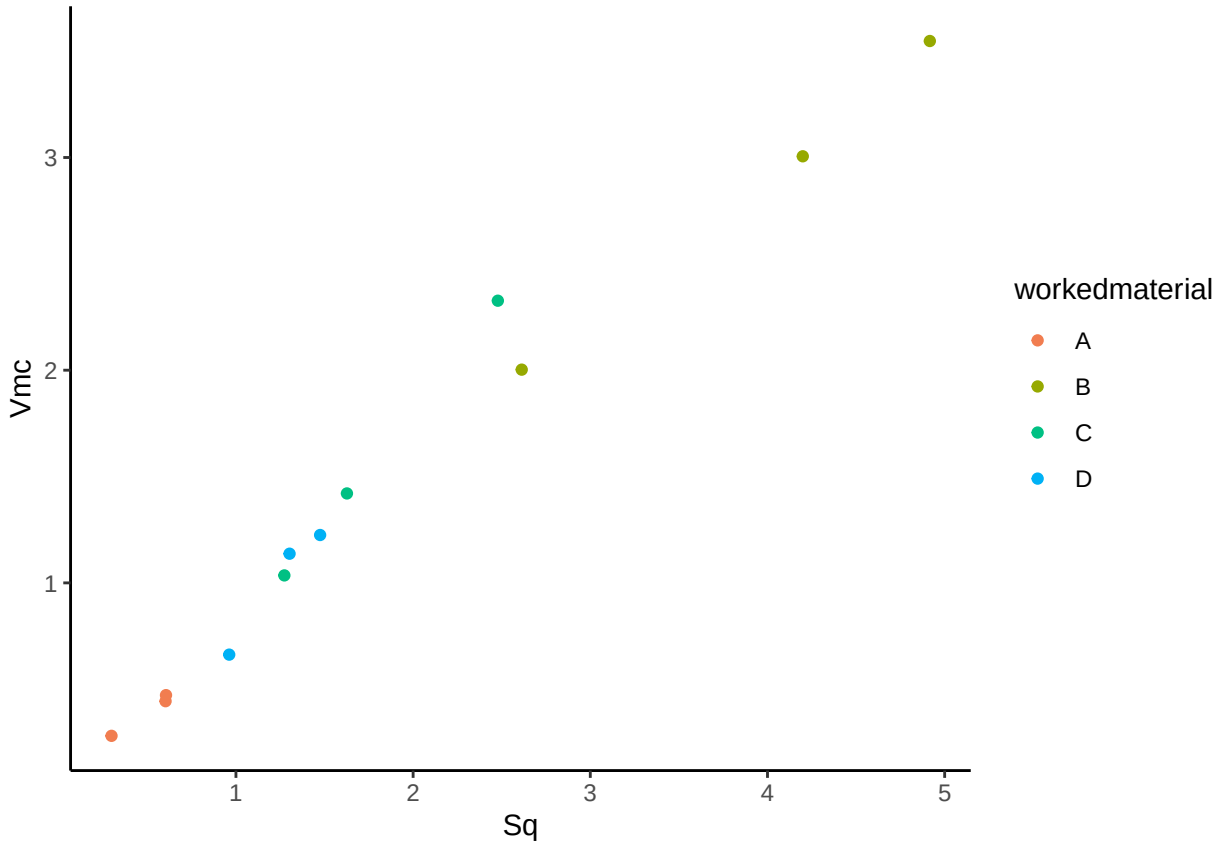
```
# epLsar vs. Asfc

ep_As <- ggplot(data = confoarch) +
         geom_point(mapping = aes(x = Fractal.complexity.Asfc, y = Lengthscale.anisotropy.Sfrax.epLsar,
         theme_classic() +
         labs(colour = "workedmaterial") +
         scale_colour_hue(h = c(25, 230))
print(ep_As)
```




```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_Asfc-epLsar", ".pdf")
ggsave(filename = file_out, plot = ep_As, path = "../plots", device = "pdf")
```

```
## Saving 6.5 x 4.5 in image
```

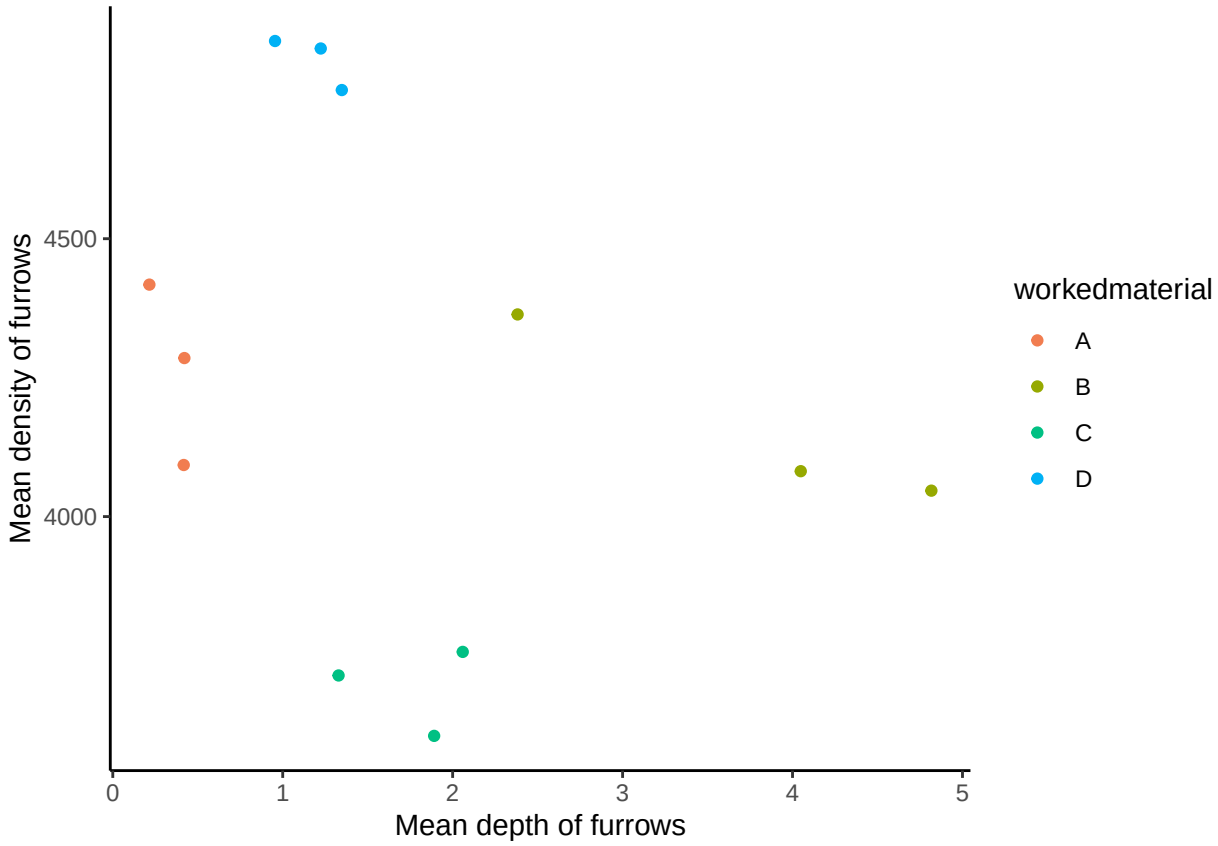
```
# Sq vs. Vmc

Sq_Vmc <- ggplot(data = confoarch) +
          geom_point(mapping = aes(x = Sq, y = Vmc, colour = workedmaterial)) +
          theme_classic() +
          labs(colour = "workedmaterial") +
          scale_colour_hue(h = c(25, 230))
print(Sq_Vmc)
```




```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_Sq-Vmc", ".pdf")
ggsave(filename = file_out, plot = Sq_Vmc, path = "../plots", device = "pdf")
```

```
## Saving 6.5 x 4.5 in image
```

