# Lithogeochemical classification of clastic sedimentary rocks using a quartz-feldspar-mica ternary diagram

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Clastic sedimentary rocks are traditionally classified using a combination of textural (clast, matrix) and mineralogical (quartz, feldspar, lithic) criteria plotted on Dott's modified 'Toblerone' diagram. Although this has served geoscientists well over the years, a novel, alternative, geochemically based classification derived from lithogeochemical data can offer complementary information that allows geoscientists to better understand the clastic sedimentary rocks under study.

Classification involves the conversion of major oxide concentrations ($SiO_2$, $Al_2O_3$, FeO+MgO, CaO, $Na_2O$, and $K_2O$) of clastic sedimentary rocks into a fixed set of mineral proportions (quartz; anorthite, albite, and K-feldspar; muscovite, biotite), and their subsequent plotting on a quartz-feldspar-mica ternary diagram. This is achieved by first dividing the major oxides by their corresponding molecular weights. Then, multiplication of matrix algebra-derived linear combinations by the resulting molar element numbers (quartz: Si-2Ca-3Na-3K, feldspar: -Al/2-Fe/3-Mg/3+2Ca+3Na/2+3K/2, mica: Al/2+Fe/3+Mg/3-Ca-Na/2-K/2) produce molar mineral numbers that can then standardized for plotting in ternary space.

Data interpretation on the diagram is straightforward, as clastic rocks containing more molar feldspar than clay minerals (referred to as 'geochemical sandstones') plot within the ternary diagram (because their linear combinations plot in the [+ + +] orthant of quartz-feldspar-mica space). In contrast, clastic rocks containing more molar clay minerals (kaolinite, chlorite, smectite, illite) than feldspar (referred to as 'geochemical mudstones') plot outside the ternary diagram to its left (because all clay minerals plot in the [+ - +] orthant). Classifications of rocks containing other minerals (calcite, dolomite, apatite, pyrite, *etc.*) are tractable because the effects of these minerals can be projected from by subtraction of appropriate components from the linear combinations (e.g., -Al/2-Fe/3-Mg/3+2Ca+3Na/2+3K/2-2$CO_2$ accurately measures feldspar in the presence of significant calcite), allowing routine investigation of a wide range of clastic sedimentary rocks.

Patterns made by clastic sedimentary rocks on the quartz-feldspar-mica ternary diagram can be related to provenance composition, chemical maturity, depositional environment, and sedimentation, authigenesis, and diagenesis processes, providing information that is not available using Dott's classification. Consequently, a number of clastic sedimentary rock systems have been examined using the quartz-feldsparmica diagram (e.g., the Aldridge-Pritchard Formation, Belt-Purcell Supergroup; the Manitou Falls Formation, Athabasca Basin; the Halifax and Goldenville groups, Meguma Supergroup; epiclastic metasedimentary rocks, Flin Flon Greenstone Belt; the Green River Formation, Uinta Basin; and the Castlepoint Formation, New Zealand). Several of

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these case histories are presented to illustrate the power and advantages of the quartz-feldspar-mica ternary diagram classification approach.


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