Clastic Sedimentary Rocks: Provenance and Tectonic Setting Name___________________
GEOS 3010 Take Home Assignment #6

SANDSTONE PROVENANCE AND TECTONIC SETTING

Objective

As we have discussed in class and in lab, the texture and mineralogy of sedimentary rocks can reveal important clues as to the rock's origin and tectonic setting in which it formed. This information can be valuable in reconstructing past environments and understanding the geologic history of a region. The objective of this homework activity is to relate textural and mineralogical information to sedimentary rock provenance and tectonic setting. These problems were adapted from Raymond, L., 1995, *Petrology: The Study of Igneous, Sedimentary and Metamorphic Rocks*, Wm. C. Brown Communications, Inc., Dubuque, IA, Chapter 19.

Sandstones - Introduction

Although they make up only 25% of the stratigraphic record, sandstones are well-studied because their mineralogical make-up can be easily identified, and because they host the majority of the world's oil and natural gas reserves due to their high porosity and permeability. The main mineralogical components of sandstone are quartz (Q), feldspar (F), and lithic fragments (L). The quartz may be in the form of single crystals, or aggregates of intergrown crystals. Feldspars include both plagioclase and alkali feldspars. Lithic fragments are essentially fragments of pre-existing rocks, including igneous plutonic and volcanic fragments, metamorphic rock fragments, and pieces of clastic sedimentary rock. Other minerals may also occur, depending on the mineralogical maturity of the sandstone. In addition to mineral and rock components, sandstones may also contain pore spaces, cement (silica, calcite, and hematite are most common) that binds grains together, and matrix (grains too small to identify by microscope).

Detrital modes (proportions of Q, F, and L) in sandstones can provide important information about provenance and tectonic setting. For example, if a sandstone is rich in both feldspar and igneous rock fragments (both volcanic and plutonic), it likely formed in a volcanic arc (subduction zone) setting. Conversely, if a sandstone is composed entirely of nearly pure quartz, its origin is likely an interior continent setting. Quartz plus lithic fragments suggest recycled sediment from mountain belts, and quartz plus feldspar suggests a cratonic origin. Note that the interpretation of sedimentary rock origin is not this straightforward; factors such as transportation, depositional environment, and diagenesis can affect sandstone rock modes in addition to provenance and tectonic setting. Textural clues such as sorting and roundness, in addition to sedimentary structures (e.g., ripple marks, mud cracks, bedding) provide additional information about each rock's history and environment of formation.

Pages 3-7 of the M&RCP discuss sandstone mineralogy, classification, provenance, and tectonic settings – read these pages and use them to complete the homework assignment.

Problems

Table 1 (next page) shows the modes (proportions of minerals, rock fragments, matrix, and cement) in 6 different sandstones. Use this information to answer the questions that follow.

Table 1. Modes of sandstone samples (in %).

Grain type	**1**	**2**	**3**	**4**	**5**	**6**
Mineral						
Quartz	90	88	40	42	51	2
Alkali feldspar	--	1	4	5	1	4
Plagioclase feldspar	--	4	6	7	--	22
Other	--	--	12	--	--	12
Rock fragments						
Chert	--	1	2	6	--	--
Sedimentary	--	1	--	--	6	--
Felsic volcanic	--	--	1	--	--	38
Mafic volcanic	--	--	--	--	--	6
Metamorphic	1	--	1	--	3	--
Other	--	--	--	8	--	--
Cement						
Calcite	--	--	33	--	30	--
Other	7	--	--	1	4	--
Matrix	2	5	1	31	5	16
TOTAL	100	100	100	100	100	100

