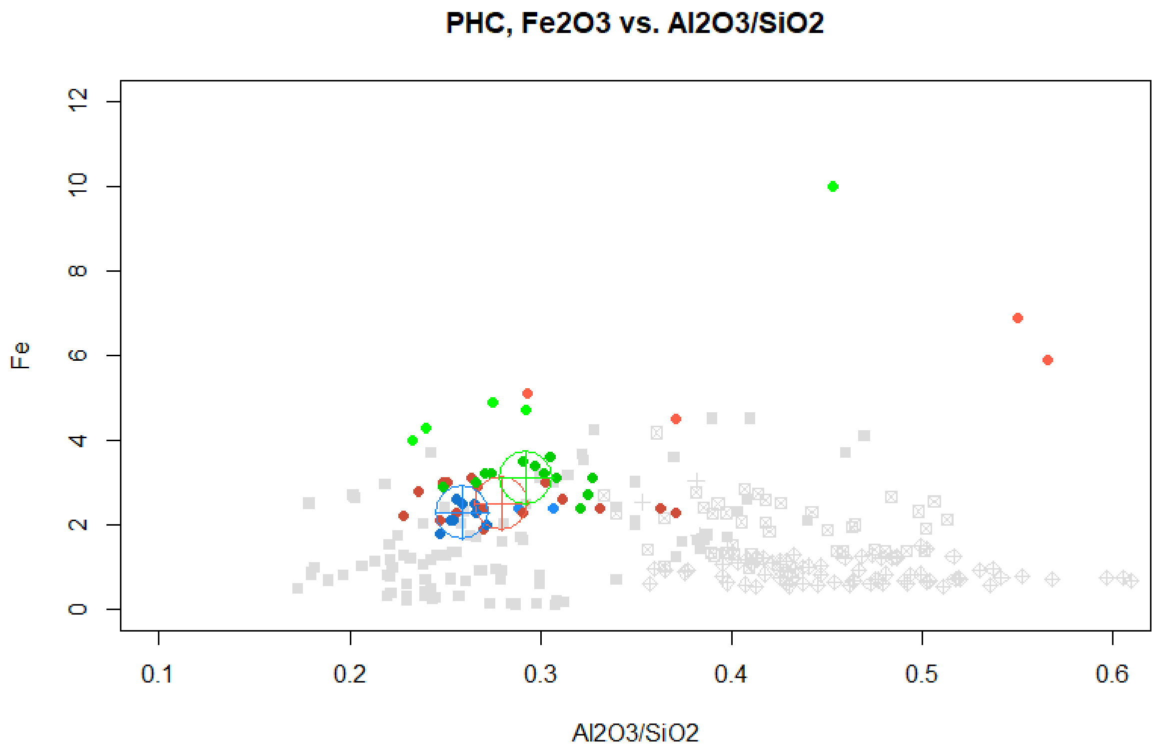
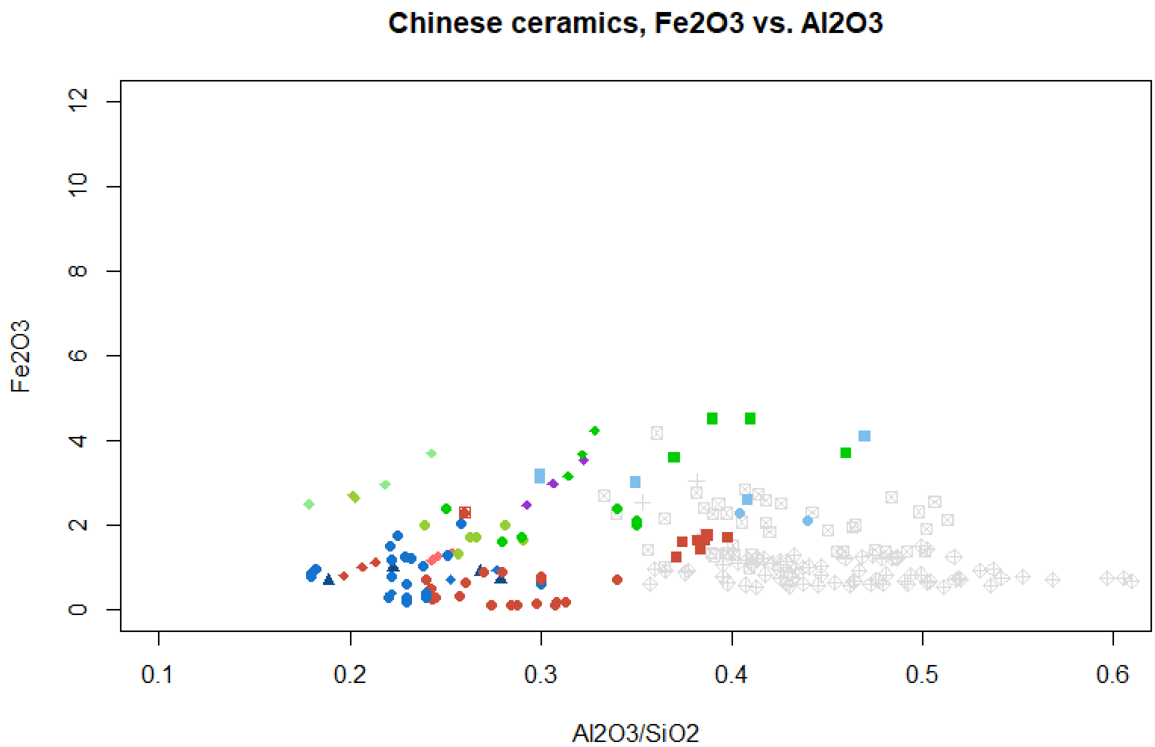
SEM results of a sampling of stoneware sherds from PHC

By Alasdair Chi, PhD (NTU 2022)

Bodies

Iron oxide (Fe_2O_3) vs. Al_2O_3/SiO_2





	Main body	Outliers	Means
Buff ware	●	●	⊕
Brittle ware	●	●	⊕
Mercury jars	●	●	⊕
Tempered jars	●	●	⊕
Chinese ceramics	■	◇⊠	n/a

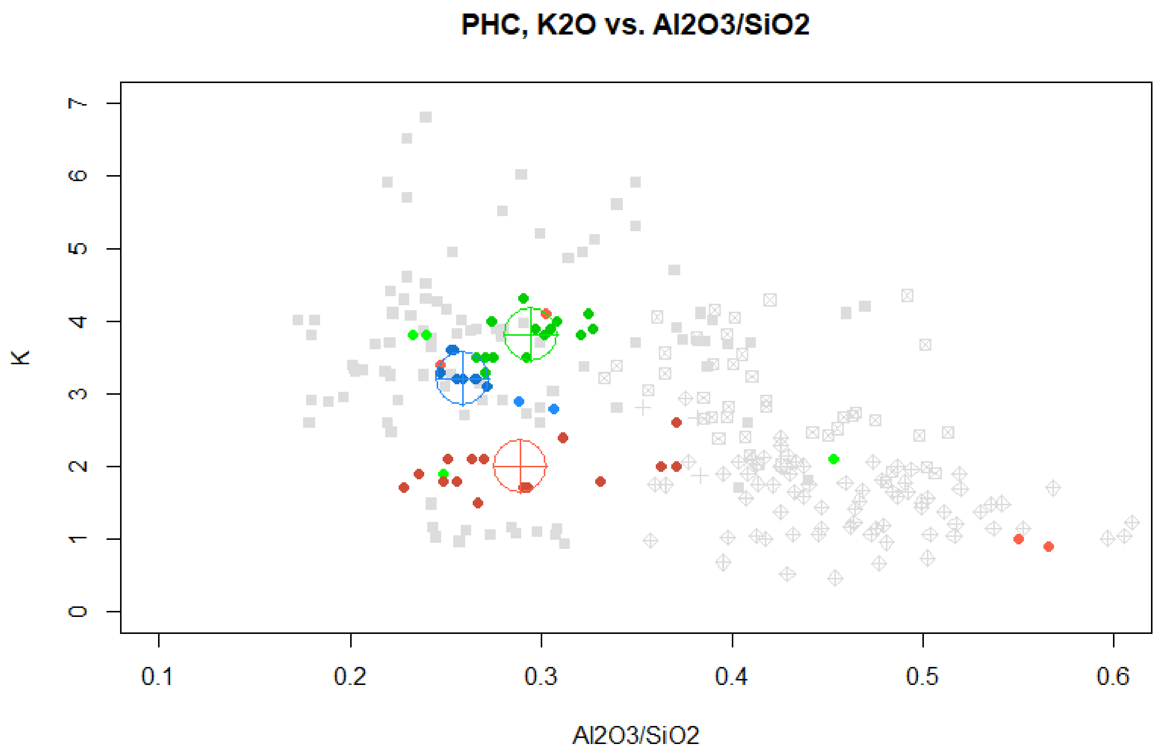
Iron oxide (Fe_2O_3) is generally seen as possessing a negative effect on the clay in the kiln during firing, whilst aluminium oxide (Al_2O_3) improves the quality of the clay, especially for stoneware and porcelain. The Al_2O_3/SiO_2 ratio (no units) is representative of the bulk properties of the clay and serves as a useful baseline / x-axis to compare the other minor-proportion characteristic elements.

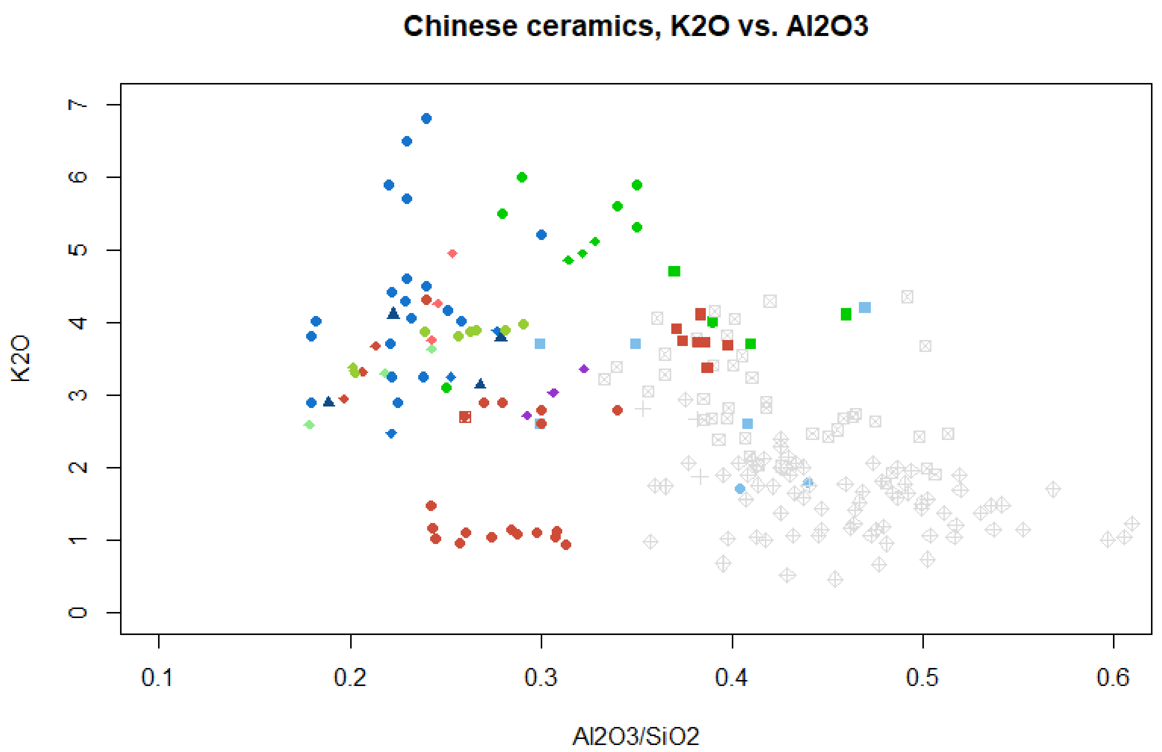
With regards to Al_2O_3 content, the KTC2020 sherds expresses typical values for stoneware in Singapore and Kota Cina, with the only notable high-Al_2O_3 outliers being two buff sherds. Mercury jars demonstrate a typical cluster of low, albeit non-distinct, Al_2O_3 values.

The differences in Al_2O_3% between categories are too small for alumina content to be used as a discriminant. However, plotting Fe_2O_3 against Al_2O_3/SiO_2 results in similar distributions to most other sites, with mercury jars and buff ware containing less iron than brittle ware.

The Fe_2O_3% vs. Al_2O_3/SiO_2 means are most compatible with Hangzhou and Longquan ware, with some outliers tending towards Longquan Guan ware, with Al_2O_3/SiO_2 ratios and Fe_2O_3 fairly distant from those observed in Jingdezhen. Other buff and brittle outliers lie far beyond measured Chinese ceramics. As with all Southeast Asian stoneware thus studied, there is no commonality with high-Fe_2O_3% Chinese stonewares.

Potassium oxide (K_2O) vs. Al_2O_3/SiO_2





Potassium oxide (K_2O) is generally seen as possessing a positive effect on the clay in the kiln during firing, permitting tolerance to higher temperatures and longer firing durations.

The K_2O distribution is typical of Singaporean sites, with mercury jars grouping closer to high-K_2O brittle ware than the buff ware.

The KTC2020 sherds group closer to Jingdezhen, Hangzhou, and Zhejiang produce than Longquan porcelains despite their Fe_2O_3% affinity. As with previous manifestations of this trend, this still does not preclude the possibility of a Longquan origin, as adding potassium is less intensive than removing iron as concerns the formation of these stoneware clays.