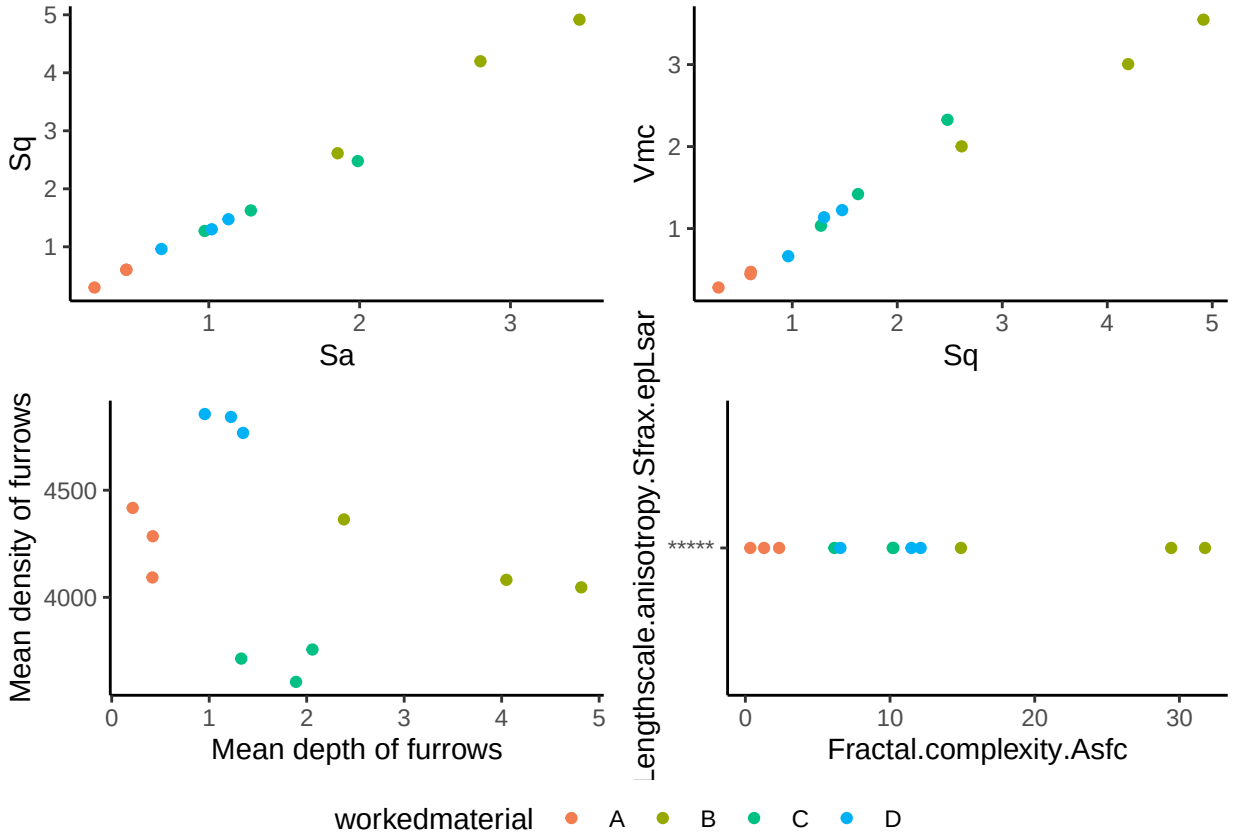
```
# Mean depth of furrows vs. mean density of furrows

furrows <- ggplot(data = confoarch) +
           geom_point(mapping = aes(x = Mean.depth.of.furrows, y = Mean.density.of.furrows,
                                    colour = workedmaterial)) +
           theme_classic() +
           labs(colour = "workedmaterial", x = "Mean depth of furrows", y = "Mean density of furrows") +
           scale_colour_hue(h = c(25, 230))
print(furrows)
```




```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_furrows", ".pdf")
ggsave(filename = file_out, plot = furrows, path = "../plots", device = "pdf")
```

```
## Saving 6.5 x 4.5 in image
```

```
# combine all in a single image

ggarrange(Sa_Sq, Sq_Vmc, furrows, ep_As, common.legend = TRUE, legend = "bottom")
```




```
ggsave("../plots/scatterplots.png")
```

```
## Saving 6.5 x 4.5 in image
```

Scatterplot matrix for the ISO 25178 Area scale, Height and volume parameters

```
data(confocaldataarch, package = "reshape")
