A Petrographic and Geochemical Database for Countertops as a Teaching Resource

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http://educ.jmu.edu/~johns2ea/countertops.htm

Abstract

A petrographic and geochemical database (http://educ.jmu.edu/~johns2ea/countertops.htm) was created for commercial countertop rocks installed as desks in the Mineralogy/Petrology classroom in the Department of Geology and Environmental Science at JMU. Leftover countertop materials from a local supplier were used to make twenty desks from ten commercially available igneous and metamorphic countertops: Baltic Brown, Bethel Ash, Giallo Fiorito, Golden Leaf, Green Butterfly, Rainbow Red, Santa Cecilia, Tan Brown, Tropical Brown, and Ubatuba. These countertops should be widely available in home improvement stores and countertop suppliers, and samples are therefore accessible by other instructors across the country. The cost of purchasing and installing the countertops was relatively affordable and comparable to the cost of installing standard black chemical-resistant laboratory countertops. It is not necessary to permanently install large countertops to use these materials in class activities; smaller pieces can be installed or can be used as hand samples. Images of whole thin sections in both unpolarized and cross-polarized light were obtained using a photo scanner. Mineral assemblages were determined using a combination of optical techniques on a polarizing microscope and EDS analysis using the JEOL-8900 electron microprobe at the USGS in Reston. Representative feldspar compositions for each rock were also determined using the electron microprobe. Modal abundances of major minerals were calculated by counting 340-400 points on an evenly spaced grid across each thin section. Representative samples were sent to a commercial laboratory for whole-rock major and trace element geochemistry using ICP-AES analyses. Instructors can use this data to create their own course activities and labs, or can use or modify example exercises listed on the database website. These include a jigsaw activity to create a poster for each countertop containing petrographic and geochemical data and interpretations; point-counting on the countertops themselves using plastic fencing as a grid; and comparing feldspar compositions obtained optically using the Michel-Levy method to those obtained with the electron microprobe.

Project Overview

The Department of Geology and Environmental Science at James Madison University recently renovated our Mineralogy/Petrology classroom. Rather than put in standard lab counters, Lab Manager Ron Phillips obtained leftover countertop materials from a nearby commercial supplier.

Two desks from 10 different commercial countertops were installed for a total of 20 desks in the classroom. These rocks are decidedly non-local, but should be widely available in home improvement stores nationwide. We realized that instructors around the country would have access to these rocks, and that the data we obtained for the samples and the exercises we developed could be useful to others!

It cost about $31 per square foot, plus the cost of labor, to install the countertops. This is roughly comparable to the cost of installing standard black chemical-resistant lab countertops. If a classroom renovation is in the future for your department, countertop stone is a relatively affordable option.

Even if a renovation isn't in your future, countertop and building stones are readily available to use in the classroom. Small samples or discards from building suppliers may be obtained for little or no cost.

Analytical Methods

Whole-rock geochemical analyses: Representative splits from extras of each countertop were sent to ALS Minerals for major and trace element analyses by ICP-AES analysis (ALS Minerals website).

Mineral assemblages: Mineral assemblages for each countertop were assessed in three ways. Research student Sarah O'Reilly independently identified and described minerals she found within petrographic thin sections using optical methods. These results were then compared to results from three semesters' worth of projects from the Introduction to Petrology course. Accessory minerals and unknowns were also identified using EDS analyses using the electron microprobe at the USGS in Reston. Results were compiled into modal abundance spreadsheets.

Modal abundances: The modal abundance of major minerals within each rock was determined by point-counting. A scanned image of each thin section was printed, and a grid with spacing corresponding to 1.35 mm on the thin section was drawn to scale on the image. A total of 340-408 points were counted for each thin section on a petrographic microscope, using the gridded image as a guide.

Thin section images: Images were obtained using an Epson Perfection V300 Photo scanner. Thin sections were sandwiched between two 2" polarizer film squares to obtain cross-polarized images (See References).

Sarah O'Reilly scanning petrographic thin sections under crossed polarizers.

Electron microprobe analyses of feldspars: Feldspar compositions were obtained using the JEOL-8900 electron microprobe at the USGS in Reston. Analyses were obtained at 15 kV and 20 nA using a 5 micrometer defocused beam. Counting times were 20-60 sec on peak.