Aluminium oxide

Category	Al_2O_3%	Category	Al_2O_3%	Category	Al_2O_3%
Mercury jars	19.1 ± 0.5	**Brittle ware**	20.1 ± 1.0	**Buff ware**	19.5 ± 1.3
PHC-MER-GA	18.9 ± 0.3	PHC-BRI-GA	20.9 ± 2.0	*PHC-BUF-GA*	*24.3 ± 1.0*
PHC-MER-02	*21.9*	*PHC-BRI-02*	*17.0*	PHC-BUF-04	21.1
		PHC-BRI-04	*17.3*		
PHC-MER-GB	19.2 ± 0.6	PHC-BRI-GB	20.7 ± 1.6	PHC-BUF-GB	19.2 ± 0.7
PHC-MER-07	*20.8*				
		PHC-BRI-UC15	*26.6*	PHC-BUF-GC	19.6 ± 1.0
		PHC-BRI-UC16	19.1		
		PHC-BRI-UD	19.8 ± 0.8	PHC-BUF-UD	20.5 ± 2.1
				PHC-BUF-UE	*29.4 ± 0.4*
				PHC-BUF-16	19.7
				PHC-BUF-UF	18.2 ± 0.6
				PHC-BUF-UG	19.3 ± 2.5

Fabric Groups

```
> summary(aov(Al ~ Type, data= PHCdata.Al))
            Df Sum Sq Mean Sq F value Pr(>F)
Type         2  14.58   7.289   1.156  0.325
Residuals   38 239.51   6.303

> with(PHCdata.Al, pairwise.t.test(x=Al, g=Type, p.adjust="none"))

        Pairwise comparisons using t tests with pooled SD

data:  Al and Type

           Brittle Buff
Buff       0.48    -
MercuryJar 0.35    0.14

P value adjustment method: none
```

The three categories are statistically indistinguishable based on Al_2O_3 alone. There are two low-Al_2O_3 outliers amongst the brittle ware (UC-15, 26.6%) and three high-Al_2O_3 outliers: two buff sherds (UC-14, 29.1%; UC-15; 29.7%) and one brittle sherd (UC-15, 26.6%) which are notable not merely in PHC but in Singapore and even the Chinese corpus.

STA 2020

Mercury jars

```
> var.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsSTA$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsSTA$Al
F = 0.30202, num df = 7, denom df = 30, p-value = 0.1052
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1099859 1.3175486
sample estimates:
ratio of variances
         0.3020243

> t.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsSTA$Al, equal.var=t)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsSTA$Al
t = -2.749, df = 20.569, p-value = 0.01217
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.1463130 -0.1582032
sample estimates:
mean of x mean of y
 19.10000  19.75226
```

PHC mercury jars appear to be significantly depleted in mean Al_2O_3 relative to STA2020 mercury jars, by about 0.7%.

Brittle ware

```
> var.test(PHCdata.Al[Type=="Brittle",]$Al, brittleTrimmedAl$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "Brittle", ]$Al and brittleTrimmedAl$Al
F = 0.69714, num df = 16, denom df = 26, p-value = 0.4568
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2954379 1.8148800
sample estimates:
ratio of variances
         0.6971402

> t.test(PHCdata.Al[Type=="Brittle",]$Al, brittleTrimmedAl$Al, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Brittle", ]$Al and brittleTrimmedAl$Al
t = -2.8804, df = 38.584, p-value = 0.00645
```

```
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.6926495 -0.4706003
sample estimates:
mean of x mean of y
 20.12353  21.70515
```

PHC brittle ware appears to be significantly depleted in mean Al_2O_3 relative to STA2020 brittle ware, by about 1.6%.

Buff ware

```
> var.test(PHCdata.Al[Type=="Buff",]$Al, buffTrimmedAl1$Al)

	F test to compare two variances

data:  PHCdata.Al[Type == "Buff", ]$Al and buffTrimmedAl1$Al
F = 5.7774, num df = 15, denom df = 30, p-value = 4.644e-05
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  2.504115 15.273859
sample estimates:
ratio of variances
          5.777378

> t.test(PHCdata.Al[Type=="Buff",]$Al, buffTrimmedAl1$Al, equal.var=F)

	Welch Two Sample t-test

data:  PHCdata.Al[Type == "Buff", ]$Al and buffTrimmedAl1$Al
t = -1.5767, df = 17.729, p-value = 0.1325
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3.4595306  0.4950145
sample estimates:
mean of x mean of y
 20.75000  22.23226
```

There is no statistically significant difference between mean PHC and STA2020 Al_2O_3% values with regards to buff ware.

STA 2017

Mercury jars

```
> var.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsTrimmedAl$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsTrimmedAl$Al
F = 0.20118, num df = 7, denom df = 14, p-value = 0.04032
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.05952291 0.92465805
sample estimates:
ratio of variances
         0.2011834

> t.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsTrimmedAl$Al,
equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsTrimmedAl$Al
t = -2.403, df = 20.671, p-value = 0.02574
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.4930083 -0.1069917
sample estimates:
mean of x mean of y
     19.1      19.9
```

PHC mercury jars appear to be significantly depleted in mean Al_2O_3% relative to STA2017 mercury jars, by about 0.8%.

Brittle ware

```
> var.test(PHCdata.Al[Type=="Brittle",]$Al, brittleSTATrimmedAl$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "Brittle", ]$Al and brittleSTATrimmedAl$Al
F = 0.9471, num df = 16, denom df = 70, p-value = 0.9566
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.4737349 2.3005594
sample estimates:
ratio of variances
         0.9470975


> t.test(PHCdata.Al[Type=="Brittle",]$Al, brittleSTATrimmedAl$Al, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Brittle", ]$Al and brittleSTATrimmedAl$Al
```

```
t = -2.2408, df = 24.751, p-value = 0.03426
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.916298 -0.080305
sample estimates:
mean of x mean of y
 20.12353  21.12183
```

PHC brittle ware appears to be significantly depleted in mean Al_2O_3 relative to STA2017 brittle ware, by about 1.0%.

Buff ware

```
> var.test(PHCdata.Al[Type=="Buff",]$Al, buffSTATrimmedAl$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "Buff", ]$Al and buffSTATrimmedAl$Al
F = 2.0804, num df = 15, denom df = 75, p-value = 0.04012
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 1.032838 5.199594
sample estimates:
ratio of variances
          2.080436

> t.test(PHCdata.Al[Type=="Buff",]$Al, buffSTATrimmedAl$Al, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Buff", ]$Al and buffSTATrimmedAl$Al
t = -1.9233, df = 18.152, p-value = 0.07028
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3.8025286  0.1667391
sample estimates:
mean of x mean of y
 20.75000  22.56789
```

PHC buff ware appears to be almost significantly depleted in mean Al_2O_3 relative to STA2017 buff ware, by about 1.8%.

KTC 2020

Mercury jars

```
> var.test(PHCdata.Al[Type=="MercuryJar",]$Al,
KTC2020dataAl[KTC2020dataAl$Type=="MercuryJar",]$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and KTC2020dataAl[KTC2020dataAl$Type
== "MercuryJar", ]$Al
F = 1.1611, num df = 7, denom df = 3, p-value = 0.9915
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.07939269 6.83849237
sample estimates:
ratio of variances
          1.16107
```

```
> t.test(PHCdata.Al[Type=="MercuryJar",]$Al,
KTC2020dataAl[KTC2020dataAl$Type=="MercuryJar",]$Al, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and KTC2020dataAl[KTC2020dataAl$Type
== "MercuryJar", ]$Al
t = -0.95656, df = 6.5484, p-value = 0.3728
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.9644182  0.4144182
sample estimates:
mean of x mean of y
   19.100    19.375
```

There is no statistically significant difference between mean PHC and KTC2020 Al_2O_3% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.Al[Type=="Brittle",]$Al,
KTC2020dataAl[KTC2020dataAl$Type=="Brittle",]$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "Brittle", ]$Al and KTC2020dataAl[KTC2020dataAl$Type ==
"Brittle", ]$Al
F = 2.3394, num df = 16, denom df = 14, p-value = 0.1173
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.8002211 6.5900223
sample estimates:
ratio of variances
          2.339361
```

```
> t.test(PHCdata.Al[Type=="Brittle",]$Al,
KTC2020dataAl[KTC2020dataAl$Type=="Brittle",]$Al, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Brittle", ]$Al and KTC2020dataAl[KTC2020dataAl$Type ==
"Brittle", ]$Al
t = -2.8109, df = 27.801, p-value = 0.00895
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.3568201 -0.3694544
sample estimates:
mean of x mean of y
 20.12353  21.48667
```

PHC brittle ware appears to be significantly depleted in mean Al_2O_3 relative to KTC2020 brittle ware, by about 1.4%.

Buff ware

```
>var.test(PHCdata.Al[Type=="Buff",]$Al,
KTC2020dataAl[KTC2020dataAl$Type=="Buff",]$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "Buff", ]$Al and KTC2020dataAl[KTC2020dataAl$Type ==
"Buff", ]$Al
F = 12.831, num df = 15, denom df = 11, p-value = 0.000141
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  3.85313 38.59245
sample estimates:
ratio of variances
          12.83067

> t.test(PHCdata.Al[Type=="Buff",]$Al,
KTC2020dataAl[KTC2020dataAl$Type=="Buff",]$Al, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Buff", ]$Al and KTC2020dataAl[KTC2020dataAl$Type ==
"Buff", ]$Al
t = -0.4843, df = 18.014, p-value = 0.634
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.446502  1.529836
sample estimates:
mean of x mean of y
 20.75000  21.20833
```

There is no statistically significant difference between mean PHC and KTC2020 Al_2O_3% values with regards to buff ware.

KTC 2017

Mercury Jars

High Al

```
> var.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsKTCTrimmedAlHigh$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsKTCTrimmedAlHigh$Al
F = 0.92838, num df = 7, denom df = 18, p-value = 0.983
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2994886 4.1784184
sample estimates:
ratio of variances
         0.9283779

> t.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsKTCTrimmedAlHigh$Al,
equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsKTCTrimmedAlHigh$Al
t = -13.542, df = 13.694, p-value = 2.568e-09
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3.296217 -2.393257
sample estimates:
mean of x mean of y
 19.10000  21.94474
```

Low Al

```
> var.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsKTCTrimmedAlLow$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsKTCTrimmedAlLow$Al
F = 0.62849, num df = 7, denom df = 21, p-value = 0.5458
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2117093 2.7980489
sample estimates:
ratio of variances
         0.6284866

> t.test(PHCdata.Al[Type=="MercuryJar",]$Al, mercuryjarsKTCTrimmedAlLow$Al,
equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and mercuryjarsKTCTrimmedAlLow$Al
t = -1.169, df = 15.693, p-value = 0.2598
```

```
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.7207172  0.2088990
sample estimates:
mean of x mean of y 
 19.10000  19.35591
```

While the mean Al_2O_3% of the PHC mercury jars is distinct from the high-Al KTC2017 group, there is no significant difference between them and the low-Al KTC2017 group.

Brittle ware

```
> var.test(PHCdata.Al[Type=="Brittle",]$Al, brittleKTCAlTrimmed$Al)

	F test to compare two variances

data:  PHCdata.Al[Type == "Brittle", ]$Al and brittleKTCAlTrimmed$Al
F = 2.6715, num df = 16, denom df = 34, p-value = 0.01578
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 1.203321 6.786166
sample estimates:
ratio of variances 
          2.671541 

> t.test(PHCdata.Al[Type=="Brittle",]$Al, brittleKTCAlTrimmed$Al, equal.var=F)

	Welch Two Sample t-test

data:  PHCdata.Al[Type == "Brittle", ]$Al and brittleKTCAlTrimmed$Al
t = -1.6512, df = 22.005, p-value = 0.1129
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.6118119  0.1828707
sample estimates:
mean of x mean of y 
 20.12353  20.83800
```

There is no statistically significant difference between mean PHC and KTC2017 Al_2O_3% values with regards to brittle ware.

Buff ware

```
> var.test(PHCdata.Al[Type=="Buff",]$Al, buffKTC$Al)

	F test to compare two variances

data:  PHCdata.Al[Type == "Buff", ]$Al and buffKTC$Al
F = 2.5869, num df = 15, denom df = 39, p-value = 0.01743
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
```

```
 1.180507 6.699081
sample estimates:
ratio of variances
          2.586925

> t.test(PHCdata.Al[Type=="Buff",]$Al, buffKTC$Al, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Buff", ]$Al and buffKTC$Al
t = 0.19166, df = 19.815, p-value = 0.85
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.834663  2.205663
sample estimates:
mean of x mean of y
  20.7500   20.5645
```

There is no statistically significant difference between mean PHC and KTC2017 Al_2O_3% values with regards to buff ware.

CCT

Mercury jars

```
> var.test(PHCdata.Al[Type=="MercuryJar",]$Al,
CCTdataAlTrimmed[CCTdataAlTrimmed$Type=="MercuryJar",]$Al)

	F test to compare two variances
data:  PHCdata.Al[Type == "MercuryJar", ]$Al and
CCTdataAlTrimmed[CCTdataAlTrimmed$Type == "MercuryJar", ]$Al
F = 0.7759, num df = 7, denom df = 4, p-value = 0.7201
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.08550687 4.28498877
sample estimates:
ratio of variances
         0.7759014

> t.test(PHCdata.Al[Type=="MercuryJar",]$Al,
CCTdataAlTrimmed[CCTdataAlTrimmed$Type=="MercuryJar",]$Al, equal.var=T)

	Welch Two Sample t-test
data:  PHCdata.Al[Type == "MercuryJar", ]$Al and
CCTdataAlTrimmed[CCTdataAlTrimmed$Type == "MercuryJar", ]$Al
t = 1.4431, df = 7.7753, p-value = 0.188
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.2666268  1.1466268
sample estimates:
mean of x mean of y
    19.10     18.66
```

There is no statistically significant difference between mean PHC and CCT Al_2O_3% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.Al[Type=="Brittle",]$Al,
CCTdataAlTrimmed[CCTdataAlTrimmed$Type=="Brittle",]$Al)

	F test to compare two variances
data:  PHCdata.Al[Type == "Brittle", ]$Al and
CCTdataAlTrimmed[CCTdataAlTrimmed$Type == "Brittle", ]$Al
F = 2.8054, num df = 16, denom df = 7, p-value = 0.1712
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.6175411 9.0317181
sample estimates:
ratio of variances
          2.805377

> t.test(PHCdata.Al[Type=="Brittle",]$Al,
CCTdataAlTrimmed[CCTdataAlTrimmed$Type=="Brittle",]$Al, equal.var=T)

	Welch Two Sample t-test
```

```
data:  PHCdata.Al[Type == "Brittle", ]$Al and
CCTdataAlTrimmed[CCTdataAlTrimmed$Type == "Brittle", ]$Al
t = 0.42363, df = 21.38, p-value = 0.6761
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.8726054  1.3196643
sample estimates:
mean of x mean of y
 20.12353  19.90000
```

There is no statistically significant difference between mean PHC and CCT Al_2O_3% values with regards to brittle ware.

