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10:00 a.m. Grantham, J. H. No 16969

THE INFLUENCE OF WEATHERING IN THE SOURCE AREA ON
SANDSTONE FRAMEWORK COMPOSITION, AND THE RUNOFF-RELIEF
INDEX
   VELBEL, M.A., Department of Geological Sciences,
      Michigan State University, East Lansing, MI
      48824-1115, and GRANTHAM, J.H., Petrostar
      Energy, Traverse City, MI.
   A runoff-relief index (RRI; introduced by a different
name by Grantham and Velbel, 1988, Jour. Sed. Petrol., v.
58, p. 219-227) provides a quantitative basis for
interpreting climatic and geomorphic effects on sand
composition. The RRI uses runoff (effective
precipitation) and relief ratio, respectively, as proxy
indicators of leaching intensity and mean residence time
of soil grains on source-area hillslopes. In the fine
sand fraction of sands from some southern Blue Ridge
streams, a factor-of-two increase in the RRI (equivalent
to doubling effective precipitation at constant slope, or
halving slope at constant runoff) produces changes in
modal sand composition from

$$Q_{67}F_2R_{31}/Q_{m60}F_2R_{t38} \text{ (low RRI)}$$
to
$$Q_{85}F_1R_{14}/Q_{m76}F_1R_{t23} \text{ (high RRI)}.$$

This represents a significant, weathering-induced shift
of modal sand composition plots on ternary diagrams.
Contouring runoff-relief indices (calibrated by modern
studies) on ternary diagrams provides a means for
visualizing and quantifying the effects of source-area
climate and geomorphology on modal framework compositions
of sands and sandstones.

10:15 a.m. van de Kamp, Peter C. No 16984

COMPOSITIONS OF SEDIMENTS DERIVED FROM GRANITIC BASEMENT ROCKS IN
GLACIAL TO HUMID TROPICAL CLIMATES.
van de Kamp, Peter C., Cornelis Corp., 1237 Coombs St., Napa, Calif. 94559 and Helmold,
Kenneth P., ARCO Oil and Gas Co., 2300 W. Plano Pkwy., Plano, Texas, 75075.

Modern, first-cycle nonmarine sands and muds derived from "granitic" basement in various
climates from glacial to humid tropical have been mineralogically analyzed to study compositional
variations with climate and topography. In the areas sampled, provenance is typically dominated
by plutonic calc-alkaline series of tonalite to granite with subordinate metamorphic and mafic
rocks. Climates are classified in the Koppen system. Modal data is treated in Gazzi-Dickinson
fashion in which plutonic rock fragments are reported as constituent minerals.

For basement rocks, Q/Q+F= 0.1 to 0.4 from mafic to granitic types and P/F= 0.5 to 0.9+.
Sands in glacial deposits of Alaska and British Columbia (climates Fi, Ft, and E) have mean
Q/Q+F= 0.3 and P/F= 0.9. Arid deserts of Nevada and Utah (climate Bw) yield sands with
Q/Q+F= 0.36, P/F= 0.7. Mountains of California and Chiapas, Mexico (climate Cs) yield sands
with mean Q/Q+F= 0.35 to 0.46 and P/F= 0.6 to 0.7+. Temperate climate (Do, Dc) areas in
Central France and the Reading Prong develop sands with mean Q/Q+F= 0.48 and 0.58, and
P/F= 0.5. Subtropical climate (Cf) in the southeastern states yields sands with mean Q/Q+F= 0.7
to 0.8 and P/F= 0.2 to 0.3. Humid tropical climates (Ar and Aw) in Gabon, Malaysia, and southern
Mexico provide sands with mean Q/Q+F= 0.8 to 1.0 and P/F= <0.1 to 0.3.

