

# Mineral spectra and chemistry of 37 copper bearing surface samples from Apliki copper-gold-pyrite mine in the Republic of Cyprus

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## 2. Citation

**When using the data please cite:**

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**The data are supplementary to:**

Koerting, F. et al., (2019) A Solar Optical Spectral Library of Rare Earth bearing minerals, RE Oxides, Copper bearing minerals and Apliki mine surface samples, Earth System Science Data Discussions <https://doi.org/to be added>

The spectral library presented here is part of a bigger collection of spectral libraries including samples from rare-earth minerals, rare-earth-oxides and copper-bearing mineral samples from mineral collections of the University of Potsdam (UP) and the Federal Institute for Geosciences and Natural Resources (BGR)(Koerting et al., 2019a and Koellner et al., 2019):

Koellner, N., Koerting, F., Horning, M., Mielke, C. and Altenberger, U. (2019): Mineral spectra and chemistry of 20 copper bearing minerals. GFZ Data Services. <http://doi.org/10.5880/GFZ.1.4.2019.003>

Koerting, F.; Herrmann, S.; Boesche, N. K.; Rogass, C.; Mielke, C.; Koellner, N.; Altenberger, U. (2019a): Mineral spectra and chemistry of 32 rare-earth minerals and rare-earth oxides including niobium- and tantalum-oxide.. GFZ Data Services. <http://doi.org/10.5880/GFZ.1.4.2019.004>

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## 3. Abstract

The data set contains mineral chemical analyses of 37 different surface materials from the copper-gold-pyrite mine Apliki in the Republic of Cyprus and their corresponding hyperspectral spectra. The field samples were sampled in March 2018 in cooperation of the Cyprus Geological Survey Department of the Republic of Cyprus (GSD) and the German Research Centre for Geosciences (GFZ). The hyperspectral data was acquired with the HySpex system in a range of 400 – 2500nm and is presented in a spectral library. Detailed information about the mineral specimen, sample area and geochemistry is presented in the data sheets. The spectral library presented here is part of a bigger collection of spectral libraries including samples from rare-earth minerals, rare-earth-oxides (Koerting et al., 2019a, <http://doi.org/10.5880/GFZ.1.4.2019.004>) and copper-bearing minerals (Koellner et al., 2019, <http://doi.org/10.5880/GFZ.1.4.2019.003>).

## 4. Samples

37 samples were taken in March 2018 in the copper-gold-pyrite mine Apliki in the Republic of Cyprus during a measurement campaign of the Cyprus Geological Survey Department of the Republic of Cyprus (GSD) and the German Research Centre for Geosciences (GFZ). The Apliki mine samples were crushed and pulverized to  $\geq 85$  % of the sample passing smaller than 75  $\mu\text{m}$ . Homogenized powders were measured as pressed powder tablets (Figure 1).

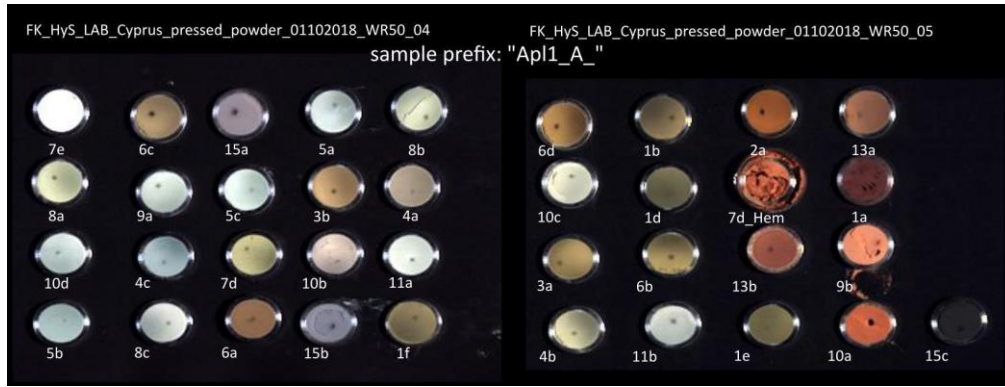


Fig. 1 Showing the Apliki mine samples prepared as powder tablets. Tablet diameter ca. 4 cm. Black spots in each tablet represent previous measurements with a Laser Induced Breakdown Spectrometer (LIBS).