Buff ware

```
> var.test(PHCdata.Al[Type=="Buff",]$Al,
CCTdataAlTrimmed[CCTdataAlTrimmed$Type=="Buff",]$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "Buff", ]$Al and CCTdataAlTrimmed[CCTdataAlTrimmed$Type
== "Buff", ]$Al
F = 3.4918, num df = 15, denom df = 5, p-value = 0.1735
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.5432395 12.4881126
sample estimates:
ratio of variances
          3.491796

> t.test(PHCdata.Al[Type=="Buff",]$Al,
CCTdataAlTrimmed[CCTdataAlTrimmed$Type=="Buff",]$Al, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Buff", ]$Al and CCTdataAlTrimmed[CCTdataAlTrimmed$Type
== "Buff", ]$Al
t = -0.97529, df = 16.969, p-value = 0.3431
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -3.690824  1.357491
sample estimates:
mean of x mean of y
 20.75000  21.91667
```

There is no statistically significant difference between mean PHC and CCT Al_2O_3% values with regards to buff ware.

FTCSG

Mercury jars

```
> var.test(PHCdata.Al[Type=="MercuryJar",]$Al,
FTCdataAlTrimmed[FTCdataAlTrimmed$Type=="MercuryJar",]$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and
FTCdataAlTrimmed[FTCdataAlTrimmed$Type == "MercuryJar", ]$Al
F = 0.85213, num df = 7, denom df = 4, p-value = 0.7982
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.09390755 4.70597012
sample estimates:
ratio of variances
         0.8521303

>
t.test(PHCdata.Al[Type=="MercuryJar",]$Al,FTCdataAlTrimmed[FTCdataAlTrimmed$Type=
="MercuryJar",]$Al, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "MercuryJar", ]$Al and
FTCdataAlTrimmed[FTCdataAlTrimmed$Type == "MercuryJar", ]$Al
t = -1.3534, df = 8.0848, p-value = 0.2126
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.0803255  0.2803255
sample estimates:
mean of x mean of y
     19.1      19.5
```

There is no statistically significant difference between mean PHC and FTCSG Al_2O_3% values with regards to mercury jars.

Brittle ware

High Al

```
> var.test(PHCdata.Al[Type=="Brittle",]$Al,
FTCdataAlTrimmed[FTCdataAlTrimmed$Type=="Brittle-HighAl",]$Al)

        F test to compare two variances

data:  PHCdata.Al[Type == "Brittle", ]$Al and
FTCdataAlTrimmed[FTCdataAlTrimmed$Type == "Brittle-HighAl", ]$Al
F = 26.932, num df = 16, denom df = 5, p-value = 0.0018
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  4.205988 94.317658
sample estimates:
ratio of variances
```

```
          26.93162

> t.test(PHCdata.Al[Type=="Brittle",]$Al,
FTCdataAlTrimmed[FTCdataAlTrimmed$Type=="Brittle-HighAl",]$Al, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Brittle", ]$Al and
FTCdataAlTrimmed[FTCdataAlTrimmed$Type == "Brittle-HighAl", ]$Al
t = -2.8116, df = 18.875, p-value = 0.01119
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.0526577 -0.3002835
sample estimates:
mean of x mean of y
 20.12353  21.30000
```

Low Al

```
> var.test(PHCdata.Al[Type=="Brittle",]$Al,
FTCdataAlTrimmed[FTCdataAlTrimmed$Type=="Brittle-LowAl",]$Al)

        F test to compare two variances
data:  PHCdata.Al[Type == "Brittle", ]$Al and
FTCdataAlTrimmed[FTCdataAlTrimmed$Type == "Brittle-LowAl", ]$Al
F = 67.329, num df = 16, denom df = 5, p-value = 0.0001918
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  10.51497 235.79415
sample estimates:
ratio of variances
          67.32904

> t.test(PHCdata.Al[Type=="Brittle",]$Al,
FTCdataAlTrimmed[FTCdataAlTrimmed$Type=="Brittle-LowAl",]$Al, equal.var=F)

        Welch Two Sample t-test
data:  PHCdata.Al[Type == "Brittle", ]$Al and
FTCdataAlTrimmed[FTCdataAlTrimmed$Type == "Brittle-LowAl", ]$Al
t = 2.0268, df = 17.277, p-value = 0.0584
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.03266414  1.67972297
sample estimates:
mean of x mean of y
 20.12353  19.30000
```

While the mean Al_2O_3% of the PHC brittle ware is distinct from the high-Al FTCSG group, there is almost no significant difference between them and the low-Al FTCSG group.

Buff ware

```
> var.test(PHCdata.Al[Type=="Buff",]$Al,
FTCdataAlTrimmed[FTCdataAlTrimmed$Type=="Buff",]$Al)
```

```
        F test to compare two variances

data:  PHCdata.Al[Type == "Buff", ]$Al and FTCdataAlTrimmed[FTCdataAlTrimmed$Type
== "Buff", ]$Al
F = 10.956, num df = 15, denom df = 9, p-value = 0.001019
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  2.906527 34.211614
sample estimates:
ratio of variances
          10.95574

> t.test(PHCdata.Al[Type=="Buff",]$Al,
FTCdataAlTrimmed[FTCdataAlTrimmed$Type=="Buff",]$Al, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Al[Type == "Buff", ]$Al and FTCdataAlTrimmed[FTCdataAlTrimmed$Type
== "Buff", ]$Al
t = 0.32149, df = 19.025, p-value = 0.7513
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.708068  2.328068
sample estimates:
mean of x mean of y
    20.75     20.44
```

There is no statistically significant difference between mean PHC and FTCSG Al_2O_3% values with regards to buff ware.

Iron oxide

Category	Fe_2O_3%	Category	Fe_2O_3%	Category	Fe_2O_3%
Mercury jars	2.3 ± 0.3	**Brittle ware**	3.1 ± 0.3	**Buff ware**	2.5 ± 0.4
PHC-MER-GA	2.3 ± 0.2	PHC-BRI-GA	3.3 ± 0.3	PHC-BUF-GA	2.5 ± 0.3
		PHC-BRI-02	*4.0*	*PHC-BUF-03*	*4.5*
		PHC-BRI-04	*4.3*		
PHC-MER-UB	2.2 ± 0.3	PHC-BRI-GB	3.0 ± 0.3	PHC-BUF-GB	2.8 ± 0.4
		PHC-BRI-UC15	*10.0*	PHC-BUF-GC	2.0 ± 0.1
		PHC-BRI-UC16	*4.9*	*PHC-BUF-11*	*5.1*
		PHC-BRI-UD17	3.0	PHC-BUF-UD	2.5 ± 0.2
		PHC-BRI-UD18	*4.7*		
				PHC-BUF-UE14	*6.9*
				PHC-BUF-UE15	*5.9*
				PHC-BUF-UE16	2.9
				PHC-BUF-UF	2.9 ± 0.1
				PHC-BUF-UG	2.3 ± 0.1

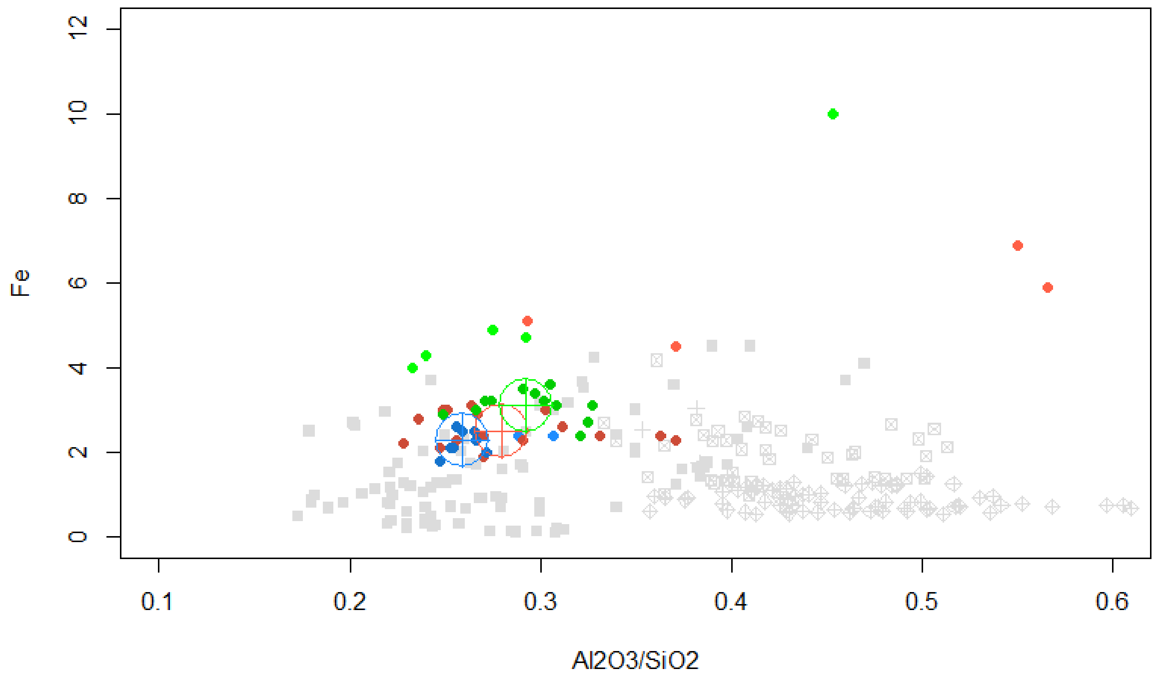
```
> summary(aov(Fe ~ Type, data= PHCdata.Fe))
            Df Sum Sq Mean Sq F value   Pr(>F)
Type         2  4.432  2.2162   20.26 1.27e-06 ***
Residuals   36  3.937  0.1094
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

> with(PHCdata.Fe, pairwise.t.test(x=Fe, g=Type, p.adjust="holm"))

        Pairwise comparisons using t tests with pooled SD

data:  Fe and Type

           Brittle Buff
Buff       9.3e-05 -
MercuryJar 1.6e-06 0.047
```

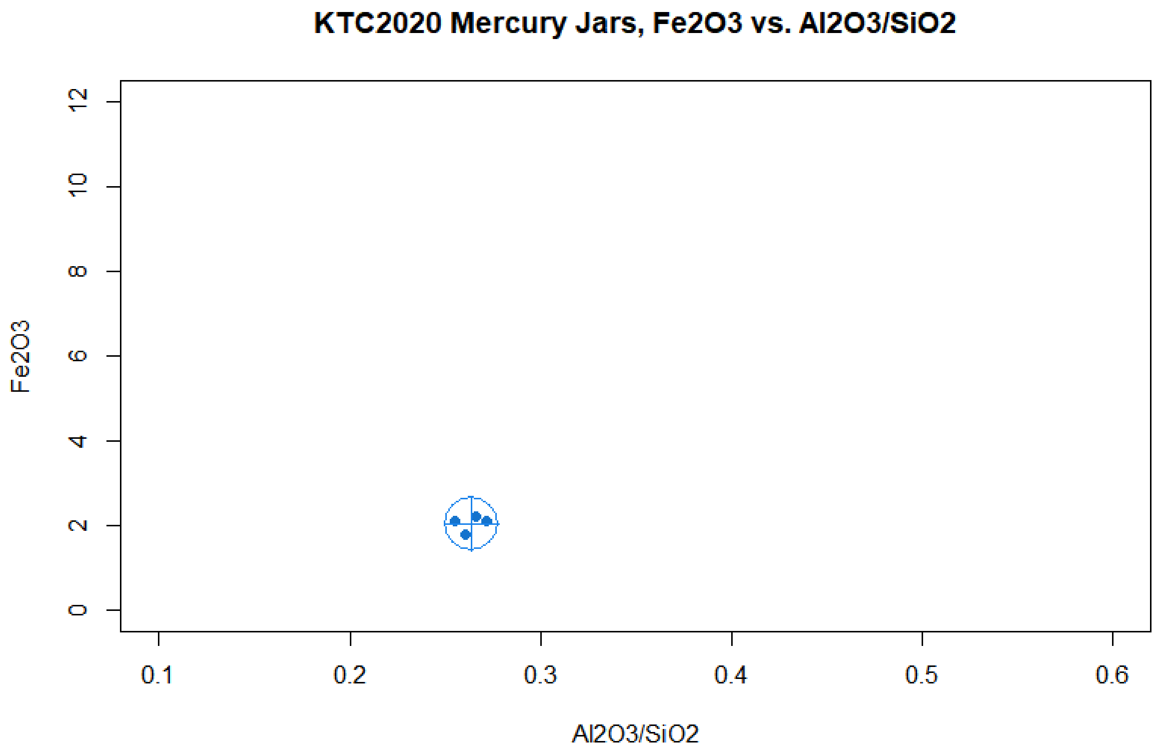
The brittle ware is significantly enriched in Fe_2O_3 relative to the other two categories, which are almost indistinguishable. Even amongst the high-Fe_2O_3 brittle sherds there are numerous outliers (GA-02, 4.0%; GA-04, 4.3%; UC-16, 4.9%, UD-18, 4.7%) with a truly remarkable one in UC-15 at 10.0%.

