PRENSKY, STEPHEN E., U.S. Geol. Survey, Denver, CO

Use of Gamma-Ray Log for Locating Cretaceous-Tertiary Unconformity, Pinedale Area, Northern Green River Basin, Wyoming

Computer-generated crossplots of the gamma-ray log versus depth in the Pinedale area, northern Green River basin, Wyoming, exhibit an abrupt shift in API gamma units over the structurally influenced depth range of 7,100-8,500 ft (2,100-2,600 m). Higher API units are recorded for all lower Tertiary rocks than for underlying Upper Cretaceous rocks. The shift, which is not obvious from viewing analog prints, coincides with the Cretaceous-Tertiary boundary as located in this area by previous workers using different methods.

Evaluation of gamma-ray spectral logs from five wells, combined with petrographic and x-ray diffraction analysis of core samples from the Pinedale area, shows that this shift is caused by a higher potassium content in Tertiary rocks than in Cretaceous rocks, due to the presence of arkosic sandstones. Within the lowermost 600 ft (180 m) of the Tertiary, the potassium feldspar content of the sandstones gradually decreases with depth down to the Tertiary unconformity and then abruptly declines, essentially to zero, in the Cretaceous.

Crossplots of gamma-ray intensity versus depth from other wells in the northern Green River basin show a diminution of this shift to the west and southwest of the Pinedale area. This relation suggests that the Precambrian crystalline core of the Wind River Range, which was upthrust and eroded during the Laramide orogeny, provided the source of the arkosic Tertiary sandstones.

In many Rocky Mountain basins, identification of the Cretaceous-Tertiary boundary is problematical due, in part, to the similar lithology and depositional environments of the nonmarine rocks as well as to the absence of outcrops and reliable biostratigraphic data. The approach described may be applicable to other areas.

QUICK, ALLEN N., Cities Service Oil and Gas Corp., Denver, CO

Exploration Planning in 1980s—Methods, Techniques, and Philosophy

The business environment, within which the oil exploration business will be forced to operate during the 1980s, will require exploration management to evaluate their investment opportunities in light of economic conditions and in conjunction with their companies' business strategies. To do so will require techniques and methods to analyze future field sizes, risks, and potential rewards. Proposed methods will allow construction of a series of portfolios of future investment opportunities that will permit a selective process for resource allocation for exploration. Various exploration strategies can then be tested by computer modeling to ascertain the exploration strategies that will be compatible with their companies' business planning and strategies.

Although the planning concept was designed primarily for the oil exploration business, methods, techniques, and concepts can be carried over to other energy mineral exploration.

In this present environment it is also necessary that explorationists understand how their efforts may be integrated into the total exploration program so they will not expend unnecessary time on prospects that will not fit into their companies' overall strategies.

RASMUSSEN, JAMES D., Energy Fuels Nuclear, Inc., Kanab, UT, CHARLES G. CUNNINGHAM, U.S. Geol. Survey, Reston, VA, THOMAS A. STEVEN and ROBERT O. RYE, U.S. Geol. Survey, Denver, CO, and SAMUEL B. ROMBERGER, Colorado School of Mines, Golden, CO

Hydrothermal Uranium Vein Deposits in Marysvale Volcanic Field, Utah

Hydrothermal uranium veins are exposed over a 300 m (980 ft) vertical range in mines of the Central Mining area, near Marysvale, Utah. They cut 23 Ma quartz monzonite, 21 Ma granite, and 19 Ma rhyolite ash-flow tuff. The veins formed 18-19 Ma, in an area 1 km (0.6 mi) across, above the center of a composite magma chamber at least 12 × 6 km across that fed a sequence of 21-14 Ma hypabyssal granitic stocks, and rhyolitic lava flows, ash-flow tuffs, and volcanic domes. Intrusive pressure uplifted and fractured the roof; molybdenite-bearing, uranium-rich, glassy dikes were intruded; and a breccia pipe and uranium-bearing veins were formed.

The veins appear to have been deposited near the surface above a concealed rhyolite stock, where they filled high-angle fault zones and flat-lying to concave-downward "pull-apart" fractures. Low pH and fO_2 hydrothermal fluids at temperatures near 200°C (392°F) permeated the fractured rocks; these fluids were rich in fluorine and potassium, and contained uranium as uranous-fluoride complexes. Fluid-wall rock interaction increased fluid pH, causing precipitation of uranium minerals. At the deepest exposed levels, wall rocks were altered to kaolinite and sericite, and uraninite, coffinite, jordisite, fluorite, molybdenite, quartz, and pyrite (with $\delta^{34}S$ near zero per mil) were deposited. The fluids were progressively oxidized higher in the system; iron in the wall rocks was oxidized to hematite, and sooty uraninite and umohoite were deposited.

