Errata in Giroux and Chouteau (2008)

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This note is to point out and correct an error in Giroux and Chouteau (2008). Equation 8 in that paper was originally derived with a definition of the specific surface different from that given in the paper, and was not corrected accordingly.

Definitions

Define a mixture with volume $V$ containing a certain amount of clay ($V_c$) and sand ($V_s$), i.e. $V = V_c + V_s$. The intrinsic porosity of the clay is $\phi_c$, defined as the ratio of pore volume in the clay $V_p^c$ to the volume of clay, i.e. $\phi_c = V_p^c / V_c$, and the intrinsic porosity of sand is $\phi_s = V_p^s / V_s$. The surface areas of the pores in the clay and in the sand are noted $S_{p}^c$ and $S_{p}^s$ respectively. Similarly, the volume of solid matrix material is noted $V_{h}^c$ and $V_{h}^s$ for clay and sand. Finally, the clay fraction $c$ is defined by Marion et al. (1992) as the ratio of the volume of room dry shale (clay minerals and associated bound water and macroporosity) to the volume of room dry sand-shale mixture, hence

$$c = \frac{V_c}{V_c + V_s}.$$  \hspace{1cm} (1)

![Figure 1: Conceptual representation of a mixture of sand and clay. Both sand and clay have their intrinsic porosity.](image)
Expressions for the specific surface

There exist at least four definitions of the specific surface $S$ (Schön, 2004). $S$ describes the surface area of voids with respect to either

1. the total volume of rock $V$;
2. the pore volume $V_p$;
3. the volume of the solid host matrix $V_h$;
4. the mass of the dry rock.

Using definition 1, the specific surface of the sand/clay mixture is

$$S = \frac{S_p V}{V_c + V_s}. \quad (2)$$

In $V$, the total surface of the pores is the sum of $S_p^c$ and $S_p^s$. Therefore, we can write

$$S = \frac{S_p^c + S_p^s}{V_c + V_s} = \frac{S_p^c V_c + S_p^s V_s}{V_c + V_s} = \frac{S_p^c V_c}{V_c + V_s} + \frac{S_p^s V_s}{V_c + V_s} = \frac{S_p V_c}{V_c + V_s} + S_s \left( \frac{V_c + V_s}{V_c} - \frac{V_c}{V_c}ight).$$

We finally get

$$S = c S_c + (1 - c) S_s, \quad (2)$$

which is equation (8) in Giroux and Chouteau (2008).

Using the more commonly employed definition 3 (the actual definition given in Giroux and Chouteau (2008)), the specific surface of the sand/clay mixture is

$$S = \frac{S_p}{V_h}.$$

Developing in a similar fashion, we find

$$S = \frac{S_p^c}{V_h} + \frac{S_p^s}{V_h} = \frac{S_p^c V_h^c}{V_h} + \frac{S_p^s V_h^s}{V_h^s} = S_c \frac{V_h^c}{V_h} + S_s \left( 1 - \frac{V_h^c}{V_h} \right).$$
Volume $V$ is the sum of solid material and pore space, hence $V_h + V_p = V$. Also, the pore space is equal to porosity times $V$. We therefore have that

$$V_h = V - V_p = V - \phi V.$$ 

This allows to write

$$\frac{V^c}{V_h} = \frac{V_c - \phi_c V_c}{V - \phi V} = \frac{V_c}{V} \cdot \frac{1 - \phi_c}{1 - \phi} = c \frac{1 - \phi_c}{1 - \phi}.$$

Let us introduce $c'$ equal to

$$c' \equiv c \frac{1 - \phi_c}{1 - \phi}. \tag{3}$$

We now have for the specific surface

$$S = c' S_c + (1 - c') S_s, \tag{4}$$

which is the formulation that should have appeared in the paper.

Considering the case where $c < \phi_s$, we have $\phi = \phi_s - c(1 - \phi_c)$ and

$$c' = c \frac{1 - \phi_c}{1 - (\phi_s - c(1 - \phi_c))} = \frac{c(1 - \phi_c)}{1 - \phi_s + c(1 - \phi_c)}.$$

If there is no clay in the mixture, $c'$ is equal to zero and $S = S_s$ as expected. If we consider the case where $c > \phi_s$, we have $\phi = c\phi_c$ and then

$$c' = \frac{c(1 - \phi_c)}{1 - c\phi_c}. \tag{5}$$

If there is only clay in the mixture, we do have $c' = 1$ and $S = S_c$.

**Acknowledgments**

This issue with eq. 8 in Giroux and Chouteau (2008) was brought to my attention by Christopher Power.

**References**