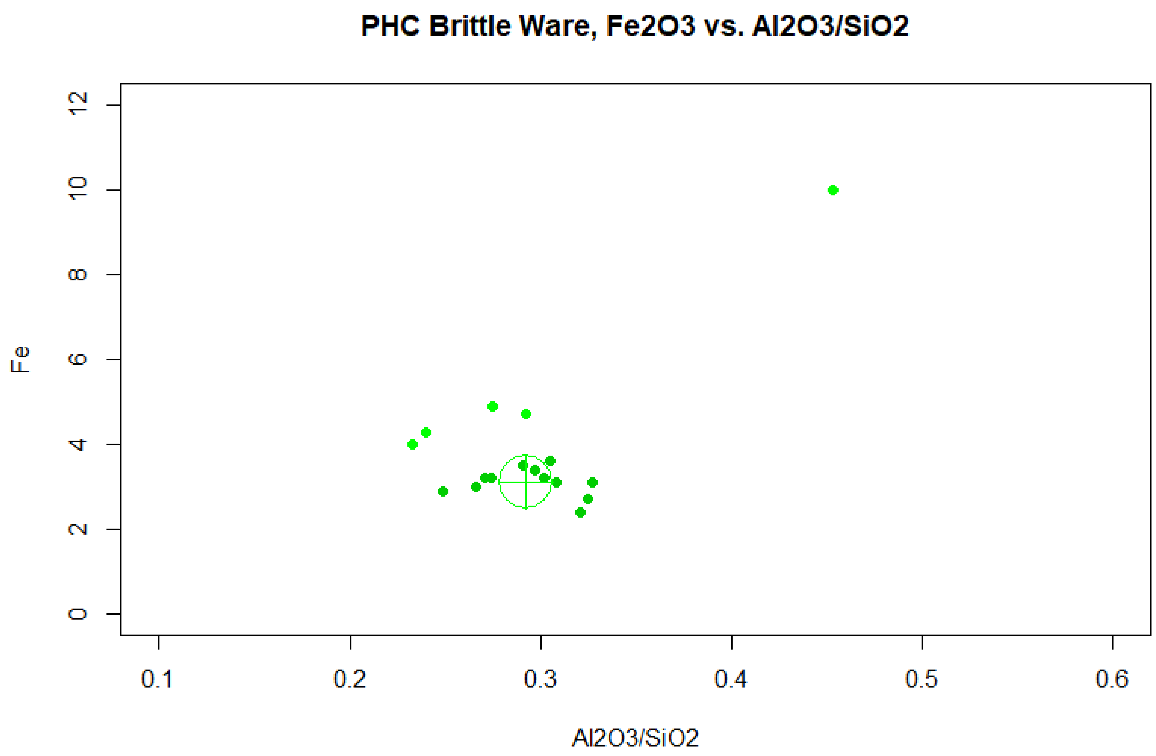
Apart from BRI-UC-16, the buff ware outliers are even more enriched in Fe_2O_3 (GA-03, 4.5%; GC-11, 5.1%; UE-14, 6.9%; UE-15, 5.9%); BUF-UE is a clear outlier in all three elements used in these comparisons.

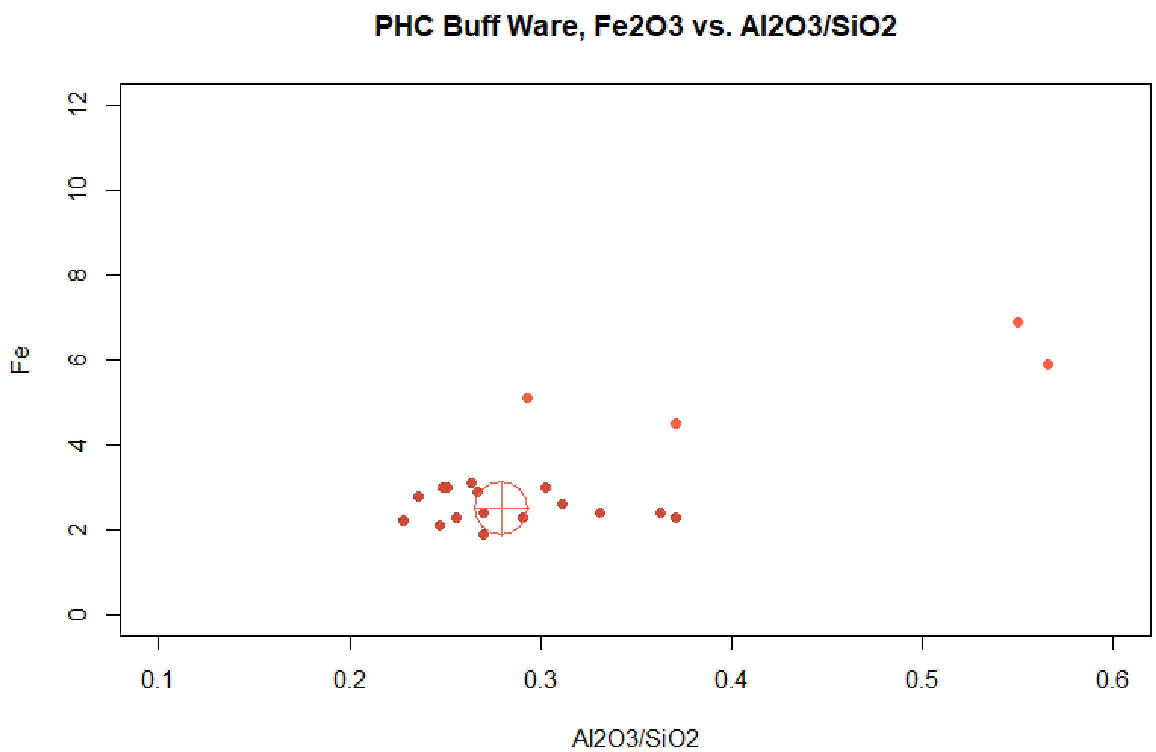
Fabric Groups

PHC, Fe2O3 vs. Al2O3/SiO2




KTC2020 Mercury Jars, Fe2O3 vs. Al2O3/SiO2
Fe2O3
0
2
4
6
8
10
12
0.1
0.2
0.3
0.4
0.5
0.6
Al2O3/SiO2


PHC Brittle Ware, Fe2O3 vs. Al2O3/SiO2
Fe
0
2
4
6
8
10
12
0.1
0.2
0.3
0.4
0.5
0.6
Al2O3/SiO2


PHC Buff Ware, Fe2O3 vs. Al2O3/SiO2
Fe
0
2
4
6
8
10
12
0.1
0.2
0.3
0.4
0.5
0.6
Al2O3/SiO2

KTC 2020

Mercury jars

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe,
KTC2020dataFe[KTC2020dataFe$Type=="MercuryJar",]$Fe)

        F test to compare two variances
data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and KTC2020dataFe[KTC2020dataFe$Type
== "MercuryJar", ]$Fe
F = 2.2259, num df = 9, denom df = 3, p-value = 0.5521
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.1537977 11.3035160
sample estimates:
ratio of variances
          2.225926

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe,
KTC2020dataFe[KTC2020dataFe$Type=="MercuryJar",]$Fe, equal.var=T)

        Welch Two Sample t-test
data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and KTC2020dataFe[KTC2020dataFe$Type
== "MercuryJar", ]$Fe
t = 1.8476, df = 8.4797, p-value = 0.09974
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.05189659  0.49189659
sample estimates:
mean of x mean of y
     2.27      2.05
```

There is no statistically significant difference between mean PHC and KTC2020 Fe_2O_3% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.Fe[Type=="Brittle",]$Fe,
KTC2020dataFe[KTC2020dataFe$Type=="Brittle",]$Fe)

        F test to compare two variances
data:  PHCdata.Fe[Type == "Brittle", ]$Fe and KTC2020dataFe[KTC2020dataFe$Type ==
"Brittle", ]$Fe
F = 0.98027, num df = 12, denom df = 11, p-value = 0.9667
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2858254 3.2559500
sample estimates:
ratio of variances
         0.9802705

> t.test(PHCdata.Fe[Type=="Brittle",]$Fe,
KTC2020dataFe[KTC2020dataFe$Type=="Brittle",]$Fe, equal.var=T)

        Welch Two Sample t-test
```

```
data:  PHCdata.Fe[Type == "Brittle", ]$Fe and KTC2020dataFe[KTC2020dataFe$Type ==
"Brittle", ]$Fe
t = 2.5701, df = 22.801, p-value = 0.01718
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.06465951 0.59944305
sample estimates:
mean of x mean of y
 3.115385  2.783333
```

PHC brittle ware appears to be significantly enriched in mean Al_2O_3 relative to KTC2020 brittle ware, by about 0.3%.

Buff ware

```
>var.test(PHCdata.Fe[Type=="Buff",]$Fe,
KTC2020dataFe[KTC2020dataFe$Type=="Buff",]$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "Buff", ]$Fe and KTC2020dataFe[KTC2020dataFe$Type ==
"Buff", ]$Fe
F = 0.23108, num df = 15, denom df = 11, p-value = 0.01002
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.06939345 0.69503581
sample estimates:
ratio of variances
         0.2310757

> t.test(PHCdata.Fe[Type=="Buff",]$Fe,
KTC2020dataFe[KTC2020dataFe$Type=="Buff",]$Fe, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Buff", ]$Fe and KTC2020dataFe[KTC2020dataFe$Type ==
"Buff", ]$Fe
t = -1.1557, df = 14.817, p-value = 0.2661
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.8005047  0.2380047
sample estimates:
mean of x mean of y
  2.54375   2.82500
```

There is no statistically significant difference between mean PHC and KTC2020 Fe_2O_3% values with regards to buff ware.

KTC 2017

Mercury Jars

High Fe

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsKTCTrimmedFeHigh$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsKTCTrimmedFeHigh$Fe
F = 1.2758, num df = 9, denom df = 7, p-value = 0.7649
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2645164 5.3546754
sample estimates:
ratio of variances
           1.27582

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsKTCTrimmedFeHigh$Fe,
equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsKTCTrimmedFeHigh$Fe
t = -10.056, df = 15.789, p-value = 2.88e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.4002622 -0.9122378
sample estimates:
mean of x mean of y
  2.27000   3.42625
```

Low Fe

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsKTCTrimmedFeLow$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsKTCTrimmedFeLow$Fe
F = 0.7439, num df = 9, denom df = 35, p-value = 0.6665
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2971023 2.6253614
sample estimates:
ratio of variances
         0.7439046

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsKTCTrimmedFeLow$Fe,
equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsKTCTrimmedFeLow$Fe
t = -0.55981, df = 16.389, p-value = 0.5832
alternative hypothesis: true difference in means is not equal to 0
```

```
95 percent confidence interval:
 -0.2562373  0.1490151
sample estimates:
mean of x mean of y 
 2.270000  2.323611 
```

While the mean Fe_2O_3% of the PHC mercury jars is distinct from the high-Fe_2O_3 KTC2017 group, there is no significant difference between them and the low- Fe_2O_3 KTC2017 group.

Brittle ware

```
> var.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleKTCFeTrimmed$Fe)

	F test to compare two variances

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleKTCFeTrimmed$Fe
F = 0.22876, num df = 12, denom df = 36, p-value = 0.008915
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.0982284 0.6692456
sample estimates:
ratio of variances 
         0.2287629 

> t.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleKTCFeTrimmed$Fe, equal.var=F)

	Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleKTCFeTrimmed$Fe
t = 1.7153, df = 43.2, p-value = 0.09346
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.04270414  0.52914905
sample estimates:
mean of x mean of y 
 3.115385  2.872162 
```

There is no statistically significant difference between mean PHC and FTCSG Fe_2O_3% values with regards to brittle ware.

Buff ware

```
> var.test(PHCdata.Fe[Type=="Buff",]$Fe, buffKTCFeTrimmed$Fe)

	F test to compare two variances

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffKTCFeTrimmed$Fe
F = 2.2163, num df = 15, denom df = 23, p-value = 0.08334
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
```

```
 0.8985722 6.0123067
sample estimates:
ratio of variances
          2.216284

> t.test(PHCdata.Fe[Type=="Buff",]$Fe, buffKTCFeTrimmed$Fe, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffKTCFeTrimmed$Fe
t = 5.1209, df = 23.967, p-value = 3.073e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.3260764 0.7664236
sample estimates:
mean of x mean of y
  2.54375   1.99750
```

PHC brittle ware appears to be significantly enriched in mean Fe_2O_3 relative to KTC2017 mercury jars, by about 0.6%.

STA 2020

Mercury jars

High Fe

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsTrimmedHigh$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsTrimmedHigh$Fe
F = 1.0311, num df = 9, denom df = 6, p-value = 0.9914
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1866832 4.4541838
sample estimates:
ratio of variances
          1.031127

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsTrimmedHigh$Fe,
equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsTrimmedHigh$Fe
t = -8.2741, df = 13.202, p-value = 1.388e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.3165267 -0.7720447
sample estimates:
mean of x mean of y
 2.270000  3.314286
```

Low Fe

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsTrimmedLow$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsTrimmedLow$Fe
F = 1.5774, num df = 9, denom df = 9, p-value = 0.5078
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.3918108 6.3507152
sample estimates:
ratio of variances
          1.577428

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsTrimmedLow$Fe,
equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsTrimmedLow$Fe
t = 0.95734, df = 17.14, p-value = 0.3517
```

```
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1202467  0.3202467
sample estimates:
mean of x mean of y
     2.27      2.17
```

While the mean Fe_2O_3% of the PHC mercury jars is distinct from the high-Fe_2O_3 STA2020 group, there is no significant difference between them and the low-Fe_2O_3 STA2020 group.

Brittle ware

High Fe

```
> var.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleTrimmedFeHigh$Fe)

	F test to compare two variances

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleTrimmedFeHigh$Fe
F = 1.3001, num df = 12, denom df = 7, p-value = 0.7526
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2786363 4.6887190
sample estimates:
ratio of variances 
          1.300069 

> t.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleTrimmedFeHigh$Fe, equal.var=T)

	Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleTrimmedFeHigh$Fe
t = -0.82069, df = 16.515, p-value = 0.4235
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.3920456  0.1728148
sample estimates:
mean of x mean of y 
 3.115385  3.225000 
```

Low Fe

```
> var.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleTrimmedFeLow$Fe)

	F test to compare two variances

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleTrimmedFeLow$Fe
F = 4.1231, num df = 12, denom df = 7, p-value = 0.06944
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.883675 14.869937
sample estimates:
ratio of variances 
          4.123077 

> t.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleTrimmedFeLow$Fe, equal.var=T)

	Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleTrimmedFeLow$Fe
t = 7.042, df = 18.418, p-value = 1.259e-06
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.5198570 0.9609122
sample estimates:
```

```
mean of x mean of y
 3.115385  2.375000
```

While the mean Fe_2O_3% of the PHC mercury jars is distinct from the high- Fe_2O_3 STA2020 group, there is no significant difference between them and the low-Fe_2O_3 KTC2017 group.