## 5. Hyperspectral measurements

The samples were hyperspectrally measured with the HySpex System in the GFZ laboratory to build a spectral library, measurement parameters see Table 1. A description of the HySpex system can be found in Rogass et al. (2017) and Koerting et al. (2019).







Table 1: HySPEX settings for laboratory measurements of Apliki mine powdered samples.








HySPEX settings		
Lamp arrangement	45°	
Distance, sample to sensor	1 m	
Sensor arrangement head to head	1m lenses, eq on VNIR	
Wavelength range	400 to 2500 nm	
	VNIR	SWIR
Sampling interval	3.7	6
Radiometric resolution	12 bit	14 bit
Light source	2 x 1000 W	
	VNIR (1600 px)	SWIR (320 px)
Frames	variable	variable
Integration time [μs]	60 000	10 000
Frame period [μs]	60 060	239 282

The area to obtain the sample's spectra was chosen over a 5 by 5 pixel window, in the center of the powder tablet to minimize influences from the tablets frame. The dark spots in each tablet (see Figure 1) were caused by the measurement with a laser induced breakdown spectrometer (LIBS), the LIBS data will be available in a future data publication. The spectral sampling spots were chosen to exclude this area in the spectral footprint





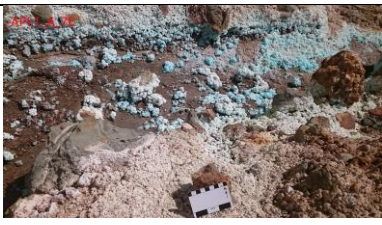

## 6. Sample description








Table 2: Apliki mine samples, including description, coordinates of sampling in March 2018 and a field photo of the sample.






Sample-ID	Description	Latitude (WGS 84)	Longitude (WGS 84)	Photo
Apl1_A_1a	"fresh" surface	35.077033	32.842833	
Apl1_A_1b	hematite coloured	35.077017	32.842833	
Apl1_A_1d	"fresh" dark green	35.077017	32.842833	
Apl1_A_1e	yellow-ish orange weathered	35.077033	32.8428	
Apl1_A_1f	"soil formation", gravel	35.07700	32.84275	
Apl1_A_2a	waste, soil	35.076867	32.84275	

Apl1_A_3a	yellow-ish weathered, soil	35.076983	32.843083	
Apl1_A_3b	brownish weathered, soil	35.077	32.84305	
Apl1_A_4a	white, soil-ish	35.076967	32.843067	
Apl1_A_4b	grey, soil-ish	35.077	32.843033	
Apl1_A_4c	grey-green	35.077	32.842633	
Apl1_A_5a	grey-medium	35.076983	32.843167	
Apl1_A_5b	grey-dark	35.07705	32.843167	



Apl1_A_5c	grey-light	35.077083	32.843183	
Apl1_A_6a	soil, gravel	35.076967	32.8431	
Apl1_A_6b	soil, gravel	35.07695	32.8432	All samples from same spot, see 6a
Apl1_A_6c	soil, gravel	not available	not available	All samples from same spot, see 6a
Apl1_A_6d	soil, gravel	not available	not available	All samples from same spot, see 6a
Apl1_A_7d	Grey, crust unstable	35.076967	32.84325	
Apl1_A_7d_Hem	Red, hematite	35.076967	32.84325	
Apl1_A_7e	blue crystal	35.076833	32.843217	
Apl1_A_8a	grey, soil-ish,	35.076917	32.8433	