Within all groups except glacial, feldspar, mica, and heavy mineral abundances are greater in
the finer grained samples. In climates Ar and Aw, sands from steeper gradient streams are more
feldspathic due to shorter weathering exposure than those in low-gradient streams. Kaolinite, as a
portion of the clay fraction in muds and silts, increases from the desert to humid tropical settings
reflecting progressively more intense weathering of parent materials. The data indicate that
arkoses, with Q/Q+F= 0.3 to 0.7, may form in climates ranging from glacial to temperate;
significant feldspathic sandstone development is unlikely in humid subtropical and tropical
climates. In the latter cases, quartzose sands are developed with kaolinite-rich muds.

10:30 a.m. Cecil, C. Blaine No 24973

PALEOCLIMATIC IMPLICATIONS FOR THE ORIGIN OF PALEOZOIC
QUARTZ ARENITES IN THE APPALACHIAN BASIN
   CECIL, C. Blaine, AHLBRANDT, Thomas S., U. S. Geological
   Survey, MS 956, Reston, VA, 22092, and HEALD, Milton T.,
   Dept. of Geology, West Virginia University, Morgantown, WV,
   26506
The origin of quartz-rich sandstones in Paleozoic strata in the Appalachian
basin is generally attributed to multicycles of sedimentation, reworking within
aqueous depositional environments, and (or) diagenesis. However, tropical
paleoclimates also may have been a factor in both textural and mineralogical
maturity. From the early Cambrian through the Devonian, the Eastern United
States was in the southern hemisphere tropical dry belt and moved
northward into the equatorial tropical rainy belt in the late Mississippian and
Pennsylvanian. Texturally mature quartz and unaltered detrital feldspars in
Cambrian through Devonian quartz arenites are indicative of a mechanical
weathering history in an arid or semiarid climate rather than chemical
weathering in a humid tropical climate. In contrast, when compared to these
earlier Paleozoic quartz arenites, late Mississippian and Pennsylvanian

deposits in the Appalachian basin tend to be texturally immature and nearly
devoid of feldspars and, therefore, could be a product of chemical
weathering rather than mechanical weathering. Residual kaolin deposits of
late Mississippian and early Pennsylvanian age, which appear to be the result
of chemical weathering in humid tropical environments, support this
interpretation. Thus, mature sandstones in Cambrian through Devonian
strata may, in part, be the result of mechanical processes in eolian
environments, prior to deposition in aqueous systems, whereas chemical
weathering appears to have been more of a factor in the genesis of quartz
arenites in Mississippian and Pennsylvanian strata.

10:45 a.m. Dutta, Prodip K. No 16980

MINERALOGICAL MATURATION OF EOLIAN SAND THROUGH BALLISTIC
IMPACT: A THEORETICAL APPROACH TO PROVENANCE STUDY
   DUTTA, Prodip K., Dept. of Geography and Geology, Indiana State University, Terre Haute;
   ZHOU, Ziye, Department of Physics, Indiana State University, Terre Haute, IN 47809;
   SANTOS, R. Paulo, Institute de Geociencias, Sao Paulo, Brazil
In the Parana Basin, Brazil, medium grained fluvial Triassic Piramboia Sandstone unconformably
overlies the medium-grained eolian Jurassic Botucatu Sandstone. A sharp change in maturity is
observed between Piramboia (Q:F:L = 76:23:1) and Botucatu (Q:F:L = 93:7:0) sandstones.
Mineralogical and paleogeographic evidence indicates that both units were derived from the same
source. We believe that the differences in maturity can be attributed to mechanical breakdown of
feldspars and subsequent winnowing from the dune fields rather than a change in provenance.

Calculations show that the total energy in Si-O, Al-O, and K-O bonds across a 010 cleavage
plane in orthoclase is 5.7×10^3 ergs/cm². Across the 001 plane K-O bond is absent and the total
bond energy is about 4.0×10^3 ergs/cm². Therefore, in any ballistic impact the orthoclase grain will
preferentially disintegrate along the 001 plane. Sand-size orthoclase grains, with dimensions of 0.5,
0.25, 0.125, and 0.063 mm, commonly found in deserts, have bond energies (across 001 planes) of
12, 3, 0.8, and 0.2 ergs respectively. Mechanical breakdown will occur if the impact energy is
greater than the bond energy across cleavage planes.

