# A More Informative Way to Name Plutonic Rocks—Reply

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> I learned very early the difference between knowing the name of something and knowing something. —Richard Feynman

We appreciate that our paper has generated comments and thank their authors for giving us the opportunity to clarify some of the points that we made.

We assume that anyone who uses the International Union of Geological Sciences (IUGS) classification to name a rock has estimated modal data, whether by eye in the field, by point counting, by electron-beam methods, etc. The main point of our paper was simply that these data should be part of the name rather than discarded or left in a field notebook. Our system permits the use of the IUGS name if one wishes. However, adding modal data to the name permits current terminology to be simplified, and it permits name boundaries to be fuzzy without loss of precision. In our view, fuzzy name boundaries have at least two advantages: the names better depict the nature of modal variation, and they eliminate the use of multiple rock names to refer to suites of closely similar rocks.

As an example, calling a rock a 30,30,30 granite tells you rather directly what is in the rock. In contrast, calling a rock "granite" is vague; the IUGS name "granite" can only be quantified as two inequalities plus an equation, in four unknowns:

$$0.2 < \frac{q}{q+a+p} < 0.6 \tag{1}$$

$$0.1 < \frac{p}{a+p} < 0.65 \tag{2}$$

$$q+a+p+m = 100 \tag{3}$$

where the variables are modal abundances of quartz ($q$), alkali feldspar ($a$), plagioclase ($p$), and the sum of everything else ($m$).

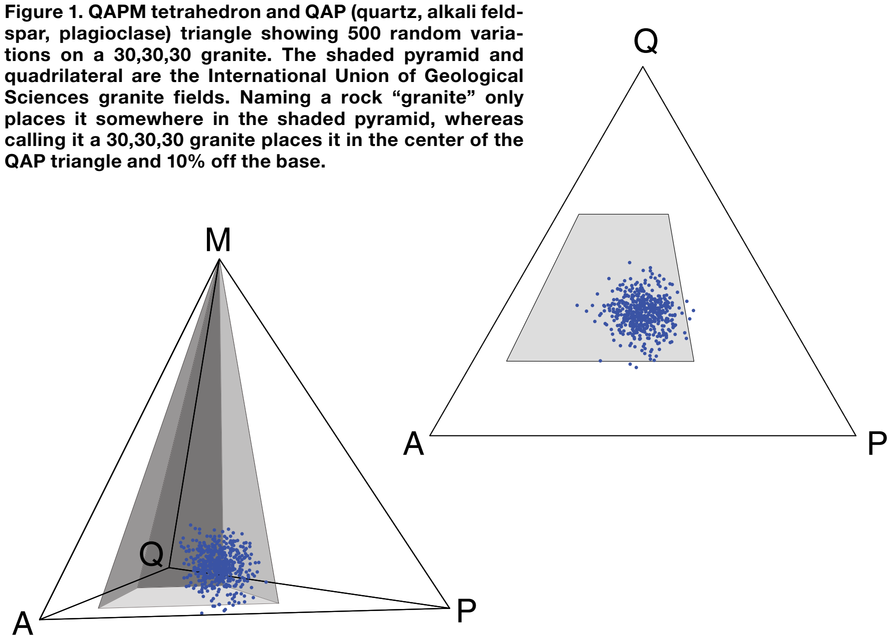
The IUGS term "granite" applies to any composition within the shaded pyramid (Fig. 1) defined by the inequalities and equation above. We know by experience that real granites lie somewhere near the base of this volume, but the IUGS name, even with a modifier such as "leucocratic," gives little help. In contrast, Figure 1 shows 500 variations of a 30,30,30 granite wherein normally distributed numbers with a mean of five were added to the modal abundances. Even with such variation in the estimates, the composition of the rock is narrowed down far better than with the bare IUGS name.

Hogan (2019) states that the IUGS classification is quantitative. It is, at the same level that knowing a postal code narrows down where someone lives—not very precisely. Similarly, he contends that color index is given quantitatively by words such as "leucocratic," which again are quite imprecise; this is akin to noting the time by saying that it is night. We contend that if the color index is observed (as it must be to apply an IUGS name), then it should be reported and not discarded.

We disagree with Hogan (2019) that rock classification is no different from biologic classification. A biologist keying out dogs and cats will find a split after Order Carnivora with dogs at the end of one branch, cats at another, bears at another, and so on; there are no doggish cats or cattish bears—they are discrete species owing to discrete genomes, which is why the Linnaean system has served biologists so well. Not so with igneous rocks; even the volcanic and plutonic realms grade into one another. Thus, any system with sharp boundaries, no matter how well-intentioned, will split continua of rock compositions.