Apl1_A_8b	grey, soil-ish,	35.076933	32.84335	
Apl1_A_8c	grey, soil-ish,	35.076917	32.8433	
Apl1_A_9a	light green	35.076883	32.843333	
Apl1_A_9b	hematite vein	35.076833	32.843317	
Apl1_A_10 a	white with pink	35.076733	32.843383	
Apl1_A_10 b	white with purple	35.076833	32.843383	
Apl1_A_10 c	green-ish veins	35.07685	32.843333	
Apl1_A_10 d	white	35.076833	32.84335	See overview photo from 10c, no detail photo available

Apl1_A_11 a	weathering crust	35.076783	32.843533	
Apl1_A_11 b	green	35.076767	32.843517	
Apl1_A_13 a	red, rock	35.076133	32.843333	
Apl1_A_13 b	red, gravel, weathered hillside rock	35.076117	32.8434	
Apl1_A_15 a	dark blue	35.076133	32.843217	
Apl1_A_15 b	light blue rock+ blue crust	35.076133	32.843217	See sample Apl1_A_15a
Apl1_A_15 c	black pyrite	35.076133	32.843217	See sample Apl1_A_15a

## 7. Geochemical analyses

The Apliki mine samples were analyzed by Bureau Veritas Minerals (BVM). The sample numbers, analysis type and BVM analysis codes can be found in table 3, an explanation of the BVM codes is presented in table 4. One sample was analyzed of the aquatic analysis type, the rock analysis type included 25 samples and soil analysis type included 11 samples.



Table 3: Apliki mine samples and the corresponding analysis type and BVM code

Analysis type	Samples with prefix “AP/1-A”-	BVM code
Aquatic	1a	SHP01, CRU80, PULHP, AQ250
Rock	1b, 1d, 1e, 4c, 5a, 5b, 5c, 7d, 7d-Hem, 7e, 8a, 8b, 8c, 9a, 9b, 10a, 10b, 10c, 10d, 11a, 11b, 13a, 15a, 15b, 15c	SHP01, PRP70-250, TC000
Soil	1f, 2a, 3a, 3b, 4a, 4b, 6a, 6b, 6c, 6d, 13b	SHP01, PRP70-250, DISP2, TC000

Table 4: Sample preparation and description of the BVM according to their sample type

BVM Code	Description
SHP01	Per sample shipping charges for branch shipments
CRU80	Crush to 80% passing 10 mesh
PULHP	Hand Pulverize samples mortor and pestle
AQ250	Ultra Trace Geochemical Aqua Regia digestion, 1:1:1 Aqua Regia digestion ( HNO <sub>3</sub> -HCl acid digestion), Ultratrace ICP-MS analysis
PRP70-250	Crush, split and pulverize 250 g rock to 200 mesh
LF302-EXT	Lithogeochemical Whole Rock Fusion, LiBO <sub>2</sub> /LiB <sub>4</sub> O <sub>7</sub> fusion ICP-ES analysis Comment: Major oxides do not sum to 100% due to possible incomplete fusion of some minerals or other element oxides may be present.
DISP2	Heat treatment of Soils and Sediments.
TC000	Carbon and Sulphur Analysis

## 8. File description

### 8.1. *Apliki-sprectral-library.zip: Envi Spectral Library File and ASCII*

The spectral libraries can be downloaded as an ASCII \*.txt file format and the Envi spectral library files format with its associated header files \*.hdr. The file names are: “GFZ\_HySpex\_apliki\_mine.” and “GFZ\_HySpex\_apliki\_mine.hdr” and for the ASCII file “GFZ\_HySpex\_apliki\_mine.txt”. The spectral library can be visualized in Envi (see Figure 2). Figure 3 shows the text file. It presents in column 1: the wavelength and the samples from column 2 – 38.