Buff ware

High Fe

```
> var.test(PHCdata.Fe[Type=="Buff",]$Fe, buffTrimmedFeHigh$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffTrimmedFeHigh$Fe
F = 1.0033, num df = 15, denom df = 17, p-value = 0.9865
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.3684443 2.8220376
sample estimates:
ratio of variances
          1.003286

> t.test(PHCdata.Fe[Type=="Buff",]$Fe, buffTrimmedFeHigh$Fe, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffTrimmedFeHigh$Fe
t = -4.4309, df = 31.522, p-value = 0.0001057
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.8308951 -0.3073271
sample estimates:
mean of x mean of y
 2.543750  3.112861
```

Low Fe

```
> var.test(PHCdata.Fe[Type=="Buff",]$Fe, buffTrimmedFeLow$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffTrimmedFeLow$Fe
F = 10.129, num df = 15, denom df = 10, p-value = 0.0007775
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  2.876255 30.997438
sample estimates:
ratio of variances
          10.12923

> t.test(PHCdata.Fe[Type=="Buff",]$Fe, buffTrimmedFeLow1$Fe, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffTrimmedFeLow1$Fe
t = 3.5343, df = 20.692, p-value = 0.002001
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1485551 0.5742390
sample estimates:
```

```
mean of x mean of y
 2.543750  2.182353
```

The PHC buff ware is statistically distinct from both the high- Fe_2O_3 STA2020 group, there is no significant difference between them and the low-Fe_2O_3 STA2020 group.

STA 2017

Mercury jars

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsSTA$Fe)

	F test to compare two variances

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsSTA$Fe
F = 0.54802, num df = 9, denom df = 30, p-value = 0.345
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.2128554 1.9511745
sample estimates:
ratio of variances
         0.5480196

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe, mercuryjarsSTA$Fe, equal.var=T)

	Welch Two Sample t-test

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and mercuryjarsSTA$Fe
t = 1.6568, df = 20.575, p-value = 0.1127
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.0438199  0.3851102
sample estimates:
mean of x mean of y
 2.270000  2.099355
```

There is no statistically significant difference between mean PHC and STA2017 Fe_2O_3% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleSTATrimmedFe$Fe)

	F test to compare two variances

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleSTATrimmedFe$Fe
F = 0.14436, num df = 12, denom df = 62, p-value = 0.0007787
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.06678069 0.41054471
sample estimates:
ratio of variances
         0.1443583

> t.test(PHCdata.Fe[Type=="Brittle",]$Fe, brittleSTATrimmedFe$Fe, equal.var=F)

	Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and brittleSTATrimmedFe$Fe
t = 0.39448, df = 50.754, p-value = 0.6949
```

```
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.2239173  0.3334167
sample estimates:
mean of x mean of y
 3.115385  3.060635
```

There is no statistically significant difference between mean PHC and STA2017 Fe_2O_3% values with regards to brittle ware.

Buff ware

```
> var.test(PHCdata.Fe[Type=="Buff",]$Fe, buffSTATrimmedFe1$Fe)

	F test to compare two variances

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffSTATrimmedFe1$Fe
F = 0.75263, num df = 15, denom df = 52, p-value = 0.5586
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.3587452 1.9140497
sample estimates:
ratio of variances
         0.7526262

> t.test(PHCdata.Fe[Type=="Buff",]$Fe, buffSTATrimmedFe1$Fe, equal.var=T)

	Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Buff", ]$Fe and buffSTATrimmedFe1$Fe
t = 1.8677, df = 28.141, p-value = 0.07225
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.0199534  0.4334911
sample estimates:
mean of x mean of y
 2.543750  2.336981
```

PHC buff ware appears to be almost significantly enriched in mean Fe_2O_3 relative to STA2017 buff ware, by about 0.2%.

CCT

Mercury jars

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe,
CCTdataFeTrimmed[CCTdataFeTrimmed$Type=="MercuryJar",]$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and
CCTdataFeTrimmed[CCTdataFeTrimmed$Type == "MercuryJar", ]$Fe
F = 9.5397, num df = 9, denom df = 4, p-value = 0.04416
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  1.071311 45.008971
sample estimates:
ratio of variances
          9.539683

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe,
CCTdataFeTrimmed[CCTdataFeTrimmed$Type=="MercuryJar",]$Fe, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and
CCTdataFeTrimmed[CCTdataFeTrimmed$Type == "MercuryJar", ]$Fe
t = 1.669, df = 11.984, p-value = 0.121
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.04585276  0.34585276
sample estimates:
mean of x mean of y
     2.27      2.12
```

There is no statistically significant difference between mean PHC and CCT Fe_2O_3% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.Fe[Type=="Buff",]$Fe,
CCTdataFeTrimmed[CCTdataFeTrimmed$Type=="Buff",]$Fe)

        F test to compare two variances
data:  PHCdata.Fe[Type == "Buff", ]$Fe and CCTdataFeTrimmed[CCTdataFeTrimmed$Type
== "Buff", ]$Fe
F = 0.33681, num df = 15, denom df = 7, p-value = 0.07289
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.07373684 1.10925038
sample estimates:
ratio of variances
         0.3368142

> t.test(PHCdata.Fe[Type=="Buff",]$Fe,
CCTdataFeTrimmed[CCTdataFeTrimmed$Type=="Buff",]$Fe, equal.var=T)
```

```
        Welch Two Sample t-test
data:  PHCdata.Fe[Type == "Buff", ]$Fe and CCTdataFeTrimmed[CCTdataFeTrimmed$Type
== "Buff", ]$Fe
t = -0.98944, df = 9.4314, p-value = 0.3472
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.7971756  0.3096756
sample estimates:
mean of x mean of y
  2.54375   2.78750
```

There is no statistically significant difference between mean PHC and CCT Fe_2O_3% values in terms of brittle ware.

Buff ware

```
> var.test(PHCdata.Fe[Type=="Brittle",]$Fe,
CCTdataFeTrimmed[CCTdataFeTrimmed$Type=="Brittle",]$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and
CCTdataFeTrimmed[CCTdataFeTrimmed$Type == "Brittle", ]$Fe
F = 0.90192, num df = 12, denom df = 7, p-value = 0.8338
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1933039 3.2527988
sample estimates:
ratio of variances
         0.9019231

> t.test(PHCdata.Fe[Type=="Brittle",]$Fe,
CCTdataFeTrimmed[CCTdataFeTrimmed$Type=="Brittle",]$Fe, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Brittle", ]$Fe and
CCTdataFeTrimmed[CCTdataFeTrimmed$Type == "Brittle", ]$Fe
t = 1.4451, df = 14.348, p-value = 0.1699
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1035606  0.5343298
sample estimates:
mean of x mean of y
 3.115385  2.900000
```

There is no statistically significant difference between mean PHC and CCT Fe_2O_3% values in terms of buff ware.

FTCSG

Mercury jars

```
> var.test(PHCdata.Fe[Type=="MercuryJar",]$Fe,
FTCdataFeTrimmed[FTCdataFeTrimmed$Type=="MercuryJar",]$Fe)

        F test to compare two variances
data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and
FTCdataFeTrimmed[FTCdataFeTrimmed$Type == "MercuryJar", ]$Fe
F = 0.58068, num df = 9, denom df = 4, p-value = 0.4573
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.06521023 2.73967648
sample estimates:
ratio of variances
         0.5806763

> t.test(PHCdata.Fe[Type=="MercuryJar",]$Fe,
FTCdataFeTrimmed[FTCdataFeTrimmed$Type=="MercuryJar",]$Fe, equal.var=T)

        Welch Two Sample t-test
data:  PHCdata.Fe[Type == "MercuryJar", ]$Fe and
FTCdataFeTrimmed[FTCdataFeTrimmed$Type == "MercuryJar", ]$Fe
t = 0.40633, df = 6.4194, p-value = 0.6977
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.3449489  0.4849489
sample estimates:
mean of x mean of y
     2.27      2.20
```

There is no statistically significant difference between mean PHC and FTCSG Fe_2O_3% values in terms of mercury jars.

Brittle ware

```
> var.test(PHCdata.Fe[Type=="Brittle",]$Fe,
FTCdataFeTrimmed[FTCdataFeTrimmed$Type=="Brittle",]$Fe)

        F test to compare two variances
data:  PHCdata.Fe[Type == "Brittle", ]$Fe and
FTCdataFeTrimmed[FTCdataFeTrimmed$Type == "Brittle", ]$Fe
F = 2.4297, num df = 12, denom df = 11, p-value = 0.1523
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.7084386 8.0701046
sample estimates:
ratio of variances
           2.42967

> t.test(PHCdata.Fe[Type=="Brittle",]$Fe,
FTCdataFeTrimmed[FTCdataFeTrimmed$Type=="Brittle",]$Fe, equal.var=T)

        Welch Two Sample t-test
```

```
data:  PHCdata.Fe[Type == "Brittle", ]$Fe and
FTCdataFeTrimmed[FTCdataFeTrimmed$Type == "Brittle", ]$Fe
t = -1.1016, df = 20.616, p-value = 0.2833
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.3408696  0.1049721
sample estimates:
mean of x mean of y
 3.115385  3.233333
```

There is no statistically significant difference between mean PHC and FTCSG Fe_2O_3% values in terms of brittle ware.

Buff ware

```
> var.test(PHCdata.Fe[Type=="Buff",]$Fe,
FTCdataFeTrimmed[FTCdataFeTrimmed$Type=="Buff",]$Fe)

        F test to compare two variances

data:  PHCdata.Fe[Type == "Buff", ]$Fe and FTCdataFeTrimmed[FTCdataFeTrimmed$Type
== "Buff", ]$Fe
F = 2.2902, num df = 15, denom df = 8, p-value = 0.2384
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.5584269 7.3258372
sample estimates:
ratio of variances
          2.290227

> t.test(PHCdata.Fe[Type=="Buff",]$Fe,
FTCdataFeTrimmed[FTCdataFeTrimmed$Type=="Buff",]$Fe, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.Fe[Type == "Buff", ]$Fe and FTCdataFeTrimmed[FTCdataFeTrimmed$Type
== "Buff", ]$Fe
t = 1.8663, df = 22.221, p-value = 0.07525
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.02571968  0.49099746
sample estimates:
mean of x mean of y
 2.543750  2.311111
```

PHC buff ware appears to be almost significantly enriched in mean Fe_2O_3 relative to STA2017 buff ware, by about 0.2%.