```

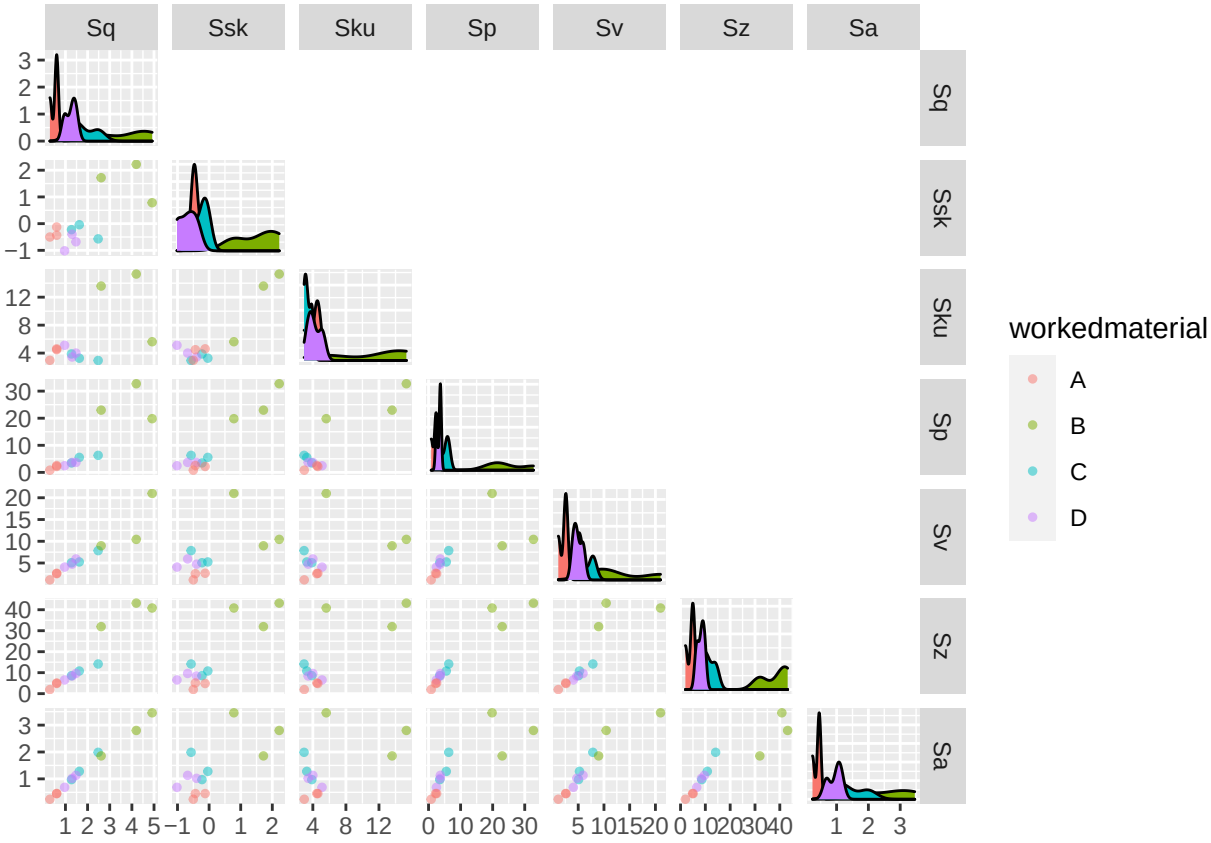
```
## Warning in data(confocaldataarch, package = "reshape"): data set
## 'confocaldataarch' not found
```

```
data(confoarch, package = "reshape")
```

```
## Warning in data(confoarch, package = "reshape"): data set 'confoarch' not found
```

```
# Only archaeological
# Height parameters

ggpairs(data=confoarch,
        columns = c(21:27),
        cardinality_threshold = 30,
        mapping = ggplot2::aes(color = workedmaterial),
        lower = list(continuous = wrap("points", alpha = 0.5, size = 1)),
```

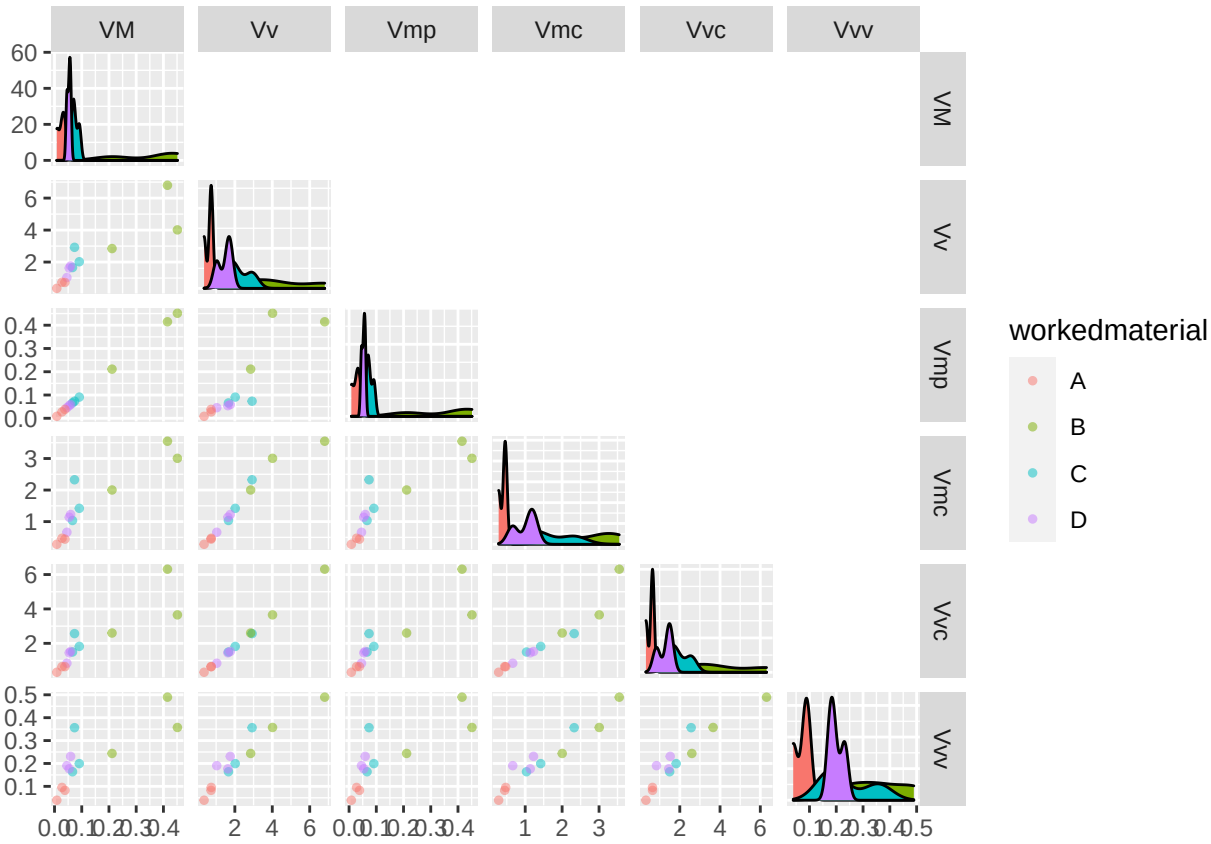
```
        upper = list(continuous = "blank"),
        legend = c(2,1)
        ) +

    theme(legend.position = "right") +
  labs(fill = "Micro polish type")
```




```
ggsave("../plots/confocalarcharea_matrix.png")
```

```
## Saving 6.5 x 4.5 in image
```

```
# Volume parameters

ggpairs(data=confoarch,
        columns = c(36:41),
        cardinality_threshold = 30,
        mapping = ggplot2::aes(color = workedmaterial),
