Mantle Boy Cards: A New Petrologic Learning Tool

Bob Stern and Amy Webber, U Texas at Dallas

I teach undergraduate petrology and want to find ways to better teach fundamental concepts to my classes. There are three key foundations for petrology: major element chemical compositions of igneous rocks, their constituent mineralogy, and their lithologic names. If a student has a good grasp of each of these fields then they are in a position to learn how each of these three foundations inform each other. For example, why do we expect to find olivine in a basalt but not in a granite? Or, why do we expect to find K-feldspar in granite and not in a basalt? What does the presence of muscovite tell us about the amount of aluminum in the magma that it formed from? Such chemical, mineralogical, and lithological understandings must grow together in a student's mind in order for them to appreciate the beauty of petrology but it is very hard for many undergraduates to wade through all the different concepts and jargons. In particular they get confused about the difference between chemicals and minerals and between minerals and rocks. How can instructors aid this learning?

It seems to me that helping students get a stronger grasp of igneous mineralogy is key; once students know the igneous rock-forming minerals, it is much easier for them to understand how different combinations of these make different rocks. In addition, student mastery of igneous mineralogy requires remembering approximate chemical formulas for each (as well as the concept of solid solution), so understanding the distinctive chemical composition of minerals leads to a deeper appreciation of what major element compositions of rocks tells us about the mineralogy of a rock.

There are thousands of minerals on Earth but only a handful are common in most igneous rocks, so how can we better embed these few important minerals in student minds? This was in the back of my mind as I went to the GSA meeting in Denver in 2013 and visited the Ward's booth. I saw their deck of 172 mineral cards https://www.wardsci.com/store/catalog/product.jsp?catalog_number=362503 , which is far more than a petrology student needs to learn. I was inspired to improve on this idea to make a deck of mineral cards that could aid student learning in igneous petrology, but this deck would be more like a regular deck of cards, with 13 different minerals in 4 suits, along with some "Jokers". I settled on a deck with these igneous minerals: Albite, Anorthite, Apatite, Biotite, Clinopyroxene, Hornblende, Microcline, Muscovite, Olivine, Orthoclase, Orthopyroxene, Quartz, and Spinel. I found a place in Florida (Custom Playing Cards, Orlando FL) that printed custom decks, minimum order 500 decks. I somehow convinced UTD undergraduate Amy Webber that she wanted to spend a good bit of her winter break perfecting the cards. We decided on 4 suites, corresponding to three plate tectonic boundaries and mantle plumes, each color-coded (Fig. 1).

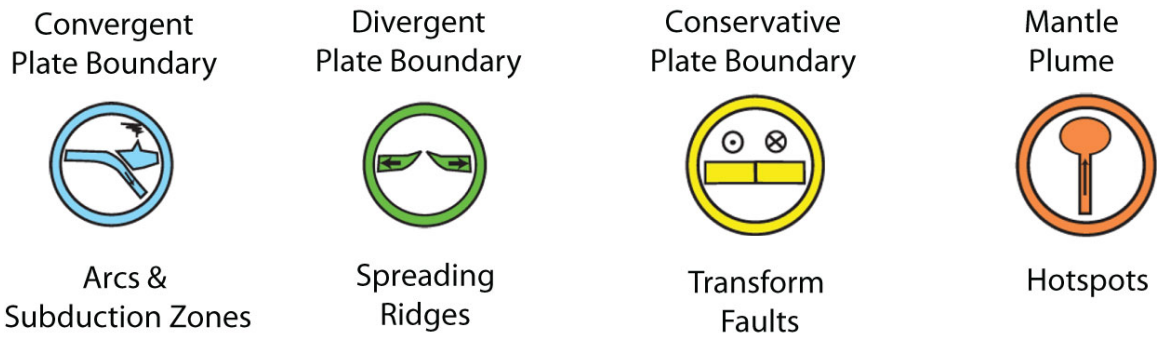

Fig. 1: The four different "suits" for the cards.