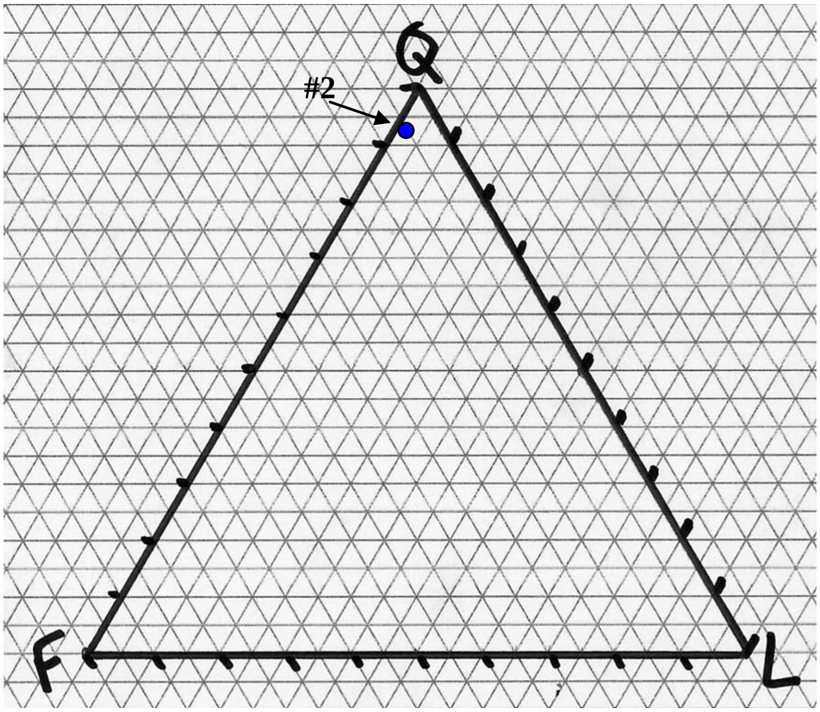
1. Determine the relative proportions of quartz (Q), feldspar (F), and lithic fragments (L) for each sandstone. Enter your results in the table and **show your work for EACH sandstone on a separate sheet of paper**. Proportions of Q-F-L for rock #2 has been calculated for you as an example.

Relative proportions	**1**	**2**	**3**	**4**	**5**	**6**
Q		93				
F		5				
L		2				
TOTAL		100				

<u>Example: Rock #2</u>
Quartz = 88
Feldspar = kspar + plag = 1+4 = 5
Lithic fragments = add all rock fragments = 1+1 = 2
Ignore everything else in the rock!

Relative proportions:
Q = 88/(88+5+2) = 92.6%
F = 5/(88+5+2) = 5.2%
L = 2/(88+5+2) = 2.1%

2. Plot the relative proportions of Q-F-L from Table 2 for each sandstone on the diagram, below. Again, sample #2 has been plotted for you as an example.



3. Use the following diagrams to determine a name for each rock based on the Q-F-L classification (Figure 1), and to determine the most likely provenance and tectonic setting for each rock (Figure 2). Also note any additional evidence (for example, maturity of the sandstone, types of lithic fragments, types of cement) that support your determination of the tectonic setting for each rock.