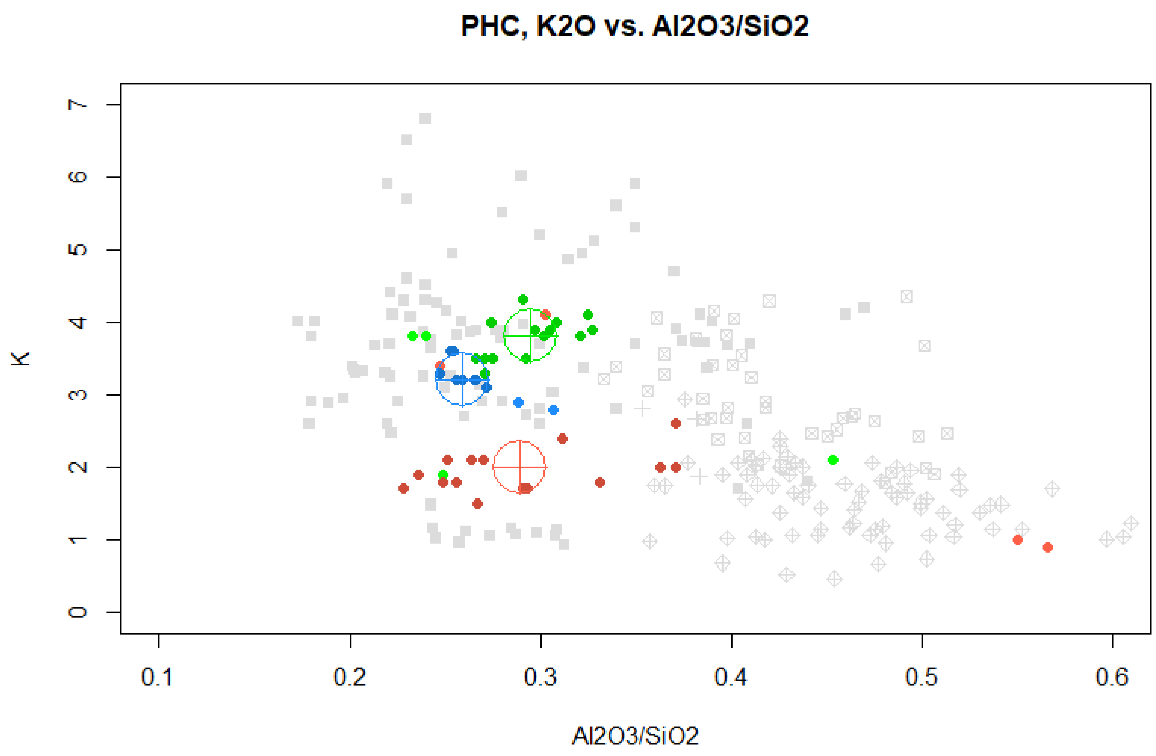
Potassium oxide

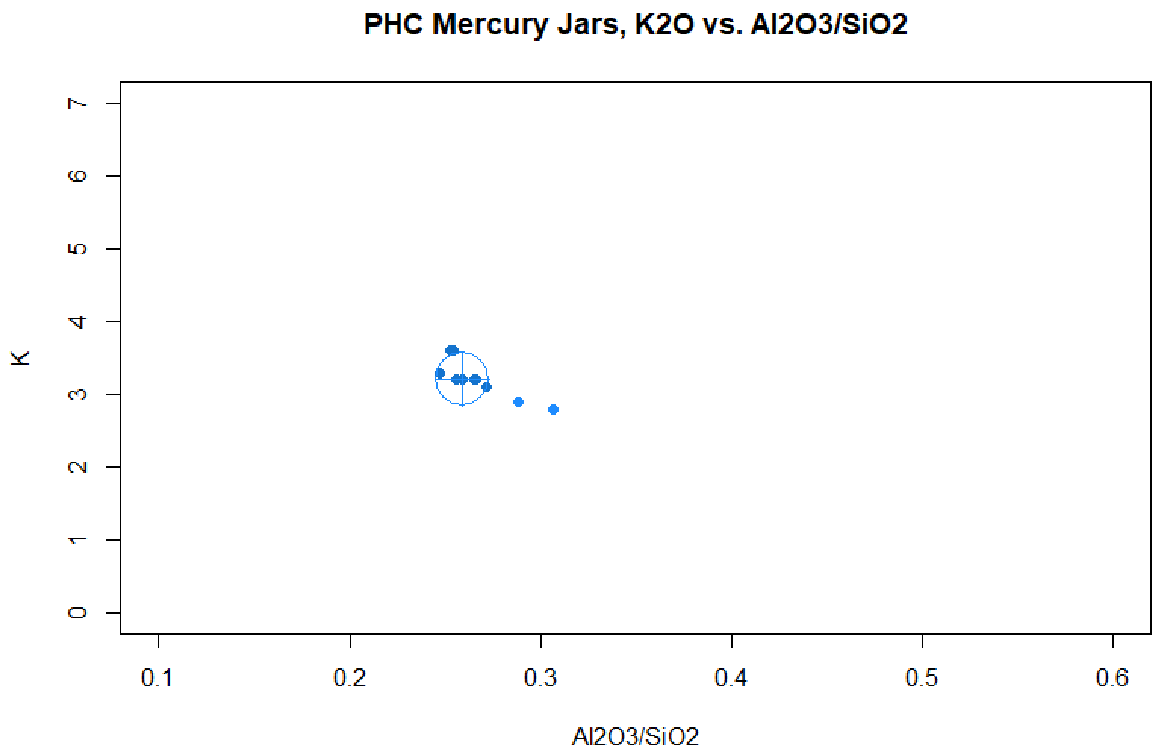
Category	K_2O%	Category	K_2O%	Category	K_2O%
Mercury jars	3.2 ± 0.3	**Brittle ware**	3.8 ± 0.3	**Buff ware**	2.0 ± 0.3
PHC-MER-GA	3.2 ± 0.4	PHC-BRI-GA	3.9 ± 0.2	PHC-BUF-GA	2.1 ± 0.3
PHC-MER-UB	3.2 ± 0.2	PHC-BRI-GB	3.8 ± 0.3	PHC-BUF-GB	2.0 ± 0.2
		PHC-BRI-12	*1.9*		
		PHC-BRI-UC15	*2.1*	PHC-BUF-GC	1.9 ± 0.3
		PHC-BRI-UC16	3.5	*PHC-BUF-09*	3.4
		PHC-BRI-UD	3.5 ±<0.1	PHC-BUF-UD	2.1 ± 0.4
				PHC-BUF-UE14	*1.0*
				PHC-BUF-UE15	*0.9*
				PHC-BUF-UE16	1.5
				PHC-BUF-UF	2.0 ± 0.1
				PHC-BUF-UG	1.7 ±<0.1

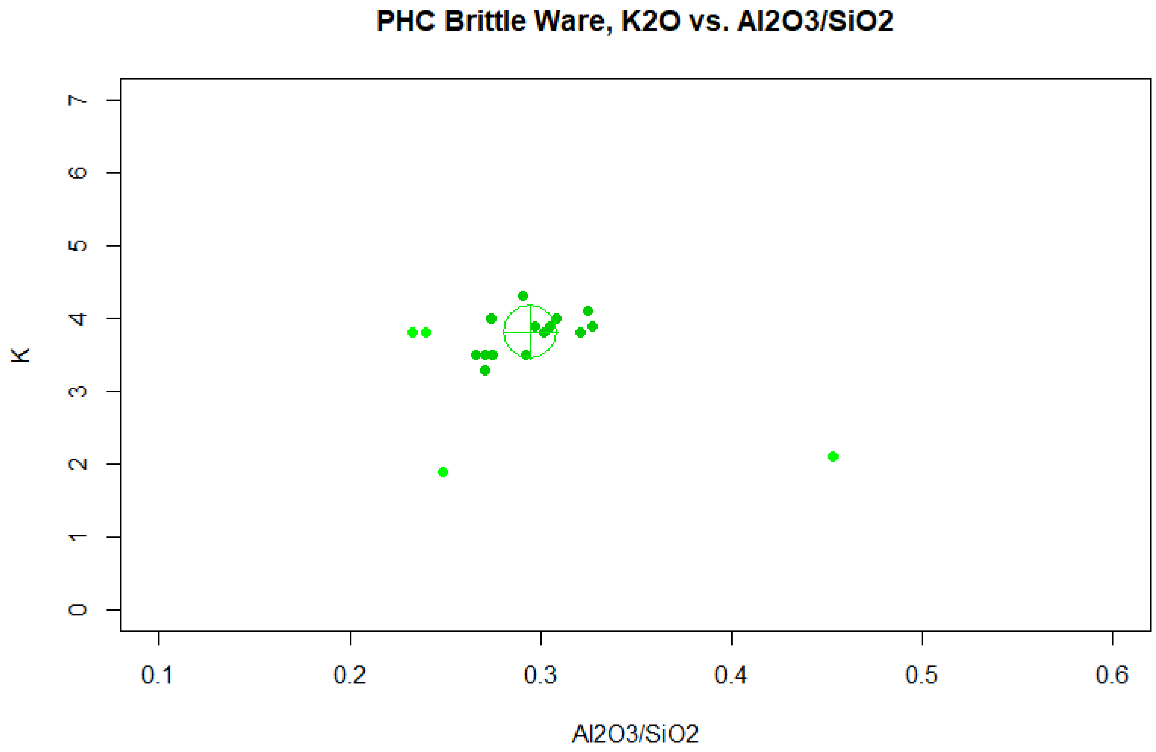
```
> summary(aov(K ~ Type, data= KTC2020dataK))
            Df Sum Sq Mean Sq F value Pr(>F)
Type         3 0.7915 0.26382    3.59 0.0223 *
Residuals   38 2.7926 0.07349
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

> with(KTC2020dataK, pairwise.t.test(x=K, g=Type, p.adjust="holm"))

        Pairwise comparisons using t tests with pooled SD

data:  K and Type

            Brittle Buff  MercuryJar
Buff        0.371   -     -
MercuryJar  0.787   0.787 -
TemperedJar 0.015   0.764 0.764

P value adjustment method: holm
```

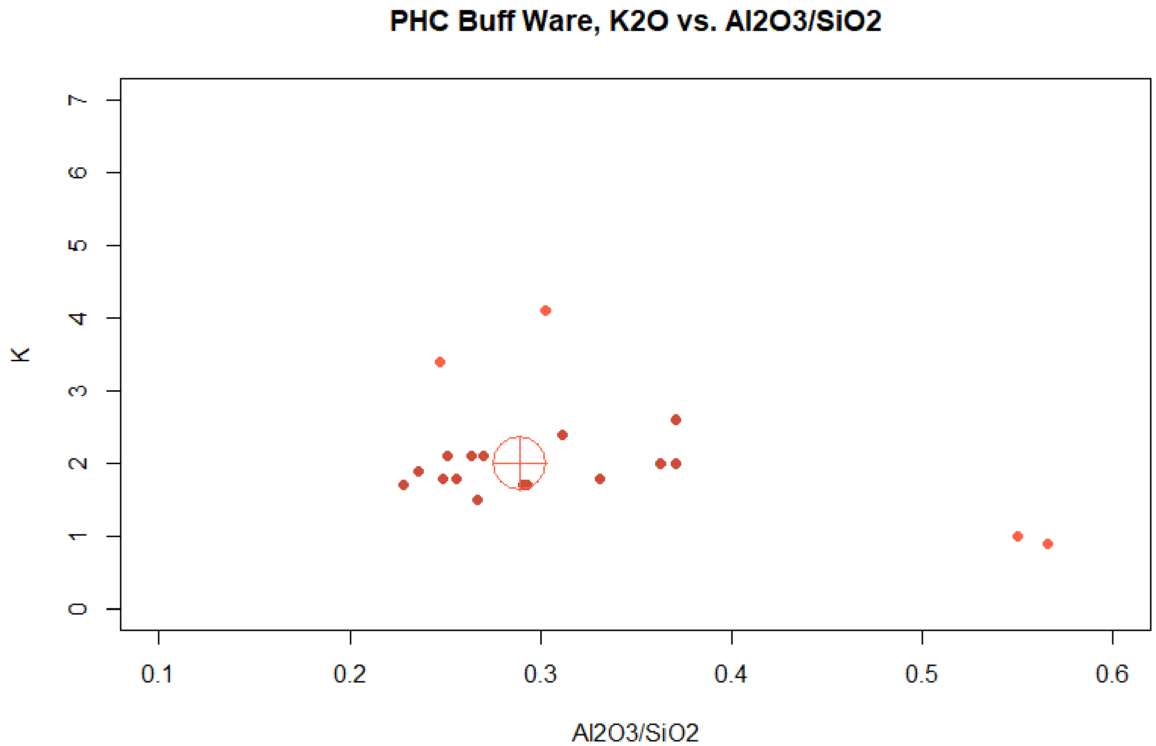
Mercury jars and brittle ware significantly enriched in K_2O relative to buff ware, a pattern consistently seen in other sites. There are two low-K_2O brittle sherds (GB-12, 1.9%; UC-15, 2.1%), but only the buff outliers (which already have rare Al2O3 and Fe2O3 values) are particularly notable (UE-14, 1.0%; UE-15, 0.9%).

Fabric Groups






PHC Brittle Ware, K2O vs. Al2O3/SiO2
K
0
1
2
3
4
5
6
7
0.1
0.2
0.3
0.4
0.5
0.6
Al2O3/SiO2


PHC Buff Ware, K2O vs. Al2O3/SiO2
K
0
1
2
3
4
5
6
7
0.1
0.2
0.3
0.4
0.5
0.6
Al2O3/SiO2

KTC 2020

Mercury jars

```
> var.test(PHCdata.K[Type=="MercuryJar",]$K,
KTC2020dataK[KTC2020dataK$Type=="MercuryJar",]$K)

        F test to compare two variances
data:  PHCdata.K[Type == "MercuryJar", ]$K and KTC2020dataK[KTC2020dataK$Type ==
"MercuryJar", ]$K
F = 26.178, num df = 9, denom df = 3, p-value = 0.02131
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
   1.808722 132.933862
sample estimates:
ratio of variances
          26.17778

> t.test(PHCdata.K[Type=="MercuryJar",]$K,
KTC2020dataK[KTC2020dataK$Type=="MercuryJar",]$K, equal.var=F)

        Welch Two Sample t-test
data:  PHCdata.K[Type == "MercuryJar", ]$K and KTC2020dataK[KTC2020dataK$Type ==
"MercuryJar", ]$K
t = -0.17715, df = 10.513, p-value = 0.8628
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.2024208  0.1724208
sample estimates:
mean of x mean of y
    3.210     3.225
```

There is no statistically significant difference between mean PHC and KTC2020 K_2O% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.K[Type=="Brittle",]$K,
KTC2020dataK[KTC2020dataK$Type=="Brittle",]$K)

        F test to compare two variances
data:  PHCdata.K[Type == "Brittle", ]$K and KTC2020dataK[KTC2020dataK$Type ==
"Brittle", ]$K
F = 1.3533, num df = 15, denom df = 14, p-value = 0.577
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.4588482 3.9130111
sample estimates:
ratio of variances
          1.353291

> t.test(PHCdata.K[Type=="Brittle",]$K,
KTC2020dataK[KTC2020dataK$Type=="Brittle",]$K, equal.var=T)

        Welch Two Sample t-test
```

```
data:  PHCdata.K[Type == "Brittle", ]$K and KTC2020dataK[KTC2020dataK$Type ==
"Brittle", ]$K
t = 7.8203, df = 28.797, p-value = 1.329e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.5125657 0.8757676
sample estimates:
mean of x mean of y
 3.787500  3.093333
```

PHC brittle ware appears to be significantly enriched in mean K_2O relative to STA2017 brittle ware, by about 0.7%.

Buff ware

```
> var.test(PHCdata.K[Type=="Buff",]$K,
KTC2020dataK[KTC2020dataK$Type=="Buff",]$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Buff", ]$K and KTC2020dataK[KTC2020dataK$Type ==
"Buff", ]$K
F = 0.52101, num df = 15, denom df = 10, p-value = 0.246
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1479436 1.5943902
sample estimates:
ratio of variances
          0.521009

> t.test(PHCdata.K[Type=="Buff",]$K, KTC2020dataK[KTC2020dataK$Type=="Buff",]$K,
equal.var=T)


        Welch Two Sample t-test

data:  PHCdata.K[Type == "Buff", ]$K and KTC2020dataK[KTC2020dataK$Type ==
"Buff", ]$K
t = -9.7775, df = 16.993, p-value = 2.159e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.622664 -1.046654
sample estimates:
mean of x mean of y
 1.956250  3.290909
```

PHC buff ware appears to be significantly depleted in mean K_2O relative to STA2017 buff ware, by about 1.3%.

KTC 2017

Mercury jars

```
> var.test(PHCdata.K[Type=="MercuryJar",]$K, mercuryjarsKTCTrimmedK$K)

        F test to compare two variances

data:  PHCdata.K[Type == "MercuryJar", ]$K and mercuryjarsKTCTrimmedK$K
F = 0.67393, num df = 9, denom df = 41, p-value = 0.5451
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.275841 2.359689
sample estimates:
ratio of variances
         0.6739261

> t.test(PHCdata.K[Type=="MercuryJar",]$K, mercuryjarsKTCTrimmedK$K, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "MercuryJar", ]$K and mercuryjarsKTCTrimmedK$K
t = 0.64515, df = 16.043, p-value = 0.528
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1387450  0.2601736
sample estimates:
mean of x mean of y
 3.210000  3.149286
```

There is no statistically significant difference between mean PHC and KTC2017 K_2O% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.K[Type=="Brittle",]$K, brittleKTCKTrimmed$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Brittle", ]$K and brittleKTCKTrimmed$K
F = 0.43088, num df = 15, denom df = 35, p-value = 0.08355
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1927904 1.1247869
sample estimates:
ratio of variances
         0.4308848

> t.test(PHCdata.K[Type=="Brittle",]$K, brittleKTCKTrimmed$K, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "Brittle", ]$K and brittleKTCKTrimmed$K
t = 7.0611, df = 42.517, p-value = 1.114e-08
alternative hypothesis: true difference in means is not equal to 0
```

```
95 percent confidence interval:
 0.4771924 0.8589187
sample estimates:
mean of x mean of y 
 3.787500  3.119444 
```

PHC brittle ware appears to be significantly enriched in mean K_2O relative to STA2017 brittle ware, by about 0.7%.

