The structural closures in the sediments above the reefs account for another type of trap for oil and gas. The Devonian Nisku and Wabamun carbonates, the Cretaceous Basal Quartz and Viking sandstones, and in several places the Cretaceous Cardium sandstone contain oil and gas accumulations with geometry of fluid segregations similar to that found in anticlinal closures. It must be pointed out, however, that in many places, porosity-permeability conditions in these reservoirs modify the geometry of the fluid accumulations to a great degree.

A third type of trap results from erratic porosity development related to the effect of buried highs on subsequent sedimentation. In several places improved porosity conditions in the Devonian Nisku formation account for the extension of oil accumulation some distance beyond the structural closures above the reef massifs. The development of thicker, more porous sands can be found in the Cretaceous Basal Quartz above the inter-reef channels. Some old topographic depressions in the unconformity surface between the Paleozoics and Cretaceous are filled with porous sand lenses in the Basal Quartz sequence.

A fourth type of trap is found in the truncated edge of several Mississippian units. Accumulations of oil and gas are found in porous Rundle carbonates as their regional updip termination crosses the Edmonton reef chain.

ROLAND F. HERBST, Lawrence Radiation Laboratory, University of California, Livermore, California

Application of Nuclear Explosives in Exploitation of Underground Resources

The Rainier detonation of 1957 and the underground detonations of October, 1958, produced phenomena of heat, fracturing, and melting which have possible application to mineral and petroleum production. Such effects may be particularly applicable to oil sands and oil shales.

G. W. HURLEY, Pan American Petroleum Corporation, Casper, Wyoming

Overthrust Faulting and Paleozoic Gas Prospects in Montana's Disturbed Belt

The Disturbed belt of Montana lies on the hinge-line between the Central Stable platform on the east and the Rocky Mountain geosyncline on the west. It lies west of the Sweetgrass arch and includes the Rocky Mountain front ranges of western Montana. The Disturbed belt is characterized by a zone of overthrust faulting and folding extending from the Missouri River northward into Canada. Some of the largest gas and distillate reserves in North America have been found in one or more thrust sheets of Mississippian rocks in Canada at Pincher Creek and Waterton Lake and a recent gas discovery was completed in the Devonian formation at Castle River. Northern Natural Gas Company's recent Mississippian gas discovery in Sec. 13, T. 26 N., R. 8 W., may be the first evidence that such accumulations are also present in Montana's Disturbed belt.

Unconformities between the Cambrian and Devonian and between the Mississippian and Jurassic are evidence that the area was tectonically active during Paleozoic time and isopachs of the Jurassic and Cretaceous formations indicate that this activity continued intermittently throughout Mesozoic time. The characteristic overthrust faulting from the west is the result of the Laramide orogeny of early Tertiary time.

The structure of Montana's Disturbed belt is divisible into three layers each younger in age: (1) a regional layer of relatively undeformed rocks comprising the west flank of the Sweetgrass arch over which the high-angle thrust layer has ridden; (2) a high-angle thrust layer of complex faulting and drag folds typical of the Disturbed belt structures; and (3) a low-angle thrust layer, commonly known as the Lewis overthrust, which overrode the high-angle thrust layer. Subsequent high-angle block faulting has added further complexity to the structures.

Three types of traps similar to those of the Canadian Disturbed belt are present: (1) fault traps on the wedge-edge of the Paleozoic thrust sheets; (2) drag folds formed as the result of thrusting; and (3) folds occurring west of the zone of drag folding as typified at Savannah Creek in Alberta. The Northern Natural Gas Company's Mississippian discovery at Blackleaf Creek is of the wedge-edge type.

Structural interpretation of this area is difficult and drilling costs are high. Therefore, much money will have to be spent before the economic possibilities of the hydrocarbons in Montana's Disturbed belt have been adequately evaluated.

VINCENT C. KELLEY, University of New Mexico, Albuquerque, New Mexico

Fractures in Sedimentary Rocks

The most abundant kind of deformation of rocks is by fracturing. There are three principal classes of fractures—(1) joints, (2) faults, and (3) small, irregular breaks (including shatter and breccia zones). In general, joints may be defined as more or less regular groups of relatively long fractures that are paralleled by little or no displacement or orientation of rock components.

Joints occur in sets that may be parallel, radiate, or concentric. Sets occur singly or severally and with no universality of systems. The angular relations of intersecting sets range from sharply acute