        lower = list(continuous = wrap("points", alpha = 0.5, size = 1)),
        upper = list(continuous = "blank"),
        legend = c(2,1)
        ) +

    theme(legend.position = "right") +
  labs(fill = "Micro polish type")
```



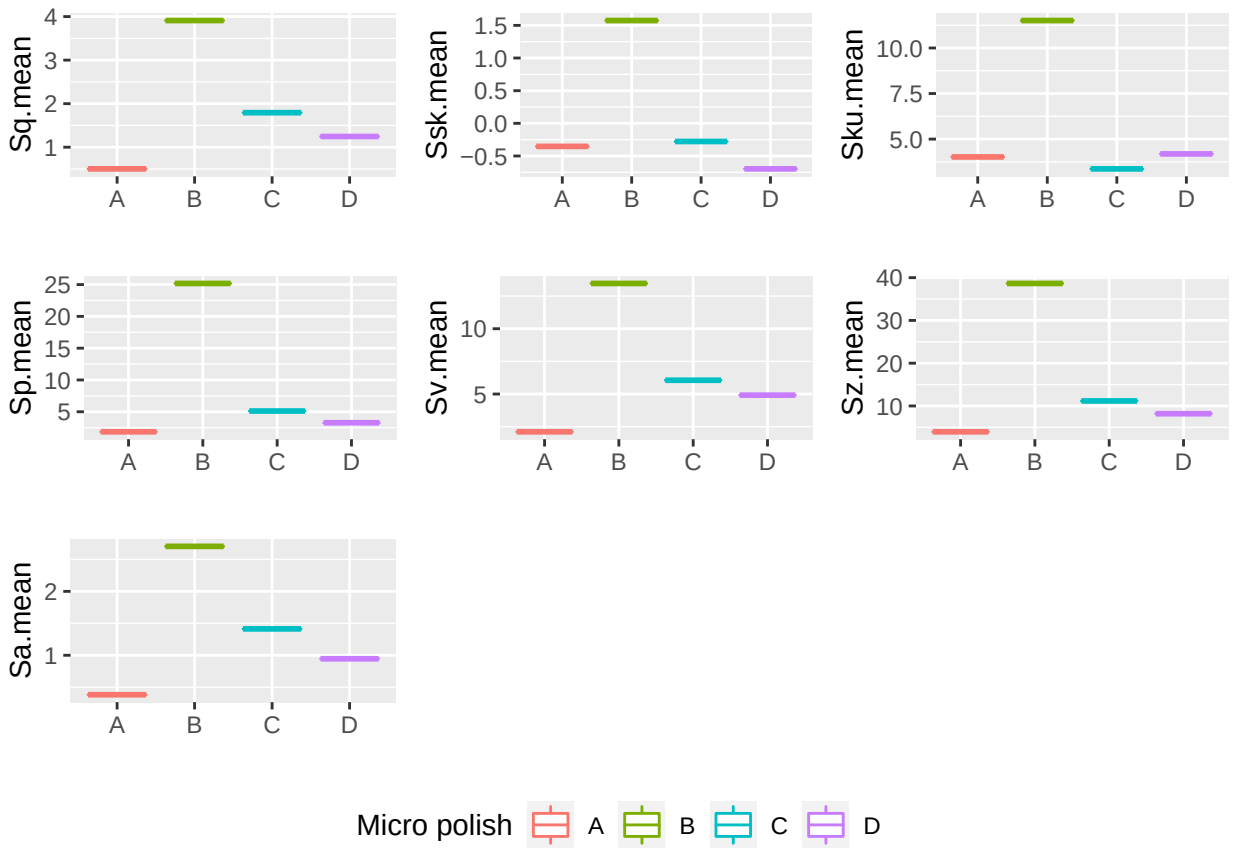

```
ggsave("../plots/confocalarchvolume_matrix.png")
```

```
## Saving 6.5 x 4.5 in image
```

Plot confostats for the ISO 25178 Area-scale, Height and volume parameters

```
# select parameter from dataset

# Only archaeological

confostatsarch2 <- filter(confostatsarch, sample == "archaeological")


heightconfostats <- select(confostatsarch2,workedmaterial, Sq.mean,Ssk.mean,Sku.mean,Sp.mean,Sv.mean,Sz

p1 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Sq.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p2 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Ssk.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p3 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Sku.mean, colour=workedmaterial)) +
```

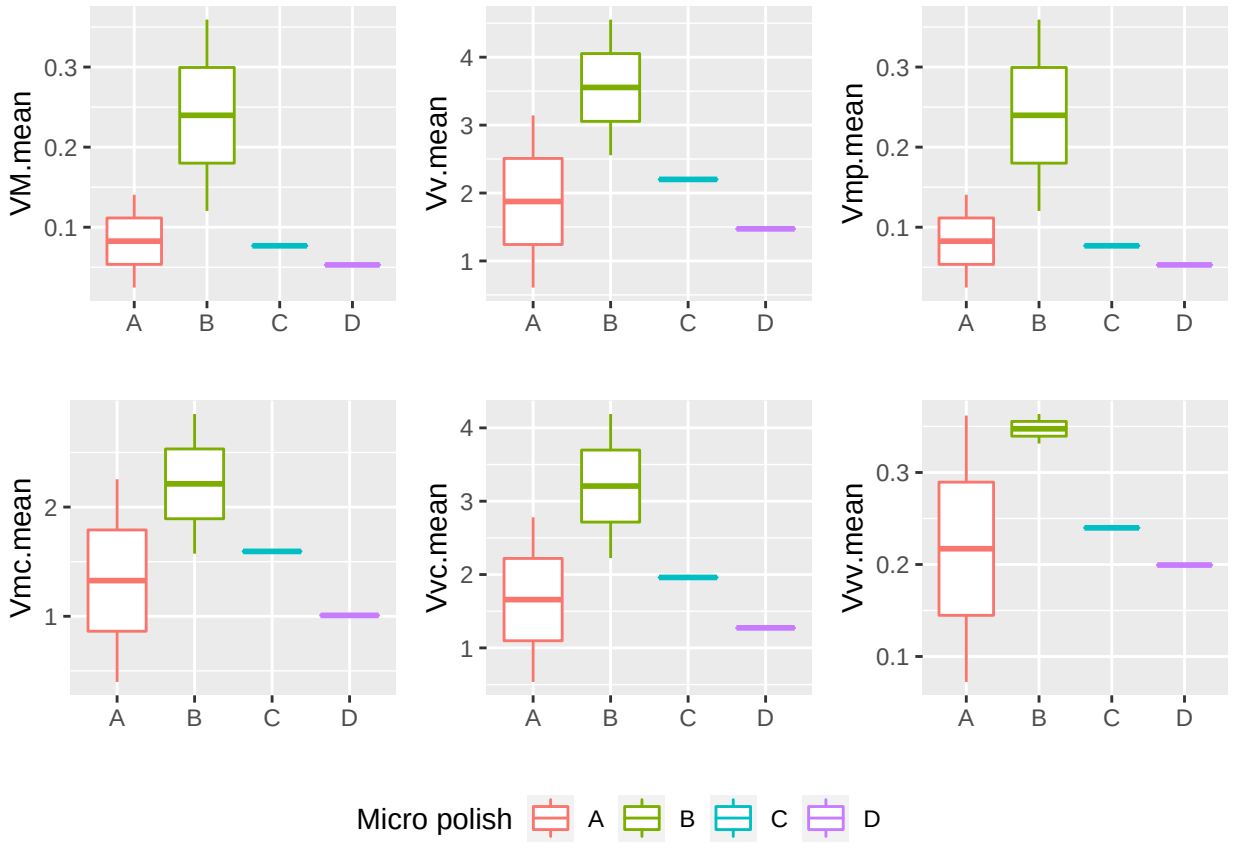