The IUGS system almost seems to have been designed to carve up cogenetic calc-alkaline suites into as many boxes as

**Figure 1. QAPM tetrahedron and QAP (quartz, alkali feldspar, plagioclase) triangle showing 500 random variations on a 30,30,30 granite. The shaded pyramid and quadrilateral are the International Union of Geological Sciences granite fields. Naming a rock "granite" only places it somewhere in the shaded pyramid, whereas calling it a 30,30,30 granite places it in the center of the QAP triangle and 10% off the base.**




*GSA Today*, v. 29, https://doi.org/10.1130/GSATG408Y.1. 

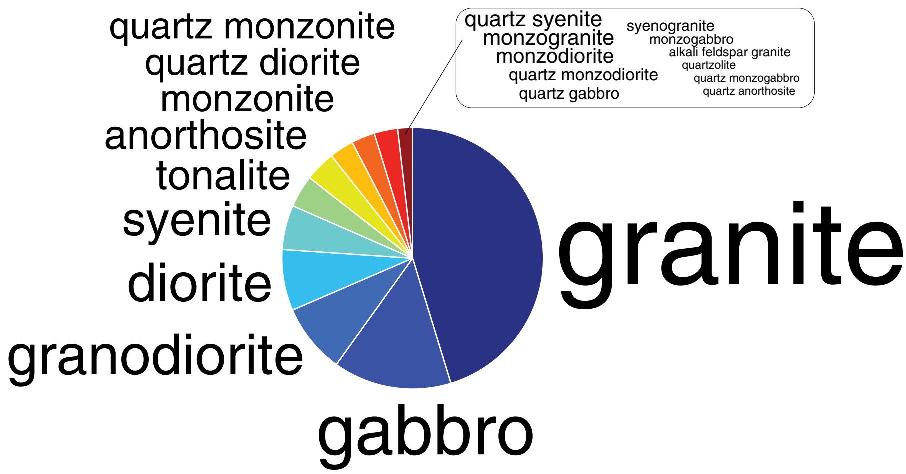



**Figure 2. Relative frequency of occurrence of International Union of Geological Sciences quartz-bearing plutonic rock names in the *Geological Society of America Bulletin*, 1890–present. Relative areas of letters are proportional to frequency. "Granite" dominates, and the top 10 make up over 98% of the names, with the remaining 14 comprising only 1.8%.**

possible. As noted by Frost et al. (2019), such systems produce arrays that radiate from near the P apex and, as we noted in Figure 3 of our original paper, one Yosemite unit crosses the four-way junction where the granodiorite, tonalite, quartz monzodiorite/quartz monzogabbro and quartz diorite/quartz gabbro/quartz anorthosite fields come together. Only confusion can come of this, as four separate field estimates of modes of a rock from near this junction could be 20,10,50; 20,5,55; 15,10,60; and 15,5,60. In our system these are all granodiorites (or tonalites, as the name is secondary), but these would end up with four different IUGS names: granodiorite, tonalite, quartz monzodiorite, and quartz diorite. One could use the full IUGS names, but as long as the numbers are there the names are not important, the similarities among the four estimates are clear, and the estimated color index is derivable.

The contention that one need not know what the IUGS names mean because they can be looked up strikes us as similar to saying that one need not memorize vocabulary to be fluent in a language because one can always just look up all the words. It is self-evident that the use of words that must be decoded interferes with communication.

Many IUGS names are rarely used. Figure 2 shows the frequency of occurrence of the rock names in the quartz-present part of the IUGS diamond in the *Geological Society of America Bulletin*, 1890–2018. As we noted in our paper, rock names generally follow Zipf's Law, in which the frequency of a word or set of words is inversely proportional to its frequency rank. The IUGS names follow this for the first 10 and then drop off precipitously. Many names have been used only a few times, and then only to define a field on an IUGS diagram, a usage that scarcely justifies their continued presence on classification diagrams.

Nothing in our method asks that a rock name be tied to its origin.

Frost et al. (2019) state that the lack of modal data in databases such as EarthChem means that "... their quantitative classification system, in addition to being of limited value in the field, is not likely to be widely applied." This misses the point. Perhaps our field methods differ, but we attempt to estimate modes in the field so that we can correlate, map, and understand the units more effectively. Most field petrologists do so, but the lack of such data in databases means that such data are effectively discarded. Our proposal aims to fix that.

## ACKNOWLEDGMENTS

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