GeoNote 03

Calculation of an Aluminum to Alkali Ratio in Igneous Rocks

In 1927 S. J. Shand in his book, *The Eruptive Rocks,* recognized the confusion in igneous rock terminology and proposed a radically new method of classification based on the Si and Al saturation in igneous rocks. He proposed:

> In attempting to set up a classification to take the place of the disorderly collection of names that does duty as a classification now, what is required of us is that we should pay less attention than we have done in the past to the individual peculiarities of the rocks, and more to the laws that govern their formation. The laws are those of physics and chemistry. The problem before us, then, is to elicit the physico-chemical significance of the various geographical, geological, textural and mineralogical characters that eruptive rocks present, and to express them in a classification.

With this philosophy in mind, Shand developed a classification for eruptive rocks that is in popular use by most geologists today.

He divided the igneous rocks into three classes:

1. Oversaturated rocks—these contain primary silica minerals.
2. Saturated rocks—these do not contain quartz or any undersaturated minerals.
3. Undersaturated rocks—these contain unsaturated minerals, such as nepheline.

Since most rocks have Si and Al as a major constituent, the concept of aluminum saturation relative to the alkali elements (Na, Ca and K) is used by Shand to form a second classification without regard to Si saturation. The following are the four classes of Al saturation:

1. Peraluminous-Alumina > Lime + Soda + Potash
2. Metaluminous-Alumina < Lime + Soda + Potash and Alumnia > Soda + Potash
3. Subaluminous-Alumina = Soda + Potash
4. Peralkaline-Alumina < Soda + Potash and less common Alumina < Potash

This alumina to lime + soda + potash ratio (A/CNK) can be utilized simply knowing the bulk chemistry (whole rock chemistry). It becomes easy to determine whether a rock is classified as peraluminous or metaluminous using the methods described below (taken from J. L. Anderson's paper).

Peraluminous—a rock in which the molecular proportions of alumina are greater than the molecular proportions of the sum of lime + soda + potash (e.g., $Al_2O_3/(CaO+Na_2O+K_2O) > 1.0$).

Peralkaline—rocks classified as those that have alumina less than the sum of the alkali elements.

To calculate A/CNK ratios, first divide the oxide weight percent by the oxide molecular weight. **Do not do the calculation using the oxide percent!!**

EXAMPLE:

Step 1) Al_2O_3 = 12.92%

Oxide molecular weight of Al_2O_3 = 2(26.9) + 3(16) = 101.96;
thus mole percent = 12.92 ÷ 101.96 = 0.1267

(over)

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Step 2) Divide the Al_2O_3 mole percent by the sum of CaO + Na_2O + K_2O mole percentages.
Do not multiply the Ca mole percent by 2!!

Example from Anderson's paper (1983, p.144):

OXIDE	WEIGHT PERCENT		OXIDE MOLECULAR PERCENTAGE		MOLE PERCENT
Al_2O_3	12.92	÷	101.96	=	0.1267
CaO	0.85	÷	56.08	=	0.0151
Na_2O	3.19	÷	61.98	=	0.0515
K_2O	4.87	÷	94.20	=	0.0517

Step 3) Do the calculation:

$$\frac{0.1267}{.0151 + .0515 + .0517} = 1.071 = \text{A/CNK RATIO}$$

OTHER MOLECULAR WEIGHTS

SiO_2	60.08
FeO	71.85
MgO	40.31
TiO_2	79.90
Fe_2O_3	159.6
MnO	70.9

If A/CNK ratio is greater than 1.1, the rock is peraluminous. If it is less than 1.1, the rock is metaluminous. In general, S-type granites are peraluminous and I-type are metaluminous.

Sources:

Anderson, J. Lawford, 1983, "Proterozoic anorogenic granite plutonism of North America," *in* Geological Society of America Memoir 161, p. 133-154.

Shand, S.J., 1927, *The Eruptive Rocks*. New York: Wiley.

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