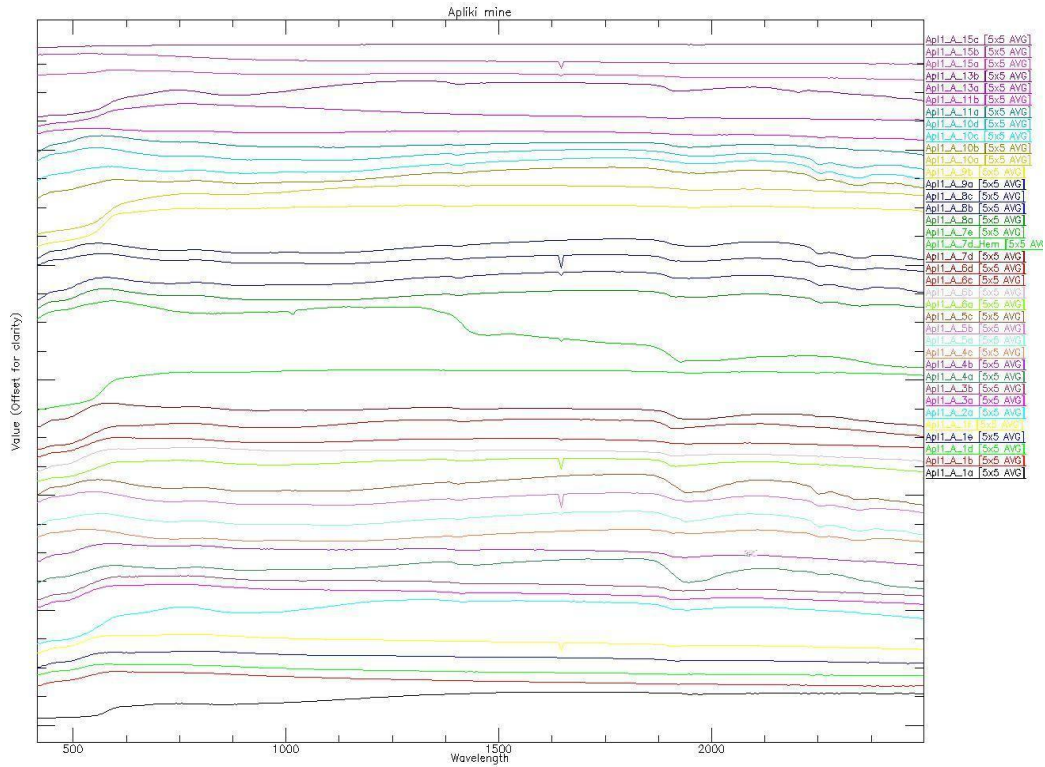


Figure 2: Spectral library of the different Apliki mine samples.

