

SOM4 - Reading and plotting Confocal data

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

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Brief description of the script

This R markdown document reads, summarizes and plots data for: *Paixao et al. 2021. The Middle Paleolithic Ground Stones Tools of Nesher Ramla Unit V (Southern Levant): a multi-scale use-wear approach for assessing the assemblage functional variability. 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.

The authors would like to thank Ivan Calandra and Lisa Schunk for their help and contribution on several chunks of code included here in the script (pieces of code are also adapted from Calandra et al. 2019, Pedergrana et al. 2020a, 2020b).

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:

Eduardo Paixão, paixao@rgzm.de

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")],
                             FUN=nminmaxmeanmedsd)

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
```

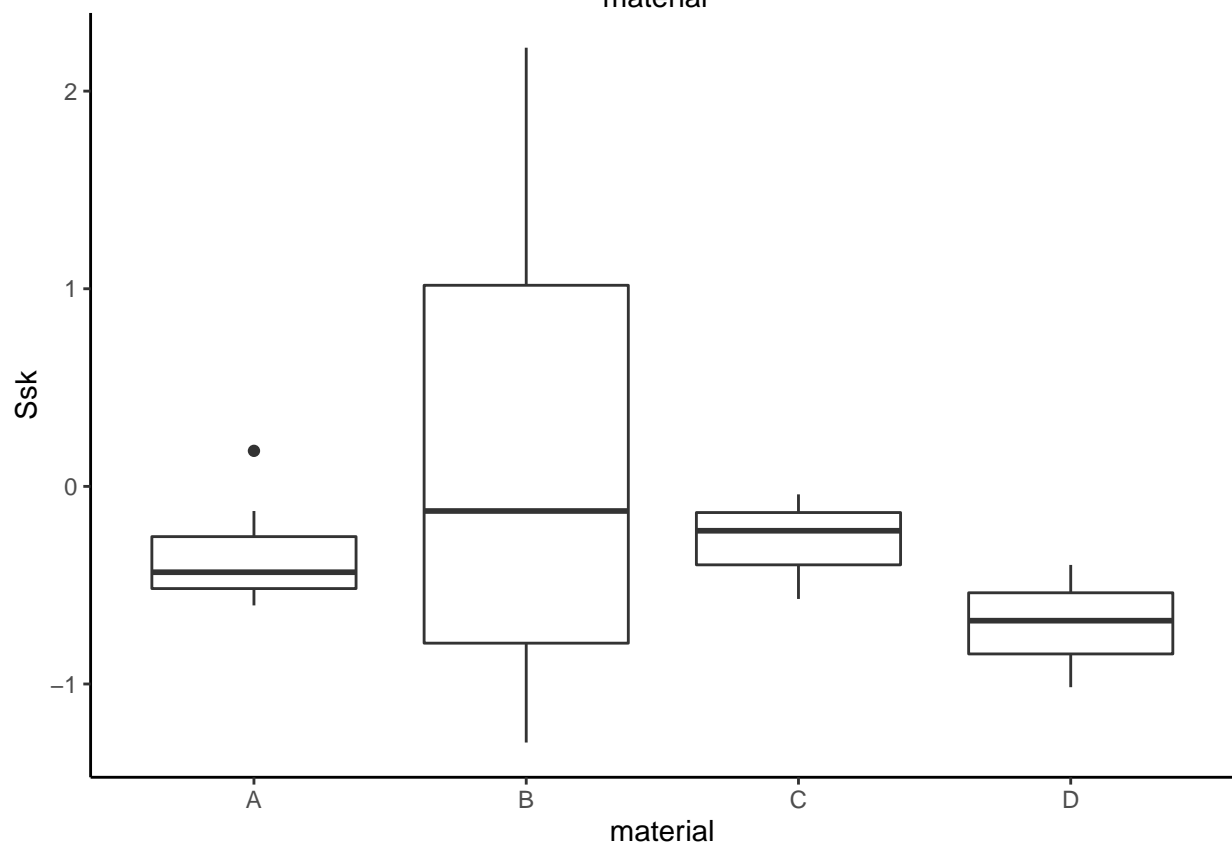
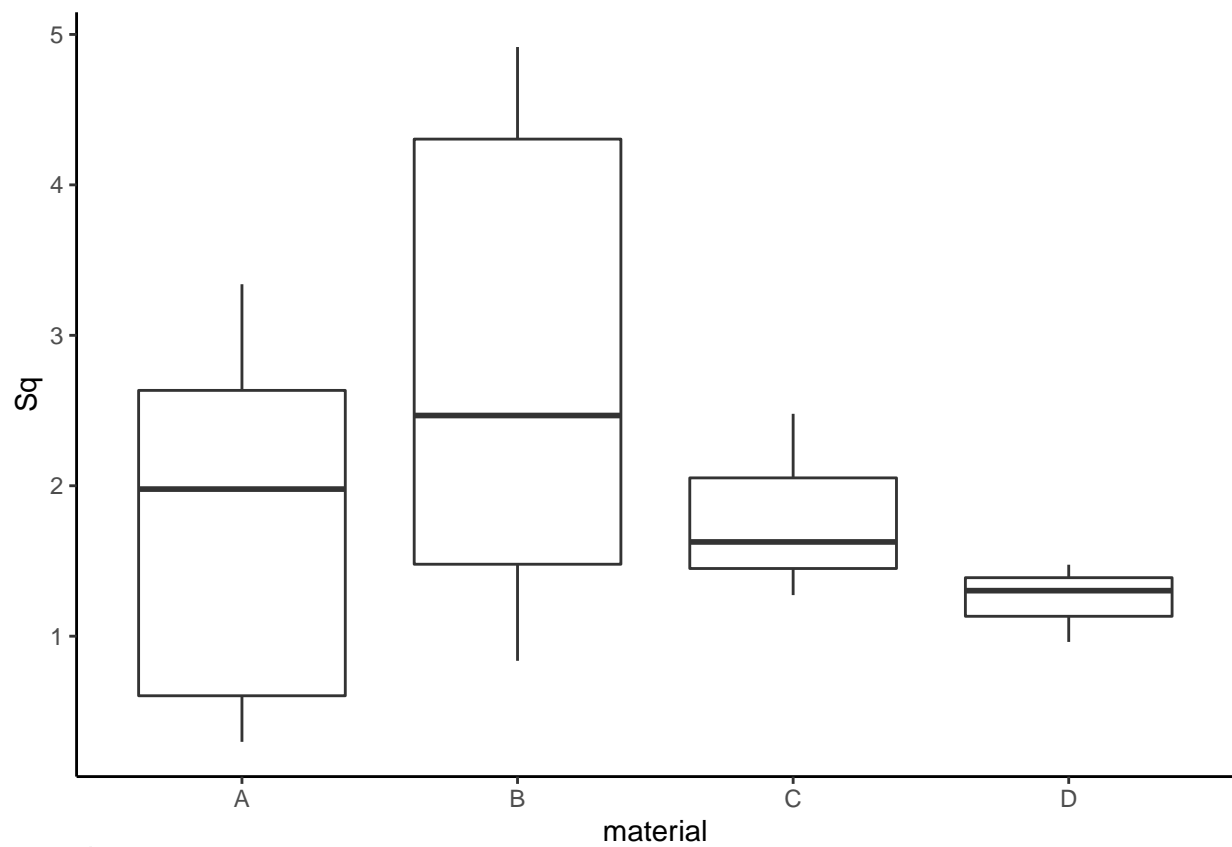
```

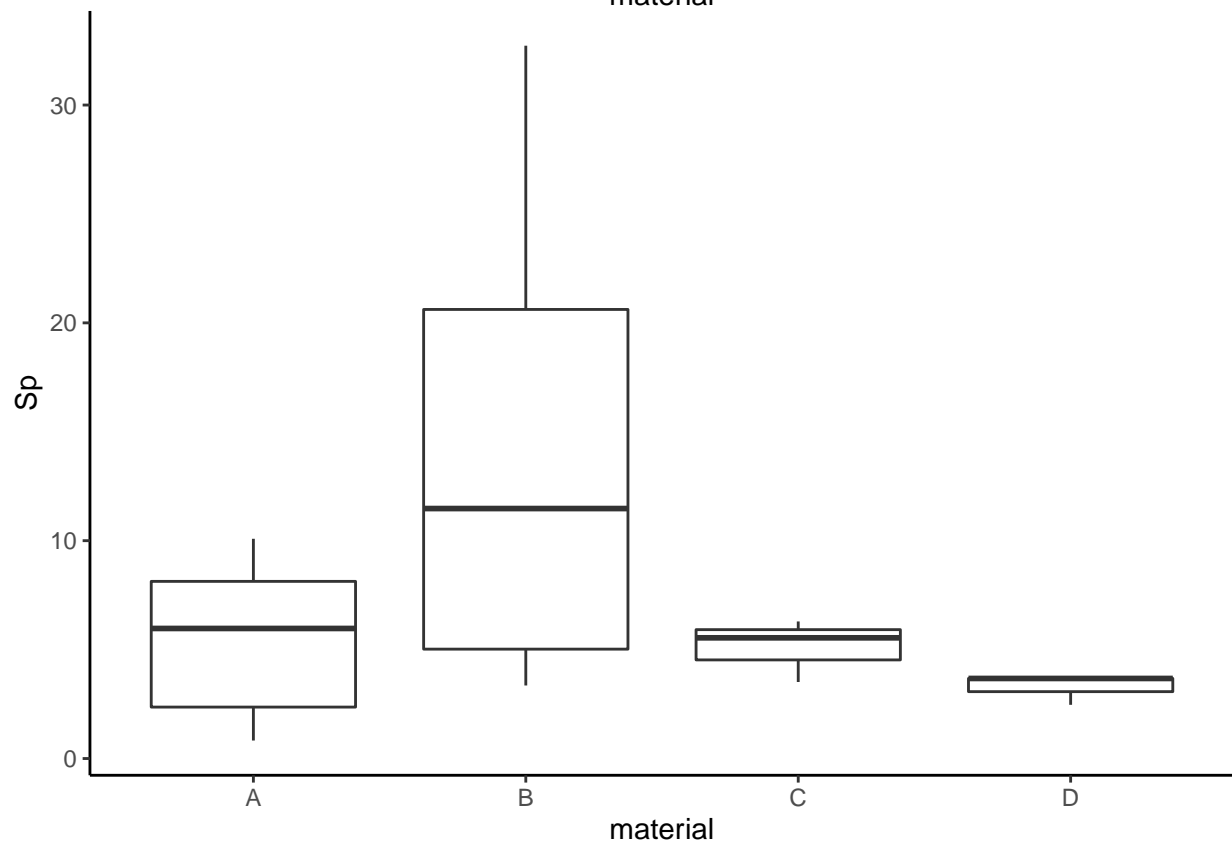
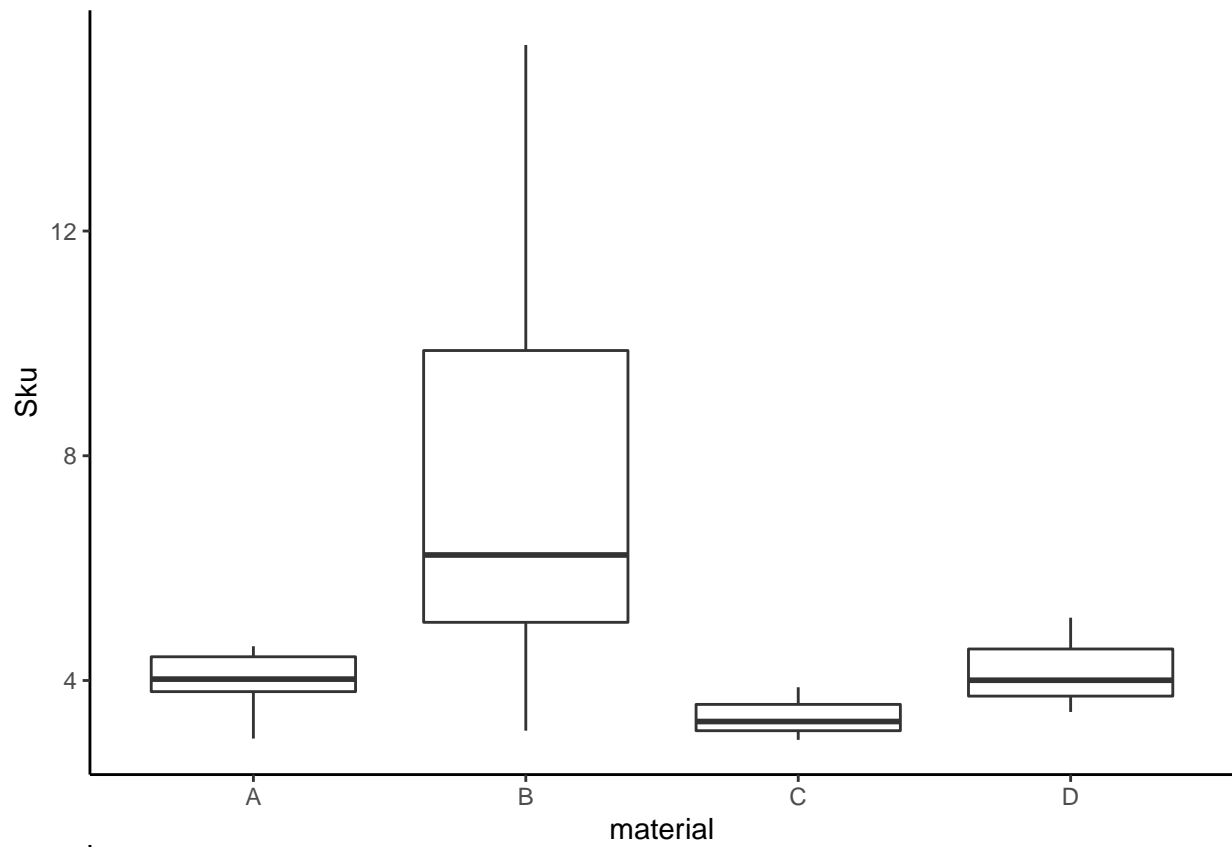
## [35] Sdr
## [36] VM
## [37] Vv
## [38] Vmp
## [39] Vmc
## [40] Vvc
## [41] Vvv
## [42] Vvv.1
## [43] Mean.depth.of.furrows
## [44] Mean.density.of.furrows
## [45] First.direction
## [46] Second.direction
## [47] Third.direction
## [48] Isotropy
## [49] Lengthscale.anisotropy.Sfrax.epLsar
## [50] Length.scale.anisotropy..NewEplsar.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

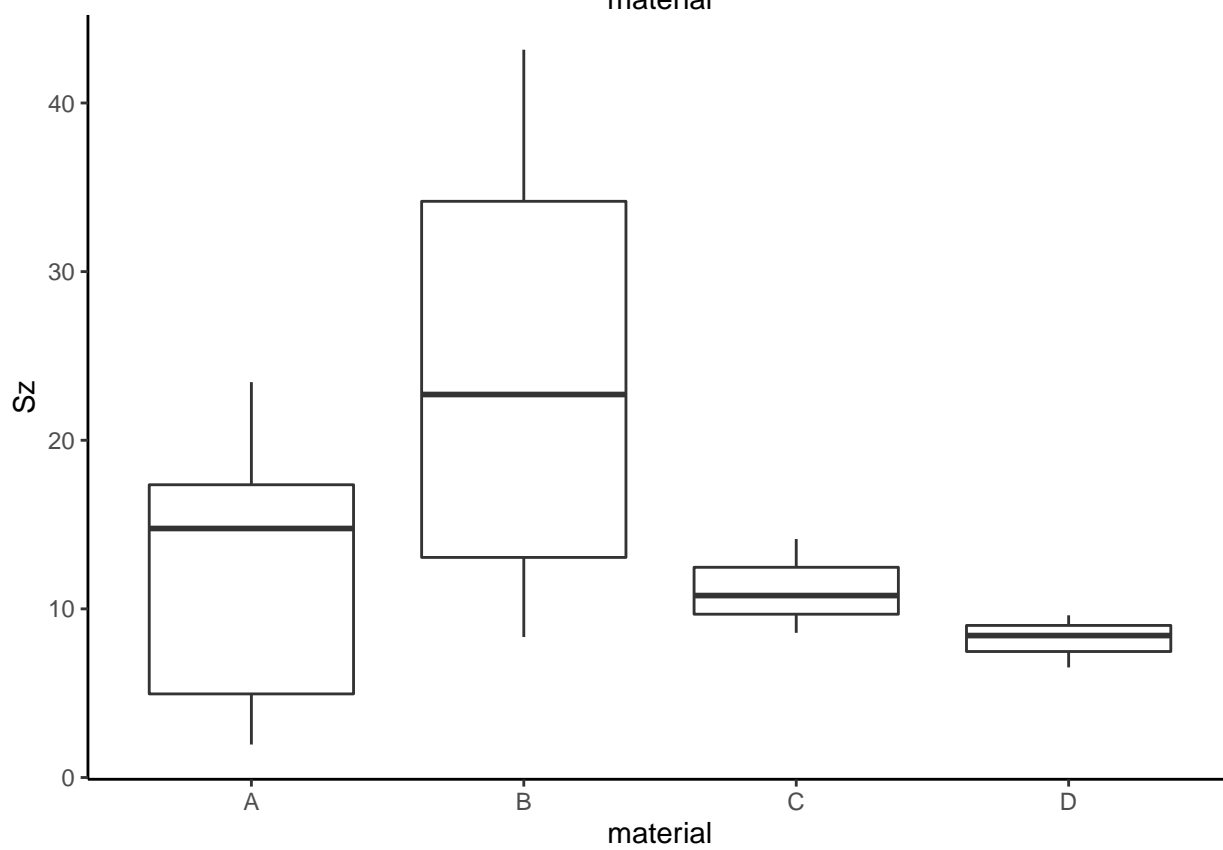
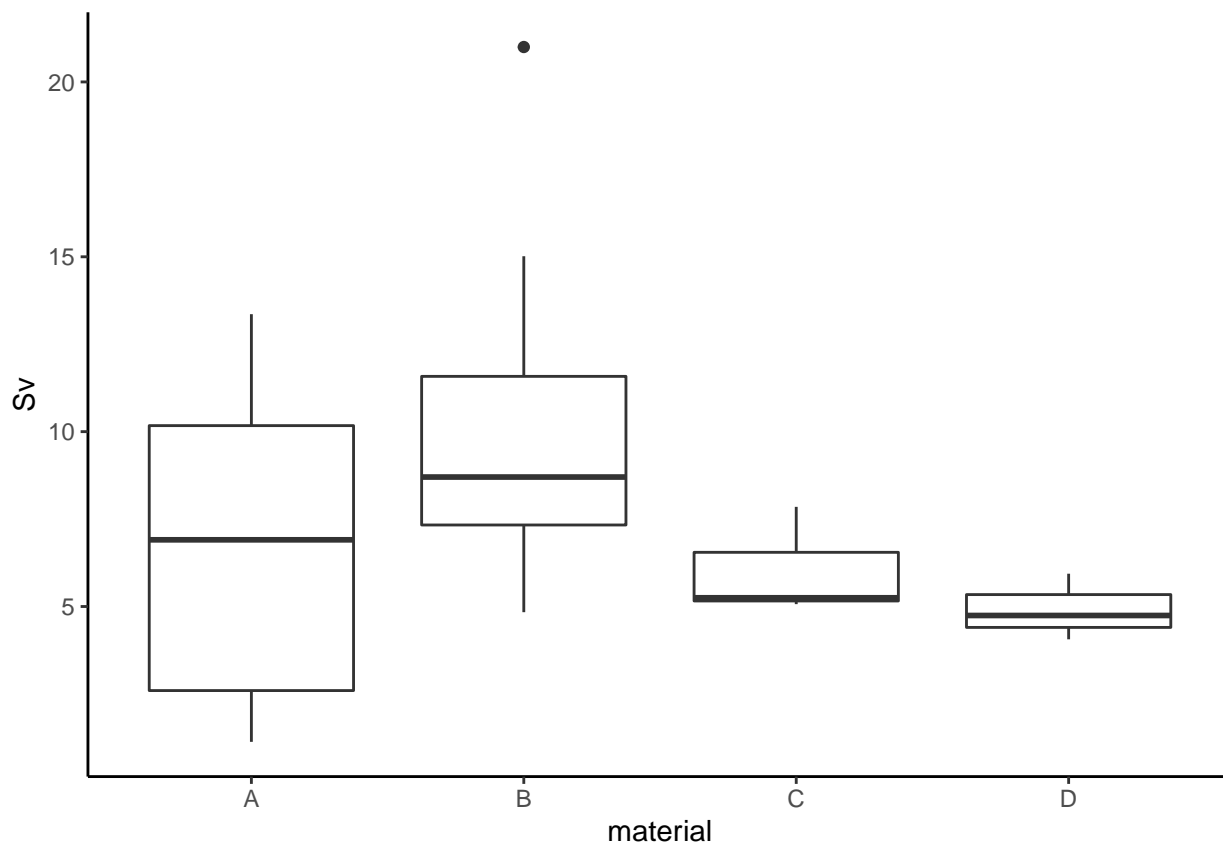
for (i in num.var) {
  p <- ggplot(data = confocaldataarch, aes_string(x = "workedmaterial", y = names(confoarch)[i])) +
    geom_boxplot() +
    # geom_line(aes(group = motion)) +
    theme_classic() +
    # facet_wrap(~ sample) +
    labs(x = "material", y = gsub("\\.", " ", names(confoarch)[i])) +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

