Abstracts

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Seismic Exploration in Raton Basin

Exploration in the Raton basin has delineated complex mountain-front structure in the asymmetric basin, and defined possible basin-centered gas. Exploration has included subsurface and surface geology, remote sensing, and seismic reflection.

The Raton basin is a north-south-trending structural basin straddling the Colorado-New Mexico boundary. It is bounded on the west by the Sangre de Cristo Mountains, on the north and northeast by the Wet Mountains and Apishapa arch, and the Sierra Grande uplift on the south and southeast. The basin is asymmetric with transcurrent faulting and thrusting associated with the steeper western flank of the basin. Rocks range from Devonian-Mississippian overlying Precambrian basement to Miocene volcanics associated with the Spanish Peaks. Principal targets include the Entrada, Dakota, Codell, and Trinidad Sandstones and the Purgatoire and Raton Formations.

Seismic data include explosive and Vibroseis data. Data quality is good in the basin center and is fair in the thrusted areas. Correlations are difficult from line to line. However, a strike line in the disturbed area would probably be more disrupted by out-of-the-plane reflections than the dip lines would be. Significant stratigraphic changes are seen in both the Trinidad and Dakota intervals.

Integrated seismic and geological studies are keys to exploration in the basin. Subsequent work will rely heavily on improved seismic information.

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"Jelly Bean" Conglomerate (Lower Permian): Record of a Forebulge in Southeastern Arizona?

The most incongruous stratigraphic unit in the Earp Formation (Pennsylvanian-Permian) is the "Jelly Bean" conglomerate (JBC), a unit rarely more than 5 m thick, but occurring over 15,000 km^2. The JBC consists mostly of clast-supported chert-pebble and limestone-clast conglomerate, litharenite, and pebbly sandstone, whereas most of the Earp Formation is marine limestone, siltstone, and shale. The JBC lies on eroded siltstone or limestone, and is capped conformably by siltstone. The JBC is probably a braided-stream deposit as indicated by presence of fluvial dunes and ripples, amalgamated bar and channel conglomerates, imbricated clasts, channeled underbeds, and lack of point bars. Paleocurrents were generally southward. The thinness and widespread occurrence of the JBC suggest a uniform, gentle paleoslope down which the streams flowed.

Deposition of the JBC occurred at about the climax of the Marathon phase of the Ouachita orogeny in west Texas and northern Mexico. The age and location of the JBC, which fringes cratonic North America, indicate that it was related to the late Paleozoic convergence of North and South America, and may have resulted from flexural forebulging caused by thrusting in the Marathon orogene and associated sedimentation in a foredeep.

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Seismic Lithology and Pitfalls in Seismic Porosity Detection

One common method of searching for seismic anomalies associated with increased porosity is to integrate the stacked seismic traces to obtain an "acoustic impedance" section or, if a suitable relation between density and velocity is known, a seismic interval velocity section. Lateral variations in the color-plotted displays can then be interpreted in terms of porosity variation associated with inferred velocity variation. Buried in this procedure is the assumption that the stacked section represents reflectivity at normal incidence.

In the developing technique of "seismic lithology," where variations in reflection amplitude with source receiver offset are used to infer lithologic properties, examples are accumulating that show dramatic changes in reflection amplitude with offset within common depth point gathers. Consequently, after stacking, the stacked section will be poorly correlated with normal incidence reflectivity.

Recent development in seismic lithologic analysis have led to a procedure that allows the normal incidence reflectivity to be estimated from the offset variation. The results of this procedure show greater continuity and geologic interpretability. More important, upon trace integration, the resultant impedance sections show greater stability leading to a higher confidence level in potential porosity anomalies.

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Integrated Geochemical and Paleoecological Approach to Petroleum Source Rock Evaluation, Cretaceous Niobrara Formation, Lyons, Colorado

Studies of the upper Turonian to upper Coniacian or lower part of Niobrara Formation (in ascending order, the Fort Hays Limestone Member and the marlstone, shale, and limestone of the lower part of the Smoky Hill Shale Member) reveal a significant relationship between petroleum source rock potential and paleoclimate. Trends in bioturbation, δO^{18} (oxygen isotopic ratio), and C_{org} (organic carbon content) during lower Niobrara deposition suggest that paleoclimatic factors limited bioturbation of the sediment, favored high C_{org} contents, and resulted in excellent source rock potential in the shale unit of the lower Smoky Hill Member. From the Fort Hays through the overlying marlstone unit, δO^{18} in inoceramid shells shows a gradual shift from nearly normal marine values (-2 to -4‰) to lighter values (-4 to -6‰); over the same interval, C_{org} changes from relatively low values (0.1-1.4%) to moderate values (0.5-2.5%). Bioturbation throughout these units is high. A marked shift toward heavier δO^{18} (-6.0 to -9.1‰) occurs upward into the shale unit and coincides with increase in C_{org} (2.3-4.9%) and an absence of bioturbation. In the limestone unit, δO^{18} shifts to less negative values (-6.2 to -6.5‰), C_{org} decreases (average 1.5%), and bioturbation returns. The trend toward more negative δO^{18} and higher C_{org} values in the shale unit is inferred to reflect a lowering of surface-water salinity in the Western Interior seaway due to climatic warming and increased freshwater imput. Resultant salinity stratification of the water column apparently inhibited vertical mixing and oxgenation of the bottom waters, resulting in limited benthic activity and enhanced preservation of organic matter.