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ENVI ASCII Plot File [Tue Jun 25 11:37:03 2019]
Column 1: Wavelength
Column 2: Apl1.A.1a [5x5 AVG]~1
Column 3: Apl1.A.1b [5x5 AVG]~2
Column 4: Apl1.A.1d [5x5 AVG]~3
Column 5: Apl1.A.1e [5x5 AVG]~4
Column 6: Apl1.A.1f [5x5 AVG]~5
Column 7: Apl1.A.2a [5x5 AVG]~6
Column 8: Apl1.A.3a [5x5 AVG]~7
Column 9: Apl1.A.3b [5x5 AVG]~8
Column 10: Apl1.A.4a [5x5 AVG]~9
Column 11: Apl1.A.4b [5x5 AVG]~10
Column 12: Apl1.A.4c [5x5 AVG]~11
Column 13: Apl1.A.5a [5x5 AVG]~12
Column 14: Apl1.A.5b [5x5 AVG]~13
Column 15: Apl1.A.5c [5x5 AVG]~14
Column 16: Apl1.A.6a [5x5 AVG]~15
Column 17: Apl1.A.6b [5x5 AVG]~16
Column 18: Apl1.A.6c [5x5 AVG]~17
Column 19: Apl1.A.6d [5x5 AVG]~18
Column 20: Apl1.A.7d [5x5 AVG]~19
Column 21: Apl1.A.7d_Hem [5x5 AVG]~20
Column 22: Apl1.A.7e [5x5 AVG]~21
Column 23: Apl1.A.8a [5x5 AVG]~22
Column 24: Apl1.A.8b [5x5 AVG]~23
Column 25: Apl1.A.8c [5x5 AVG]~24
Column 26: Apl1.A.9a [5x5 AVG]~25
Column 27: Apl1.A.9b [5x5 AVG]~26
Column 28: Apl1.A.10a [5x5 AVG]~27
Column 29: Apl1.A.10b [5x5 AVG]~28
Column 30: Apl1.A.10c [5x5 AVG]~29
Column 31: Apl1.A.10d [5x5 AVG]~30
Column 32: Apl1.A.11a [5x5 AVG]~31
Column 33: Apl1.A.11b [5x5 AVG]~32
Column 34: Apl1.A.13a [5x5 AVG]~33
Column 35: Apl1.A.13b [5x5 AVG]~34
Column 36: Apl1.A.15a [5x5 AVG]~35
Column 37: Apl1.A.15b [5x5 AVG]~36
Column 38: Apl1.A.15c [5x5 AVG]~37
414.803009 918.467041 1134.609741 1074.268921 1078.173950 1146.552979 669.843567 1413.650513 1355.069214
2070.199463 2525.883057 2477.867188 3518.140137 2831.294189 3367.534912 1087.221191 1360.358398 1309.460571 1135.758057
1717.682495 1433.411133 5196.522461 1951.020874 2795.250977 2509.612305 2984.748291 1797.642334 1041.719116 2820.337402
3153.809814 3153.888428 3383.581299 3444.813232 1187.421143 1095.185791 2607.533447 2604.240234 757.107056
418.440002 912.145203 1143.140259 1063.203735 1125.655151 1187.173462 696.306274 1466.178589 1366.595093
2088.167236 2576.509277 2483.236572 3565.874268 2898.433594 3452.591064 1115.494385 1410.762207 1358.649292 1161.805542
1758.162842 1422.506958 5269.125488 1969.757935 2882.051758 2568.085449 3030.638916 1796.454590 1068.869629 2844.383301
3232.942383 3215.790527 3441.580322 3470.371094 1198.828125 1088.800171 2623.356201 2631.734131 745.724060
422.075989 913.930359 1153.500732 1085.362915 1135.141113 1204.639038 691.242310 1487.087524 1390.763916
2128.700439 2605.846436 2525.250732 3662.356934 2946.044922 3510.343262 1121.157715 1416.602051 1389.490479 1175.566772
1805.118164 1436.894043 5353.198242 2008.459106 2960.762207 2604.251953 3105.143066 1846.783447 1066.870728 2921.990479
3265.742432 3267.317871 3507.958984 3507.783447 1196.713867 1106.002808 2635.951904 2650.189941 765.279968
425.713013 933.170227 1173.614868 1105.953125 1172.910156 1237.121338 714.298401 1529.635986 1433.362183
2172.798828 2675.949463 2574.704590 3730.326416 3001.864014 3579.379883 1153.778320 1480.778564 1416.038086 1209.228271
1872.463257 1453.260864 5415.516113 2081.286377 3019.767822 2664.338623 3174.772217 1860.258179 1095.058594 2978.155518
3325.113281 3332.702148 3589.597412 3546.569580 1213.092896 1132.734009 2613.163574 2634.736328 745.168762

```

Fig 3: Text file of the spectral library.

## **8.2. Aplikasi samples hyperspectral parameters.xlsx Extensive sample list and measured variables:**

The excel file “**Apliki\_samples\_hyperspectral\_parameters.xlsx**” lists the samples and descriptions and the measurement parameters of the HySpex measurements. The Excel file header is described in Table 5.

*Table. 5: Explanation of excel-file header of the hyperspectral measurements*