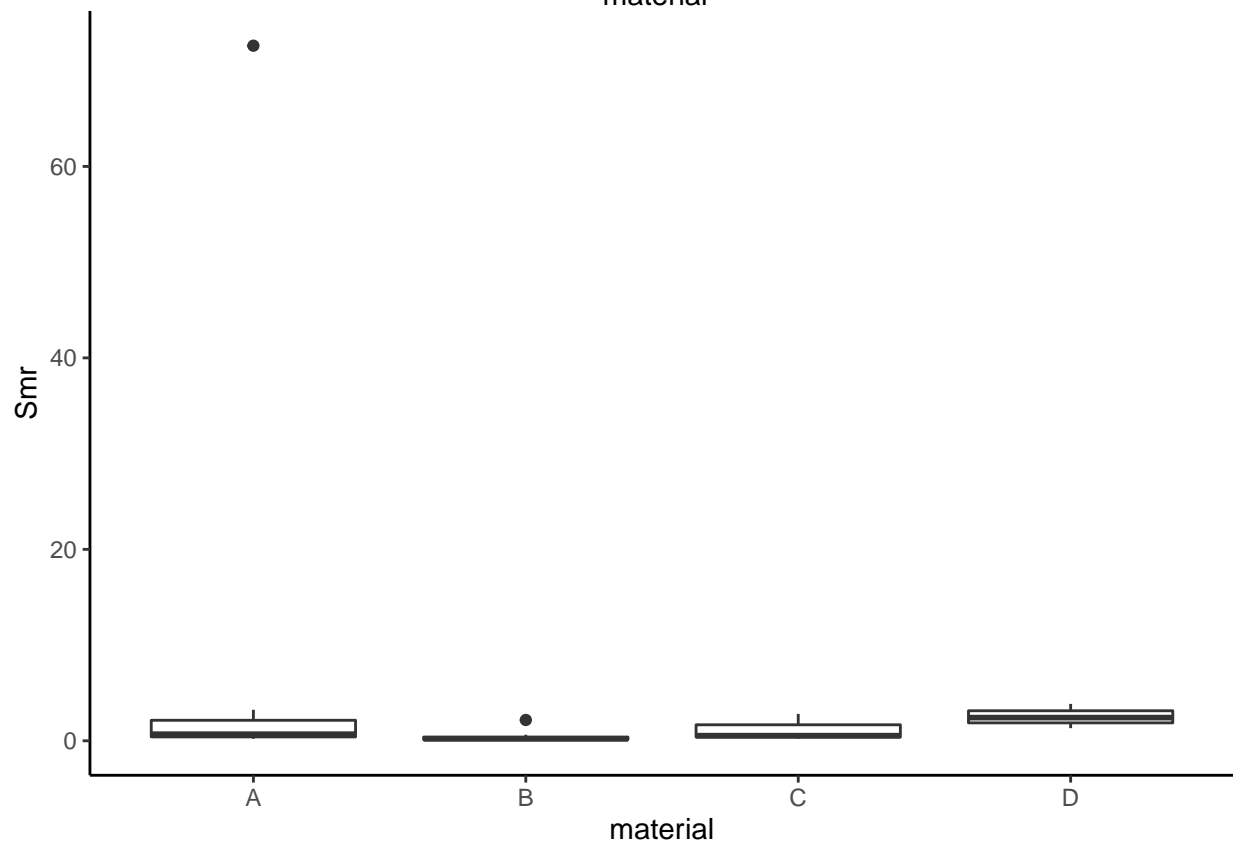
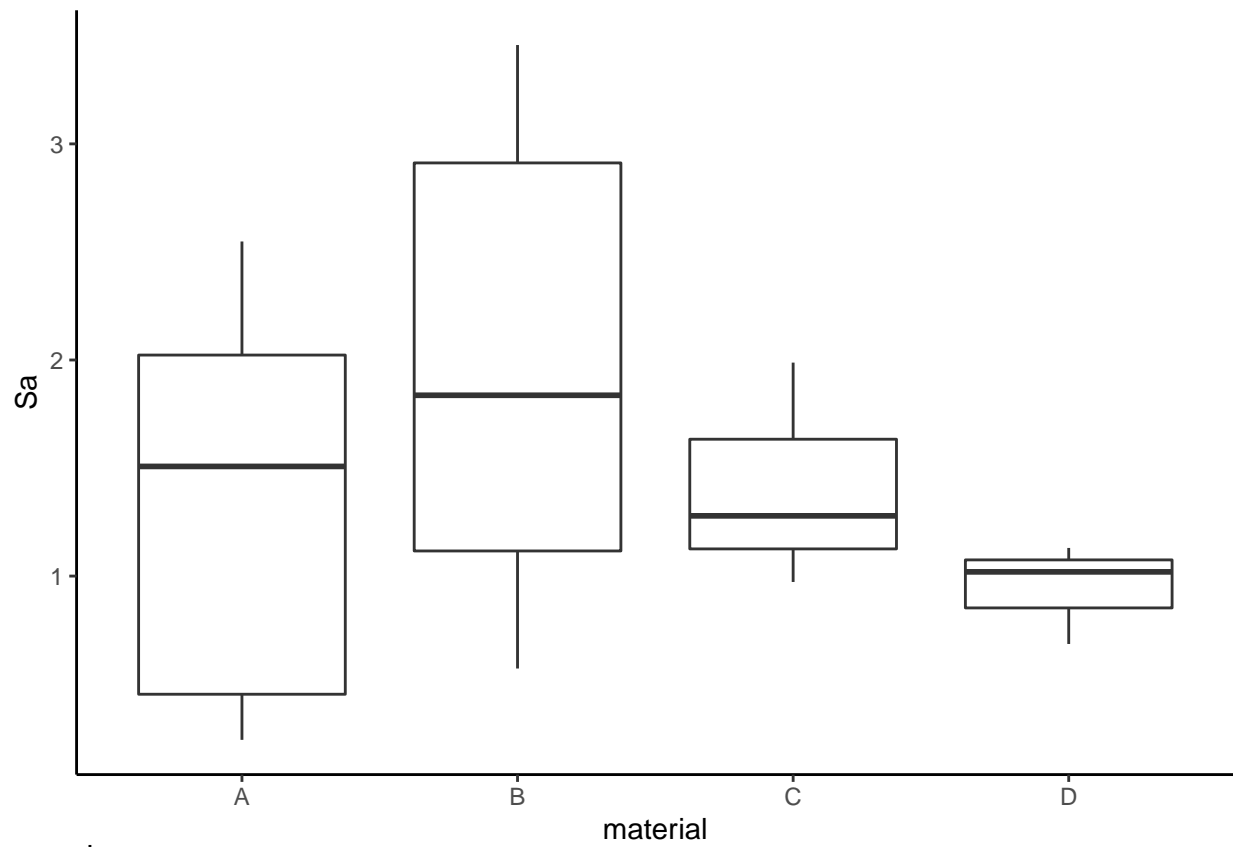
  # saves the plots
  file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_plot_",
                     names(confoarch)[i], ".pdf")
  ggsave(filename = file_out, plot = p, path = "../plots", device = "pdf", width = 26,
          height = 21, units = "cm" )
}