RAYMOND, ROBERT, JR., Los Alamos National Lab., Los Alamos, NM, THOMAS D. DAVIES, Exxon Production Research Co., Houston, TX, NATHAN W. BOWER, Colorado College, Colorado Springs, CO , and SUSAN H. FREEMAN, Los Alamos National Lab., Los Alamos, NM

Relationship Between Reflectivity and Organic Sulfur Content of Macerals with Respect to Total Organic Sulfur Content and Rank of Coals

The potential exists for predicting organic sulfur (S_o) contents of specific macerals within a coal based on total S_o content of the coal, rank of the coal, and maximum reflectivity in oil (R_o) of the macerals in question. In the past, determination of S_o content of specific macerals necessitated either a microanalysis technique, such as electron probe microanalysis (EPM), or analysis of maceral separates. Ten coal samples ranging in rank from low volatile to lignite and total S_o content from 0.47 to 4.51 wt. % were studied. Within each of the 10 coals, approximately 100 macerals ranging from the lowest reflecting exinites to the highest reflecting inertinites were analyzed for S_o content (using EPM techniques) and R_o (using petrographic techniques). For each coal, log of maceral S_o content was plotted versus log of maceral R_o, and a linear regression of the data points was performed. On a three-dimensional plot, slopes of the 10 linear regressions were plotted versus the respective coal ranks versus the respective coal total S_o contents. Results indicate that relationships between S_o content and R_o of macerals within a coal are dependent on both the rank and total S_o content of the coal. As total S_o content of a coal equals S_o content of the vitrinite in that coal, the results suggest that predictive relationships exist between maceral S_o content, maceral R_o, coal total S_o content, and coal rank that may allow determination of maceral S_o contents without the need for microanalysis.

REHRIG, WILLIAM A., and WILLIAM A. GALLANT, Applied Geologic Studies, Inc., Englewood, CO

Tectonic Analysis of Belt Terrane of Northwest Montana–Northern Idaho and Its Implications for Oil and Gas Potential West of Disturbed Belt

From a recently completed comprehensive regional geologic map and cross sections across the Cordillera of the northwestern United States, the following conclusions have been made. (1) Paleozoic as well as probable late Precambrian Belt miogeoclinal sedimentation developed west of northern Idaho off the edge of the continental crust. Present position of the thick sediment wedge thereby suggests 100-200 km (62-124 mi) of eastward displacement on a passively involved cratonic basement. (2) Mesozoic orogeny started west of the continent margin, shifted east, and did not involve the Disturbed belt until earliest Tertiary time. Thus, a significant time span separated mobility and uplift in the core region of the orogene from thrusting of the foreland. Continental subduction (underthrusting) beneath the uplifted and "cold" core is a probable explanation for the great shortening during the Laramide orogeny. (3) Immediately following thrusting, the entire northwest was swept by a 40-50 m.y. extensional orogeny involving, from place to place, widespread calc-alkaline magmatism, listric faulting on a grand scale, subhorizontal detachment faults, and basement mylonitization. This tectonism influenced the Belt region by fragmentation and eastward tilting of strata and thrusts, and creation of structural relief on the pre-Belt basement surface by normal faulting. A less obvious and speculative effect may be ductile mylonitization in the basement, as is exposed in the metamorphic core complexes of northeastern Washington and northern Idaho.

Regional cross sections show no serious obstacles to the presence of an autochthonous or detached slab of Paleozoic rocks beneath the overthrust Belt section, although subhorizontal mylonitic rocks are not outside the realm of geologic possibility. Nevertheless, oil and gas favorability beneath Belt rocks is affected by such factors as ratio of source rock to reservoir rock, thermal and/or pressure conditions after overthrusting, and the postmigrational effects of Eocene extensional tectonism (i.e., dip reversals, magmatism, and fragmentation).

RIGGERT, V. L., Univ. Calgary, Alberta, Canada

Geometry and Mechanical Development of Heart Mountain Thrust Stack, Exshaw, Alberta

Heart Mountain is located near Exshaw, Alberta, and forms a peculiar localized thrust stack along the otherwise relatively linear Exshaw thrust trace in the Canadian front ranges. Data from stratigraphic and structural mapping on a scale of 1:5,000 were used in the construction of balanced cross sections, longitudinal sections, and stratigraphic separation diagrams to reveal the true three-dimensional geometry of the mountain. The structure (the "heart") is composed of a gently south-plunging canoe-shaped body of rock. Near its southern termination, however, the heart plunges steeply northward.

Several previously unrecognized features of the Heart Mountain structure were discovered during mapping. The heart is a faulted syncline with its east limb thrust up relative to its west limb. The heart's "collar" is composed of the Loomis Member of the Mississippian Mount Head Formation, not the Mississippian Livingstone Formation as previously mapped. The panel of Livingstone rocks west of the heart is stratigraphically up to the east.

Based on both stratigraphic and structural considerations, the thrust stack formed in an east-to-west sequential development from rock panels of relatively local origin. Mechanical considerations of the mountain's east-to-west sequential development require the location of the Exshaw thrust to be along the eastern margin of the structure. The Heart Mountain thrust stack, therefore, formed in the hanging wall of the Exshaw thrust.

Hydrocarbons have been found in structural traps similar to Heart Mountain. Understanding the geometry and order of mechanical development of these traps is essential to profitable exploration ventures.