We abbreviated minerals to follow CIPW norm terminology as much as possible; these abbreviations in the color of the suit, dominate the upper left. A photo of the representative mineral dominates the center of the card, with a photomicrographs also shown. Around these we spelled out the mineral name, along with crystal class, chemical formula, and density (Fig. 2).

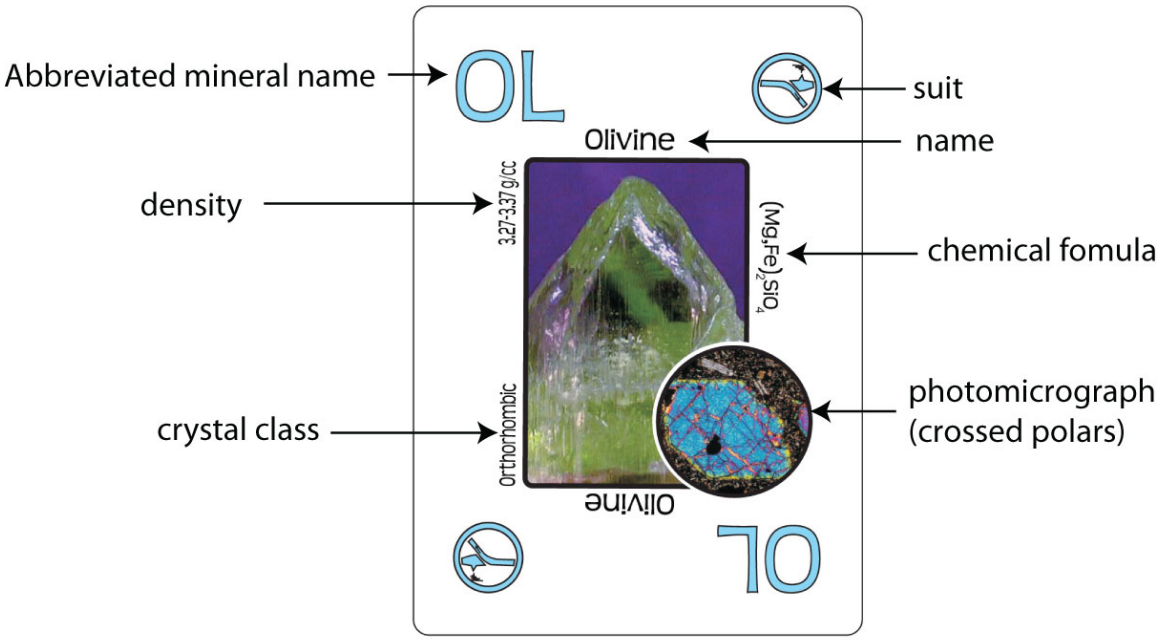

Fig. 2: Format of a typical card.

There were two undersaturated minerals, Nepheline and Leucite as "Jokers". These jokers have the same format as the main cards but instead of a suit in the upper right we show a stylized QAPF plutonic rock classification diagram (http://en.wikipedia.org/wiki/QAPF_diagram ; Fig. 3); this internationally accepted mineral-based nomenclature is described by Streckeisen 1974).