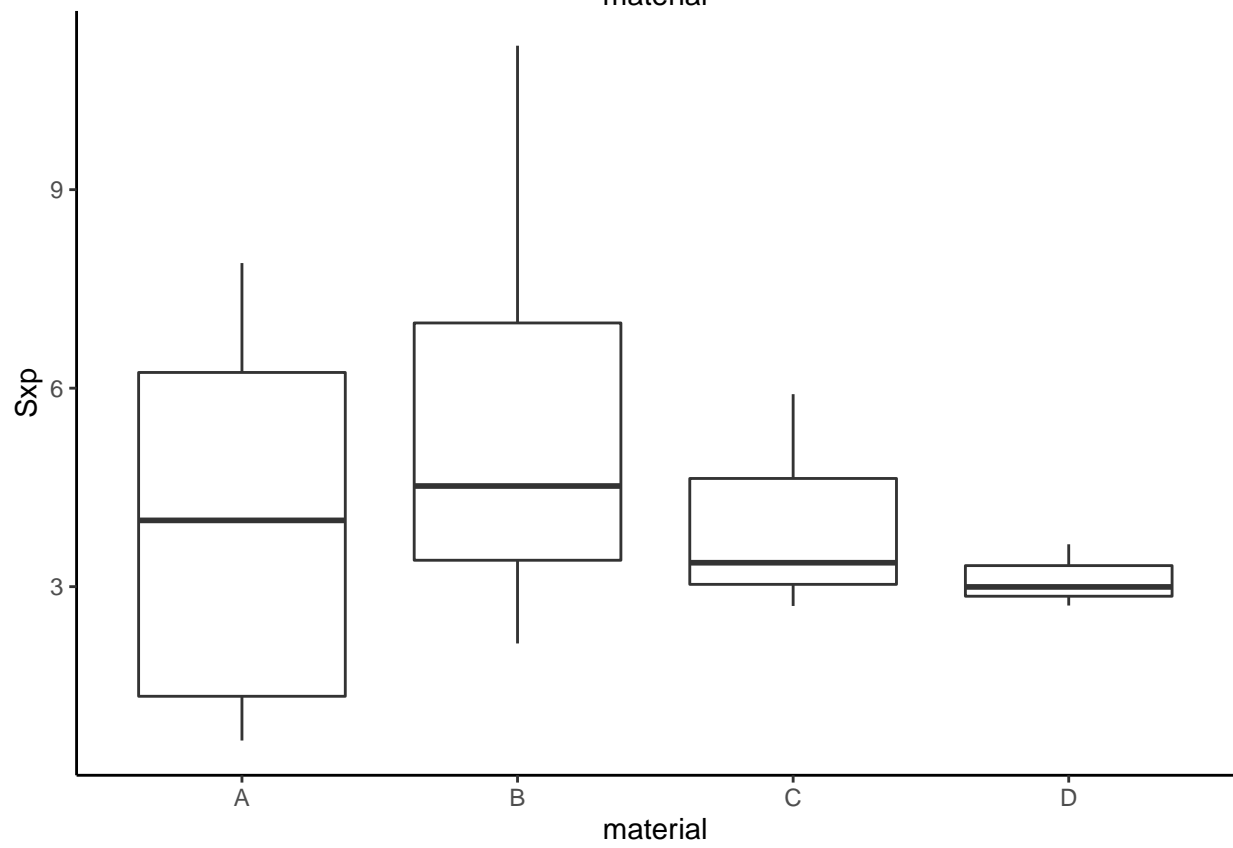
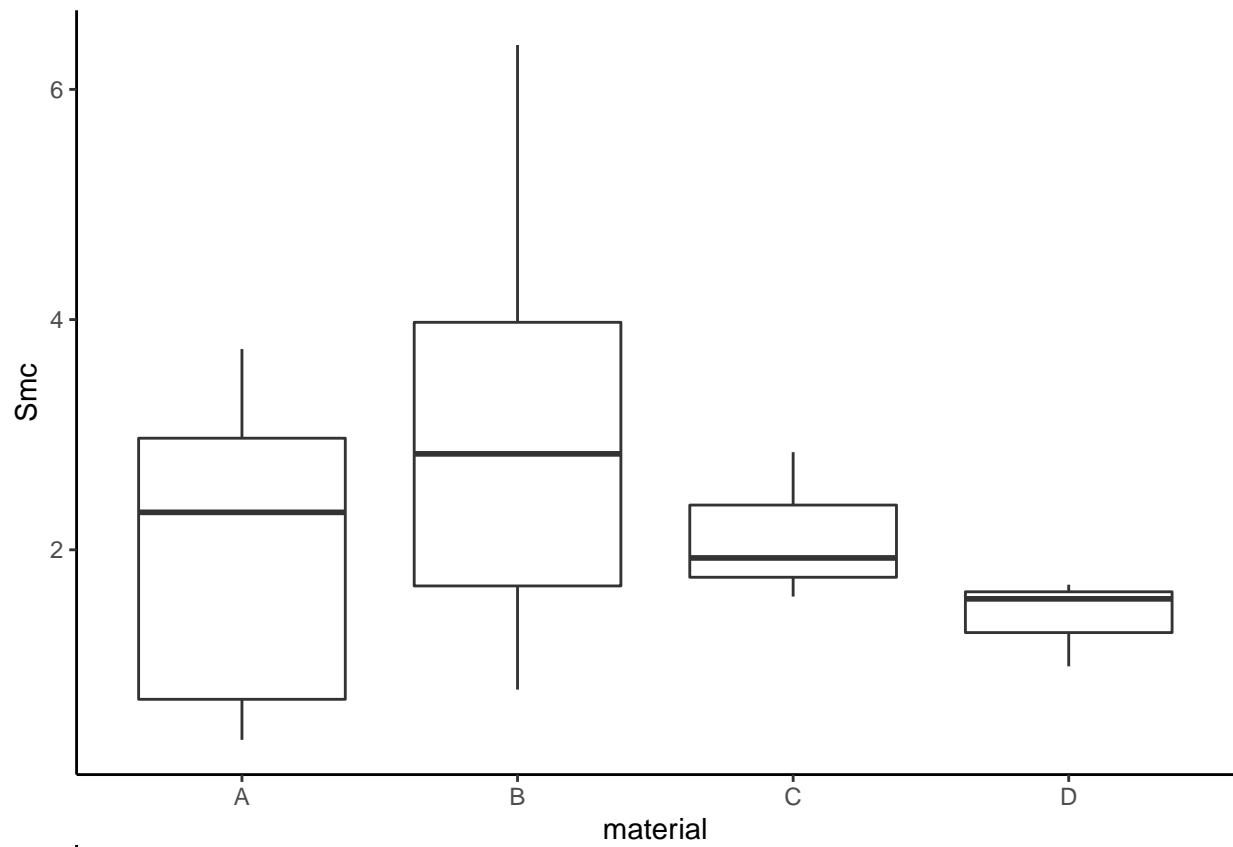
```

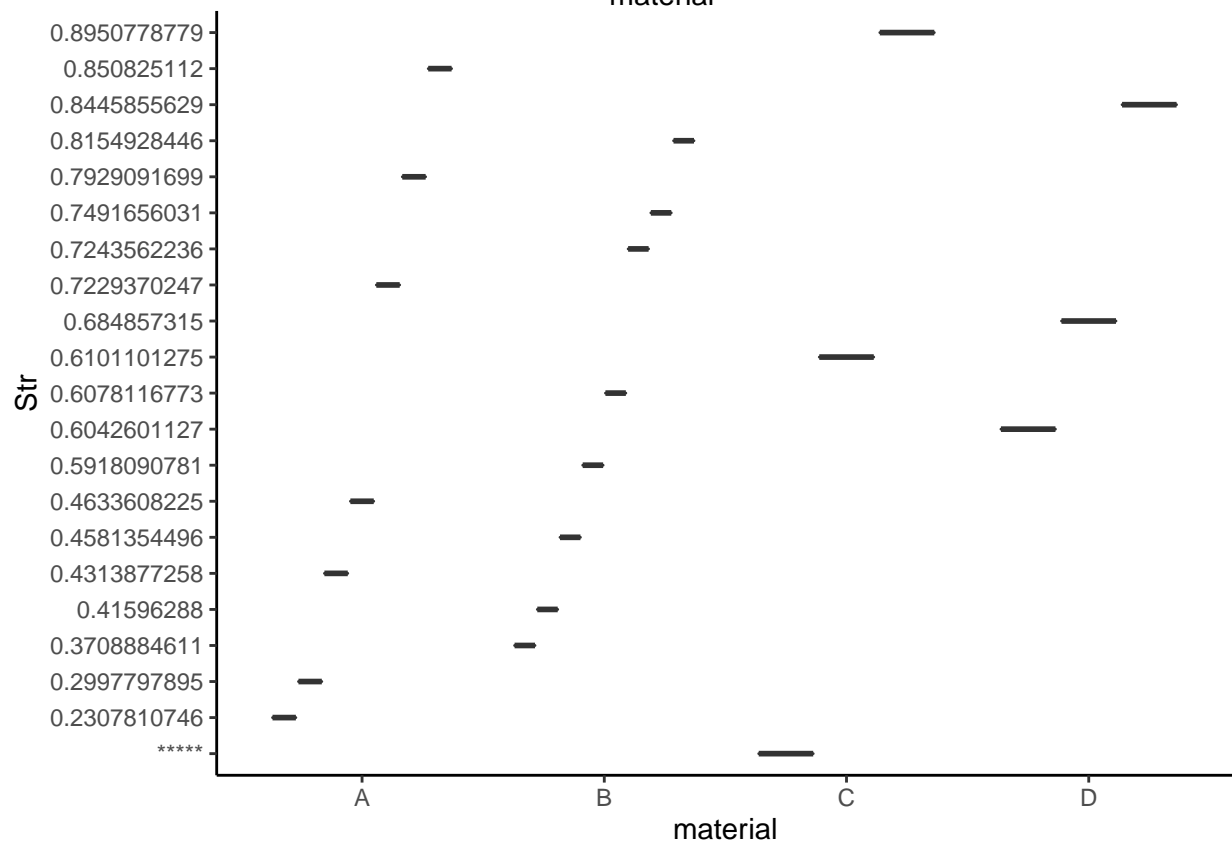
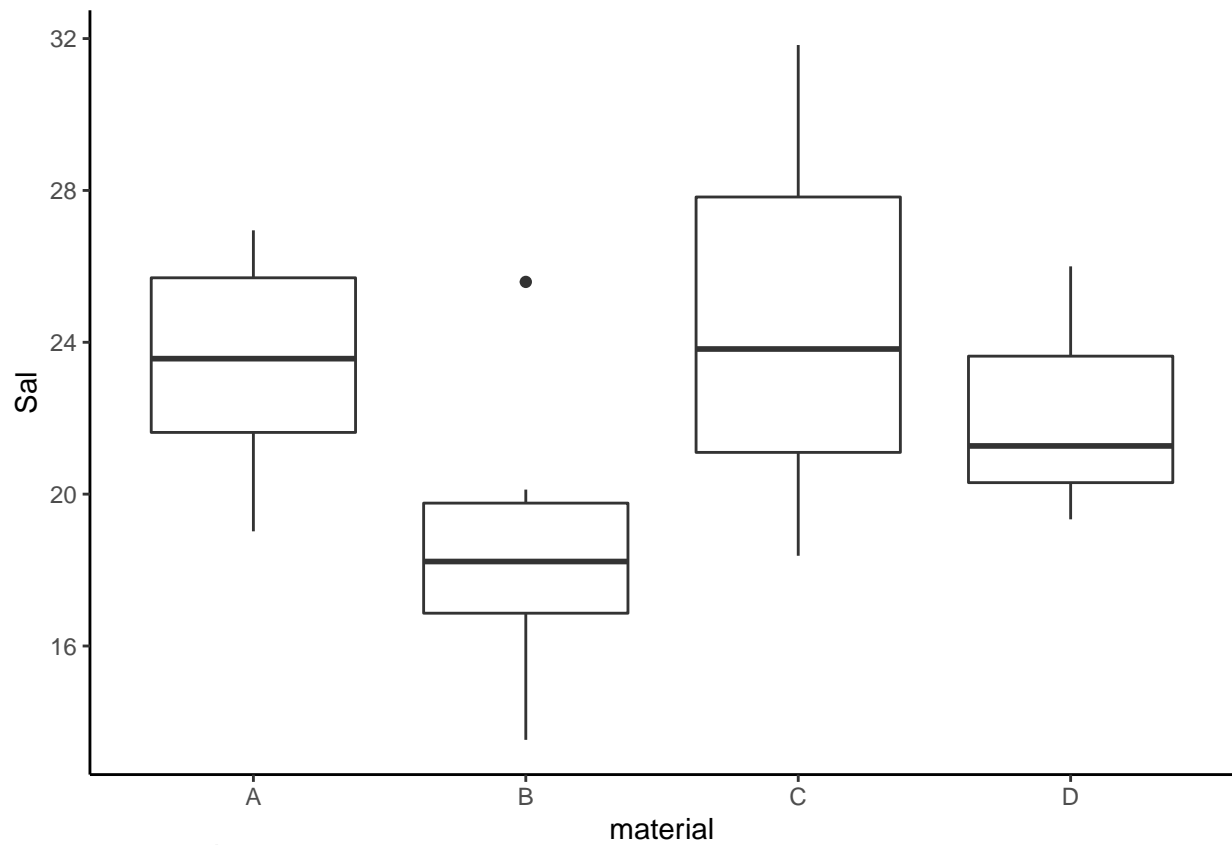


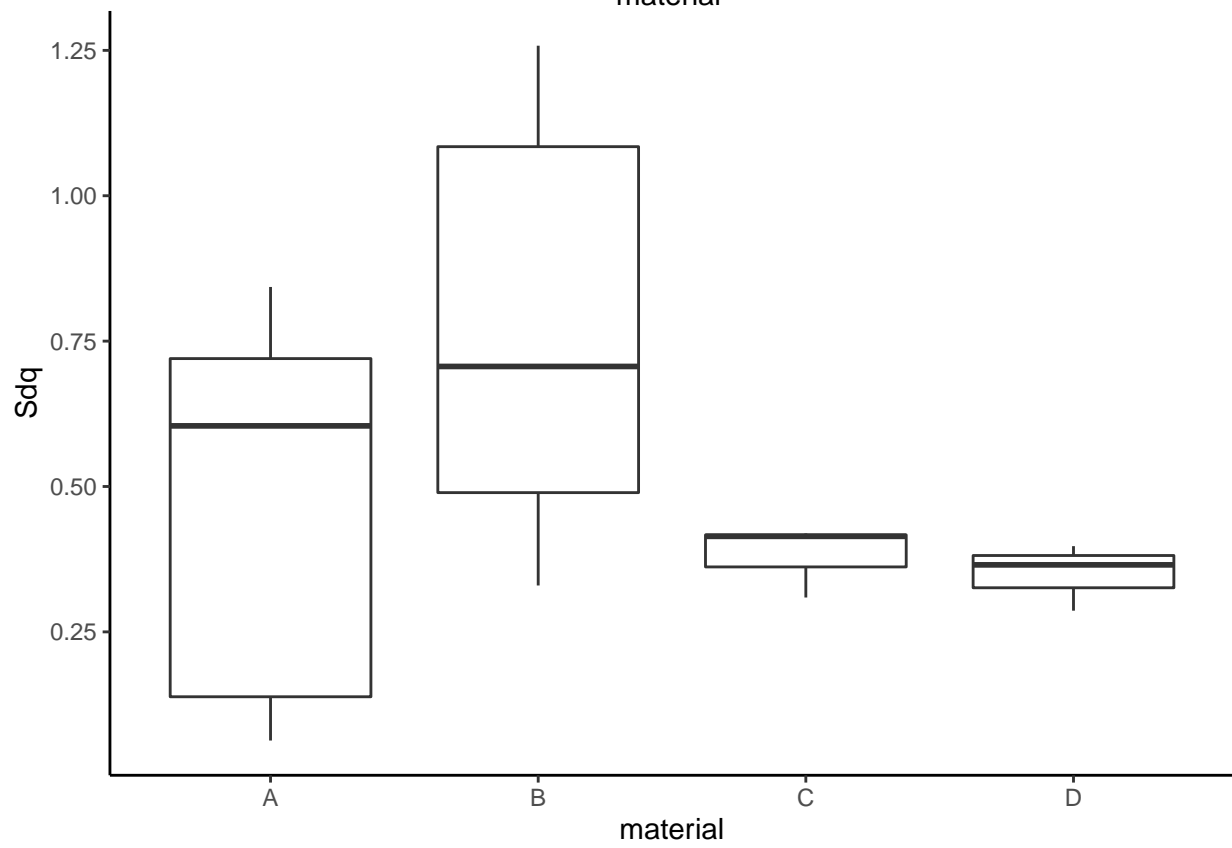
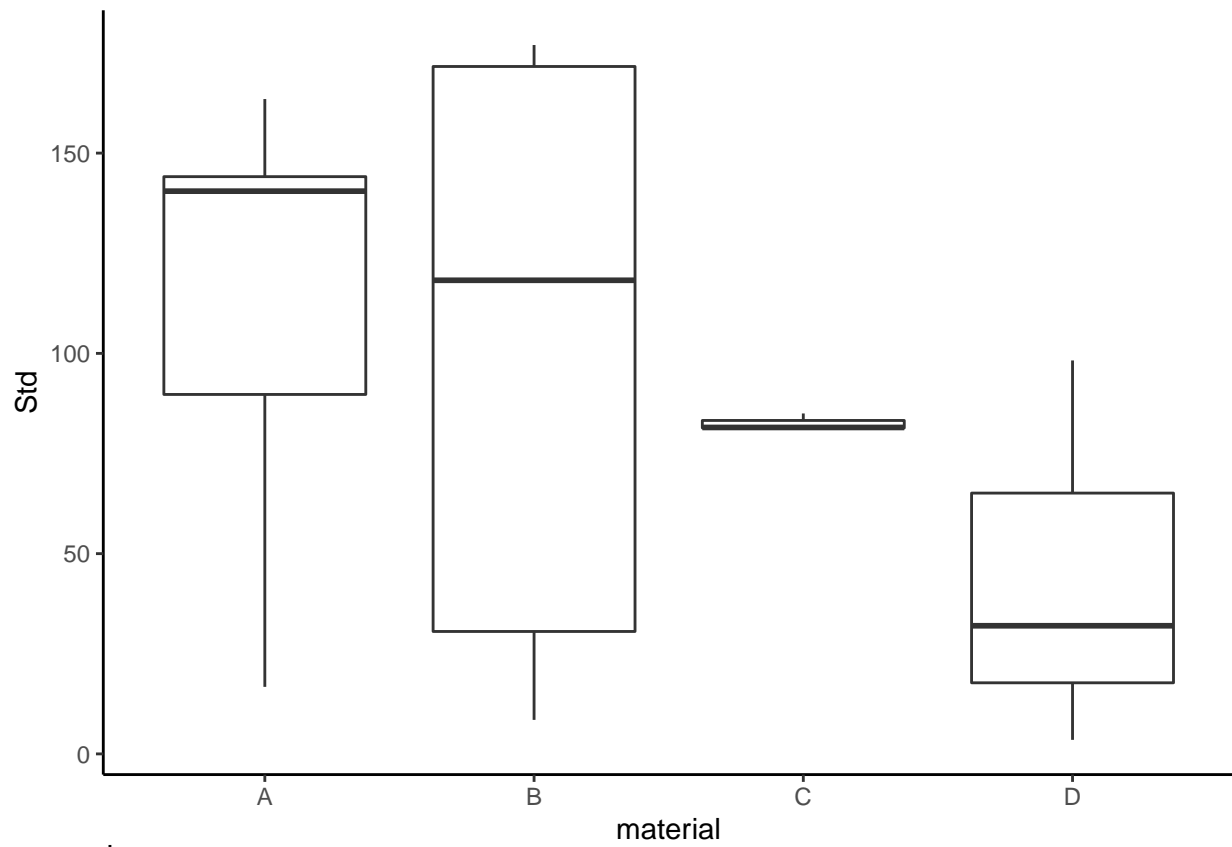


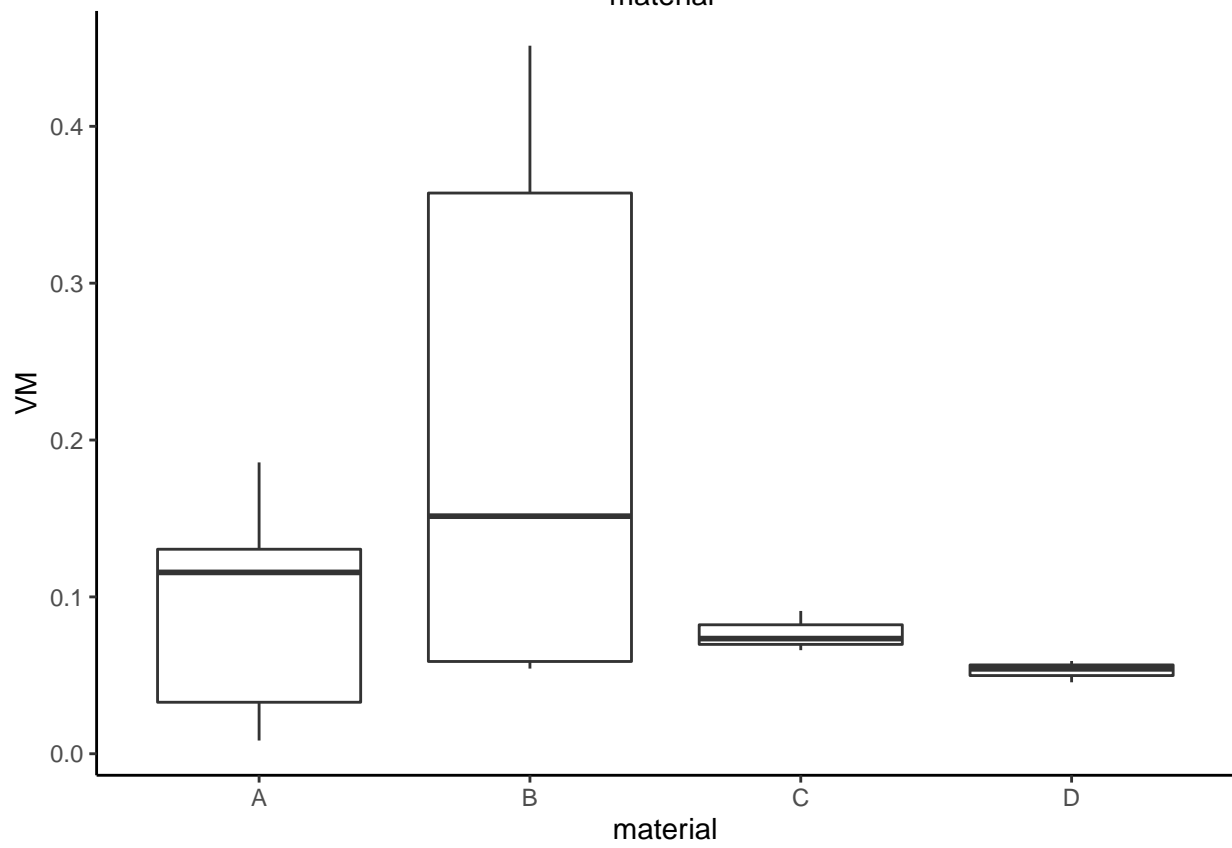
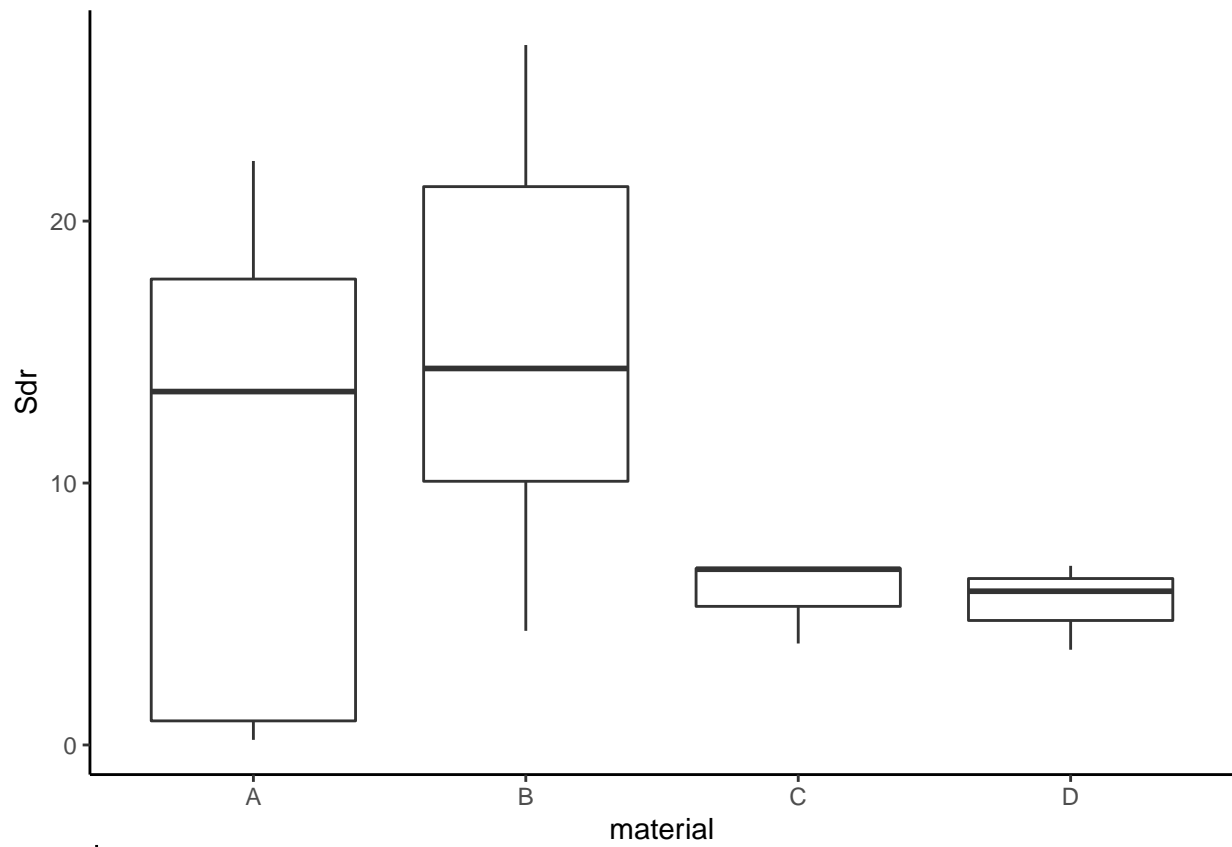


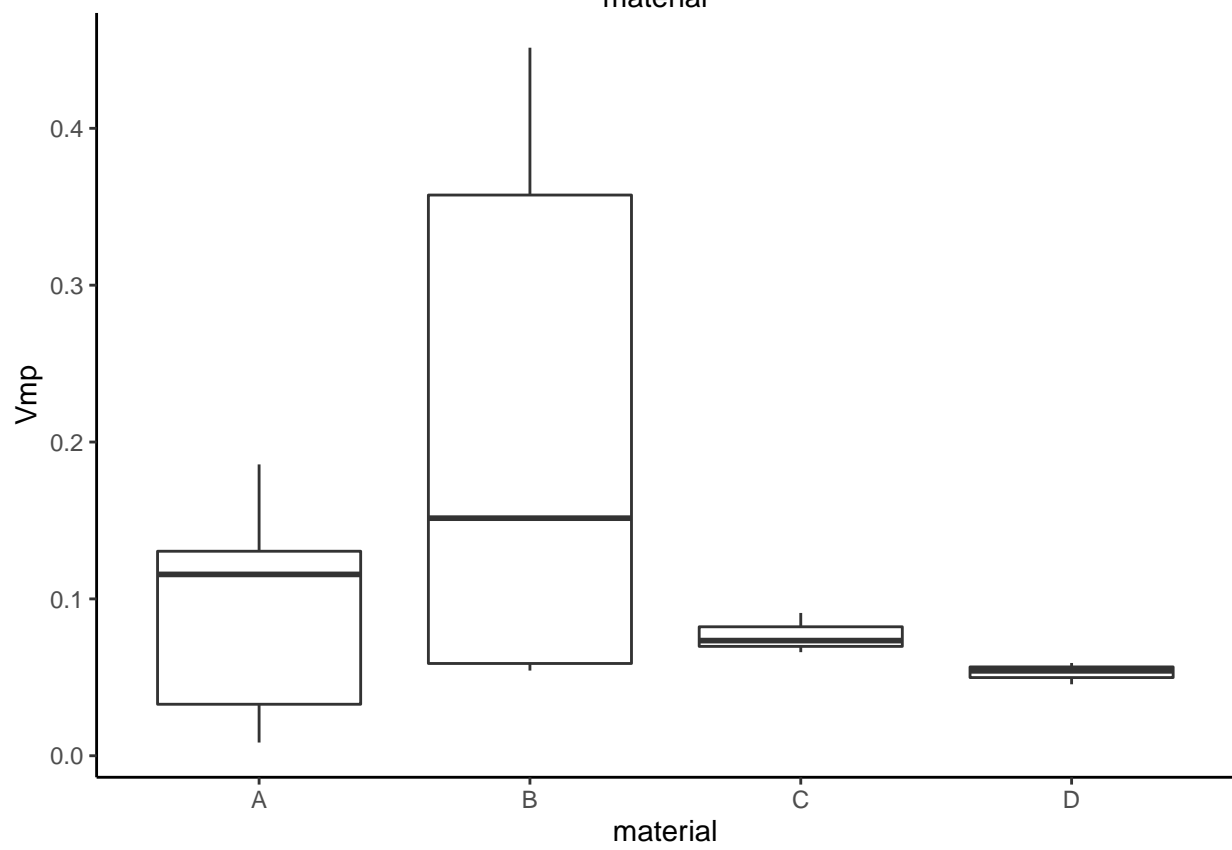
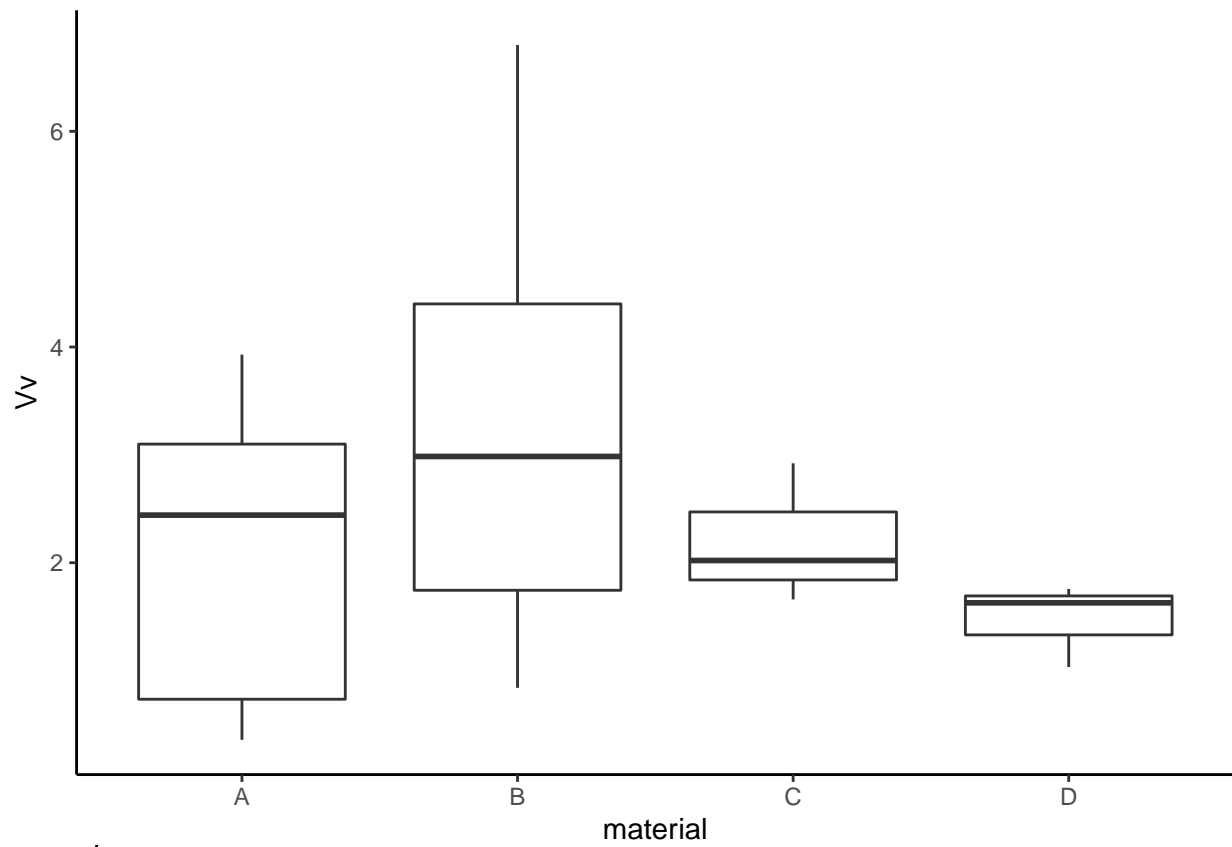


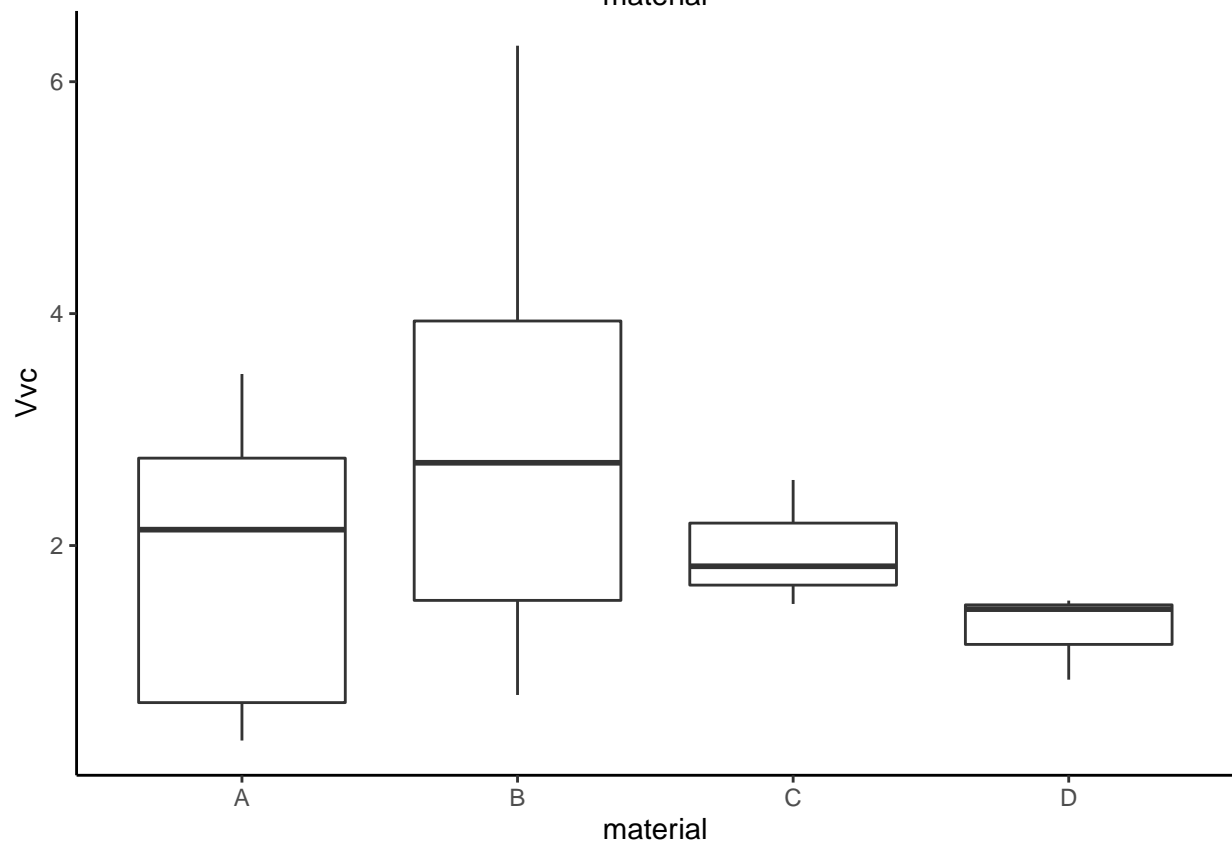
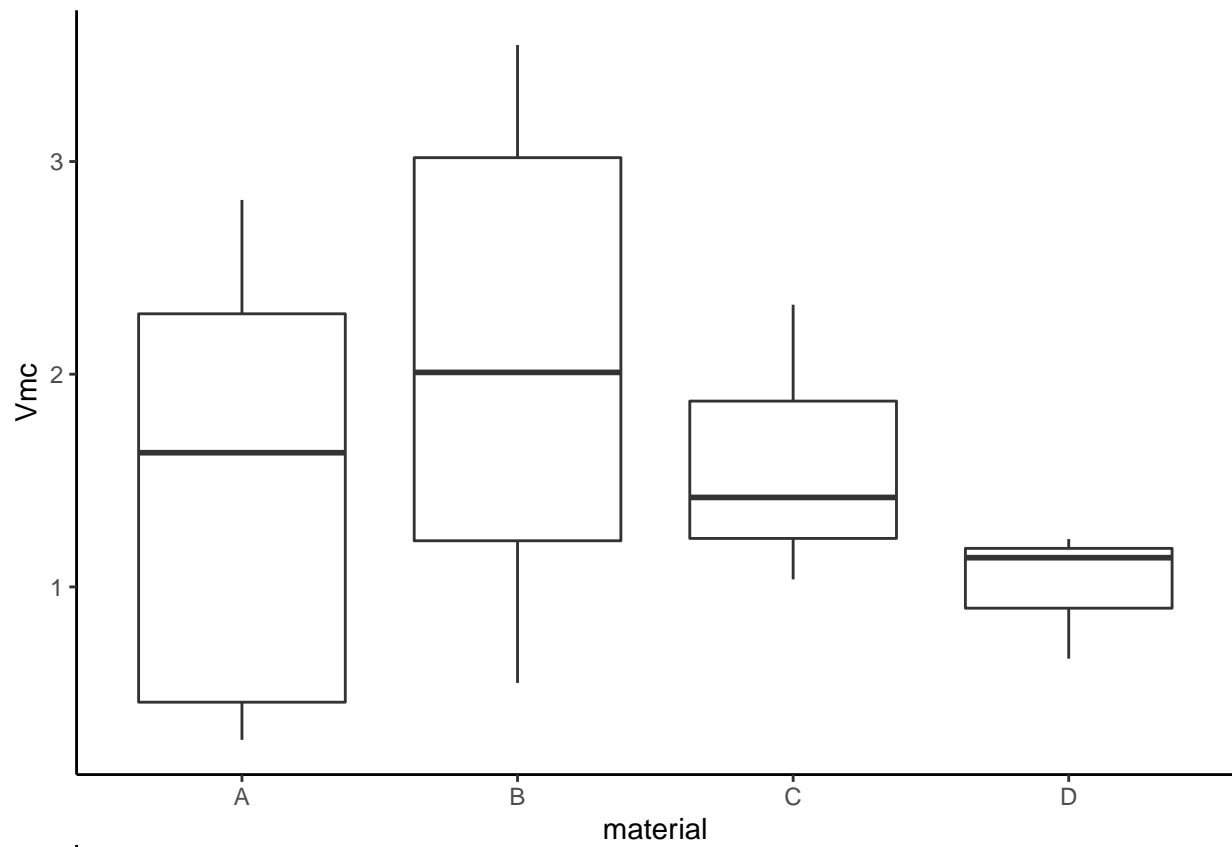


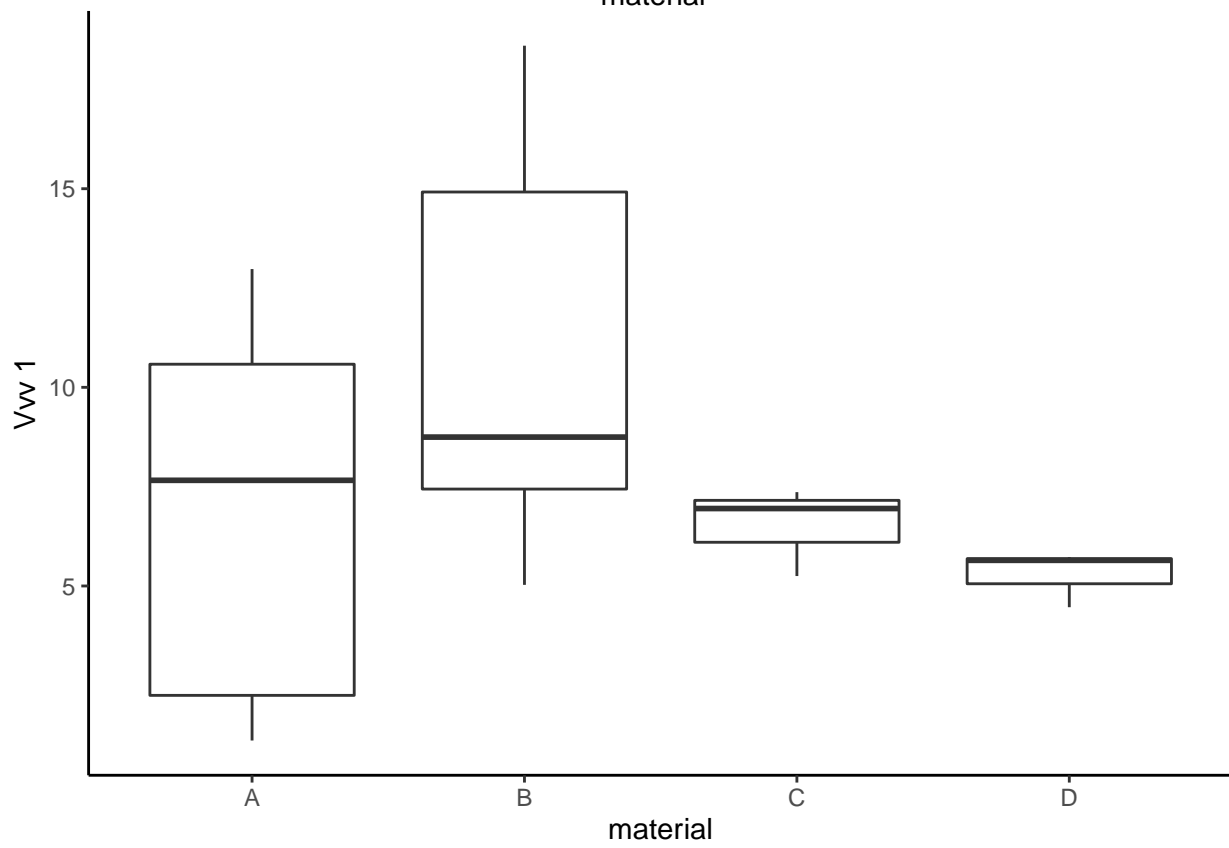
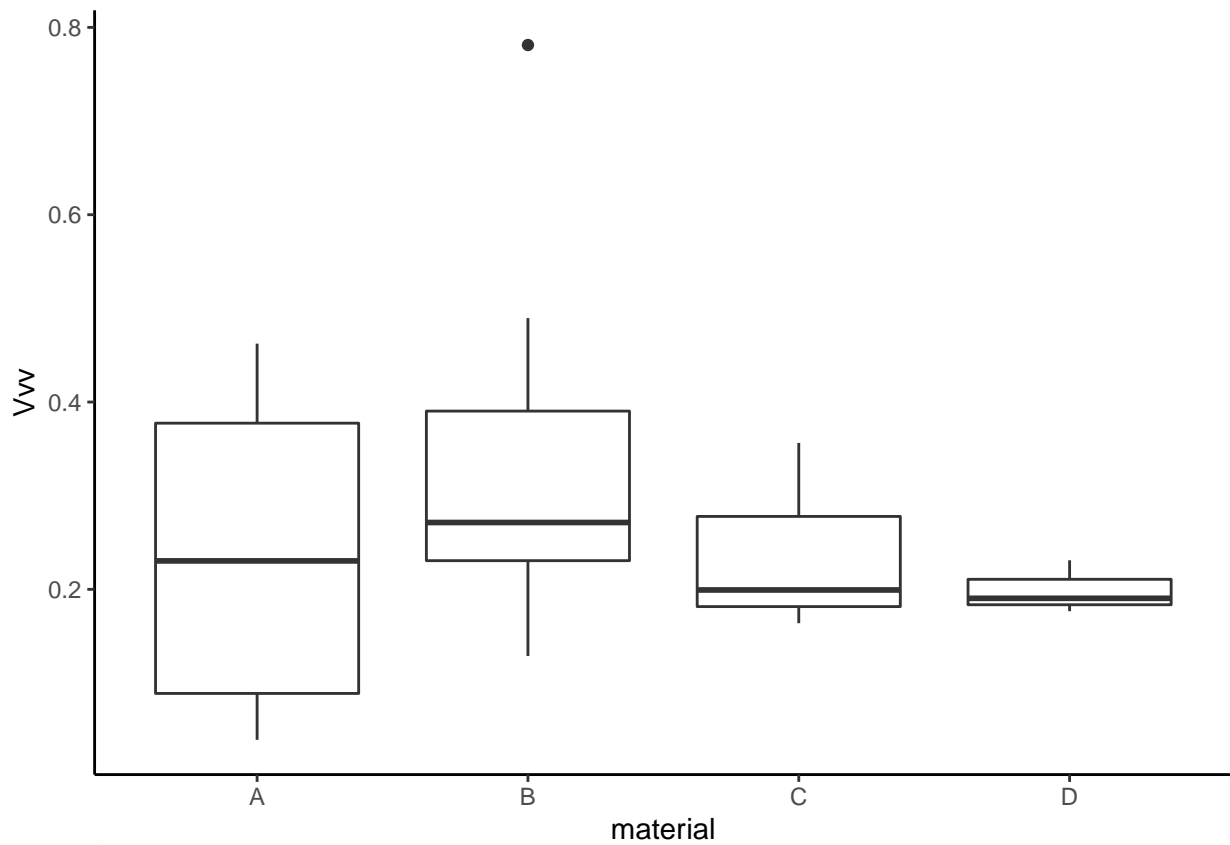


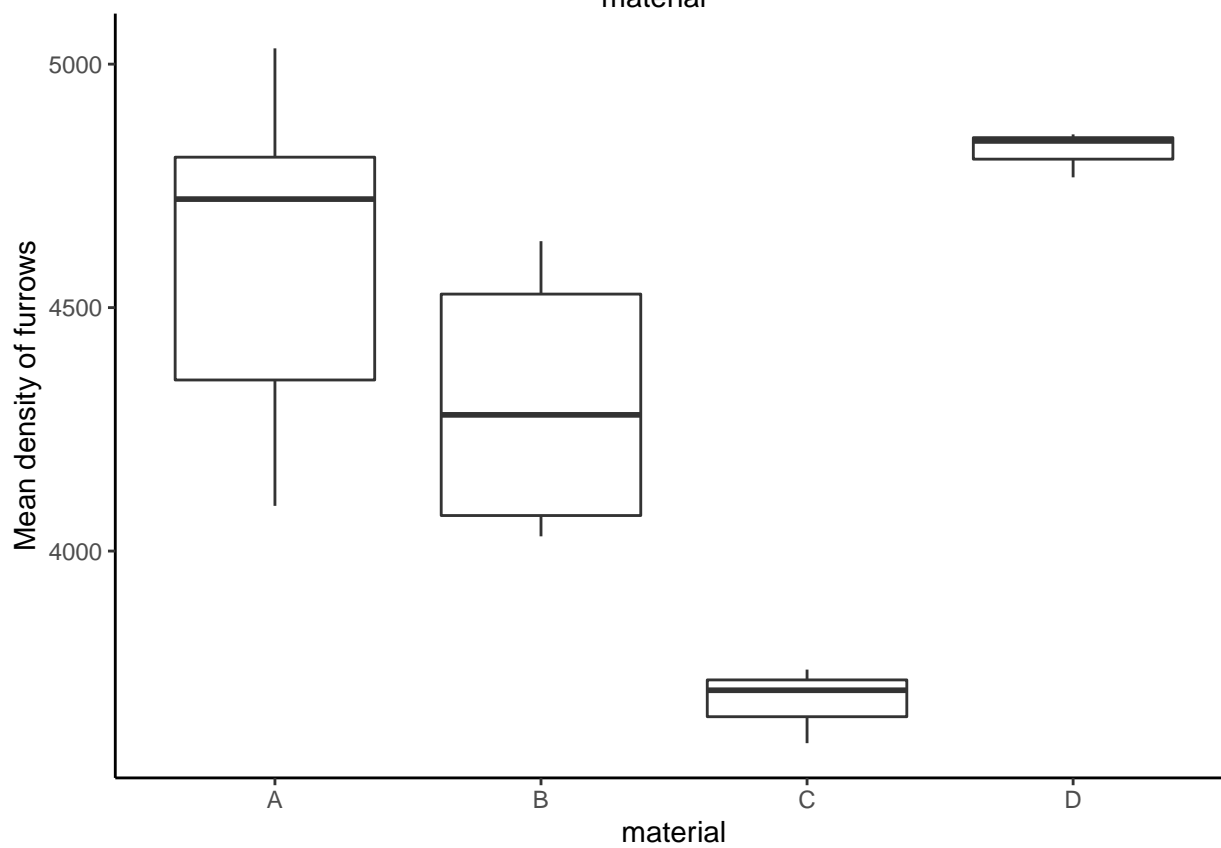