Buff ware

```
> var.test(PHCdata.K[Type=="Buff",]$K, buffKTC$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Buff", ]$K and buffKTC$K
F = 0.2521, num df = 15, denom df = 39, p-value = 0.005887
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1150426 0.6528379
sample estimates:
ratio of variances
         0.2521006

> t.test(PHCdata.K[Type=="Buff",]$K, buffKTC$K, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "Buff", ]$K and buffKTC$K
t = -8.4794, df = 50.99, p-value = 2.611e-11
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.1823426 -0.7296574
sample estimates:
mean of x mean of y
  1.95625   2.91225
```

PHC buff ware appears to be significantly depleted in mean K_2O relative to STA2017 buff ware, by about 1.0%.

STA 2020

Mercury jars

```
> var.test(PHCdata.K[Type=="MercuryJar",]$K, mercuryjarsSTATrimmedK$K)

        F test to compare two variances

data:  PHCdata.K[Type == "MercuryJar", ]$K and mercuryjarsSTATrimmedK$K
F = 1.1974, num df = 9, denom df = 27, p-value = 0.6729
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.4551539 4.2921816
sample estimates:
ratio of variances
          1.197444

> t.test(PHCdata.K[Type=="MercuryJar",]$K, mercuryjarsSTATrimmedK$K, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "MercuryJar", ]$K and mercuryjarsSTATrimmedK$K
t = 2.317, df = 14.732, p-value = 0.03533
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.0167923 0.4103506
sample estimates:
mean of x mean of y
 3.210000  2.996429
```

PHC mercury jars appear to be significantly enriched in mean K_2O relative to STA2020 mercury jars, by about 0.2%.

Brittle ware

```
> var.test(PHCdata.K[Type=="Brittle",]$K, brittle$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Brittle", ]$K and brittle$K
F = 0.078479, num df = 15, denom df = 19, p-value = 8.876e-06
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.0299869 0.2176259
sample estimates:
ratio of variances
        0.07847924

> t.test(PHCdata.K[Type=="Brittle",]$K, brittle$K, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "Brittle", ]$K and brittle$K
t = 3.8384, df = 22.635, p-value = 0.0008586
alternative hypothesis: true difference in means is not equal to 0
```

```
95 percent confidence interval:
 0.392626 1.312291
sample estimates:
mean of x mean of y
 3.787500  2.935042
```

PHC brittle ware appears to be significantly enriched in mean K_2O relative to STA2020 brittle ware, by about 0.8%.

Buff ware

```
> var.test(PHCdata.K[Type=="Buff",]$K, buff$K)

	F test to compare two variances

data:  PHCdata.K[Type == "Buff", ]$K and buff$K
F = 0.14791, num df = 15, denom df = 12, p-value = 0.0008648
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.04655261 0.43829026
sample estimates:
ratio of variances 
          0.147907 

> t.test(PHCdata.K[Type=="Buff",]$K, buff$K, equal.var=F)

	Welch Two Sample t-test

data:  PHCdata.K[Type == "Buff", ]$K and buff$K
t = -1.8919, df = 14.886, p-value = 0.07812
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.86138533  0.05157764
sample estimates:
mean of x mean of y 
 1.956250  2.361154 
```

PHC buff ware appears to be significantly depleted in mean K_2O relative to STA2020 buff ware, by about 0.4%.

STA 2017

Mercury jars

```
> var.test(PHCdata.K[Type=="MercuryJar",]$K, mercuryjars$K)

        F test to compare two variances

data:  PHCdata.K[Type == "MercuryJar", ]$K and mercuryjars$K
F = 0.40493, num df = 9, denom df = 20, p-value = 0.1646
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1427547 1.4848410
sample estimates:
ratio of variances
         0.4049303

> t.test(PHCdata.K[Type=="MercuryJar",]$K, mercuryjars$K, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "MercuryJar", ]$K and mercuryjars$K
t = 0.48284, df = 26.267, p-value = 0.6332
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1875539  0.3027920
sample estimates:
mean of x mean of y
 3.210000  3.152381
```

There is no statistically significant difference between mean PHC and KTC2017 K_2O% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.K[Type=="Brittle",]$K, brittleSTA$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Brittle", ]$K and brittleSTA$K
F = 0.084106, num df = 15, denom df = 74, p-value = 4.32e-06
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.04170229 0.21031820
sample estimates:
ratio of variances
        0.08410577

> t.test(PHCdata.K[Type=="Brittle",]$K, brittleSTA$K, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "Brittle", ]$K and brittleSTA$K
t = 4.9926, df = 81.419, p-value = 3.331e-06
alternative hypothesis: true difference in means is not equal to 0
```

```
95 percent confidence interval:
 0.3748792 0.8715875
sample estimates:
mean of x mean of y
 3.787500  3.164267
```

PHC brittle ware appears to be significantly enriched in mean K_2O relative to STA2017 brittle ware, by about 0.6%.

Buff ware

```
> var.test(PHCdata.K[Type=="Buff",]$K, buffSTATrimmedK$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Buff", ]$K and buffSTATrimmedK$K
F = 0.24056, num df = 15, denom df = 75, p-value = 0.003478
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1194257 0.6012220
sample estimates:
ratio of variances
          0.240558

> t.test(PHCdata.K[Type=="Buff",]$K, buffSTATrimmedK$K, equal.var=F)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "Buff", ]$K and buffSTATrimmedK$K
t = -2.4639, df = 45.737, p-value = 0.01757
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.42976689 -0.04325943
sample estimates:
mean of x mean of y
 1.956250  2.192763
```

PHC brittle ware appears to be significantly depleted in mean K_2O relative to STA2017 brittle ware, by about 0.2%.

CCT

Mercury jars

```
> var.test(PHCdata.K[Type=="MercuryJar",]$K,
CCTdataKTrimmed[CCTdataKTrimmed$Type=="MercuryJar",]$K)

        F test to compare two variances
data:  PHCdata.K[Type == "MercuryJar", ]$K and
CCTdataKTrimmed[CCTdataKTrimmed$Type == "MercuryJar", ]$K
F = 1.1481, num df = 9, denom df = 4, p-value = 0.9652
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1289376 5.4170530
sample estimates:
ratio of variances
          1.148148

> t.test(PHCdata.K[Type=="MercuryJar",]$K,
CCTdataKTrimmed[CCTdataKTrimmed$Type=="MercuryJar",]$K, equal.var=T)

        Welch Two Sample t-test
data:  PHCdata.K[Type == "MercuryJar", ]$K and
CCTdataKTrimmed[CCTdataKTrimmed$Type == "MercuryJar", ]$K
t = -0.82116, df = 8.6446, p-value = 0.4336
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.414941  0.194941
sample estimates:
mean of x mean of y
     3.21      3.32
```

There is no statistically significant difference between mean PHC and CCT K_2O% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.K[Type=="Brittle",]$K,
CCTdataKTrimmed[CCTdataKTrimmed$Type=="Brittle",]$K)

        F test to compare two variances
data:  PHCdata.K[Type == "Brittle", ]$K and CCTdataKTrimmed[CCTdataKTrimmed$Type
== "Brittle", ]$K
F = 0.52743, num df = 15, denom df = 5, p-value = 0.3096
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.08205565 1.88631383
sample estimates:
ratio of variances
         0.5274314

> t.test(PHCdata.K[Type=="Brittle",]$K,
CCTdataKTrimmed[CCTdataKTrimmed$Type=="Brittle",]$K, equal.var=T)

        Welch Two Sample t-test
```

```
data:  PHCdata.K[Type == "Brittle", ]$K and CCTdataKTrimmed[CCTdataKTrimmed$Type
== "Brittle", ]$K
t = -0.58667, df = 7.0811, p-value = 0.5756
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.4812052  0.2895385
sample estimates:
mean of x mean of y
 3.787500  3.883333
```

There is no statistically significant difference between mean PHC and CCT K_2O% values with regards to brittle ware.

Buff ware

```
> var.test(PHCdata.K[Type=="Buff",]$K,
CCTdataKTrimmed[CCTdataKTrimmed$Type=="Buff",]$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Buff", ]$K and CCTdataKTrimmed[CCTdataKTrimmed$Type ==
"Buff", ]$K
F = 0.43796, num df = 15, denom df = 6, p-value = 0.1824
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.08312619 1.49550084
sample estimates:
ratio of variances
         0.4379642

> t.test(PHCdata.K[Type=="Buff",]$K,
CCTdataKTrimmed[CCTdataKTrimmed$Type=="Buff",]$K, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "Buff", ]$K and CCTdataKTrimmed[CCTdataKTrimmed$Type ==
"Buff", ]$K
t = -0.57714, df = 8.3963, p-value = 0.579
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.5007292  0.2989435
sample estimates:
mean of x mean of y
 1.956250  2.057143
```

There is no statistically significant difference between mean PHC and CCT K_2O% values with regards to buff ware.

FTCSG

Mercury jars

```
> var.test(PHCdata.K[Type=="MercuryJar",]$K,
FTCdataKTrimmed[FTCdataKTrimmed$Type=="MercuryJar",]$K)

        F test to compare two variances
data:  PHCdata.K[Type == "MercuryJar", ]$K and
FTCdataKTrimmed[FTCdataKTrimmed$Type == "MercuryJar", ]$K
F = 5.0342, num df = 9, denom df = 4, p-value = 0.1343
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
  0.5653417 23.7516941
sample estimates:
ratio of variances
          5.034188

> t.test(PHCdata.K[Type=="MercuryJar",]$K,
FTCdataKTrimmed[FTCdataKTrimmed$Type=="MercuryJar",]$K, equal.var=T)

        Welch Two Sample t-test
data:  PHCdata.K[Type == "MercuryJar", ]$K and
FTCdataKTrimmed[FTCdataKTrimmed$Type == "MercuryJar", ]$K
t = 0.73201, df = 12.967, p-value = 0.4772
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1366425  0.2766425
sample estimates:
mean of x mean of y
     3.21      3.14
```

There is no statistically significant difference between mean PHC and FTCSG K_2O% values with regards to mercury jars.

Brittle ware

```
> var.test(PHCdata.K[Type=="Brittle",]$K,
FTCdataKTrimmed[FTCdataKTrimmed$Type=="Brittle",]$K)

        F test to compare two variances
data:  PHCdata.K[Type == "Brittle", ]$K and FTCdataKTrimmed[FTCdataKTrimmed$Type
== "Brittle", ]$K
F = 0.42138, num df = 15, denom df = 13, p-value = 0.112
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.1380344 1.2324942
sample estimates:
ratio of variances
         0.4213793

> t.test(PHCdata.K[Type=="Brittle",]$K,
FTCdataKTrimmed[FTCdataKTrimmed$Type=="Brittle",]$K, equal.var=T)

        Welch Two Sample t-test
```

```
data:  PHCdata.K[Type == "Brittle", ]$K and FTCdataKTrimmed[FTCdataKTrimmed$Type
== "Brittle", ]$K
t = 1.0751, df = 21.787, p-value = 0.2941
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1278859  0.4028859
sample estimates:
mean of x mean of y 
   3.7875    3.6500
```

There is no statistically significant difference between mean PHC and FTCSG K_2O% values with regards to brittle ware.