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Facies Control of Mississippian Porosity, Whitney Canyon–Carter Creek Field, Wyoming Overthrust Belt

Mississippian Mission Canyon carbonates are the most prolific Paleozoic reservoir in the Wyoming Overthrust belt. At Whitney Canyon–Carter Creek field, the Mission Canyon Formation holds recoverable reserves of 240 million bbl of oil equivalent. Production comes from a 350-ft (107 m) gross interval of shallow-water shelf carbonates. Capping the reservoir interval is a 300-ft (91 m) section of anhydrite and tight dolomite that represents sabkha deposits that prograded seaward (westward) over the shelf carbonates.

Production from the shelf sequence comes exclusively from sucrosic dolomites that are interbedded with tight limestones and tight crystalline dolomites. Examination of cores spanning the entire reservoir interval reveals that it is composed of a series of nine shallowing-upward sequences, reflecting a history of progradational events across the Mississippian Wyoming shelf. A single complete sequence averages 40 ft (12 m) in thickness and grades upward from open-marine through restricted-marine to intertidal and/or supratidal environments. Open-marine units are predominantly fossiliferous grainstones and packstones—rocks containing little or no carbonate mud. The overlying restricted-marine and intertidal and/or supratidal units are primarily mud-supported carbonates. Petrographic evidence indicates that carbonate mud was dolomitized preferentially relative to grains. The best reservoir-quality dolomite, therefore, usually occurs in the mud-rich, upper portions of the shallowing-upward sequences, and tight intervals separating the porous zones generally represent grain-supported, open-marine units.

Such facies characteristically are continuous for great distances along depositional strike. At Whitney Canyon–Carter Creek field, individual porous zones can be correlated for more than 12 mi (19 km) across the

*Denotes speaker other than senior author.

field. This understanding of facies-controlled porosity development has application both in regional exploration and in field development.

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Seismic Line Across Wind River Thrust Fault, Wyoming

A seismic line was acquired by ARCO Exploration Company in 1977 in southern Freemont County and extends northeast from the deepest part of the Green River basin across the Wind River thrust onto crystalline basement rocks of the Wind River Mountains. A COCORP line across the area has been discussed previously, but the ARCO line shows more detailed information beneath the thrust.

The seismic line is significant because it shows a strong reflection at the base of the Precambrian granite, which overlies sedimentary rocks of the northern Green River basin. It also illustrates an apparent anticline beneath the thrust fault which is the result of lateral velocity variation caused by a shallow wedge of low-velocity Miocene sediments superimposed on a velocity pull-up related to the high-velocity Precambrian granite. The effects of the velocity variations can be analyzed by ray tracing and by studying the near offset and far offset stacks of the seismic data. A post-thrusting normal fault, the Continental fault, appears to extend downward and causes diffraction energy and time offset on the seismic section. Proper field technique, appropriate processing, and ray tracing interpretation are all necessary in areas of granite overthrusts.

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Stratigraphic Reconstruction Using Digitized Well Logs: Lewis Shale, South-Central Wyoming

Advances in manipulating and displaying log data and improved methods of well-log digitizing have greatly enhanced explorationists' ability to incorporate large volumes of well data into basin-wide stratigraphic reconstructions. Computer manipulation of digital traces expedites construction of cross sections, generation of log-derived lithologic columns, normalization of log response, and updating of regional studies. The ease and speed with which cross sections can be changed and printed allow use of numerous datums to test correlations and permits construction of paleoslope configurations. Additionally, the ability to reduce a large cross section to a single field of view, without loss of definition, produces enhanced basin-side perspective and reveals stratigraphic relationships not apparent at larger scales.