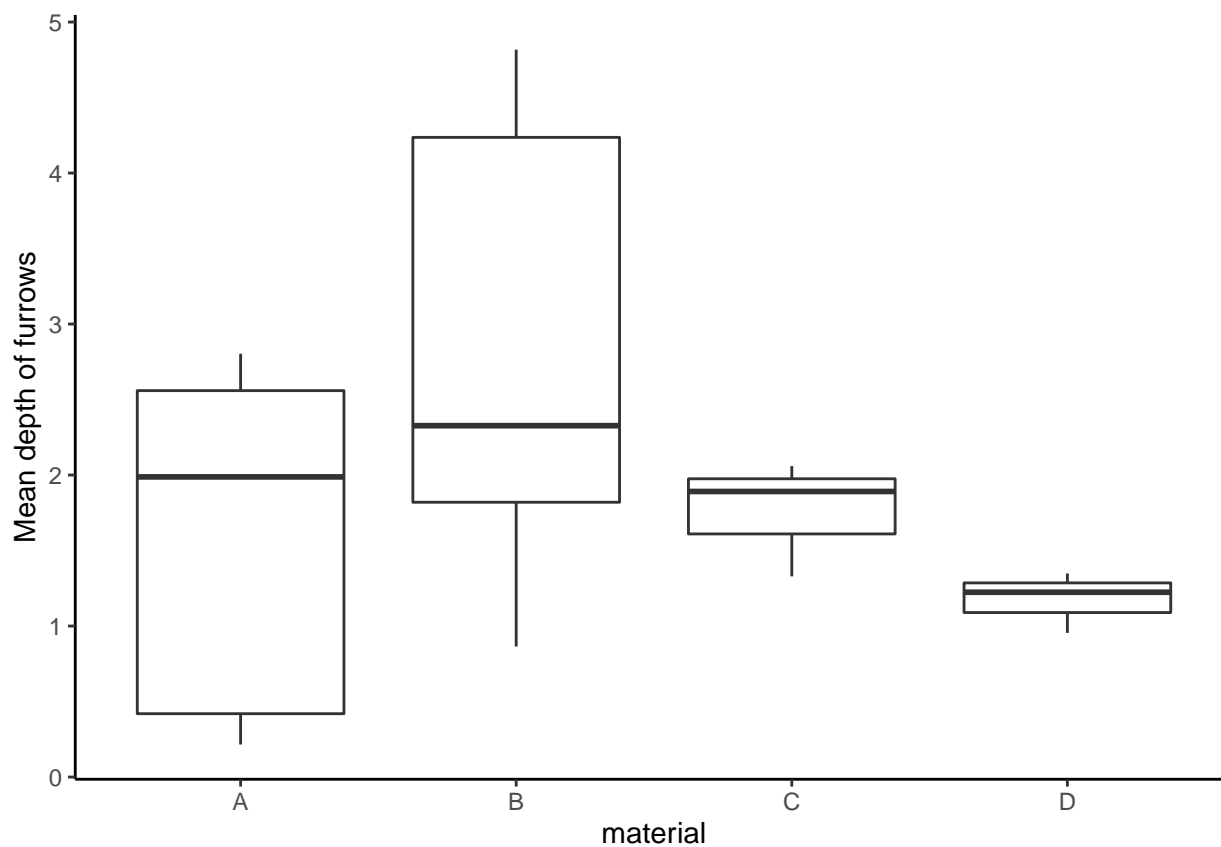


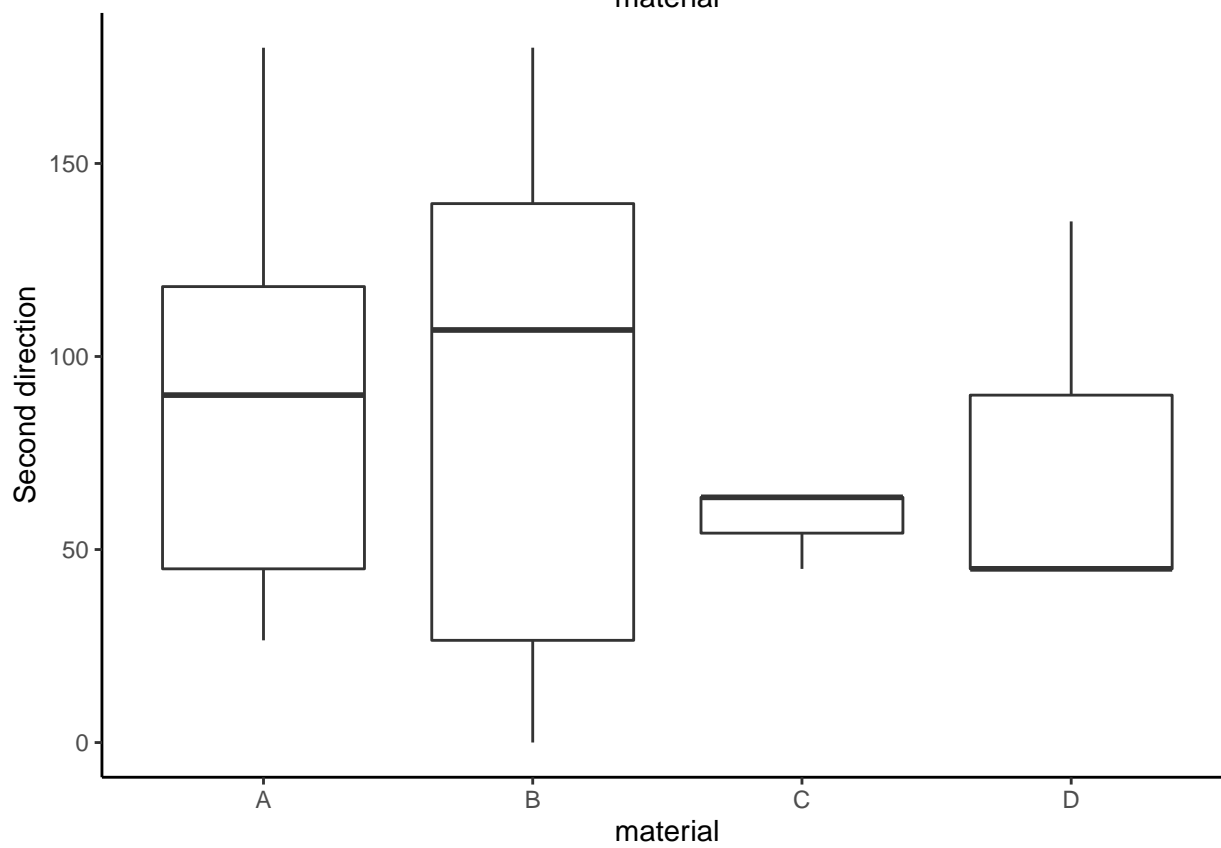
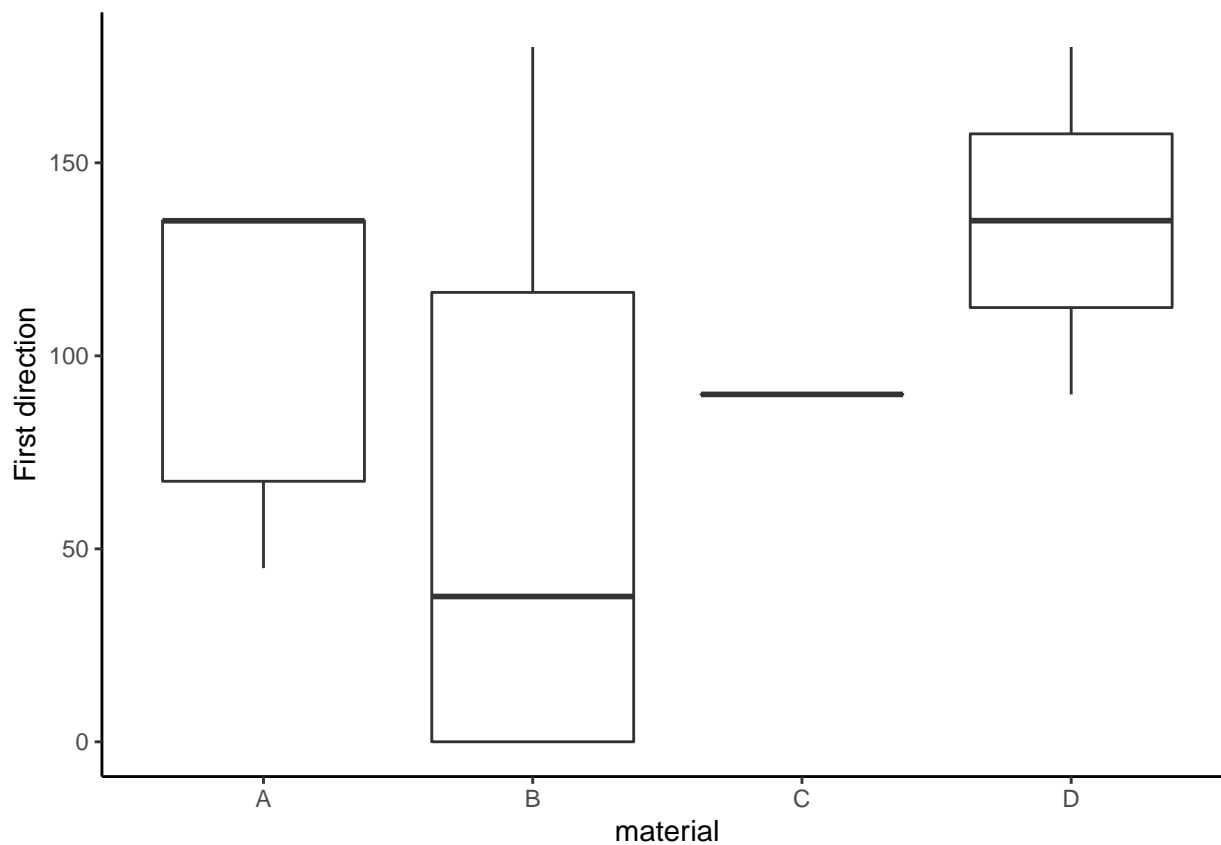


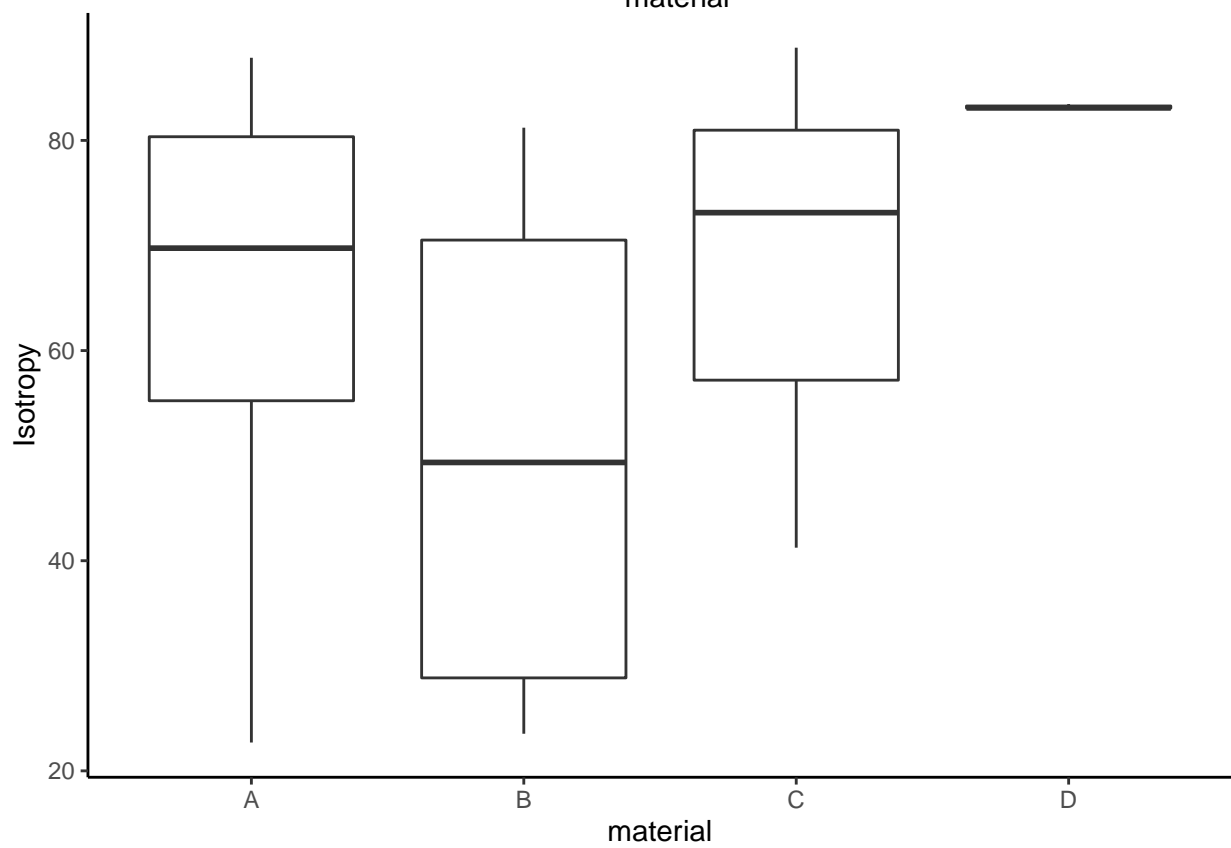
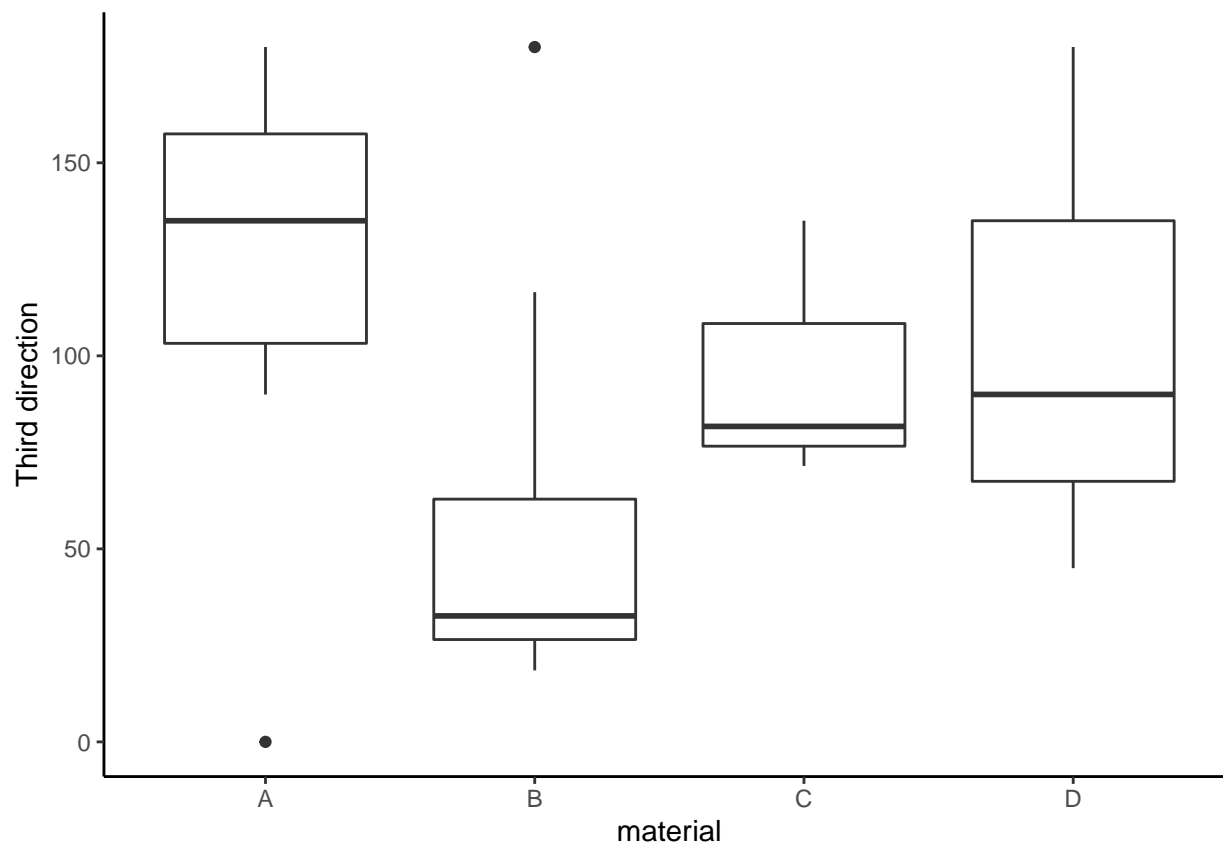


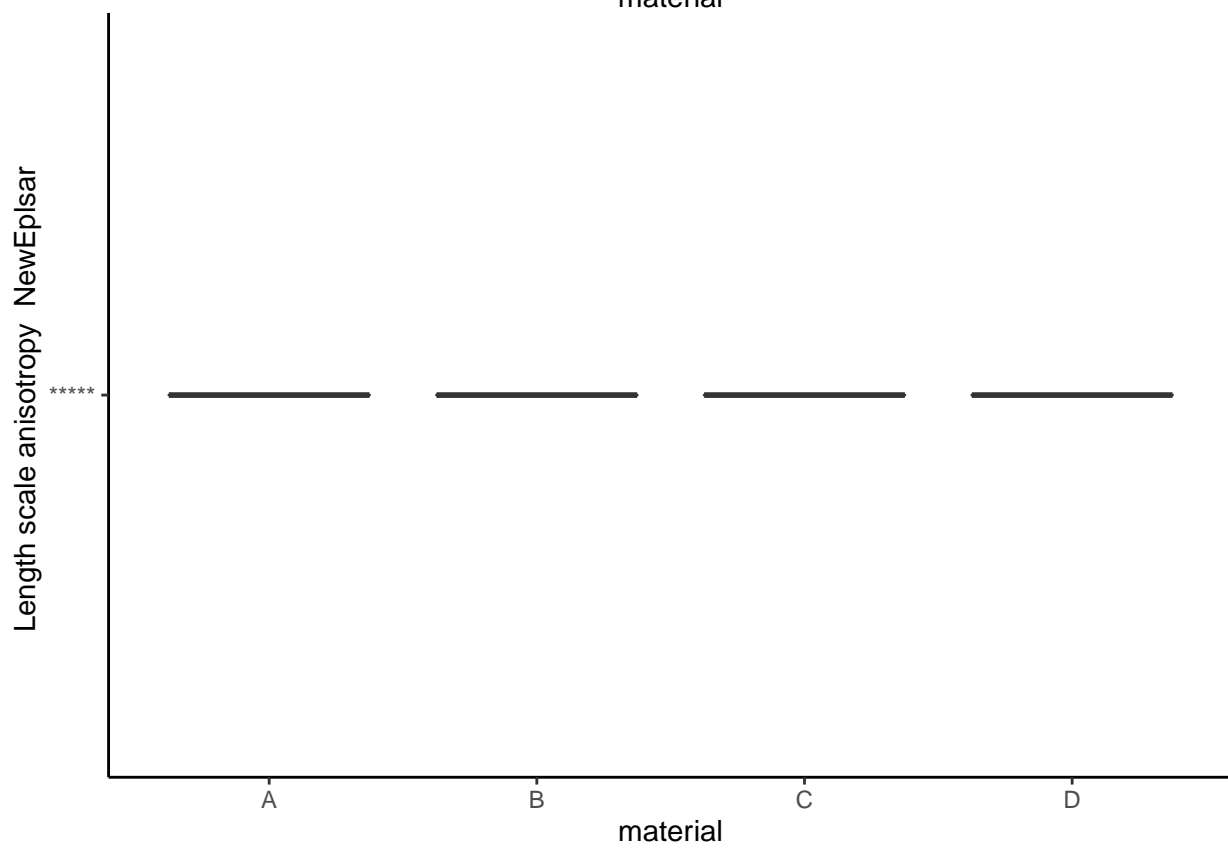
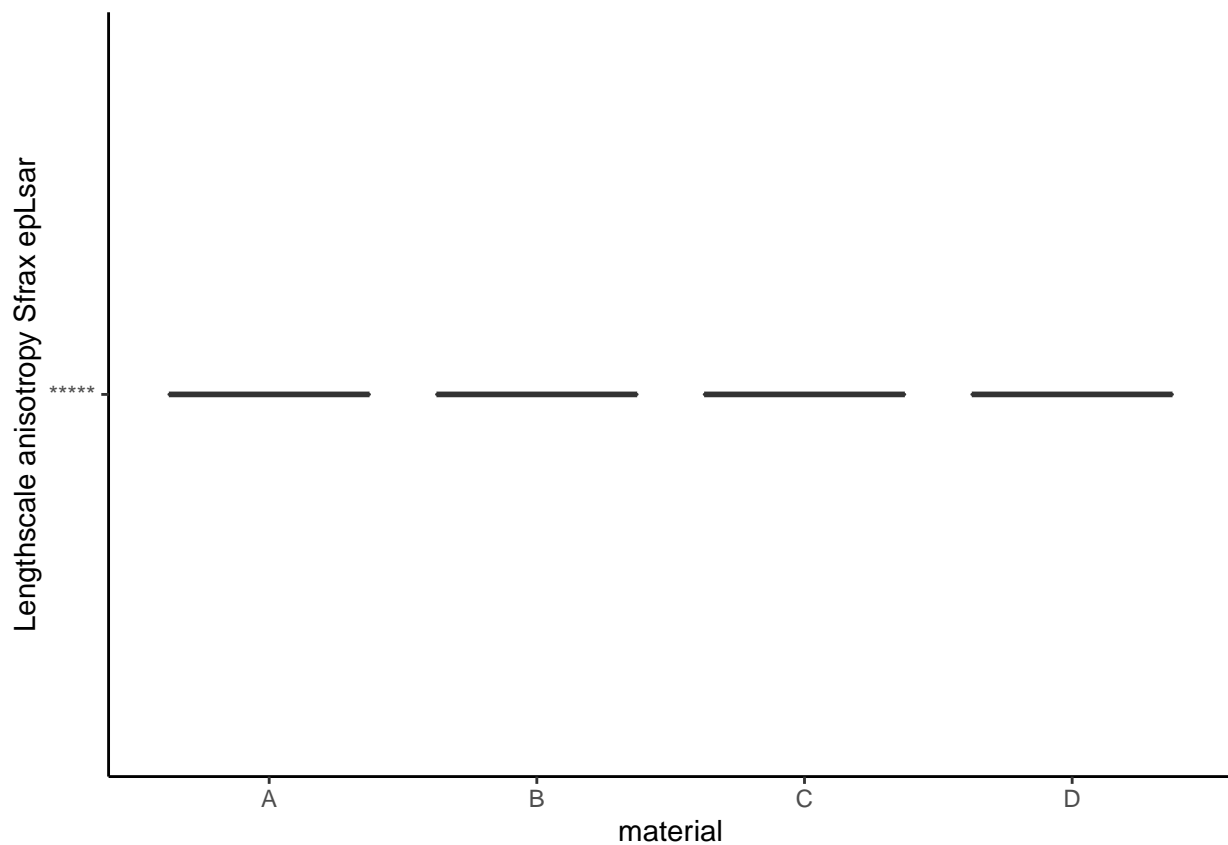


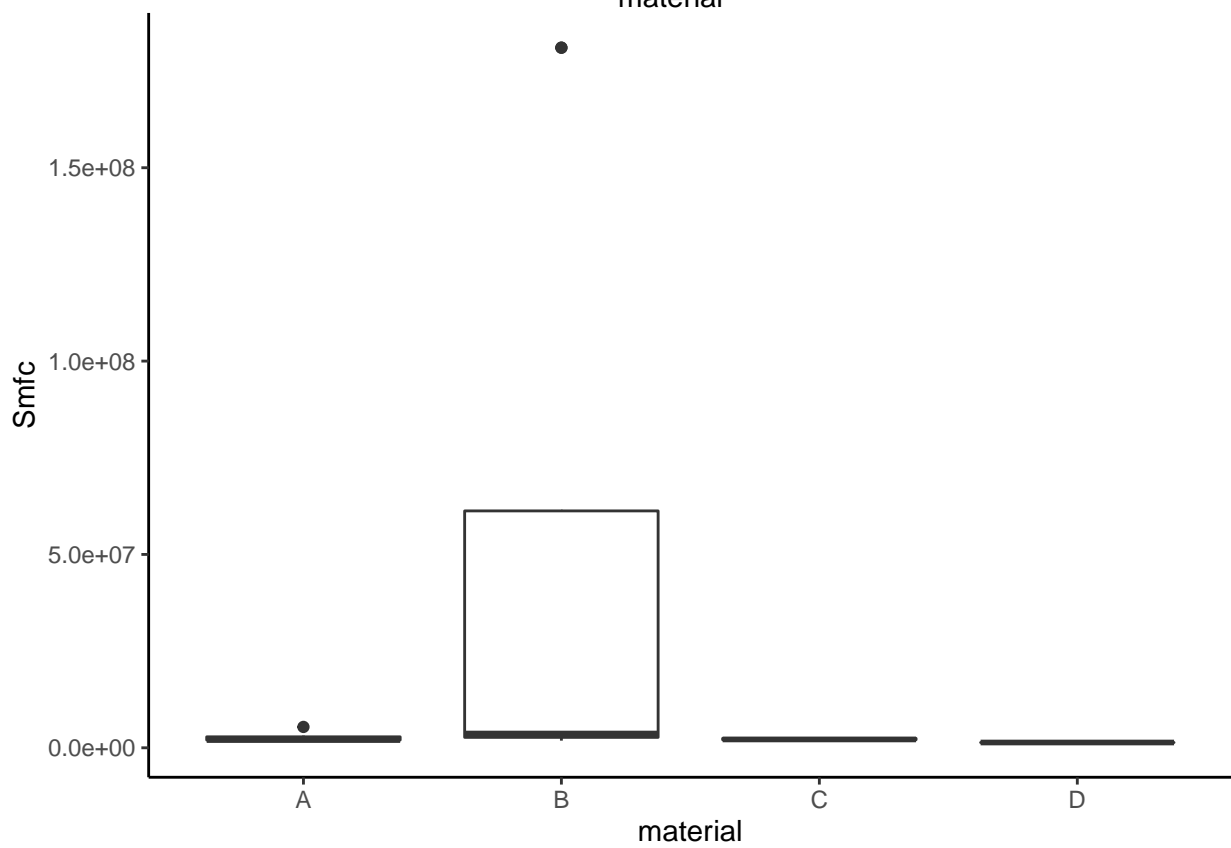
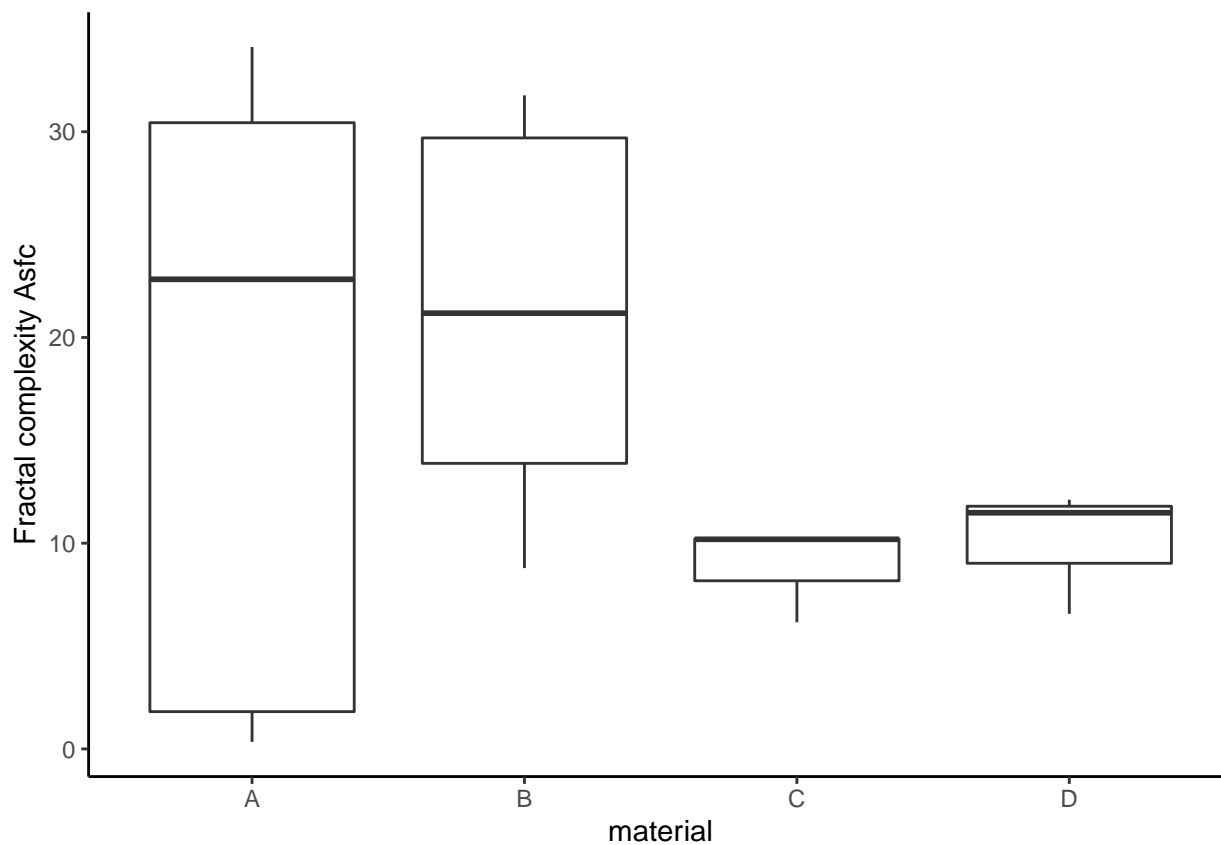


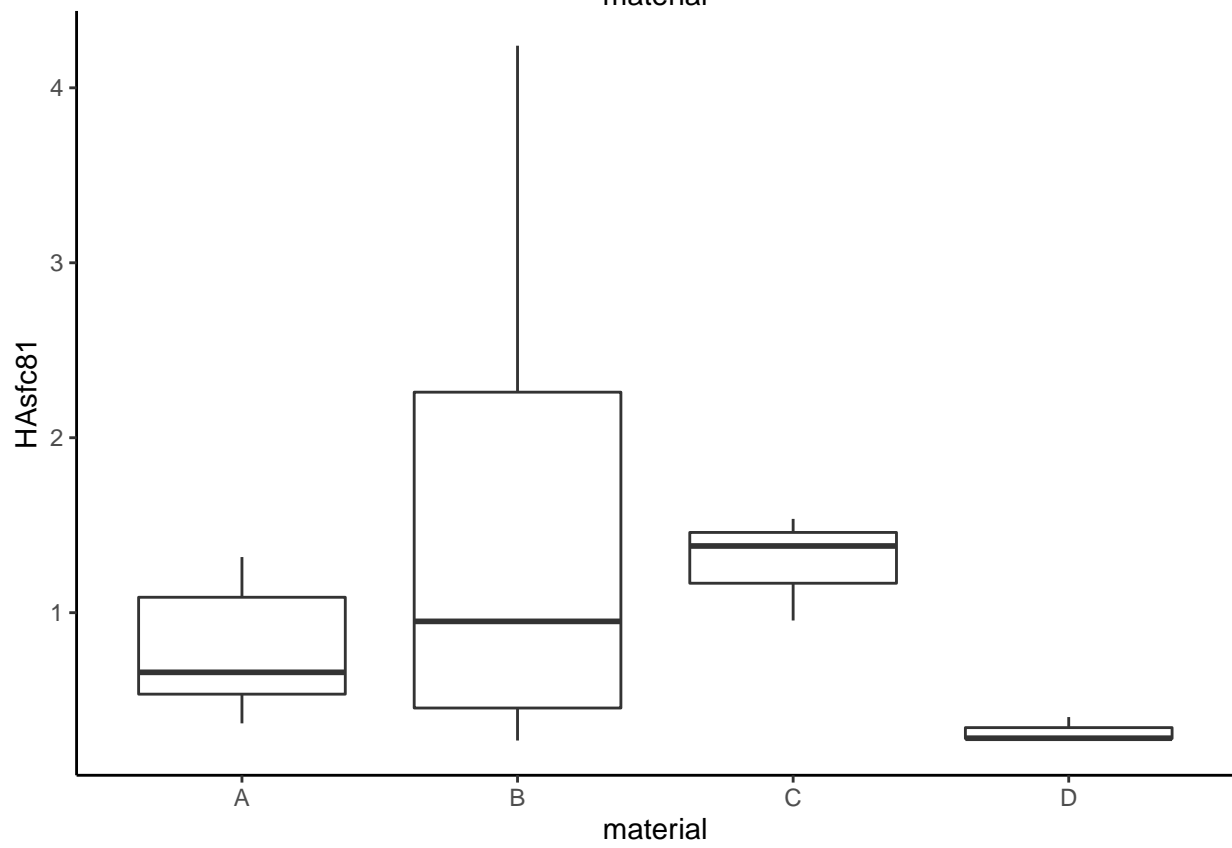
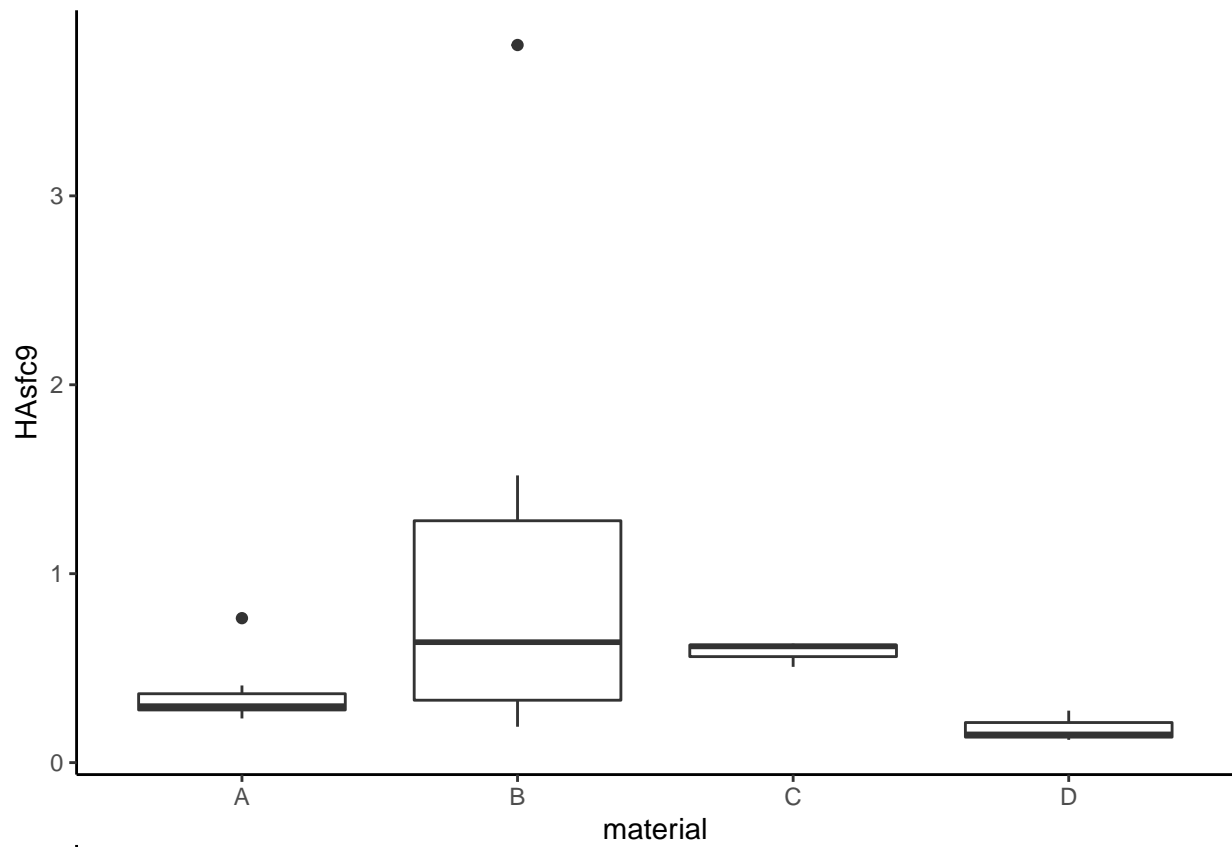








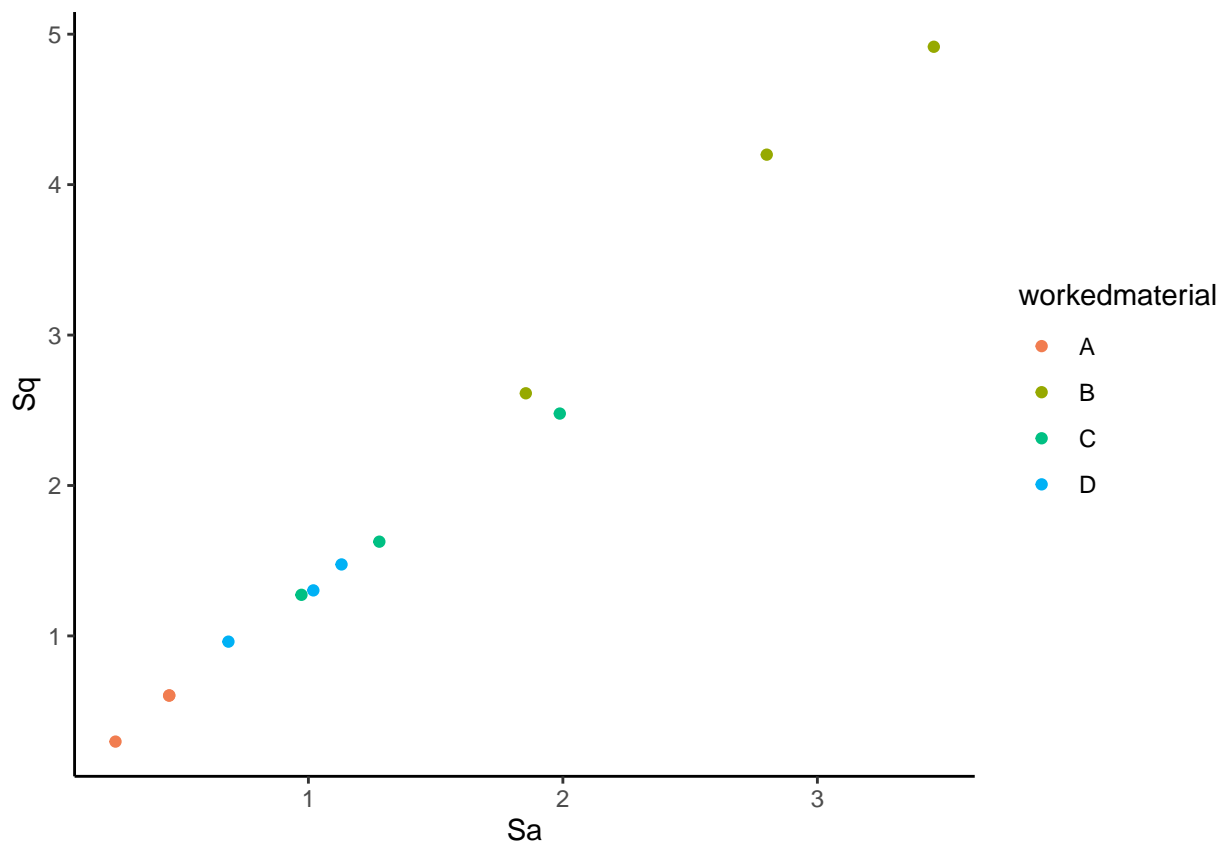




Scatterplots of selected variables combined by “Worked material” and “Motion”