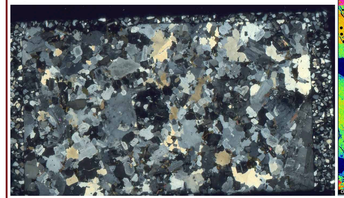
Data

The database includes the following information for each sample:

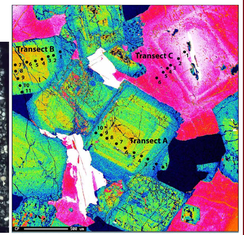
- Hand sample image;
- Modal abundance, mineral assemblage, and IUGS classification (spreadsheet);
- Major and trace element geochemistry (spreadsheet);
- Petrographic images: full slide in unpolarized and cross-polarized light;
- Electron microprobe analyses of feldspar compositions (spreadsheet);
- Map of feldspar compositional analyses;
- Source information from commerical countertop websites.

Example: Bethel Ash

Original Location: NH. Second source: Brazil.



Thin section of Bethel Ash scanned using crossed polarizing films. Thin section glass is 27mm x 46mm; epoxy contains quartz grains on edges of section.



False-color back-scattered electron (BSE) image of feldspars in Bethel Ash. Locations of electron microprobe analyses of feldspars are marked on this diagram.

BETHEL ASH

IUGS: Granodiorite

Electron microprobe analyses of feldspars. Spreadsheets in online database also include wt% oxides and calculated formulae.

Mineral Abundances

	Mineral	Modal Abundance	Size	Morphology	Features
1	K Feldspar	37.4	0.5-4mm	Subhedral	Oikocrysts, Perthitic Intergrowths
2	Plagioclase	32.6	0.5-5mm	Subhedral-Euhedral	Extensive Zoning, Polysynthetic Twins
3	Quartz	25.6	0.5-2mm	Subhedral	Undulatory Extinction and Twinning
4	Biotite	2.3	0.5-2mm	Anhedral-Subhedral	Brown in PPL
5	Chlorite	1.2	1mm	Anhedral-Subhedral	Green in PPL
6	Oxides	0.9	<1mm	Subhedral	Opaque
7	Muscovite	Trace	0.5-1mm	Anhedral	Colorless in PPL, High Birefringence
8	Zircon	Trace	<0.1mm	Euhedral	Pleochroic Halos in Biotite

Transect A	An	Ab	Or
Spot 1	27.3	71.8	0.9
Spot 2	21.2	77.6	1.2
Spot 3	24.0	74.1	1.9
Spot 4	31.8	66.7	1.6
Spot 5	26.8	71.9	1.6
Spot 6	32.8	65.9	1.3
Spot 7	33.1	66.1	1.2
Spot 8	33.5	64.9	1.6
Spot 9	25.2	73.5	1.4
Spot 10	20.1	78.8	1.1

Transect B	An	Ab	Or
Spot 1	16.6	81.5	1.9
Spot 2	20.2	77.8	2.0
Spot 3	25.9	72.1	1.9
Spot 4	30.3	68.4	1.4
Spot 5	33.9	64.8	1.3
Spot 6	32.1	66.7	1.2
Spot 7	32.1	66.5	1.4
Spot 8	34.0	64.7	1.3
Spot 9	24.6	73.6	1.8
Spot 10	23.3	75.1	1.5

Transect C	An	Ab	Or
Spot 1	0.8	12.8	86.6
Spot 2	0.2	13.9	85.9
Spot 3	0.4	13.0	86.6
Spot 4	0.1	13.0	86.9
Spot 5	0.4	10.6	89.0
Spot 6	0.3	11.5	88.2

Textures:
Phaneritic
Poikilitic
Myrmekitic
Chloritization

Average plagioclase composition from electron microprobe analysis:
Anorthite= 18.01%

Minerals identified with EDS during electron microprobe analysis:
Chalcopyrite
Ilmenite
Zircon
Magnetite
Sphene

Whole-rock geochemical analysis.