During eolian transport ballistic impacts between saltating grains and the grains at rest are very
common. Assuming that 50% of the kinetic energy of the saltating grain is absorbed by either grain
involved in the collision, we calculate that a minimum collision velocity of 3.5, 4.9, 7.0 and 9.9
meters/sec. will be required to overcome the 001 plane bond energies for 0.5, 0.25, 0.125, and 0.063
mm orthoclase grains respectively.

In deserts, collision velocity attained by sand grains are usually much higher than the above cited
theoretical minimum velocities and all feldspar species can be broken. Elimination of feldspars from
sand-size fractions through such a process has been observed in active desert environments.
Mechanical disintegration can also be accomplished by salt weathering but is important only in
certain local conditions. Our analysis indicates that maturation of eolian Botucatu Sandstone in the
Parana Basin is a result of ballistic impact.

11:00 a.m. Kairo, S. No 32571

VARIABILITY IN DETRITAL SANDSTONE COMPOSITION AS A FUNCTION
OF PHYSICAL PROCESSES IN COARSE-GRAINED DELTA SYSTEMS.
   SUTTNER, L.J., and KAIRO, S. Department of Geological Sciences, Indiana
   University, Bloomington, IN, 47405
The detrital mineralogy of arkosic sandstones from the Fountain and Minturn
Formations (Pennsylvanian) of Colorado was studied to evaluate effects of mechanical
disaggregation and hydrodynamic sorting on modification of detritus within coarse-
grained deltaic systems. Modal analyses of sandstones from coeval facies assemblages
of both river-dominated (Minturn) and wave-dominated (Fountain) systems, show that
proportions of quartz (Q), feldspar (F), rock fragments (R), and mica vary between
fluvial, shoreline, and offshore deposits. Braided and meandering fluvial deposits of
the Minturn have Q:F:R contents of 47:16:37 and 34:32:34 , respectively. Associated
marine wave-reworked deposits have average feldspar compositions nearly identical to
the fluvial deposits but are enriched in either quartz (up to 15% more) or rock fragments
(up to 10 % more). Quartz is particularly enriched (up to 39% more) in fine-grained
sandstones deposited as turbidites and distal offshore sand sheets. Fountain braided
fluvial deposits have an average Q:F:R content of 61:34:4. Quartz is enriched by 7% in
foreshore deposits and feldspar is enriched by 9% in fine-grained offshore deposits. In
both the Minturn and the Fountain, detrital mica comprises up to 18% of grains in
offshore deposits, whereas wave-reworked shoreline deposits contain 1% or less.
   Differences between Q:F:R compositions of Fountain and Minturn fluvial
deposits reflect differences in provenance. However, because of constraints on
sediment transport and on burial history of sandstones studied, compositional
variations within each formation can be attributed to environmental processes. Marine
reworking in both types of deltaic systems effectively modifies detrital composition
from that of fluvial deposits in spite of relatively high rates of sedimentation. In
shoreline settings, disintegration of rock fragments yields different percentages of either
quartz, feldspar, or smaller rock fragments, depending on composition of sediment
being reworked. Medium and fine grains of mica, feldspar and quartz are subsequently
winnowed from coarse shoreline deposits and hydrodynamically concentrated in
offshore sandstones. Compositional variation between samples from similar
subenvironments (e.g. foreshore, washover fan, etc...) can be explained by grain-size
variation.

11:15 a.m. Cox, Ronadh No 7012

LONG-TERM SEDIMENT RECYCLING: A FUNDAMENTAL CONTROL ON THE COMPOSITIONS
OF SANDSTONES AND SHALES
   COX, Rónadh and LOWE, Donald R., Department of Geology, Stanford University,
   CA 94305-2115; CULLERS, R., Department of Geology, Kansas State
   University, Manhattan, KS 66506-3201

Recycling accounts for about 80% by volume of material in transit within the modern
sedimentary system (Garrels, 1986) and has probably been of similar importance