```
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p4 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Sp.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p5 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Sv.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p6 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Sz.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p7 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Sa.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

ggarrange(p1, p2, p3, p4, p5, p6, p7, common.legend = TRUE, font.label = list(size=8), legend="bottom")
```




```
ggsave("../plots/confostatsarcharea_boxplots.png")
```

```
## Saving 6.5 x 4.5 in image
```

```r
# Now Volume parameters

volumeconfostats <- select(confostatsarch,sample,workedmaterial, VM.mean,Vv.mean,Vmp.mean,Vmc.mean,Vvc.m

p8 <- ggplot(volumeconfostats, aes(x=workedmaterial, y=VM.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p9 <- ggplot(volumeconfostats, aes(x=workedmaterial, y=Vv.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p10 <- ggplot(volumeconfostats, aes(x=workedmaterial, y=Vmp.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p11 <- ggplot(volumeconfostats, aes(x=workedmaterial, y=Vmc.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p12 <- ggplot(volumeconfostats, aes(x=workedmaterial, y=Vvc.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

p13 <- ggplot(volumeconfostats, aes(x=workedmaterial, y=Vvv.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

ggarrange(p8, p9, p10, p11, p12, p13, common.legend = TRUE, font.label = list(size=8), legend="bottom")
```




```
ggsave("../plots/confostatarchvolume_boxplots.png")
```

```
## Saving 6.5 x 4.5 in image
```

End and Session info

```
sessionInfo()
```

```
## R version 4.0.4 (2021-02-15)
## Platform: x86_64-apple-darwin17.0 (64-bit)
## Running under: macOS Catalina 10.15.7
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.0/Resources/lib/libRblas.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.0/Resources/lib/libRlapack.dylib