```
# 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)
```

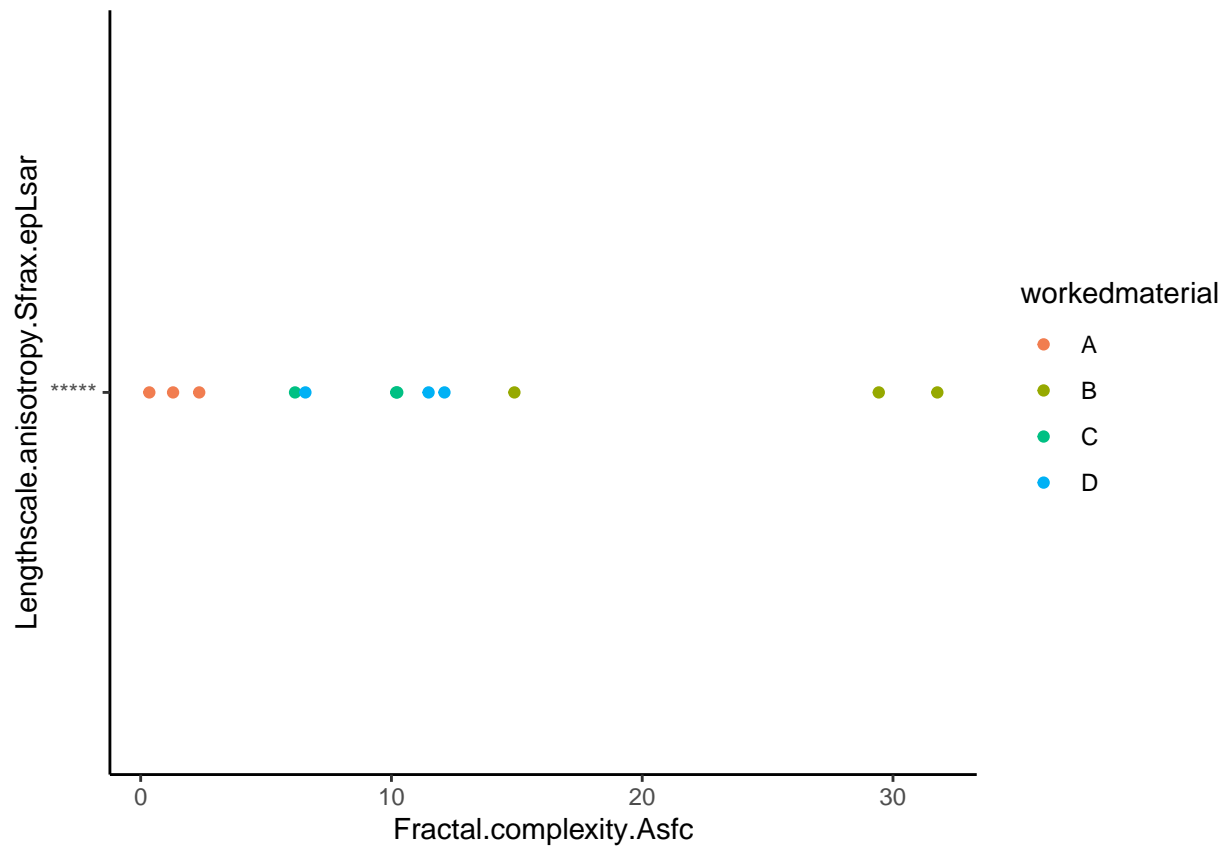