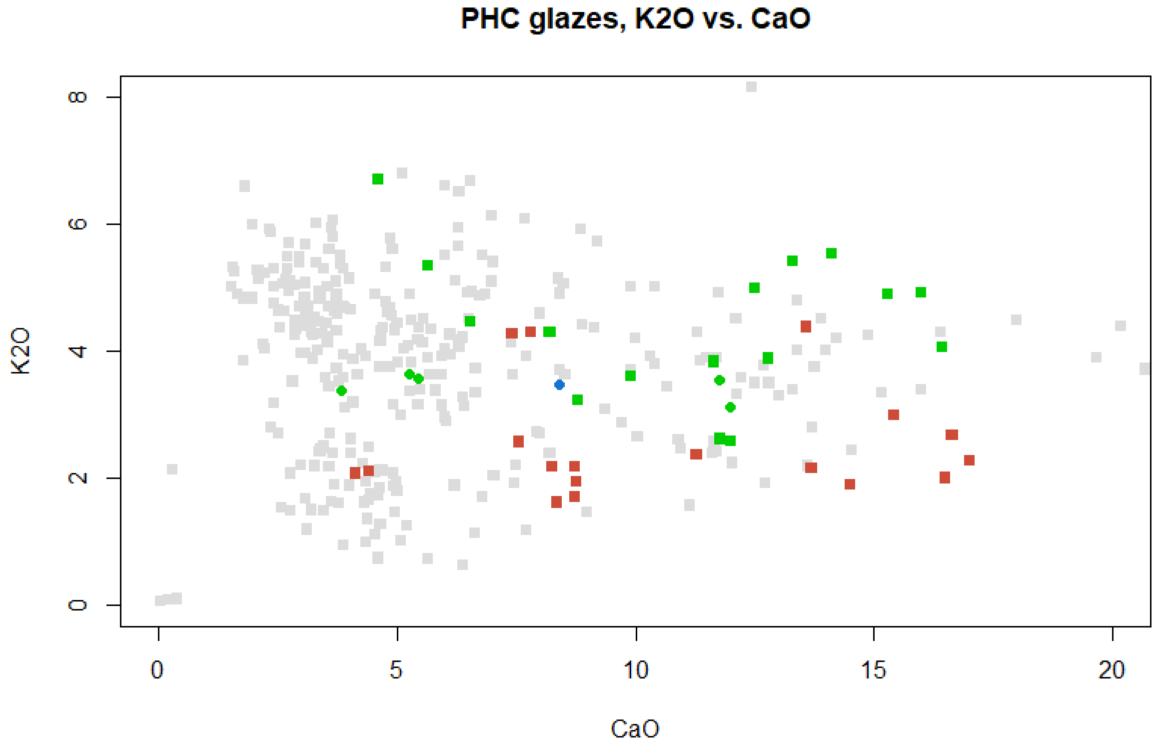
Buff ware

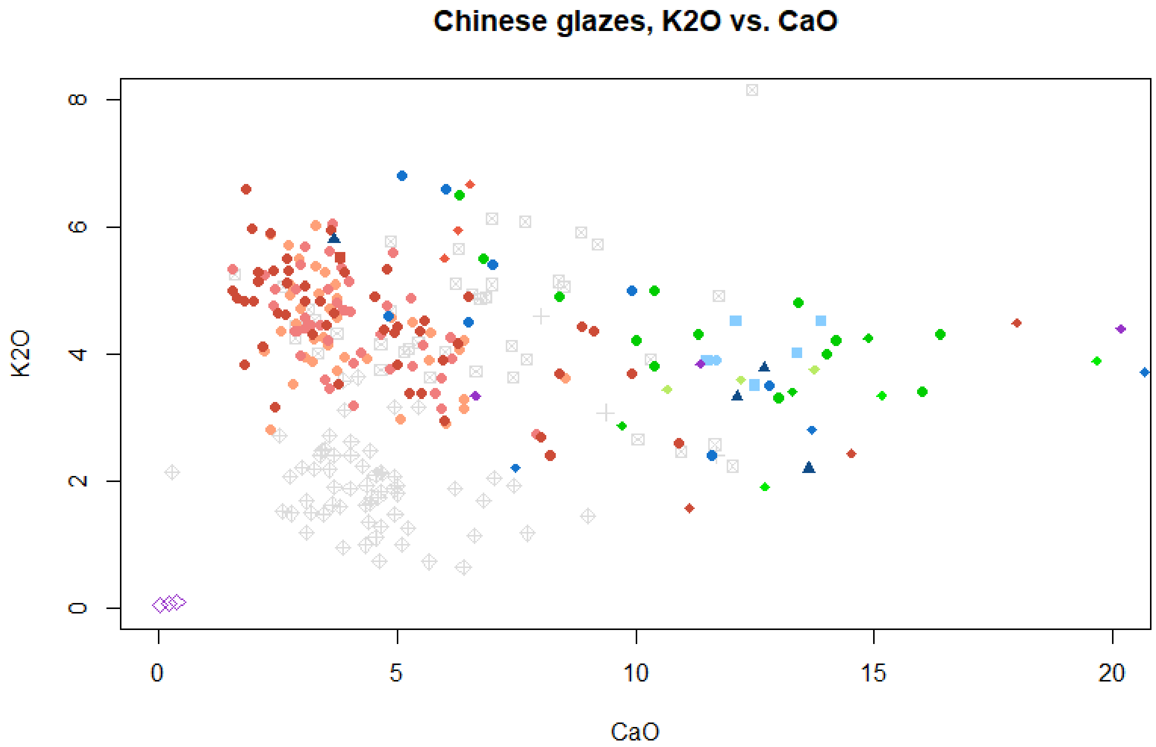
```
> var.test(PHCdata.K[Type=="Buff",]$K,
FTCdataKTrimmed[FTCdataKTrimmed$Type=="Buff",]$K)

        F test to compare two variances

data:  PHCdata.K[Type == "Buff", ]$K and FTCdataKTrimmed[FTCdataKTrimmed$Type ==
"Buff", ]$K
F = 1.7579, num df = 15, denom df = 10, p-value = 0.3705
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 0.4991593 5.3794467
sample estimates:
ratio of variances 
          1.757876

> t.test(PHCdata.K[Type=="Buff",]$K,
FTCdataKTrimmed[FTCdataKTrimmed$Type=="Buff",]$K, equal.var=T)

        Welch Two Sample t-test

data:  PHCdata.K[Type == "Buff", ]$K and FTCdataKTrimmed[FTCdataKTrimmed$Type ==
"Buff", ]$K
t = 0.11392, df = 24.713, p-value = 0.9102
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1844892  0.2060801
sample estimates:
mean of x mean of y 
 1.956250  1.945455
```

There is no statistically significant difference between mean PHC and FTCSG K_2O% values with regards to buff ware.

Glazes

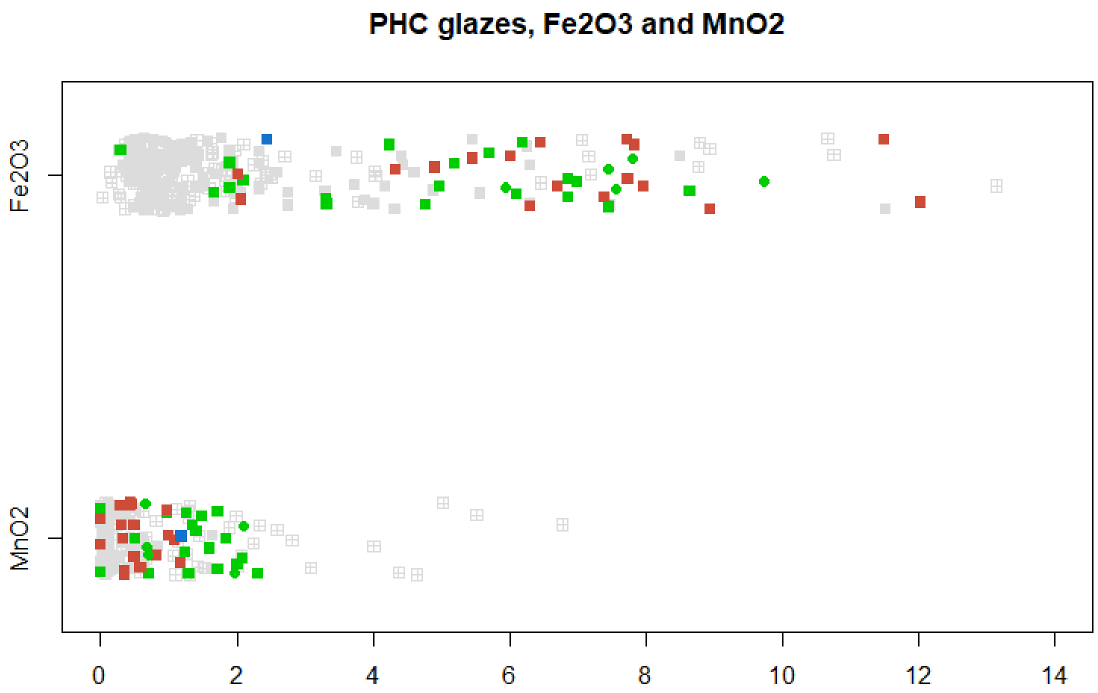
K_2O vs. CaO





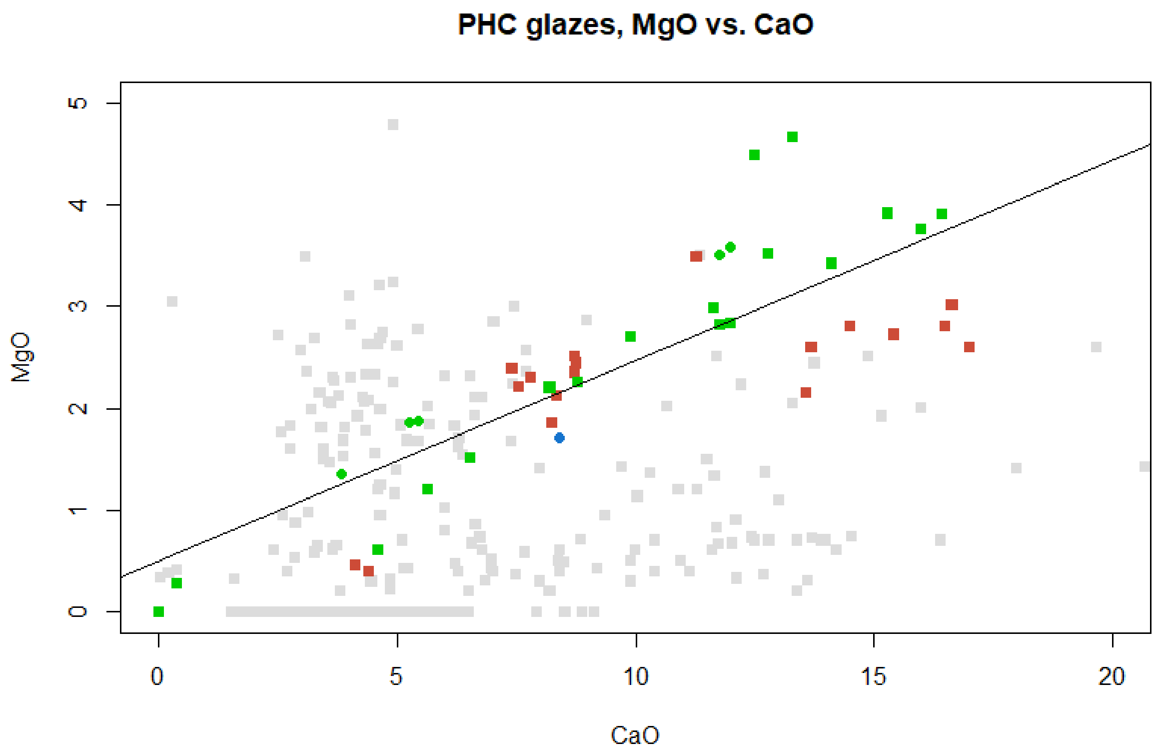
All but two buff glazes—the K2O-glazed exceptions being GA-02 (12.6%) and GA-03 (6.7%)—had CaO as their chief fluxing agent. The brittle ware (in **green**) and buff ware (in **red**) glazes have little in the way of overlap, the brittle glazes containing more K2O per CaO across all ranges. The sole glazed mercury jar sherd (in **blue**) groups closer to the brittle than buff ware. There is little to distinguish the PHC glazes from contemporary Chinese formulae.

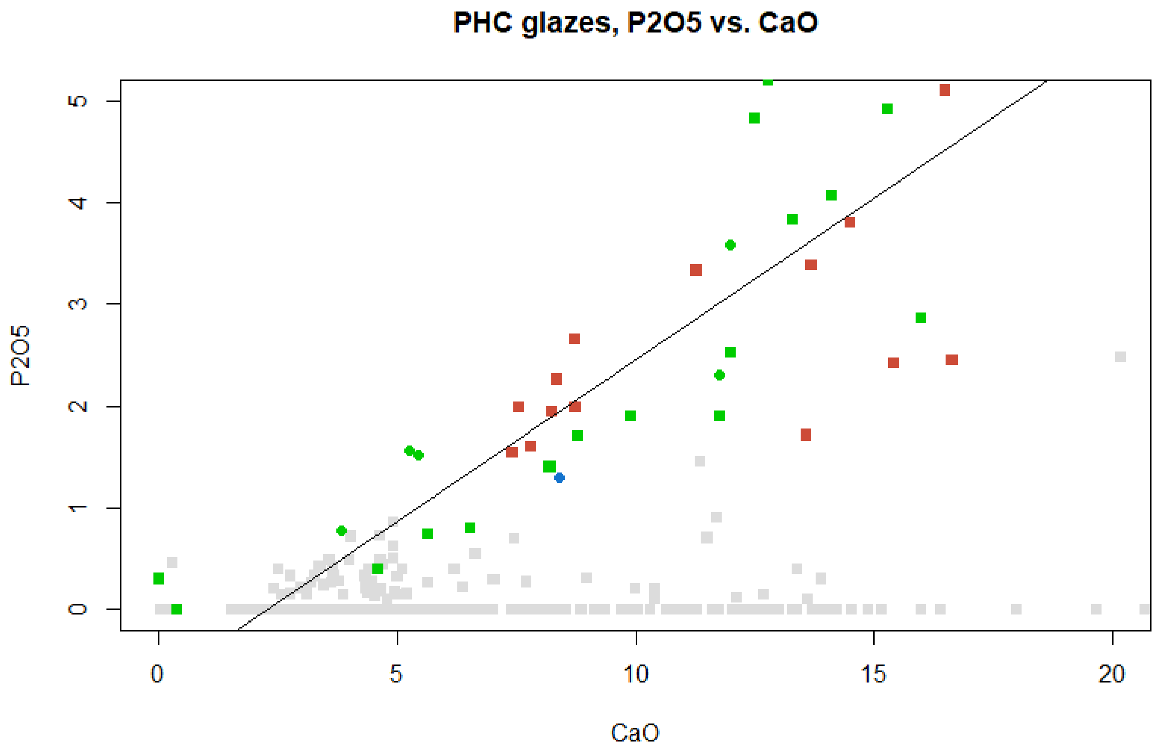
Fe_2O_3 and MnO_2



As with most sites in Singapore and previous measurements from KTC, it appears that iron and not manganese oxides are the chief colourants. Unlike their overall formulae, **brittle** and **buff** glazes are largely indistinguishable in Fe_2O_3 content, although the brittle glazes seem to have more MnO_2 overall. The mercury jar sherd does not contain much of either oxide.

MgO and P_2O_5





As with all other sites, the positive correlation between both MgO and P_2O_5 *and* CaO, once again strongly suggests that Chinese-style glazes seen in Southeast Asia are made with formulae with a higher organic component contemporary glazes in China.