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## attached base packages:
## [1] tools     stats     graphics  grDevices utils     datasets  methods
## [8] base
##
```

```
## other attached packages:
##  [1] ggpubr_0.4.0     doBy_4.6.9       GGally_2.1.1     kableExtra_1.3.4
##  [5] janitor_2.1.0    knitr_1.31       forcats_0.5.1    stringr_1.4.0
##  [9] dplyr_1.0.5      purrr_0.3.4      readr_1.4.0      tidyr_1.1.3
## [13] tibble_3.1.0     ggplot2_3.3.3    tidyverse_1.3.0
##
## loaded via a namespace (and not attached):
##  [1] httr_1.4.2         jsonlite_1.7.2     viridisLite_0.3.0  carData_3.0-4
##  [5] modelr_0.1.8       assertthat_0.2.1   highr_0.8          cellranger_1.1.0
##  [9] yaml_2.2.1         pillar_1.5.1       backports_1.2.1    lattice_0.20-41
## [13] glue_1.4.2         digest_0.6.27      RColorBrewer_1.1-2 ggsignif_0.6.1
## [17] rvest_1.0.0        snakecase_0.11.0   colorspace_2.0-0   cowplot_1.1.1
## [21] htmltools_0.5.1.1  Matrix_1.3-2       plyr_1.8.6         