```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_Sa-Sq", ".pdf")
ggsave(filename = file_out, plot = Sa_Sq, path = "../plots", device = "pdf")
```

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)
```

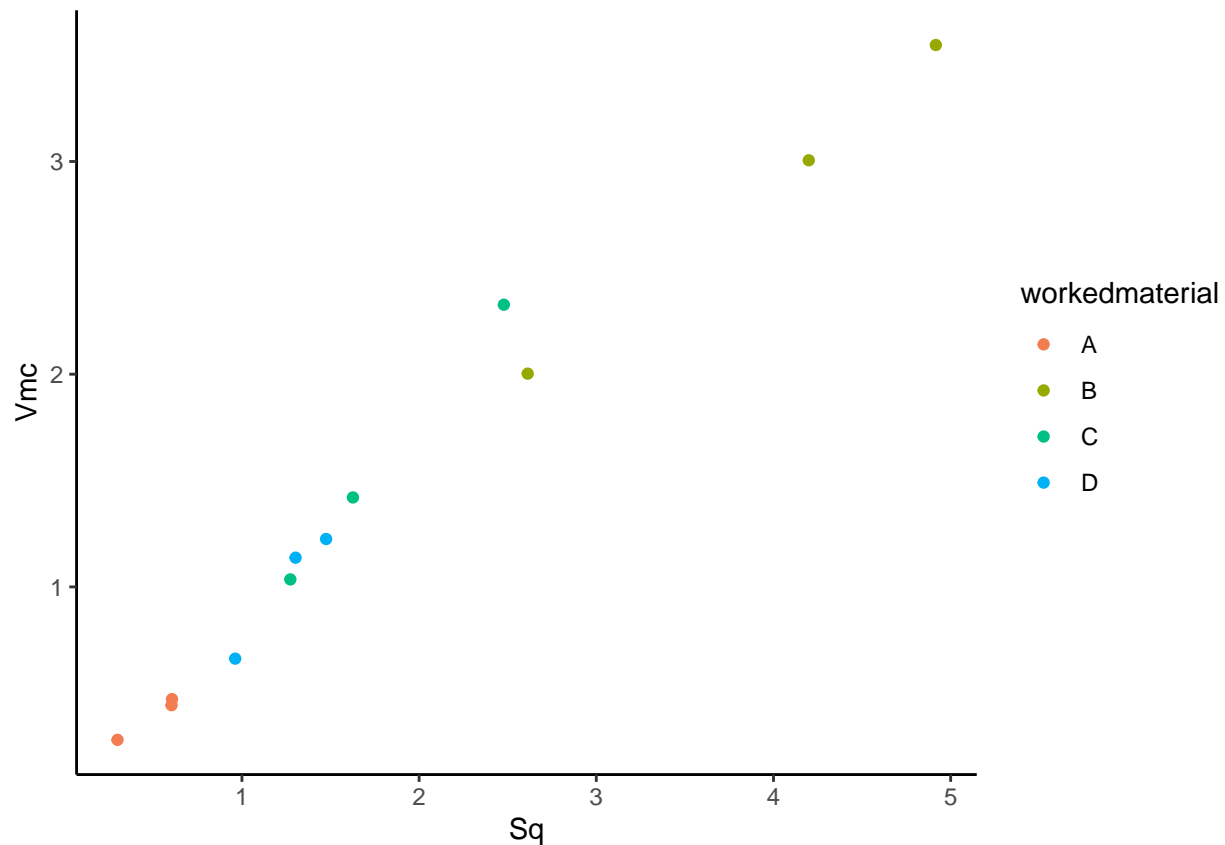


```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_Asfcr-epLsar", ".pdf")
ggsave(filename = file_out, plot = ep_Asfcr, path = "../plots", device = "pdf")
```

```
## 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)
```

