trapped sediment. This mechanism allowed the mounds to grow
upward into a zone near wave base. As mud-mound buildup
reached wave base, an ecological regime suitable for the
skeletal facies, stromatoporoid-coral facies, and brachiopod
significant facies are crinozoan facies, bryozoan facies, mixed
facies. Additionally, empirical data were used to define an algal
sand facies. Quartz sand shapes do not change significantly with changing
size either upstream or on the shelf. A size-shape dependence
does exist in downstream, river mouth, and slope environments
(fine sand is more angular than coarser sand) and on beaches
(fine sand is more abraded than coarser sand).

It is significant that environments in which size-shape relation­ships exist are also sites of mixing between sands of different
origins and transport histories. For example, samples studied
from downstream and river mouth areas indicate mixing be­
tween fine-grained, angular fluvial sand, and coarser, smoother
residual sand. Mixing occurs because fluvial sand is deposited on the shelf only when storm-induced flooding results in river-
mouth bypassing.

This study suggests that investigations into the origin of size-
shape relationships can aid in understanding climatically con­trolled, short-term changes in terrigenous output.

GORDY, PETER L., Shell Canada Resources Ltd., Calgary,
Alberta, Canada

Hydrocarbon Accumulations in Overthrust Belt of Alberta

Estimated proved and probable ultimate reserves of
marketable natural gas in Alberta are 80.5 tcf, of which approx­i­mately 10.5 tcf are in Paleozoic carbonate reservoirs that have
been involved in thrust faulting in the Foothills belt of Alberta.
Interpretation of exploration data in this belt has contributed
significantly to our understanding of the geology of the southern
Canadian Rocky Mountains as a whole.

The Precambrian basement is overlain by a westward-thick­ening prism of Paleozoic sedimentary deposits that contain im­portant reservoirs in Upper Devonian and Mississippian car­bonate rocks. Approximately 8% of the reserves are in the Up­per Devonian and 87% in the Mississippian. There is close cor­relation between reserves found and facies trends within the
Mississippian Rundle Group. A widespread organic-rich source
rock, the Eshkaw Formation, provided the major charge for both Mississippian and Devonian reservoirs. Jurassic marine
shales overlie the Mississippian in the southern part of the belt
and form an effective seal and possible source rock. In the
northern part of the belt, the Mississippian is overlain by Triassic sedimentary rocks in which reservoirs are present.
Cretaceous sandstones generally lack reservoir qualities and less
than 5% of the reserves found to date are in the Cretaceous.

The Outer Foothills are characterized by closely spaced listric
thrust faults that repeat the Mesozoic section. Some of the
thrusts cut deep enough to carry a single or multiple thrust slices

GOLDEN, WILLIAM, Shell Oil Co., New Orleans, LA,

Dispersal and Provenance of Terrigenous Sand by Fourier
Grain Shape Analysis, Northern Puerto Rico

The narrow, steep, north insular shelf of Puerto Rico con­tains terrigenous sands and silts derived from rivers originating
in nearby mountains. This compact system provides an ideal set­
ting for the study of sand sized sediment dispersal and pro­venance in coastal and nearshore environments using Fourier
shape analysis.

Quartz sand shape on the north shelf reflects the lateral
change in source-rock composition. The shelf can be divided into
a western part containing dominantly angular quartz grains
and an eastern part containing rounded abraded quartz sand.
Rivers feeding the western shelf drain a significant body of
granitic rock, whereas rivers to the east drain a quartz-poor,
volcanic rock terrane. Rounded grains on the eastern shelf are
mostly relict.

Quartz sand shapes do not change significantly with changing
size either upstream or on the shelf. A size-shape dependence
does exist in downstream, river mouth, and slope environments
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GOLDEN, WILLIAM, Shell Oil Co., New Orleans, LA,
of Mississippian carbonate rocks. Trap capacity is governed by horizontal displacement, vertical uplift, convergences of allochthonous and autochthonous structural strike, and probable seal quality to the thrust planes. Approximately 18 significant gas-bearing structures containing 5 tcf marketable reserves have been discovered.

The surface geology of the Inner Foothills is characterized by outcrops of Paleozoic carbonate rocks and relatively undeformed Mesozoic strata. Usually two or more thrust sheets are stacked in a general anticlinal form and provide multiple objectives. To date, 14 gas-bearing structures have been discovered in this zone containing approximately 5.5 tcf of gas. The gas-bearing structures in the Waterton-Carbondale and Moose Mountain Panther River areas are typical. The gas-bearing post-lower Paleocene structures probably are related to the time of maturation of the major source rock and the west-to-east deformation of the southern Canadian Rocky Mountains. Despite the large areas of the Alberta Foothills belt in which exploration is restricted, it is estimated that 6 to 14 tcf of gas may still be found.

GRETENER, P. E., Univ. Calgary, Calgary, Alberta, Canada
On the Use of the Modified Lopatin Method

The modified Lopatin method (detailed description in AAPG Course Note Series 17) can provide quick estimates of the state of organic metamorphism. To do so, it is necessary to evaluate the thermal history of a potential source rock. Under favorable conditions, such as uniform burial in an environment of constant geothermal gradient, it is possible to approximate the actual thermal history by a linear temperature rise. For such simple situations, the method yields essentially instantaneous results without the help of any artificial aids. The method is equally applicable to more sophisticated models, but those require a careful analysis of the burial history and an evaluation of the possible changes of the terrestrial heat flow during the lifetime of a source rock.

Examples of the use of the method will be shown and the current limitations imposed by various uncertainties and approximations will be discussed.

GROVER, G., JR., Gulf Oil Exploration Co., Midland, TX, and J. F. READ, Virginia Polytechnic and State Univ., Blacksburg, VA
Near-Surface to Deeper Burial Cementation Patterns and Foreland Basin Evolution, Middle Ordovician Ramp Carbonates, Virginia

Middle Ordovician ramp carbonates, Virginia, were deposited in a subsiding foreland basin bordered by developing tectonic highlands. Ramp carbonates are largely occluded by nonferroan, clear rim, and equant cements which contain cathodoluminescent zones consisting of nonluminescent (oldest), bright and dull (youngest) cements. The zonation largely relates to increasingly reducing conditions of pore waters. Zoned cements in peritidal beds have complex zonations, pendent to pore-rimming fabrics, and are associated with vadose silt (which abuts all cement zones); these cements are vadose to shallow phreatic. Major cementation of subtidal facies occurred under burial conditions. Zoned burial cements have a simple zonation reflecting progressive burial (up to 3,000 m) of carbonates. Shallow burial nonluminescent cement formed from oxidizing, meteoric waters which expelled anoxic, connate marine waters; meteoric waters were carried by aquifers from tectonic upland recharge areas. Deeper burial, bright and dull cements formed at depths (2,000 to 3,000 m) and temperatures (75 to 135°C) associated with hydrocarbon emplacement during the Late Devonian or Mississippian. Final, clear dull cement fills tectonic fractures and was emplaced during late Paleozoic deformation. Deeper burial diagenesis appears to be genetically linked to late Paleozoic, Mississippi Valley-type mineralization. Zoned peritidal and burial cements are mainly confined to southeastern parts of the ramp, where cementation was influenced by meteoric waters from developing uplands on the southeastern margin of the foreland basin and carried northwest by aquifers. Cements in northwestern peritidal and subtidal ramp facies are dominated by nonzoned dull cements, where cementation was little influenced by upland-source meteoric waters. The close association of zoned cements and regional