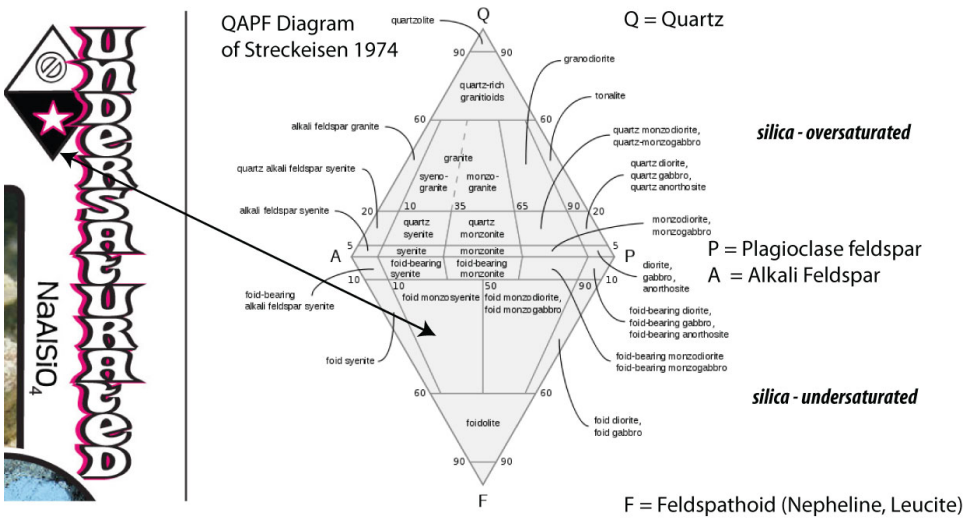

Fig. 3. Upper right corner of the jokers, showing how feldspathoids leucite and nepheline. These provide a very different suite of rocks that trend towards carbonatites and kimberlites.

The back of the cards is illustrated with "Mantle Boy" of Katzu Michibayashi (Shizuoku U, Japan). Katsu had posted a "mantle boy" sketch on Facebook and he agreed to let us use it for the card back. Mantle Boy represents the solid Earth itself, home of the great family of igneous minerals as explained in Fig. 4.

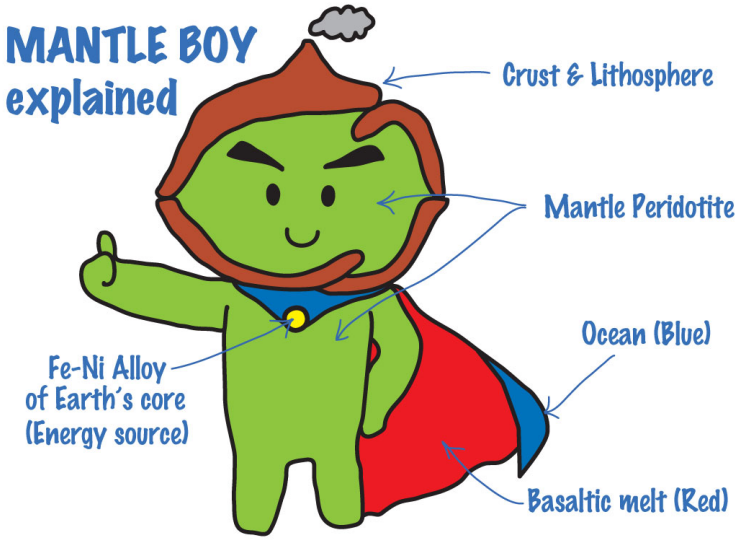

Fig. 4: Mantle Boy of Katzu Michibayashi

The hope is that some learning games using these cards will evolve, but the cards have no relative value so normal card games like gin or poker are difficult to imagine. Some geologic-themed games seem feasible but these need to be thought up. I think a game could be built around Bowen's reaction series. This series relates equilibrium mineralogy to evolving melt compositions (Bowen 1922). BRS is

particularly appropriate because it clearly links a few common igneous minerals to chemical compositions of the most important igneous rocks:

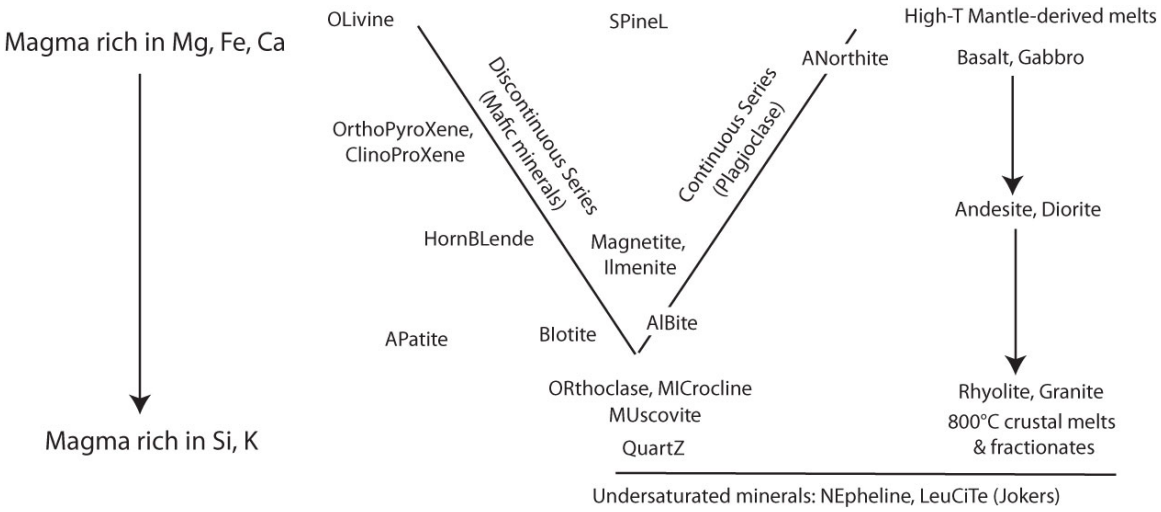

Fig. 1: Bowen's reaction series. The series is broken into two branches, the continuous (right) and the discontinuous (left). Minerals at the top of the illustration are first to crystallize from hot mantle-derived (primitive) magma. From top to bottom shows how magmas and minerals would change as magma cooled and evolved. Note that magma chemistry (left), equilibrium minerals (center) and lithologies (right) change together.

It seems that a game where students are dealt hands and then have to play cards either down or up BSR would work.

The deck seems also very suitable for helping students master the igneous rock classification diagrams that the IUGS endorsed.

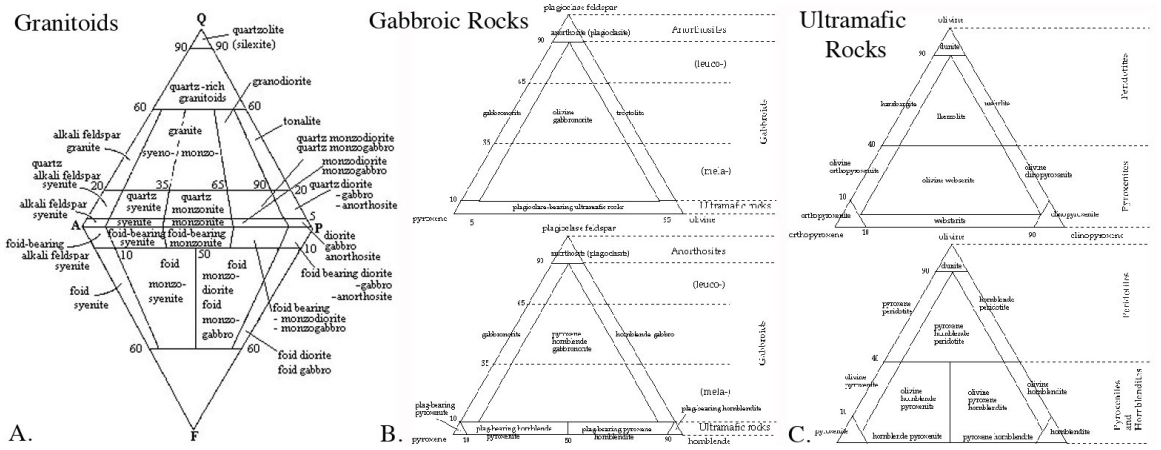

Fig. 2: IUGS classification for phaneritic igneous rocks A. granitoids, including undersaturated varieties; B. Pyroxene and hornblende gbbros; C. Ultramafic rocks

References

Bowen, N. L., 1922. The Reaction Principle. Journal of Geology 30, 177-198.

Streckeisen, A. 1974. Classification and nomenclature of plutonic rocks recommendations of the IUGS subcommission on the systematics of Igneous Rocks. Geologische Rundschau 63: 773–786.