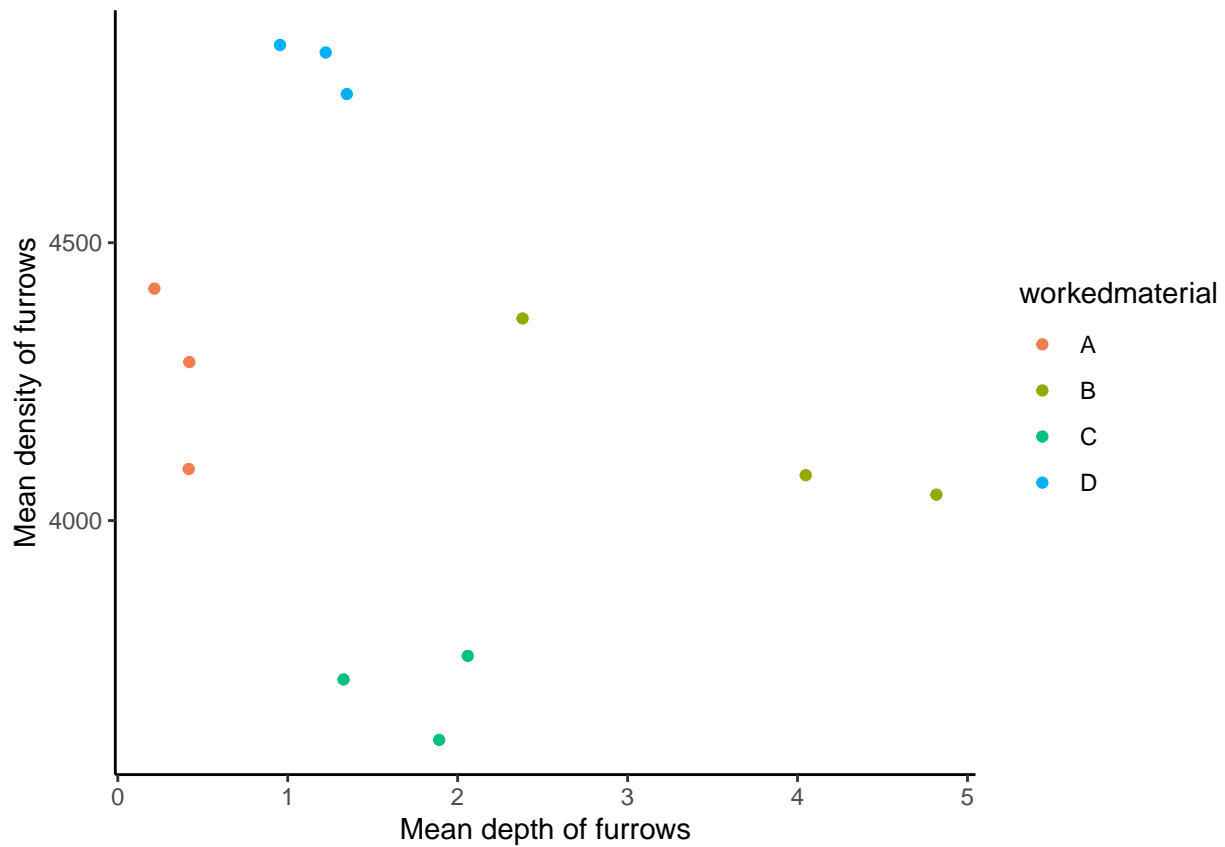


```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_Sq-Vmc", ".pdf")
ggsave(filename = file_out, plot = Sq_Vmc, path = "../plots", device = "pdf")
```

```
## 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)
```