The approach proved critical in depositional reconstruction of the Maestrichtian-aged Lewis Shale in the Washakie and Red Desert basins, Wyoming. Deep-water sandstones within the Lewis are hydrocarbon reservoirs at Wamsutter and Hay Reservoir fields. Core data, cross section thickness patterns, and lithology computed from logs show the Lewis to consist of a thin transgressive shale overlain by progradational sequences. Progradation occurred as deltas entered the basin initially from the northeast and later from the south. Correlation of log response indicative of volcanically derived clay-rich layers results in stratigraphic patterns on log cross sections similar to patterns on seismic sections. The transgressive shale onlaps the Almond Sandstone; progradational sequences are depicted as irregular, sigmoidal clinoforms. Patterns indicate high sediment input and very rapid basin subsidence.

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Anatomy of a Regional Play in Rio Grande Rift Basins of New Mexico and Colorado

The integration of regional Cretaceous stratigraphy, surface mapping of different structural styles, seismic data, and accumulating subsurface well control has blended over the past 16 years into a regional Cretaceous play encompassing many of the subbasins of the Rio Grande rift from Texas, north through New Mexico, and into the San Luis basin of southern Colorado.

Different structural styles, as well as changing stratigraphy, can make exploration in one of the subbasins a very different problem from exploration in another. Remnant structures of pre-rifting tectonics vary radically along the course of the rift from north to south, and are present and preserved beneath the subsequent rift-valley fill. Although the same basic tectonic causes for the rift are common throughout its length, this later Tertiary tensional event was imposed across all previous structural grains from Precambrian to Laramide.

In areas such as the northern Albuquerque basin, which was relatively undisturbed by Laramide thrusts, the predominant structural style is listric faulting caused by the rift. However, areas such as the Espanola basin show strong evidence of pre-rift thrusting during the Laramide orogeny. This structural style is still quite evident, and in places is the predominant style preserved beneath Tertiary valley fill.

In other areas, such as the San Luis basin, the rift has superimposed itself across earlier block faulting that occurred during the Precambrian and late Paleozoic and was modified by Laramide thrusts. The area was then covered by Oligocene-Miocene volcanics and rift-valley fill.

Such complex tectonic history makes exploration in the various subbasins of the rift extremely difficult. It also presents rare opportunities for hydrocarbon exploration in potential new provinces where abundant stratigraphic and structural trap potential is combined with adequate source rocks and a favorable maturation history.

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Hydrocarbons in Northern Basin and Range, Nevada and Utah

Occurrences of surface and subsurface hydrocarbons in the northern Basin and Range province indicate that oil and gas have been generated in several areas in this province. Documented surface occurrences include: (1) oil in ammonites found in Triassic shales in the Augusta Mountains northeast of Dixie Valley, (2) the Bruffey oil and gas seeps and asphaltite dikes in Pine Valley, (3) Diana's Punch Bowl (probable gas seep) in Monitor Valley, (4) droplets of oil in goniatites of the Mississippian Chainman Shale and oil staining at one locality of the Sheep Pass Formation in the ranges surrounding Railroad and White River valleys, (5) oil shale in the Tertiary Elko Formation near Elko and the Ordovician Vinini Formation in the Roberts Mountains, and (6) numerous outcrops with petroliferous odor and a few with oil staining.

Subsurface oil and gas shows are more widespread, but most have been found in the same general area as the surface shows. However, there are some important exceptions.

To date, all commercial and noncommercial oil and gas fields in the northern Basin and Range are located near the sites of the surface hydrocarbons. This relationship emphasizes the importance of source rock studies to exploration in this province. Prospective areas that lack surface hydrocarbons might be delineated by source rock studies.

Eleven oil and gas fields have been discovered in this province of which only three or four can be classified as commercial fields. All of these fields are located in Neogene basins--no fields have been found in an exposed mountain range. The significant fields have some additional common characteristics: (1) the traps are associated with a Tertiary unconformity, (2) the reservoirs have a relatively thick oil column, and (3) fractures usually enhance the reservoir quality. Fields in Railroad Valley and the Great Salt Lake illustrate these and other characteristics.

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Red Wing Creek Field, North Dakota: Growth-Faulted or Meteoritic-Impact Structure?

During the early stages of development at Red Wing Creek field, meteoritic impact was the accepted explanation for structure. Spectacular structure that apparently did not persist below the Mississippian Madison Group and the presence of shatter cones, which were thought to be indisputable proof of shock metamorphism from impact, were the primary points of evidence.

More subsurface information from new wells, and more careful correlation, subsurface mapping, and cross sections appear to indicate that there are two interpenetrating systems of fault slivers that persist down through the Ordovician Red River Formation. These fault slivers seem most likely to be torn from northeast- and northwest-trending, reactivated lineaments at their intersection. This deep structure, which is offset from the central high, supports the concept of at least 100 m.y. of progressive structural growth at Red Wing Creek field.