Sample Name	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	Na_2O %	K_2O %	Cr_2O_3 %	TiO_2 %	MnO %	P_2O_5 %	SrO %	BaO %	LOI %	Total %
Bethel Ash	70.5	14.45	2.95	2.57	0.53	3.84	2.99	<0.01	0.27	0.07	0.08	0.07	0.12	0.8	99.2

Ag ppm	Ba ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Cu ppm	Dy ppm	Er ppm	Eu ppm	Ga ppm	Gd ppm	Hf ppm	Ho ppm	La ppm	Lu ppm	Mo ppm	Nb ppm	Nd ppm	Ni ppm	Pb ppm	Pr ppm	Rb ppm	Sm ppm	Sn ppm	Sr ppm	Ta ppm	Tb ppm	Th ppm	Tl ppm	Tm ppm	U ppm	V ppm	W ppm	Y ppm	Yb ppm	Zn ppm	Zr ppm
<1	1045	66.6	3.4	<10	2.02	15	1.92	1.1	0.87	18.3	3.29	4.8	0.37	35.7	0.17	<2	8.7	22.7	<5	20	7.08	87.4	3.49	4	580	0.7	0.41	11.15	<0.5	0.16	2.81	24	2	10.7	1.07	69	179

Examples of Projects and Exercises

Objective: Describe rock textures and create hypotheses to explain how they formed during cooling. All of these countertops are made of similar minerals, but look very different. Students describe grain size and overall texture of their countertop. Students can then hypothesize about order of crystallization and how features like rapakivi or exolution lamellae might form.

Objective: Evaluate radon risk from countertops.
Use whole-rock geochemistry to evaluate radon risk. From EPA: U and Th in countertops pose insignificant radon risk compared to levels in soil and bedrock. "... it is extremely unlikely that granite countertops in homes could increase the radiation dose above that the normal, natural background dose that comes from soil and rocks."

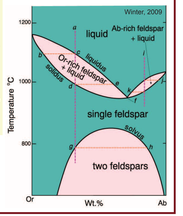
Objective: What makes a good countertop?
Identify the major minerals within one or more countertops, and come up with a representative Moh's hardness for each one. The examples in this database are composed mostly of feldspar and quartz, making them resistant to scratching.

Countertop geochemistry detectives: Where did this rock come from?
Objective: Learn to plot and interpret tectonic discrimination diagrams using geochemical data.
Although we may have some idea of the country or region of origin for many of these countertops (see individual data pages for each countertop), we still don't know the exact location of these rock units. Another way to trace the origin of the countertops is to plot the appropriate whole-rock trace element data on tectonic discrimination diagrams (Pearce et al. 1984). These diagrams empirically distinguish among tectonic settings for granites.

Michel-Levy method to determine plagioclase composition
Objective: Learn the procedure and limitations of the Michel-Levy method.
Plagioclase is present in most of the countertops. This database includes electron microprobe analyses in transects across plagioclase crystals. Students can learn how to perform the optical Michel-Levy method using the polrizing microscope using thin sections of the countertops, and then compare their answers to the electron microprobe data for that sample. It is likely that students will encounter issues with using this technique (trouble finding correctly oriented grains; zoning within the crystal), which can become a teachable moment about the complexity of using natural samples.
Many optical mineralogy texts have descriptions of the Michel-Levy method (e.g. Nesse 1991).

Poster Project: Jigsaw Exercise
Objectives: Students review identification of minerals under the polarizing microscope and learn how to complete a petrographic description of a sample. Students also learn how to name rocks based on the IUGS classification diagrams. Geochemical classification diagrams can also be introduced. The jigsaw provides an opportunity for peer review.
Available on webite: Lab instructions (.doc), Sample description worksheet template (.doc), Grading rubric (.doc), Poster template (an 11" x 17" .ppt slide)

Objective: Calculate temperature using feldspar thermometry.
A few of the countertops contain both plagioclase and alkali feldspars. Students can calculate temperature empirically from a phase diagram. Spreadsheets for a two-feldspar thermometer and a feldspar thermometer can be found online (supplementary materials for Reviews in Mineralogy and Geochemistry volume 69, 2008). Zoning and other textural information should be used to evaluate equilibrium.



Objective: Learn to calculate modal abundances of minerals.
Students point-count minerals on the countertop using deer fencing as a point grid.
Available on website: Instruction guide.

References

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Baltic Brown | Bethel Ash | Giallo Fiorito | Golden Leaf | Green Butterfly | Rainbow Red | Santa Cecilia | Tan Brown | Tropical Brown | Ubatuba