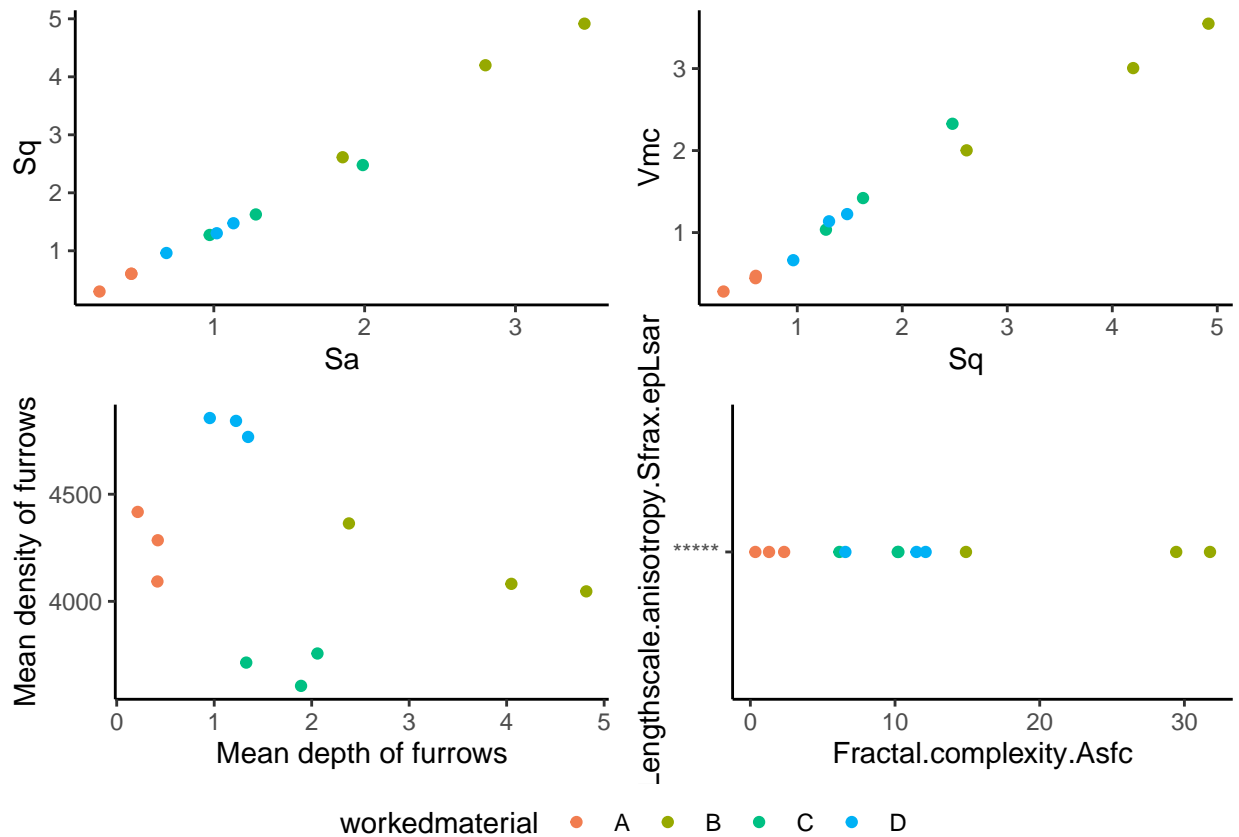



```
file_out <- paste0(file_path_sans_ext(info_in[["file"]]), "_scatterplot_furrows", ".pdf")
ggsave(filename = file_out, plot = furrows, path = "../plots", device = "pdf")
```

```
## 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
```

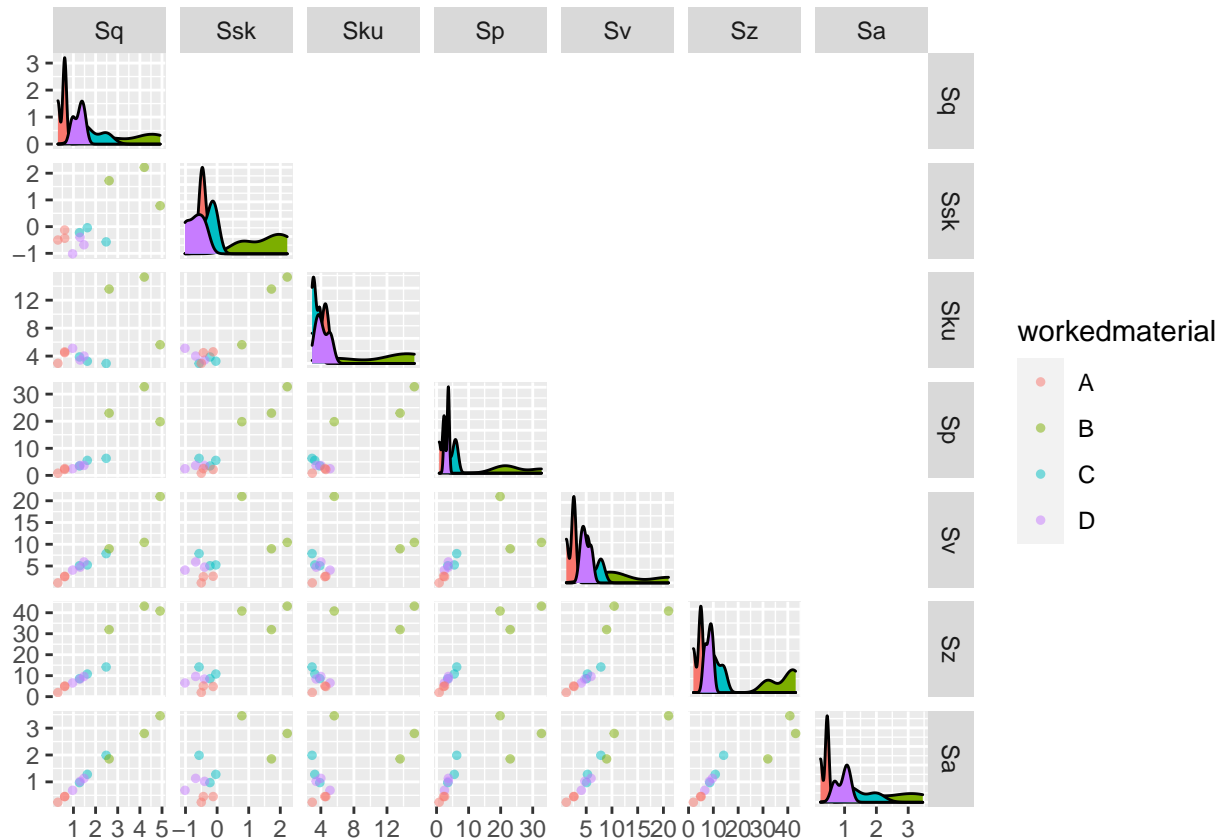
```
ggpairs(data=confoarch,
        columns = c(21:27),
        cardinality_threshold = 30,
        mapping = ggplot2::aes(color = workedmaterial),
        lower = list(continuous = wrap("points", alpha = 0.5, size = 1)),
```

```

    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

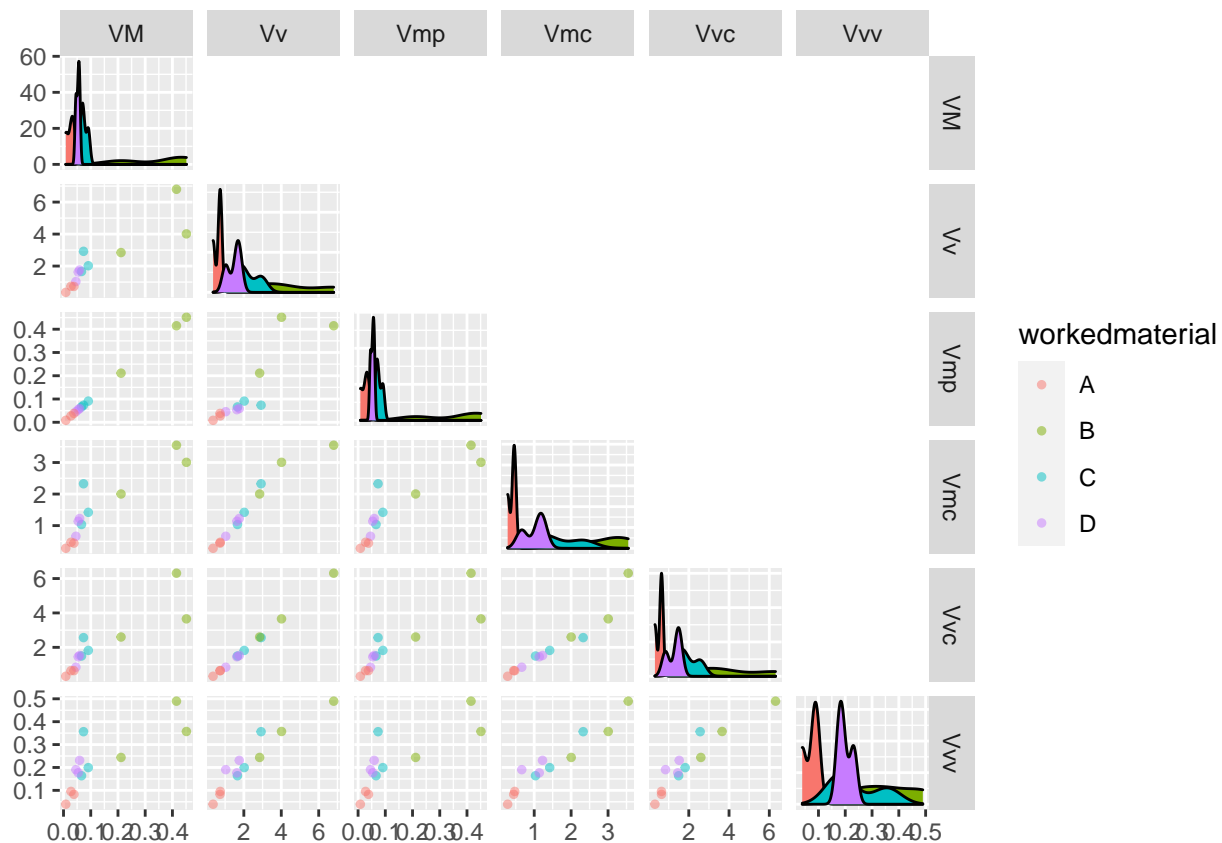
Volume parameters

```

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")

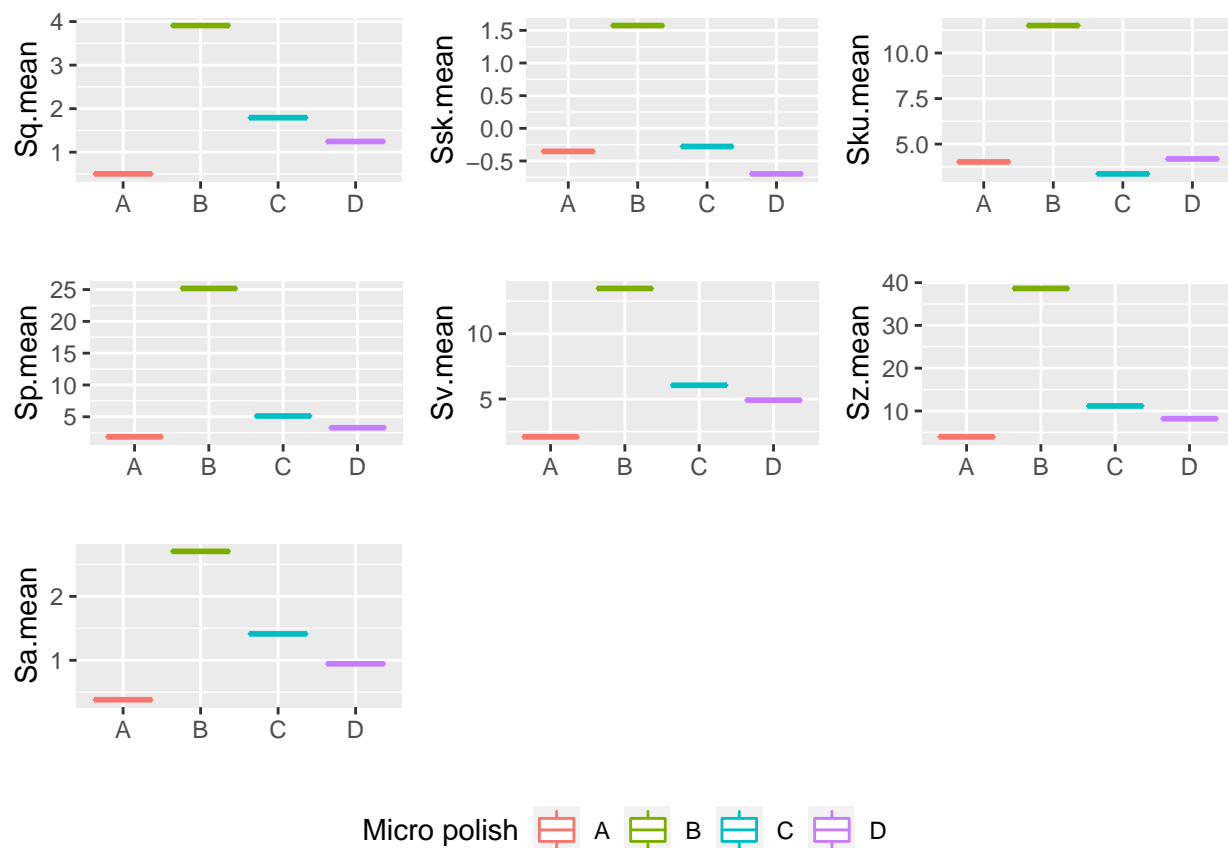
p5 <- ggplot(heightconfostats, aes(x=workedmaterial, y=Sv.mean, colour=workedmaterial)) +
  geom_boxplot() +
  labs(x="", colour="Micro polish")

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
```

```
# Now Volume parameters
```

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

```
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")
```

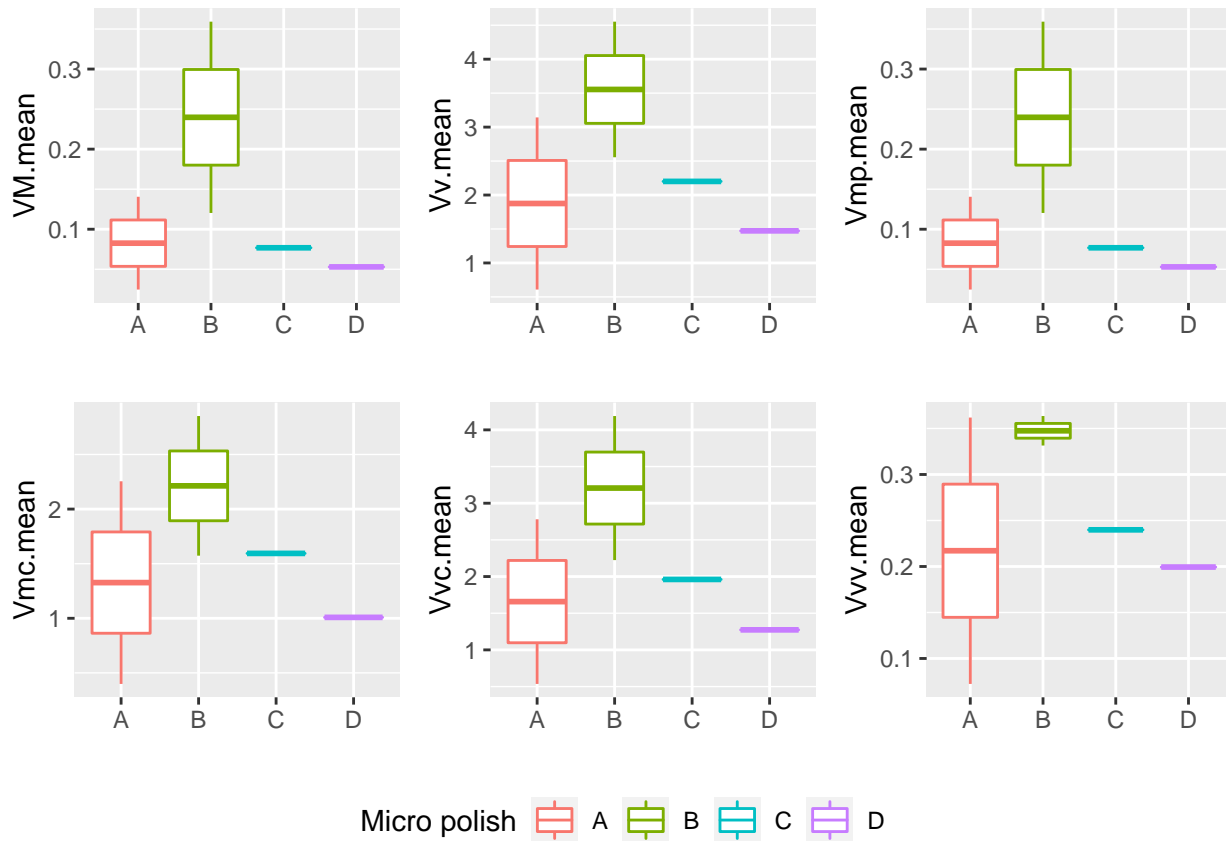
```
p10 <- ggplot(volumeconfostats, aes(x=workedmaterial, y=Vmp.mean, colour=workedmaterial)) +  
  geom_boxplot() +  
  labs(x="", colour="Micro polish")
```

```
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()
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## 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
##
```

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## 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

```