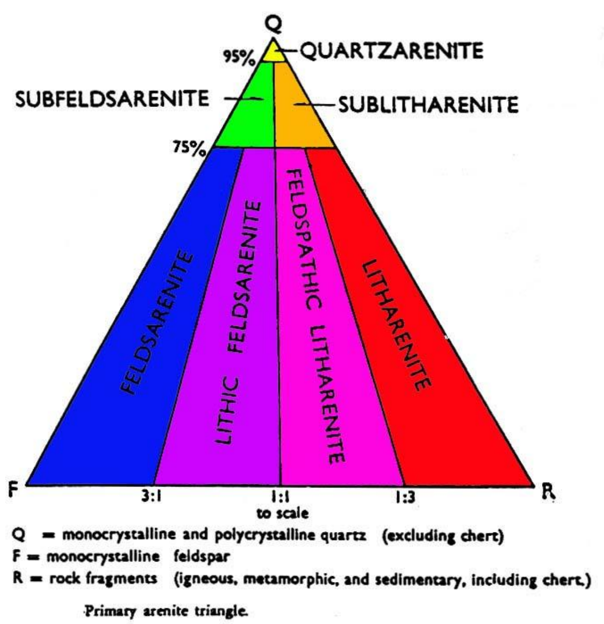


Figure 1

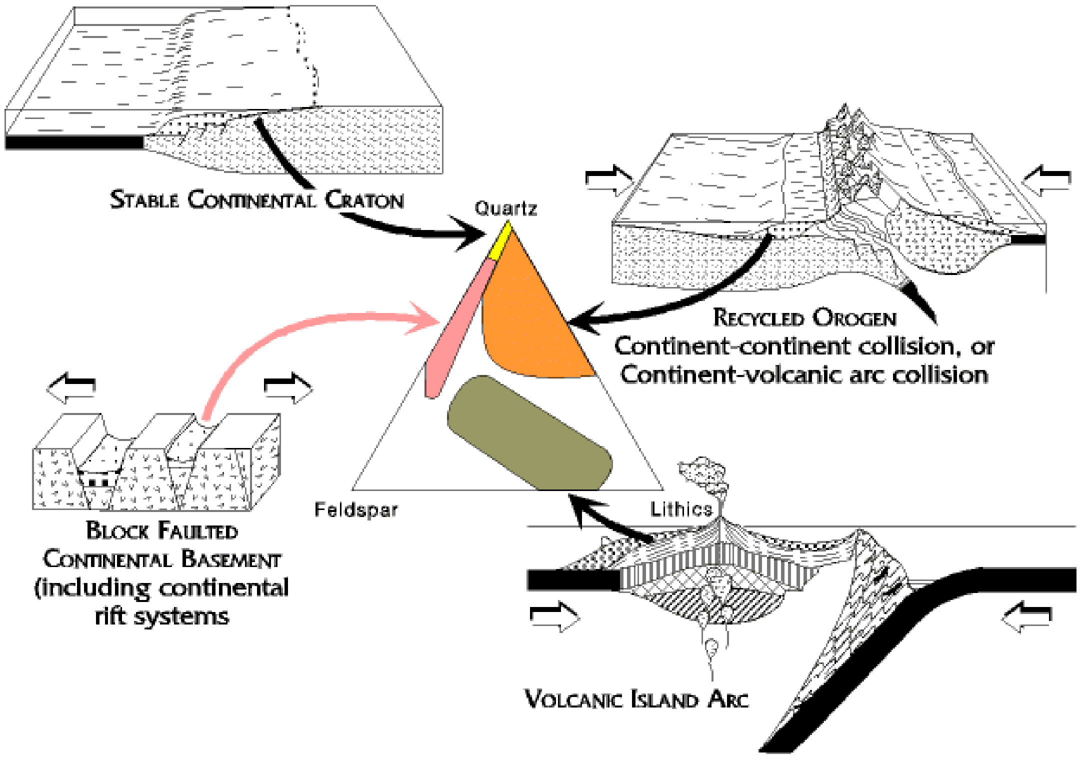


Figure 2.

Rock #1: Name: ______________________________ Likely setting: ______________________
Supporting evidence for tectonic setting:

Rock #2: Name: ______________________________ Likely setting: ______________________
Supporting evidence for tectonic setting:

Rock #3: Name: ______________________________ Likely setting: ______________________
Supporting evidence for tectonic setting:

Rock #4: Name: ______________________________ Likely setting: ______________________
Supporting evidence for tectonic setting:

Rock #5: Name: ______________________________ Likely setting: _______________________
Supporting evidence for tectonic setting:

Rock #6: Name: ______________________________ Likely setting: _______________________
Supporting evidence for tectonic setting:

4. Which of the rocks (choose 1 or 2) is/are the most mineralogically mature? Which are the most mineralogically immature? What is your evidence supporting each answer?

5. Textural maturity (in particular, sorting and rounding) tends to correlate well with mineralogical maturity. For the rock(s) that you chose in #4 as being mineralogically mature, speculate as to what sort of texture this rock might have. Also speculate as to the texture of the rock(s) you chose as being mineralogically immature in #4.