ROBERTSON, CHARLES E., Missouri Geol. Survey, Rolla, MO

Landsat and Field Studies Link Structural Lineaments and Mineralization in St. Francois Mountains, Missouri

Late-stage Precambrian granites in the St. Francois Mountains are among the most uraniferous in North America. The St. Francois province has potential for uranium mineralization of economic importance, especially in the later differentiates.

Structural lineaments and circular features displayed on images produced by electronic data processing of Landsat multispectral scanner data may be related to late-stage intrusives with uranium potential. Strong north-south lineaments and associated circular and arcuate features may correspond to major weaknesses in the earth's crust along which fracturing, faulting, and volcanism have occurred. The strike of the lineaments transects the older dominant northwest-southeast and northeast-southwest structural grain of the region. This, and the remarkable preservation of Precambrian structures of volcanic origin, indicate that the lineaments may be related to late-stage, uranium- and thorium-rich intrusives. The Ironton lineament, a major north-south lineament, is closely related spatially to Precambrian iron and manganese deposits.

Field work along the Ironton lineament suggests that it is related to a late period of Precambrian volcanism and that structural deformation along the lineament continued into early Paleozoic time. Areas of faulting, shearing, and hydrothermal alteration affecting both Precambrian and Paleozoic rocks have been located. A circular feature along the lineament has been found to be centered by a manganese deposit of possible hydrothermal origin.

RUSSON, MIKE, Brigham Young Univ., Provo, UT

Stratigraphy and Economic Potential of Castle Gate Area, Carbon County, Utah

Unexcelled exposures of the coal-bearing Blackhawk Formation near Castle Gate, Utah, provide a cross section of sediments deposited by wave-dominated deltas along the western shoreline of the Cretaceous Interior seaway. Four sandstone tongues resulted from deltaic sedimentation, each overlain by thick coal. A clear genetic relationship exists between the occurrence of coal and geometries of paleoshorelines and fluvial channels. Coals are thickest where underlain by thin shoreface sandstones, and they pinch out abruptly against beach-ridge sandstones responsible for swamp proliferation. Fluvial channels subsequently cut wide swaths in swamp deposits normal to shoreline trends. Commonly, thick coals of different seams occur together, as the compaction of vegetation controlled subsequent swamp accumulation. Excellent exposures and considerable subsurface data provide the details necessary to construct a predictive exploration model useful in the Cretaceous coals of the central Rockies. Cretaceous deltaic deposits also create hydrocarbon potential, as three facies associated with Blackhawk deposition produce ideal stratigraphic relationships for hydrocarbon accumulation. Porous delta-front sandstones interfinger with the underlying organic-rich marine shale of the Mancos formation. Shale and siltstone of the flood plain then cap the sandstone. Hydrocarbons derived from the marine shale or from associated coal may accumulate in porous sands of stream channels or in mouth-bar or beach-ridge deposits of the delta front. A clear understanding of deltaic sedimentation, provided by analysis of the Blackhawk model, could aid in predicting the occurrences of similar subsurface sandstones.

SALES, JOHN K., Mobil Oil Corp., Dallas, TX

Heart Mountain, Wyoming—Blocks in a Collapsing Volcanic Pile

The Heart Mountain "detachment" was caused by volcanic collapse and not free sliding. These huge blocks could hang together if immersed in volcanics, but not in air. Block separation is logical during sideward volcanic collapse, but inertia and the rate required make free sliding untenable. Lack of erosion of the fault surface requires instant burial if free sliding was the cause. However, if the detachment was part of a volcanic collapse, the fault surface was never exposed. Free-moving blocks would gouge the delicate Grove Creek pavement, but the equal loading by a glacier-like collapse of volcanics would allow this stratigraphy to remain intact. Nothing in present experience moves free blocks on so large a scale on that flat a surface, especially up and over a transgressive ramp in a free setting. A collapsing volcanic pile propelled by its profile of repose, not by the slope under it, would allow movement. Earthquake vibration is ineffective in a free slide, but extremely effective in collapsing a weak pile. The Reef Creek structure is an imbrication; the South Fork is an unloading bulge. A long dip slope with a basin-facing monocline below it, a large young volcanic pile, seismicity, a swampy toe, and artesian pressure combined to cause failure. It may have been steady-state, incremental, or catastrophic, the latter being favored.

SALES, JOHN K., Mobil Oil Corp., Dallas, TX

Collapse of Rocky Mountain Basement Uplifts

Several Rocky Mountain uplifts have collapsed, usually back down the root zone of the thrust that raised the buckled slabs. Basement is juxtaposed against sedimentary fills and subcrust is juxtaposed against granitic crust. Thus, uplifts have "anti-roots" and strong positive gravity anomalies with slabs held up by strength rather than buoyancy, making them susceptible to collapse. The Rio Grande rift trends along the crests of older uplifts. Collapse is accentuated by regional uplift that removes basin fills. This substitution of "air for rock" increased gravity stressing.

Large gravity faults, including the San Luis basin boundary fault with relief that may exceed 20,000 ft (6,100 m), are caused by this mechanism. Their large size may be caused by a significant increment of displacement above the isostatic equilibrium position added to the normal buoyancy mechanism that drives these faults.

The north side of the Brown's Park graben in the Uinta Mountains