pkgconfig_2.0.3
## [25] broom_0.7.5        haven_2.3.1        scales_1.1.1       webshot_0.5.2
## [29] svglite_2.0.0      openxlsx_4.2.3     rio_0.5.26         farver_2.1.0
## [33] generics_0.1.0     car_3.0-10         ellipsis_0.3.1     withr_2.4.1
## [37] cli_2.3.1          magrittr_2.0.1     crayon_1.4.1       readxl_1.3.1
## [41] evaluate_0.14      fs_1.5.0           fansi_0.4.2        MASS_7.3-53.1
## [45] rstatix_0.7.0      xml2_1.3.2         foreign_0.8-81     data.table_1.14.0
## [49] hms_1.0.0          lifecycle_1.0.0    munsell_0.5.0      reprex_1.0.0
## [53] zip_2.1.1          compiler_4.0.4     Deriv_4.1.3        systemfonts_1.0.1
## [57] rlang_0.4.10       grid_4.0.4         rstudioapi_0.13    labeling_0.4.2
## [61] rmarkdown_2.7      gtable_0.3.0       abind_1.4-5        DBI_1.1.1
## [65] reshape_0.8.8      curl_4.3           R6_2.5.0           gridExtra_2.3
## [69] lubridate_1.7.10   utf8_1.2.1         stringi_1.5.3      Rcpp_1.0.6
## [73] vctrs_0.3.6        dbplyr_2.1.0       tidyselect_1.1.0   xfun_0.22
```