<b>Header of Excel file</b>	<b>Explanation</b>
Sample	Sample name
Decimal Latitude	Latitude location of the sample
Decimal Longitude	Longitude location of the sample
Description	Explanation of alteration condition of sample material, colour, surface conditions
HySpex Measurement	Filename
VNIR integrationtime (us)	Light exposure on VNIR sensor
VNIR frameperiod (us)	Time per line that the sensor allows data acquisition
VNIR frames	Number of frames measured
VNIR lens	VNIR lens used
SWIR integrationtime (us)	Light exposure on SWIR sensor
SWIR frameperiod (us)	Time per line that the sensor allows data acquisition
SWIR frames	Number of frames measured
SWIR lens	SWIR lens used
WR (%)	White reference standard used
SNR frame averaging	Number of frames that are averaged per measured frame
Temperature (°C)	Room temperature
Pressure (hPa)	Room pressure
Humidity (%)	Room humidity

## **8.3. Aplikasi geochemistry.xlsx: Geochemical Analyses**

The geochemical analysis is explained in detail in Koerting et al., 2019). The geochemical analysis provided by Bureau Veritas Minerals (BVM) can be found in the excel sheet “**Apliki\_geochemistry.xlsx**”. The sheet contains three tabs, dividing the analysis results based

on their analysis type as seen in table 3. One sheet includes the aquatic samples, one the rock samples and one the soil samples.

Header of Excel file	Explanation
Sample	Sample name
Decimal Latitude	Latitude location of the sample
Decimal Longitude	Longitude location of the sample
Method, Analyte, Unit, MDL	Method of analysis as explained in table 4, analyte (e.g. SiO <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub> , etc.) unit (either kg, %), PPM, method detection limit

Header of Excel file	Explanation
Method L300 (rocks and soils)	Lithogeochemical Whole Rock Fusion, LiBO <sub>2</sub> /LiB <sub>4</sub> O <sub>7</sub> fusion ICP-ES analysis Comment: Major oxides do not sum to 100% due to possible incomplete fusion of some minerals or other element oxides may be present.
Method TC000 (rocks and soils)	Carbon and sulphur analysis
Method AQ250 (aquatic)	Ultra Trace Geochemical Aqua Regia digestion, 1:1:1 Aqua Regia digestion ( HNO <sub>3</sub> -HCl acid digestion), Ultratrace ICP-MS analysis
Analytes LF300 (rocks and soils)	SiO <sub>2</sub> , Al <sub>2</sub> O <sub>3</sub> , Fe <sub>2</sub> O <sub>3</sub> , MgO, CaO, Na <sub>2</sub> O, K <sub>2</sub> O, TiO <sub>2</sub> , P <sub>2</sub> O <sub>5</sub> , MnO, Cr <sub>2</sub> O <sub>3</sub> , Cu, Ba, Zn, Ni, Co, Sr, Zr, Ce, Y, Nb, Sc, TOT/C, TOT/S
Analytes AQ250 (aquatic samples)	Mo, Cu, Pb, Zn Ag, Ni, Co, Mn, Fe, As, U, Au, Th, Sr, Cd, Sb, Bi, V, Ca, P, La, Cr, Mg, Ba, Ti, B, Al, Na, K, W, Sc, Tl, S, Hg, Se, Te, Ga
Units	Either kg, % or PPM
MDL	method detection limit varies by element/ oxide



## 9. References

Koellner, N., Koerting, F., Horning, M., Mielke, C. and Altenberger, U. (2019): Mineral spectra and chemistry of 20 copper bearing minerals. GFZ Data Services. <http://doi.org/10.5880/GFZ.1.4.2019.003>

Koerting, F. et al., (2019) A Solar Optical Spectral Library of Rare Earth bearing minerals, RE Oxides, Copper bearing minerals and Apliki mine surface samples, Earth System Science Data Discussions <https://doi.org/to be added>

Koerting, F.; Herrmann, S.; Boesche, N. K.; Rogass, C.; Mielke, C.; Koellner, N.; Altenberger, U. (2019a): Mineral spectra and chemistry of 32 rare-earth minerals and rare-earth oxides including niobium- and tantalum-oxide.. GFZ Data Services. <http://doi.org/10.5880/GFZ.1.4.2019.004>

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